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Journal of the United States artillery

United States.
Coast Artillery
Training Center, ...

details of instruction being constantly reviewed. While it may now appear that there is not much accurate information in the service with respect to artillery target practice it will be found that each officer of experience has absorbed, learned or discovered something and when all these results of experience shall be collected and tabulated it is impossible to say what light may emanate from them. In order to work together we must understand one another: this condition requires that we talk with one another. To bring about free communication of ideas and a condition of systematic work is the object of the following discussion.

EDITOR.

FORT MONROE, VIRGINIA,
August 10, 1893.

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SIR:

With the approval of the Committee of General Direction and Publication it is proposed to draw out and, as far as possible, to collect into one number of the *Journal* practical ideas, methods, and information with respect to Coast Artillery Practice. By collecting and printing in a single volume the best suggestions and practices now in vogue it is hoped to create additional interest in the subject, to place much scattered information before the reader in shape suitable for use and reference, and to bring to each the benefit of the experience of all.

The following synopsis indicates the scope and object of the proposed discussion.

A. The selection and preparatory instruction of the Artillery soldier.
  I. The elementary instruction of the recruit.
  II. The organization, equipment, and instruction of the detachment, platoon and battery.

B. The fundamental fire-instruction of the Artillery personnel.
  I. THE FIRST PERIOD OF COAST-ARTILLERY FIRE INSTRUCTION.—*Ballistic Firing.*
    A. The determination and reduction of fundamental ballistic data. *a.* Operations involved in obtaining these data and considerations relating thereto. *b.* Range tables. *c.* Methods of obtaining the values of all deviating causes affecting the trajectory, such as jump, atmospheric conditions, drift, etc., and their correction in practice. *d.* Probabilities, deviations, etc. *e.* Fire game. *f.* Where and how should this instruction be given?

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American Military Institute
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II. THE SECOND PERIOD OF COAST-ARTILLERY FIRE INSTRUCTION.—*Target Firing.*

A. Present conditions and methods and their improvement. *a.* The present allowance of ammunition and the best means of using it. *b.* The old guns and their value as instruments of instruction. *c.* Present auxiliary apparatus such as plotting boards and observation instruments. *d.* Auxiliary methods of checking results. *e.* What is the best method of measuring lateral deviation of shots, by transit alone or by co-operation with station observers; the best means of plotting shots, with respect to range of target or with respect to range corresponding to elevation given? *f.* The value of sub-caliber practice. *g.* Best methods of conducting target practice. *h.* Suitable ranges. *i.* Range finding. *j.* Kinds of targets. *k.* Moving targets.

B. Powder. *a.* Desirability and practicability of manipulating the powder in any way at the beginning of a target season. *b.* Practical use to be made of laboratory data with respect to moisture, density, etc.

C. Conditions of loading. *a.* Importance of noting the density of loading. *b.* How can this be done, especially in the 15-inch S. B. gun?

D. Records. *a.* What records should be kept? *b.* How can they be utilized with view to drawing from them the maximum amount of instruction?

III. THE THIRD PERIOD OF COAST-ARTILLERY FIRE INSTRUCTION.—*Tactical Firing.*

A. Considerations relative to the fire of the guns of a battery. *a.* Fire discipline and control. *b.* Concentration. *c.* Rate.

B. The fire relation of one battery to another.

C. The fire relation of a group of batteries to another group of batteries.

The purpose of the discussion is to include questions relating to Artillery fire instruction from the elementary instruction of the recruit to the duties and responsibilities of the Artillery Commander. You are therefore requested to contribute to this discussion and to devote your attention to the whole general subject or to any particular part, division, or sub-division, as you may feel disposed to do.

Trusting that you may enter into the spirit of the proposed discussion and give it attention in keeping with its importance,

I am, very respectfully,
your obedient servant,
(Signed) JOHN W. RUCKMAN,
1st Lieutenant, 1st U. S. Artillery, Editor.

Ref 37 sta Providence R.I.

1st Lieutenant *E. M. Weaver*, R. Q. M., 2nd Artillery.—In accordance with the request contained in the above circular of August 10, 1893, I venture to offer a few suggestions on the points put forward in the synopsis presented as a guide for discussion.

Selection of the Artillery Soldier.

When the nature and scope of the duties to be performed by a coast artilleryman are considered, it will be readily granted that the selections should be made from a special class of men. The mechanism of the carriages and of the accessories made use of in the defense of modern coast forts is as complicated and as difficult to manage as that of locomotives or other engines. Our recruits should, therefore, possess a measure of intelligence and aptitude that will always furnish material for gunners who shall know something practically of mechanics, electricity and the use of mathematical instruments employed in gunnery. The duty of coast artillery has associated with it considerable work in small boats in connection with placing targets, attending to sub-marine mines, and in making water-surveys in front of batteries. For this duty men enlisted along the shore would be of great service. In the selection of the recruit we should therefore keep these desiderata in mind. To be sure such men cannot be had for the wages now offered to artillery soldiers, but we all hope, I presume, that the change that must sometime come in the organization of the personnel of coast defense will give a rate of pay to our artillerymen that will enable us to supply our needs from the labor market of the country.

Elementary Instruction of the Recruit.

This should begin with a vigorous physical training which should aim to develop the man to the full possibilities of his body. In no branch of the service are there greater demands made upon human muscle; and if in action the firing were continued for any length of time the endurance of the cannoneers and ammunition servers would be severely tested.

Along with this physical training should proceed his artillery training. All recruits would be carried through the school of the soldier, the service of the several coast defense guns and the standard exercises in mechanical maneuvers, small boat drill and cordage. These drills should be gone through with assumably, both to train the recruits and to keep in training the older men. It is not always the custom at coast artillery posts to have small-boat drill. This is thought to be a serious omission.

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It would soon be possible to differentiate the man according to intelligence and aptitude, into two classes, viz.: first classmen and second classmen. The former should receive higher pay than the latter and would constitute the material from which gunners would be appointed. First classmen should receive further instruction in practical mechanics, gunnery and electricity. After a certain specified course and examination they should receive certificates as *Gunners* and be exempt from further theoretical instruction, unless, through some exhibition of ignorance, a gunner be required by his commanding officer to go over a part or all of the gunner's course. Gunners should receive extra pay per month while they hold certificates. Examination to enter the Gunner's class should be made annually at Fort Monroe at the close of the instruction season by a board of officers, all candidates being ordered to Fort Monroe for the examination.

Non-commissioned officers would, as far as possible, be taken from the Gunner class of men.

Organization of the Detachment, Platoon, and Battery.—The gun detachment of ten cannoneers should be the fundamental maneuvering unit for drill and disciplinary purposes. On all occasions and under all circumstances the identity of the detachments should be preserved. In forming the battery the chief of each detachment should supervise, under the first sergeant, the formation of his detachment. A battery in time of peace would consist of eight detachments and have eighty privates, eight corporals, four sergeants, two lieutenants and one captain. It would be adapted to the service of two 16-inch guns, four 10-inch or 12-inch guns, eight 8-inch guns or 12-inch mortars. In time of war the detachments could be doubled in size, and, if necessary, in certain cases, the number of detachments could be increased.

FIRE INSTRUCTION.

Ballistic Firing.

The whole problem of the determination and reduction of fundamental ballistic data will be solved for *all practical purposes* of firing when we shall have a set of charts after Whistler's method for each of our guns. Instruction of a simple character in the deductions and applications of ballistic formulas and the use of the charts would be given in the Gunner's course, and also instruction in the use of ballistic instruments would be given in this course.

Target Firing.

Present Conditions and Methods.—The maxim which should govern in target firing is, that whatever is done should be, in so far as possible, an exemplification of what we would have to do in action against hostile war ships. It seems that we come wide of this mark. If we should be forced to prepare for real action at the present time not one feature of our present system could be put into operation. We should have to put aside plotting boards, observers at A and C stations, etc., and come down to the primitive simplicity of the gunner taking the best sight he could over the gun at a man-of-war at a *guessed* range moving at a *guessed* rate in a *guessed* direction. Mortars would not be fired as now standing in the open and by direct sight on the target. The transit instrument would disappear from the plane of fire also. The barometer and anemometer would hardly be consulted by the gunner under the circumstances. The degree of humidity of the atmosphere would also be neglected by him. In short it is believed we are practicing methods which would have to be neglected in some of their features if war were to come suddenly upon us. We strain after certain refinements which are possible on the proving ground and of service in determining range tables, but which cannot be put in practice in the rush and excitement of combat.

Artillery target firing should progress along the lines small-arm practice has. We should not be content with fire at known ranges and at stationary targets, but the firing should include practice at unknown ranges and moving targets and with a time limit between shots.

The system as now followed is in some of its aspects unmilitary and suggestive of lax discipline. The spectacle presented at artillery practice of men lying over the slopes and lounging here and there waiting for the angles to come in, or, perhaps, for the transit cross-hairs and the line of metal to get into the same plane, is trying to one who realizes that this, of all drills, should see the bonds tightly drawn, the men kept strictly in their positions at the gun, and war conditions simulated as nearly as possible. Then, too, the great number of assistants required to conduct the target practice of a battery, making observations, signaling, and keeping the multifarious details of the record required to be kept, could never be allowed in the war service of the guns.

It ought to be possible to conduct target practice with no other outside assistants than the observers and the plotting board officers, with, perhaps, one enlisted man to assist each.

Present Allowance of Ammunition and the Best Means of using it. Sub-caliber practice.—Ten shots per gun per year is thought to be a fair allowance with standard loading. With the new guns it is doubtful if a greater allowance than this would be authorized by congress under any circumstances short of actual war, by reason of the enormous expense entailed by the firing of such large charges of powder and ponderous projectiles. There is no reason, however, why suitable sub-calibers should not be devised to be mounted inside the bores of the larger guns, or alongside the larger gun, attached to it. If this be done there would be no difficulty in getting all the ammunition necessary for target practice, and, if the practice take place on reduced targets at reduced ranges it is believed the instruction would have great value in producing a high degree of gun-service efficiency and also have a bearing on gunnery efficiency.

The sub-calibers should be so arranged as to make it possible for the troops to mount and dismount them. This could be arranged as a regular drill exercise and take its place among the mechanical maneuver exercises.

The old guns and their value as instruments of instruction.—We can do everything with the present guns that we shall be able to do with the new guns except those things which depend on gun-power and on gun service. The ranges of the new guns will be much longer for the same angles of departure, the remaining energies at the same ranges will be greater with the new than with the present guns, new drills will have to be prepared for the service of the new pieces, but everything else will remain unchanged, in principle at least. The entire field of gunnery remains unaffected. Like every abstract science it is adaptable to any material and the same principles always apply. The principles governing the firing at stationary and moving targets are largely independent of the gun, and it is within the limits of these

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gunnery principles that artillery lives, moves and has its being. As long as we have something that will throw a projectile we can work to determine the most efficient way of doing it. Emerson says there is a best way of doing everything—even ~~to boil~~ an egg. We may derive much instruction in the use of our present guns.

The present auxiliary apparatus, such as plotting, plotting boards, and observation instruments.—This at most posts, at present, consists of azimuth circles at the extremities of a base line and a plotting board near the guns to which the angles read at the observing stations are transmitted. The chief defect in this system is, the delay attending the transmission of angles. There should be electrical connection between the plotting house and the observing stations by means of which the position of moving targets could be either continuously plotted on the chart, or plotted at minute or half minute intervals or even less. If this can be done, satisfactory practice at moving targets may be made. Any good position finder will give a continuous plotted trace of a moving target, and a simple connection of each observing station with an ordinary hotel annunciator, at the plotting board, running up to 60 for minutes, and another division running up to 180 for degrees, would enable the observers to transmit angles by merely pressing the proper buttons and thus, practically, a continuous course could be plotted by reducing the time intervals to a very few seconds. These annunciators are simple and inexpensive and might readily be supplied to every post at any time, as they are standard articles and on the market at all times for sale.

Suitable Ranges.—The most "suitable ranges" are those at which we shall have to fire in war. Practice should therefore take place over the *entire field of fire.* It is a mistake to require all shots to be fired at the same range, and especially so when it is continued from year to year as is our present practice. The method gives no exercise to the gun detachment in laying the gun under varying conditions such as it would meet in warfare. If each shot were fired at a different range, and, if the gunner were required to estimate the range of the target and its direction and rate of motion if moving, more real instruction would be imparted in target practice than is done under our present method. Each gunner should receive an annual mark of efficiency on the manner in which he performs his duty *at the guns.* It is only here that any true measure of efficiency in estimating ships' motion and distance can be had. A test made of gunners firing at different ranges over the whole field of fire and at moving targets would show truly their relative efficiency. If it costs too much to do this with the large guns, the test could be made just as accurately with small caliber rapid fire guns.

Range finding.—The plotting board will always give the range if arranged as above indicated. When two observers are used, with a horizontal base line, it is important that the observing stations be so chosen that the lines of sight through the telescopes passing out over the water will cross about at right angles in the most important part of the field. The accuracy of the plotting is much affected by the relative acuteness or obtuseness of the angles, the right angle being, of course, always the most favorable for accuracy. One station should be as near as possible to the plane of fire, the other about opposite the mid-range of the guns. The reason for this is, that azimuth deviations from the plane of fire are best taken from that plane, and range deviations from a point opposite the point of fall perpendicular to the plane of fire. It is not always practicable to fill these conditions, but they should be attained as far as possible. With smokeless powder it may be possible to place one observing station directly in front and below or behind the guns in the plane of fire.

Gunners should be instructed to determine the range from the time of flight and splash. In case of injury to the instrumental range finder it may be necessary to fall back on primitive methods. Therefore estimation of distance by sight and by time of flight should not be neglected.

Kinds of Targets—Moving Targets.—For stationary targets a simple board, properly weighted to cause it to float upright, carrying a good sized flag, appears to be all that is necessary. For a moving target a boat-shaped float might be arranged with a sail so fixed that if the float were anchored by a long rope the float would swing back and forth across the field of fire under the influence of the wind on the sail.

At Fort Monroe in 1886-8 we fired at a target towed across the field of fire by the *General Wool*. This worked very well, but at the cost of much nervous force on the part of the captain and crew of the boat. With a 300-ft. tow-line there was no real danger, and where there is a steam boat it is, perhaps, the most satisfactory way of getting a moving target. Shots must be limited, however, to passage directly across the field; no straight-away, straight-on, or quartering shots could be had, and this is a serious objection.

It ought to be possible to make use of the principles applied in some of the electro-motor torpedoes which are directed from shore. A small boat-like float supplied with a suitable motor arranged to work a small propeller and rudder through a line of wire reeled off as it passes through the water could perhaps be devised in the Electrical Department at Fort Monroe.

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Desirability and practicability of manipulating the powder at the beginning of a target season. The firing should, if possible, be always with *the same muzzle velocity*. A ballistic test should be made of the powder at the beginning of the target season and the weight of powder adjusted to give the standard muzzle velocity. When this is done the graduations on the sight may be given in terms of the range, and all previous data may be drawn up with confidence. If ballistic screens are not at hand the muzzle velocity may be determined from the angles of departure and ranges of a few preliminary shots carefully fired and carefully plotted.

Assuming a quantity of powder of the same powder characteristics available for the firing, the ballistic test is the one test that the artilleryman should insist upon. It integrates all affecting causes. If it be properly made moisture and density data will not be required subsequently during the firing. It also involves the question of *density of loading*, because the *standard muzzle*

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velocity based upon a given weight of powder, necessitates that all conditions of loading shall be reproduced each time as nearly as possible. The same force should be used in pushing the powder charge and projectile home, a mark on the rammer staff being useful to accomplish this.

What records should be kept?—It is thought that some of the records now required might be abandoned without detriment to accuracy of fire. It is well enough that every person should know how to read the barometer and the wet and dry bulb hygrometer, and that practice should be had at some time in taking powder pressures with the crusher gauge, but it cannot be said that this information is or can be made of practical use in our target firing. The relative humidity of the atmosphere and the air pressure should be noted before each day's firing, perhaps, to see if there be any marked departure from standard conditions, but any attempt to regulate each shot or every few shots by this data creates confusion, causes delay, and, in the result, is more harmful than beneficial. Certainly nothing of the kind would be resorted to in the heat and hurry of actual combat.

As to powder pressures, they could be taken with the preliminary shots fired to determine the muzzle velocity, and would be of service in checking results.

The records to be kept should be those that will be of practical use for subsequent firing at the same range; such as, muzzle velocity,* projectile, charge, pressure,* angle of elevation, points in azimuth allowed, range of target, coördinates of splash, velocity and direction of wind, total number of times the gun has been fired.

The transit record as now kept is unnecessary if the positions of the observing stations be chosen as herein suggested.

Tactical Firing.

Considerations relative to the fire of the guns of a battery.—This is, no doubt, the most important sub-division of the entire program. It involves the method and manner of using the guns of a battery in combat, and the consideration of this matter is the lap in which all previous discussion must finally rest. A treatise might be written on this one point if all aspects were treated freely. Only one or two points can be introduced in these brief comments:

It seems to the writer that the one point we have most flagrantly neglected is *practice at moving targets.* It may be readily admitted that if we ever have to fire at hostile ships they will be in motion. No ship dare remain stationary within the range of modern guns, mortars, or pneumatic-gun-torpedoes. Any vessel remaining at anchor for even a few minutes at ranges beyond 4000 yards would be sunk by mortar fire alone. But when ships attack a fort as Admiral Porter's ships attacked Fort Fisher, for example, or if they should follow this plan in bombarding a city at long range over the fort, we shall have to do some "wing shooting." What have we done or are we doing to

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* Assumed to be constant for the season's firing.

prepare ourselves for this work? I have never seen the attempt made in regular practice to fire at a moving target in the eighteen years of my service in the artillery, except once at Fort Monroe. In the summer of 1887 Captain S. M. Mills, 5th Artillery, then in charge of target practice, had a target towed across the field of fire and it was fired at from a 15-inch S. B. gun. The practice was not good. The difficulties connected with the practical problem of causing the projectile and target to meet at a guessed-at point ahead, were, I think, a revelation to most of those who were called upon to fire the gun. The experiments had to be discontinued after a few trials because of objections raised by the captain and crew of the boat as already intimated above.

Considerable study was given to the question by the writer after these trials, and sometime, not long afterwards, certain conclusions were reached. He has wished to test these in a practical way, ever since, but duties have fallen to his lot which have kept him away from the guns. When the invitation to take part in this discussion was received the subject was reviewed, and authority was asked to fire ten rounds of ammunition from the eight-inch rifle at this post [Fort Adams, R. I.] in testing the system. The authority wes granted, and the test was made on October 16, 1893. Seven shots were first fired to test various features of the system, and then three shots were fired at imaginary moving war ships. The problem given to the one charged with the firing of the last three shots was as follows: *A ship is at a point* (*A*) *in the field of fire, moving in a direction* (*X—Y*), *at rate of* (*K*) *knots per hour. Required: to hit the ship.* "(*A*)", "(*X—Y*)" and "(*K*)" were given *two minutes before the projectile was required to be at its destination* (determined by the splash of the shot). It can be said that the entire series of shots gave satisfactory results, especially the shots at moving targets. Of the last three shots, the first struck 30 yards in front of the ship and would have hit, probably, on ricochet, about one-sixth the length of the ship ahead of the stern; the second shot was lost because of an error at A station; the third shot was a direct hit 10 yards abaft midship. The rate of movement, the range, and the direction was different in each case. It is not known, of course, that these results can be reproduced, but there is, on the other hand, reason to think that even better practice can be made. The mechanical arrangements for aiming were improvised out of such material as could be picked up, and were fitted to the gun by inexperienced workmen. Furthermore, there were no data of previous firings with the system from which index errors could be determined and corrections made. With the crude mechanism used replaced by better constructed and more delicate apparatus, and with instrumental errors determined, it is certain that an improvement could be made in the firing.

At all events the question of firing at moving targets is the most important and practical one connected with target practice. No attention whatever is given to it now in our regular system. Whether by the system herein referred to or by some other, practice at moving targets should be made a feature of our annual target firing without further delay.

Intimately connected with this subject of fire at moving targets is that of *parallel fire*. By this is meant the fire of a group of guns with axes parallel. Some severe criticism has recently been directed against parallel gun fire, but it is believed that *for fire at moving targets* the principle of parallel fire is correct, and that the advantage to be derived by its use is so decided that no other kind of fire should be used against moving ships in combat. In order to bring out clearly the point to be made, let us assume that *all instrumental errors* connected with range and position finding, the aiming apparatus, the gun and the projectile are eliminated, so that the only remaining factor connected with the gun is, *man*—the man charged with predicting the point ahead at which the projectile and the moving target will meet. This is essentially an act of mind; machinery can never be made to perform this one act, and therefore, unfortunately, we must deal with human frailties, human imperfections. The one who predicts the meeting point of projectile and target must do precisely what the sportsman does who shoots at a bird on the wing: 1. The distance, rate, and direction of the moving target must be determined; 2. After having done this, all *time* factors between the first epoch and the instant of meeting of the shot and target must be allowed for; 3. The gun must be aimed on the predicted point of meeting with as much accuracy as at a stationary target.

In regard to the first of these three separate acts it is to be noted that (a) the range at the instant of observation will not be accurately determined; (b) the rate of the moving target is very difficult to determine even if the rate were to remain constant, but in actual combat the rate will be constantly changed by the captain of the ship being fired at, for the special purpose of making it more difficult for the shore gun to hit the ship; (c) the direction of the target is also difficult to determine, even approximately, and in combat it would be constantly changed. Instead, therefore, of firing at a body moving in a straight line with a uniform velocity, we must be prepared to fire at one moving promiscuously in different directions and at varying velocities; the feat presented is not unlike that of a man with a small arm who attempts to shoot a bat flying. It must be granted, that, after the most expert gunner has done his best, a large error factor will always remain for which allowance must be made.

As to the second, the time estimates, it must be pointed out, that the artilleryman firing at a moving target has a much more difficult task than the sportsman. The latter, after he has analyzed the bird's flight, has to allow only for the time involved in pulling the trigger and that required by the shot to go to the point of meeting. The former has to transmit his orders for laying the gun, give the gun proper elevation and direction, give the orders for firing the gun, fire the gun, and then allow for time of flight; while this is being done the target is moving along towards the point predicted, and if the *time estimated for each separate sub time division* be not accurate, the projectile and target cannot meet at the predicted point.

It must be kept in mind that after the prediction has been once made *any* *variation of time elements* from those considered in making the prediction will make the prediction erroneous.

Thirdly, in addition to these major sources of error in firing at a moving target we shall have all those ordinarily associated with fire at a stationary target.

From these considerations it follows, that, apart from the gun and all machinery used in firing it, *deviations will necessarily be had due to errors of estimates made by the predicting officer.* That is with perfect gun and instrumental conditions there will, in firing at moving targets, *be material personal errors.* Experience goes to show that the deviations due to these personal errors will, as a rule, be such as to make a single gun throw its shot outside the limits of the target (ship), just as this *same personal factor* will make a good small arm shot miss a flying bird (with a rifle) which he would surely kill if stationary.

If, then, the actual conditions be such that *the chances are that an expert gunner will not hit with a single gun a hostile ship* moving as in combat, at combat ranges, it follows that the only way *to increase the chance of hitting* is to increase the number of projectiles discharged at the same time. Now it is clear that if several guns were discharged in this way *at the same predicted point of meeting*, for a ship, say, at 4000 yards, moving 10 knots per hour (about 600 feet per minute), the shot of each gun would have the same chance of missing as a single gun. All of our eggs would be in one basket; we should either hit with all or miss with all, with the chances greatly in favor of the latter. In the same way several riflemen firing at a flying bird *if each predicted the same point of meeting* would have only the chance of hitting that one would. But if the riflemen predicted points of meeting say two inches apart in front of the bird it would be exposed to the chance of being hit over a considerable portion of its flight instead of at a single point. On the doctrine of probabilities each shot fired at the same time *at a different predicted point of meeting multiplies the chance of hitting.* The efficiency of the shotgun over the rifle in wing shooting is due precisely to these considerations; the shotgun gives many lines of fire nearly parallel, which at a certain range produce a "pattern;" that is, the space has the shot evenly distributed throughout and a bird entering this "pattern" is almost certain to be hit by one or more pellets of shot.

In the same way in firing at moving targets in artillery practice we should consider the "pattern" of each group of guns as the unit of fire. If there be four guns in a group and they be fired at a moving target with axes parallel the chance of hitting would be four times greater than if the guns be fired in succession on separate predictions or if all be fired at once on the same predicted point.

It must be kept in mind, therefore, that, at best, in firing at moving targets, there is *only a chance of hitting*,—a chance so broad that the probability is very great that a single gun under the most advantageous conditions will *miss* the moving target, and in no way can this *chance* be eliminated. As the "scattering principle" introduced by *parallel fire* operates to *increase the* *chance of hitting* in direct proportion to the number of shots in the "pattern," it is sound in theory and will be found sound also in practice. Views held in opposition to the principle of parallel fire should be modified in so far as fire at moving targets is concerned.

In regard to the last topic presented in the program of discussion, namely, the relations of the fire of batteries and of groups of batteries, it can only be said that this must be a matter of special study for each locality. Two fundamental principles will, however, determine all the conditions in every problem, *viz:*

1. All navigable water areas must be dominated by a fire having a weight and volume proportionate to the character of ships that can sail over the areas.
2. Adjacent batteries and adjacent groups should be placed in mutually supporting relations.

1st Lieutenant *Charles D. Parkhurst*, 4th Artillery.—The important results achieved by and the benefits derived from small arms target firing need no enconium from me. Important however as they may be, and necessary for the proper instruction of troops, similar results for the coast artillery are of far greater moment. It is my object in this paper to try and show why this is so, and to suggest some means whereby our present system of practice may be improved, so as to enable artillery target practice to be of similar benefit to the artillery service.

It is next to impossible to touch upon this subject without repeating many things that have already been said. Such repetition, however, is to be taken as showing that I agree with whatever may have been said, and to lend what further emphasis I may upon the points covered. It is also next to impossible to discuss this subject without the appearance, at least, of being a fault-finding critic. But it is to be understood that I do so in no captious or fault-finding spirit, simply for the sake of fault-finding. On the contrary, it is because I see what I think are faults, and therefore point them out for our own good and the good of the service. Certainly criticism and suggestion can come from some one in the service, and for the good of the service, with a better grace than from some one outside, whose motives may be to tear down, while mine are to build up.

We are all more or less familiar with small arms target practice and its methods. We know that many and many a shot is expended in preliminary instruction, as well as in "qualifying" marksmen and sharpshooters. And this is proper too, as I take it, for the small arms rifle shot is being educated *practically* upon the range to estimate and allow for the "variables" that enter into his problem. His ammunition is cheap; a shot that does not hit the target is not necessarily thrown away; he may, and probably does, know nothing and cares less than nothing about any of the ballistic qualities of his gun, or the varying elements that would enter his ballistic equations if he was required to use or solve them. Probably ninety-nine hundredths of the small arms distinguished marksmen we have in the army never heard of "*C*" and do not care to hear about it. What they do know they have learned from experience, and they set sights and allow for deviation as their judgment dictates, according to the wind and weather, light and shade of the day upon which they are shooting.

And in small arms practice, and ~~the~~ actual warfare with small arms, shots that do not hit their target, that is the object they are aimed at, are of comparatively small loss. In practice they may serve to "help find the bull's eye" and are the means and methods by which the small arm expert gets his proper "angle of departure" and "deviation." In warfare they may yet do execution upon some one other than the immediate target. In fact it may be assumed in warfare, as it has heretofore been conducted, that but a very small percentage of "direct hits" are made. The homely expression of "firing at the goose and hitting the gander" probably describes about all of the shooting and hitting done; for the "target" is large horizontally, is generally obscured by smoke, and the best one can do is to fire away at as near the proper elevation as possible, and "trust to luck" that the bullet will hit some one somewhere, inside the "dangerous space" of the bullet.

And the small arms expert has been able to become such in perhaps one season because of many things that he little realizes or understands, and perhaps never thinks of. His rifle has been made for him as carefully and accurately as machinery can make it within the limitations of proper cost. His rear sight has been graduated for him in *yards of range*, and not "angles of departure." *His ammunition has been made for him in the most painstaking and careful manner not only as to constant weight and quality of charge of powder, form, size, weight, and density of bullet*, but it also HAS BEEN HERMETICALLY SEALED, so that hygrometric conditions of the atmosphere, as they vary from day to day, only affect his shooting by varying resistances to bullet, and not by *changing the quality or condition* of his powder. He has lost the use of the old caution about "keeping his powder dry," *for he could not wet it if he would* in a cartridge as it is turned out by the factory.

We see therefore that about all of his "ballistics" have been solved for him before hand. He needs no "range tables" or any other tables. He soon learns to judge how much to "allow" for variations in the wind and weather, light and shade. He soon acquires the necessary steadiness of position, and in pulling the trigger. The "variables" that enter his problem *reduce down to a few feet*, having been reduced by experiment and expert manufacture *to the smallest possible limits;* hence about all he has to do is to learn by practice, have fair eye-sight and good nerves, and he can hardly fail in becoming a fair shot. Ninety-nine times out of an hundred it is the "man behind the gun" and not the gun or ammunition that is at fault when a miss is made.

With coast artillery however how different the case! Our ammunition costs too much to permit of reckless and indiscriminate use in target practice, hence we are limited to the small number allowed by "regulations and orders." With us, in actual service, a "miss is a miss," and is as "good as a mile;" for, from the nature of the case, all our shots are, should be, and will be *aimed* *shots*, *at some object we desire to hit*, which object we *must* hit, or fail in our proper duty and function, and perhaps bring disgrace upon ourselves, and disaster upon our country. It can hardly be conceived that any fleet of war vessels will ever come against us so numerous and so close together that we can ever "fire at the flock." We must pick our object and fire at it *and fire to hit*, *and* TO HIT EVERYTIME in order to accomplish the very reason for our being, and to fulfill the expectations of those who place their dependence upon us for proper protection.

Our target practice then assumes an importance far and away above any importance which can by any possible argument be given to small arms practice. From the nature of the case we must be competent to do many things that the small arms expert never dreams of. We must come to the target range ready and able to determine many things that vary from day to day, and from season to season, so that, given the necessary data from the observing station as to range, we will be able to determine our "angle of departure" to fit the day and hour and the "variables" that have been determined for the shot, and then, *by our skill and practice with the gun*, so lay it and shoot it that the target suffers. In other words we must be *theoretically* good shots and know what we have to do and how to do it, as well as *practical* experts at the gun. We must be so skilled that our enemy will respect us and our shooting and "stop to think awhile" before he concludes to try to run the gauntlet of our guns. Granted that our guns have power enough to work destruction if our projectiles hit, we never should see an enemy's ship go steaming by showing its contempt for our poor practice; for that is just what would result if we "shoot and shoot and never hit."

How to arrive at, or to approximate, to this perhaps ideally perfect state is the question. And it is this question upon which I now shall try to give my ideas.

It is assumed that our work must be and is *scientific*, and to succeed it must be conducted in a truly scientific manner. By this I refer to the *practice*. Actual service may apparently throw theory and science to the winds at the time; but actual service based upon proper scientific education and practice will always have something to fall back upon. When the time comes when shot and shell are singing and bursting about us in reply to our own, we will not have time to solve ballistic formulas, but must then work as best we may for our own salvation. But if we have conducted our practice properly, we will, long before that time comes, have accumulated data in proper shape for "ready reference," and hardly a moment's time would be lost in laying our guns for the particular range, powder, weight of shot or shell, barometer, thermometer, &c., &c. We would be beyond "guess work" and ready and able to put the *first* shot so close as to be very uncomfortable, and the next shot probably into the "bull's eye." We certainly would be in better shape than we are now, and ready and able to do better than the recent fiasco at bombardment in the harbor of Rio Janeiro.

As an illustration of practice *versus* science as ordinarily accepted, let us look at any ordinary brick or stone mason. He does not strike us as a particularly scientific man. Yet, rough and ready as his science and his tools may be, we all know that in so much as his work is truly scientific, though he may not know or realize it, just in so much his foundations and walls will be true to plumb and stable. In just so much as his work is not scientific, will it be defective and unreliable.

Similarly our practice must and always will be scientific, rough and ready as it may be in actual service. The broader and better our foundation of scientific education, the simpler and more readily applicable becomes our practice in emergency. We never can throw science and theory to the winds in actual fact. In just so much as we do will we fail. In just so much as we cling to proper fundamental science in our rough and ready practice, just so much will we suceed, and make our service to be feared and respected.

I think I hear the remark that "we will do all that, or try to do it, when we get our new guns; but that it is useless to try to do anything now with our old, obsolete, smooth-bore or converted ordnance." Now is that so? Is it obsolete? Granted that it is not what we would like it to be, and falls far short in range and power, yes, and in accuracy too, to our modern high power rifles it is *not* obsolete; we will have to use it yet for many years in some places as the *only* battery, in others as an important part of the armament as secondary battery.*

We might just as well then make up our minds to what some may consider a "bad job," and make the best of it, and go to work and do what we have not done heretofore, learn the *full power of these guns*, and collect and tabulate data for them for use in actual service, from which we can at a glance determine the proper "angle of departure" to use when the time comes to use them.

By so doing our time will be well spent, and we will be only the better prepared when the happy time comes for us to serve an 8", 10", or 12" B. L. R. of modern make.

If we are to content ourselves with ideas of the obsolete character of our present ordnance, and wait until we have better, when will we stop waiting and go to work? By the time the guns now building are ready for us, mounted and emplaced, who knows but that they will have passed into the obsolete class? They are high powered to-day. May there not be something better and higher powered to-morrow? Would we then wait again for the "gun of the future"?

The *reductio ad absurdum* should be evident. For in spite of all desires and ~~and~~ efforts upon the part of any of our Departments to the contrary, guns and emplacements cannot be built in a day, and in the meantime the wheel of progress is ever revolving, ever bringing something new on top, and it is simply impossible, try as best they may, for the gun makers to keep pace with such possible progress. We never will have anything if we are always reaching for something new, abandoning the old before completion. Changes

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* **See Report of Endicott Board.**

and improvements may be foreseen, and provided for as best they may: but they do not alter the character of material already on hand that has yet to be built up into guns on the score of economy alone. The work of improvement must therefore go on as fast as the limitations of the gun-making plant and annual appropriations will permit. Slow at best, in spite of all the energy, enthusiasm and zeal that may be brought to bear to expedite the solution of the problem of the best and cheapest gun, or the "gun of the future."

In the meantime we should be doing something besides "marking time". We should take what we have, and make the best of it. Consistent and persistent effort would meet with its proper reward in putting guns and carriages that may need attention in proper order, and then we could do something.

In target practice itself, as we all know, there are many factors that enter the problem to affect the results. Let us now look at them and see what we can do or should do in taking them into account, or eliminating as many as possible.

First. The Gun.—Our guns are permanently mounted, and, even when in case-mates, are more or less exposed to the inclemency and influence of the weather. Do we give them care enough? How much thought or attention is given to the state of the bore as to its smoothness, freedom from rust, &c., &c.? How many guns are there that have not become so fouled and corroded by rust and dirt, and residue from previous firings, that the wonder is they shoot as well as they do? Does the small arms expert allow his rifle to receive any such treatment? Would he ever hit anything with it if he did? Are there any artillery garrisons where the guns are regularly divided up and each part assigned as the permanent assignment of some particular battery of the garrison, so that they may be cared for and *inspected* as part of that battery's equipment, for whose good order and condition it can be held responsible? Will they ever be kept in order until such an assignment is made? Ordnance sergeants and weekly details may work well and conscientiously, but it is thought that this is not enough. We should cease to be "red-legged infantry", never inspected except as infantry. We should be *partly* artillerymen at least, and have inspection at our proper stations at our guns, and these guns, equipment, carriages, &c., &c., would be kept in order or some one would know the reason why. With our present smooth-bores this may not be of such vital importance. With our 8″ C. R. it does become of importance. With our new ordnance we hope soon to have it will be a vital question; for surely as the sun rises and sets, these guns are never intended for such neglect and should not be neglected as is our present equipment.

Another point as to the gun before we pass to the ammunition. We are to shoot to-day we will say:—the weather has been a long continued spell of cold and wet weather, followed to-day by a sudden change to a hot and moist atmosphere. Will the gun "warm up", or will it act as a condenser of moisture, and its bore become damp and clammy from the "dew" that has collected theron? What sort of condition will the cartridge be in after ramming home and lying there while we are laying the gun, &c., &c. True enough we sponge the gun, but will that stop the dew from again collecting while we are waiting for reports by which to determine range, elevation, &c., &c. In other words, what effect will the state of the gun have, and do we make proper allowance therefor? We all know that the long range small arms expert makes allowances for a cold gun when he fires his first shot. We know that he fires shots *as warming* shots, if he can, before he begins upon his score. But we cannot throw our costly ammunition away in that manner, and hence data should be taken from which calculations could be made, so that, from a long continued series of accurate observations, the ballistic expert could formulate and tabulate the allowances necessary for the *first shot* from a *cold* and *damp* gun.

Again our gun may be just the reverse after a long *hot* spell, with a sudden *cold* day for firing. Certainly the effect would be considerable as compared with a *cold gun* on a hot day, and proper observation over a long period, so as to eliminate all possible sources of error, are necessary to determine what their effect may be. When once tabulated, the results would then be available for use on short notice in actual warfare.

With our short muzzle loaders the influence of continued heat or cold upon the change of form of our guns may perhaps be inappreciable. By this I mean its bending or flexure, and not its expansion or contraction. When we come to our long guns however, it is easily conceivable that the gun will vary from day to day, or season to season.

Without having any "droop" of the muzzle due to any weakness of structure, or the long over-hang of the muzzle, it is not beyond a possibility that the gun may droop due to the expansion of its *top elements*, exposed as they may be from day to day to the rays of the hot summer's sun. In cold or winter weather this inequality of expansion would be less, hence the possible droop would be less.

We then should be ready for such possible change of form, and ready to allow therefor, so that we may be able to serve our guns irrespective of weather, whenever we may be called upon for such service.

Second. The Projectile.—Unfortunately our smooth bore projectiles leave much to be desired as to constancy of weight, and smoothness of exterior. But, even as they are, can we not make more of them than we do, if we only keep an accurate record of their exact weight, and also see that they are clean, and free from lumps of rust, or the thick coating of lacquer with which they have sometimes been supplied, and that not in uniform thickness over the exterior? Would it do any harm if they were all weighed and *sorted out by their weights*, so that the firing of any one gun or gunner could be with those that approximate closely to the same weight? Then, the range once having been found, and the first shot fired, changes in elevation to correct for errors in firing the first shot would only have to consider a closer scrutiny of the elements that determined the angle of departure for the first shot, warming up of gun, &c., and would not be complicated by a change in the weight of projectile, requiring another allowance to be made, and hence practically making the second, as well as the first, a trial shot.

Then again when any gunner begins by using solid shot would it not be better to let him keep on and fire *all* of his shots with the *same class* of projectiles, instead of letting him fire two or three of one, and then two or three of another? The moment a change is made from shot to shell, or *vice versa*, changes in elevation, allowances, &c., &c., must be made, making again a series of trial shots, and we have not enough ammunition to go around and let each man have a sufficient number of *each* class for any one season to permit of proper instruction with each. Therefore I think that more progress would be made by using *all* solid shot for one season, and having enough to teach what can be done with them, as corrections are made from shot to shot by observed errors. The next season *all* shell could be used, with similar beneficial results. As it is now, a gunner may be right on the point of making a "bull's eye" as the result of his experience with previous shots, but he has fired his last solid shot, and hence must go to firing shell; he has another complication to allow for, misses the target, and begins again to try to "get on" with varying degrees of success. If the small arms expert were to be handicapped in the same manner I doubt if we would have many sharpshooters or distinguished marksmen.

Helpless as we may be with regard to variation in weight of our projectiles, we now come to a factor fully as important in which we *can* help ourselves in a very great degree; this factor is:

Third. The Powder.—Granted that much, if not most, of our powder has been made and stored for many years, that alone does not account for the want of uniformity in results obtained. By proper care in mixing, averaging, and cleaning, much may be done that now is not done to secure good results.

Lieutenants Whistler* and Davis* have said so much, and said it so well, upon this point that there is no necessity for me to repeat; what I would say is only to emphasize what they have said, and to carry the matter a little further.

Instead of Whistler's mixing barrel, which would be an admirable thing if we could get it, a large paulin will answer very well, and I would *mix all the powder to be used for the season at one time*, and, then, instead of putting it back into the barrels, make it up at once into cartridges, care being taken to *clean the powder free from all fine particles*, and pack them away in metallic cases, such as we now have in small quantity, for want of better, in *hermetically* SEALED cases if we can get them, until required for use. We would then be reasonably sure that our cartridges approximated to uniformity more nearly than they now do, for the entire season.

As shown by Lieutenant Ruckman's report in Lieutenant Davis's paper above referred to great care is requisite to secure uniformity in length and diameter in making up cartridges. Without such uniformity there can be no

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* See *Journal U. S. Artillery*, January, 1893.

hope of any uniformity in density of loading; hence the weighing and making up should be carefully done *under the supervision of an officer*, to insure proper results. Once loaded and packed, all future handling should be in the cases, to prevent deformation and irregular packing by handling of the loose cartridges themselves, as they go from magazine to service magazine, and from the latter to the gun.

From personal observation it is known that sphero-hexagonal powder varies in the amount of small particles or of broken grains that may be present. One shipment of powder has been handled more than others, and perhaps it has been caked at some time, and afterwards broken up by rolling, &c. Whatever the origin, it goes without saying that all such small grained powder should be removed from among the large pellets of which we are to make up cartridges. If left in, and put into a cartridge, certainly that cartridge will have an entirely different effect in the gun from another that ~~it~~ is not so contaminated. We might as well purposely put in a pound or so of cannon or mortar powder and then expect the cartridges made of this mixture to give good results, as to use that which is fouled by its own abrasion. Yet, though doubtless this should be done, I have yet to see any instruction to that effect, nor have I ever seen or heard of any implements for that purpose. I have searched dilligently, and have inquired of others for any possible information they might possess upon the subject, and all have the same reply, that they know nothing of such a process ever having been contemplated or directed, or that implements have ever been provided for the purpose.

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Though doubtless a record should be kept of the marks upon barrels of powder that have been mixed, it is doubted whether the records of initial velocities ~~is~~ of any value whatever. Even with *new* powders, the record of initial velocity merely shows that it was obtained at some time, at some place, in some gun and under conditions probably unknown, and which may *never* be repeated. It is well recognized that initial velocity falls off, even in our hermetically sealed small arms cartridges, from long storage, hence, at best, records of initial velocities on powder barrels are only guides by which to select a powder that will approximately answer our purpose.

It goes without saying that, when our cartridges are made up, samples should be taken and tested for density and hygrometric condition. If, as I should like to see done, the cartridges are put in *sealed cases*, one set of such tests should answer for the entire season. If not then, if the season lasts any very great length of time, or there have been any great changes in weather, subsequent tests should be made to determine whether the powder has changed or not.

But, even with our ammunition in the very best possible state of preparation and preservation, something yet is necessary to produce uniform results in its use. The fourth very important factor is:

Density of Loading.—Among the many things that has been done for the small arm~~s~~ expert, about which he has not to trouble himself, perhaps the almost exact constancy of his density of loading is one of the most important

That there is not an absolute constancy is shown from the unavoidable variations in dimensions of cartridges in manufacture. But these variations are reduced to the lowest limits, and the effects are very small. The extreme case of a minimum sized cartridge in a maximum sized chamber is one not likely to occur very often, hence, probably, such a thing as attributing variations in shots to this cause has never entered the average small-arm expert's head.

But with sea coast artillery it is an all important factor, and one that I fear has received too little attention. It has been my observation that more is given to accuracy in the motions 2-3-4-5-6, which, valuable as it may be, is but the means to an end, and *not* the aim and object of drill at the piece.

It is not necessary for me to go into details as to means and methods to obtain the not only desirable, but *absolutely necessary* result of approximate invariability of the density of loading. That has been done before, and all who care for accuracy can profit by the lesson.

I will therefore only pause to remark that recently I have seen the mathematical work showing what the initial velocities must approximately have been in the firing of certain batteries last season, working backwards from observed results. From this it is shown that initial velocities varied from 1390 f. s. to 1277 f. s. and that the introduction of the pressure gauge into a cartridge had a very marked effect in reducing the initial velocity. With the plug in the density of loading was reduced because the projectile could not be forced down to the same position that it had had before without the plug; hence the plug probably caused an increase in air space much greater than its own volume with a corresponding decrease of density of loading, with the attendant result of a reduced initial velocity and shorter range, for the same elevation.

Passing now to influences outside of the gun we know already what should done, and the only thing is *to do it*, and not "play at" making observations simply to have something with which to fill in certain columns upon the firing report. Better not to make them at all and to leave these columns blank, than to fill them in with observations that are perfectly valueless as I have known to be done. Such work tends to discredit *all* observations; whereas we should know that true scientific observation makes careful record of everything observable attending upon the subject under investigation. The results recorded may *seem* valueless, and wholly out of accord when made; they may be wholly incomprehensible to the observer at the time; and yet, when the subject is studied at length, in all its details, some apparently useless and obscure consideration may serve as the key by which the whole matter becomes plain, placing the investigation and observations in an entirely new light, perhaps leading to the discovery of some important law or truth heretofore unobserved or unknown.

Barometric and thermometric observations are certainly of importance, *if properly conducted.* After-work upon observed results need these observations, for rarely is the atmosphere in a normal condition. I have seen a drop of *tenths of inches* in the barometer in an afternoon's firing, with a change of several degrees in the thermometer. And yet again I have seen *no* observation made: the record was of no value as put down, for it might as well have been made "day before yesterday" as at the time made for record on the record sheet.

If the hygrometer is to be used, it too should be used by those familiar with its use, and according to the instructions given for the use of such instruments, so as to produce reliable results. As I have seen it used, its record was of no value, for *but one observation was taken* and not a *series of observations;* hence there was nothing to show that the record as made was "the lowest reading possible." According to the instructions "the lowest reading of the wet thermometer, and the reading of the dry thermometer *obtained at the same time* will be the readings to be recorded." As I have seen it done *the dry thermometer was not read at all*, only the wet thermometer was read, after being whirled for a moment or two, and, as said above, only *one* whirling and observation was made, hence the record may have been anything but the "lowest reading obtainable."

For record of wind velocity, we have now only the signal service anemometer, which, valuable as it may be for signal service work, is almost valueless for target practice, because it only gives the *average* velocity of the wind per hour, and, so far as I know, *there is no possibility of telling the velocity at any instant of time.* Hence the gunner cannot tell, or be told, the velocity to lay his gun for, when there happens to be variable wind blowing: nor can he tell, or be told, the velocity at the instant the gun was fired. In a variable wind, *averaging* say ten miles per hour, he may lay his gun with an allowance for that wind, either in elevation or deflection, according to the wind's direction; but when he actually fires the gun there may be a lull, or a sudden hard puff: in either case his allowances will be wrong, and there is nothing from which to give him proper information so as to tell him whether his allowances were correct or not, or what allowances to make for the next shot.

What we need and should have is an instrument that applies the principle of the tachometer to the velocity of rotation of the anemometer spindle. It is known, or can be found out, how fast a certain wind will rotate this spindle: then the velocity of wind at any instant becomes a function of spindle rotation within certain limits that would have to be determined experimentally. A tachometer applied to give instantaneous indications of the fluctuations of the speed of the spindle, as the wind varied, could be graduated to read "miles per hour", and we then would have something of an approximation to indications of the wind's velocity at any instant.

It is thought that other forms of instruments, applying the principle of the variable pressure of the wind, with an instantaneous index electrically connected therewith could be devised, and so calibrated as to give fairly accurate approximate results, giving the gunner a fair indication of the velocity to allow for.

It goes without saying that whatever instrument is used should be properly set up, not only mechanically, but at a proper elevation to observe true currents of wind, and not eddy currents, calm streaks, &c., &c., caused by proximity to walls, ditches, &c., &c.

The wind vane or wind clock needs but mention to be recognized as a necessity. It is so simple and cheap that there is no reasonable excuse for its not being provided, the same as for small arms target ranges, except that it has not been asked for, or considered a necessary part of the equipment. It is thought that if persistent and consistent efforts were made it would be forthcoming, as well as a good many other things we now hope and sigh for and yet do not possesss.

But with everything in the way of instruments and proper ammunition on hand and ready to use, from what data are we find the angle of departure for our first shot? Every range table we have, or can have, must be based upon some assumption as to initial velocity. Are we certain that our powder will produce anything like the initial velocity for which our range table has been calculated?

This leads at once to the necessity for some means for the determination of our initial velocity, either with the regular apparatus, or by working backwards from observed range for any angle of departure we use for the first few shots, fired for that purpose at a fixed angle and for observation as to range. By very careful work and observation at the base line stations we may get ranges closely enough to give a fairly approximate idea as to what was the initial velocity which produced that range; but of course much better work can be done with the regular screens and the apparatus for observing initial velocities, and, whenever possible, such apparatus could well be used every season, not only for the value of the results of the observation, but for the benefit received from proper instruction in its use.

With proper ammunition fired under proper or observed conditions comes the observation of results, and in this there should be no excuse whatever for complaint. We have proper instruments, a carefully measured base line, and observing stations, and it is thought and believed that errors in observation are due to the observer in every case, and never to the instruments, or station.

True enough the instruments for proper use should be properly set up, including leveling, adjusting of telescope, if one is used, to the proper lines of collimation, and accurate setting over terminals of base line. All these are simplicity itself, and the fundamental principles in the use of all such instruments. When, therefore, as I have seen, instruments are not leveled, or are not set over terminals, nor telescope properly adjusted, and *this by officers*, it either betrays a gross and inexcusable ignorance, or a careless and criminal inattention to proper, though perhaps small details, that stamp the observer as entirely unreliable. Every one knows that the expert engineer, so called, would be anything but an expert, and would soon be "out of a job", if he was guilty of such carelessness or inattention in "running a base line", or taking observations in trigonometrical work. On the contrary, we all know that in such work the utmost painstaking care is exercised to eliminate even the smallest possibility of an error, and checks and counter checks are the rule, and not the exception. Hence in our work, too much painstaking care cannot be taken, and then it will be known that, so far as instrument setting is concerned, no errors have been committed.

It may be thought that this is making "mountains out of mole hills", trying to magnify difficulties, and make trivial things of great importance. Such is not the case. What I mean to say, and do say most emphatically, is that, if we are to conduct our work properly, attention must be given to even the smallest detail, no matter how tedious and uninteresting the work may be. When I see *an officer*, who knows better, or should know better, with his instrument half an inch ~~off of~~ the end of the base line, as shown by his plumb bob hanging there and telling the story, it shows to me that *all* the observations made by that observer are just as loosely taken. His motto is "Oh! that is good enough!" and perhaps (?) he observes the first splash, and perhaps he misses that and catches the second; perhaps (?) he reads his his angles correctly, and then again perhaps he does not. Perhaps he says to himself, "Oh! that's near enough" and clamps and reads when he knows he is not on ~~the~~ line with the splash, but "close to it", or, when he reads, reads "close enough" as he thinks, and sends in his report, when a closer reading might show his angle to be "out" some few minutes of arc.

If a slight error in setting was all, that would be of but little moment. For we all know that the error in the angles, otherwise properly taken, would be so minute as to be inappreciable in practical results. But I claim that the carelessness and inattention betrayed by this faulty setting shows a careless and indifferent spirit that runs through *all* of that observer's work, making his observations of no reliable value whatever. Until we come to the time when *all* work conscientiously and faithfully, even in the smallest detail, we cannot hope to have anything but indifferent results, results that hardly compare for accuracy with "good guess work".

I am saying nothing new when I say that everyone knows how important correct observations are to put the long range small arm~~s~~ expert "on the target." He may shoot and shoot, and shoot again, with a miss as the result, until the observer begins to show where he is missing, high, low, right or left. We all know, if he cannot get results from the observers, his only hope is to "go for dirt", and, by the observed impact of his bullet, learn what he is doing and then get "on the target".

So with us. We *must* have reliable observations, if they are to be depended upon to correct errors in range or deviation. We *must* have reliable observations, as from these the record is made up, by which a man's shooting is judged. The record may be of but trivial importance compared with the experience gained. *But the record must stand*, and hence every effort must be made to make it *truthful* and reliable, and of such a nature that the ballistic expert can take it and confidently draw data from it that will be of value in actual warfare, or in future target practice.

Fortunately for us, perhaps, our projectile leaves its mark of impact, on land or water, not to be mistaken, and everyone at the gun can see for himself where it strikes. At times it is difficult, perhaps impossible, to tell whether the shot fell "short" or "over", but deflections are seen beyond doubt. What, therefore, must be the respect for observations when as a result of reports from base line stations the shot plots "away off to the right", when every one saw for himself that it went to the left, and the observer behind the gun so reports, and gives it as shown by his instrument. No wonder we sometimes hear remarks of dissatisfaction and contempt concerning the plotting board and base end observations, and that the man at the gun gets disgusted, and has a contempt for observations and observers, knowing that his shooting is discredited thereby, and that he has no proper data by which to calculate his allowances for a succeeding shot.

Besides errors in deflection it is also well known that errors in range have also resulted from faulty observation. Shots that fell short, and that everybody saw fall short beyond a doubt, have plotted anywhere up to 500 yards over, again to the disgust of the gunner, and the discredit of the record, and not only the record but *all observations of every kind*, bringing everything into ridicule and contempt.

I would therefore suggest that whenever possible a station be placed on a line as nearly as possible perpendicular to the range for the express purpose of being a check upon base end stations, to see whether the first or second splash is the one observed. With three stations it is hardly conceivable that *all* will be in error, and the checking station should be given precedence in determining location of shot, when it appears that an error has been made at either of the base ends. In fact this observer, together with the observer for deflection behind the gun, could be upon an independent base line of their own, and their reports should be taken to confirm or disprove those from base ends. By such independent plotting from two sets of observations the shot should be pretty closely located, so closely that there should be no reasonable grounds for complaint. Deviation should *always* be recorded as shown by the observer behind the gun, and *never* from the plot from base end stations, except when the two agree.

The variations in initial velocities already mentioned as the result of working backwards from observed results show that either some of the observations were wrong, or that something very abnormal attended the firing of one or more shots. With the pressure plug, the initial velocities for five shots ran from 1351 f. s. to 1304 f. s. with a variation varying from 12 f. s. to 19 f. s. between the shots, except for one case, where it happens that the highest and the lowest velocities were for successive shots, with variation of 47 f. s.

Without the plug, the velocities were 1390 f. s., 1370 f. s., 1350 f. s., 1375 f. s. and 1277 f. s. Care had been exercised as to density of loading, mixing of powder, &c., and therefore there is only one inference to draw, and that is that some of the observations were in error. It is hardly to be conceived that a variation of 113 f. s. could occur where every effort had been made to secure uniformity of results: probably the 1390 f. s. and 1277 f. s. velocities are both in error through incorrect plotting from incorrect observations; for the velocities of another set of shots, fired with the same guns, conditions, &c., run 1366-1357-1391 f. s. without pressure plug, and 1330-1335-1328 f. s. with pressure plug, showing that 1390-1277,1351 and 1304 are abnormal, or observation in error.

In some cases ranges as plotted from base line observations are not in accord with the time of flight as observed and reported. Although much is to be desired in the way of a better method of observing time of flight than that now in use, it still should appear that the range of the shot agrees with time of flight as observed, particularly when the times of flight show that they have been carefully taken, and are in harmony with the rest of the shots recorded. In one case that I have been told of the time of flight was the final determining cause to throw a shot out of the record, it appearing from the time of flight that the shot could not have gone the distance as shown at the plotting board. This range was entirely abnormal, and not in accord with any previous results, and the shot was protested for that reason, and, as I say, was finally thrown out.

As intimated above, observations as to time of flight leave much to be desired. To say nothing of stop watches that beat anywhere from seventy to eighty seconds to the minute,—and I have seen such,—the method depends for its accuracy too much upon the accuracy of the observer.

Unfortunately we have nothing yet but our eyesight and will, with which to complete the record when the shot strikes. But we can have the watch, clock, chronograph, or whatever may be used, *started automatically* by the rupture of an electric wire stretched over the gun's muzzle. We then know that the record was *begun* right, and the errors due to nervous strain, shock of discharge and many other things are eliminated. As the shot is sure to strike, the observer can then stop the clock or chronograph by simply closing his key quickly, yet quietly, and the record be then taken. Such a record would be of value because, first, the recording instrument can be of a much more delicate form and register much closer than any ordinary stop watch, and, second, personal errors of observer are practically eliminated; for watching a shot and closing a key at the instant of splash or impact is much simpler than starting the watch by hand *exactly on time;* this *starting* is where the great error is likely to be, and with the gun making the start automatically there can be no question as to its accuracy.

As the final result of target practice conducted as I have tried to indicate, what should we finally have? Beyond a doubt we would have data from which many things could be deduced that now we know of only by theory. The record being kept for each gun by its proper number, the peculiarities of each gun would finally become familiar, as to its "jump", its tendency to shoot to the right or left &c., &c. What we do *not* now know about "jump" is a good deal more than what we *do* know; until we know what *each gun* do, and can be depended upon doing, we can never expect to do good in the excitement and confusion of a general action.

In the quiet of peace we have plenty of time in which to deduce everything of value with respect to all our guns, as the result of careful and scientific practice. The yearly reports for the entire department could be worked over by ballistic experts, and the variation in initial velocities, ranges, deviations, &c., &c., all be determined and tabulated for all the sorts and kinds of weather that have been encountered in the practice. Gradually these results would formulate themselves into tables of fire, covering pretty nearly every sort and kind of condition that may be met in practice, and finally some practical mind would put these into such a shape as to be readily used on the gun platform in actual warfare, by the average mind of the gunners, without any necessity for an expert mathematician or ballistician to be at his elbow to show him how to do it. We already have a start in this direction in Roger's and Whistler's tables deduced *theoretically*. I want to see these, or similar tables, *proved practically*, and put in such shape that "he who runs may read"; in such shape that they can be read almost intuitively and by any-one of an average mind, and made so simple and familiar that the artillery-man may have but little more trouble in laying his gun and staying on the target than that which the small arm expert encounters.

An old and trite saying tells us "that the proof of the pudding is in the eating". The proof of *our* pudding will be the excellence or the deplorable character of the work we do in actual combat in our sea coast defense. It behooves us all to stop trifling or playing and go to work in sober earnest, so as to be ready and able to merit approbation for services well rendered, as the result of our artillery target practice.

1st Lieutenant *John A. Lundeen*, 4th Artillery.—I have hesitated to express any views or offer any suggestions on the subject of heavy artillery target practice as last season was my first year's experience with heavy guns under the present rules, but as I have been asked by several of my brother artillery-men to make public the result of some of my calculations made from data furnished by the three batteries at this post [Fort McHenry, Maryland], I do so hoping it may help to induce some others to make the necessary preparations before this year's target practice commences, and then during the firing to make as careful, accurate and complete *records* as possible, whether the shooting itself be good or bad. The object being to learn all about our guns and what we can do with them.

About a month ago I wished to obtain the initial velocities of the projectiles that I fired from the 8-inch converted rifle at Fort Monroe last summer, and made the computation from the range, elevation and computed value of C for each shot. To my surprise I found that some of the values of V obtained in this way varied very much from each other even when the air space, as recorded, was the same. It therefore occurred to me that this would be a good method of testing the accuracy of the *data*—*i. e.* of the correct reading of the angle of elevation and the accurate location of the shot from the two base ends.

Before giving the results of these calculations and in order to show what value may be attached to the observed data I would state that I carefully mixed and weighed the powder used myself, using a pan scale that weighed accurately to within two pellets, packing the cartridges carefully so that each one would just fill the old metallic pass box on hand, also saw that No. 4 took the proper precautions to have the teeth of the elevating wheel when clamped,—when the piece was properly elevated,—press against the lower faces of the toothed arc, thus acting *against* a lowering of the breech—this for the purpose of making the jump constant for the same elevation. The corrections due to thermometer, barometer, wind, &c., were made from Whistler's chart. I did not aim the gun myself nor set the sight, but verified the reading before each shot as my non-commissioned officers were new to this work and to the sight used. I also verified the measure of the distance of the base of the shot from the bottom of the bore, using for this purpose a tape and measuring from the base of the projectile when the rammer head was fitted over its nose to the iron clamp on the staff. The final ramming home of the projectile was done after the gun was run in battery and approximately elevated.

The following were the results obtained with gun No. 74, and, as the angles of elevation varied but slightly, the jump was assumed at 22′ in each case.

No. of shot.	Distance of base of shot from bottom of bore in inches.	Initial Velocity, f. s.	Remarks.
1	21⅜	1366	Numbers 2, 4 and 6 had pressure plugs in cartridge—the others not.
2	21¾	1330	
3	21¼	1343	
4	22¼	1335	
5	21¾	1371	
6	22	1328	

Captain Leary fired alternately with me from another gun (No. 44), using powder from the same mixing and as carefully weighed, with the following results—assuming the jump to be 22′ for this gun and elevation also:—

No. of shot.	Distance of base of shot from bottom of bore in inches.	Initial Velocity, f. s.	Remarks.
1	22½	1271	Numbers 1 and 3 had pressure plugs in cartridge—the others not.
2	22½	1338	
3	22½	1297	
4	22½	1312	
5	22½	1303	
6	22½	1314	

The density of loading in the second series of shots, it will be seen, was less than in the first, which will account for most of the differences in initial velocities. The jump is probably also different for the two guns.

I would also call attention to the difference in initial velocity when a pressure plug was in the cartridge and when not; the average difference being nearly the same in both series, or about 29 f. s. All being much below what was marked on the powder barrels.

There are evidently some anomalous results, in which either the angles of elevation were not correctly read or the shot was incorrectly located from the base ends.

In case of Battery "C", which fired 10 shots during July with gun 74, the *calculated* initial velocities were found to be much more irregular, varying from 1304 f. s. to 1351 f. s. with a pressure plug, and from 1277 f. s. to 1390 f.s. without one. If the extreme shots are rejected the mean of the others is almost exactly the same as in the first series.

Although no doubt a great deal of care has been taken in our target practice, it is evident from this that there is yet room for improvement, at least in some particulars—for with the same kind and amount of powder and the same air space the initial velocities of projectiles weighing the same ought to vary but very little, and when they are found to vary considerably there must be something wrong with the *data*.

I would suggest that those who are to do the observing at the base ends, whether officers or enlisted men, be carefully trained beforehand to do *accurate* and quick work with the azimuth circles; and as some are much more apt at this work than others that the best available men be made to do it. Also, that particular attention be paid to the accurate measurement of the space occupied by the powder in the gun.

Captain *Henry J. Reilly*, 5th Artillery.—**A.** The foot artillery troops "serve the sea coast and siege guns", further, "the foot artillery of an army consists of the batteries which man the guns of position, and the siege train, and of those which escort and guard the ammunition and supply trains of the artillery".*

No distinction has yet been made between the sea coast and siege troops; in fact the garrisons of the sea coast fortifications are expected to be instructed in the duties of both, as far as practicable.

It would seem to be better, if such distinction was made and at least one or more batteries of siege guns, and of howitzers or field mortars, were mounted and stationed at posts where the ground is suitable and where there are already mixed commands, as at the Presidio of San Francisco or Fort Riley, so that the work of both field and siege artillery could be practically demonstrated and taught. These batteries, with the other troops, would help to form a small division with which practical problems in handling troops could be solved. An additional reason for the change lies in the fact that new siege material is now being made, and enough is almost ready for issue, for trial, under service conditions, to determine what if any modifications are necessary.

Presuming that such distinction will be made eventually, coast artillery may be considered in its own special relations.

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* Light Artillery Tactics.

A. I. "The high standard of practical gunnery required of artillery troops" and the expense necessarily involved in the instruction of gunners "demand a proportional degree of intelligence, and capacity for instruction, in the individual soldier. Artisans and mechanics should form a large proportion of the artillery soldiers".*

The individual should be of good size and weight and he ought to have a fair knowledge of arithmetic, to include decimals.

He should be thoroughly instructed in the school of the soldier, Infantry Drill Regulations; the manuals of the different pieces of artillery, sea coast, Q. F. and flank defense; the machines and appliances for handling them, and in the use of instruments employed in target practice. A certain number of men in each battery, the artisans, ought also to have instruction in the use of machinist's hammers, ratchet drills, stock die and taps; be taught how to pack a stuffiing box, and how to clean and set a valve, so that they may act intelligently in keeping guns, carriages, machines and appliances in order, and in replacing broken parts with spare ones.

The artillery soldier should also have thorough instruction in Parts I, II, III and VII of Small Arm Firing Regulations; the firing at known distances and stationary targets to be limited entirely to the recruit course of the first season; thereafter all practice should be at moving targets at distances ranging to 600 yards and further when practicable.

A. II. The battery should be organized into detachments, sections and platoons, and it should be armed and equipped as it is now; the detachment to consist of seven men and a corporal; two detachments to form a section, the command of a sergeant; the section to be an administrative rather than tactical unit, the sergeant being responsible for it under the regulations as for the squad, and to call its roll at all battery formations.

When turned out for gun drill the size of the detachment to be varied, depending on the gun to be handled. For marching maneuvers and ceremonies the detachment to be the basis, as the squad now is in extended order Infantry Drill Regulations.

The marching maneuvers and ceremonies of the battery to be the same as, and to be limited to, those in the school of the company in closed and extended order, Infantry Drill Regulations; except, that all inspections shall take place at the guns assigned to the battery; that the system of marching by fours shall not be used; and in the Heavy Artillery Manual all paragraphs from 24 to 105 and from 116 to 130 inclusive, shall be omitted.

I am well aware that in advocating the armament of sea coast artillery troops with small arms I am not in agreement with paragraph 582 Artillery Manual, but after carefully considering the matter I cannot help thinking that such armament is a necessity; having the arms, of course the men must know how to handle them. The small arms are necessary because, from experience gained in war, it has been amply demonstrated that adequate results cannot

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* Tidball, page 584.

be gained by fleets in fighting batteries, unless at the proper time, either there is an auxiliary force to land, or the vessels engaged can land a sufficient number of men to take the works, even temporarily, to dismantle them and destroy the material.

A great deal of attention is given to the organization of such parties, to their successful landing, and tactical handling on shore, by our own navy as well as by the navies of Europe; that such a landing would be made in an attack on sea coast fortifications cannot be doubted, indeed when we consider the relatively small quantity of ammunition carried by war vessels, the difficulty in renewing this supply, and how hard it is to hit the small target presented by the guns on shore, such an attack frequently becomes a necessity.

The heavy guns and flank defense pieces are not sufficient to repel such an attack, as the party making it may effect a landing entirely out of their range; theoretically, there will be infantry to protect the batteries, but even if there is, and it is sometimes very doubtful, the garrison must be so armed that the men not actually serving the pieces may be able to assist in their defense; to do so, and to guard them successfully, they must have the rifled musket.

In addition, the instruction in rifle firing is recognized as a most valuable preparatory course for instruction in aiming heavy guns accurately; therefore the time devoted to it is a clear gain.

The system of selecting and training great gun captains in our navy is an example:

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"It consists (1) of small arm practice for the whole ship's company, (2) the selection from those who excel in this exercise of four times as many men as there are guns, (3) the further selection from this number, by causing the competitors to sight and fire small arms, according to methods closely resembling those employed with great guns, of two men for each gun on the ship; (4) the substitution of weekly sub-caliber practice in lieu of the great gun drills usually held".*

The sub-caliber practice is executed with a rifle barrel rigidly secured to the gun, either on the outside, or in the bore; the English and the men of other navies are also instructed in the use of the rifled small arm.

I cannot learn that any fortress artillery in Europe are otherwise armed than with the rifled musket. It may be objected, as stated in the Artillery Manual, that artillery work requires all the time of the garrisons; it does, when the garrisons are totally inadequate in numbers, as they usually are, for the size of the post and the number of guns, but a garrison with the minimum number of men, as set forth in the Report of the Artillery Council of 1887, will always have time for its proper instruction; in any case, the instruction necessary to teach men how to aim correctly should take precedence and displace other less necessary work. Aboard ship the crew have not only to learn great gun drill, but also that of the rifle and cutlass, in addition to the other work of caring for and managing the vessel.

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* Naval Information Series.

I know that at one time there was a strong feeling in the artillery against the small arm, and justly so because at that time its use and infantry formations were carried on almost to the exclusion of artillery work; this was due in a measure to the encouragement extended to men to become expert in the use of the rifle, and also to the fact that troops in infantry formation presented a better appearance on occasions of ceremony, as inspections, &c.

These objections no longer hold, as the use of the small arm has been relegated to its proper subordinate sphere, and as equal encouragement may be expected for men to acquire skill in gunnery; besides, a well drilled artillery command at the pieces will present a more imposing if not so handsome a spectacle than it would in an infantry formation. The misuse of a method does not always warrant its abandonment.

The end to be gained by artillery instruction is to have the individuals of the garrison so trained that the greatest number of accurately aimed rounds may be fired in the least practicable time, and that the firing may commence within the least possible interval after the bugle sounds "to arms".

To accomplish these ends and keep the men up to the standard of maximum efficiency, it is necessary that each battery may have its assigned guns, with all their equipments complete ready for use at any moment: that suitable provision is made for transporting the ammunition from the storage to the service magazines, that the men are permanently assigned to their places, as far as practicable, and so well drilled in their duties that whenever the alarm sounds, night or day, they are able to take their posts and be ready for battle without confusion or delay; exactly as is now required in case of an alarm of fire.

The thorough drill required to fulfill these conditions can only be had by making the military instruction of the soldier the primary object, and making all administrative and fatigue work subservient to that end; consequently, during the drill season the compulsory attendance of every man, at the exercises, should be insisted upon, excepting only those actually on guard, the sick, and one cook for each battery.

When all attend, and attend each day, except Saturdays and Sundays, the thorough training of the whole garrison would be accomplished so soon that thereafter a drill of thirty minutes daily would be sufficient to keep the individuals in the maximum state of efficiency—to that time should be added ten or fifteen minutes daily to be devoted to the care of the guns and carriages, especially those of the new system which are more complicated, more costly, and require constant care to keep them in serviceable condition.

B. I. *a.* Ballistic firing ought to take place in my opinion, only at the Artillery School, where the scientific skill and accuracy, so necessary to inspire confidence in the results, are best available.

That School should always be the first post to be supplied with a piece of each caliber of sea coast artillery and its complete equipment; and each piece should be fired there under service conditions; its sights tested, its range tables calculated and verified, and its manual for loading, firing and mechanical maneuvering determined. The results obtained should be communicated to all artillery officers in printed memoranda similar in size to general orders, War Department. Any defects discovered, or improvements suggested, by the test should be reported for remedy or adoption before any other pieces or carriages are manufactured.

After two years' experience with the Rogers range tables, both in practice firing and in the instruction of non-commissioned officers in their use, I can suggest no improvement in them, except if the 15″ S. B. is to be used only in firing at squares, the deviations in the table would be more convenient if expressed in minutes; if the gun is to have a service sight similar to that on the 8″ C. R., as it should have, then only an additional column of deviations in minute values would be necessary.

In preparing the sights for rifled guns, the sight angle for drift should be determined and the sight slot permanently set at that angle, to eliminate the necessity for computing the drift when firing.

B. II. *a.* The whole superstructure of the artillery personnel depends upon its foundation, the battery; no battery is in a state of maximum efficiency unless it has as many skilled gunners as it has detachments of the minimum size.

As at present organized it ought to have eight gunners, and for their instruction in firing and for keeping them up to the standard the present allowance of sixty rounds of ammunition is a barely sufficient minimum; it is presumed a special allowance will be made for mortars. Each gunner should fire at least five rounds per annum at a moving target, and the minimum qualifications for that grade ought to be his ability to put four of the five shots within the area of a modern war vessel, say 350′×20′, while it is passing the gun at an average speed of six knots per hour; the gun to be loaded and the aiming to commence when the vessel arrives within 3,000 yards, and the firing to cease when she passes that distance beyond the gun.

At the stated speed it would take the vessel about 26 minutes to cross the field of fire, the minimum range being 1,500 yards, this would give ample time to fire the five rounds with, say the 8″ C. R., aiming deliberately; and probably with the 15″ S. B., also.

In experiments made in England the 9″ 12-ton M. L. rifle, front pintle, was fired at the rate of one round per minute, at a moving target with an area of 25 sq. feet, and good shooting was done. Six knots is taken because it is the average speed prescribed for target practice with heavy guns* for the English, French and German navies; the steerage way of the Italians is about the same rate. An examination of the accompanying figure will show that some restriction will be necessary to prevent the gunner from firing all his shots at practically the same range.

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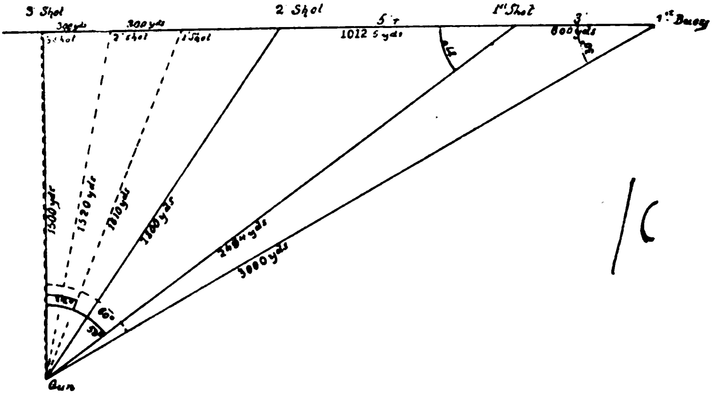
* Naval Information Series, 1890.



For instance, firing with the 8″ C. R., I. V. 1414 ft., and giving one and one-half minutes for each shot, it would take only six minutes for the five shots, or while the vessel was moving 1200 yards, or 600 yards on each side of the minimum distance, which would give an approximate extreme variation in range of only 110 yards, see dotted lines on figure, equivalent to a change of about 12 minutes only on his tangent scale; in other words, he could fire his five shots without altering his elevation, and by moving his gun through a training angle of only about 44° and still keep his shots in the 20′ vertical plane.

To prevent this, the first shot should be fired within two minutes after the target passes the first buoy, and each successive shot at intervals of not less than three nor more than five minutes; this would give the approximate ranges noted in the full lines of the figure and require the piece to be traversed through a training angle of 106°, approximately.

It may be noted in this connection that if the gunner waits until the bow of the war vessel intersects his line of sight, and he then removes the sight, puts in the friction primer, jumps down and gives the word fire, all being easily done within five seconds, the shot will hit the vessel at about 1500 yards range 73 feet abaft the bow, at 1800 yards, 85 feet, and at 2500 yards, 112 feet; all somewhere abaft the foremast or turret and forward of amidships, he will thus always have a definite object for the third point of his line of sight although firing at a moving object.

After the gunner has qualified once if there are not more than eight to be qualified, his allowance should be increased in proportion to the number of candidates where that number is less than 12—if more than 12 the total allowance should be increased at the rate of 5 rounds for each candidate.

The present method of competition between batteries seems to me to be objectionable inasmuch as it does not contribute as fully as possible to the end desired, the production of the greatest number of skilled gunners, and by skilled gunners I mean men who can so aim their guns on a moving object that the shot will hit it; competition should be between the gun detachments, and the winning detachment should not only have the privilege of wearing the insignia now prescribed, but a sum of money also, to be equitably divided among them; the relative standing of gunners to be determined by the mean absolute deviation of the shots in the vertical plane, and the best battery and regimental gunner to be similarly rewarded.

There is a great deal of old ammunition at different posts which was intended for use with the 8″ and 10″ S. B. and the 100, 200 and 300 pdr. Parrott guns. This ammunition is useless for any other purpose, and can be most advantageously used in instructing gunners and developing a suitable system of firing: it ought most unquestionably to be so used. It is true that the Parrotts are reputed to be unsafe, but they can be fired by electric primers from a safe place; if they burst they will be of more value to the government than now, because they can then be sold for old iron.

b. The old guns, *i. e.*, the 8″ C. R., 10″ and 15″ S. B., are just as valuable for purposes of instruction up to 3,000 yards, as the new ones; that is a gunner who cannot make good practice with them at such a target as will be presented by a torpedo boat say 90′ × 11′ will not be able to do it with the new guns, the accuracy being determined by the penetration of an imaginary vertical plane of that area.

At the same time I believe there should be no class of guns in a garrisoned fortification with which the troops have not had regular annual firing practice under service conditions, no matter what is the cost of the ammunition, or what the life of the gun.

The present expense incurred for projectiles for high power guns may be easily avoided, because, as stated by the Chief of Ordnance, U. S. Navy,* "cast steel shell which will penetrate nearly a caliber of steel armor without breaking, can be procured at a cost but little exceeding that of cast iron shell". In regard to the gun itself, supposing an extreme case, that there is only one high power gun at the post and that its life is only 150 rounds, if three rounds per year were fired from it, it would be 25 years before half its life was spent, and who is willing to say that our new guns will not be in a fair way to become obsolete within that time, or that, at the least, some simple comparatively inexpensive method of re-lining them will not have been devised and put in successful operation.

It cannot be too strenuously urged that any gun mounted in a fortification is there only for the purpose of making a successful defense, and to accomplish that purpose it *must* be used in regular firing practice.

c. The plotting boards, azimuth and other instruments now supplied are amply sufficient for the purposes, and

d. No necessity for other, or auxiliary methods for checking results in target firing, has presented itself so far as I know.

e. The present method of measuring the lateral deviation of shots answers well enough; when the base line has been accurately located, and the

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* Annual Report, 1892.

observers get the first splash of the shot, its position is determined with sufficient exactness for any target shooting; in such a case I have noticed that the difference, in lateral deviation as given by the azimuth readings, and that of the transit was so small and regular, as not to justify the use of the latter.

The only plotting of a shot needed is the point on which it penetrates an imaginary vertical plane erected at the target; its mean absolute deviation to be computed from a point which is the intersection of a perpendicular line in the middle of that plane with the water line; this would give the greatest value to a shot striking a ship between "wind and water", and usually opposite to the boilers or machinery.

Too much importance cannot be given to sub-caliber practice; it is principally by that practice that skill of hand and eye, and the exercise of good judgment, can be trained to act simultaneously, and by that means, the gunner will come to understand each other, so that the pointing may be done most accurately and in the least time. Sub-caliber practice should come after practice with the small arm, and precede the firing practice with the heavy pieces; the sub-caliber gun should be used in turn with every caliber of sea coast piece mounted in the work; the firing should always be at a moving target, and the heavy gun handled exactly as it would be in battle; no gunner, and no candidate for that grade, should be permitted to fire the heavy gun with its normal charge and projectile, until he has demonstrated his ability to make a certain number of hits, within a specified time, with the sub-caliber piece, the gun being handled by its regular detachment; the number of hits and time required to be determined by experiment. Sub-caliber practice, always at a moving target, should be had either once or twice a week in lieu of the ordinary drill; the target can be attached to a rope which should pass round a drum which would automatically record the revolutions, and thus determine the speed. Two men could easily manipulate it, if properly constructed.

g. The present methods of conducting target practice fulfil all necessary requirements, and could be readily adapted to firing at a moving target; the firing to be done by the gunners only and without assistance from the officers, as under the system of instruction here advocated, the actual firing is to determine the sufficiency of the instruction already given, as well as to familiarize the detachment with the actual handling of the piece under realistic conditions; the theoretical *examination* for gunners now in vogue to be dispensed with, as in my opinion it simply demonstrates the possession of a good memory, natural ability, or a fair education by the candidate; it does not demonstrate that he can hit an enemy's vessel passing in front of his gun. It ought to be noted that I refer to the examination not to the course of theoretical instruction, although in my opinion, the latter may be advantageously curtailed, and the time saved given to firing with the small arm and sub-caliber.

h. Inasmuch as England, France, Germany, Italy, and, I believe, this country limit the target practice with the great guns principally to distances between 600 and 2000 meters, it is reasonable to suppose that the coast artillery may expect to do most of its fighting with heavy guns within these ranges, and as the majority of channels will be covered by fire ranging to 3000 yards no changes in the ranges now used appears to be necessary, except as they may be varied by the use of moving targets as already stated.

For the rifled mortars which will be used to prevent a war vessel from lying off at long range and bombarding extensive works, dockyards, or cities, the range should extend from 3000 to 8000 yards.

i. For finding the range for the mortars, and for guns firing at a target greater than 3000 yards, the azimuth circles now in use answer well enough, until something better and simpler is devised; a simple method for communicating the ranges from the plotting station to the gunners is necessary; one or more posts on which numbers of sufficient size to be plainly seen can be placed, and changed, by a man whose duty it is, as indicated by a Wheatstone dial in electrical communication with the plotting station, appears to be a practicable method; but no system of range finding can take the place of or excuse the want of skill in estimating distances, within limits, on the part of the gunner, because when the vessels get in close, and there is a fleet of them, it will be impracticable to keep the observers and the gunners on the same vessel unless the firing be by division or battery, which is not likely at short range; in war, the ranges covering the water in which the ships will be compelled to maneuver by its depth, should be marked by lines of buoys of different colors, as the same buoys now mark the channels.

j. The province of the artillery target is to afford a distinct object on which to aim; it must be so it can be easily handled, able to stand up in a rough sea, and be easily towed. From experience gained in placing eight targets, that number having been rendered necessary in one target season, by the rough water and strong currents of the road-stead, it was evident that the only target which filled all these conditions, was an old flat-bottomed boat about 16 feet long, decked over with ¾″ flooring; a mast about 10 feet high was erected amidships and secured by one fore and aft and one thwartships guy; upon those guys the cotton cloth furnished by the Ordnance Department was stretched; before the firing was over the boat had a hole knocked in it, and it filled, but as there was no ballast in it, it kept afloat, and as the mast remained perpendicular and the canvas was plainly visible the firing was continued; the boat was easily towed in afterwards and repaired; a seventy-five-pound anchor held it in place easily; such a target is readily towed by a 1½″ line; the Italians in their practice with great guns use a tow line one hundred yards long,* so a similar length would appear to be sufficient for our work.

B(ab). It does not appear to me to be necessary or desirable that there should be any manipulation of the powder at any post, other than the Artillery School, except to test its velocity before target practice by using the chrono-

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* Naval Information Series, 1890.

graphs already supplied, or the pressure gauge when there is a variation from the service charge.

C. As all firing, at posts other than the Artillery School, should be carried on as nearly as possible under service conditions, a standard density of loading should be determined for each gun. The longitudinal space occupied by the cartridge and projectile once determined, should then be accurately marked upon the rammer staves of all muzzle-loading guns, and thereafter every care should be exercised, when the piece is loaded, that the mark is in the same vertical plane as the face of the muzzle.

There has been such an advance made in drawing cartridge cases, that in a short time it will be apparently entirely practicable to put up the charges for B. L. guns in the same manner as they are now prepared for the small arm and Q. F. guns. This would practically settle the density of loading for all B. L. guns.

D. There are entirely too many records now. All the vouchers to Form 11 ought to be discontinued, except the report of the plane table observers; even that should be modified to show the angles for only one station. To get the information necessary the form could be changed to show under observed results, that the shot struck above below, instead of short and beyond; the mean deviation in the column now devoted to transit deviation; the mean absolute deviation to be shown at the bottom of the column of mean deviations for each gunner—the columns, previous fires, and total fires, to be omitted; the plotting to be restricted at the most, to the position of the shot in an imaginary vertical plane erected at the target; the instrumental velocity at the time of firing ought also to be shown. The post record target book modified to conform to Form 11 would then contain all the information necessary for studying the firing from the records. In order, however, that the pointing may be accurate, and the gun laid properly, each battery should be supplied with a telescopic sight, similar to that on Gurley's solar compass, which is inexpensive and can be readily placed upon the service sight without necessitating any change in the latter.

III. *A. a.* In order to facilitate control in action, and permit the simultaneous firing of more than two guns at the same object, the battery of pieces ought to be divided into sections and platoons; the section to consist of one piece, its three reliefs, and complete equipment ready for action; two sections to form a platoon; two or three platoons a battery; two batteries a division, the command of a field officer. This would give a complete chain of responsibility and command from the gunner, chief of section, chief of platoon, battery commander, division commander, commander of the post, to the commander of the harbor defenses, and furnish adequate means for fire discipline and control in action.

b. The principle governing the fire of a battery is concentration; the fire of every heavy gun ought, primarily, to be concentrated upon the flagship to disable her, or demoralize her crew, so that the direction and unity of the attack may be destroyed.

The fire of the Q. F. guns ought to be concentrated upon the secondary battery, and upon the guns in the tops of the vessel whose fire interferes most with the service of the heavy guns of the fort.

c. It does not seem practicable to express the rate of fire in time, owing to the differences in the guns themselves, and the crude appliances for handling them; it can only be satisfactorily determined by experiment; the governing principle now, as heretofore, is that the loading must be done with the greatest rapidity consistent with doing it properly, and the aiming should above all things be done accurately.

B and *C.* In harbor defense, as in any other military operation, to obtain the best results control and responsibility must be inseparable. There can be but one commander for any one harbor; he alone can be responsible for its proper defense, and he alone must have complete control of all means provided for that purpose. He should hold exactly the same position in relation to the different forts, torpedo lines and means of obstruction, as the admiral does to the vessels of his fleet.

He prepares his plans and communicates them, or so much as may be necessary to secure intelligent coöperation, to each commander of a fort, torpedo line, or auxiliary defense. His subordinate commanders must also be allowed to exercise independent command over their own units, in carrying out his plans, exactly, for illustration, as the captain of a war vessel carries out the instructions of the fleet commander.

The harbors themselves, the means for their defense, and the methods of attack will vary so much that the only general principle governing the fire of the batteries, in relation to each other, or one group to another, that can be enunciated, is that already stated; part or all must be available for the best effort, in repulsing an attack, in the discretion of the commander of the harbor defenses.

Of course it is understood that there must be an electric plant at each post to furnish telegraphic or telephonic communication between the batteries and torpedo lines in the harbor, the current for the search light, and the power for the ammunition hoists, and training the guns.

2nd Lieutenant *Wilmot E. Ellis*, 5th Artillery.—A clear distinction should be preserved between range tables (which are strictly professional papers, and founded on the science of exterior ballistics), and those tables that are intended to be used either for the instruction of enlisted men, or under service conditions.

This consideration leads to the following natural classification: first—those, which are computed from ballistic formulæ, and furnish all the elements of the trajectory; second—those intended for the purpose of training gunners in the science of gunnery; third—those that are adapted to actual service conditions. These classes may be designated respectively:—Range Tables, Gunners' Tables of Fire, and Service Tables of Fire.

Range Tables should contain all the "ballistic elements", and might, very properly, provide such auxiliary information as would be of use in preparing records of artillery target practice. The tables computed by Major J. I. Rodgers, 1st Artillery, and published in G. O. No. 10 of 1892, may be taken as model types of this class.

The Gunners' Table of Fire is intended for purposes of instruction only, and should contain all the information essential to the solution of problems in gun-laying. The data should be neither too complex, nor too simple. They should not be so intricate as to unduly tax the intelligence of the gunner, nor on the other hand, should they be so conveniently compiled as to solve problems that he should solve for himself.

In the Service Table of Fire, all refinements should be eliminated, and simplicity should rule. It should be adapted to the individual peculiarities of each piece, as shown by its record of fire. In its handiest form, it would consist of a placard hanging upon the same peg with the gun equipments.

As yet, no fixed and invariable curriculum for the School of the Gunner has been established, nor has any standard of preliminary qualifications for entrance into it been defined. In the absence of these guides, it would be useless to attempt to construct ballistic tables to be used in the school.

Gunners' Tables of Fire, and Service Tables will be dismissed without further remark, as it was intended only to point out in tables of fire a distinction, that is something more than a theory.

The rest of this paper will be devoted to a discussion of tables to be used in connection with gun-laying drill at the 8-inch M. L. rifle, and the 15-inch smooth bore gun. In order to avoid confusion of terms, these tables may, temporarily, and for the purposes of this paper, be called "Gun-laying Tables".

THE 8-INCH CONVERTED RIFLE.

The service sight is provided with an oblique vernier, and admits of a minimum reading of one minute. The deflection scale is divided into points about one-nineteenth of an inch in length, each point corresponding to one one-thousandth of the range. The limit of visual sub-division of the minimum units may fairly be taken as one-half, both for the elevation and deflection.

Preliminary Suggestions.

I. A constant ballistic co-efficient should be assumed.

II. All strictly auxiliary data, such as angle of fall, maximum ordinate, etc., should be omitted.

III. It would be well to neglect all allowances for drift, as the amount is small at the ordinary ranges, and the consideration of it introduces into the gun-laying problem, a complexity that admits of permanent elimination by mechanical means.

The method which has been employed in the English service for guns of position consists in inclining the sight to the left of the vertical by an angle known as the "permanent angle of deflection". A calm day having been selected, a series of shots, ordinarily ten in number, is fired, using varying angles of elevation. The formula of Major R. W. Hay, R. A. (which is easily demonstrated by the relation of similar triangles) gives for the angle of deflection for each shot, θ representing the angle:—

$$\tan\theta = \frac{\text{deflection}}{\text{range}} \times \operatorname{cosec}\varphi$$

The mean of the angles so obtained is taken as the "permanent angle of deflection".

IV. In the Gun-laying Table, angles of sight should be substituted throughout for the angles of departure of the range table. The information wanted by the gunner relates to the angle, at which he shall sight his gun, and not to the angle that the axis of the piece makes with the horizon at the instant that the projectile leaves the muzzle. While it may be true that data for the jump ~~is~~ incomplete and unsatisfactory, the fact that it *always* has to be taken into consideration argues the propriety of making preliminary allowance according to the data, whatever they may be.

V. The employment of the number "ten" as a unit of reference will be found to present many practical advantages. It can be used in computation with the same facility as unity, and with a proportional reduction in "approximation errors". Moreover, ten (in miles per hour) fairly represents average conditions as to speed of wind and target.

VI. As the construction of the service sight practically precludes any subdivision of the minimum units smaller than an estimated bisection, the consideration of fractions of a denomination less than one-half would, to say the least, be superfluous. We might except those cases, where, in making corrections for variations from the tabular data, the multipliers used are unusually large, or the original correction very small, or both. Common fractions should be used in preference to decimals.

VII. In laying the gun for a moving target, due allowance must be made for the time elapsing between the completion of the aim and the firing of the gun. This interval was found to average five seconds, and may appropriately be termed the "firing interval".

While temporarily in command of a battery some time ago, I constructed a table to be used in connection with the gun-laying drill that I was then conducting. The details were changed from time to time, and the form finally adopted (which is the embodiment of the above suggestions) was the outgrowth of the lessons taught by these exercises.

The form employed is shown below. Major J. I. Rodgers's table (I. V. 1475 f. s.—charge, 35 pounds hexagonal powder—projectile 157 pounds) furnished the data for the compilation, and Lieutenant G. N. Whistler, 5th Artillery, is my authority for jump.

GUN-LAYING TABLE FOR THE 8-INCH M. L. RIFLE.

Range.	Angle of Sight.		Value of one minute.	Time of Flight.	Corrections in Angle of Sight.		Deflection Allowances.	
					For Variation in I. V. of 10 f.s.	For Movement of Target.	For Movement of Target.	For Cross-wind.
Yards.	°	′	Yds.	Secs.	Minutes.		Points.	
1700	2	28	$8\frac{1}{2}$	4	2	5	26	$1\frac{1}{2}$
2000	3	02	$8\frac{1}{4}$	$4\frac{4}{16}$	$2\frac{1}{2}$	6	24	2
2700	4	$25\frac{1}{2}$	7	$6\frac{9}{16}$	$3\frac{1}{2}$	$8\frac{1}{4}$	$21\frac{1}{2}$	$2\frac{1}{2}$
4000	8	42	—	$11\frac{1}{16}$	$5\frac{1}{2}$	—	$19\frac{1}{2}$	$3\frac{1}{2}$

NOTE.—The velocity of wind and of target are each taken as 10 miles per hour. For any other velocity, multiply tabular number by the velocity, using ten as the unit of measure. Corrections for movement of target, both in the line of fire, and perpendicular to it, are computed for the interval,—time of flight plus the "firing interval" (5 seconds).

The above table is mainly intended for those cases of fire, where the track ordinarily pursued by vessels is approximately parallel to the front of the battery (which is the general case); but for purposes of instruction, it can be used for oblique fire, resolving the target's motion into two components, one parallel and the other perpendicular to the line of fire. Unfortunately the small number of divisions on the transverse scale materially restrict the employment of the service sight in the manner contemplated, especially for short ranges and high speeds.

A brief description of the method pursued in gun-laying drill may be of interest in this connection.

Information as to the distance and speed of the target was regularly received at the gun at intervals of one and one-half minutes. The loading of the piece having been completed, the gunner waited the next information from the range finding system. Upon the receipt of this, the sight was set by the chief of detachment, who handed it to the gunner, who in turn placed it in its socket. Meanwhile the gunner caused the piece to be traversed so as to point always slightly in advance of the target, elevating for the water line of the target. This, in most cases was effected before the forward smokestack came into the line of sight. This point was selected, as being a convenient one amidships, thus giving a "lee-way" of half the length of the ship for incident errors.

Directly upon the co-incidence of the point selected with the line of sight, the gunner removed the sight from its socket, and the piece was fired as soon as he was clear of the carriage. The electrical firing apparatus was used, and the chief of detachment did the firing.

The accuracy of this method of sighting was tested in the following simple way. The aim having been completed, the screw of the deflection scale was rapidly turned so as to give a reading of zero. At the end of an epoch equal to the time of flight plus five seconds, the forward smokestack should again intersect the line of sight, or be slightly to leeward of it, if allowance for wind had been made. These tests, as a rule, proved to be satisfactory.

THE 15-INCH SMOOTH-BORE GUN.

Indirect pointing, employing the standard system of squares, is the means prescribed for the laying of this gun. The gun is elevated by means of a quadrant, whose minimum reading is five minutes, and laid for direction by traversing the carriage in azimuth. It is customary to indicate by a permanent mark on the traverse circle, every five-degree point in the field of fire, a true north and south line through the center of the pintle being the line of reference. An index is attached to the carriage at some convenient point over the traverse circle, and furnishes the means for setting the gun at any desired azimuth angle.

Sub-divisions of five degrees are ordinarily made with the assistance of a pointing board constructed so as to coincide with the outer rim of the traverse circle. Sometimes additional graduations for points (the length of each being one one-thousandth of the radius of the traverse circle) are also provided for making deflection allowances. It is difficult to see any reason for the introduction of this new unit of measure, when we already have at our disposal the units employed in laying the gun in azimuth (circular measure).

The remarks in regard to simplification made under the head of the 8-inch rifle are equally applicable here. For an elevated battery the tabular angle of departure should be diminished by the angle of depression for each range, and the jump for the new φ should be deducted to give the quadrant elevation.

Let us next determine upon the most probable method that would be employed in laying guns by the system of squares, using present service appliances. The central station telephones to each of the guns, under its control, the square number, and the time at which the vessel will arrive at some predicted position. Each gun is then laid on the square indicated, and will be ready for firing at the epoch antedating the predicted epoch by the time of flight.

Lieutenant Harris's discussion on gun laying by the system of squares (page 23, Artillery Circular E) seems to contemplate a more complete sighting apparatus for the 15-inch gun than is at present issued for service, and it seems that his detailed instructions are applicable to vessel-tracking drill only: for the system employed cannot be one of indirect pointing, if the gunner is to have any check on the range finding system. Lieutenant Harris says, "In actual firing practice at moving targets, the necessary allowances for drift, wind, etc., must be made in pointing"—but how, unless the gunner have an actual target and he knows the direction of its motion and that of the wind with reference to his line of fire, the data being different for each gun of the system?

Let us next examine the nature of the gunner's duties under a system of indirect pointing. From the crudest system up to those whose details are mysteriously guarded as military secrets,—one statement is equally true of all; the gunner does not *sight* his gun at all, but *lays* it as ordered and fires it at the word of command.

All the suggestions given above (if accepted as facts) go to show that in a system of indirect pointing there is no room for the science of practical gunnery. If it is deemed advisable to instruct the gunner in anything beyond the laying of his gun, and to go into the whys and wherefores of the range-finding system, the plotting room is the place for that instruction.

In other words, a Gunner's Table of Fire and a Gun-laying Table would be practically one and the same thing, and should contain the following elements for every square within the field of fire, viz:—Quadrant Angle, Azimuth Angle and Time of flight.

While the data for the Table would be extremely simple as to form, it would of necessity be rather voluminous. Reference to the artillery records of this post (the Presidio) shows that the average number of squares tabulated for each of the 15-inch guns, mounted at the post, is about 1500, and each tabulation covers some odd forty pages of a port folio book. For each square, is given the distance and the azimuth angle. With this information, and knowing the height of the gun above mean tide water, each battery is enabled to determine the forty-five hundred elements for any of the guns assigned to it.

As time is a most important element in laying guns for a moving target, the following form of table is proposed as being in a simple form for handy reference:

— **Gun No. . . .** —

East and West.

North and South.	1	2	3	4	*North and South.*
1	Az. . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	1
2	Az. . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	2
3	Az. . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	3
4	Az. . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	Az. . . . . . Q. E. . . . T.	4
	1	2	3	4	

East and West.

For 1500 squares, assuming squares of ½″ by ½″, this table could be made out in placard form within the dimensions of 25 inches by 25 inches.

The author has not witnessed any gun-laying drills under the system of indirect pointing, and what is suggested on that point is merely conjectural. It seems, however, that a drill would be limited in its scope to laying guns by reference to a practical table as above outlined, and firing after allowing for the time of flight. The open sight now provided would furnish the means of testing the laying of the gun for direction (only) and (incidentally) the accuracy of the range finding system and of the table, as the point selected for observation should be in the line of sight at the predicted epoch.

In conclusion—the tables as above proposed to be used in connection with our best service guns may be open to objection on the ground of ballistic inaccuracy. The objection is not an unreasonable one, assuming a fixed target and abundance of time. For a moving target, the conditions are different. It is an indispensable assumption in sighting with any kind of a gun at a moving object, that the object will continue to move as it was moving at the time of observation until the fire shall have been delivered. Captain Chester has remarked that "this assumption is a very convenient one for the range-finding system, but the enemy may not choose to act upon it". Briefly, the "epoch of assumption" should be minimized, and what may, at first sight, appear to be a loss of accuracy, may result in more actual accuracy in the saving of *time*.

While this paper has been mainly devoted to a discussion of tables to be used in connection with laying guns for moving targets, such tables are really but part of the means to be used. The *end* is to secure such efficiency in the service of the gun that the gun-detachment works as a machine, not as a labor-saving machine but as a time-saving machine, so that the unavoidable "epoch of assumption" may be reduced to the smallest possible limits.

1st Lieutenant *Samuel E. Allen*, 5th Artillery.—The "synopsis" for proposed discussion of artillery instruction and practice, issued by the *Journal*, is a most excellent guide for a course of professional study by artillery officers. The scope of the subject is very great, but between the lines may be read the suggestion that for study, as well as for discussion, it can most advantageously be divided and sub-divided.

At every artillery post must be exhibited more or less variety among the officers as to inclination and aptitude for both theoretical and practical work. In post work as well as in general professional advancement this variety may well be used, not only for the "greatest *good* to the greatest number", but for the better preparation and equipment for the artillery work of the post.

As intimated in the synopsis, the prosecution of instruction and practice involves:

A. The selection and preparatory instruction of the soldier.

B. The fundamental fire-instruction of the personnel.

The preliminary steps for the following year's work may well be taken immediately after each season's practice is over, while the errors, failures or successes are still fresh in the memory. The assignment of subjects for the lyceum may be made then, that given to each officer being very intimately connected with the work to be assigned to him in the practical instruction, drills and firing of the next season. This will lead to a careful investigation and formulation of the details to be followed in sequence, the preparations to be made, the devices to be procured, ordered, repaired and adjusted, or even invented, and experiments to be made. This study will also prepare the mind of at least one officer present to more readily comprehend particular causes of failure or discrepancies in results.

To captains, for instance, would very appropriately be assigned subjects **A** (I and II), (see synopsis).

One officer might be required to determine the exact data as to the powder on hand to be used, decide upon and prepare the cartridges (so as to get the equivalent of service charges of fresh powder), and attend to the ammunition service and loading; another be placed in charge of the records, use of instruments (meteorological, observation and plotting); another have charge of the reduction of data for gunners, use of range and reduction tables, or graphical charts if used, inspection of pointing or sighting instruments and operations.

Such divisions of duties undoubtedly suggest themselves to a commanding officer, but the details are often made on the ground, or just before the practice, too late for any special preparation other than a hasty glance at a handbook. If, instead, these details are made from careful consideration of the character of the officers of the command and as above suggested, each one would have complete preparations made for the proper performance of his part of the duties, and would feel in much greater degree responsible for success or failure.

The careful study of the separate subjects that would be required in the preparation of a paper to be read in the lyceum would not only add to his proficiency and the efficiency of the target practice, but would usually arouse in the officer, and others as well, a deeper interest in the subject and its important relations to practical work.

The dearth of professional literature at many posts is a handicap on extended technical study. A patient search through what is available will but develop the deficiency and utter inadequacy of the average post library, but it will lead to definite demands for fundamental literature which may sometime result in systematic measures being taken to properly supply important books and periodicals.

In the meantime letters to the Ordnance or Engineer Departments, Military or Naval Bureau of Information, or the *Artillery* or *M. S. I. Journal*, will often procure the information immediately desired, or pertinent references to reliable sources from which it may be obtained. The *Artillery Journal* and the Staff of the School would no doubt gladly respond to such calls, thus extending their field of usefulness.

Requisitions for material and devices, made after careful investigations, stating specifically the uses for which they are desired, urging the necessities of each case, and its important relation to efficiency of service, will prod up the supply departments to better provision for the many details required for proper instruction and practice.

"The way to resume is to resume"—so pertinent a statement at one time of the financial situation—may be made to read for the artillery, "the way to practice is to practice". Prayer to Jove for assistance in drawing the wagon from the mire is effective only when the shoulder is at the wheel. Doing all that can be done with existing material, appliances and allowances, is the best way to learn the requirements and how to meet them. No one accomplishes so much work, or obtains so much assistance as an intelligent but persistent "crank".

The "target practice craze" secured for small-arms instruction the present efficient system and liberal appropriations (once undreamed of) for the proper equipment of ranges. So with the artillery. Instruction will teach us what the system of instruction should be, and practice will reveal all that intelligent practice demands. If the necessity for a greater allowance of ammunition is made decidedly apparent by a general demand, supported by evidence of thoroughly good work already done, it will undoubtedly be authorized. When a loud wail arose over the abolition of the sunset gun, the echoes reached the congressional halls, and money for the few pounds of powder was provided in the next appropriation bill.

The present is the time to work upon the primary elements of artillery education and training. Fitness and capability for taking up the more general problems of artillery fire and defense will then be assured as the production and mounting of the new armament proceeds, and the new defensive works are completed.

Captain *John L. Tiernon*, 3rd Artillery.—The tendency of modern science is toward the creation of specialties: experience has proved that it is only by restricting the field of research that rapid progress can be made. It is believed that the new problems, purely military, pertaining to the artillery arm of the service, are enough to absorb the attention of our artillerists, however able and diligent. What is true for the officers is equally so for the enlisted men. The argument used that the batteries of heavy artillery can, in time of war, be utilized as foot troops in the field, is the bane of the artillery service, and its chief trouble can be traced to this fallacy. Under the operation of this idea it has been withdrawn from its legitimate work, which has been in the highest degree subversive of the interests of this arm. Coast defense stands in every sense directly opposed to the idea of mobility. It is essentially a passive, fixed, immobile service, and is limited to the line of the sea frontier, and manned by a force essentially specialistic. The duties and multifarious details pertaining to this service all require special studies, most of them high order. The Artillery School at Fort Monroe, Va., is instructing officers and enlisted men of the artillery in the science and practical work pertaining to this arm. This school has increased its standard until it is now abreast [illegible] of all similar institutions. Our heavy artillery was for years employed in duties apart from those rightly belonging to it, and absolutely neglecting those of its own proper sphere It has only been for the past few years that it has been partially relieved ~~of~~ from the evils referred to, which enables it to pursue to a reasonable extent a course of instruction and training in its own line of work, and the good resulting therefrom is noticeable from year to year. The progress made in the science of artillery has necessitated a new specialization for the service of the national defense, lying along the sea frontier, having its own expert personnel from the private soldier to the officer in command. The whole value of artillery in coast defense depends on the efficiency of its fire, and this fact cannot be too strongly impressed on officers and non-commissioned officers. Good fire discipline simply consists in rapid and correct drill under all possible circumstances.

Target practice under such conditions becomes of prime importance: and the artillery must be able to fire quickly and accurately. To accomplish this artillery troops should be divided into classes, according to their capabilities, and instructed in the duties of the class to which each belongs, so that each one can be relied on for the proper performance of such duty. Cannoneers should be able to execute the manual and perform the mechanical maneuvers of any piece prescribed in the drill-book. Gunners should be expert cannoneers and know how to manipulate and use practically all instruments pertaining to gunnery. Artillerists should be experts and able to teach all duties pertaining to the two former classes, and their own course should include all that pertains to the profession. It was thought by some, that it would be difficult to find men in the service sufficiently intelligent to become gunners. Many have been found who have shown themselves capable of mastering the course. Not as many of this class of men are found as should be, nor do I think there will be until some means are devised making this arm of the service more attractive for those possessing the essential qualifications. As stated by Captain Chester, 3rd Artillery, "furnish the captain with proper material, and then hold him responsible that they are taught and trained into efficiency." If this policy is followed it will produce efficient non-commissioned officers, who can be placed in responsible positions, and effect professional pride, without which no battery can be efficient. It is unfortunate that our sea-coast armament is yet composed of the old guns and their carriages, but as they are the ones with which the artillery must work we will show how the best results may be obtained: in correct loading, in accurate laying, in the correct application of any corrections which have to be made at the gun.

The many details necessary to secure successful results in firing must be carefully observed. Those of loading are of the utmost importance; for instance, the charge not properly rammed home, will result in a loss of muzzle velocity, consequent loss of range, and the throwing away of the shot; and will cause a false correction for the next shot, thus throwing it away also. Therefore, great care must be taken and attention be paid to the density of loading in muzzle-loading guns. Any variation affects the initial velocity and consequently the accuracy of fire. Every officer and non-commissioned officer should be familiar with the proper grade of powder to be used in each gun, and know the initial velocity of each particular grade to be used in any particular gun. New powder will give greater velocities and pressures than that which has been in store for some years. Before the season's practice firing is commenced a number of barrels of powder should be thoroughly mixed, to insure uniformity. Projectiles should also be selected as near the same weight as possible. The previous history of the particular piece to be used should be known, sights and sight-seats inspected and adjusted if necessary. As regards laying, any error in setting the sights will cause errors in range and direction. Gun-layers must not give the signal that they are on unless they are properly laid A careful compliance with the foregoing will insure as good results as possible with the guns in use.

During the firing the artillerist in charge of the guns must be kept fully informed of all obtainable data of importance to him. Many officers consider the time spent on the old material thrown away. This is not so. The practice affords opportunity for beneficial instruction. It necessitates the use of methods, of instruments, and much data that will be required with the high power modern gun. A greater knowledge of the scientific principles pertaining to the practice firing and improvement in the practical work have been observed each year since the practice began; for instance, the methods of obtaining the values of all deviating causes of the shot, affecting the trajectory, jump, atmospheric conditions, drift, etc., are taught, and their correction made at the guns during practice. The use of plotting boards and observation instruments, ~~are~~ necessary in all practice, with all kinds of guns, for plotting targets and measuring deviation of shots.

In regard to mortar firing it is almost the universal opinion of officers having had charge of such firing, that there is but little instruction of a valuable nature obtained from it. The pieces are generally mounted on rickety carriages, rotten and insecure platforms, which render every element of the practice unreliable. It is necessary that officers of artillery possess a great deal of technical knowledge, to enable them to instruct those under them, as well as for an efficient discharge of their own duties. The following contributions are of value to those having charge of target practice: Major Rodgers's Tables, in Artillery Memoranda; Whistler's Graphic Tables; Lieutenant Ruckman's Tables of Wind and Atmospheric Data, and pamphlet of Lieutenant Millar. The latter gives complete information, in detail, of all that is necessary for conducting the practice firing from the beginning to the end. The form for keeping the records required, is simple, all on one sheet, does away with the multiplicity of papers required by the department, yet it embodies all data essential to a perfect and complete history of the firing. The present conditions and methods of instruction are as good as can be devised. Experience has shown that the best method of measuring lateral deviation is by transit in coöperation with station observers: for the reason that should the transit fail, which very frequently happens, the shot would be lost; with three instruments obser~~ving, the~~ failure of one would still supply data for plotting. I agree with those who think the record of firing should be accurate and full, only giving such data as is of use. I do not agree with or see the force of the argument that all lateral deviations should be taken only by transit, and when this is not practicable then trust to the eye, rather than to base line observations. I have had charge of my battery practice for years and was present during the firing of many other batteries. When both the transit and base stations were used in coöperation I always found a great diversity of opinions among those present as to where they saw the shot strike and the distance, no two agreeing In my opinion, if the work at the base stations is carefully done by intelligent observers, there can be no comparison between the reliability of their data and that of the eye. I have had considerable experience, but would not be willing to hazard my practice on such data unless the other was not obtainable. There is no way by which accuracy of range determination is better obtained than by instruments.

After close observation since the instruction of individuals for gunners commenced, it is my opinion that the method at present pursued, by battery, is the best; it stimulates the men, being a battery competition, each man does his best to excel in the work. The necessity of obtaining uniformity of instruction and generally in the substance of it, is what is needed. The course of instruction as now prescribed, which has been followed for the past four years, and under which great progress and improvement has been made, should be revised to meet such progress and improvements as experience suggests.

Of the necessity for systematic training of gunners there is no question. What is most needed is a uniform standard for boards of examiners. I have been a member of the regimental board, of the Artillery School board, and have had more or less to do with other boards while they were examining my battery, and each board had a standard of its own. I believe this is true of all such boards. There should be but one board of examiners in each department: better still, one for the artillery arm. If this is impracticable, the War Department should describe a definite standard, uniformity of work, and limiting powers, for the guidance of all such boards of examiners. This would enable a comparison to be made of the relative merit of different organizations, an impossibility under the present system. The good work done must be continued, and as time and instruction develop progress and improvement, the standard should be raised to meet it.

A great deal has been done, but there remains much more to be accomplished. The artillery is mastering the difficulties met with in the use of the old armament, thereby better fitting it for using the new. The difficulties that will be met with in the new will not be all of the same kind as in the old, but will be quite as numerous. It is remarkable, what progress has been made by the coast artillery personnel in the past few years, or since it has been realized that it is impossible to make it both first-class artillerymen and infantry soldiers. It has pushed its way on in the face of many difficulties and disadvantages. It has never been an attractive service to the enlisted men, though its work is often extremely interesting to its votaries. Its doings are little seen and seldom rewarded. It scarcely ever receives any honors or promotion out of the ordinary way. The trials of the artillerymen are not enumerated to suggest that they are ill-used, but to show that their merit is great in that, in spite of the disadvantages, they have brought their arm into a condition of efficiency. They are producing the necessary system. No pretence is made for its perfection, but it is workable and advancing. Contrast the condition of the heavy artillery of ten years ago and of the present time: it will show what great advance has been made both in the theoretical and practical work of the profession. Ten years ago target practice was not known, now it is being had at all posts where guns are available, with excellent results, which would have been incompatible with the conditions existing a few years ago. These statements are made to show the advance made in fire discipline.

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It may surprise those who have never given the subject thought, that in the United States, with its population, its wealth, and its defenceless condition, excepting the regular artillery, there is not a single organization of any size instructed and trained as heavy artillery. This may be considered due in a great measure to the fact that our sea coast defenses have been neglected and unprotected, save by a few obsolete fortifications and armament. The people of the nation are beginning to realize the necessity for better protection and security, and when the improvement is reached our regular heavy artillery will have its duties increased many fold. I have no doubt but that when that time arrives and the sea coast is equipped with modern armament, the national guard of the country will become interested and form heavy artillery organizations for sea coast defense. The regular heavy artillery will have to perform the duty of instructor. The fact that our regular artillery is so small will necessitate the country depending on its national guard for re-enforcements. As the multifarious requirements of modern defensive works cannot be acquired within a limited time, some provision for the instruction of this peculiar organization should be made, to make it an efficient auxiliary volunteer force properly instructed in heavy artillery. In time of peace such organizations are not under the authority of the federal government. This precludes the idea of making it efficient unless some law is enacted making it amenable to such authority. The necessity for such auxiliary force is conceded, therefore it should be placed under the control of the federal government.

1st Lieutenant *G. N. Whistler*, 5th Artillery.—Within a comparatively short period samples of the new ordnance will be mounted upon our fortifications;

and it is to be hoped by the end of the century we will find at least our most important works fully equipped with the modern armament. With the advent of new guns will come the necessity for new methods and new systems of instruction; and the proposed general discussion of the subject of artillery instruction in the *Artillery Journal* would therefore appear to be very apropos.

Our Corps is undoubtedly very much hampered by its organization; without a head and consisting merely of independent regiments (organized upon an infantry basis) there is no source from which we are to look for a systematic plan of seacoast defense and artillery instruction. What is everyone's business is proverbially no one's business, and even were it possible for each individual Post Commander to establish a system for his own command, there is no reasonable probability that more than one in ten would undertake the work; and it is certain that there would be no uniformity in the plans adopted. The Colonels of our regiments are not in any sense artillery commanders except so far as their own posts are concerned.

Whatever may have been the force of the arguments advanced in past years in favor of a Chief of Artillery we have now reached a point where a chief of some kind is absolutely indispensable.

As we read of the methods of defense of seacoast fortifications, and the direction and control of artillery fire, adopted in foreign services we are at once impressed with the fact that the entire system of artillery work has undergone a revolution. Even in England the very titles given to the various sub commanders of sections and batteries sound unfamiliar to our ears. We recognize at once that the new armament has produced entirely new conditions, requiring an entirely new system of organization and method of work. Now as we are soon to receive our new armament, we ask from whence are we to receive our system of defense? Whose duty is it to formulate and build up a suitable system? And when we remember that in order to maintain an efficient system there must necessarily be an authority somewhere, whose duty it is to maintain the system at its maximum efficiency and to adopt new ideas, new scientific discoveries, and new methods, we are impressed with the idea that a Chief of Artillery has become absolutely necessary. Our infantry organization is entirely unsuited to our necessities and the usual system of instruction, which consists of an infantry drill with artillery instruction engrafted thereon, is simply ridiculous.

While the future artilleryman must necessarily be a soldier in so far as his personal set-up and the discipline maintained over him is concerned, his duties will be entirely different from those of the infantry or cavalry soldier and will in fact approach much nearer to the duties of a man-of-war's-man on board ship. I use the term man-of-war's-man intentionally, as I desire to express the duties of the crew of a man-of-war not as sailors, but as artillerymen, that is their service at the guns.

On board ship each man is assigned to a particular gun and station. When called to quarters he goes to his gun and station; this is his rallying point, his place of assembly so to speak. He must know thoroughly the duties of his station and his gun, and so far as his artillery duties are concerned, the entire system of instruction is regulated so as to fit each man for a special duty and a special work. Of course he may be paraded for muster, or he may be required to land and to maneuver, and must therefore have a certain amount of drill suited to this character of work; but this general drill is entirely secondary.

I maintain that we must adopt some such system for our artillery service. The practical unit of seacoast artillery is the gun detachment. Each man should be assigned to a particular gun and station, this should be his rallying point, his place of assembly, and the entire system of instruction should be to fit each man for such service; he should be encouraged to take pride in his particular gun and battery. Of course he may be paraded for muster and ceremony, and must be able to unite with others in a certain grade of military maneuvers; he must therefore receive a certain amount of the foot drill, but this should be entirely secondary.

To carry this idea to its legitimate conclusion, our entire post system must be changed. At present our posts are merely infantry stations, our parades, formations and duties are infantry pure and simple; it is of course understood that during war, each battery is to be assigned to the guns, and a system of defense is to be established, but so far as I am informed, there is not a single post in which any instruction is given in the duties of the service of an artillery station during action.

Our infantry endeavor in their drills and instructions, to simulate the conditions of warfare; outpost duties, picket duties, reconnaissance, etc., are taught and practiced. Our cavalry are taught the mounted and dismounted methods of fighting. Minor battle-tactics are taught and practiced by all branches of the Service save our own. It is true that some of our post commanders are very particular that infantry battle-tactics should be taught and practiced, but at what artillery stations do we find any artillery battle-tactics?

At one post to my certain knowledge, some effort has been made to map out the harbor, determine and plot the effective range of fire of the various batteries and guns, and I believe the same thing has been done at other places. I have, however, never heard of a single post where any instruction has been given as to fire control, or even as to how the work was to be manned or fought in case of war; and I am sure that at no post, not even the Artillery School, is there any attempt to maintain the service and discipline upon a war footing. It is true that our commands are small and no extensive service could be maintained at any station. There is, however, no reason why each battery should not be assigned to particular guns and full and thorough instruction be given as to duties in action, both in night and day service, just as though the entire fortification was properly manned. This should include range finding, ammunition service, torpedo service, signal service and guard duty.

Recruit Instruction.

In considering the subject of systematic artillery instruction, we should however begin with the instruction of the recruit. I am one of those who believe that the musket is the proper personal weapon of the foot artillery soldier; and that the artilleryman should be thoroughly taught the school of the soldier, including the manual of arms, and a certain amount of rifle practice at short ranges. It is absurd to teach an artilleryman skirmish work: and long range target practice is a waste of time. I am of the opinion that the artillery service should be recruited by re-enlistments of men who have served in the infantry, so that time should not be wasted in teaching men the elementary duties of the soldier. In case of recruits, however, the primary instruction should not differ from that given to the infantry recruits. This instruction should be followed by a thorough course in the nomenclature of the guns and fortifications, with the object and use of each and every article and instrument used in artillery service. After this they should be grouped in detachments and taught the gun drill. This should be followed by instruction in the preparation and service of ammunition, cordage, and the use of instruments for mechanical maneuvers.

Should any of the recruits show an aptitude or a sufficient amount of education, they may be given further instruction in those matters which pertain more particularly to the gunner class.

The Gun Detachment.

To my mind there are few things so ridiculous as our present system of artillery drill. Day after day, and year after year, our men are marched to the guns and required to go through with the everlasting "From Battery", "Load", "In Battery", "Fire", "Change Posts", etc., *ad infinitum.* The average post or battery commander considers that if he has required one hour a day of this sort of work from his command, that he has done his full duty and that the artillery instruction of his command is complete. Any average man can learn the gun drill in a week, certainly in two weeks, and if we find any men in the service who cannot, they should better be discharged as imbecile. With the exception of a few new men, one month's gun drill at the beginning of the drill season should be sufficient for any battery in the service. To keep the men perpetually "heaving and hauling" at hand spikes for the entire drill year is simple torture. In days gone by, ~~with~~ our old smooth-bore guns, this was all that was necessary and our nick-name of "red-legged do boys" was well deserved.

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Captain Gordon, Ordnance Department, has shown us that a system of artillery instruction and drill may be devised, which far exceeds in practical value anything that has ever been attempted in our service.

In presenting the following plan of instruction for the gun detachment, I desire to acknowledge the suggestions given to me by Captain Gordon: in fact very much of the system is merely a development of his ideas.

Harbor Instruction.

Assuming a gun detachment or battery assigned to one or more of our seacoast guns, the first line of instruction should be what I call Harbor Instruction.

The men being at the guns, a properly constructed map is laid out and the men are taught to orient the map, and locate thereon the various marked points in the harbor, such as buoys, islands, beacons, &c., and to trace the channels, locate points where vessels may lie at anchor, and finally to determine ranges to such points, by means of the map and scale. Having familiarized the men with the character of the harbor, we next require them to estimate the range to moving vessels, that is to teach them to locate the vessels upon the map or in their minds, in such manner that they can determine the range to the vessel from their own guns, by the means of their knowledge of their harbor. There is no reason why in the majority of our harbors, the men should not be taught in this way to estimate ranges with great accuracy.

To make instruction of any kind efficient some means must be devised to interest the men in the work, and the best incentive is to introduce the element of competition.

In the competitive drills, it may possibly be best to admit only the gunner class. The plan is as follows: The gunners are grouped in squads of say five men, these squads are taken to the guns, a detachment being also sent to the range-finding station. The range-finding station is connected with the battery by means of an electric bell. Each man in the squad is furnished with a card having ten numbers printed thereon, and a pencil. The range-finding station is directed to "track" a certain vessel, making ten observations, at certain intervals of time; as each observation is taken, the electric bell is rung at the battery, and each man in the squad is required to note on his card at the ringing of the bell, his estimation of the range and azimuth of the vessel. These cards are then taken and compared with the range table record; and each man given a mark indicative of the accuracy of his work. Thus if he has estimated nine out of ten of the observations accurately within a certain tolerance plus or minus, he will receive 90, the maximum being 100.

These cards are then returned to the men and the range-finder record is posted up in the squad rooms so that each man may compare his own work. A similar plan may be used in connection with estimating the speed of vessels. It is of course impossible to say how great accuracy will be obtained, but I think we may safely predict that for most of our harbors we will be astonished at the closeness of the estimated ranges after a few months of practice.

Ballistic Instruction.

This consists of practicing gunners in estimating the force and direction of the wind, in making allowance for atmospheric conditions by means of the Graphic Tables, the use of ballistic instruments and other instruments of precision.

Fire Drill.

This idea, which we owe to the ingenuity of Captain Gordon, is the most important of all. The plan is as follows: The battery is ordered to the guns, range-finders, &c., all as for action. A vessel entering the harbor is assumed to be an enemy and fire opened thereon, of course only using friction primers: this fire is kept up precisely as it would be in case of action, except that the exact data as to elevation, deviations, wind and atmospheric conditions is taken down for each shot, and the exact time at which each shot is supposed to be fired is carefully noted. After the practice is over, the exact position of the vessel when each shot was supposed to be fired is plotted on the map; and the probable place where the shot would have hit as determined from the ballistic data, by means of the Graphic Tables is also plotted. The gunner by an examination of this map learns the accuracy of his work.

It will be noted that by this method the entire system is put in practice: rapidity of fire, working of the range and position-finders, instruments of precision and graphic-tables. A continual practice of this kind will soon indicate the value of any particular contrivance or system. By this means we can learn whether information can be transmitted by any particular device with sufficient rapidity for practical work; whether direct or indirect pointing is the most satisfactory; whether base line systems can be used advantageously; and in fact each day's work will be a semi-practical test of the entire artillery system used in any particular fortification.

The value of such instruction to both officers and gunners must necessarily be very great; without firing a single shot, each day will furnish actual practice in the fire drill of seacoast artillery. The competitive idea may also be introduced into this practice, and each day's work made exceedingly interesting to both officers and men.

In order to make the system complete, actual warfare should be simulated. The batteries and ammunition should be served as in action. Each service magazine should contain dummy cartridges with velocity marked thereon, projectiles of differing weights should be used; and the service from the main to the battery magazines should be completely organized. In fact the work should be so regulated that in case of action the men would know exactly what would be required of them. Night work should be done, involving the use of search lights, and calling for the application of the various devices for indirect fire that are required in such practice.

One exceedingly valuable feature, connected with the system, is its value as a means of instruction in case of the breaking out of a war. Whatever may be our future artillery organization we must nevertheless depend in case of war largely on volunteer troops. The number of instructors will be few and the amount of necessary instruction exceedingly great. If, however, every enlisted man has been in the habit of going through with simulated warfare in his daily drills, each private in the ranks will be a competent instructor in his own particular branch of the work.

Target Firing.

The target firing is the natural completion of the year's fire drill. It is intended for instruction of the non-commissioned officers in the actual service of the gun. If the ballistic instruction and fire drill has been thorough, the result should be shown in the character of the work done at the targets.

The annual target firing should be carried on with great care and precision, not a shot should be wasted. Each non-commissioned officer should be impressed with the fact that from each shot fired he should obtain some information.

Ballistic Firing.

My views on the subject of the importance of ballistic firing are so well known that I hardly think it necessary to say anything upon the subject in this paper, save to call attention to the great and essentlal importance of ballistic firing in the study of a new class of ordnance. Without a thorough investigation and ballistic study of our new guns we will be unable to reap any advantage from their increased range and accuracy.

Tactical Firing.

This subject involving as it does the entire question of harbor defense, fire direction, and fire control, and the method of fighting a seacoast work, is too comprehensive to admit of discussion in a paper of this character, nor does it properly pertain to the realm of artillery instruction, as it includes the character of the apparatus to be used. The subject is one, however, which we must soon face and I fear that we will find great difficulty in solving the problem.

Entirely without a head, with no Artillery Bureau, the colonels of our regiments mere post commanders, with no artillery districts and with no one whose duty it is to attempt the development of a system, I see no prospect of an early solution of the problem. In the absence of a Chief of Artillery I think the most practical plan would be for the General of the Army to detail a board and direct them to prepare a system giving them say, three years' time in which to make their report.

A plan established by such a board could hardly be expected to be entirely satisfactory, but it would form a nucleus and a beginning which would in time be developed into a perfected system. In the meantime every artillery officer should persistently present the absolute necessity for the creation of the office of Chief of Artillery.

In this paper I have endeavored to present merely an outline of my views upon the subject of Artillery Instruction, hoping that the proposed discussion will bring forth a sufficient number of ideas upon the subject, and arouse sufficient interest, to warrant a more detailed paper at some future time. It would be presumptuous in any one in our service to attempt to elaborate a plan suited to the needs of the service. My idea has been that by presenting a plan, or as it were a skeleton system, that it would lead to a thorough discussion of the subject generally, and by bringing out the views of the officers of the Corps, lead to the formation of a consensus of opinion upon the subject.

1st Lieutenant *Henry C. Davis*, 3rd Artillery.—In reply to the above circular soliciting discussion upon the general subject of target practice, I would say that my ideas on target practice were outlined in a previous article under that head, and I have little to add. The details of any scheme must be worked out on the ground, as the facilities for scientific target practice vary with each location.

The present seems specially suited for a discussion of this topic: 1st, because of the horrible example of poor practice recited in the reports of the Brazilian trouble, and 2nd, because of the advent of a new era in our professional history caused by the appearance of a modern gun at an artillery station.

It is very important to begin aright with this new weapon, to keep a complete history of its performances, to study it *ab initio ad finem*.

Undoubtedly we need a closer connection between ballistics and artillery, as taught in our schools, and target practice. Theory must be *proven* by practice and practice must be *directed* by theory.

The supply of ammunition available for target practice with the 8″ rifle will, doubtless, be relatively small compared with the work to be done, hence a complete scheme must be worked out beforehand and the practice carried on in accordance therewith. Subsequently the data so obtained must be closely scrutinized, each shot furnishing the basis of a problem. All irregularities noted and the causes sought for. This preliminary and subsequent work belongs to the domain of theory, or better still to the theoretico-pratical branch of the artillery science.

The increase of accuracy of the new, over the old ordnance, necessitates a closer attention to the small things which affect the practice and these and their effects must be thoroughly understood.

As a preliminary to the practical work a study of the "Artillery-fire Game" (see *Journal* Nos. 6, 7, 8 and 9) will be advantageous in connection with making the fork, *i. e.*, in placing the center of impact on the target.

For the first year a probable error will either be assumed or taken from the ordnance reports and the table constructed therefrom. Each subsequent year these tables may be corrected from data obtained in the previous practice.

The table being prepared, section room work may be had in placing the center of impact. This will certainly educate the *judgment* of the artillerist by familiarizing him with what variations to expect, teaching him what to do under given circumstances and how to interpret observed results. His belief in his judgment being strengthened he will be better able to trust to it when an exceptionally long or short shot may tempt him to change elevation.

Observations being more accurate for seacoast guns than for field artillery, for which the game was specially designed, one variable factor is eliminated and the game very accurately simulates actual practice.

It is to be regretted that the explanation and discussion of probabilities entered into the body of the article and particularly at its beginning as its introduction may, for some, give the whole a smack of mathematical gymnastics. The adaptation of the law of probabilities to practical work is no new departure. Our great insurance companies annually risk millions on the deductions therefrom, and should we, in our practical profession, discard a help recognized as reliable in the commercial world?

There is one point of great importance in target practice that must not be overlooked: that is, firing at moving targets.

Aiming ahead is the only method available, at present, unless there is time for a calculation, based on the predetermined target velocity, and the setting off of the requisite number of points.

Of course tables (graphical possibly) can and should be prepared (the arguments for entering which being target velocity and range) but this correction would be better made by a specially constructed sight (of which more anon).

Whatever method may be adopted it should be frequently practiced, utilizing the many vessels passing in and out of our more important harbors. The present practice of ship tracking is good as far as it goes. It must be *connected* with target practice. Deductions of *target velocity must be actually made*, in any [illegible] manner, and furnished to the artillerist at the gun, who must *actually set his sights and point his gun, and all before the target gets out of the range furnished.*

This must be actually done, as no amount of knowing how to do it will compensate for a lack of facility in doing it.

The foundation of our target practice is good. All the different functions of obtaining range, target velocity, wind velocity, barometer, &c., &c., may be classed as belonging to a supply system for the artillerist. These are all more or less provided for, but *there is a lack of co-ordination*: the supplies come, but they should flow in more authoritatively, opportunely and connectedly.

George O. Squier, Ph. D., 1st Lieutenant 3rd Artillery.—It is comparatively easy to elaborate a system of artillery practice based on an unlimited supply of ammunition and a certain standard of intelligence among our gunners, but if I understand one of the first objects of a discussion at this time it is to orient ourselves on this all-important question, draw the logical lessons from the past six years of practice and determine what improvements should be adopted *now* for the practice of the coming season. In other words, [illegible] and admit the present conditions and limitations as they exist and endeavor to meet them, instead of spending too much time in elaborating systems on paper which cannot possibly be carried out *at present*.

The practical question applies to what [illegible] can be done [illegible] General Orders No. 132, A. G. O., of [illegible] [illegible] battery, regimental and general artillery competitions, [illegible] practice.

What have we learned thus far?

In looking back over the past six years of practice [illegible] found [illegible] most expensive manner. [illegible] which it is thought [illegible]

(a) Practice with the 4.5-inch muzzle-loading rifle is dangerous on account of the liability of bursting the gun.

(b) The 8-inch converted rifle will shoot accurately if intelligently handled.

(c) Practice with the 13-inch and 10-inch sea coast mortars is useless and in many cases detrimental, unless they are provided with suitably leveled platforms.

(d) The 8-inch and 10-inch siege mortars, quite contrary to *manual*, should be pointed and elevated before loading.

(e) The utmost care should be taken to insure uniform "density of loading" with the 8-inch converted rifle.

(f) Reliance for deviations should be upon the transit when a difference exists between the readings of that instrument and the plotting from the shot angles.

(g) The present method of keeping the battery firing records is cumbersome and unnecessarily complicated.

(h) The great practical value of Whistler's graphic tables of fire has been shown in the practice with the 8-inch converted rifle.

The above are a few of the *general* results which have become evident, I think, as the seasons of practice have come and gone; not to mention, of course, the many minor details of practice which have been learned, the valuable training and familiarity with heavy artillery attained, and the interest and activity among both officers and men which have been awakened in this our own proper kind of work.

Uniformity Necessary.

Since our battery target practice is necessarily competitive in character, justice demands first of all uniformity in the details of such practice, still nothing is more evident to anyone who has had a season's experience at target practice as now conducted, than the lack of uniformity which prevails in interpreting and carrying out the provisions of the orders and circulars governing this practice. In what follows I speak from experience with the 3rd Regiment, with which alone I am familiar. In General Orders No. 108, A. G. O., of 1888, we read: "Each battery commander will superinted *in person* all the details of the practice of his battery"; and again, in special instructions from the Department of the East it is stated that "the duty of adjusting sights pertains *exclusively* to non-commissioned officers."

In some batteries the above instructions are so interpreted as to allow lieutenants of the battery, under the guise of verifying the accuracy of the non-commissioned officer, practically to aim and determine the elevation for every shot of the battery during the season, whereas in other batteries there seems to be little need for the lieutenants: the loading, aiming, and first plotting as well, being done by non-commissioned officers. This latter theory forbids an officer from interfering to prevent a careless gunner, through some gross error, from throwing away a shot into the sea. Between these extremes practices differ in the different batteries, but are mainly actuated by the fundamental idea of making a record and not with the true spirit of learning how to shoot under service conditions.

When "figures of merit" are obtained in such a variable manner, it is safe to say that the compiled and published "relative merit" order, which should mean so much to our service as measuring actual efficiencies, is of little value.

Uniform methods alone will give us comparative results of value, and without them we can have no just competitions either in theory or practice.

As to the manner of attaining this, first the instructions governing the practice should be explicit and capable of but one interpretation, and then they should be enforced both in letter and spirit, by having the practice conducted under the supervision of the Inspector of Artillery of the Department, or a disinterested field officer, who should be present during the firing of every shot.

Classification of Gunners.

In connection with the subject of *uniformity* a word may be said in regard to the examination of gunners as prescribed in General Orders No. 132, A. G. O., of 1890. There is no doubt but that the advance made since the issuing of that order has been great, but the experience of the past three years has naturally brought out defects and it seems that the time is ripe for revision and improvement, especially in the method of conducting the official examination for gunners.

First of all, the regimental examining boards should be given uniform, definite, and limiting instructions for conducting such examinations.

In General Orders No. 14, of 1893, Department of the East, which publishes the classification of gunners for last season, it appears that out of the 461 gunners in the three regiments stationed in the Department which were subject to classification,—194 were found in one regiment and but 114 in another, or an average of 19.4 gunners per battery in one regiment as against 11.4 in another, about 59%.

As now conducted, one regimental board fixes one standard, another an entirely different one; one year the standard is comparatively high, the next comparatively low. One board is strong on the practical part of the examination, another pays little attention to this. Yet the results are all classed together and published as presumably a just comparison. It is noticed further that the 20 points allowed in the "minimum qualifications" for soldierly character results in most battery commanders giving every man he presents to the board the maximum, or in other words there is no *grading* at all in this respect. It is also thought that experience has shown that the *judgment* elements in the "minimum qualifications" for gunners bear too large a proportion to the whole, being 39 points out of 100, especially since at many of our posts this examination necessarily consists in pure guessing when the judgment of an old sergeant might be equally as good as that of a member of the board. Of course improvements must come as the result of experience, but it is suggested as a means of getting nearer uniformity in practice, that prior to the examinations by the different regimental boards they should receive uniform and definite instructions for conducting the examinations in all its details, and as far as possible the questions to be asked under each head, which questions could be formulated by the Inspectors of Artillery of the different Departments in advance, and sent under seal to the regimental boards for their guidance. Another point which has suggested itself to the writer, is the advisability of considering the proficiency which the men have shown during the season's course of instruction in determining the result instead of making everything depend upon a single examination at the end of the course. This would have the effect of making the men feel that each recitation had its effect and would stimulate them to a more sustained effort. Each battery commander would then be required to submit to the board not only the names of his candidates but their respective grades as well, as determined by the season's instruction.

The Record.

A simplification in the present method of keeping the battery records is desirable and should be made. The use of the eleven different forms now prescribed for each series of shots in which much of the data appears again and again, not only takes an unnecessary amount of time employed in purely clerical work, but requires extra care to prevent the loss of parts as their number increases.

The record of each series of shots should be forwarded as soon as completed, instead of waiting until the entire season is over, thus preventing the practice which has grown up in some batteries of putting the whole original data together in a drawer, and depending upon three or four days of hard work at the end to hunt up missing inspection reports and otherwise straighten matters out. Instead of often requiring longer than to fire the shots themselves, the making of the record should be but the work of a few minutes, and should be done on the same day with the firing when every circumstance is fresh in the memory.

The plot both in plan and for the 20 foot plane could be on the right hand page of a single folded sheet, with all the necessary data on the left hand page, so that everything necessary to a perfect understanding of the shots would appear at a glance. The form devised by Lieutenant Millar, 3rd Artillery, and printed at the Artillery School, is a good one, but the plots should be printed with squares similar to coördinate paper, and definite conventional signs prescribed for targets, shot and shell.

The 15-*in. S. B. Gun.*

Since the 15-in. gun is to remain a part of our new system, as well as the 8-in. converted rifle, every effort should be made during the coming season to improve this practice while we are waiting for our new material. The present allowance of four shots should be increased at least to 6, and these should be fired at one range instead of two shots at each of two ranges as at present.

There is certainly more instruction in four shots at one range than divided between two ranges. Methods for securing uniform density of loading with this gun are wanting and should receive special attention. Since elevations are required to be given by quadrant, these instruments should be either new or accurately repaired and adjusted before the practice begins. This is an important point since a slightly bent quadrant or one whose level is not in accurate adjustment will cause great mischief. Remembering that the cost of firing a round with the 8-in. M. L. rifle, using 35 lbs. of powder, is $21.00, and with the 15-in. S. B. gun, using 130 lbs. of powder, is $64.00, economy if nothing else requires that a few dollars be spent in securing accurate quadrants for this practice.

With regard to the practice with the 8-in. M. L. rifle, we now have a comparatively accurate graphic range table, and it is thought that it is about time we begin *service* target firing with this gun at a moving target. This, after all, is the only *real* target firing,—fixed target firing is merely instructional and preliminary.

Ballistic Firing.

Lieutenant Davis's division of artillery practice into three periods, viz: Ballistic Firing, Target Firing, and Tactical Firing, is a good one and the few shots which were so carefully and intelligently utilized in a study of the 8-in. converted rifle at Fort Monroe gave us more real, tangible, valuable results as far as the treatment and behavior of this particular gun is concerned than all the irregular battery firing which had been done with it up to this time. It was discovered that variations in the "density of loading" under ordinary conditions of practice may cause changes of as much as 90 f. s. in the initial velocity, which at an elevation for 3000 yards would correspond to a variation of 300 yards in range.

If we had known the results of this firing in 1888 before we began battery target practice and utilized these results to the best advantage, how different would have been the battery records with this gun for the past six years?

The plain truth is, we rushed into target firing before we knew anything about ballistic firing. We attempted to teach gunners what we knew nothing about ourselves.

Before beginning battery target practice with any gun we should know all we can learn about its performance from the most careful and intelligent ballistic firing by a competent board of artillery experts, and then when this information is at hand and in its most available form we are ready to undertake target firing by battery; which should be conducted as nearly under service conditions as possible. A sergeant is not the man to discover some new fact about jump, nor is the gun the proper place to *work out* allowances for deviating causes. All this is the work of ballistic firing and should be done prior to any practice by enlisted men.

This is the secret of small arms success. With uniform ammunition and a carefully graduated sight the infantry soldier takes his rifle with all his bal-

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listics worked by more competent hands than his own, and all he has to do is to master his own personal equation.

The main idea which I wish to submit is the following:

Within a very short time there will be mounted at the Artillery School an 8-in. B. L. rifle and a 12-in. B. L. rifled mortar, and they will, I understand, probably be available for practice during the coming season. These pieces are type weapons in our new system of defense and therefore should be studied most thoroughly prior to any regular battery target firing as such. We have no *practical* range table for these pieces and we know very little about the influence of natural deviating causes upon their behavior. It seems, therefore, in the light of our past experience with the 8-inch converted rifle already referred to, as well as being the natural scientific method of procedure, in any case, that before allowing a shot with these pieces at target firing, they should be turned over to a competent board of artillery experts as soon as they are mounted for a series of shots for a ballistic study of them under variable conditions.

The results of this work when carefully interpreted and put in some such simple form as Whistler's graphic tables will furnish each battery with what can be learned about these pieces independently of the individual skill and judgment of the gunner, and then and not till then should battery target practice proper begin.

There is no denying the fact that we have but too few *artillery experts* in our service and among these we have the more theoretical specialists and again the more practical men.

It is needless to urge that the work before such a board as that proposed for the near future is of such paramount importance to our whole future progress that these specialists, regardless of rank, roster, or anything else, should be put on the board and give the artillery the benefit of their special knowledge.

The idea of a School of Gunnery for officers is the one practically in vogue at Shoeburyness, England, and at our naval proving ground at Indian Head. As our new armament is completed, the work which must be done in this line and which the Ordnance Department cannot possibly have the time to accomplish, will necessitate such a school in some form or other, and the plan outlined by Lieutenant Whistler in the last number of the *Journal* is in the right direction. We have too many paper gunners among our enlisted men when compared with the few *real* gunners among our commissioned force. Better educate the officer, the only permanent part of our organization, rather than devote too much attention to the comparatively advanced instruction of men who may leave the service at any time,—and experience shows that they do leave.

But to establish a School of Gunnery for officers, secure an Experimental Artillery Gunnery Station, requires time and legislation, and we sincerely hope and believe they will come; while to order a board to study the type pieces which will soon be mounted at Fort Monroe is something which can be accomplished by a general order, and give us a practical advance in 1894. In fact such a board would be a first step towards the School of Gunnery referred to, as well as be the means of placing in the hands of each battery commander the best practical data for the training of his gunners.

Colonel *John Hamilton*, U. S. Artillery.—Most of theoretical target instruction can be applied in practice without the loss of powder or shot.

INSTRUMENTS REQUIRED.

1. *Angle Finders* at ends of a good base-line. [For this instruction the base-line may be somewhat less advantageous in position and length than what would be necessary to catch the drop of a shot accurately. This latter is a very difficult practical problem.]

2. The observers at the ends of the line to have *Watches* regulated on clock at the *Firing-house.* [By the firing-house is meant the point where the *Instructor* keeps himself near the guns to receive reports, transmit signals, file or plot results.]

3. A good sea-worthy six-oared *Boat* to represent a moving target. [The coxswain should be an officer, when practicable. The boat should carry a *Mariner's Compass* and a signal-man. It should be equipped with a stout *Jackstaff* carrying a flag. The staff should be white and have a diameter of about five inches and height of twelve feet. Links of stove-pipe would answer as a substitute, but a light metal cylinder made for the purpose would be handier. It is believed that this arrangement would serve for all weathers and lights.]

4. One *Clock*, beating seconds. [The beat should be a sharp one that the ear may catch well, for this same clock can also be better used for *time of flight* than a stop watch. The second hand should be on the central arbor and extend to the limit of the dial to help the eye to catch the time. The hour hand is subordinate. The best way to read fractions of seconds is by the ear, which is readily taught to read to a tenth of a second: an accuracy not needed in this *instruction*, but useful in recording time of flight.]

5. *Maps* of the harbor, for the use of the *gun-captain*, and for the firing-house.

6. Telegraphic communication between the firing-house and the ends of the base-line.

7. *Anemometers* and *such other instruments* as measure the elements affecting trajectories. These are not absolutely necessary to carry out this instruction, since any data can be assumed by the instructor and delivered as a problem to the gun-captain, but it is generally advisable for the instructor to go by actual conditions in order to simulate real states of atmosphere. An exception, for instance, that presents itself is when the practice is had in a dead calm; a force and direction of wind should be *assumed.* By *gun-captain* is meant any person in command of the gun, officer or non-commissioned officer.

8. *Zalinski or other direct sight* on which the allowances for deviating elements and for the moving of the target can be made.

9. For this instruction the traverse circle must be accurately oriented and graduated. [Quoting Lieutenant Ruckman, 1st Artillery, "as most of our channels are narrow, all traverse-circles should be accurately oriented and graduated, in which case *the azimuth will at once give us the range*".]

Exercise.

The details being all made, the instructor having prepared the problems he purposes requiring the gun-captain to solve, the detachment at its gun, the boat in the position previously appointed by the instructor,—the instructor sends to the gun-captain the first problem and notes the time of its reception. This problem gives the data following, viz: the position of the boat; the direction it will steer [and this should be given to the gun-captain in terms of the true meridian, while the coxswain is required to make the same allowance on his compass. This can be done for each harbor by a *card* correction without requiring the coxswain to occupy himself solving numerical questions]; the *assumed* speed of the target [from three to eight miles generally except when the instructor in a late stage of the season's instruction may assume a high rate to catch a vessel trying to "run a battery"]; the direction and force of the wind; and the temperature, hygrometry, and weight of the air.

The instructor at once signals the boat to start giving it its course (E. or E. B. S. *vel al.*), and warns the range-finders, who will keep their sights steadily on the jackstaff as it moves.

As soon as the gun-captain receives his problem he commands *Load!* (to be executed with dummy cartridge, and by the tactics), and fixes primer the moment the missile is sent home, makes his calculations, lays and sights his gun, and reports to the instructor, *Sir*, *First* (or other) *gun ready*, and immediately adds *Fire!*

As the *instructor* sees the traversing mainly completed, he will signal *Attention!* to the range-finders. At the notification "Sir, First gun ready", the *instructor* will signal a continuous clicking of the telegraph key till the primer snaps, when he will instantly stop.

At the signal "*Attention*" from the *instructor* the range-finders with renewed care will follow the progress of the boat and use every faculty to have an exact sight on the jackstaff at the moment the signal key ceases clicking (the indication of the firing of the primer), when they will record the time of the shot to the second, read the angles, report them promptly to the firing-house, record them and then continue to follow the progress of the boat with their sights.

The moment the gun is fired the *gun-captain* will enter on a Form his elevation and azimuth, his allowances for wind, weight, temperature, and humidity, and his range, and turn the data over to the *instructor*, who will enter on it the times of loading and firing and carefully file the same for record.

[It is seen that this will not give *absolute* results since the distance the boat passes over between the pointing and firing will be different from that of the *assumed* vessel, whose speed is given as from three to eight miles. But the instructor knowing the speed of the boat can make the necessary allowance in posting the day's work and thus obtain an absolute result. He must also allow for drift of boat.]

By regulating the time of loading, two or more guns can keep up this exercise in succession only limited by the circumstances of the sea-way of the harbor and by the speed of loading. Of course there is little limit if we have plenty of instructors, men, boats, and independent telegraphic and range-finding terminals to our base-line.

The speed and accuracy of fire of the gun or guns will be determined by the instructor at the earliest practicable moment after the exercise ceases and the results supplied to the captains for their information and future guidance. Where more than one gun is used this exercise should be considered competitive, but in *all* cases an accurate record of the whole should be kept for future reference.

When the boat has reached the terminus of its rhumb, the instructor will signal *Halt!* and *Reverse!* signaling at the same time to the range-finders *Report angle!* He will then signal the boat its next direction (N. E. or N. E. B. E. *vel al.*) such as his judgment may direct for the best practice, when the exercises will be continued as in the preceding run.

After a sufficient period of instruction has been given the officer gun-captains to assure a uniformly respectable accuracy, a precisely similar course should be given the gunners under the guidance of the *captains* of their batteries, when practicable, a similar competitive record should be kept, and when possible, privileges granted accordingly, or suitable rewards or marks of honor be based on the results. If a five dollar medal is granted a victorious sharpshooter with the musket, at least a fifty dollar one should be awarded to him whose shot may sink a ship.

After a proper degree of all-round accuracy is confirmed through this exercise, information of the position and direction of the boat will not be given to the gun-captains; they will be required to make their own estimate of distance by the eye.

To insure earlier success for the gun-captains the instructor should in inclement seasons practice them in the problems hereabove involved, so that speed and accuracy of calculation may be reached before the subsequent practice at the guns.

All posts of small artillery commands may not be able to carry on the above exercises as herein proposed, keeping up concurrent infantry instruction, but one battery with three officers at the Post or two with one intelligent non-commissioned officer (to serve as coxswain) should be able to use one gun to great profiting, dispensing with the musket during the artillery tactical firing season.

For this exercise the instructor should be the highest available field officer when practicable, as captains of batteries no matter how old they be in theoretical knowledge should be the first practiced in the quick application of the rules. Furthermore, the bane of every army, where it is permitted or tolerated, is the tendency to delegate work and duty from the senior to the juni

Under such a system no arm can be a success. It results in atrophy and imbecility.

In writing this outlined system it will be seen that we are merely giving a working application of Lieutenant Whistler's concurrent article, which we have had the privilege of reading. As we progress in it we see much omitted minor detail and even important points. For our shortcomings Lieutenant Whistler is in no way responsible. To complete a well rounded system in full detail will require the practical tests on the firing ground. Thus the dunnage may prove heavier than the cargo. Still we must have some skeleton to build on and this one is presented in all humility. We would defend one apparent violation of existing tactics, viz: The fixing of the primer before pointing is completed. Many inestimably precious seconds are lost in pricking and priming which can be better advantaged of in prompt firing on a moving target, eliminating these seconds from the gun-captain's calculations and adding an element of certainty. No case of premature explosion after the missile has been set home is on record, to our knowledge.

An important question here suggests itself: can we ever have an artillery till the musket is boxed up for at least half the year; or until an inspector is appointed from the navy, whose eye is trained on the love and care of his battery rather than on the polish of the cartridge-box plate. ?

1st Lieutenant *E. A. Millar*, 3rd Artillery.—*Records.* The records of the artillery target practice are intended to give the history of each piece and of each shot fired, to show what has been done by each battery with its allowance of ammunition, and to inform the gunner of the results from shot to shot during the practice.

The first is kept in the "Post Record Book of Artillery Firing" and contains the history of the piece and the data necessary for reducing the elevations for the ranges to standard conditions.

The second, the record submitted by each battery commander and should contain the above data with the results obtained in reference to the target fired at, and the data necessary for replotting; this includes correct transcripts from the records kept at the plotting board, base ends and transits.

The third gives the positions of the targets and shots in reference to the gun used and may be entered with the above record.

The form of record should be that which accomplishes these objects with the smallest amount of work, the smallest number of papers, and presents it in the most convenient shape for use.

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To be of use for future reference the data must be correct and complete in every essential detail. The forms used at the Artillery School were designed to accomplish these objects and they have received the approval of the battalion and battery commanders.

Copies of these forms are appended.

Some data ~~is~~ entered which ~~is~~ perhaps unnecessary but ~~it is~~ still required.

Form "A" for each battery was kept during the practice by a recorder who entered 1, 2, 3 and 5 from the Post Record Book; 4, 6, 7 and 8 from the plotting

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records; 9 from the report of the Ordnance Officer; 10, 11, 13 to 17 from the observers at the plotting house. The values $\frac{\delta'}{\delta}$ are found from Whistler's Graphic Table No. 4 or Ingalls's Table IV, using the barometer and thermometer readings. The *components* of the wind up or down and across the range are determined from the readings of the anemometer, wind vane and dial. These values are entered as they are in the shape required in reducing results to standard conditions or by the gunner in applying corrections in accordance with the tables of fire.

The form was then sent to the gunner who entered 12, 18 to 30 and 43 and when he reported his piece "ready" returned it to the recorder at the plotting house. Where it is not convenient to send the form from the battery to the plotting house the data can be communicated.

The recorder entered as much as possible for the following shot, and 31 to 42, 44 and 45 when taken with instruments, as soon as obtained. 33 to 36 being the information for the gunner, was measured as described by Lieutenant H. L. Harris in Artillery Circular "E", page 21, lines 33 and 34, *i. e.*, longitudinal 33 or 34, difference between 31 and 32, and lateral 35 or 36 measured on line through target perpendicular to the line from gun to target and from the target to point of intersection of line from gun to shot.

The form was then sent to the gunner to inform him of the result of his last shot, and to enable him to enter the data for the next.

Under 47 was entered any injury to material, excessive recoil, tumbling of shot, &c.

This form was corrected, using the original forms "B" and "C", and with this data the replotting was done: 48 to 52 were entered, 49 taken on the dividers and applied to the measuring rod or other scale reading to .01 of an inch, and the result entered in yards: 50 was computed, using the angle of fall as that of range of target under standard conditions. The rectangular coördinates of the shot referred to the target are measured and used in transferring the plot of the shots to the common targets indicated on the form: these are not entered, as they are not necessary and might be confused with the deviations entered for the information of the gunner.

This form and the original forms "B" and "C" were the retained, and a fair copy of the corrected Form "A" was submitted by each battery commander. The complete records and plots of the forty-four shots allowed each instruction battery were submitted on four of these forms. One form contained the records and plots of the thirteen shots from guns: one, the thirteen shots from the 8-inch siege mortar at 1000 yards: one, the thirteen shots from the 8-inch siege mortar at 1500 yards and one, the shots from the 10-inch siege mortar.

These forms folded in half and then in thirds fit an official envelope.

Separate forms "B" and "C" were kept for each battery: the signal "ready" indicating the battery and the target at which it fired. The headings of Forms "B" and "C" are as follows:

[FORM "B".]

OBSERVER'S RECORD.

STATION "........."

Date .... *189* ...

Battery "..........", ... Artillery.

Gun Angle ....

NUMBER OF FIRE.	SHOT ANGLE.		TARGET ANGLE.		REMARKS.
	°	′	°	′	

[FORM "C".]

OBSERVER'S RECORD.

TRANSIT.

Date .... *189* ...

Battery "..........", ... Artillery.

POSITION OF TRANSIT.
IN REAR OF GUN .... YARDS.
TO RIGHT .... YARDS.
TO LEFT .... YARDS.

NUMBER OF FIRE.	DEVIATION IN MINUTES OR POINTS.		DEVIATION IN YARDS.		REMARKS.
	RIGHT.	LEFT.	RIGHT.	LEFT.	(TANGENT 1′ = .000291)

Form A1 is to be used with mortars fired at land targets. The target is staked out corresponding to the lettering on the plot and the distances are measured with a 100-foot line.

A register in the battery house gives a transcript [illegible] shot as fired for the Post Record Book. This [illegible] up to date the previous number of fire [illegible] [illegible] and afterward for several weeks.

The Post Record Book of Artillery Firing should [illegible] ment with the form adopted in order to [illegible].

The following are a few of the details of the [illegible] U. S. A. [illegible] School. *Targets*.—As there is no government [illegible] have to be placed in position by a tug boat [illegible] this account the targets are not brought [illegible] left in position until shot or carried away. [illegible] anchor. It was found that the ordinary anchor [illegible] the tide would wind the chain around the anchor [illegible] out of the sand. A block of granite was [illegible] manage in a small boat. The arrangement [illegible] for the last two years is shown in Fig. 1.

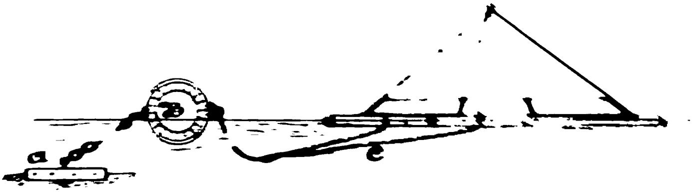

Fig. 1.

A traverse wheel from a 15-inch carriage was used for the anchor "A", from this the chain, in length, three times the depth of the water, led to the buoy "B", which was a water-tight barrel; from the buoy a rope twenty feet long led to the bridle, "C", which was attached to each leg of the target. The targets are placed over a bar where the average depth is three fathoms. A line of direction is taken on some prominent land-marks and at the beginning of the season the positions for the required ranges determined along these lines by means of temporary lines established by the instruments at the base end stations on flags. From these positions the cross lines from other land-marks are noted and it is found that by these lines established by land marks the targets can be easily and quickly re-located within the prescribed limits without the need of observers at the stations. After trying different colors, a black target was found to show best under differing conditions of light and water.

A leveling table is found in the ordnance store-room on which the quadrants could be quickly adjusted.

The sights and sight-seats for the Zalinski sight are adjusted several times during the practice; for leveling the piece when making these adjustments the level shown in Fig. 2 is placed in the bore.

Two semi-circular metal disks "A" are connected with a board "B", on which are placed two levels at right angles to each other. The level in the direction of the length of the board is adjustable and the level is tested at intervals to see if the bubbles are at the centers of the tubes when the surface on which the disks are resting is horizontal.

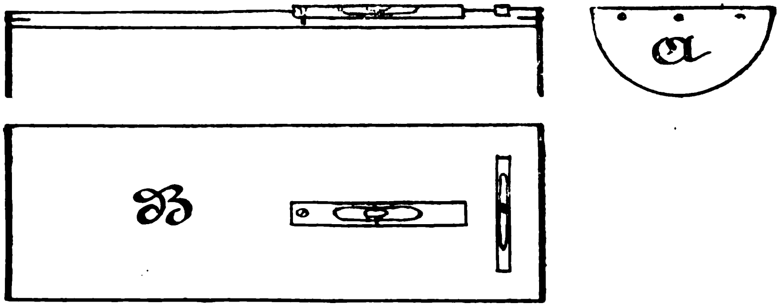

Fig. 2.

The rammer staves are graduated in feet, tenths and hundredths, to agree with the table in Lieutenant H. C. Davis's article on target practice* and to check these readings there are graduated wooden rods. Details from each battery are allowed to mix, weigh and make up the cartridges and to select the projectiles. As the plotting house is quite near the guns, it was found that the concussion was apt to injure any delicate instruments and for that reason the barometers and thermometers are not at the plotting house but the readings of these instruments are sent to the recorders at beginning of each practice. The wind vane and dial are near the guns.

The anemometer is placed on a high pole on the parapet and wires brought to the bell in the plotting house. The operator placed the angles as received on a blackboard in the plotting house, so that those at the plotting board and the recorders could see them.

For use of the gunners the following were kept at the plotting house: Major Rodgers's tables, Whistler's graphic tables, other range tables, wind tables, and tables from the articles on target practice published in the *Journal.*

The very interesting and instructive article on target practice by Lieutenant H. C. Davis, published in the *Journal* of January, 1893, begins with the quotation: "If we do not attain more than 75 per cent. efficiency with the old material, we shall not attain so high a percentage with the new". The question whether or not this per cent. has been attained cannot be answered until a standard of efficiency has been established. Although the per cent. of efficiency is not shown, yet the following figures give what has been done in the last few years with the 8-inch M. L. R. They are compiled from orders announcing the mean absolute deviations, in yards, of the batteries in this Department for the years 90—93:

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* *Journal*, Vol. II, No. 1.

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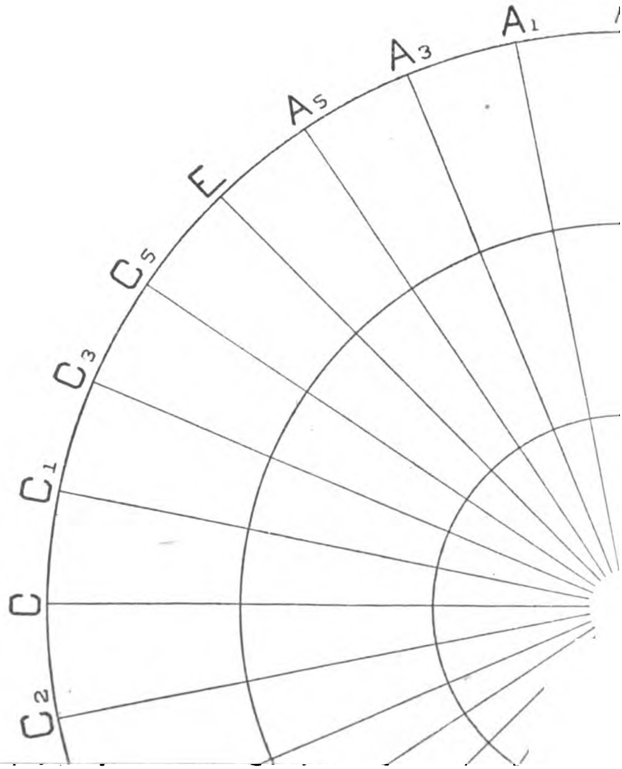
Shots at   yard target plotted in BLACK INK.



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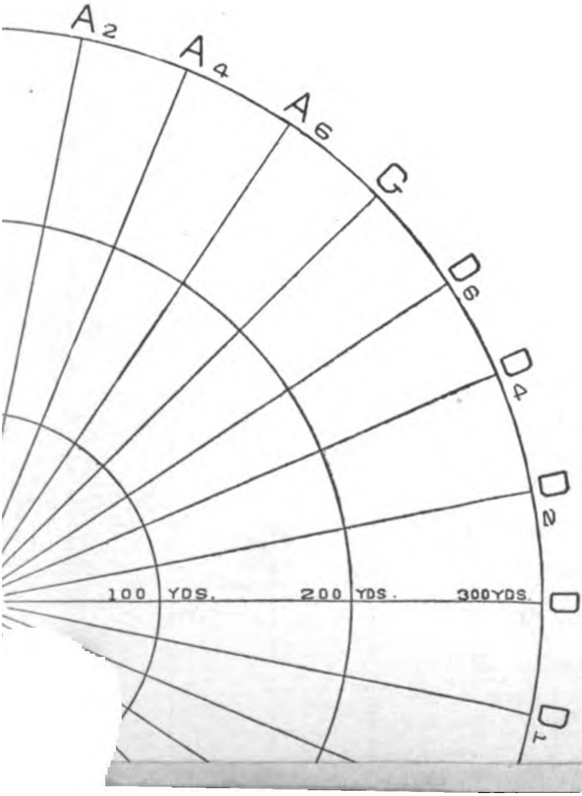
Shots at yard target plotted in RED INK.



	1890	1891	1892	1893
1st Artillery	155.86	121.29	210.04	101.35
2nd Artillery	120.50	98.41	90.88	74.28
3rd Artillery	115.03	94.32	62.96	**
4th Artillery		**	*	77.76
Instruction Batteries, U. S. Artillery School.			70.05	81.33

The firing with this piece should have improved; since during this time there have become available, Whistler's graphic tables, Major Rodgers's tables, the articles on target practice published in the *Journal*, the improved sight for the piece and the increased allowance of ammunition.

Figure 3 shows the plots of the best targets made by the instruction batteries of the Artillery School during the years 1892 and 1893.

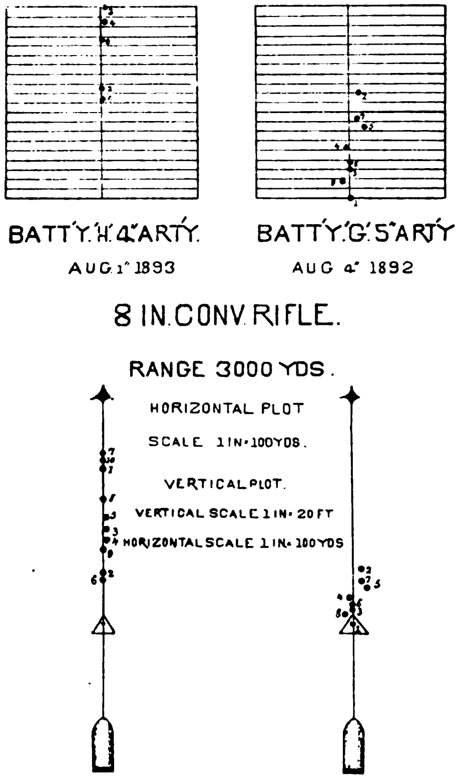


Fig. 3.

** Only two batteries firing. * One battery firing.

The target made in 1892 by Battery "G", 5th Artillery, shows a mean absolute deviation of 14 yards and 8 hits in the 20-foot vertical target out of 8 shots fired with solid shot. At this practice the first shot carried away the target, the direction was then taken on another target and the distance taken as 3000 yards.

Gunners,—1st Sergeant Gallagher, Sergeants Turney and Eagan, Corporals Doner, Spokes, Sweeney and O'Berry. Mean range 3017 yards. New Ordnance sight mean elevation 6° 12′. Wind 12 miles retarding, 0. deviating. $\frac{\delta'}{\delta} = 1.055$, shot 182 lbs. Powder 35 lbs. Hexagonal, Oriental Mills, 1876, Granulation 81, Moisture 1.765%, Specific Gravity 1.761.

The target made in 1893 by Battery "H", 4th Artillery, shows a mean absolute deviation of 56 yards, with 5 out of the 10 shots in the 20-foot vertical target. The target varied during the practice from 3250 to 3261 yards.

Gunners,—Sergeants Tscherning, F. Jones and Shull. Mean range 3256 yards; New ordnance sight; mean elevation 6° 34′; shot 180 lbs.: ~~wind~~ deviating to R. 6.5 miles, longitudinal component 0. $\frac{\delta'}{\delta} = 1.045$. Base of shot from bottom of bore 22.25 inches. Powder—35 lbs. Hexagonal Dupont 10A, 1881; Granulation 67; Moisture 1.22%; Specific Gravity 1.785.

The lack of data in regard to the density of loading prevents a correct comparison, but the following figures give the laboratory reports as to the physical properties of the powder used and the initial velocities computed by taking the results of a large number of shot each year, reducing the elevations to standard conditions and finding the corresponding velocities from Whistler's Table No. 1.

Year.	Brand.	Gran.	Moisture.	Sp. Grav.	I. V.
1890	Oriental Mills, 1876	81	1.55%	1.762	1320
1891	"	81	1.90%	1.777	1300
1892	"	81	1.76%	1.761	1280
1893	10A, 1881	67	1.22%	1.788	1370

It should be more definitely settled whether the gunner is to be given the range and told to lay the piece on the target, or on the target with a certain elevation and deviation. If the results of the practice are to be used in comparing the different batteries, the battery commanders should have complete supervision of the laying of the piece, deciding by inspection, if they so desire, before the piece is fired, whether the gunner has set the sight properly. The gunner to be responsible for the still important part of directing the line of sight properly at the target.

At the same time the non-commissioned officers who show on examination for gunners that they thoroughly understand the application of the tables of fire and have attained a certain efficiency in the firing with the batteries, should be allowed to fire a certain number of shots for the sighting of which they are entirely responsible, and the results of which used in comparing merits of individual gunners.

As the artillery competitions depend on the results of the examination for gunners, should not the methods, scope and marking be made more uniform throughout the artillery? Under the heading "laying of guns" should be included the use of the tables of fire; and headings under which a lucky guess may be made should not count so much in comparison with the other headings. It is to be hoped that the contemplated competitions will soon be held, as undoubtedly a great deal of instruction will be had in connection with them: but the many details of such competitions should be definitely prescribed in advance.

1st Lieutenant *Willoughby Walke*, 5th Artillery.—*Practical Ideas, Methods and Information with respect to Coast Artillery Practice.* The scheme proposed by the Committee of General Direction and Publication of the *Journal of the U. S. Artillery* is a most admirable one, and it is not only the privilege but the duty of every artillerist to avail himself of the opportunity to contribute his share whether of theoretical or practical knowledge toward developing the efficiency of our coast artillery.

The scheme is sufficiently broad to embrace the most diversified views, and he would indeed be a fully equipped artillerist who could or would undertake to discuss this important subject in all of its various phases. But I do not understand that to be the object of the *Journal*, but rather does it suggest that each contributor select that particular division or sub-division to which his attention may have been especially directed.

With this understanding of the scheme, I cheerfully offer my quota to what I trust may prove a full and complete compendium for future use in our coast artillery practice.

I. THE FIRST PERIOD OF COAST ARTILLERY FIRE INSTRUCTION.—*Ballistic Firing.*

For years it has been difficult—almost impossible—to impress upon those in immediate charge of target practice the importance of securing, previous to marching to the guns, the necessary ballistic data for an intelligent laying of the piece. It has been quite sufficient for all puposes if the ordnance officer or ordnance sergeant has copied from the heads of the barrels the granulation and specific gravity of the powder, and sent that information to the recorder in time to fill up the blank. In years gone by, and even now occasionally (when a lot of 1867 powder is used for 1894 practice), the valuable information, the initial velocity, determined presumably when the powder was packed and stored, is also found suitably painted in white letters on a black barrel head! The practical application of this data was given but little thought, certainly never intelligently used until Lieutenant Whistler (to whom be given all credit for the sudden awakening from our Rip Van Winkle nap) published his Graphic Tables of Fire. It is true that Captain Ingalls had already blazed a way through the hitherto unbroken wilderness, but it required too much work and worry to apply his formulæ to our daily practice. Therefore it was a happy inspiration that prompted Lieutenant Whistler to reduce the results of Captain Ingalls's labors and so present it that "he who runs may read."

Of what value are these tables to-day, and to what extent are the scientific principles of gunnery embraced therein intelligently and properly applied? Take Table No. 1, for instance:

Angles of Departure.—The three elements of this table are *Initial Velocity*, *Range* and *Angles of Departure.*

Once at the battery, the pieces loaded and in battery, *the* element required to properly lay the gun and the *one* almost uniformly *unknown* is the initial velocity. And how can it be otherwise, when in reply to a query only twelve months ago, as to whether preliminary ballistic firing would be had before the regular practice began, it was asserted that such firing was a useless expenditure of time, energy and money, since all the necessary data was plainly marked upon each barrel of powder. Unfortunately (?) the 1867 lot had been exhausted, and but for the publication of Lieutenant Davis's (H. C.) paper on target practice in the *Journal*, the laborious calculations of Captain Ingalls and the exact tables of Lieutenant Whistler would have gone for naught.

There are some almost insuperable difficulties in the way of determining necessary ballistic data at the majority of our sea coast forts, and those stationed at such should in no way be held responsible therefor. There are ~~other~~ forts well equipped, however, and until each fort can determine th~~is~~ data for itself, it is suggested that the necessary preliminary ballistic firing be conducted at some one or two points, the results tabulated, published and furnished to every fort at which target practice is to be held during that season. The operations necessary to the proper determination of the initial velocity which enters so largely into the accuracy of fire are too well known to be referred to. It has been proposed to supply chronographs and their appurtenances to the more important sea coast posts, and if not already on hand, the scheme should be carried out at once. The ballistic value of air is readily calculated from data supposed to be found on the daily post hospital records—barometer, thermometer, hygrometer—if not there, the post signal officer should be able to give it. Th~~is~~ data must be determined daily at each fort where practice is to be had, and should be placed in the hands of one person—preferably a commissioned officer.

Fortunately we have excellent range tables, calculated by our own officers, Major Rodgers and Captain Ingalls, 1st Artillery.

Unfortunately, on the other hand, the calculated jump, drift and other inherent properties furnished with the guns and carriages are more often found in practice to be unreliable and should be determined along with the initial velocity, etc., during the *annual preliminary* firing.

If the scheme to have the preliminary firing done at one or two points, and the data thus compiled sent throughout the Departments for use, be adopted, then too much care cannot be exercised in selecting those who are to have charge of this most important work. Only those specially qualified, and who, in addition to possessing practical knowledge of the apparatus employed, can ese

call to their aid the habit of close and accurate observation supported by years of experience should be entrusted with the preparation and compilation of this data.

The U. S. Artillery School, as the headquarters of artillery, as well as on account of its complete scientific equipment, is above all other places qualified to undertake this work and to thoroughly perform it. Until the smaller forts are equipped, they have a right to look to the school as the source of all such information, and on the other hand it should be a matter of pleasure and pride to the School to be able to furnish it.

II. THE SECOND PERIOD OF COAST ARTILLERY FIRE INSTRUCTION.—*Target Firing.*

B. Powder, etc.

During the past six years, while in charge of the Chemical and Explosive Laboratory of the Artillery School, I have been called upon to furnish the laboratory data of each kind of powder to be used during the firing season. This data consists of a determination of the exact composition of the powder, the percentage of moisture in various samples, absolute density (or specific gravity), gravimetric density and granulation. This information has been embodied in an annual report, together with suggestions as to such manipulation as would, in my opinion, correct certain defects discovered in the powder, and the report submitted in time to be of use for the firing season.

This data, properly understood, will be found of equal value with the ballistic data already referred to; but, unfortunately, other conditions, especially those of loading, have been so grossly neglected that the closest examination of the records fails to show the exact relations between varying percentages of moisture, for instance, or the varying densities of the same grade of powder to the initial velocity, pressure or range.

That these properties do exercise a material influence upon one or all of the above elements does not admit of doubt for an instant.

A few years ago an officer complained to me that the powder furnished for practice was absolutely worthless, and supported his statements as follows: With precisely the same charge, and an elevation of 2° 29′, a range of 1510 yards was obtained; 2° 28′ 30″ sent the projectile 1605 yards, or 95 yards further than an increased elevation of 30″; while all calculation (or *guessing*) was "knocked out" when carefully adjusting the sight to 2° 28′ 45″, the projectile dropped just 115 yards short of the first range plotted. Admitting slight errors in observing the splash, there was no doubt in the minds of those at the piece that the record in the main was correct. The powder used on that occasion contained from 2.07% to 2.32% of moisture, and acting upon a suggestion, the battery commander whose battery fired the day following had the 1st sergeant unload every cartridge, empty the powder on a tent fly and expose it to the warm sun, raking it over and over for an hour before firing began. The charges were re-weighed and the cartridge bags refilled. The result was that after the first two shots, the firing was regular, and no such abnormal results as those mentioned were obtained. All powder contains a certain percentage of moisture, and experience has indicated that whenever the percentage exceeds 1.25, the above precaution is necessary in order to secure uniform results. As already stated the exact relations that the laboratory data bear to the various other data to be considered in scientific gunnery is at present unknown, and until the other conditions, especially those of loading, are carefully noted and recorded, no theory much less practical application can be suggested, beyond that alluded to.

While recognizing the many difficulties attending the application of the principles of gunnery to such ordnance as our forts are now equipped with, yet by painstaking and intelligent effort on the part of those in charge, and especially by substituting for a portion at least of the present *target firing*, a modicum of *ballistic firing*, we may hail the dawn of a new era for the artillery.

1st Lieutenant *George A. Zinn*, Corps of Engineers.—*Tactical Firing*. Instruction or training in order to be practical must have a definite end in view, and this end must be kept clearly before the mind to accomplish it with the least expenditure of time and trouble.

It is therefore necessary before a system of training can be devised for the coast artilleryman to set down clearly and definitely what that training is expected to make him capable of doing.

I conceive the object of this training to be to fit him to use the materials furnished him for coast defense to the best advantage in time of battle; to so use his weapons, supposing them to be of the proper kind and number, separately and in combination, as to be successful. No matter how perfect the arrangements of these elements may be, or how perfectly the artilleryman understands the theory of using them, he must actually use them in time of peace, or he cannot effectually do so when they are required in real earnest.

Setting up exercises, marching around the parade ground, the manual of the piece, mechanical maneuvers, firing the piece for ballistic constants or for practice at fixed objects whose positions are known and can be seen, all are preliminary to that grand end of artillery training, the use of all the elements of defense in combination against fixed and movable objects whose positions are unknown until the time of firing.

In order to deduce some definite principles upon which a system of drill may be based, we must first get a clear idea of the means and methods of attack upon coast defenses, of what constitutes a perfect system of defenses, and of the principles of Grand Tactics applicable to their use.

In coast defense, the battle field is known in advance, the positions which the enemy may take up and the movements he may make can be foreseen, and the elements of defense be so located as to give it every advantage and to make it stronger at every point than the attack.

The grand tactics of the battle field will be somewhat different from that of a battle between armies in the field, yet many rules derived from land operations are applicable.

The nature and shape of the harbors or points to be defended are so various that the defense of each is a local problem and must be studied by itself; yet the subject of coast defense may be looked at in a general way; and while the phases of a naval attack may change from moment to moment, yet certain general principles must be followed.

Knowing then the weapons and tactics of the attack, and the weapons and tactics of the defense, we may readily formulate a system for training the sea coast artilleryman in tactical firing.

The subject now under discussion does not deal with the defense of the land side of coast works, because the principles involved are those of land defense.

The means of attack by sea are at present; (1) Armored battle ships carrying armor of 17″ to 21″ and guns of 10″ to 17″ caliber, also lighter quick fire and machine guns; (2) Battle ships and armored cruisers—lighter vessels than the first class, with armor of 8″ to 12″ thickness and carrying 8″ to 10″ guns, with a number of smaller Q. F. and machine guns; (3) Belted and armored cruisers—vessels with 6″ to 10″ armor, 6″ to 10″ guns, Q. F. and machine guns; (4) gun boats with 6″ to 8″ guns and a number of lighter rapid fire guns; (5) Protected and unarmored cruisers without armor, carrying 6″ to 8″ guns, with rapid fire and machine guns; (6) Torpedo boats. Nearly all ships are supplied with search lights.

A powerful fleet will be made up of a combination of these different kinds, but an attack upon seacoast works may be made by a single ship of any kind or by any number of ships depending of course upon the object of the attack and the strength of the works. It is not probable however that strong works would be attacked by any but the most powerful vessels and in the greatest possible numbers. The object of this paper does not require a discussion of the relative value of guns afloat and ashore, nor for the introduction of historical examples of attacks upon coast works.

The armor and armament brought to the attack of any sea port are of course fixed by the depth of water as well as by the nature and shape of the harbor or channel. The mode of attack is also limited in the same way.

The fleet would endeavor to advance in well developed lines in order to come into action simultaneously and to present the most unfavorable target to the batteries. A narrow channel may require the ships to engage successively or even singly.

The formation for attack by armored vessels will be in single line or column, under weigh or at anchor. Experience has shown that ships must anchor or move up to a buoy to insure accuracy of fire. The practical range of fire will vary from 500 to say 4000 yards. The guns used will depend upon the object of the attack, whether the destruction of a city or naval stores, the destruction of the shore batteries, or a passage by force. In the latter case, any obstructions in the channel must first be removed.

Attacks by night however will necessarily be rare. A difficult channel without lights cannot be navigated without running greater risks than the enormous cost of modern men of war would justify, and it is not to be supposed that an elaborate system of channel obstructions would be left so unguarded as to allow the enemy quietly to remove them either by day or night.

General Abbot sums up this point in the following conclusions: (1) We should be prepared to meet the largest calibers which the draught of water in the channel will admit; (2) That from five to ten ships, carrying from 30 to 60 guns of six-inch caliber and upwards should be estimated for each mile of the line of battle—the character of the approaches determining the exact number; (3) That the attack will be made at anchor or at least from fixed buoys, in order to increase the precision of fire and (4) That it will be made at as close quarters as possible.

The probable strength and form of attack having been laid down it is possible to fix the number and caliber of guns required, their distribution and mode of mounting, and what accessory means of defense are required.

In general terms, the superiority of the defense is established when we give it a well developed front and compel the enemy to take up a contracted front.

The works must have a preponderating value over the means of attack, and the burden of resistance must not fall upon a single work. Concert of action between the works may be assured by taking advantage of the natural conditions of the harbor.

The great principle, therefore, is the concentration of fire of the greatest possible number of guns upon all points where the enemy may present himself, and the batteries must be disposed to secure this mutual support.

A wide dispersion of the batteries will avoid smoke, favor cross-fire, and prevent a concentration of the enemy's fire upon contracted sites.

The practical dispersion is limited in many cases by the requirements of security, and tactical handling. Where guns are directed by a position finding system from a single observing station their fire is easily controlled and they may be more widely dispersed.

A high site possesses many advantages—better fire on ship's decks, guns are more easily protected, and enemy must keep at a distance to bring his guns to bear—but for flanking the submarine mines and for the advantages of ricochet in the use of our old smooth-bores, a low site may be selected.

The elements required for a first-class defense are therefore: (1) Obstructions in the channels of approach, either automatic or controlled from a secure place; (2) Guns of a sufficient power to penetrate the armor of the attacking ships, and not less in number than half of what can be deployed against them; (3) Smaller high-power guns, quick-fire and machine guns, to destroy the personnel and upper works, to repel boat attacks, to destroy torpedo boats and to flank the obstructions. The old smooth-bores will answer very well for this latter purpose; (4) Mortars for attacking the decks of vessels; (5) Provision for offensive returns against counterminers (automobile torpedoes); (6) Land fortifications (sand, concrete, iron) to protect guns and personnel; (7) Means of illuminating the surroundings at night; (8) Torpedo boats to attack enemy at favorable opportunities. [illegible] Guard boats to watch the channels by night and to warn the commander of the approach of the enemy.

Attacks by sea will in general have for their object the destruction of cities or depots of military stores, and the occupation of important roadsteads. They will be carried out either by bombardment of the defenses, by attempting to pass them, or by a combination of both. When there are known to be "live" mines in the channels the latter method is the most probable, because the fire of the flanking defenses must be subdued before the mines can be removed. Hence it is seen that all the elements of defense will be in play at the same time.

The most intense fire will be directed, at every phase of the engagement, at that part of the attacking force whose action inflicts the greatest damage upon the defense.

As it is probable that the bombardment will be made at anchor, a fire of heavy guns will be opened at long ranges to prevent the ships from quietly taking up their positions. As the ships approach nearer, armor piercing projectiles will be used against the decks; then common shell against their unarmored portions. As they get still nearer, armor piercing projectiles against the side armor, and finally the smaller guns will open on the upper works, and at close range, the most rapid fire consistent with accuracy.

It is recognized that forts and batteries must work together. Their fire cannot be individual, but must unite upon a common object. An overwhelming fire upon a single ship may throw the enemy into such confusion as to put him completely at the mercy of the defense. At the same time, it will not do to neglect the other ships, and perhaps allow some of them to approach so closely as to obtain command of the batteries. Even this fire cannot be left to the choice of group commanders. It must at all times be under the control of the commander of the defenses.

Tables can readily be made out giving the names of all ships that may be brought to the attack, with their armor, armament, size of target they present (side, end and deck), speed, descriptions of their appearance, their vulnerable points, the kind of gun and projectile to be used against them, at what ranges the armor is penetrated by the various guns of the defense and the best methods of conducting an action against them. The tables given in the Report of the Board of Fortifications for 1886 give some of this information. Lieutenant Weaver's article in the *Artillery Journal* for October, 1891, supplies more of the desired information.

In no other fighting force is a more perfect organization required than in the personnel of sea coast defense. The interests to be protected are so vast, the consequences of defeat so disastrous, the weapons of defense so costly, that success must be insured and it can only be obtained by perfect organization, discipline and training. It may be said that the same thing is required in a higher degree in the attacking squadron. It is not so in fact. The attacking squadron may withdraw when defeat is imminent and return when better prepared. The coast forts however are immovable and a defeat means a total loss of the object which they were constructed to defend.

This perfection of organization and training is only attained when the forts can be manned and a rapid and effective fire opened at the best objectives in the shortest possible time and such a fire kept up until the desired object has been accomplished.

Each man must know his station and duty. The responsibility and sphere of action of each must be fixed. Each gun detachment must know its place of rendezvous and its station in the forts. Symbols of some kind must be used for each group of guns and everything belonging to it must be marked.

The defenses of a harbor must all be under one head. Subordinate to the chief commander is the section commander, who controls the fire of the forts in his section, then the fort commander controlling the groups in his fort; and lastly, the group officer who commands two or more guns and is reponsible for their proper action. Circumstances may alter this chain of responsibility, or may render necessary additional links; but the simplest form is the best. A single gun detachment is the smallest unit of organization for discipline and administration, but as the fire of a group will in general be directed at the same object it will form the smallest tactical unit.

Other tactical units are those operating the electric lights, the movable torpedoes, the submarine mines, torpedo boats, &c. The commander of each is responsible to the commander of the defenses and should be in electrical communication with him.

Special attention must be directed to the supply of ammunition. A sufficient number of men being detailed for the purpose, ~~and~~ who will be thoroughly instructed.

These are the primary elements of the organization, but in late years the phases of a naval attack change so rapidly, and the cost of firing the heavy guns of coast batteries is so enormous, that every care must be taken to make each shot tell, and to convey quickly to the group commanders the changing objectives.

A good system of range and position finding and of communicating rapidly and accurately between the different commanders of the defense is therefore a great desideratum. A perfect system would be a single instrument recording ranges and azimuths and transmitting them automatically to the proper groups.

The only way so far provided for the United States coast forts is to communicate orders in writing, or verbally, by men on foot or horseback, or by flag signals, and to find the range for each group by the "long and short bracket". Some of the Posts have base-lines with plane tables at the ends, and telegraph communication between these ends, but not to any other point.

How would the battle be carried out on the side of the defense?

The commander takes his post of observation secure from the enemy's fire, where he can see every part of the harbor, and where his view will not be obscured by smoke. He has a properly prepared chart with the table giving data in regard to the enemy's fleet.

The most important orders he may have to communicate are those in regard to the objective, the kind of ammunition to be used, the rate of fire, and to commence and cease firing.

There is considerable difficulty in pointing out the objective to the group or section commanders. The field of view is covered by a number of stationary and moving objects and their relative position differs at the different groups. Without position finders mistakes are very liable to occur and thus cause a waste of time and ammunition.

The only way at present to secure an accurate fire upon the selected objects, is for the commander to send a description by signal or in writing of the appearance of the vessel and its approximate direction to the group officers with the name of the vessel if possible and direct them to ascertain by trial the exact range. Officers should be trained to judge the result of their fire by the eye, but assistance of course will be rendered them by observations from the commander's station.

We readily see the necessity for some reliable means of establishing the relative positions of batteries and ships and some simple, rapid and reliable method of indicating it to the group officers. Various instrumental systems have been proposed, but none of them are yet considered sufficiently simple or reliable to answer the rough and ready usage of the battle.

The system of squares seems so far to have given the best results. An accurate chart of the harbor and batteries is divided into squares of say one hundred yards side, and on it are also marked by arcs the squares upon which the different groups can bear. Each group is supplied with a table giving the range and azimuth to the center of each square upon which it bears.

The commander having ascertained upon what square the object lies sends the number of the square to the proper group officers, and, when necessary, to the sub-commanders of the submarine mines, torpedo boats, &c. The guns are then pointed on the object by means of the range and azimuth given in the tables and the action kept up even if the object is obscured by smoke. The traverse circles of the guns and mortars are marked with azimuths.

Captain Stone, R. A., in an article on "Fire Control in Fortresses", Volume XVII, Proceeding‸R. A. Institution, explains a method for indicating the objective with position finders. The chart of the harbor and batteries is marked with the arcs of fire of each gun, and these arcs are marked in degrees of azimuth. A pointer is laid down on the chart in the direction of the object whose position has been determined by position finder. The position of the object is then marked on the chart. A line drawn from this point to the position of each group officer's position finder or to any gun of his group will show by its length the proper range and by the numbers on the arcs of fire where the line intersects them, the proper azimuth. The range and azimuth are then sent to the group officer who at once picks up the object with his position finder and marks it on his own chart. If the object be moving its rate can be ascertained by plotting its position at the beginning and end of an interval of time; its position at a later time is readily predicted. The guns to fire upon it can be loaded and aimed ready to be fired at the proper instant by electricity; allowance being made for drift, wind, time of flight, &c., &c.

The essentials of a good system for carrying on a battle are: (1) One or more good and secure points of observation for the commander; (2) A reliable system of range and position finding; (3) Rapid and accurate means of communicating orders between the commander and the groups; (4) A system of pointing guns and mortars by direct and indirect methods and of making rapid alterations in their azimuths and elevations; (5) a good chart of the harbors and batteries; (6) Tables giving data for handling the guns and correcting their fire.

We are now able to formulate a system of training for sea coast artillerymen.

It is assumed that officers and men have been instructed in assembling rapidly, in marching to the guns, in the manual of the piece, and in firing it at fixed targets whose positions are known and which can be seen.

The training still required is therefore:—

(1) For the proper officers, non-commissioned officers and men in the use of the methods of position finding and locating objectives, and in the means of communicating orders—whether by the eye alone (judging distances and tracking) by base line and transits, by the depression range finder, or position finder, and by flag signals, telegraph, telephone or dial. This instruction is necessary and should not be omitted even if the appliances are of the worst kind. The noise and confusion incident to the handling and firing of the guns render the accurate and rapid conveyance of messages very difficult. It is better to know how to use the means at hand than to be absolutely ignorant.

(2) For the proper officers and men in the service of ammunition, the location of the magazines, the kinds of ammunition contained in them, how it is transported to the guns, what groups of guns are supplied from the various magazines, and how the magazines are replenished.

(3) For the group officers. To familiarize them with their guns and magazines, with the methods of position finding and communicating orders, with the tables supplied for their guns, with the chart of the harbor, and the batteries which they support, in picking up quickly the objective indicated and in giving the proper orders to the gun detachments.

(4) For the gun detachments. To teach them to load and aim quickly, to follow a moving objective and to change rapidly from one objective to another.

(5) For the commander of the defenses. To make him thoroughly familiar with the chart of the harbor, the location and armament of the batteries and other means of defense, with the batteries which mutually support each other, with the possible modes and means of attack upon his harbor, with the best methods of destroying the attacking vessels, with his means of communica-

tion and position finding—their capabilities and limitations. In other words, to familiarize him with his defenses and the methods of handling them.

(6) For the section commanders and others of field rank. The same as for the commander.

Time is such an essential in firing at moving objects that all drills must be drawn with the object of insuring that the various operations shall be performed as safely and quickly as possible.

To carry out this training will require some expenditure of time and money. The end to be attained more than justifies it. Very little more ammunition will be required than is now allowed, especially if the course laid down is extended over several years.

The conditions of a battle must be simulated as nearly as possible, this will require a number of fixed and moving targets.

Each artillery post is supplied with the charts of the harbor, and a base line can easily be laid out. Flags in lieu of something better may be used for communication. The tables of azimuths and ranges are easily prepared. Yet with these and a small supply of ammunition, tactical firing can readily be carried out. Our old smooth-bores may be obsolete, but they will teach all the lessons of tactical firing. The main thing is to understand thoroughly the use of the means now at hand, even if they are nothing but smooth-bores, stone casemates and the signal flag.

The crowded condition of some of our harbors might make some of the practice difficult, but an accident or two or a simple scare would at least impress upon all concerned the difficulties and importance of their duties in time of war.

To show how the training may be carried out, let us suppose there are no targets available.

The commander takes his place at the observation station.

The alarm is then sounded, the entire command will be assembled quickly and marched to their stations in the various groups. The implements will be taken and the guns gotten ready for firing.

The commander selects one or more imaginary objectives, determines their location on his chart, and sends the order to the proper section or group officers to "Prepare to fire on Square No. . . ." The group officers consult their tables, give the proper orders and the gun detachments go through the motions of loading and aiming and report to the commander when ready to fire. A record is kept of the time required to do all this as it is the test of efficiency in the drill.

The next step will be to fire the guns at the imaginary objectives. When the guns are laid as before by the orders from the commander, he fires them in succession by word of command transmitted by flag or electricity. The observers plot the shots to check the work of the group officers, the corrections are reported to them, and another round may be fired, or another objective taken, or the different groups may fire at the same time upon different objectives.

The next step will be to see how quickly the firing can be accomplished from the moment when the assembly is sounded to the time the guns are fired. Several rounds may then be fired in quick succession, and the objective changed during the firing. Wild shooting can readily be detected. Due allowances must be made for the time occupied in getting from the point of assembly to the different stations.

The next step will be to fire at moving objects. As there are no targets available, part only of this can be carried out. The firing may be done at imaginary moving objects by predicted positions with ammunition, or at passing vessels with friction primers only. Several passing vessels may be tracked, orders sent to the group officers who aim their groups by direct laying, since the object can be seen, and place friction primers in the vents. When the vessels arrive at the predicted positions, the primers are fired by lanyard or electricity. Calculations made from the actual observed positions of the vessels and the time of firing show the accuracy of the work done. Or if an imaginary moving object is taken, and its rate of motion assumed, projectiles may be fired and a comparison made between the position of the plotted shot and the predicted position of the vessel. This method may also be used in firing the submarine mines.

If electric wires have not been laid to the guns, the watches of the group officers may be set with that of the commanding officer. If there are not enough men at any post to man all the guns, a single detachment may be placed in each group.

This is not target practice but it *is* tactical firing, and will teach officers and men their respective duties.

If targets are available the instruction becomes much more valuable. Deliberate fire at targets in fixed and known positions will first be carried out as target firing. To obtain tactical training, the targets (and there should be three or four) must be placed at various unknown parts of the harbor. Now the targets must first be located, the proper commands transmitted, the group officers must pick up their own targets by the aid of the azimuth tables, the guns are laid by direct sighting and the firing will proceed as before. The rapidity with which it is done being the test of efficiency.

If a moving target can be had, so much the better, and especially if it is constructed to record the hits. A number of guns may be fired singly or in groups or the entire armament may be used.

The artillery is in much the same condition as the infantry was some years ago before the introduction of skirmish firing. Firing at fixed objects is all very well, but let us introduce into artillery practice a little skirmish firing, then we shall have arrived at *Tactical Coast Artillery Practice.*

The details of this practice would develop in time, but it can certainly be carried out at any of our posts. To insure uniformity of practice, an Inspector of Artillery is required.

This method of squares has limitations. It is a simple method of indicating to the group officers what they are to fire at. If the object can be seen and is stationary, of course the gun is aimed by direct laying. If for the moment the object is obscured, it furnishes a method of getting close to it, sufficiently close that the chances of hitting are probably 50 per cent., and it has the advantage of being the only method that is practicable with our present means.

The range and accuracy of our modern guns calls for an accurate system of position finding. With a moderate amount of training and the exercise of a little judgment, however, the possibilities of our present weapons will be much increased. If a reliable and accurate position finding instrument should be invented and arranged to transmit the range and azimuth automatically of a moving object, the chances of hitting an obscured object would be much greater and the system of squares would not be needed. There is no system that will ever replace direct laying when the objective can be seen. The important point under such circumstances is to be sure that the group officers fire at the proper object, and the system of squares does furnish a ready means of communicating this and of thus controlling the fire of the entire defense, as well as of giving a very close approximation to the exact range, and it has the merit of simplicity in the orders required to transmit the location of the objectives.

In order to explain more clearly the proposed system of drill, a chart of the harbor of Hampton Roads has been prepared. The information on the chart is not correct, but it is sufficiently so to illustrate the principles.

This chart is prepared for the use of the commander of the defenses and will show him what groups have guns bearing upon any selected square.

If there were but 20 or 30 guns the chart could be made to show the arcs of fire of each gun without confusion. A table could be made out, if necessary, showing for each square the emplacement number and kind of gun bearing upon it. Such a table has been prepared, I believe, for Fort Monroe. Where the guns are so numerous, as at that place, a chart could be made out for each group commander showing him the arcs of fire of each gun in his group.

The base line is O A, O H. Its length and azimuth are known. Along the edges of the drawing are laid off azimuths from the ends of the base, the outer ones for station O A, the inner ones for O H. The scale of the drawing is so small that this graduation is merely indicated. On a chart of the proper size it could be carried to quarter or half degrees. By means of these graduations and strings stretched from the stations, the location of any object can be quickly marked upon the chart. The azimuths of the object are obtained by transit or plane table. A telegraph line connects the two observing stations, and can be connected with the groups or sections.

The guns are grouped as shown upon the chart—eleven groups—groups A, B and C may be under a field officer as section commander, also D E F and G, H I and J, &c., &c.

During the summer there are enough batteries at the post to man nearly all the guns, at least enough to give a complete tactical drill.

The Post Commander commands the defenses, the field officers the sections, the captains command groups and the subalterns one or more gun detac ments.

The arcs of fire of the groups are marked on the chart, from which t commanders can see upon what parts of the harbor the various groups bea The mortar batteries have an all round fire. Groups D and E flank the lin of submarine mines. The operating room is at X, the search light at Y, an the torpedo boats at the wharf.

The table of ranges and azimuths for each group would show in the fir column, the number of the square, in the second, the emplacement numbe of the guns which bear upon the square, in the third, the range to the cent of the square and in the fourth, the azimuth. To make a table for group A giving the information for each gun would require nearly 500 pages, but table for the 15″ gun of 40 pages would not be unwieldy and its value amply justifies the trouble of computing it. An allowance for deviation due to the dispersion of the guns would be required. If this is not over 150 feet it would be very small. A mechanical device might be invented to overcome this difficulty.

The manner of constructing such a table is shown on the chart for group E, —the limiting arcs of fire are drawn, and the tabulation of distances and azimuths for each square is easily made.

With this chart, and tables, and Whistler's tables for the different guns, the tactical drill is carried out. The traverse circles of all the guns must be marked with azimuths.

The extreme range of the 8″ rifles is about 7000 yards, and of the 10″ smooth-bores 4000 yards. These guns will therefore come into action somewhat within these distances and the heaviest fire is confined to a length along the channel of about 2500 yards eastward of a line drawn from group A to the Ripraps. The channel of approach is narrow and will require the attacking fleet to advance in column. It is not likely that a distant bombardment will be undertaken, but a passage by force may be attempted to reach the Navy Yard at Norfolk. The means and methods of attack are thus determined and the tactics of the defense laid down. The training of the garrison could proceed on those lines.

The first drill will be with the imaginary targets to familiarize each officer and man in the garrison with his station, with the means of communicating orders and indicating objectives, with the chart and tables, with the methods of laying the guns, and of following a moving object to be fired upon by direct laying or by prediction.

The commander of the defenses takes his position at O A. He will have a good view of the harbor and will control the groups by telegraph. The detachments forming the groups have a separate rendezvous, either at the barracks, camp or elsewhere. Group A—nine gun detachments—at the north end of the barracks, group B on its right and so on. The groups are then marched to their places quickly. The commander selects a square, say 22-5, finds that groups B, C, D, F, H, G, I, J and K fire upon it, and telegraphs to the

group commanders to "Prepare to fire on . . .". The group commanders consult their tables, and go through the motions of loading and aiming as before explained.

The next drill will be with the fixed targets. The tug towing them (three or more) would move out from the wharf before the drill call was sounded. It drops the anchor of the first target at a range of say 1500 yards, the second at 2000 to 2500, the next at 3500 and so on. A signal is then hoisted, whereupon the alarm is sounded in the Post, the groups are formed and marched quickly to the guns, the targets located, the proper orders given to the group commanders whose guns fire upon the different targets, the firing commenced, and the shots carefully plotted. A record is kept of the time required by each group to march from the barracks and to fire one round: allowance is made for the distances to be marched from the barracks to each group.

The implements and ammunition should not be laid out beforehand, but should be taken from the store-houses and magazines by the detachments themselves after they have assembled. This is necessary in order to make them thoroughly familiar with the locations of the magazines and passageways.

At a following drill a number of rounds may be fired in succession, the objectives being changed during the firing in order to see whether any confusion is apparent in the groups and that the garrison is well in hand.

It would not be difficult to construct a moving target to be towed with a line of 300 yards length, with which excellent drill could be had.

The drills can be varied in such a way as to give the group officers a thorough knowledge of the limits of fire of their guns—so much so that when the chain of communication becomes actually broken they may still carry on the action with perfect knowledge of what their guns can do and how it should be done.

If officers and men have been thoroughly drilled in aiming at the imaginary targets, or in tracking vessels, the allowance of ammunition in the actual firing need not be very large. If groups A, B, C, D, E, F, G and H are used there will be in all say sixteen 8'' rifles, six 15'' and ten 10'' smooth-bores and four 13'' mortars. For the imaginary targets say three rounds, for the stationary targets six, for the moving targets ten—or nineteen in all—or for the season's training of eight batteries, 304 8'', 114 15'', 190 10'', and 76 13''—684 in all—not much over the present allowance.

The perfection of tactical training would be with self-moving targets and an automatic position finding and transmitting system.

No attempt has been made to elaborate the details of the drill. The various difficulties can be solved as they come up, and it is not doubted that there are plenty of officers who can do it and do it well when they have seen by practical trial what the requirements of the system are. The greatest difficulty however lies in position finding and communication, and perhaps a little encouragement would call forth a number of practical systems worked out to the smallest detail.

The main thing is to make a beginning, and it is believed that the above system of drill is practicable.

1st Lieutenant *John W. Ruckman*, 1st Artillery.—If the foregoing agitation of the question of our artillery fire instruction needs any defense, it is believed that the recent fiasco in Rio Janeiro Harbor alone would be a sufficient justification for the effort. In view of this horrible example of wasted ammunition the attempt to collect suggestions and data for future use, and to stimulate general interest in the question, seems timely. Can any excuse justify the miserable yet laughable results of those *artillerists* who have been firing for months without effect, and can any feeling of revulsion be too strong for this sham firing, which has elicited the ridicule of the whole world? When one hundred projectiles were fired at the *Aquidaban* while passing the shore batteries, inflicting no injury upon her, what must have been the crew's feelings when they sailed by in defiance? Could any contempt for such gun practice have done the subject justice? The affair was not only not exciting, it was not even interesting. Can the moral effect upon a ship-crew under such circumstances be imagined?

Had the shore batteries used ninety of the one hundred projectiles in intelligent practice and the remainder in the crisis, with accuracy from the start, the result would have been different; had they fired ninety-nine for instruction and retained but one to be delivered with the requisite skill to produce injury and death the morale of their personnel would at least have been saved, and the enemy would have been awed by such precision. As it was, the ship's crew were able to pass unharmed through the fire, and nothing afterward could ever inspire them with fear for the shore guns, and no amount of drill and discipline would ever restore to the latter their lost prestige and confidence in their weapons. Thus, it is believed, will be found in the affair more lessons than one.

The ship is reported to have returned the fire, inflicting considerable damage. If ship guns could, with all their real disadvantages, inflict damage, what might the land guns have done had they been handled with efficiency?

It is now an accepted principle that a gun ashore is more than a match for the same gun afloat, and yet we do not know of a case where shore guns have ever proved themselves to be of any particular value. This statement is borne out by another well recognized principle that ships unobstructed by passive or other obstacles than gun fire can sail past shore batteries at pleasure. Are both these principles true, or are shore guns wholly worthless as a means of defense? While the alternative here may place us in an awkward position, the present light upon the subject seems to leave room for no other conclusion; and close study, it is believed, will reveal certain time honored considerations and conditions of drill and teaching which render any other result impossible.

In the following remarks we shall endeavor to point out some of the causes for this low efficiency and the policy which will improve it.

1. *Character of Defense.*—The character of a land defense is purely passive so far as position and many other important matters are concerned, and instead of counteracting as far as possible in our teachings the natural effect of passiveness in a combat, all artillery training for a century at least, has been to exaggerate and strengthen it. Teach men that when attacked by a ship or ships, their guns must immediately be silenced; that they cannot hold out against the mass of projectiles which will be hurled at them from small caliber guns; that ships can and will come up to short ranges: and that as the projectiles begin to fly they must retire into elaborate cover, and there is no doubt but they will believe and do all these things. They have been taught such doctrines so long and so thoroughly that it need not occasion surprise when a seacoast defense results in failure. So long has coast artillery been taught erroneous ideas instead of principles of gunnery, tactics and concerted action, superiority of weapons and confidence in its own ability to win a victory, that there is no longer any spirit left. All this has been educated out of the artillery arm, and when these qualities die in soldiers all usefulness dies with them. It would seem about time that coast artillery instruction should be reconstructed according to new principles, with view to elicit from the coast artilleryman's weapons their natural superiority and a reasonable amount of success.

2. *Small Arms.*—The second consideration in the inefficiency of artillery defense in the past and present is the great prominence given to the small arm, in the artilleryman's education. The sentiment in our service of not only retaining but of using it both in and out of season still remains strong. Hopeful views are occasionally expressed that it is being pushed aside and relegated to its proper place in the artillery arm; it is hoped these sanguine views may be correct, but the writer's experience in this line is not by any means confirmatory of such a conclusion. The small arm in itself does not and cannot hurt the artillery soldier; it is the prominence that is given to it on all occasions,—the leading part it has played and still plays in the life of officer and private, that overwhelms and obliterates the artillery part of their nature.

There can be no doubt that aiming drill with the musket, or any other kind of aiming drill, will teach the artillery soldier the principles of sighting: but we deny the assumption that any other kind of drill will do him so much good, as an *artilleryman*, as the same amount of exercise at the service gun with the service sight and under service conditions. We deny that the small arm is even an auxiliary in training him as a gunner. When we give as much of his time and our attention to teaching him the sighting principles of *his gun* as we have heretofore given to the small arm, it will be found that he will know a great deal more about them than he does now or could obtain by any other means possible. So far these remarks have assumed that we shall need this accomplishment developed to the highest degree in the artillery soldier,

—an assumption that may well be doubted; for with mortar fire, indirect fire, telescopic sights and numerous other refined sighting devices, aiming with the naked eye by direct sight is likely to be a thing of the past. In any case it will form a small part of the artilleryman's duties. The old idea of marching to the guns in heavy marching order, of stacking muskets for service of the pieces for a short time; but, finally, at the favorable moment to resume the musket for the decisive blow, still lives in the artillery service and still predominates amongst us.* The existence of such sentiments is greatly to be regretted and it is believed that no artillery combat can succed under such influences, and that we will be pardoned for expressing the opinion that artillery methods have changed decidedly since such practices were in vogue and that in future an artillery defense following such a course will submit without the necessity for an assault. Either this view is correct or all our work, science and development for the last twenty years have been educed in vain. The future successful artillery soldier will not depend upon the musket for victory.

In addition to other arguments, it is urged that a coast artillery command should be supplied with the small arm in order to move as a land army to prevent landings at a distance from the works. Is this a safe principle to inculcate? Will it be wise to arm and train men for the express purpose of abandoning their guns in the crisis? If modern guns be accurately served no landing will ever take place within their field and range; to remove the cannoneers to distances beyond this for such purpose would be criminal. In such case, what would become of the guns abandoned and what restraint upon the hostile vessels would remain? It is true that navies instruct their crews in landing operations, but they are not likely to be executed against modern fortified places; if attempted they will almost certainly be defeated. Landings, as in the past, will continue to be valuable against unprepared, disorganized and barbarous people; but that they will, as a rule, be attempted against well equipped defenses, is doubtful. It matters little whether they be tried or not, the cannoneers must not be withdrawn from their guns, when threatened, under any circumstances. Landing expeditions when beyond the range of artillery must be specially provided for and when on a large scale must be met by a land army. To depreciate or ignore the artilleryman's legitimate functions and teach him the efficacy of everything else is certainly not the way to inspire him with confidence in himself and his weapons in the hour of battle, a time when he will need not only physical but mental and moral strength to sustain him.

The difficulty is not in the musket, but in the time honored sentiment and kind of idolatry which has clustered and still clusters about it. A conclusive proof of this will be found at all posts in the never-ending discussions in reference to insignificant quibbles of infantry tactics. In nearly eleven years' service the writer does not recall one instance where a discussion took place

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* These ideas were expressed recently to the writer by an officer of artillery, who gave them as his idea of defending a coast fortress.

in reference to a tactical artillery question. This is given not to show facts of any importance except the bent of the whole service due to many decades of preparatory teaching. Remove the small arm and with it will pass away the excuse for quibbling, to which it now gives rise, and require the time thus liberated to be spent in developing the details of coast artillery problems.

When once the infantry screen is removed artillery questions will appear in their natural size and importance, illumined by the admitted light. There will then be no longer occasion for wasting time in other directions since our own duties will come upon the scene such as will be worthy of the talents of anyone and in the discussion of which all may participate. Such a move, it is believed, would be a death blow to "infantryism" in our arm, and all thought would be directed into proper channels. When the artillery personnel becomes so interested in its own work that nothing but guns, powder, implements, sights, range tables, targets, competitions, etc., are thought of, the small arm could be reintroduced if found desirable in the meantime. Its misuse could then be risked. When the artillery becomes as infatuated with its own work and duties as it was about ten years ago with small arms practice, when no artillery work was thought of, then will the musket occupy its proper place and will not be likely to encroach upon our more essential functions.

Now to return to the results of the artillery fire at Rio Janeiro, it is no exaggeration to say that a very short time ago our own guns could not have been served more efficiently. It is within easy remembrance of most of us when the reports would come in *seven hundred yards over* for one shot and *five hundred yards short* for the next. Fortunately the last four or five years' earnest endeavor for improvement has removed from our records such deviations as are above given, and a growing appreciation of the necessity for accuracy above all things in heavy gun practice is reducing the dispersion of shots from year to year. This fact is conclusively shown by Lieutenant Millar in his contribution to this discussion. But as is clearly outlined in more than one place in this collection other problems exist and with the introduction of new ordnance many new ones will arise.

Though without a modern armament, for which it has become fashionable to clamor, there are many principles to be learned, which, as has been amply demonstrated in the *Journal*, can be determined with our present equipment. It will not do to postpone all investigation until all conditions and apparatus become perfect, or we shall find ourselves with a large number of apparatus on hand about which we know nothing: these in their turn may become obsolete while we are becoming familiar with them. To continue with all haste in the work now being carried on with present facilities seems to be the only way to prepare for the new equipment, and to attain the proper degree of efficiency for immediate service.

That the only way to create an efficient artillery service is to study all theoretical considerations and apply them in practical instruction needs no demonstration. The theoretical instruction of our officers must be characterized as "excellent". Their instruction in the science of ballistics cannot be excelled if equalled anywhere in the world. What they need in addition is a similar course of practical work in which should be treated practically all the problems which must be solved before we can hope to enter intelligently upon the functions of the new armament and thorough defense. Theoretical study alone makes the student top-heavy and likely to become dependent upon it, and inclines him to the idea that all questions can be solved by means of pencil and paper. Pure ballistics like pure mathematics furnishes the key by which the way may be opened to concrete results. In mechanics the mathematical principles are applied bringing the most fruitful practical results. So with our knowledge of ballistics we must go into the field of our out-door work in order to reap its benefits. Having now reached our present high standard of theoretical education it seems essential that we should install a practical course of equally high character. There can be no doubts as to the effect of such policy upon our future development.

Having in this manner solved all important problems from both standpoints, and collected the necessary data, there would remain for each command but to drill and shoot until all duties became matters of second nature.

To shoot heavy guns sufficiently to do this would require an enormous expenditure of ammunition. Can the supply be obtained, especially with the new ordnance? Under the new conditions shall we be able to secure an allowance for the purpose of giving the personnel yearly practice? The present annual allowance of ten shots per battery for the 8″ C. R., although liberal in itself and the greatest we have ever had, is not enough under our present methods to instruct thoroughly our gunners in the science of hitting. Are we likely to have this amount or half of it with the new breech-loaders? Will such practice *ever* begin? This may seem like a strange question, but let not judgment be passed until all sides of the subject have been considered There must not be any misconception of the fact that in future, target practice with breech-loading rifles will be expensive business and the question naturally arises how many projectiles per battery, if any, are to be expected?

The anxiety for new guns expresses the natural desire for the best available tools. In many cases the feeling prevails that there will be nothing to do but to commence firing ammunition into the water as we did with our present guns several years ago. It may as well be recorded here as elsewhere and now as at any other time that in practice with new material something more valuable than smoke and noise must be obtained from our allowance.

It will not be wise to rush into the expenditure of costly ammunition without a well considered and matured plan by which every shot fired will be made to yield the maximum return (1) by adding to information for future use and (2) in the practice, instruction and skill developed in the individual firing. This subject is dwelt upon because it is believed that it cannot be urged too strongly that we have new problems before us and that it is time to grapple with them in order to obtain for them an early solution.

To be a little more definite let us assume that the same annual allowance will be prescribed for the 8″ breech-loader as that at present for the 8″ muzzle-loader. How is a battery of artillery to be instructed? How can it be done? Can any reader answer this question? At the same post may be mounted 10″, 12″ and 16″ guns. What will be done with them? Are we to expect the same amount for each, and continue as at present trying to instruct all batteries in all the details of firing all guns serviceable at the post? These and many other questions will come up only too soon; in fact, although we may not know it, they are upon us now. How do we propose to answer them?

An annual allowance of ten or even five rounds per caliber per battery is out of the question, yet some practice with each caliber is necessary for efficient service. Are we ever likely to have any practice with the largest calibers, if not, will they possess any defensive value? The overwhelming details of efficient service of modern ordnance we believe can only be learned by actual service firing conditions. The cannoneers will need to be familiar with the gun's peculiarities, not excluding smoke and noise; but what will be of greatest importance will be the full confidence they will have in their gun when based upon previous experience of its accuracy and power. In other words to make our guns thoroughly efficacious the men who will use them in war must drill and fire with them in time of peace, until they feel absolutely certain they can use their weapon with facility and precision. All who are familiar with infantry practice know how true this is: what is true of human nature for infantry is also true for artillery. In our strenuous efforts to obtain fortifications, guns and other essentials and auxiliaries, the necessity for service of the guns and practice with the guns must not be forgotten. Any portion of an armament the use of which is too costly to permit being fired at least to give familiarity with its operations will be a poor dependence in the day of battle. Guns and forts in themselves are poor harmless masses, whatever their inherent power and strength, unless they become endowed with the knowledge, skill, and determination of well drilled and instructed men, who have learned by experience to bring out the capabilities of their defenses. Little need be expected of a detachment which for the first time fires its gun on the morning of the engagement.

In consideration of the facts as given in the review of the question here presented, it is believed that new methods of drill and practice with other attendant changes are imperative. The problems which exist and will grow out of the necessary changes will be found difficult and will require careful consideration. Guns are now ready for mounting; emplacements, in some cases, are completed. Therefore the time for action is at hand, if the advent of new ordnance is to find us prepared to receive it.

In relation to the difficult question of distributing the ammunition so as to obtain the maximum of instruction, the following propositions are advanced:

The impracticability of giving all our personnel practice with each caliber of gun will restrict the instruction to one type of gun. This condition, it is believed, will impose the necessity of assigning batteries to the particular type they will use in action. As a natural corollary of this assignment the battery would become responsible in all respects for guns, condition of its equipment and ammunition, and all particulars relating to its service. Such policy making officers and men directly and wholly responsible for their material, would induce a certain amount of pride in their work and enable battery commanders and officers to concentrate their attention upon the details of their own types and make the instruction as thorough as possible.

In the following distribution of ammunition, and other propositions, we shall endeavor to outline briefly how this may be done.

Assuming that a battery assigned to the 8″ B. L. R. will be entitled annually to ten rounds, the amount will be wholly inadequate for the task imposed. Here then we have a problem for solution.

With a given amount of money yearly for coast artillery target practice, how can it be expended to secure a maximum result? If there be several ways of expending the money, that one which will give the largest amount of real instruction is the one which we must seek and put into execution, otherwise we are not as officers doing our duty to our profession and country. From what has just been said present light upon the question of future fire instruction for the artillery indicates that the following distribution of ammunition and course of instruction will become necessary and should be put into operation.

I. Ballistic Firing.

It has been said in the *Journal* that officers are required to instruct their batteries in scientific gunnery, without ever having had an opportunity to learn its principles. It may be added further that scientific gunnery in this country is a new art, never before having been attempted or even contemplated. As it is a new idea naturally coming with the advent of accurate guns it would seem that the desired result would be most quickly and satisfactorily attained by giving all officers an opportunity of learning its details before endeavoring to instruct men. As none of us have ever had any chance to learn this essential branch of our profession, we are slow to appreciate the entire absence of the principles of gunnery in our service. A complete realization of this fact, and its removal, must be slow processes, requiring time and patience. Considering the backward condition of our practice a few years ago, it is now making excellent progress. Many causes conspiring to this end are foreign to this discussion: while rejoicing in the fact, and expressing appreciation, it becomes desirable to hasten the results, by carefully devising plans for the co-operation of all parts, and their arrangement in a complete and efficient system.

For this division of firing instruction, it is proposed to set aside each year from the total allowance of ammunition for the artillery, a sufficient amount to carry out a reasonable course of ballistic firing with any gun or guns whose types have not already been investigated.

After the first general determination of ballistic data for a given type of gun, a small yearly allowance for the determination of data found desirable, and for the solution of new problems, would answer all reqirements. u

This division of our work has been very expressively termed Ballistic Firing. Its nature has been already fully set forth in the *Journal.*

As an argument in favor of such a course of experimentation, we need only refer to the admirable work undertaken and executed in New York Harbor in the winter of 1889-90, and the more recent work in the same direction done at the Artillery School at Fort Monroe, Va., in the summer of 1892. The first was pioneer work, in which the obstacles were almost insuperable, due to the general indifference of the artillery to this kind of work, and many other adverse circumstances. It, however, was carried on notwithstanding these difficulties, and resulted in Whistler's *Graphic Table of Fire.* The second, though prosecuted under more favorable circumstances, was accomplished only by much labor in the construction and erection of the apparatus, and the removal of many unexpected embarrassments. The result of this work has already been published in the *Journal.* Notwithstanding the trouble involved, the effect of these experiments is emphatically recorded in the great improvement of our practice in the last two years. The fact that the regiment which had its practice at this post last year, and which had access to all the facts obtained by both series of experiments, showed highest regimental efficiency in the Department, bears directly on this question. Up to the time of the beginning of the first investigation everything was theory as to artillery practice in general, on the one side, or skepticism and indifference on the other. This work knocked considerable theory out of the practice, dealing skepticism and rule-of-thumb guess-work a blow at the same time. The second, coming later, and being presented so ably by Lieutenant Davis, gave a new impulse to the subject, and showed, beyond all doubt to many of the ~~im~~practical minds, that some of his conclusions might profitably be applied to target practice. If the increased number of hits in the service in the last two seasons be counted as shots saved, the above-mentioned "ballistic firings" have already more than repaid the ammunition expended. Now that the value of this preparatory work has been shown, it seems reasonable that it should be made a permanent department in our instruction. Taking, for example, the new 8-inch B. L. rifle, one hundred shots, if carefully used, in accordance with a well-developed scheme, would probably be all that would ever be required for ballistic firing with this gun. Each caliber, on coming into the service, would require a similar amount.

The subject of jump is now recognized as one of the most important causes of deviation. This it would seem must be mechanical in its nature, and should yield to a mechanical remedy. It is not at all improbable that if once thoroughly investigated in ballistic firing, and its cause discovered, it would be entirely obviated. While ballistic machines whenever available can always be used to advantage, the *regular* ballistic firing should be done at one place, preferably at Fort Monroe, until a firing ground for such purpose can be obtained.

II. An Allowance for Sub-caliber Practice.

Under new conditions a thorough course of sub-caliber practice will be necessary. In this course should be utilized all facts, rules, principles and information determined in the course just described. As a rule it is believed that sub-caliber practice as usually carried out for large guns falls far short of the object for which it is designed. The gunner acquires a certain familiarity and facility in the use of the sight, but this is all. These remarks are especially applicable to the practice with the small-arm barrel inserted into the bore of the gun. Unquestionably such practice is better than nothing, but it is believed that if greater atttention were turned to this important method of instruction, many improvements could be made without transcending the limits of reasonable expense. In order to state briefly a method for improving upon the old or ordinary means, we will begin by a consideration of some of the fundamental principles of exterior ballistics. From the *Hand-book of Problems in Direct Fire** we have for flat trajectories

$$X=C\left\{S(v)-S(V)\right\}$$

and for a different projectile

$$x=c\left\{S(v')-S(V)\right\}$$

when the two projectiles have the same muzzle velocity. For a given value of v in the first trajectory, there will be a point in the second, at which v' will be equal to v. Introducing this condition into the above equations, and dividing the second by the first, we have

$$\frac{x}{X}=\frac{c}{C}, \text{ or } x=\frac{c}{C}X,$$

in which for any assumed value of X, we obtain the value for x, or the range at which the remaining velocity in the second case is equal to that for X. This equation expresses the relation between the ranges at which the remaining velocities are equal.

Again

$$t=c\left\{T(u)-T(U)\right\}$$

for elevations less than 5°. By using the similar expression for T, and a course of reasoning similar to that above, we obtain

$$t=\frac{c}{C}T.$$

Angles of elevation are determined by the equations $\sin 2\Phi=AC$, and $\sin 2\phi=ac$, and by division

$$\frac{\sin 2\phi}{\sin 2\Phi}=\frac{ac}{AC},$$

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* By Captain James M. Ingalls, 1st Artillery. All reference to tables, etc., in this discussion, refer to this book.

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A and a being determined by $\frac{X}{C}$, $\frac{x}{c}$ and V, since V is the same for both projectiles, and since

$$\frac{X}{C}=\frac{x}{c},\ A=a,\ \text{and}\ \sin 2\phi=\frac{c}{C}\sin 2\Phi.$$

From this equation, the values of ϕ can be determined, when c, C, and Φ are known. Taking advantage of these simple relations between the quantities of the two trajectories, for a given caliber of service projectile, it becomes possible to select a projectile of smaller caliber, the principal elements of whose trajectory will either be identical with or proportional to those of the trajectory in question.

To illustrate the use that can be made of these principles in our fire-instruction, let us assume 5000 yards to be the maximum range for the new 8-inch rifle. For this gun and range we find from the table computed by Captain Ingalls, published in *Journal* No. 9, that the elevation is 4° 52′.8, or less than 5°. Let the reduced projectile be assumed similar in all respects to the service projectile, the weights of the projectiles will then be proportional to the cubes of their diameters, or $8^3:d^3::300:w$. As already shown,

$$\frac{x}{X}=\frac{c}{C}=\frac{w}{d^2}\times\frac{64}{300} \qquad (1)$$

Simplifying (1), and reducing the proportion, we have

$$64Xwd=300d^3x \qquad (2)$$

$$512w=300d^3 \qquad (3)$$

By division, we have

$$x=\frac{Xd}{8} \qquad (4)$$

Substituting in (4) for large X its assumed maximum value we have $x_{,}=625d$. This equation therefore expresses the relation between the range and caliber of reduced projectile which will give conditions assimilated to those of the 8-inch projectile at 5000 yards.

Now, as the scheme projected, to be of value, should be adapted to ranges obtainable at artillery posts, as well as for reducing cost of practice, the value of x must be considerably less than 5000 yards. Practicable ranges will vary in length at different posts; it may become necessary to install apparatus specially designed to the peculiar conditions of each. The relation $x_{,}=625d$ being an equation of two variables, one can be assumed at pleasure, the other determined. Therefore this equation lends itself to the needs of the case in the most convenient manner. As, in the discussion of the problem, the range is likely to be limited at each post, it will be better to assume suitable values for $x_{,}$, and determine the values of d. Substituting the following values for $x_{,}$: 625, 1000, 1500, we obtain the following respective values for d/ 1″, 1″.6, and 2″.4 Taking 1000 yards as a practicable range at Fort Monroe, the 1″.6 caliber apparatus would naturally be selected.

Again assuming 1000 yards to be the minimum battle range for the same gun, a course of reasoning similar to that just given we obtain 200 yards for the corresponding reduced range. By substituting 1.6 for d in (4) and considering X to vary from the maximum to the minimum fighting range, for each value of X, we obtain the corresponding reduced values of x. Therefore, the assimilated conditions obtain for all parts of the trajectory, and the circumstances of flight for all points of the long trajectory will be reproduced in that of the sub-caliber projectile.

Let us now consider in view of this deduction, some of the most important deviating elements in the reduced trajectory.

(1.) *Wind deflection.*—From the relation $S(v)-S(V)=S(v')-S(V)$, or $v=v'$, we see that the two projectiles have suffered equal retardations, and deflection depending directly upon retardation,* the effect of the wind will be the same for each case. Therefore in practice with a smaller projectile at a reduced range the allowance will be the same as for the larger one, and can be made on the service sight as under service condition. This will be the first great advantage of the assimilated sub-caliber system.

(2.) *Longitudinal wind deviations.*—For the reason just given, and the established relation between the projectiles, it follows that at all points of equal remaining velocities in the respective trajectories, longitudinal effects will be equal.† Here we have a second important result of which we may take advantage.

(3.) *Atmospheric changes.*—Since changes in atmospheric conditions simply affect the resistance of the air, and affect the projectile's motion similarly to longitudinal components of wind, once more these atmospheric effects will be equal when the prescribed conditions are imposed upon the velocities.

We see then, that all the variations caused by uncontrollable changes in the air, reduce to equality with those in actual service.

(4.) *Drift.*—Drift should be allowed for mechanically on the sight; since it is fixed for a given range, its correction in this manner should be easy. If advisable, the actual amounts of drift for the ranges can be determined and allowed for by a permanent inclination, and these values for service ranges marked opposite the corresponding reduced ranges.

(5.) *Elevations.*—From

$$\sin 2\phi = \frac{c}{C}\sin 2\Phi,$$

the elevation for reduced ranges can be computed and placed inside of a double-slotted sight; on one side the service ranges, on the other the reduced ranges, those corresponding being connected by oblique lines. A better solution still, and one directly in touch with our future development, will be to connect the elevating apparatus with a simple mechanism which will move pointers over a dial. The dial for the standard initial velocity could be calibrated so that the pointer would always stand at the range for which the gun

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* *Journal*, Vol. I, No. 1, p. 17.

† *Journal*, Vol. I, No. 3, p. 201.

is elevated. Such an apparatus imposes that the gun give always a constant muzzle velocity—a condition which should be considered essential in time of war. Experience has already shown that with proper care, this is by no means impossible. In order to ascertain if any changes have taken place in this factor, the muzzle velocity should be measured at regular intervals. If a lot of powder is found to have deteriorated, a new dial should be constructed and calibrated. The dials should be easily removable. In such a system the dial for sub-caliber practice would be graduated in ranges by the above equation, giving value of $\sin 2\phi$, and other necessary equations. In fact up to 10°, as the sines and arcs are practically proportional, no appreciable error will be made if sines of the angles be substituted for sines of double the angles. Under this assumption

$$\sin\phi = \frac{c}{C}\sin\Phi\text{, and since in this case } \frac{c}{C} = \frac{1}{5},$$

a simple change of gears, increasing the motion of the service pointer five times, would permit the use of the same dial for both the regular and reduced practice. If in any day's practice, at say 3000 yards, a falling off in velocity and range is observed, and the shot falls 200 or 300 yards short, the cannoneer need only elevate the wheel until the pointer indicates 3200 or 3300 yards and the correction is made. As now provided, the gunner must go to his table, make a calculation, and determine the increment of elevation, then go to his sight, lay off the angle with a vernier, and after all this fuss direct the same cannoneer to elevate the requisite amount. He thus with considerable delay, succeeds in aiming his gun. In each of these processes, or in their combination, enters liability to error. The use of the range-dial does away with all these operations, complications and possible errors. In short this simple method involves no computation, re-adjustment, consultation of tables or other delay, and is correspondingly free from possibility of mistake.

Having thus brought out the similarity of conditions and the ballistic properties of such reduced-caliber practice. let us now consider briefly the plan of construction of the apparatus and the details of using it. The principles already described are illustrated graphically in the accompanying figure. A sketch is also furnished, giving the principal parts of the sub-caliber gun in position and their relations to one another. The general conditions have already been laid down. The sub-caliber barrel may for this description be considered as the same length as the 8-inch bore.* It must be strong enough to resist pressures which would be necessary to give the 1″.6-projectile a muzzle velocity of 1950 feet, and rifled to give the same muzzle rotation. As such a barrel would allow a very large number of expansions, the maximum pressure would be comparatively low, and the powder charge would therefore be small. The barrel would have to be centered in the 8-inch bore, held from being drawn out through the muzzle, and prevented from revolving as the

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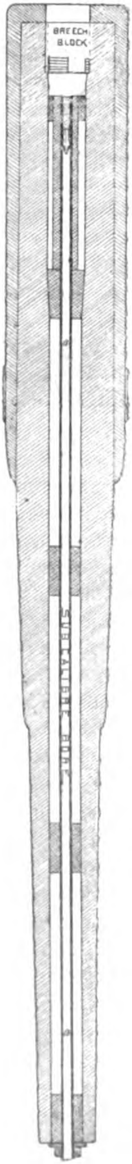
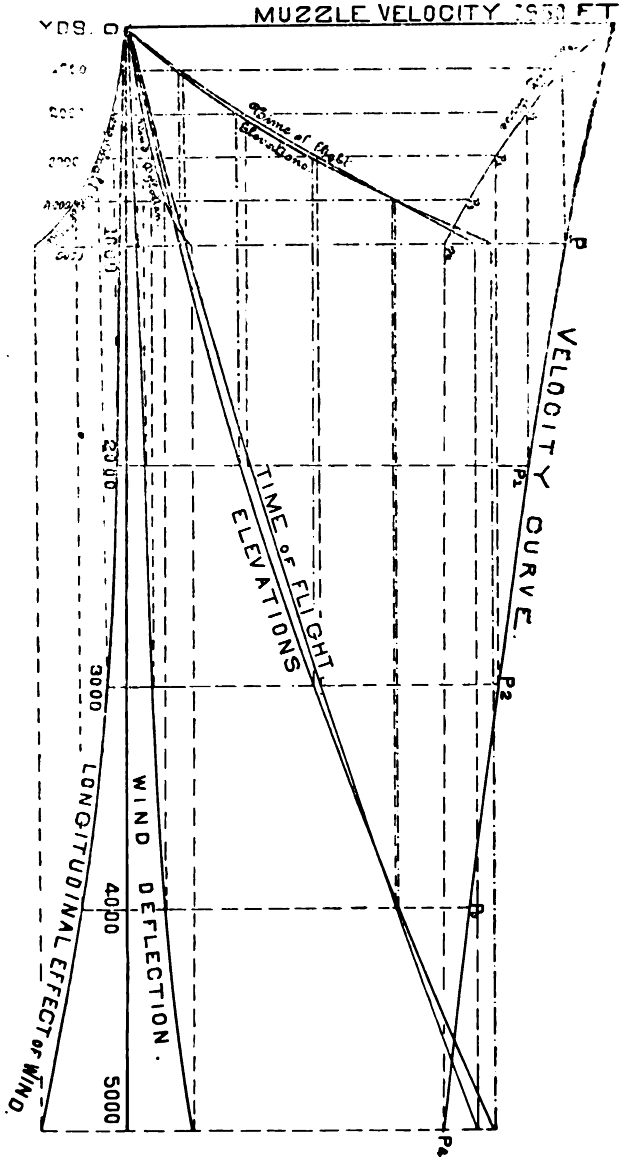
* This is by no means necessary. The problem will be to determine the cheapest construction which will fulfill the required conditions.


BREECH BLOCK
SUB CALIBRE BORE


MUZZLE VELOCITY FT
YDS. 0
1000
2000
3000
4000
5000
Time of flight
Elevations
P
P1
P2
P3
P4
VELOCITY CURVE.
TIME OF FLIGHT
ELEVATIONS
WIND DEFLECTION.
LONGITUDINAL EFFECT OF WIND.

projectile was forced through it. These questions may be satisfactorily solved in the following manner: the breech of the sub-caliber barrel centered by means of a hollow frustum of a cone, through which the barrel passes being forced up until the shoulder rests against the rear face of the cone, the latter may be arranged to fit into the chamber of the service gun, and beginning of the bore proper, and the surface of the frustum may be thinly covered with some soft metal to prevent injury to the lands. The sub-caliber barrel may be keyed to the frustum. As shown in the sketch, a screw thread is turned on the end of the muzzle of the barrel and a nut is set up tight against the muzzle centering piece, the flange of which bears against the face of the muzzle of the service gun. The tension exerted by the nut should exceed the maximum forward pressure in action, due to discharge, and when thus drawn up, the rear face of the sub-caliber barrel should fit accurately against the closed breech-block. Further details of centering need not be dwelt upon.

The sketch indicates a center-fire reloadable cartridge-case of suitable weight and size in position. The method contemplates obturation by means of the regular service breech-block. The cartridge could be re-loaded and used an indefinite number of times; it thus fulfills the strictest demands of economy, obviates the necessity for any special or additional designs, and compels the gunners to use the same mechanism, handle the same weights, and perform the same duties that they would in service.

The projectile would have to be prepared in accordance with the foregoing principles. It could be made of cheap metal, rotating bands put on in the same manner, and given the necessary weight within prescribed limits, the point and shape being the same as those of its prototype, and possessing the same co-efficient of reduction. It is quite probable that a large number of these projectiles, if fired into a sand-bank, could be recovered and by replacing bands fired several times. It is also within the possibilities that a simple method and apparatus might be provided for replacing the bands, at the post.

Charge and Pressures.—The great length of the barrel will ~~reduce~~ the charge of powder and maximum pressures to their least values, and give a ~~high~~ efficiency to the charge with little strain upon the gun. This would greatly ~~reduce~~ the maximum pressures, and required thickness and strength of the tube. All ~~which~~ facts tend to simplify and cheapen construction. The whole apparatus should be constructed without great expense, in fact a system fulfilling the conditions which it is believed can be embraced in this plan would be cheap at any cost.

One apparatus for each caliber of gun at the post should be sufficient. The only objection that is likely to be urged is the trouble and cost that would be necessary to install such a plant for instruction; but as it is claimed, we believe beyond all argument, that some kind of sub-caliber practice must be adopted, we must prepare ourselves to overcome all obstacles and endeavor to select the best practicable system as soon as possible.

In this discussion efforts have been made to outline the principles of a system which in drill and firing should give all the fundamental instruction that would result from firing the gun with service ammunition and under service conditions. The method, if practicable at all, can be applied to all types and calibers of breech-loading guns, field and siege as well as sea-coast guns, and is applicable at any sea-coast post. It should find easy and economic application in smaller calibers of breech-loaders. It is evident that each set of conditions, furnished by each post, would probably require a special design, but this can scarcely be urged as an objection, when it is a question of securing the maximum amount of real instruction. At least three or four types should be designed by means of which it might be possible to satisfy the different range conditions of all artillery posts.

In drill for instruction, during time of peace, it is believed that every subject should be learned a knowledge of which would be required in time of battle. It is time that we appreciate the important fact that peace drill, instruction, etc., fulfilling no real fighting conditions, are not only worthless, but injurious, since they must all be not only quickly unlearned, but supplanted by others which must be learned in short order. In all cases where there are two ways of doing work, a right way and a wrong, let us try to select the right, no matter how much trouble may be involved; in all, when possible, let us cling to what we know to be actual service conditions in preference to any easier methods, since by these conditions only can efficiency be judged. They should be taken up systematically and persistently until they are mastered, and the duties of the cannoneers become to them as second nature. In firing the knowledge acquired must be applied *promptly;* in competition all refinements should be thrown aside, and the competitors should proceed with the application of their skill as in actual battle.

In the foregoing, efforts have been made to assimilate all needed information of heavy-gun practice to that which can be obtained from a sub-caliber gun; the idea being to obtain a large number of rounds for drill and competition. The assimilation has been carried as far as possible in order to obtain from each of the reduced projectiles, as nearly as possible, all the experience and information that could be obtained from firing the type gun—the 8″ B.L. rifle—at its practicable target ranges. By use of the service gun, breech-block, sight, all allowances the same, and with the ranges corresponding, it seems that no possible excuse would be left for poor work.

It is also probable that a relation will soon be deduced between the mean deviations and the ranges at which they take place; in which case the deviations on the sub-caliber target can be directly applied to the heavier gun and projectile at battle ranges.

For time fuze shell, if use of such be contemplated, the fuze can be cut according to

$$t = \frac{c}{C} T,$$

in which t is proportional to T, and by a special graduation for the time-fuze, the readings of time on the instruction fuze may become identical to that prescribed for service.

Practice at Targets.—We assume that only a few rounds need be fired at a fixed target, that is, simply a sufficient number to test the sub-caliber gun, and give the gunners and competitors a clear idea of its apparatus and operation. After this result has been secured the moving target practice should begin, and no other kind be permitted.

Let it be assumed that a target has been constructed which is of suitable shape and reduced dimensions to represent a ship at the maximum range, and that we have suitable tracks and apparatus for giving it any assumed reduced speed. For a ship entering the harbor at 5000 yards, the target would begin to move at the 1000-yard point, and move obliquely or directly towards the gun. To allow for possible variations in courses of the ship, two or three oblique tracks should be provided, but where there is but one possible course for a ship to follow, a track to simulate this would suffice. The motive apparatus could be of the simplest kind. In this manner all problems of a ship's approach could be studied and solved; the target runs over the course and back again, while the gun detachment practices upon it with the gun and carriage to which ~~they are~~ assigned. The target should be self-recording. The hits could easily be marked (or received through a telescope) as fired, and recorded. The permanent record made should enable the gunner to study his target with view to the correction of errors for the next time.

The azimuth of the gun or any range-finding method adopted, for service, would fix the range at any time. The shot-hole on the target would tell the accuracy with which a shot had been aimed. All deviations should be carefully measured and analyzed. The loading and firing should be timed to service intervals, and according to a *Manual of Regulations for Sea Coast Artillery Fire.*

The gunners and cannoneers having become proficient in this kind of practice, a competition could be held in which all engaged should be required to follow the Regulations of fire, observing service rules as to time, etc., and the gunners should be given such data only as will be furnished them in an engagement.

In the drill the gunner should learn accurately the values and applications of all co-efficients, all of which can be placed on tablets in some convenient place near the gun. In the competition he depends upon himself for the correct use of all such information.

It may be claimed that all these refinements may be impracticable in war; to determine them with perfect accuracy may be difficult, but it will not hurt a gunner to know that a strong wind across his range will deviate his 183-lb. 8-inch projectile about one yard per mile of wind at 3500 yards, and that if he estimate the wind velocity to be thirty miles per hour (which he can do with a very small amount of practice) and allows thirty yards in the proper direction, his chances of hitting his mark are greatly increased; and that for the same range with a 30-mile wind blowing up or down it, he must add to or subtract from his range about three times the above number of yards; and that on a cold day he must aim higher than on a hot one, and similar facts connected with gunnery. Any man intelligent enough to be a gunner will, with practice, soon learn these facts, and apply them almost without knowing it.

It is easily seen from the foregoing questions considered in reference to this sub-caliber scheme, that many valuable data can be secured from its prosecution. Care and accuracy would promote the construction of tables, which could be applied in various ways, in imparting instruction. For example: a few simple tables would permit the application of the fire-game to be introduced as a factor in our fire-instruction, and many interesting and useful problems could be solved in-doors during the inactive season.

3. *An allowance for the verification of sub-caliber results.*—Owing to the irregularities which might exist, and the variations of the practical from the theoretical, some check upon the results of the preceding course would probably become necessary. This work would have to be done with the service gun at service ranges, with service projectiles, with great care and a view to ascertain with a few projectiles possible variations from the sub-caliber results and their correction.

4. *An allowance for tactical exercises.*—This allowance should be as liberal as possible, consistent with economy and intelligent expenditure. For the present, these exercises could be very advantageously carried out with our present guns. The old 10-inch smooth-bore will answer very well for a beginning. It would be useless to undertake such firing with new guns, until the system was devised and well under development. The difficulties in the beginning with the great blunders which will be made, render it undesirable to commence with anything but the very cheapest material. Old ammunition, practically useless, and in the way at many posts, might profitably be used in this manner. In the beginning, progress would of course be slow, as with nothing to serve as a guide, it would be necessary to feel our way with caution.

This drill, it will be remembered, will be essentially one of organization, command, service, communication, position and range-finding, and a thousand other details about which we know absolutely nothing, All the fundamental principles remain the same, whether we use one gun or another.

The value of such instruction has been amply considered theoretically, but never in this country within the writer's knowledge has the problem been treated practically, yet this must be done before any additional light can be thrown upon the subject. Many discouragements will be met in the beginning, and many apparently insurmountable obstacles will present themselves, but the sooner all these difficulties are discovered and defined, the sooner will they be cleared away by practical solutions. Whatever may be the plan, it should embrace the following considerations:

a. It should be carefully planned and practiced, and all possible improvement made before commencing with projectiles. It should be persistently studied, developed, and organized with each day's work, and with each year. It may not be possible to have such exercises at every artillery post, but it certainly could be carried out at several of our largest garrisons. The conditions at Fort Monroe are now becoming especially favorable for such work and a beginning could be made here more easily than elsewhere.

b. It should always be made with moving targets. In considering the question of moving targets, there are several important points with respect to direction of fire which must be settled. We must adopt some method of directing our guns, in drill, such as we must apply in time of war. Amongst these considerations the most important is the question of concentration on the one side, and dispersion on the other. The advocates of dispersion maintain that it will be best for this practice to point our guns along parallel lines, thus scattering our projectiles over a greater space. They advance long arguments to show that from this scattering effect a higher percentage of hits will result. Taking the case of a flying bird, and a line of men ready to fire upon it, it is held that the most advantageous way would be to aim their guns parallel. This question, it is believed, will depend upon the skill of the marksmen; if they be unskilled, by firing in "parallel", they may, by filling the air full of bullets, accidently hit the bird; but even this chance is extremely doubtful. On the other hand, if they all be very skillful and fire at the same instant, that is, by volley, each man, feeling conscious that he can kill the bird, will aim a sufficient distance in front, as indicated by his experience; thus, all concentrating their fire upon the same point, the chances are that each individual will hit his object. It is believed that the latter state of efficiency is the one for which we should strive, and which should govern in the selection of our methods. With our best endeavors to secure concentration, our target records show ample scattering, and probably will continue to, for some time to come. Our present practice will bear a good deal more effort after concentration, before it will be profitable to set about undoing the work accomplished and introducing principles of a directly opposite tendency. It is the capacity of the skilled gunners, rather than that of the opposite character, which we should consider in constructing our firing regulations. Taking the question more in detail, the following are some of the objections to "scattering" methods:

(1.) It will destroy all confidence in the fire of individual guns.

(2.) It assumes firing by salvos, which for service conditions will probably be impossible. In Hohenlohe's *Letters on Field Artillery*, we find the following pertinent remarks:

"On the use of salvos by batteries."

* * * * *

"I am in general a declared enemy of artillery salvos as a system of fighting. A battety has to load, set its tangent-scales, lay its guns, fire, observe and correct each shot, each of which duties has to be performed by a different man, while they must all be correctly carried out if it is proposed to hit; it thus forms such a complicated technical machine, that only from the strictest pedantry and the most steady supervision of the execution of each duty can the best possible results be anticipated. As soon as, instead of a quiet calm, haste and precipitation arise, and as soon as the detachments feel that they are not closely looked after, mistakes will begin; this is true of the practice camp, but is still more true when they are in front of the enemy. Suppose that out of a battery salvo only one shot hits the mark, whom is the captain of the battery to hold answerable for the failure? He does not know, after the salvo, which of the six guns has been properly laid. But when shot after shot is watched by the captain, and when he can make the gun which is concerned responsible for each "deserter", then the detachments take far more trouble in loading correctly, in setting their tangent scale and fuzes, in laying, etc., etc. Only thus can the captain obtain that command over the fire which makes men say, "He holds his fire in his hand". Believe me, I speak from experience, it is hard enough now to keep one's fire under control. It is only necessary that a gun shall miss fire, or that the firing number shall be killed at the moment when the word "Fire!" is given, or that any such interruption shall occur, and another gun will fire immediately, and then, unless the captain intervenes with the severity of a Draco, independent firing at once takes place, such as is not recognized by our regulations, such as, unwatched, uncorrected, and often unaimed as it is, has no result except an impenetrable cloud of smoke. I trust only to that fire which works pedantically from one flank, where the captain stands to windward with his field-glass to his eye, watches each shot, and can intervene whenever a "deserter" occurs, since no shot is fired until the preceding shot has been marked on the target. This is also the object of the regulations, since it is there laid down that the shortest pause between two guns is to be from 6 to 8 seconds, while in 6 to 8 seconds the shell will traverse the longest range (2500 to 3000 yards) at which, in my opinion, rapid firing ought ever to be employed. No more shells are thrown against the enemy by the use of salvos than would be the case if a rapid fire were used, since well-laid battery salvos cannot be fired quicker than with an interval of from 36 to 48 seconds; thus the regular quick fire from a flank sends just as many shells into the enemy's ranks, with this advantge, that they are more likely to hit, and that when shrapnel are used, and it has been found necessary to change the elevation or the range, shrapnel shells which have been loaded beforehand, and of which the fuzes, previously set, will not admit of correction, need not be fired except in a few cases."

While these remarks refer to field artillery, they are almost literally applicable to heavy guns. This is not only true of the part just quoted, but also of almost every sentence in that wonderful book. There is no book within the writer's knowledge which is so replete with wisdom for the sea-coast artillerist.

(3.) Distances between our new guns are so great that enormous errors must result from systems of parallel fire. There are fifty yards at least between 10-inch guns, and still more between 12-inch guns.

(4.) The method of predicting positions will prove not only impracticable but unnecessary. Relative to this subject we here insert a partial record of moving target practice at Fort Monroe, in the summer of 1891. In the table, + indicates *over*, — *short*.

+300		+ 50	line.
+350		+ 10	
—100		+100	
— 25		+350	
— 30		+350	
+200		— 14	
—100		+ 25	line.
— 5		— 6	destroyed target.
— 5		+300	
— 20		+ 40	
+500		+ 90	line.
+150		+200	
+ 25		— 10	line.
+200		+350	line.
+ 10		+300	
— 60	line.	— 8	line.
+200		— 14	line.
+ 10	struck target.	+300	
+200		+ 15	
— 50		— 12	
+250		+300	
+ 50		+ 15	
+500		—200	
———	water line hit.	+300	
+100		+600	
+ 75			

Distances estimated by officers on tug.

Mean longitudinal deviation 141.2 yards.

Mean longitudinal deviation of thirty shots fired from same gun at fixed targets, 145.4 yards.

A simple comparison of the mean longitudinal deviation in the two cases shows the practice at the moving target to be slightly better in this respect than in the other case. As, however, the method in question is not intended to influence this deviation, we shall restrict the few remarks following to deflections in the lateral direction.

A comparison of the lateral deviations cannot be given, since no figures are recorded for this element in the moving practice. The line shooting, it is clear, from the above record, was excellent. The three hits and large number of shots with no lateral deviation leaves no doubt upon this point. In this respect, also there is reason to believe that the shooting was as good if not better than in the other case.

The fixed practice was done under the most favorable circumstances. Most of it was done with the Zalinski sight and as much time as desirable was allowed for aiming. The moving practice, on the other hand, was done under the most disadvantageous circumstances. In fact it was done without *any* facilities for such work. Predicting positions was simply out of the question. There were no rear sights of sufficient height to use in aligning the gun at these ranges, and it became necessary to use a long priming wire for rear sights In some cases short chalk marks were arranged in form of a scale, transversely upon the upper surface, near the muzzle. By using the priming wire and the chalk scale, or other devices equally crude, the guns were aimed sufficiently in advance to allow for the officer sighting the gun to jump from the carriage, and for the time of flight. With proper apparatus for traversing the gun continuously up to the last moment, as is now provided in the new barbette carriage for the new 8-inch rifle, and with a sight suitable for making allowance for the ship's motion, the guns could have been continuously aimed up to the instant of discharge. If the line shooting under such unfavorable conditions was good, what efficiency may be obtained under new conditiions, where apparatus is adapted for this particular work? Assuming what we already have in the new barbette carriage, and electricity as the moving agent, is it likely that *prediction of positions will be necessary?*

So far we have assumed visibility of object from the gun; certainly, so far as we have data and experience upon which to base judgment, there is no demand for scattering methods. Cases will arise where it will be desirable to shoot at a hostile ship by indirect fire. The solution of this part of the question will depend entirely upon position finding methods. If the position finding instruments can be trusted to locate the object with accuracy, scattering methods should no more be necessary than in the case just considered: if they cannot, the results of experiment must be applied to the case in question, to determine whether or not firing shall commence.

c. Battle conditions must be studied and, as soon as possible, introduced into the exercises.

d. It should endeavor to ascertain the needs of the service to supply them, correct mistakes, and improve existing material when possible.

Let us select the summer months for this work. With the batteries temporarily here (Fort Monroe) for practice, we have at a time three battalions, all of which could participate.

Let us assume that two of them are detailed for the drill. One battalion would be deployed along the works at four different points, the second battalion held in reserve, or both battalions deployed, each having its own reserve (which?); the majors would command their respective battalions, a senior would command the whole. A captain would command a group of guns—say, two, and if he had a sufficient number of men would have his three reliefs, ammunition detachment, and other details. Then would come the question: where are the projectiles, the fuzes, the implements, the powder, and how are all these things to be gotten to their places? The reader is requested to try to solve these questions, for the writer is compelled to confess his inability to do so. They can all be answered and answered satisfactorily,

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but they must be answered through the media of men and machines in operation.

In addition to the tactical problems involved, it is believed that a good deal of light would be thrown upon questions of our organization. Taking, for an example, a battery assigned to two 10-inch or 12-inch guns—how many officers would be required? What would be the captain's duties? They, presumably, will be of a general nature, and will prevent his attending to the details of loading and firing. Will, or will not, a subordinate officer be required for each gun? Will an officer be needed to look after the ammunition? These, and many other questions, taken in connection with the arrangement of our new guns in variable groups of one, two, three, etc., will demonstrate the necessity for a flexible organization, a condition which would be fulfilled in a corps.

Now, let us return to the question of competition. As shown above, the general competition can be carried out with sub-caliber ammunition. This we may compare to the infantry's firing-season, in which companies and regiments are given a figure of merit in accordance with their proficiency. After the individuals have fired all through the season, the most skilful are allowed to enter Department, Division and Army Contests, for suitable medals, etc., all of which details are familiar to the reader. The infantryman must use a large amount of ammunition, and demonstrate his competency to enter the great contest and aspire to the prize. Such a course has many years of experience to prove its excellence.

Now, passing to our own competitions—from our small allowance of ammunition, the gunner is obliged to commence his contest each year without any previous practice, and rarely, if ever, has more than two shots with the same gun and projectile at the same range. Under these conditions, so different from those governing the competitions in other arms, a corresponding difference in results must be expected.

Our battery competitions, therefore, we believe, have been more or less disappointing; notwithstanding it is quite probable that the spirit of emulation produces greater interest, and at least as good results as could be secured by any other method under the given circumstances.

The sub-caliber scheme just outlined, if carried out as it is believed possible to execute it, should give each contestant a large amount of preparatory practice, and this could in all respects occupy the same place in his instruction as does the preparatory practice for the infantryman.

After this has been finished, all those with high scores could be selected for a grand competition, such as is now contemplated in orders, but is found impracticable so far, simply from the lack of ammuninition to secure sufficient practice to attain the necessary standard.

Let us suppose that the high score men are all concentrated at one or two of the largest posts, where tactical exercises are to be held, and permitted to participate in them. It is quite probable that the grand competition could be embraced in the schedule of exercises. From the start all should be made to understand that to enter *this* competition will be a high honor, and that to secure a prize therein will be the highest reward for which the gunner will strive. The firing should, if possible, be with service ammunition.

In the course of tactical firing, as well as in the preceding, as many officers and non-commissioned officers should be present as can be brought together.

Whatever may be the best way to treat these questions, must be discovered by actual grappling with them and settling them on the firing ground.

The following data and suggestions, so far as the writer knows, have never been published, and are added in hope that they may be of some use in future practice. In the accompanying tables, variations in range due to changes in barometer and thermometer, have been computed from the formula:

$$\delta X = X\left\{1 - \frac{\tan\phi}{\tan\omega}\right\}\frac{\delta C}{C} = X\left\{1 - \frac{A}{B}\right\}\frac{\delta C}{C}.$$

For the deduction of this remarkably simple and useful formula, we are indebted to Captain James M. Ingalls, 1st Artillery. With his permission, we give it here, believing that it will be found valuable in all cases where δX is required, δC being known. To illustrate its application to the problems of practical ballistics, let it be required to find δX for different ranges, corresponding to a change in temperature of 17 degrees. Considering C unity, from Table IV we find δC to be .033, and the formula becomes:

$$\delta X = X\left\{1 - \frac{\tan\phi}{\tan\omega}\right\}.033 \qquad ,$$

Having obtained the value of the parenthesis, the remainder can be obtained by a mental calculation. Table IV shows changes in C proportional to changes in barometer, or thermometer, and that a change of 17° in the former is equivalent to $1''$ in the latter. In the accompanying tables, the + is set in front of numbers which must be added to the target range, and similarly, the — in front of those to be subtracted.

Observation.—Much trouble has been experienced in the past from bad or indifferent observation. In these days of increasing interest, all observers should be especially careful to obtain the best results possible with the instruments available, and other given conditions. We hope that the spirit of progress may soon be so strong that the battery commander will consider himself and his battery defrauded of their legitimate rights when their shots are thrown away or the results vitiated through faults of observation.

Were the sentiment strong in favor of work, and against loose ideas of artillery service, officers would not dare observe carelessly, and turn in erroneous results. In cases where carelessness becomes apparent, a rigid inquiry into the circumstances would be in order. The demoralizing effects of sending in incorrect angles, for instance, and thereby throwing the gunner far out of his range for a single shot, cannot be removed in an entire season, maybe several seasons. The annihilation of all confidence in accurate methods, simply through ignorance or indifference, where the utmost confidence should obtain, has more than any other consideration kept back the development of an efficient systematic scheme of post artillery practice.

In observing the splash of a shot, the following facts based upon experience, are offered for what they may be worth. The projectile strikes the water with a high velocity, and often leaves it again on ricochet; the first impact sends up a large column of water which is thrown with tremendous force in the direction of the projectile's motion, forming a high ridge of spray, several yards in length, lying in the plane of the trajectory. This effect is increased by the emergence of the projectile (on ricochet) which again throws up a column of water in advance. It thus happens that the splash is always long, being sometimes as much as fifty yards in length. For good results in observing this appearance, it becomes imperative to catch the inner, or *gunward*, part of the splash, *instantly*, on its creation. Again, with open-sight alidade, elevated some distance above the water, the observer is apt to catch the upper part of the column of spray, which, in a few seconds, under a strong wind, will have moved several yards leeward, before the observer succeeds in taking it. In Lieutenant Whistler's experimental firing, at Fort Wadsworth, during the winter of 1889-90, the writer was observing lateral deflections, with the transit then in use at Fort Hamilton. The Fort Hamilton-Wadsworth plane-table system was used to determine the ranges. The transit was placed near the Wadsworth observation-house, on the line of fire which had been chosen so as to prolong the line joining the Wadsworth base-end and the gun-pintle. In this work, therefore, we had the plane-table-alidade and the transit on the line of fire to observe each shot. As we were observing these shots, with both instruments at the same instant, more favorable circumstances for comparison cannot be imagined. A strong wind was almost always blowing. The following results were soon made manifest. In strong side winds, the deflection by plane-table exceeded that by transit, from 12 to 20 yards. The wind having, in all cases, been allowed for, the line shooting was good, according to the transit, while by the plane-table the deflections frequently amounted to 20 yards. We soon became convinced that the plane-table was unreliable for lateral deviations, and its use for this purpose was abandoned. The discrepancy is not difficult to explain. In the open alidade the small slit obscures for some time the vision, already dim, through distance or haze, and the eye does not catch the splash quickly, and when it does catch it, observes the most prominent part, which is that portion thrown highest, and made white through the effect of light upon it. With the transit, the shot falls in the field of view, and the small cone of water or the *base* of the splash, is clearly visible, and may with ease be bi-sected by the movable hair. This observation is made before the spray becomes prominent; in fact, it will, in many cases, not appear in the field at all. Therefore, in observing with any kind of instrument, the sight should be directed low on the splash, taking quickly that part nearest the gun.

From the above difference between transit and plane-table determination, we believe that the transit should always be given precedence for lateral deviation. In the case just cited, where the difference was 20 yards, it will be seen that a projectile may fall 10 yards to the right, and yet plot by plane-table 10 yards to the left. If it falls this distance to the right, there will be no diversity of opinion amongst men who clearly see it, as to whether it struck right or left: they may differ as to the amount of deviation, but not as to its character. In such cases, in fact in all cases where one is close to the gun, a good eye is perfectly certain as to the character of lateral deviation.

Again, it is a great mistake to suppose that transit results are vitiated by placing the instrument a reasonable distance one side of the battery. If placed 50 or even 100 yards to one side the guns, unless the errors in range are unusually bad, and the whole firing erratic and worthless anyway, transit deflections can without appreciable error, be used to correct the aim at our prescribed target ranges. If, after the firing is over, it is desirable to enter into refinements, and correct the record for errors due to side position, a simple formula for parallax will give the necessary corrections.

The tendency is observed in our target nomenclature to multiply units unnecessarily. For example, we find degrees, points, and clock dial measure used to express the same kind of quantity. As all our instruments are graduated in degrees of arc, and since this system is not likely to be changed, the introduction of points, etc., simply complicates our work needlessly.

It is popularly believed that the initial velocities as marked on the powder barrel heads are of value to the practical artilleryman; this is a mistake. These velocities can be of no possible value to anyone except in ballistic experiments, where they may serve as a kind of index to guide the experimenter.

The tendency to hurry through practice was at one time universal, and still exists in a marked degree. To hurry for the purpose of "getting through" is certainly a wrong course to follow. The method of firing followed at Fort Monroe is especially advantageous, inasmuch as by manning several guns at a time, all necessity for haste is removed. When six or seven guns are in action, each gunner has ample time to consider all questions relating to his instruction and there is no necessity for clipping details. This practice permits the firing of a large number of shots, giving at the same time to the details of each due attention.

This course may not always be practicable, but it is not always followed where the facilities exist. The writer has known batteries to postpone firing for days in order to be able to fire the gun which other batteries were using, and then fire their six shots in half-an-hour on account of the self-imposed delay. All this time another gun of the same type was standing next the one in question. The enemy is not likely to be so considerate as to let all batteries use the same gun.

After bad observation the tendency to tamper with the elevation after each shot, has done more injury to the service than any other consideration. To illustrate this point, the writer once heard a report come in five yards short. The captain called to the lieutenant, "What elevation did you give that time, Mr. ——"? "Seven degrees, twenty-eight minutes", was the answer. "Give it seven, twenty-nine", said the captain. The lieutenant gave the gun "seven, twenty-nine" next time. It is needless to say that the target still survived, and the shot hit nothing but the broad expanse of water surrounding the target for thousands of yards on every side. This exploit is on a par with an incident within the writer's experience, where the observing officer went to sleep at the observing station, and was awakened only by the report of the

15" GUN—SOLID SHOT 456 LBS.

Standard Temperature 60°; Standard Barometer 30"; Atmosphere two-thirds saturated with moisture.

Range.	Velocities. $V=1706$.	Times of Flight.	Coefficients.								
			Wind			Atmospheric Changes.					
			Deflecting.		Longitudinal. $V=1706$	Thermometer. 1°			Barometer. 0.1"		
			$V=1535$	$V=1706$							
1000	1268	2.05	.16	.16	.15	.33			.55		
1100	1231	2.29	.20	.20	.18						
1200	1196	2.54	.24	.24	.21						
1300	1164	2.78	.28	.28	.26						
1400	1133	3.05	.34	.33	.31						
1500	1104	3.34	.39	.39	.36	.80			1.36		
1600	1077	3.60	.46	.45	.43						
1700	1052	3.88	.54	.51	.49						
1800	1028	4.17	.62	.58	.58						
1900	1006	4.47	.68	.66	.65						
2000	985	4.76	.78	.74	.74	1.27			2.16		
2100	965	5.06	.90	.82	.84						
2200	946	5.38	1.00	.91	.96		100	—90			
2300	927	5.70	1.10	1.01	1.05		95	—79			
2400	910	6.03	1.20	1.11	1.16		90	—68			
2500	893	6.36	1.30	1.21	1.26	1.75	85	—57	2.97	30".5	+19
2600	877	6.70	1.45	1.32	1.38		80	—45		30 .4	+15
2700	862	7.05	1.60	1.43	1.51		75	—34		30 .3	+12
2800	846	7.40	1.75	1.55	1.63		70	—23		30 .2	+8
2900	833	7.75	1.90	1.60	1.75		65	—11		30 .1	+4
3000	819	8.13	2.10	1.81	1.87	2.26	60	+0	3.84	30	+0
3100	804	8.50	2.30	1.98	2.00		55	+11		29 .9	-4
3200	792	8.87	2.50	2.12	2.13		50	+23		29 .8	8
3300	780	9.26	2.70	2.26	2.27		45	+34		29 .7	-12
3400	768	9.64	2.90	2.41	2.40		40	+45		29 .6	15
3500	755	10.04	3.10	2.57	2.54	2.82	35	+57	4.80	29 .5	--19
3600	744	10.44	3.30	2.73	2.68		30	+68			
3700	731	10.84	3.50	2.89	2.83						
3800	721	11.25	3.75	3.06	2.98						
3900	711	11.66	4.00	3.24	3.13						
4000	701	12.08	4.25	3.49	3.28	3.44			5.85		

gun. He sprang up, and caught the splash as quickly as possible, under the circumstances, and plotted the shot. The projectile had *in fact* cut the cable and set the target drifting out to sea; by the time he had observed and plotted the target's position, it had, to the spectators, clearly moved some distance: the result came to the battery, "200 yards to the right"!

CONVERTED RIFLE, CORED SHOT. WEIGHT 183 LBS. WEIGHT OF SHELL 153 LBS.

Range.	Shot.		Coefficients.								
	Velocities. V=1403.	Time of Flight.	Wind.			Atmospheric Changes.					
			Deflecting. Shot.	Deflecting. Shell.	Longitudinal.*	Thermometer. 1°			Barometer. 0.1"		
1000	1213	2.23	.09	.11	.21	.25			.44		
1100	1195	2.53	.10	.12	.25						
1200	1181	2.78	.12	.15	.30						
1300	1165	3.04	.15	.18	.36						
1400	1150	3.30	.17	.21	.43						
1500	1136	3.54	.20	.24	.52	.47			.79		
1600	1122	3.80	.23	.28	.61						
1700	1108	4.07	.26	.31	.70						
1800	1095	4.34	.29	.36	.79						
1900	1083	4.61	.32	.39	.88						
2000	1072	4.87	.36	.43	.98	.65			1.10		
2100	1061	5.15	.40	.48	1.08						
2200	1051	5.42	.44	.55	1.19						
2300	1041	5.70	.48	.58	1.30						
2400	1032	5.97	.52	.63	1.41						
2500	1023	6.25	.56	.67	1.52	.95			1.62		
2600	1014	6.55	.61	.73	1.64						
2700	1006	6.83	.66	.79	1.76		100°	—62			
2800	998	7.13	.71	.85	1.88		95	—54			
2900	990	7.43	.76	.92	2.00		90	—47			
3000	983	7.71	.81	.97	2.13	1.26	85	—39	2.14	30".5	+13
3100	976	8.00	.86	1.03	2.27		80	—31		30 .4	+11
3200	969	8.28	.91	1.10	2.41		75	—23		30 .3	+ 8
3300	962	8.58	.96	1.16	2.55		70	—16		30 .2	+ 5
3400	956	8.92	1.01	1.23	2.69		65	— 8		30 .1	+ 3
3500	950	9.23	1.06	1.27	2.83	1.55	60	± 0	2.64	30	± 0
3600	944	9.55	1.11	1.33	2.98		55	+ 8		29 .9	— 3
3700	938	9.87	1.17	1.40	3.13		50	+16		29 .8	— 5
3800	932	10.19	1.22	1.49	3.28		45	+ 23		29 .7	— 8
3900	926	10.51	1.28	1.56	3.43		40	+ 31		29 .6	—11
4000	921	10.84	1.34	1.65	3.58	1.88	35	+ 39	3.20	29 .5	—13
							30	+47			

* Lieutenant Whistler's table. *Journal*, Vol. I, page 245.

Knowing from the instruments the variations in temperature and pressure from the standard, the effect upon the range in yards may be found without computation and applied in aiming.

It must be remembered that changes in thermometer and barometer are opposed to each other in their effects.

Thus: Effect of higher temperature and lower barometer must be subtracted from the range; that of lower temperature and higher barometer must be added.

When they rise or fall together they tend to neutralize each other. The differential effect, if important, must be applied with the sign of the greater.

Lateral and longitudinal deviations vary with the velocities of their respective deflecting and longitudinal components.

When for any cause the gun is given an elevation for a shorter or greater range than *that of the target, the allowance for lateral deviation must correspond to the elevation.*

Thus, if on account of wind or atmospheric conditions the gun is given an elevation for 2500 or 2900 yards to reach 2700 yards (the range of the target), the side allowance must be made for 2500 or 2900 yards accordingly.

It is worthy of note that the lateral and longitudinal coefficients for the 15″ S. B. gun are practically equal and that the longitudinal coefficient for the 8″ C. R. may be approximately determined by multiplying the corresponding lateral coefficient by 2.7.

COAST ARTILLERY PRACTICE.

By Colonel J. B. Richardson, R. A., Commandant, School of Gunnery.

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Reason for want of interest in Coast Defense.—There is a comfortable belief, deep seated in the mind of the British public, in the inviolability of our shores, and it is probably due to this feeling of security that but small interest is generally exhibited in coast defense questions, and that the organization for that defense has taken the remarkable form in which it is at present crystallized.

Necessity for careful preparation.—Coast defense is capable of easy solution as long as the absolute command of the sea is in the hands of friends. Neither the open coast nor sea fortresses can be seriously attacked, though irritating raids are possible or even probable. But party government renders the keeping up of an all-powerful fleet a difficult matter, and modern invention has produced such a change, not in the general principles but in the details of sea fighting, that, in the absence of actual experience, a feeling of insecurity is engendered in many thoughtful minds, which gives force to the argument that it is unwise to put all the eggs of defense into one basket, and renders a careful preparation for coast defense a sound step for a rich nation to take.

The two forms of Coast Defense.—Coast defense, treated merely with regard to land forces, divides itself into two distinct headings:—

1. The defense of open coasts from landing in force.
2. The defense of coast fortresses, and the land and limited area of sea immediately adjoining.

Coast Defense not practiced.—With the artillery practice of the first of these problems I do not propose to trouble you. The defense of coasts outside the influence of coast fortresses is, in the absence of naval protection, best undertaken by a field army under generals skilled in ordinary warfare. Practice in this work is, no doubt, desirable, and it is somewhat remarkable that the peace maneuvers of a nation like ourselves, with such an extent of coast line, nearly all run in the direction of fighting imaginary battles inland, and rarely assume the form of coast defense in conjunction with the navy. There is, however, little or nothing technical in this form of defense.

Technical knowledge needed by Officers in command of Coast Fortresses.—With coast fortress defense it is different. Here it is most important that officers in command should have a considerable amount of technical knowledge, for a large proportion of the troops they deal with need much technical knowledge to make good use of the instruments given to them for defense. No portion of the army so much needs the application of discipline, as defined by Hamley. He says:—

"Discipline means cohesion of the units and suppleness of the mass. * * * It means the most efficient combination of many and various parts for a common end."

Want of unity in our system.—In our service the defense of a sea fortress is carried on simultaneously by several necessary branches. Where this is the case there is a tendency for each branch to work entirely for its own hand, regardless of the rest, although all are working for a common cause. Every effort must be made to counteract this tendency. Information, vital to the very existence of one portion of the defense, is apt to be withheld from other portions on whom its existence depends.

Coast Fortress Defense by the Navy.—Now and then we hear the cry (rarely, or never, I think, from the navy itself) that these and other anomalies should be knocked on the head by copying foreign nations, and handing over the defense of coast fortresses entirely to the navy. If our navy intended to relinquish the command of the sea, there would be some reason in copying the system of nations who will probably shut themselves into their ports in wartime; but is there any doubt that the *rôle* of the British navy is to shut up foreign fleets? When it ceases to do so and takes to doing land work, the end of our great Empire will be within measurable distance.

System bad, but simple remedies only needed.—The organization for coast fortress defense in these islands may be a little sick, but it seems hardly necessary to prepare for its funeral before trying cheap, simple and common-sense remedies. Small changes in organization and an alteration in the system of command might do much, but if this fails, unification of the various branches into a coast defense corps would, without doubt, bring about the "efficient combination of many and various parts for a common end."

Practice of Coast Artillery mainly dealt with.—This lecture deals with the practice of one of these separate branches; one which, so far, only deals with guns and aërial torpedoes. A fair definition of the goal of coast gunners is given in the new "Garrison Artillery Manual":—

"The sole test of a perfect artillery organization is the power exhibited by the defenders of any unit, whether section, fort, group, or single gun, to direct on an indicated target, at the shortest possible notice, a rapid, accurate, and effective fire, and to maintain that fire until its object is secured." Let us see what approach has been made to this ideal.

Great advance in last decade.—Probably no portion of the British army has, by internal change of method and organization, during the past decade, taken so close an approach to a new departure, or made so remarkable an advance in its preparation for war, as the coast artillery. It is the only arm which has pushed itself markedly in advance of the corresponding branch of other nations, while it has derived less help from their methods. More than any other it has tackled the difficult problem of utilizing but partially trained militia and volunteers to the best advantage. It has depended little on the pomp and glitter of parade: indeed, it was not until coast artillery were relieved from battalion drill and ceased (as infantry) to swell the ranks on show parades, that any real advance in their own profession was possible. During a whole century they realized the impossibility of their being made both first-class artillerymen and tip-top infantry soldiers. Coast artillery has, in fact, pushed its way on, with great determination, in the face of many disadvantages. It has never had, and from the nature of things never will have, the newest possible armament: this is rightly given to our first line of attack—the navy; but it may fairly claim to have developed new beauties out of old weapons, and to have enabled these to hold their own with the new.

Reasons for Coast Artillery being unattractive.—Coast artillery has never been made an attractive service; though its work is often extremely interesting to its votaries. Its doings are little seen and never rewarded. No honors, titles, or promotion, out of the ordinary run, fall to the lot of the coast artilleryman, while blame and censure are always before him. No clear range can be secured for his shooting, as is the case with other arms; and all ranks go to their practice from day to day with a heavy responsibility on their shoulders. If, after hours of weary waiting for a clear range, any link in an extensive chain chances to give way and an accident, or anything near an accident, occurs, the British public cries loudly for a victim, and the coast artilleryman is apt to be offered up. He has had, in the past, little or nothing to do with the position in which his guns are placed; but if, owing to faulty position, he chances unwittingly to bombard ships or adjacent or opposite land, his is the meed of blame.

Difficulties met with by Coast Artillery the immediate cause of improved methods.—The trials of the coast artilleryman are not enumerated merely to suggest that he is an ill-used being, but to show that his merit is great in that, in spite of disadvantages which would have discouraged less sterling metal, he has brought his arm into a condition of efficient organization; and that this satisfactory result would probably never have been attained but for the practice which he has been compelled to carry out under conditions which, unlike those of other arms, impose a heavy load of responsibility, even during peace, on the shoulders of its leaders. "Necessity is the mother of invention," and the necessity of some working organization has been impressed on the minds of coast artillery by the risks they run during peace practice. They have produced the necessary system. There is no pretence that it is perfect, but it is workable.

Personal retrospect.—If you will excuse the use of the personal pronoun for a brief space for convenience in relation, a short personal retrospect may help to bring home more forcibly the difference between coast artillery practice of the present day and that of ten years ago.

In 1883, circumstances necessitated my exchanging from field artillery, and I was given the command of the artillery sub-district which contained the Spithead sea forts. Several years had elapsed since I had been a garrison gunner, and I made up my mind to resume the study of coast artillery work as a humble learner. I soon found, however, that there was little new to learn. The one thing my officers looked forward to was a change into the then more favored branches of their corps. Armaments had got a little heavier, but, in their use, there was no advance. Ammunition was stowed anyhow, unsorted: that is to say, cartridges with quite different shooting powers were mixed up in the same magazine, and shells of the same nature, but of different shapes and sizes, were placed together for use. Guns in casemates were still laid over sights both for elevation and direction. No practical means were provided for the commanding officer to enable him to ascertain the direction in which any given gun could fire. Range-finding was both slow and uncertain. Nothing was provided to enable orders, direction of targets, ranges, &c., to be passed from the top of the fort, or other place where a target could be seen, to the guns in the gun floors; or instructions to the magazine floors, except some miserable speaking tubes, the use of which irritated everybody who had to deal with them, or the alternative use of a large proportion of the available force as orderlies on ladders, to pass the word from mouth to mouth during all the noise of firing, hammering of levers, and shouting of executive words of command, which was then part of the drill. With communications in a mere single fort in so defective a condition it will readily be conceived that I could exercise absolutely no control in action over the other four forts, for whose doings I was supposed to be answerable, and no combination between these was possible. This, at the time, did not much concern me or attract serious attention, as the whole of the men of my division, supplemented by all the force I could borrow from a brother lieutenant colonel, were not sufficient to man completely one of my forts. Militia and volunteers were not utilized as they now are.

The mere gun drill of individual guns was very good; but this, the elements of gunnery, and the moving of guns, were nearly all that was taught. Stationary targets, generally barrels with a flag on them, were alone provided;

and moving targets, except when these chanced to drift, were not recognized. An old tug, only partly at my disposal, was the sole means of transporting my troops to the forts, or of enabling the forts to be visited.

Station Practice.—Very soon after I had taken up my command, I was ordered to carry out what is called "station practice," a most wise and useful expenditure of ammunition, which consists in firing three rounds from every heavy gun which can be safely fired, every two years, to test the working of guns, mountings, and the fittings of the forts generally.

Experiences of a day's firing.—I shall never forget the experiences of that day!

The usual barrels were moored as targets. I could easily distinguish them from the top of the fort, where, as nothing was laid down for my guidance, I took my station; I soon found, practically, that they were not as easily seen from the guns. After much speaking through tubes and sending verbal and written messages, it was reported that certain guns could bear on one of the targets which I had endeavored to indicate, and of which I had given the range. Word was passed that the guns were loaded with Palliser shot, and as soon as I saw that the range was perfectly clear in the direction of the indicated target, the order was conveyed through the speaking tube to fire. After what seemed to me a long delay (caused by passing the order), a gun went off. To my horror I saw the huge shot going wide of the mark in the direction of a buoy, not very far from which were some boats. It pitched, fortunately, over the buoy and well clear of the boats. There were recriminations, but owing to want of real organization it was difficult to justly affix the blame. The buoy instead of the barrel had been aimed at.

After a long delay, I was able to point out the targets from the guns themselves; their bearings on the traversing arcs were marked, and practice recommenced.

Later on a man-of-war came along from behind. When I considered that she was nearly within the limits of danger, I sent down messages to stop firing. Owing to the length of time occupied in conveying the order, just as she was passing fairly close to the fort, a 38-ton gun loaded with shrapnel was fired. The shell burst at the muzzle, the sea was churned with splinters, &c., and I looked anxiously in the direction of the ship. I could see the people on the bridge come to the side and look towards the fort; and I also saw one large fragment going high in their direction. Fortunately for me it fell well over the ship, and nobody on board seems to have been looking that way, or I should have heard more about it.

After this day's experience I saw that my commission, and even my liberty, was not worth a day's purchase unless I devised some system, which did not then exist, to enable me to control the fire of guns and carry out practice with safety. I have labored almost continuously at the task ever since, in the fullest sympathy with officers who are called on to assume the responsibilities of heavy gun practice, but I have found it very difficult to bring home the necessities of the situation to those who have never had to assume these responsibilities of fire from elaborate forts into a crowded seaway.

Organization, 1883, *non-existent.*—Organization, other than that in pure drill, was non-existent.

Contrast 1891.—Contrast this condition of affairs with the organization of coast artillery which existed two or three years ago at Plymouth. I mention this somewhat antique date because since then a change in the sequence of command has been made.

Description of Organization at Plymouth.—The fortress was divided into three sections, two of which had to do with the sea front; and it is only with the latter that we have to deal.

Section C. R. A.—Each of these sections had a C. R. A., a lieutenant colonel, who was responsible for, and with a very little better means would have been actually capable of, controlling the fire of any group of a very large number of guns, mounted in many forts, dispersed over some miles of sea coast. With well trained subordinates it was, however, quite unnecessary for him to exercise so elaborate a control. His function was preferably to assist, and not to worry, those engaged in practice, by using his head as one free from details, watching the course of events, interfering as little as possible when all was going well, but with full powers and opportunities of checking wild fire or of indicating any action he thought advisable, particularly with reference to causing the fire of forts to support each other. He could, in fact, switch fire in any direction he thought best.

C. R. A.'s Station.—He was supposed to have a station, covered in, and supplied with charts and various appliances, from which he could observe all the water commanded by his guns, and indicate exactly what he wanted them to do, but only in one case was this nearly arrived at; while it is evident that in any section comprising many miles of coast line there must be cases in which the forts will see their targets sooner and better than a sectional C. R. A. can hope to do—an additional reason why he should be chary of interference. Unless great tact is used, a long line of wire is but a poor prop for discipline to rest against.

Fort Commanders.—The immediate subordinates of the section C. R. A. were his Fort Commanders. Each of these had the entire command of a fort or battery of guns, and was responsible to the section C. R. A. for fighting that fort to the best advantage. He, too, was supposed to have a station in, or as near as possible to, his fort, with range or position finders, however far away, in easy communication with him, worked by his staff under his direction. Good communications with every part of his command were very necessary, but were seldom forthcoming, and generally temporary expedients were rigged up by, and too often at the expense of, the artillery themselves. If any one of his appliances broke down, the fort commander was on the spot, and could take up any means available of continuing fire to the best advantage. Thus at target practice the position finders were sometimes put out of action, and the fort commander, without much delay, continued fire with depression range finders. He was deprived of these in turn, and of his communications, and repaired to the gun floors, when he was in no worse a position than was a C. O. in 1884. A fort commander, with the aid of his staff, had to watch his target, indicate it to his groups, judge its speed, range his guns, and, having a far less area of sea to deal with, go into fighting details to a much closer extent than the C. R. A. of the section.

In large forts the fort commander had the next senior officer or officers to assist him, to be ready to take his place in the event of accident, or to temporarily occupy his station if he chose to visit any portion of his command. They were called sub-commanders, and he generally employed them as his substitutes during target practice, on the gun floors of casemates, or in the more distant parts of large open forts, to prevent any friction between lesser units and to see that the range was clear, which can only be decided with safety from the neighborhood of the guns.

Groups and Group Officers.—The guns were divided into groups, each generally consisting of four or less guns, and forming a subaltern's command. Each subaltern thus became the "Group Officer."

Numbering Groups.—Each group was numbered in succession from the proper right of the fort and had a symbol, easily seen at a distance and in comparative darkness, consisting of a figure, the number of points on which indicated the group number. Everything connected with this group that was peculiar to it was marked with this symbol, so that the most untrained artilleryman, if he once knew the form of his symbol or its number, could hardly help finding his way in the most complicated fort. Militia and volunteer artillery were taught these symbols in their drill sheds.

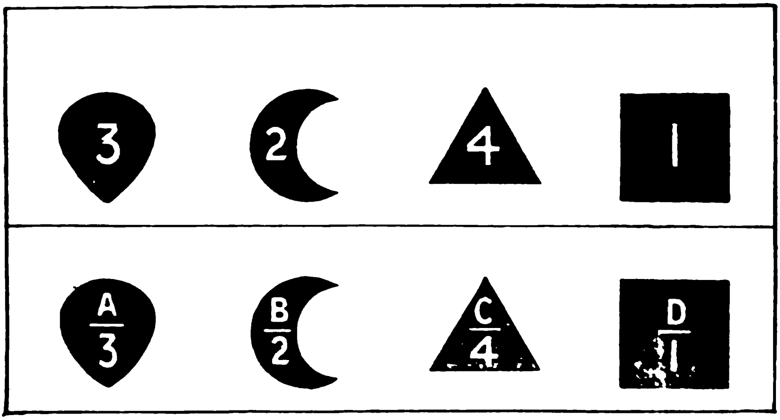


Figure 1.

Unfortunately this simple system of group symbols has been complicated by adding letters as well as numbers to the groups. And this has lately nearly led to accident at practice. The groups instead of being numbered from the right, from 1 upwards, are now lettered A, B, C, D, &c., but there is a great similarity of sound in B and D, and mistakes are made, while the form of symbol has no reference to the letter.

* * * * *

Every gun had one or more trained layers, and laying was enormously simplified by these men having to perform but one operation, viz., to lay correctly for line, elevation being given by clinometer or arc on which ranges were marked.

Each gun was commanded by a No. 1 or gun captain, who was responsible to his group officer for its correct service.

Magazine Officer.—The officer in charge of magazines was, or should have been, in direct communication with the fort commander, so that, in the event of the guns being short of supply, the latter could adjust the matter on complaint being made; again, avoiding friction between units. The fort commander could give him early and direct intimation of what nature of projectile he proposed firing, or of any change, so that he could prepare for and prevent any delay in ammunition service.

Permanent Staff.—Each fort had a small permanent staft, under a master gunner or acting master gunner, quite independent of the troops allotted to it, who knew all about its working and stores, and was answerable that these were kept complete and in working order.

Somewhere in or near each fort or place of landing, a place of parade was carefully arranged, with group symbols and the number of officers and men required for each particular duty painted up, room being allowed for the troops to fall in opposite to these, while, close to the actual stations of the various units, arm racks were provided, in which each man on reaching his station deposited his arms and accoutrements in such order that they could readily be snatched up in the event of surprise on the land side.

Even had a body of undisciplined recruits arrived, it was possible to marshal them in a few minutes, while, by the aid of the symbols they would have found their exact places in action, and all without reference to a paper. These marked parades were found very advantageous in manning at night. It was quite easy to ascertain whether any man was missing from his place, and confusion was avoided.

Difficult Range at Plymouth the cause of good Organization.—The evidence taken before the Board of Trade Committee on target practice seaward (of which I chanced to be a member) tended to show that the coast artillery have nowhere a more difficult range to deal with than at Plymouth. It is frequently crowded with boats, and advantage has to be instantly taken of every chance which offers of a clear space for fire. Under such difficult conditions it was almost a certainty that a system developed at Plymouth would prove the most practical. The coast artillery there could not afford to toy with abstract theories in the face of real danger.

Volunteer Brigades.—Volunteers in large numbers were assembled in the fortress by brigades for a week's training. Most of these had never even seen guns similar to those they found in the forts, though they had learnt the elements of drill with old pattern guns in their drill sheds. They were trained for five working days, and on the sixth were committed to practice: the sectional C. R. A.'s at first in fear and trembling, but, as confidence in the working of the system developed, at last boldly, trusting them to fire at towed moving targets, from several forts combined, in this difficult water area. They did so without accident, and made at times excellent practice, a result incompatible with the conditions which existed in 1884.

Militia Brigades.—Militia regiments also came in considerable numbers, but, as these were available for a month or so, the pressure of training was not so great, and, though no better practice, if as good, resulted, the actual discipline was better, and, consequently those directing fire had certainly greater confidence.

Characteristics of Volunteers and Militia Artillery compared.—Comparisons are somewhat invidious; but, as it may help those concerned, I may mention that artillery officers engaged in solving the problems of rapid training found that, on the whole, militiamen needed more driving, and were much more difficult to teach than volunteers, who always worked very hard and enthusiastically; but that the militia officers had a far better grip of their men, sooner grasped the chain of responsibility, and needed less close supervision and coaching when placed in command. The earlier experiments in giving either class a free hand with really heavy guns were very anxious work; and it would be better for coast artillery if the officers of auxiliary forces were more in advance of the training of their men. Other peculiarities were that the volunteers never took very kindly to the dreary work of the magazines; militia were apparently quite happy there. Volunteers appeared to love night alarms; militia would have done without them without complaining.

Existing Conditions of Target Practice.—The conditions under which target practice is at present carried out differ apparently only in name from the system last described, but, in reality, a somewhat vital alteration in the chain of responsibility is involved, which may lead to danger at target practice, and will certainly delay coast artillery from attaining the ideal organization laid down for them in their Manual.

"*Battery Officer.*"—New officials have been created, and the chain of responsibility has been lengthed but not strengthened. The first of these are "battery officers." These are expressly said to have no fire control, no fire direction. They are not to interfere with group officers firing, nor with ammunition officers; are not to concern themselves with the target nor with the order or rate of fire. It is possible a battery officer of an active and energetic disposition may, with the best intentions, seriously impede work, for lack of something else to do.

"*Fire Commander.*"—The "fort commander" is abolished, and the new creation is a "fire commander." It is laid down that "he exercises fire direction over one or more forts" (which approaches the duties of the section C. R.

A.), and that he may be assisted in the duty by one or more sub-commanders having fire direction under him.

One Fort may have two Fire Commanders.—There is a converse which appears to have escaped notice, viz., that there are instances under this system where one fort will be burdened with two or more fire commanders. As they will probably be each some long distance away, forts so circumstanced will have sub-commanders. Will two sub-commanders, under two separate fire commanders, at the same fort, be likely to strengthen discipline and add to the facility and safety of practice? On the other hand, if there is only one sub-commander, will he not have rather a tough time of it between two superior officers? Communications are very delicate, and the temptation to find them out of order would prove sometimes too strong. Possibly with experienced and well-disciplined troops it may work for a time, but the large majority of those who work our forts cannot be so described.

Resistance to current of Discipline.—On the test board of an electrical system, each key added increases resistance to a current which flows best where no keys are interposed. So it is with the current of discipline. A commanding officer should be placed as close to his troops as circumstances will permit; they will fight best when he, who can praise and recommend them for reward, witnesses their deeds. Placing a commanding officer at a great distance from his troops, and adding officers to filter his orders through, adds to the difficulty of fixing responsibility in the event of accident, or faulty shooting, at target practice, which is a valuable test of good discipline. Fire commanders, if far away, will find the control of partially trained artillery more difficult, for they will not be able to visit them, and danger and anxiety at target practice will ensue.

Position-finding Instruments used as Range-finders.—Quite lately, however, a great concession with regard to the use of position-finding instruments has been made to the coast artillery gunner, and it is now recognized that he may use them as he uses a depression range-finder, which, though it has always been comparatively very badly found, has hitherto, from its simplicity, and from the rapidity, accuracy, and safety of the practice carried on with its assistance, always been a favorite with coast artillery, though they have never been supplied with a sufficiency of these instruments to enable them to fire at more than one of two targets, even though eight or ten groups were in action. This concession will have far farther-reaching results than is generally recognized. One position-finder has usually to work a few guns grouped together. Group-firing by prediction—in which the position-finding operator predicts a point at which a target will cross, sets his telescope on that point, sends down automatically the necessary elevation and bearing to the group of guns, and fires them by electricity if the target comes on the guessed spot—has been well described as "a method of ensuring inaccuracy of fire," for the guns either fired parallel to each other (though they might really be further apart than the ship or target is long), or their fire was concentrated for one particular range, when displacement and other causes of inaccuracy were involved, unless each gun had a position-finder to itself, an alternative complicated in working and expensive both in men and stores. With the position-finder worked as a predictor, it was useless to attempt the destruction of a given portion of a ship. Coast artillery are now within measurable distance of having it in their power to do so, and, thanks to the labors of Captain Orde Browne, they will soon have the chance given them of selecting not only a particular ship as a target, but the most vulnerable part of that ship, and of pouring on to that portion a hail of concentrated, as opposed to a slow dispersed, fire.

Diagram of War Vessel, with vulnerable areas indicated.—Here is a diagram

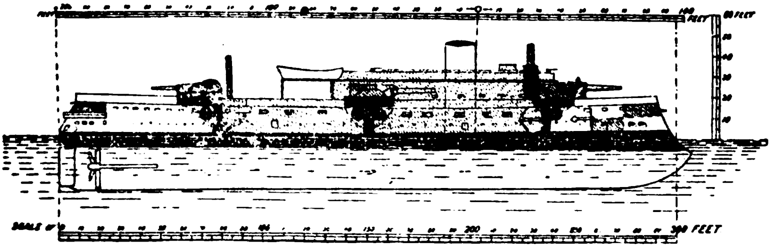


Figure 2.

(Fig. 2), taken, with no attempt at accuracy, from "Brassey's *Naval Annual*," but shaded with red, and with still deeper red spots, representing favorable places for attack in proportion to the intensity of the coloring. An officer, responsible for fire direction, can choose at a glance which section of the ship offers him a chance of doing the most damage, according to the quality of his guns, and he has the power of so ordering deflection and elevation that, while the layers continue steadily to lay at stem, stern, or funnel, at his will, he has a good chance, when once his guns are ranged, of pouring all his fire into that section. This was formerly impossible.

Predicted Firing.—Predicted firing is slow and uncertain. Steamers towing targets at no great pace sometimes make several long runs without a shot being fired when *real* accuracy is sought. It is an advantage, of course, to have the power of prediction, especially for long-range, high-angle fire, and in the very rare instances in which smoke interferes with correct laying for line from the gun and does not interfere with the position-finder; in fact, in cases where the guns cannot see their target and the position-finder can; but, as our science advances, smokeless powder will be more and more used, and the necessity for placing position-finders far away from the guns they aid will be removed.

Coast Defense requirements.—These illustrations are perhaps sufficient to show the advance made in, and the existing state of, fire discipline and in practical methods of rapidly bringing semi-trained troops into the fighting line of coast artillery; what is urgently wanted, both in organization and stores, to enable coast fortress defense to approach nearer perfection, remains to be pointed out.

Unification.—1. In organization; the various branches of defense need placing under one head in each fortress, not merely on paper, but for constant practice during peace. Without such practice it is impossible that they can work together on the outbreak of war, and the defense will be divided against itself. Unification is imperative. It absence has already led coast artillery to almost ignore mine defense, guard-boat defense, and moving torpedo defense, though none of these can exist without gun protection.

Knowledge of what is being done elsewhere.—Next it would be most advantageous to each separate fortress if it knew what was being done to advance the common cause in other fortresses and on the experimental ground. Coast artillery has lost much by the abolition of the Inspector General of Artillery, whose inspections, when he understood that branch, conveyed useful hints, kept them up to the mark, and prevented useless deviations from the path of true advance. Experience then points to the advantage of the appointment of an Inspector General of Coast defense, whose general experience of many fortresses should be of the greatest value to each commandant. Such an appointment would tend to apportion the comparative value of each branch of defense, and lead to the money of the nation being sensibly spent.

Requirements of Coast Artillery.—As regards coast artillery practice taken by itself, the following appear to be the present chief wants.

Good and fast Steamers.—Men and stores must be transported rapidly to and from the forts, and targets need towing at a pace somewhat corresponding to that of modern ships. Such steamers are still needed everywhere. It is highly probable that if coast artillery are enabled to practice at really fast moving targets, very much will be learnt, disputed points will be cleared up, theories will disappear, and many fallacies will be exposed.

Good Communication.—The term "communications" has been frequently used. It covers a multitude. The perils of peace artillery practice show clearly enough that every section C. R. A. in coast defense should be able to receive and send messages by night and day without confusion, both from and to those above him, and his adjoining C. R. A.'s, and to his fort commanders. Unlike field warfare, there is no difficulty in the matter, for fixed stations are operated from. This necessity is most rapidly and surely met by telegraphs, and it has lately been suggested by more than one able coast artillery officer that the best form would be a printing telegraph. There could then be no mistake. Telephones are slow, irritating, uncertain, and inaccurate, especially during firing. It is still more necessary that the fort commander should have rapid and unmistakable means of sending, at any rate, some orders, and getting back intimation of their correct receipt. It is, for instance, of vital importance in peace practice that he should be able to countermand an order to fire. A case occurred where militia were manning a large fort, some groups of which were casemated, when a fort commander, believing he had his groups in hand, sent an order to fire by "Groups from the right." He had no sooner done so than circumstances led him to countermand the order. Bugles, telephones, &c., announced his determination, but without effect. The casemates had wooden floors and were exceedingly noisy, and nothing could be heard; group after group, once committed to action, continued to fire until hastily dispatched messengers reached them.

Electric Bells.—A remedy for this would be communication in the form of electric bells over every gun, started by the fort commander, and arranged to continue ringing until switched off by the gun captain, who would at once order "Stand fast," and report to his group officer.

Order Dials.—Order dials are sometimes suggested, and have been used, but they are not satisfactory. Passing orders from mouth to mouth is worse. The changes of elevation and direction from the existing elaborate position-finder dials, which entail the use of a large trained staff, are a source of noise, confusion, and error, which tend to keep fort commanders in a state of anxiety. If dials are used they should be extremely simple, easily worked, and close under the eyes of the men who have to comply with the order they convey, nor is there probably much difficulty in meeting these conditions.

Targets.—The question of targets for coast artillery is one of far more importance than is generally realized. While mere anchored barrels and targets of that kind were the only articles made available, coast artillery practice never soared above sight-laying and the service of individual guns. Such targets teach no tactics. If they are visible they offer few of the difficulties a layer would experience in firing at ships, and but little practice in picking up a range. As often as not when they are knocked over it is by a shot more or less abnormal to the rest of the practice. Shooting at such marks led to slow work and a feeling that luck had more to do with results than brilliant training and good work.

Small towed Targets as imaginary Ships.—Shooting at more or less imaginary targets, as for instance, towing some small target and building up, in

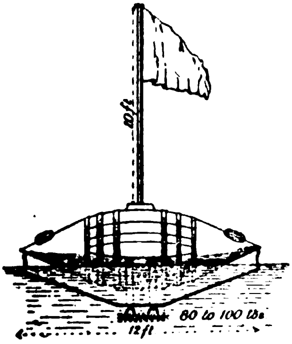
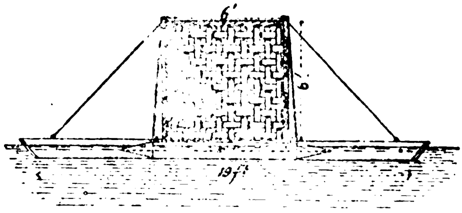
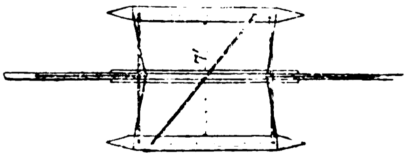


FIG. 4.

HONG KONG.



SIDE ELEVATION



PLAN

fancy, a ship round it, has been tried (Fig. 4, and Hong Kong). It is very cheap, but is but a shade in advance, and has delayed progress. Nearly everything is guesswork. Somebody in the fort, often not exactly behind the guns, guessed the line, and the range officers guessed the unders and overs, sometimes aided by rude instruments. The results of all these guesses were tabulated, the angle of the falling shot calculated, and the whole referred to diagrams, resulting, without much trouble, in the whole of the shot striking an imaginary battle-ship; yet our practice at record targets, where each shot has really to make its mark, hardly bears out the beautiful accuracy of this class of shooting. The target, a comparatively small point when seen over the sights, is easy to lay on. It is really the point fired at, but for the purpose of these calculations was generally transferred to the center of the imaginary ship, a method which especially suited the dispersed fire of the position-finding system. Unders and overs, shots ahead and shots astern, alike counted as hits, the positive impossibility of laying at the real center of a ship being ignored.

Record Targets.—The diagrams, Figs. 4–7, show the comparative size of most of the targets which have been used for towing, except one large, clumsy, and expensive structure, which was used at Plymouth long ago, and which was the first attempt at a large target. All the large "record" targets (so termed because each hit leaves its record on them) are, somewhat unfortunately for me, after my designs. Thoroughly convinced of the gain which would accrue to coast artillery from firing at rapidly moving large record targets, I have spent time and money in successive attempts to produce one. It has been uphill and thankless work. Here is a model of the latest which has been made. It seems to offer less resistance to towing, and has answered well in several trials to which it has been subjected. It costs about 13*l.* when of the size of 36 ft. by 12 ft., and is very simple to repair. The original has received an immense amount of punishment and is still as serviceable as ever.

All these "record" targets merely tow behind a steamer, which, for considerations of safety, can only move more or less *across* the front of a battery. None have as yet attained a high towing speed, though this one promises it. No steamer has been available for towing it fast.

Targets are much wanted which will advance and recede rapidly from the batteries. It is quite easy to produce targets, actuated by the wind, which will do this, but if made of anything solid and left to move free they are said to be dangerous to navigation, and would be objected to. I endeavored to produce a target made of large india-rubber balls, but the price was prohibitive and the wind acted singularly little on them. With a wind registered at 20 miles per hour blowing off shore, a thin india-rubber bladder (such as children play with), about 10 in. in diameter, though it seemed to displace an exceedingly small amount of water, travelled for 1,200 yds. at the insignificant rate of two miles per hour, its progress being recorded by taking its range every half minute with a depression range-finder. Only a very limited trial has, however, been yet made of these, and probably this is the direction which

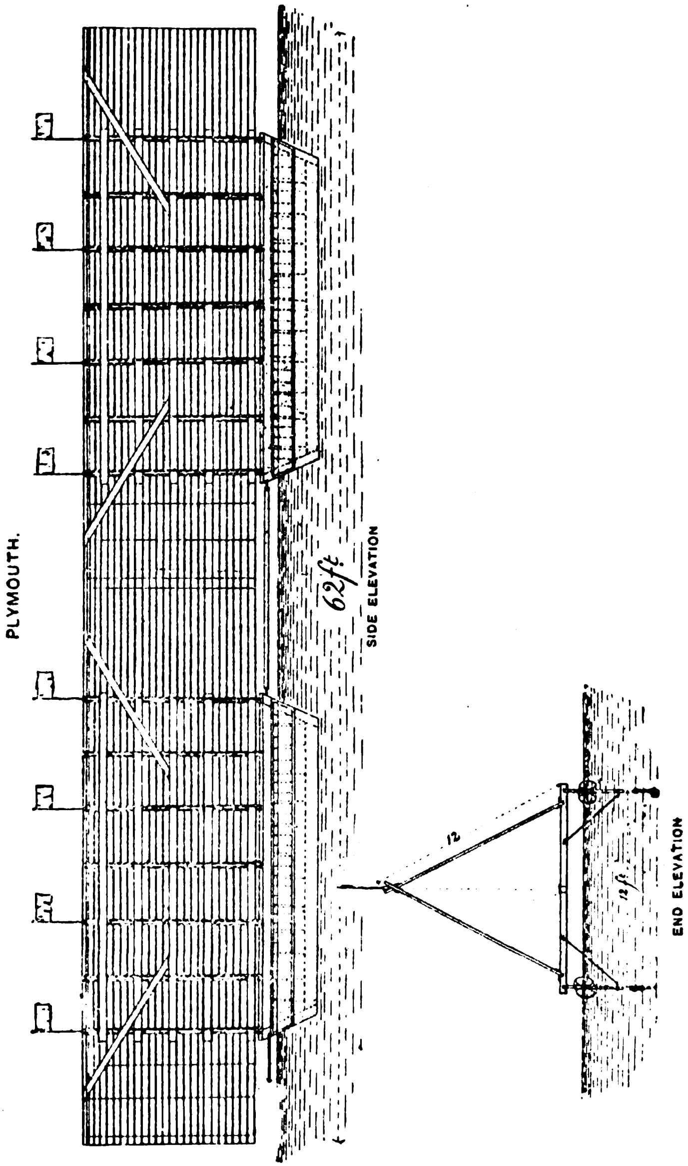


Figure 5.

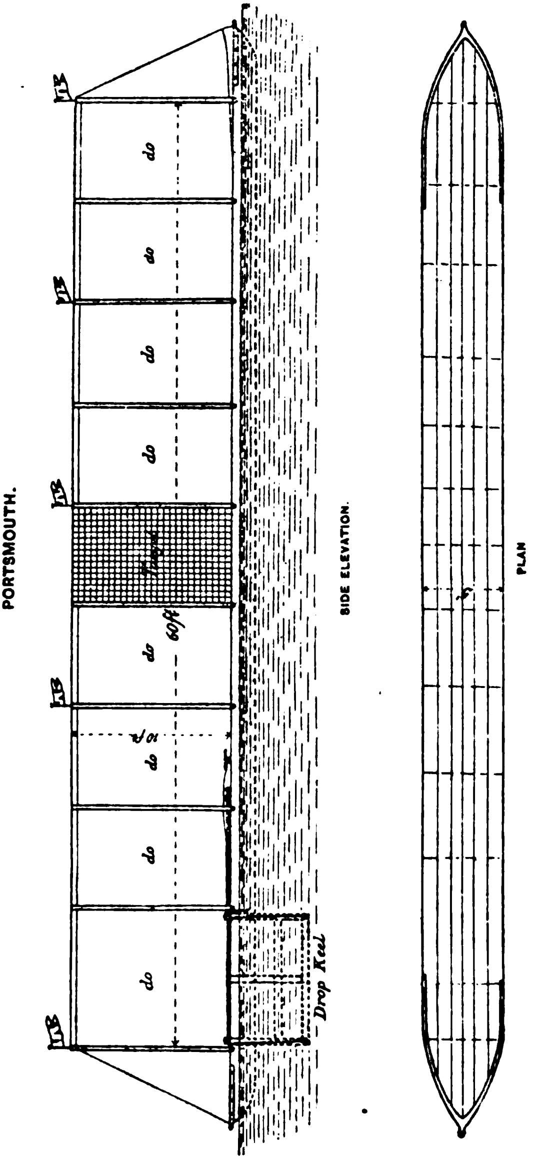
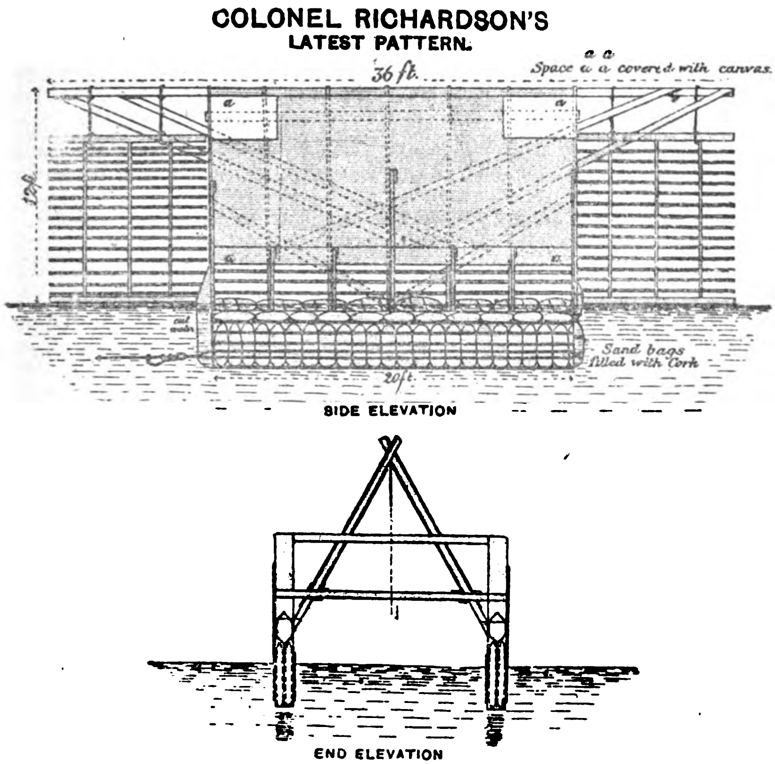

PORTSMOUTH.
SIDE ELEVATION.
PLAN
do
do
do
do
Target
60 ft
do
10 ft
do
do
do
Drop Keel

Figure 6.



COLONEL RICHARDSON'S
LATEST PATTERN.

SIDE ELEVATION

END ELEVATION

Figure 7.

is most promising.

Nothing short of a battleship is a perfect target for heavy coast guns, but these cost half a million, and it is doubtful if they will make themselves targets, even in war time, if coast artillery are really well prepared. In the hope, however, that the publicity this Institution gives to lectures will induce someone to come forward and release me of a self-imposed but costly task, the conditions which large targets should fulfill are appended.

Towing Targets.

(*a*.) A towing target must not present a less area than the probable vertical rectangle of guns fired in groups under service conditions with a practical maximum of correct service, but the larger the better if it fulfills other conditions.
(*b*.) Must offer little resistance to towing when moving at a good pace, say, from 7 to 12 knots per hour with a tow-rope of not less than 300 yards.
(*c*.) Must be inexpensive, as it may be destroyed by exceptionally accurate fire.
(*d*.) Must be capable of easy, rapid, and inexpensive repair.
(*e*.) Must be capable of being towed in reasonably rough and stormy weather.
(*f*.) Should be a "record" target, *i. e.*, should register all hits.
(*g*.) Must show a water-line of somewhat the same nature as that given by a ship.

(*h.*) Should admit of something being carried away by each shot, so that a range party in the towing vessel may know when it is struck.
(*i.*) Should have some beam, so as to equalize to some extent the conditions of fire from high and low-site batteries.

Other Moving Targets.

A target which is capable of moving either towards, from, or across the line of fire is a desideratum. There is, however, little objection to one target for moving in and out, and another for towing across. Unless easily dirigible, these must not be solid or dangerous to navigation.

A smaller target, representing a torpedo-boat, capable of very rapid movement, is also much needed. It should be capable of being worked both by day and by night.

At many of our large fortresses the form of attack coast gunners have the greatest difficulty in meeting is the modern equivalent of the old cutting-out expeditions, viz., attack, by small squadrons of torpedo-boats, on the shipping covered by their guns. To produce a good defense, practice at very rapidly moving targets, which sit low in the water, is very desirable.

Navies have elected to meet torpedo-boat attack chiefly by quick-firing gun fire, and coast fortresses appear to be following the lead without trial; but the result of all-round fire of this nature on other ships of the same squadron has not, perhaps, been sufficiently considered. In many of our coast fortresses it is, at any rate, probable that free shooting into the opposite forts and shores will be seriously objected to. Opportunities of practice at targets somewhat resembling torpedo-boats in size and speed may lead to the discovery that small quick-firing guns are not the most suitable weapons to meet torpedo raids.

When shooting big game with great vital powers, large bores and heavy bullets are used. Small game is far more easily disposed of by fairly large bores and small shot, while the danger to outsiders is minimized; and the analogy may hold good in coast artillery practice, but without real practice at good representative targets, everything is wrapped in theory and doubt, and coast artillery cannot solve the question as satisfactorily as they have met the altered conditions with regard to battleships.

Defense by Night.—Again, if such a target is made available for coast artillery, they will be in a position to solve another problem, which is at present in a backward state of solution, namely, how gun defense in all its branches is to be made as effective by night as by day. The way in which the water area commanded by the guns is to be lighted at night and in damp weather, with smoke hanging, has not, so far, been placed in the hands of coast artillery to deal with, though it so intimately concerns their efficiency. Even the electric lights they now work are run by another branch of the defense, in their own fashion, an additional instance of the need for unification. When really rapid targets come into use it is more than probable that, better recognizing the difficulties with which they have to contend, artillery will demand better methods of application of the electric light itself for their own purposes, or even abandon it altogether in cases where the configuration of the shore admits of the use of a better light for showing up torpedo-boats, &c.

Use of High Explosives will have to be considered.—In the near future, arrangements will have to be made to produce targets for practice with high explosives, but these present little difficulty. There is no reason, as far as the range for peace practice is concerned, that there should be more danger to be apprehended from such projectiles than at existing practice. The shells go into very small bits, and these do not range anything like as far as the ricochets of the projectiles now fired. If the shells do not burst in the gun or at the muzzle, they will not burst until they reach the end of their flight.

Placing of Guns.—The practice of coast artillery is enormously influenced in its quality by the way its guns are placed and mounted. Gunners endeavor to make themselves responsible for the efficient gun defense of their fortress, but their difficulties are increased by the forts, batteries, and gun sites being designed and placed by others. Defense would be very much strengthened, probably at a considerably reduced outlay, if the position and style of mounting of guns were largely influenced by coast artillerymen, and the same may be said of the position and construction of range-finding cells and lights. Peace practice often affords an excellent practical test of the wisdom expended in choosing sites. If guns are placed in bad positions, and are ill-mounted for the work they have to do, danger at practice almost always results. Guns that would do more harm to friend than to foe in war-time had better not be mounted. It would be perfectly easy to test sites by target practice before expending large sums in permanent emplacements and batteries; and the real defense of fortresses would be enormously improved, while coast artillery would not be troubled with the work of forts in the practical value of which they do not believe.

Caution of Coast Artillery during Practice.—The very great caution used by coast artillery during target practice is evidenced by the fact that, though some 63,000 rounds are annually fired seawards at targets by royal artillery, militia, and volunteers (excluding Shoeburyness), up to the date at which the Target Practice Committee commenced sitting only 11 complaints of accidents, or approximation to accidents, had reached the War Office since 1864, a period of 28 years, while in only one of these cases was any injury done to anybody, when artillery, firing from Plymouth Citadel, in 1864, with old smooth-bore guns, struck a boat, after a shell had made several ricochets, and unfortunately killed a man.

Cases of Chance of Accident not officially recorded. But though these are the only officially recorded cases, there have no doubt been instances where projectiles have gone a great deal closer to boats than the officers in charge of practice liked, and still more frequent instances in which, though no danger to vessels or boats ensued, projectiles have not pursued a course intended by the commander of the practice, either from his orders not being correctly conveyed; from mistakes, most frequently caused by too great reliance on the use of instruments; by long and weary delays; by commanders themselves not having experience of the work; or, in the vast majority of instances, by the uncertainty of ricochet.

Ricochet.—Coast artillery practice would be generally simple and safe were it not for that scourge of the coast gunner—ricochet, which is responsible for nearly all the mishaps which have from time to time brought the artillery into trouble.

Shell fired from guns *ought*, theoretically, on striking a plane surface to ricochet to the right, unless they strike at such a falling angle as not to ricochet at all; and inexperienced (and even experienced) officers at times have trusted too much to this theory, and judged that the target was safe for practice when they saw that the line of fire and all to the right of it was clear. But the surface of the sea is hardly ever a plane surface, and what are called abnormal ricochets, though they are strictly in accordance with natural laws, occur. Every now and then a shell striking a wave flies to the left. There is no possibility of telling when this may occur, but it happens most frequently in rough weather.

Suggestions for minimizing Ricochet.—No witness who appeared before the Committee offered any practical suggestion for minimizing ricochet—the greatest source of danger in target practice; yet the matter is fairly simple, and from its importance, not only to the increased safety of target practice, but as a solution of the difficult question of land-locked channels by gun fire, in which at present friend and foe are involved in equal destruction, it is very much to be desired that attention should be drawn to it. It will be only one more of the many additions to practical defense which have been brought out by target practice.

Non-ricochet Heads.—It is known to many artillerymen that flat-headed projectiles ricochet but little, and it is probable that a slightly recessed head would ricochet even less, while those of the service shape ricochet more freely, or as freely as any. Projectiles for fort guns in locked-in situations, and especially those on high sites, would be as effective as at present, and in some cases more so, if they were made with non-ricochet heads, while many forts which cannot now practice their armaments and their personnel could and would be far more ready for war if made available for target practice. It has also been suggested that coast artillery should do as the navy do, and practice with reduced charges. This may be practicable with B. L. guns not on disappearing mountings, and where recoil is a matter of no moment. The naval mountings for the most part differ from land service mountings. In the latter, and especially in muzzle-loading gun mountings, the rapid service of the guns depends largely on a full recoil.

But ricochet is undoubtedly greatly reduced by using reduced charges. * * * With an angle of descent of 10° there is generally no ricochet from water. It is impossible for any inspecting officer to be sure that forts, guns, and mountings are really in an efficient condition, however close his inspection, without firing ammunition such as would be used on service; and experience shows that practice, and practice alone, under conditions which resemble what may be expected in war, can ensure perfect preparedness. Perfect readiness and organization are what coast artillery attempt, and the nearer these are attained the more it becomes certain that the fortresses, of whose defenses they are the first line, will never be attacked from the sea by ships.

Destructive criticism is easy enough; but whenever remarks have been made adverse to existing systems of practice it has been my endeavor to suggest corresponding remedies. Discussion is the most valuable aid to improvement, and I hope that coast artillery practice will gain much in this way to-day. It is frequently the case that more is learnt from the remarks made after lectures at this Institution than from the lectures themselves, and this occasion will, perchance, prove no exception.

THE ATTACK OF A COAST FORTRESS.

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"CELER."

DUNCAN GOLD MEDAL PRIZE ESSAY, 1893.

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At first glance the subject of the "Attack of a Coast Fortress" would appear to be almost purely a Naval one. But the subject of the Attack is so intimately connected, and interwoven, with that of the Defence, that the consideration of the former must greatly assist us in forming proper ideas as to the latter. This intimate connection with the subject of Defence, about which so much has been written and published—and notably the valuable and comprehensive article by Colonel J. B. Richardson, published in the "Proceedings", R. A. Institution for January last—makes it almost impossible not to travel again, to a certain extent, over ground already traversed by others. In writing on this subject there is no desire to pretend to naval knowledge, further than that which ought to be possessed by every officer who studies the question of Coast Defence, and the Attack is therefore considered chiefly from the point of view of the defenders. This would appear the more reasonable, as we gunners are little likely to have to take an active part in attacking—except on Land Fronts—foreign Coast Fortresses, while we may very likely be called upon to defend our own coasts against hostile attack.

It is very desirable to avoid, as far as possible, all purely speculative views, and to form our opinions on the substantial basis of history. It will consequently be necessary to describe, as shortly as possible, certain actual incidents, chiefly drawn from events of quite recent years.

SECTION I. ON THE NATURE OF ATTACK WHICH IS MOST PROBABLE UNDER THE CONDITIONS OF THE PRESENT DAY.

It must be stated, as an axiom, that no attack will ever be undertaken without some definite object. A consideration of the most probable *objects* of an enemy will therefore give a key to the nature of attack which he may undertake.

It is shown conclusively, and proved from numerous historical examples, by Admiral Colomb, in his exhaustive work, "Naval Warfare," that before any attacks on sea-girt territory can be successful, or satisfactory, the Power making such attack must, at any rate temporarily, hold the command of the surrounding sea. This *command of the sea* will have to be established before the attack on territory can be undertaken, and maintained so long as the Land Forces are on foreign soil.

Now a modern ship can hardly be built and equipped during the continuance of a modern war. There is, therefore, no possibility of replacing casualties to ships by building others, and as the command of the sea must, *ceteris paribus*, depend upon the number of ships of war that each Power can maintain afloat, the value of each individual vessel is enhanced, far beyond its intrinsic value, great as this may be.* Under circumstances of a near equality in naval strength, the sudden destruction, or even total disablement, of two or three large ships might be a disastrous blow to the Power thus struck. It is not difficult to imagine combinations which might bring about this near equality.

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* Since the above was written, the following words, spoken in the House of Commons on the 7th of this month (March, 1893) by Lord George Hamilton, the ex-First Lord of the Admirality, show that the opinion of one whose judgment in these matters must be regarded with the highest respect, is quite in agreement with the view here expressed—"It must be recollected that, if we engaged in a really serious war, the command of the sea really rested with that Power which had the most battle-ships and the most fighting power."—*Standard*, March 8th, 1893.

From the foregoing considerations the following inferences may be safely drawn :—

(1.) Without waiting for pitched battles, or fleet actions on a large scale, *the destruction, or capture, of individual ships, as soon as possible, is the objective of the first importance to a Power attacking a maritime nation.*

(2.) The possibility of replacing lost or badly damaged ships during the time of war being so small, *both sides will hesitate, even more than formerly, before they risk their more valuable vessels in attempting to attack fixed defences.*

Coast Fortresses exist in a great measure for the purpose of acting as *points d'appui* for fleets. They generally contain, and are intended to protect, a dockyard, stores and coal, together with ships in various stages of preparedness for service, both men-of-war and colliers. Modern ships cannot keep the sea for months together, as could the old sailing ships of former days, and, in war time, they must have protected bases from which to operate, where they can take shelter, take refuge, refit, and replenish supplies. These bases are furnished by the Coast Fortresses.

It may be considered as a certainty that, in time of war, Coast Fortresses will constantly have under their protection valuable ships building, fitting out, repairing, or coaling. *These ships will be the primary objects of attack,* and their protection will be the primary duty for which the defenders of such fortresses will be held responsible.

A ship in port, in a state of comparative unpreparedness, is, in many ways, a more vulnerable object than a ship in full war trim on the high seas, and an additional reason for attacking ships in port is the profound political and moral effect which would be produced on a nation by the sudden destruction of their valuable ships in their very ports, and behind the shore defences.

The deliberate attack, on a large scale, of a Coast Fortress, with a view to its actual capture or destruction, not only requires, as shown by Admiral Colomb, a fully commanded sea, but is besides an operation of great magnitude, demanding all the resources of a great State, and demanding some time for preparation. The difficulties of our own Baltic fleet in 1854, and those of the French fleet in 1870 in effecting anything, even when they held the command of the sea, show how difficult it is for a sea force, alone, to seriously injure a nation through its shore defences. Even an attack with a view to the mere destruction of works is, so far as present experience goes, in many ways wasteful, the results hardly being commensurate with the expenditure, while the risk to big ships venturing into narrow hostile waters must be very great.

The bombardment of the works of Alexandria by our fleet in 1882 is a modern and most interesting example of how little really can be effected by a fine fleet, operating in a sea over which it has undisputed command, against indifferent works on low sites, indifferently armed and manned, and unassisted by any auxiliary defense, such as torpedo boats or mines.

It is therefore quite unlikely that, at any rate at the commencement of a war, either side would feel itself in a position to attempt an attack on any fixed defences on a large scale. There remain then for consideration, attempts to bombard dockyards at long ranges, and attempts to destroy ships by other methods. The former partakes of the nature of a deliberate attack on works. The latter will be considered first.

In the American Civil War, in 1861, the Confederates were fitting out the schooner "Judah" in Pensacola Navy Yard to prey upon Federal commerce. The Confederates *believed her to be so safe that no naval force would attempt to cut her out.* The vessel lay alongside the wharf, to which she was secured by chains. She was manned and armed with three guns, and on shore two more guns (one of them a 10-inch) were mounted to command her decks and the wharf, while no less than 1000 troops were kept in and about the yard.

The Federal Commodore *considered the destruction of this vessel of so much importance as to warrant the risk of a failure and the loss of men.*

At 3 a. m. on September 14th, 1861, an expedition of 100 men in four boats was despatched from the Federal frigate "Colorado." The crew of the schooner were found at quarters and ready to repel boarders. *Two of the boats made for the shore,* and this party successfully spiked the two guns there mounted. The other made for the schooner and, after a sharp fight, drove her crew ashore. *Finding it impossible to move the vessel* she was successfully set on fire. The boats made good their retreat. The schooner burnt to the water's edge, floated away, and sank.

The above incident took place little more than thirty years ago. It has been selected as comprising in small compass several most valuable lessons to be referred to hereafter.

Now the modern equivalent of a cutting-out expedition is *the torpedo attack.* Modern ships, unless actually under steam, are too heavy to remove, even if they could be successfully carried by boarding parties; and their construction is such that they are likely to be but little harmed by being set on fire. Their *destruction,* however, with as little risk as possible to the attackers, can be best and most speedily effected by means of *the torpedo.*

That this has already been realized by those nations who have had recent experiences of war can be fully proved. In the Civil War in Chili on the 27th January, 1891, the Government armed merchantman "Imperial" was lying in the harbor at Valparaiso, when an attempt to torpedo her (unsuccessful) was made by a picket boat belonging to the Congressional battle-ship "Blanco Encalada."

On the 23rd April, in the same year, the "Blanco Encalada" herself was lying in Caldera Bay, when she was *surprised,* about 4 a. m., by two Government torpedo gun-vessels, the "Condell" and "Lynch." These *acted in concert.* The "Condell" leading, steamed straight for the "Blanco," fired her bow torpedo (which missed), and then, turning sharp to the right, fired two in succession from her port side, one of which appears to have struck the "Blanco" near the bow. The "Condell" then steamed away. The "Blanco" kept her fire on the "Condell" as she fled, *without apparently noticing the approach of the "Lynch,"* which, following the "Condell," discharged two torpedoes, the second of which struck the "Blanco" amidships, sinking her in two minutes, with a loss of 11 officers and 171 men.

The destruction of a Turkish gun-boat in the Danube in 1878 by a Russian torpedo boat is another instance which will be recalled in this connection.

Such are the effects of the torpedo.

In the early part of 1882 a Committee of the Board of Trade was considering the proposal to make a channel tunnel between England and France. The opinion of the War Office was sought as to what formalities, if any, were customary between opposing States at the outbreak of war. A somewhat startling result was arrived at by Colonel Maurice, R. A., then of the Intelligence Department, after a most careful compilation of all the cases in which hostilities have occurred between civilized powers, prior to a declaration or warring, between 1700 and 1870. The words of the Report presented to the Board of Trade Committee are worth quoting:—

"The result of the investigation . . . . is to show conclusively that there has not been . . . . any established usage whatever on the subject."

"Less than 10 instances have occurred during the above period, when 'Declarations of War' have been issued prior to hostilities; 107 cases are recorded of hostilities without declaration."

"In 41 of these cases the manifest motive (in several cases the actually avowed motive) has been to *secure the advantage by the suddenness of the movement, and the consequent surprise of an unprepared enemy.*" (The italics are the writer's).

The argument can now be carried a step further.

In the British Naval Maneuvres of 1890, a hostile torpedo boat flotilla was established at the Island of Alderney, 100 miles from Plymouth. *It was determined to attack the British Fleet at Plymouth as soon as possible after receiving an intimation that hostilities had commenced.*

Fearing that Alderney *might be watched* by British cruisers, *the flotilla shifted* to Guernsey (90 miles from Plymouth). The boats were divided into two divisions, according to their speeds: one division lay in Peterport, the other *in a convenient bay* at the south-east end of the island.

Information that hostilities were to commence reached Guernsey at 6 p. m. on August 8th, 1890.

The boats immediately put to sea, each division travelling independently, *so that the faster division, at any rate, might strike a blow,* even should the speed of the others be insufficient to get them up in time.

By 2 a. m. that same night the fastest division of boats rounded the east end of Plymouth Breakwater, and surprised the ships lying there. Doubtless several of them would have been sunk or disabled. Furthermore, the confusion caused by their attack *enabled the second division of boats to come up unobserved*—the parallelism between this incident and the real attack of the "Condell" and "Lynch" on the "Blanco Encalada," just described, is worth remarking—and rounding the western end of the Breakwater, to make a second effective attack.

The Plymouth forts appear, on this occasion, to have taken no part in covering the ships. Possibly they had not been warned to take part in the operations. But they would have been hampered by the ships being in the way of their fire.

It is proper to remark that, up to this point, nothing has been quoted that has not *actually been accomplished*, while the power of all warlike appliances, and the speeds obtainable from boats, are still rapidly increasing. In the above operations the speed of the fastest division of boats never exceeded 19 knots. The new French torpedo boats have a displacement of 150 tons, and a sea speed of no less than 25 knots, while it was stated in the *Times* of 24th January last that one French boat had actually attained a speed of over 27 knots.

The number of torpedo boats belonging to France is 229, the greater number of which are of good size and speed.

This torpedo boat attack on Plymouth illustrates another great fact. *Modern speeds have narrowed the Channel*, but so silently that it is doubtful whether, as a nation, we have yet realized the fact. If, by some great convulsion of Nature, the coast of France, with all its fortresses and ports, its bays, harbors, and inlets, still uninjured, had suddenly been thrust forward, until Cherbourg was visible from the Isle of Wight, and all the possible bases of action for French ships and boats stood visibly close to our shores, what a popular outcry there would have been, and what examinations into the preparedness of our defensive system—yet this change has virtually taken place.

The following table shows the distance *in hours* betwen certain English and French ports under modern conditions, for (A) the fastest torpedo flotilla capable of doing 24 knots, (B) an ordinary torpedo flotilla at 17 knots, and (C) a fleet of battle-ships at an estimated speed of 12 knots. It is believed that these speeds would be endorsed by the Navy as approximately correct. The times are somewhat startling, when it is remembered that the

Between	French Port.	and	English Port.	Distance in miles (approximate).	Distance in hours			Remarks.
					A. Fastest torpedo flotilla, speed 24 knots.	B. Ordinary torpedo flotilla, speed 17 knots.	C. Fleet of battle-ships, speed 12 knots.	
PORTS IN CHANNEL AND ATLANTIC.								
	Cherbourg and adjacent coasts....		Portsmouth	90	3¾	5½	7½	Fractions less than quarter hours neglected.
			Isle of Wight (nearest point)	65	2¾	3¾	5½	
			Alderney	30	1¼	2	2½	
			Guernsey	50	2	3	4¼	
			Jersey	60	2½	3½	5	About 12 hours run is assumed as a limit to the radius of action of boats.
			Plymouth	140	5¾	8¼	11¾	
			Portland	80	3¼	5	6¾	
	Brest and adjacent coasts...		Plymouth	160	6¾	9½	13¼	
			Falmouth	140	5¾	8¼	11¾	
			Queenstown	300	12½	—	25	
	Dieppe and coasts		Dover	80	3½	5	6[illegible]	
			Portsmouth	115	4¾	6¾	9½	
	Boulogne, Calais, Dunkirk, &c. ...		Dover	22	1	1¼	2	
			Sheerness and Mouth of Thames	75	3¼	4½	6¼	
PORTS IN MEDITERRANEAN.								
	Toulon, Marseilles and adjacent coasts.		Malta.	700	out of radius*		58¼	*Out of radius of direct action, but boats could, and probably would, be convoyed by ships, and might act effectively at Malta from some of these ports in 48 hours from the outbreak of hostilities.
	Sicilian Coast (nearest point).			50	2	3	4½	
	Sardinian Coast (nearest point).			350	o't of radius		29	
	Corsican Coast.			480	o't of radius		40	
	Biserta (Tunis).			280	11[illegible]	—	23½	
	Toulon, &c.		Gibralter.	780	o't of radius		65	
	Minorca.			580	"	"	48	
	Iviza.			420	"	"	35	
	Sardinia and Corsica.			800	"	"	66½	

class of vessels to which columns A and B refer could deliver thoroughly effective attacks without any delay, and without attracting any attention by preliminary preparation. The fitting out of a big ship or ships must be publicly known, and that knowledge can hardly be prevented from reaching the enemy, but the movements of a torpedo boat or two need attract no notice.

That the change of conditions caused by these modern speeds has scarcely yet been thoroughly realized, is proved, not only by the surprise of the fleet at Plymouth,* but by the surprise of the "Blanco Encalada." There is no doubt that the Captain of the latter, having trustworthy information that the two Government ships were some 400 miles distant on the previous day, neglected precautions, which he would have taken had he realized that they were within striking distance.

SECTION II. ON THE GENERAL PRINCIPLES WHICH GOVERN THE ATTACK.

(1.) *Good information* is absolutely necessary, before planning an attack, as to the names and numbers of ships in each harbor, and where they are lying, their state of preparedness or otherwise. The strength, composition, and *morale* of the garrisons of the forts, the number, nature, positions, and mountings of the guns, and how fought, whether by P. F. or other systems. *The exact position of the P. F. cells for both guns and mine-fields—search-lights where placed*—position of Brennan torpedo station and how defended. Good charts of the channels and harbors, and pilots if possible. The general character of the defence contemplated, whether by guard-boats, mines, &c., &c.—if the latter, the exact position of the mine-fields and *where the shore ends of the cables are led ashore*, &c., &c. Most of this information is probably available to our possible enemies. The recent conviction of a N.-C. O. of the Royal Engineers for selling plans of a fortress to the French will be recollected in this connection. It may be

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* It is fair to the Admiral of this fleet to state that he mentioned to his ships the *possibility* of torpedo boat attack, but expressed some doubt as to whether the rules of the manœuvres would admit of it. The ships were certainly caught in a faulty position and more or less unprepared.

remarked here, *en passant*, that it is high time that our laws increased the punishment of such offences—the present maximum of 12 months' imprisonment is miserably inadequate.

2. *Speed and Secrecy* are essential; these were the secrets of Napoleon, and no words can express the importance of the former. In these days an hour or two more or less may be of inestimable value—even 30 years ago, the value of a few hours is strikingly illustrated by the case of the "Merrimac" and the "Monitor." In the American Civil War the Confederates were building the formidable armored ram "Merrimac," while the Federals had on the stocks the turret craft "Monitor," the only vessel likely to be able to cope with the "Merrimac." A month before the "Monitor" was to be launched, the Confederates, *through their spies*, learned the exact condition of the vessel, and the day on which she would probably be put into the water, and, in consequence of this information, strained every nerve to complete the "Merrimac" first, doubling the number of workmen, and working both by night and by day. The result was that, on March 8th, 1862, the "Merrimac" attacted the Federal wooden fleet, sank the "Cumberland," burnt the "Congress," and had the fleet at her mercy, when at 8 p. m. that evening the "Monitor" appeared on the scene, and prevented the "Merrimac" from doing any more mischief. These few hours' start, however, enabled the Confederates to destroy two valuable ships of the Federal fleet.

Speed caused the surprise and destruction of the "Blanco Encalada." *Speed* takes the defenders unawares—*acts* before the cumbrous paraphernalia of mines, booms, *et hoc genus omne*, can be got ready and in working order. *Speed* produces the highest moral effect—*bis dat qui cito dat* applies to blows as well as to gifts—in short, *speed* and *promptness* are more than ever before the key notes of a successful attack.

(3.) *Directness of Object.*—For an attack to be successful, it must have a definite object, laid down beforehand, to be carried out, and *all side issues must be avoided.* This applies to subsidiary attacks, as well as to chief ones. Every boat concerned must, as far as possible, have its particular mission. Any fighting should be left if possible to the covering boats, and *the real attack should* *never fire a shot* or even look aggressive, but steam *rapidly and silently* to its intended object.

It is related by General Marbot that, on one occasion, during the Russian wars, while serving as A.-D.-C. to a Marshal of France, it fell to his lot to have to convey an order to a French regiment, cut off from the remainder of the Army, and entirely surrounded by thousands of Cossacks. Two Orderly Officers had previously attempted to reach the regiment, but both had been slain. Marbot, however, had observed that both of these had started with drawn swords, and thus invited attack. He, consequently, never attempted to draw his sword, but trusted entirely to his horse, and although recognized, and "hooroooshed" by the Cossacks, yet none really attacked him, and he actually passed unscathed through their midst, reached his goal, and delivered his message.

(4.) *Subsidiary Attacks.*—The attention of the defenders must be distracted and drawn from the real attack—by false attacks, possibly in several directions at once, and by real attacks subsidiary to the main one directed against local objects—these will include *landing parties* for the *destruction of P. F. cells*, Brennan torpedo stations, and the *shore ends of mine-field cables*, with the elaborate, complicated, and easily injured appurtenances belonging thereto. Feints, and real attempts, at creeping for cables, and countermining, will also be undertaken, generally in connection with other operations, but, above all, noise and smoke must be largely relied upon to cover operations of all kinds and distract the attention of the defenders. In the midst of all the above, and probably also in darkness and thick or rainy weather, the boats of the real attack, manned by picked and determined men, must steam rapidly and silently to their real objective.

(5.) Every endeavor must be made *to get mixed up with the defenders*. If this can be managed, both the gun and mine defence are paralysed and rendered impotent for the time, and an entrance to a defended harbor may be thus gained. To escape afterwards will be comparatively easy, as there is sure to be some uncertainty in the minds of the defenders as to whether boats *leaving* a harbor or channel may not be friends.

Another point in which the defence may be made to positively a

assist the attack is by drawing as much fire from the shore guns as possible, and using their smoke as a cover.

(6.) *No attack must ever be attempted by a single unsupported boat.* An interesting instance of this occurred during the war between Chili and Peru in April, 1880. The Peruvian corvette "Union" was lying moored in the harbor of Callao. She was surrounded by a stout boom. A Chilian torpedo boat, fitted with spar torpedoes, was sent *to attack* the "Union," but on her way came into collision with a fishing boat, and one of her two spars was broken. Nevertheless the boat made for the "Union," and, finding her surrounded by the boom, exploded her other spar torpedo against the latter, destroying a portion of it, and opening a clear way to the ship. Having, however, no other torpedo available, *and no consort to take advantage of the opening thus made*, this boat had to retire, without effecting anything, at the moment when success was assured, had a consort been present. The success due to combined action is illustrated by the sinking of the "Blanco Encalada" previously quoted.

The attack by torpedo boats should be exactly similar to an attack by cavalry. The boats should act in several successive lines, following one another in pairs, or threes if possible, and slightly echeloned. By this means P. F. predictions, if lost, as they probably will be, with reference to the boats for which they were intended, will be of no use for the following lines. This point will be referred to later. Even if the leading boats get destroyed or disabled, yet success may be attained by those following, while the knowledge of support, and *witnesses*, close behind, must nerve the leaders, as also the knowledge that in case of a breakdown assistance is at hand.

(7.) *Every advantage must be taken of meteorological conditions.* Probably few of us landsmen fully realise the stupendous importance to both Attack and Defence of meteorological conditions. The most obvious instance is the difference between daylight and darkness, but everyday incidents, such as fog, haze, rain, the state of the sea, the tides, *direction* and *force of wind*, and *state of the atmosphere with reference to the hanging of smoke*, *are* all factors of immense importance, and it is not saying too much to affirm that the success or failure of an enterprise may depend upon the use made of these natural conditions. For instance, during daylight, a good or bad light for aiming is chiefly dependent upon the position of the sun with reference to the various objects, and this is partially the case even when the sun itself is not visible. At Alexandria the low morning sun was full in the eyes of the gun-layers of the fleet, the batteries being in shadow, while the men in the latter viewed the ships brightly illuminated against a dull background. In a morning attack on say Plymouth, it would, therefore, be advantageous to select the western defences of the sound, which face more or less eastwards, for attack, rather than those on the other side.

The effect of *fog* is completely paralysing to the Defence, but an active attacker will utilise ~~it~~ specially to injure submarine defences. *Haze* and *mist* are modified fogs, and are far more troublesome to the Defence than to the Attack, on account of *their effect upon telescopes*, which form parts of certain instruments upon which the gun power of the Defence greatly depends. A very moderate haze, such as would afford little obstacle to navigation, has considerable effect upon telescopes. In certain very moist states of the atmosphere, films form between the glasses of these instruments and give very great trouble. *Rain* is also prejudicial to the instruments and observations of the defenders, while the drift, and especially the "hang" of smoke, which latter varies greatly according to the barometer, are of extreme importance. Combinations of the above with one another, and with darkness, may render useless the best schemes of defence depending on the shore alone.

(8.) Every sort of *strategem* should be resorted to, and as it is hardly possible for a maritime nation like ours to absolutely block our ports to all vessels, there is some scope for ingenuity.

(9.) *The probable hour of Attack.*—This depends upon : (*a*) the object to be attained and (*b*) meteorological conditions. In the case of an attack upon works on a large scale, the hour chosen must almost of necessity be daybreak, for this alone allows of preparations being made under cover of darkness, and also affords probability of sufficient daylight in which to reap the fruits of the operations. But for torpedo boat attacks night-time offers many advantages, and the hour should be *a little before* high tide when the [illegible] within such limits is [illegible] enable the attacker to get away after accomplishing his mission [illegible] daylight. [illegible] high tide. This will give them the best chance of clearing the electro-contact mines, many of which will be [illegible] the water at high tide [illegible] be touched by a light draught boat [illegible] the largest French torpedo boats [illegible] The tide will also help them and increase their speed [illegible] ward journey. [illegible] the best possible hour for an attack is about 3 or 4 a.m., when the garrison, after a long strain of watchfulness, will be in all probability relaxed [illegible] largely. A bold attacker might at this hour possibly catch the whole of the Defence unprepared.

SECTION III.—ON THE OBSTACLES [illegible] ATTACK, AND HOW THEY MUST BE S[illegible]

It is desirable next to consider what obstacles [illegible] stand in the way of an attacker, what are weak points of each and how each should be dealt with.

In the first instance, the would-be attacker may find himself forestalled by a quicker and more enterprising enemy, and *blockaded in his own port.*

On this head all present experience goes to show that it would be difficult if not impossible for a blockader to keep shut in [illegible] large ships. To keep torpedo boats from breaking out may be said to be an impossibility. These little craft are so dangerous to the ships of the blockading fleet that the tendency [illegible] the ships to keep as clear of them as possible, and [illegible] *merely* [illegible] *real* [illegible]

Guard-boats.—On reaching the vicinity of the port to be attacked, guard-boats and patrol [illegible] will probably be met with. How these should be dealt with is not for a [illegible] to say, but if the attack can draw on a running fight and get [illegible] with the defending boats, all the gun and [illegible] defence [illegible] paralysed and the attack may be able to get through the defended water unscathed.

The following instance of a guard boat action took place [illegible]

May 25th, 1880, during the war between Chili and Peru. At Callao, two Chilian torpedo boats encountered a Peruvian launch which fled. One of the boats succeeded in exploding a torpedo under the launch's counter, the latter simultaneously exploding one under the torpedo boat's bow. The latter was sunk, and the launch, in a sinking condition, surrendered *to the other torpedo boat* —another instance, if one were needed, of the importance of boats acting in couples, or larger numbers.

Electric Lights.—Though not strictly obstacles, yet careful consideration must be given to the best manner of evading or baffling the beams of search-lights. *To be as inconspicuous as possible* is the first point, and it is worth noting that nothing shows up better in the beam of a light (or on a very hazy day) than a cloud of white steam or smoke, and some arrangement should be made, if possible, to enable boats to discharge their waste steam under water. *To obscure the water-way*, by shrouding it in a screen of smoke, will be the next desideratum, and here the guns of the Defence may greatly aid the Attack by pouring forth volumes of smoke, unless prevented by good organization. *High speed* and an *erratic course* will assist to baffle the lights, and chief of all will be the method, referred to above, of *advancing in successive* lines, some of which, while attracting attention to themselves, will entirely divert it from others. Should the force available admit of it, an actual subsidiary attack, real or feigned, *on the lights themselves*, will be a sure way of engaging their attention while the channel is passed by the main attack.

Stratagem, and creeping in under the shadow of the shore, or under the shadow of a passing ship or barge, will also be made every use of, and, of course, favorable atmospheric conditions will be of the greatest assistance.

The Gun Defence.—The weak points of the gun defence are its dependance upon good visual conditions, its slowness where large guns are concerned, the contracted arc of fire of guns mounted in closed works or behind shields, and the amount of smoke evolved. There is also the difficulty—not yet fully realised—of maintaining at all times, both of day and night, proper discipline, and instant vigilance in the garrisons, composed as they probably will be of reserve and auxiliary forces, and the want of high training consequent upon this composition—all the above points will militate against the effectiveness of the gun defences. Even where the P. F. system is relied on, a judicious choice of time and weather, a high speed, and an erratic course, will probably neutralise these instruments and the guns dependent upon them. Note that boats should never follow one another in the same course, otherwise if, as is highly probable, a prediction prepared for a leading boat be lost owing to her high speed, the following boat, if in the same track, might be made the recipient of the salvo.

Where the guns are known to be fought by P. F., in all probability a determined subsidiary attack by small landing parties, covered by gun fire, upon the P. F. cells will be attempted.

Where the guns are laid by sights, a high speed, and the dazzling of the gunners by the use of ships' or boat search-lights, turned full into the battery, will be very effective in spoiling their aim and rendering their fire worthless. In addition, all the measures enumerated as suitable for evading electric lights are applicable to the problem of getting safely past the gun defence.

And the Attack may remember that even in daylight, with well trained men, a very slow moving target, and all conditions as favorable to the guns as possible, actual *hits* are not numerous. How much more difficult then will it be to destroy a scarcely visible enemy, appearing suddenly, at any hour of the night, and in any weather, moving at high speed, and in an erratic course, and probably disappearing long before the ranges can be taken and guns laid. A method of dealing with the problem of the application of heavy guns to such objects will be proposed immediately.

But a portion of the gun defence, far more formidable to torpedo boats and lightly armored craft, is fire from *the lighter quick-firing guns*, such as the 6-pr. These guns should be liberally supplied to the defence *mounted on transporting mountings*. They can thus be utilised just where required, and the sites where they will be found need never be known beforehand to the attacker, who will thus be hindered in planning beforehand any special attack upon them. Of course the ammunition should be smokeless. The important point of the supply of quick-firing guns will be considered later.

The Submarine Defence—Mines.—Here we have the real "dark horse" of coast defence. In their earliest form they were used in the American Civil War, and on several occasions with effect. At the battle of Mobile, the Federal "Tecumseh" was sunk by a mine, as was also the "Cairo" in the Yazoo river on December 12th, 1862. In their present elaborate form, however, they are quite untried, for, unfortunately, they do not appear to have been used in any of the operations of recent years. But dangerous as they undoubtedly may be, they have many weak points. They are highly elaborate, take some time to lay correctly and effectively, and while constantly liable to injury, not only from tides, currents, and weather, but also from craft and shipping, are difficult to repair. Save in the case of purely mechanical mines, which would only be used in exceptional situations, their use involves great responsibility, and the risk of destroying friendly vessels by mistake, or accident, is considerable, and this must greatly paralyse their action, especially at night, and in thick weather. There are also great practical difficulties in keeping observers always at their posts, and vigilant and clear-headed. Furthermore, mine defence is more likely to be effective against large ships with considerable draught of water, than against the light draught torpedo boats. The French sea-going boats of 150 tons only draw 7 feet, and *at the top of the tide* and running fast, might very likely safely traverse a mine-field again and again.

Remembering all this, the main attack may traverse a mine-field by a rush, while, as in the case of lights, the attention of the defenders and observers is distracted by subsidiary attacks. The under-water cables are almost sure to be protected by chains, &c., and will require some time to find and cut, but to a bold attacker the weakest point of the mine-field will very possibly be found *on shore.* The shore ends of cables are generally, for convenience, brought in close to a good landing place. Probably a determined attempt by a *small landing party* on the shore arrangements of the mines will be the best way of covering the passage.

This subsidiary attack should try and damage the P. F. cells and test-rooms, and their valuable instruments and contents, by exploding hand charges in them.

In the attack of mines, as of other branches of the defence, an early and rapid attack, on a well laid plan, should have an excellent chance of being successful.

Brennan torpedoes may be met with, but an attack of the nature here considered can afford to disregard them. No Brennan is likely to catch a torpedo boat even if it were thought worth while to launch it against it.

Entanglements and obstructions will be certainly laid down by the defenders, and if placed, as they should be, where a heavy gun fire can be brought to bear, they may be very serious obstacles. But, at the same time, all important ports must have a fairway for the passage of friendly vessels, and of this fairway the attacking torpedo boats will probably be able to avail themselves.

Inner Guard-Boats.—An inner squadron of guard-boats may now be encountered. Many of these will probably be armed tugs, and other vessels of comparatively low speed. *Avoidance of encounter,* rather than attempting to fight them, must be the guiding principle in the mind of the Attacker. As before stated, the best thing for his purposes is to get well mixed up with the defenders.

Infantry and machine gun fire from the shore will become hotter as the harbor is approached, and the waters become narrower. It will, however, probably be wild and more or less ineffective, and will not of itself be a serious danger.

And finally, the ships, the real objective of the attack, will be found protected, possibly by their *boats,* and almost certainly by *booms, &c.* These booms should be destroyed by spar torpedoes —attempts at "jumping" them would appear to be very risky and wasteful of boats.

The ship's own defenses of quick-firing guns, &c., fired, as many of them assuredly will be, at random, will probably do as much damage to friends as to foes. It has not yet been demonstrated what will be the effect *upon one another* of the promiscuous firing of several ships with modern armament during a night surprise. It will undoubetedly be very great.

Once close to his object, a bold attacker, well supported, should be able to inflict a decisive blow. Escape afterwards should be comparatively easy, owing to the uncertainty which must almost of necessity exist in the minds of the defenders, as to the identity of boats *leaving* their harbors.

It will appear from the foregoing that the obstacles presented by the Defense to a really prompt, well planned, and bold attack, are not nearly so insurmountable as might be thought at first glance. Further, the Attack has immense advantages. It knows its own mind, chooses its own time, object, and atmospheric conditions, starts fresh to its work, employs its best and most dashing officers and men, and is a manageable force. On the other hand, the Defense is crippled by its very complexity, the extent of ground it covers (often such as makes rapid communications, or passing of men from point to point extremely difficult), the multiplicity of its details, and the colossal difficulty, apparently not yet properly realized in our country, of ensuring concerted action between the several sections of the Defense, some in the hands of the Navy, some in those of the Artillery, and some in those of the Engineers. Further, this concerted action cannot be rehearsed in time of peace, except at great cost, so the defense may be said to be practically untrained at the outbreak of hostilities. Its officers and men, too, will be largely composed of auxiliary forces, certainly unable, at any rate at first, to compete, in these days of rapid movement and action, with the dash and speed of the Attack.

The Attackers, too, being presumably Naval men, besides being in training, have far more experience of practical work under varying meteorological conditions than the defenders--a knowledge which must give a still further advantage.

And also the *morale* and discipline of the garrisons and covering forces will inevitably be a source of trouble to the Defenders. Men, especially those only partially trained, cannot be always kept screwed up to a high pitch of vigilance and discipline. Crowded into confined works, the novelty will soon wear off. The nervous tension produced by constant anticipation of attack, especially if attack does not come, must be followed by relaxation. It will probably be found necessary to relieve the garrisons entirely every 12 or 24 hours.

If, therefore, the golden moment of attack, viz., the very commencement of hostilities, be, for any reason, not taken advantage of, it will be best for the attackers to *refrain* from mere attempts to harass the garrisons. Frequent attacks, especially if not pushed home, must be a positive advantage to the garrisons, as giving to the men excitement, interest, and occupation, and to the officers, practice, and opportunities of finding out their weak points. Far more harassing to the Defense will be the dead monotonous silence, the wearisome suspense, the feeling that an attack is always impending yet never coming, which must lower the spirits and energy of the garrisons. Fixed defenses cannot take the offensive, or even compel the enemy to come and attack them, though they are themselves always open to attack. Their garrisons have thus a morally inferior position and will be dimly conscious of it. Finally, the tendency of most modern improvements has been in the all-important subject of *speed*, not only of movement, but also of fire, and it must be admitted that the Attack has benefited far more from these improvements than has the Defense.

The state of things obtaining at this moment, in the matter of the relations between the Defense and Attack of Coast Fortresses, bears a striking resemblance to the condition of the military nations of Europe, before the bursting upon them of the armies of the French Republic, and the inauguration of a new era in things military. We read in History how the slow cumbrous methods of land warfare, traditional, and in vogue, up to the time of the French Revolution, were suddenly completely upset by the new style of warfare of the French armies whose *celerity of movement*, and consequent *rapid striking power*, gave them their enormous advantage over their slower, and less alert opponents. Somehow the state of Coast Defense in relation to the Attack at the present moment strongly recalls this position. The Defense compared with the Attack is wanting in *speed*. What then is to be done?

SECTION IV. ON THE MEASURES REQUIRED TO PLACE THE DEFENSE ON A LEVEL WITH THE MODERN ATTACK.

It is hoped that a few suggestions on this point will not be considered out of place. The subject is of great importance to artillerymen, as a failure to cope successfully with the Attack, should a disaster unfortunately happen, would not only cast great discredit on the Defense generally, but a considerable portion of it would, rightly or wrongly, be thrown upon those manning the Forts.

1st.—First and foremost, then, it is necessary to mention the pressing need for greater *unity of command.* With us, at present, the responsibility for the Defense of Coast Fortresses is shared between the Naval and Military authorities. In Germany, on the contrary, this dual system has been abolished, and the Navy alone is responsible for the Coast Defenses, and the same change appears to have been carried out by the French recently. There can be no doubt as to which system would work most smoothly in time of stress, and it is greatly to be hoped that it may be found possible to introduce it.

It is impossible to have written the foregoing without being impressed with the fact, which has probably also struck the reader, that the considerations bearing on the subject of this essay are chiefly of a naval character. This is of itself a strong argument in favor of entrusting the Defense to the Naval authorities.*

The proposed change would be one of great magnitude and need not be further discussed here.

For the present we must suppose that things remain as they are, and the problem is how, under present arrangements, is the greatest unity of command to be attained.

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* That this subject has been under the consideration of the Admiralty, was stated by Lord George Hamilton, in the speech of the 7th inst., quoted above. He said:—

"But there was one point in our defense to which he desired to call particular attention, and that was the part the Army and Navy were to take in it. Every country, except our own, entrusted to the Navy and not to the Army, the defense of great Naval ports and stations. To entrust their defense to the Army was a wrong system. . . . . He was very anxious that, if the House wished it, nothing should be done by neither the Admiralty or the War Office to impede a gradual transfer of the defense of Naval ports and stations from the Army to the Navy."—*Standard*, March 8th, 1893.

In the first place, then, it is necessary that an officer of *high rank* should be deputed by the Commander-in-Chief of a Coast Fortress to be in entire charge of all the sea defenses. The Commander-in-Chief, himself, has multifarious duties constantly requiring his attention, and it is most necessary that the commander of the sea defenses should be able to give his whole mind to his special department. He should be assisted by several Staff Officers, both Naval and Military, detailed, not ~~as~~ belonging to different arms of the service, but each as *in charge of a distinct section of the defenses,* as will be explained immediately. The Commander-in-Chief of sea defenses should also, if a soldier, be placed in direct, constant, and confidential communication with the Naval authorities. The Staff Officers should also be officers of rank, and would each be responsible that, not one particular arm, but the whole of the various branches of the services in their section, representing guns, mines, lights, pickets, guards, &c., &c., at all times worked thoroughly well together, and according to the broad scheme drawn up by the Officer Commanding the sea defenses. Some such supervision is absolutely necessary to ensure combined action. Each Staff Officer should hold frequent conferences of the R. A., R. E., and Infantry officers of his section with the special view of encouraging *personal intercourse* among them, than which nothing is more effective in reducing friction, and promoting a clear understanding of each other's needs.

(2.) *Good communications* between the different parts of the defense are of such vital importance that *no trouble or expense should be spared to render them thoroughly satisfactory.* Signaling by flags and lamps though useful in the field, where permanent appliances are impossible, is not sufficiently reliable, on account of its dependence on atmospheric conditions, and should only be used where obligatory, viz., in communications between the shore and guard-boats afloat, and on land in cases of a breakdown of other systems.

Telephonic communication is not really satisfactory, being very liable to break down at critical moments owing to noise and excitement preventing the proper reception of messages—these frequently getting garbled in transmission, and causing mistakes which in time of war might lead to the gravest consequences.

Actual telegraphy, using the Morse alphabet, is far more reliable, and in the end takes no longer than telephony. To apply it everywhere would however require a larger number of trained men than are ever likely to be available.

Doubtless the most suitable system for Coast Defenses and Forts would be the *Printing Telegraph*, printing off its messages automatically on a tape or sheet of paper. These instruments are in great use for business and club purposes, and are nothing new.* Their adoption for Coast Defenses would greatly increase the speed and certainty of communications.

In answer to the usual objections, viz., the expense involved, it should be pointed out that good communications between the various parts of scattered defenses are of vital importance on the broadest grounds, and their establishment in time of peace—for there will be no time for all this on the outbreak of war—should take precedence of all expenditure on local detail.

(3.) *Organization.*—The area-to be defended, and the approaches thereto must be mapped out into clearly defined zones—naval or boat defense zones, and military or gun and mine zones. The limits of these zones must be distinctly marked both by day and night. No boat is *under any circumstances whatever* to enter a military zone. No gun is *under any circumstances whatever* to be so trained that its projectiles will fall or ricochet into a naval zone. In the case of guns this must be provided for mechanically, by means of stops bolted down on the racers in the case of permanently mounted guns, and by placing large stones, timbers, banks of earth, &c., &c., beside the trails of any Q. F. or other guns which may be in temporary positions, so that by no carelessness or forgetfulness, in moments of excitements, could the guns be so trained as to be dangerous to friends. It will be the first duty of each Staff Officer to personally see that this is done, and to ascertain by actual trial that these stops are really in their correct positions and sufficient.

The above zones should be marked out by marks unmistakable

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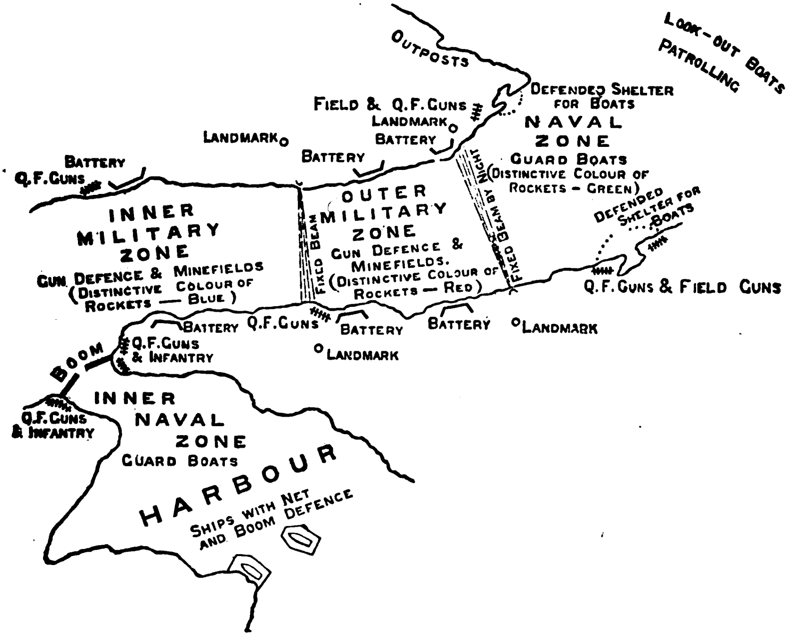
* Probably the best of these instruments is that known as the "Exchange Telegraph Company's Column Printing Telegraph." This is an excellent instrument, but the price is high.

both by day and night. The attached plan of an imaginary defence is intended to illustrate what is meant. (Fig. 1.) It represents a channel leading to a dockyard. Here the outermost zone

Fig. 1.

N. B.—Lights not indicated except those marking out zones.



of all would of course be naval, and patrolled by guard-boats. These boats should thoroughly examine all merchant shipping approaching the port and would be responsible for the *regulation of the traffic*—a most important and necessary measure in time of war. This, however, is not the place to go into detail on this point. One (or more if possible) harbor of refuge, defended by mechanical mines, &c., &c., and supported by a special force on shore, should be provided for these boats within their own zone, whose limits landwards would be marked by buoys and landmarks by day, and possibly by a fixed beam by night.

(4.) *Information and Warnings.*—To give warning at night of the approach of attackers each boat should have a supply of rockets, and in each zone, whether Naval or Military, a rocket station, or stations, must be established, where they are under the control of the officer commanding the zone. These stations are *not* intended to repeat one another's signals, but to throw up rockets *only so long as an attacker is within their own zone.* No signal rocket must ever be fired except by the order of an officer. The rockets of each zone should be *of a distinctive color*, so that it would be apparent to the whole defense which zone was signaling, and the inner defenses would be thus kept progressively informed of the passage of an attacker, and would know approximately when he was nearing their zone.

Behind the outer naval zone will come a military zone, or zones, to be defended by guns, mines, and infantry. Inside of this again will be another naval zone where boats should lie to deal with any attacker who may have successfully run the gauntlet of outer defenses. Should a boom exist, this might suitably mark the line between the zones, its seaward side being swept by fire from the shore, while behind it would lie the inner squadron of guard-boats ready to fall upon any one who might get by.

(5.) *Lighting the approaches.*—The beams of electric lights alone should not be relied upon. At uncertain intervals parachute lights, or something similar, should be discharged, during the burning of which a *coup d'œil* could be taken of the whole area to be defended.

(6.) *The Gun and Mine Defense.*—It is the duty of the guns, in conjunction with the mines, to sink or destroy every floating thing which may enter their zone between sunset and sunrise. The guns must, moreover, so arrange that their smoke does not obscure the mine-field.

The present systems of gun defense require certain modifications. As already stated, heavy guns worked by P. F. and D. R. F. are too slow to be worked with effect against small, rapid, and erratic objects, especially at night, and under the distraction of subsidiary attacks—and heavy guns also produce great volumes of smoke. The Q. F. gun, firing smokeless powder, is the most dangerous enemy of the torpedo boat, and *a very large increase in our armament of these guns is an imperative necessity.* Rapidity must be met with rapidity, and it is not fair to those who will be blamed, should they fail to keep the enemy out, not to supply them with suitable weapons. These Q. F. guns should not all be placed in fixed positions, but some of them should be upon *transporting mountings*, a few thus mounted being kept in every work ready to be run out to suitable points of vantage whenever required. Others, on fixed cone mountings (which are quicker and better for rapid fire than the transporting mountings), should be mounted *en barbette* (not behind walls or shields) in the works or in suitable situations.

No attempt should be made, with the bulk of the *heavy* guns, no matter how well provided with P. F. or D. R. F. installations, to follow, or aim at, these swift craft, though a few guns, here and there, with specially selected men, should be told off for this purpose. Promiscuous firing, if indulged in, will inevitably cover the channels and mine-fields with smoke, and do more real harm to the Defenders than to the Attackers. But these guns can nevertheless be utilized.

The power of *heavy shrapnel shell* is very great, and torpedo boats are ill adapted to resist it. The thickness of a French sea-going torpedo boat is only $\frac{3}{32}$-inch of steel, with an additional protecting plate ⅛-inch thick over the conning towers, boiler spaces, and torpedo dischargers. Without reckoning the large, heavy and irregular fragments of the bodies of such shells, which would probably be capable of going clean through such a boat at 600 to 800 yards from the point of burst of the shell, the bullets can penetrate such plates up to 300 yards from the point of burst.

Instead, therefore, of attempting with half trained garrisons, in the midst of darkness, confusion, and excitement, to carry out the elaborate and slow processes of range-finding, group of differences, predictions, &c., &c., requiring large fort garrisons and staffs, and almost certain to fail under the circumstances enumerated, the Gordian knot should be boldly cut, and the gun defense reorganised as follows :—

(*a.*) The Q. F. guns must be greatly increased in numbers, and must deal with the torpedo boats by direct fire.

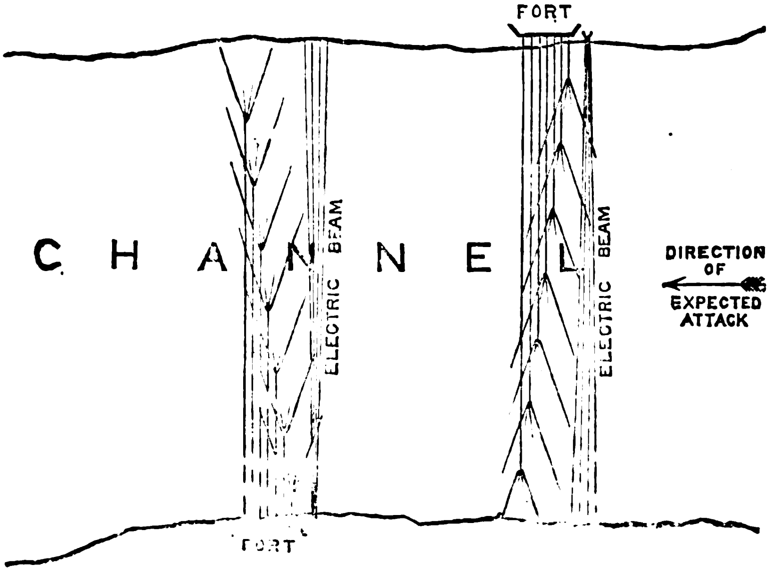
(*b.*) A few specially selected, well placed, medium, or heavy guns, with picked detachments and observers, should be detailed for the same duty.

(*c.*) *Fire-swept Areas.*—All the rest of the heavy guns should be told off into groups, as large as possible,* and kept loaded with shrapnel shells and time fuzes and tubes in the vents. The guns of each group should be laid on parallel bearings but at different elevations, and the fuzes set to suit these elevations, the result being that, on their being fired, as a salvo, the whole of the water in front of that group would be swept by a storm of missiles. The idea is represented roughly by Fig. 2. A beam of light should be so placed as to be crossed, by the Attacker, a few moments before he reaches the fire-swept area, and the

FIG. 2.

N. B.—The guns to be fired in salvos as soon as the object crosses the beam. Shells to burst as shown.

Only the work on the lee-ward side is to be allowed to fire, the groups being considered as secondary to the main gun defense of Quick-Firing Guns.



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* Several tactical groups of guns may be combined into one for this purpose. This is specially applicable to old works where the guns are close together.

guns should be fired by the officer on look-out duty. Those guns which are laid for the higher elevations, and consequently have longer times of flight, should be those furthest from the direction of the Attack, as shown by the figure. The exact training and elevation of each gun must be plainly marked on their respective arcs. Spare shells, with fuzes fixed *and set*, would stand beside each gun. The moment a salvo has been fired, every gun would be instantly reloaded and relaid exactly as before. They will then be in readiness for the supporting boats, which will be in all probability following the first line.

Of course, more than one of these "fire-swept areas" must be prepared in each military zone. In cases where a channel is defended by works on both sides, it must be distinctly arranged that the *leeward side only* is to fire when the wind is across the channel. The Staff Officer in charge of the Section will give his orders on this point, from hour to hour, according to the wind.

As regards the proper moment to fire, moving beams can be utilized for this purpose, if a fixed beam is considered, for any reason, undesirable; the guns being fired electrically at the moment when this beam, which is following the object, reaches a certain bearing. This could, in fact, be made automatic by arranging the firing contacts on the training arc of the lamp, safety being insured by a removable firing plug in charge of the officer at the light, which would be inserted only when the light was actually following up an object.

By day the bearings should be on landmarks if possible, the bearings being also marked by buoys in the channel, some comparatively near to the observing station, in case haze or smoke obscured the more distant ones.

(7.) *Protection of Observing Stations, &c.*—These, as well as the shore ends of cables, are especially liable to attack by small landing parties, and must be protected by infantry pickets. The vigilance of these latter should be the constant care of the Staff Officer of the Section. The parties guarding a possible landing place should be provided with a machine gun. P. F. cells, no matter how far back they may lie, should never be without a guard.

(8.) *Position of Ships.*—Ships must never lie "under the guns of forts," but always far in rear of them. This was found practically by the Peruvians in the war with Chili.

Want of space has unfortunately prevented any reference to any form of attack, save the one which is most likely at the outbreak of hostilities. This, however, is the most important as it is the one with which we shall first have to deal for, as already pointed out, attacks on works on a large scale cannot ~~take place~~ until later. The interesting subject of the attacks to which our colonial and coaling stations are liable, has also to be left untouched.

Finally, the proposals, made above, are intended to meet the exigencies of the moment with the means existing, and to be practical rather than theoretical. The only point strongly pressing is *the provision of many more Q. F. guns, suitably mounted.* These are instantly necessary. Let us hope that the motto of this paper will be borne in mind by those responsible for the supply.

THE ATTACK OF A COAST FORTRESS.

BY MAJOR R. F. JOHNSON, R. A.

"LE COUT FAIT PERDRE LE GOUT."

SILVER MEDAL PRIZE ESSAY, 1893.

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INTRODUCTION.

A Coast Fortress can be defined as an area of land and sea defended with an artillery armament.

The attack of its land portion does not differ in its tactics from ordinary siege operations, and therefore only the attack of the works commanding its sea area will be discussed in detail in this paper.

"Purely naval attacks on fortresses have been few in number, and have only been successful when the ships possessed a decided superiority over the batteries, or at places where the garrison were decidedly inferior in skill and courage to the attacking crews."

"The old wooden line-of-battle ships were no match for the fortresses of their day, and there is no reason to suppose that modern ships of war, protected in a great measure as they are against projectiles, are more fitted than their predecessors for an attack on batteries on shore. No doubt ships have been successful against forts."

"Every modern improvement in guns and their ammunition tends to increase the superiority of shore defenses over ships."

"On the whole it may be said that at the present day a purely naval attack on a properly designed fortress, garrisoned by the troops of a civilized Power, might be *magnifique* but under no conceivable circumstances could it be termed *la guerre*. Instances of naval success may be quoted in opposition to this view, but, as a rule, they occurred prior to the days of direct shell fire and accurate shooting."

"In combined naval and military operations against fortresses the co-operation of a fleet has often proved most valuable to the attack."

"Another legitimate use of ships is to force a passage defended by batteries. . . . . I know of no instance of ships having been prevented from passing batteries by artillery fire alone, unaided by natural or artificial obstructions."

The above extracts* illustrate the conclusions arrived at when the subject has been approached from the attacker's point of view, and so form a fitting introduction to a consideration of it from the defender's. The value of a coin is often shown most clearly on the reverse.

Probably there are few naval officers who do not feel obliged to acknowledge the soundness of Admiral Selwyn's advice:† "I hope that naval officers will consider that a fort is a thing to be avoided."

In the past, however, there have been occasions obliging them to take the risks, and history is continually repeating itself. Even the very improbability may be an inducement to a bold commander, and it is the first duty of the Defense to investigate the probable action of the Attack in such a case, so that it may be anticipated and defeated.

More especially does it concern Garrison Artillery officers, on whom the responsibility of conducting the defense must chiefly rest.

For them unfortunately such an investigation is extremely difficult, because, although their business is to fight them, they have no facilities for making themselves practically acquainted with ships and their handling; being very seldom even afforded the chance of obtaining the slight knowledge to be derived from the co-operation of the Navy in sea-fortress maneuvers.

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* Ships *versus* Forts; Jackson. R. E. Occasional Papers, 1889.

† Attack of Armor-clad Vessels by Artillery; Orde-Browne. R. U. S. Institution Journal. Vol. XXVI.

In fact one can only try to interpret history, carefully using the light given by those, who, by training or opportunity, are better qualified.

The reasons for attack may be:—

1. To compel a weak or semi-civilized government to yield to demands made on it, through moral effect, *e. g.*, Lord Exmouth's attack on Algiers. Tne bombardment of Kagosima in 1863.
2. As a tactical maneuver, either in support of army operations as at Fort Wagner, Roanoke Island, Grand Gulf, Fort Fisher, &c., in the American Civil War; or in the form of a demonstration for the purpose of inducing the defender's fleet to leave port to give battle as, it has been suggested,* might have been justification for a bombardment of Kolberg by the French in 1870.
3. To gain possession of the harbor or anchorage defended, which is required for subsequent operations, or whose loss will injure the enemy, *e. g.*, Port Royal and Alexandria.
4. To test the powers of specially built ships or floating batteries, of which the bombardment of Fort McAlister, Ogeechee River, is an example.
5. To reach for the purpose of capture, for use or destruction, the charge of the fortress, such as a water-way like the Mississippi; the enemy's ships, as at Mobile; or torpedo-boat depôts, as are to be found on the coast of Italy.
6. For strategical purposes by drawing attention and troops from other points of the theatre of war, of which Dundonald's raids in the *Imperieuse* during the Napoleonic wars may serve as an example.

When the attack is made for any of the first four reasons it will be in the form of a bombardment, because the temporary or permanent destruction of the defensive power of the forts is essential. But in the other cases, if the object of the attack is not included in the gun-defended area of the fortress, bombardment will only be resorted to so far as it is necessary to prevent injury to the ships or boats forcing the defended passage.

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* Ships *versus* Forts; Jackson. R. E. Occasional Papers, 1889.

In a bombardment the immediate aim is at all hazards to inflict injury on the Defense; in forcing a passage, to avoid injury to the Attack.

BOMBARDMENT.

Speaking of ships generally Admiral P. H. Colomb, R. N., has said[*] that "each presents three targets, (*a*) the 'vital' target, injury to which either sinks her, injures her engines, or damages her steering gear; (*b*) the 'effective' target, where her fighting power is contained, and where her men are; (*c*) the 'ineffective' target."

Among battle-ships may be classed those whose vital target and primary armament, as far as its service is involved, are protected by armor against the direct fire of the primary armament of their enemy; the secondary armament being also in a few cases somewhat protected against similar ordnance.

Among protected cruisers may be classed ships whose vital target is defended by either horizontal or vertical armor against the direct fire of secondary armament, including a few whose effective target is also to a certain extent protected.

All other ships have very slight, if any, protection, and for fighting purposes only differ from the old wooden ships in being less liable to be set on fire, but having less weight of metal in the broadside and forming better bursting screens for shells.

Torpedo boats have only offensive power against floating defenses and dock gates, and their only defense is their speed and handiness.

Captain Jackson, R. N., writes:[†] "Ordinary sea-going ships of war are not, and never have been, intended by their designers to engage forts. They are built to fight other ships."

Rear-Admiral S. Long, R. N., said at the R. U. S. Institution[‡] "If ships are pitted against guns on shore, unarmored ships do not appear so favorably situated as in the days of wooden ships."

And Vice-Admiral Sir E. Freemantle, in the subsequent discussion, agreed "that the armament of our cruisers is such that

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[*] Attack of Armor-clad Vessels by Artillery; Orde-Browne. R.U.S. Institution Journal. Vol. XXVI.

[†] Ships *versus* Forts; Jackson. R.E. Occasional Papers, 188).

[‡] Probable Influence of Quick-Firing Guns on Naval Tactics and Construction; Long. R.U.S. Institution Journal. Vol. XXXVI.

the strength of a cruiser is only sufficient to fight its own equal, that she is not of much value against a fort."

The Director of Naval Construction has expressed the opinion* that "it is possible a ship may be put out of action without her armor being pierced;" and history supports the opinion. At Lissa† the Italian ship *Formidable* was not penetrated, but was so punished in her close action with the forts that she was unable to take part in the subsequent naval battle. At Charleston, on 7th April, 1863, five out of the seven especially built "monitors" were disabled, although neither their "vital" nor "effective" targets were penetrated. except in the case of the *Nahant*, which had her steering gear damaged.

Colonel Clarke, C.M.G., R.E., after discussing various types of ships, writes:‡ "The inevitable inference from the above analysis of naval development is, that the progress of gun-power, and the necessity for building ships to fight other ships, has resulted in types of vessels which become less and less qualified for engaging coast defenses with any chance of success. . . . ."

"In engaging coast defenses, however, this powerful weapon (the ram) disappears, and the task must be accomplished by the gun alone. It is for this reason that the exposure of the *personnel* of the modern ship becomes a factor of the first importance. The crews are, in this case, the real 'vitals' of the ship, and to inflict heavy loss upon them will suffice for all purposes."

It is clear that ships have little defensive power, but as long as Admiral Colomb's "vital target" remains intact they can choose their position, and can withdraw out of fire when they please.

Their offensive power lies entirely in the fire of their guns, and gun for gun in the same space will probably be greater than that of forts if the latter are placed like the ships (*i. e.*, on or near the water level), because the guns of the primary armament of ships are generally of a more advanced type and of a heavier nature than those in forts, while concentration and simultaneity of fire are easier. If the fort is penetrable, like the casemates of

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* Probable Influence of Quick-Firing Guns on Naval Tactics and Construction; Long. R.U S. Institution Journal. Vol. XXXVI.

† Attack on Lissa, 1866; Lewis. R.E. Occasional Papers. Vol. IX.

‡ Fortification; Clarke. 1890.

Fort Pharos, Alexandria, or untraversed, like Fort Walker, Port Royal, every hit will tell; and in some cases even if the fort is armored beyond actual penetration it may be so damaged as to be silenced; for instance, it has been calculated that a shot from the 16-in. R.M.L. gun, striking the Dover turret at 2000 yards range, would have the energy required to lift the whole mass 16 feet, and it is scarcely conceivable that the turret would remain serviceable after such a blow.

But hits are not easily made from an unsteady platform, and even with accurate shooting, the offensive power of ships lessens considerably if the fort is constructed of earth, is well traversed, and amply provided with bomb-proof cover for its garrison, although it may be placed near the water level. Then, certainly, the garrison may be unable to carry on the combat continuously, but it will be impossible to render the fort quite unserviceable. Forts Wagner and Fisher, in the American Civil War are convincing examples of this.

When the forts are at altitudes over 100 feet, the ships' power to inflict injury or to drive the garrison from its guns dwindles to almost nothing, and disappears entirely if the works are properly constructed of earth and the guns judiciously dispersed.

Referring to the battle of Algiers, Captain Jackson writes:* "Here we have the old story which cannot too often be repeated: —Closely packed guns on low sites silenced by the fire of ships; dispersed guns on high sites holding out." And again, in connection with the naval attack on Sebastopol, 17th October, 1854, "Two little open batteries on a high site drove six ships out of action; while an open barbette battery on a low site was silenced, and the fire of a casemated battery much reduced, by three ships, assisted by others at long range." The two little batteries were the "Wasp" and "Telegraph," at heights of 130 feet, and 100 feet, each only having five medium guns bearing on the ships.

Commander Mahan, U. S. N., remarks when commenting† on the attack of the river flotilla, on the Confederate position at Grand Gulf, on 29th April, 1863: "The limitation of the power

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* Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

† The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

of the vessels was very clearly shown here, as at Fort Donelson; the advantage given by commanding height could not be overcome. On a level, as at Fort Henry, or with slight advantage of command against them, as at Arkansas Post, the chances were, that they would, at close quarters, win by disabling or silencing the guns; but when it came to a question of elevation, the guns on shore were too much sheltered."

The same lesson was again repeated at Lissa.*

Colonel Clarke has well shown the difficulty of the task of the seaman-gunner.† "Thus with the service 10-inch R.M.L. gun, using the 70 lb. charge, a ship must be at 1750 yards distance to obtain a horizontal trajectory at the crest of a battery 300 feet high, while to obtain an angle of descent of 6 degrees she must move to 3350 yards. If the crest of the battery is 100 feet high the corresponding ranges are 1050 yards and 2950 yards. A common shell arriving at an emplacement with a horizontal trajectory can do little injury to the revetment wall. Striking only a few feet short of the crest, it will be deflected up, unless the burst is instantaneous, in which case (as proved at Eastbourne) the splinters all clear the emplacement. Practically therefore, to be really dangerous, the shell must burst *exactly at* the crest, which means hitting a target a few inches high, as well as securing an instantaneous burst."

Vertical fire, of which the Zalinski gun is a powerful development, especially at short ranges, is all in favour of the Defense.

Ships present a large horizontal target on which, except in a few cases, the whole "effective target" is exposed. Gun emplacements on land are very small targets, and in the worst placed and designed batteries can be given an impenetrable concrete roof. On land, the laying is done on a perfect platform, with the aid of range instruments, and with facilities for observation of fire. On the ships, the platform is unsteady, the obtaining of the range much more difficult, and observation must be of a most imperfect description.

Colonel Clarke says:‡ "For several reasons the result of the

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* Attack on Lissa, 1866; Lewis. R.E. Occasional Papers. Vol. IX.

† Fortification; Clarke. 1890.

‡ Fortification; Clarke. 1890.

practice carried out from H.M.S. *Hercules*, off Shoeburyness, in August 1886, was inconclusive. The fact nevertheless remains, that though the ship anchored in smooth water, such an excellent gun as the 8-inch 70 cwt. howitzer, was unable to plant a shell within 20 yards of a conspicuous target flag at only 1500 yards, and that two rounds fired with the same elevation and charge, on the same day, gave a difference in range of 370 yards." And again, "The original experiments made with a 9-inch poly-grooved gun were remarkably successful, and proved that, thanks to the position-finder, it would be impossible for a ship to anchor at 8000 yards from such guns without receiving frequent deck hits of a dangerous nature."

It is true, if a large number of specially armed ships can be placed in perfectly smooth water, sheltered from the fire of the works attacked, and the latter are cramped and weakly constructed, the effect of *vertical* fire from the ships may be considerable. With these conditions 20 mortar schooners shelled Fort Jackson, below New Orleans, in 1862, and Colonel Higgins who commanded the fort has left on record:* "On the first night of the attack the citadel and all the buildings in rear of the fort were fired by bursting shell, and also the sand-bag walls that had been thrown around the magazine doors." "I was obliged to confine my men to the casemates, or we should have lost the best part of the garrison." But this fire decidedly did not render the armament unserviceable, and the vessels owed their successful passage on the 24th April, to the crushing effect of their broadsides.

It is particularly worthy of note that the same mortar boats at a fair range effected nothing against the weak but dispersed Confederate batteries at Vicksburg, when Farragut passed them on the 28th June, 1862. They do not appear to have been of any use on the Atlantic coast, and Farragut had none with him at Mobile, though Fort Morgan would have been an ideal target.

Ships always have auxiliary armaments, forts frequently are without them. When this is so the ships will have a decided advantage, provided they can engage at sufficiently short ranges.

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* Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

The experience gained by the Inchkeith experiments, and at Alexandria, justify the following table of ranges as the greatest for effect:

Rifle Calibre Machine guns	1000 yards
1-inch " " "	1800 "
6-pr. Quick-firing guns ...	2500 "
4.7-inch " " ...	not much more.

If the forts have auxiliary armaments the advantage must rest with them because their guns will be better protected and better ranged, while the searching power of this class of guns, at the ranges admitting of correct observation of fire, is very small.

Such, broadly speaking, are the conditions of the combat to-day, but in the near future they will, in all probability, be modified in detail by "high explosives" carried in "armor-piercing" common shell, and by "Harvey" armor.

The effect of the introduction of the general use of shells, in the time of wooden ships, is well-known, and probably the Defense will gain even a greater advantage from the use of high explosives.

The French trials against the old wooden iron-clad corvette *Belliqueuse* (offering, it is said, as much resistance as a great part of the modern French ships and cruisers), in which the heaviest shell used weighed 99 lbs. and contained only 8.82 lbs. of melinite, the effects are thus noted.* "The bursting often took place after perforation, sometimes in the actual side. Fragments from $\frac{1}{3}$ oz. to $1\frac{1}{3}$ oz., of which the number reached about 1500, and which were animated with enormous velocity, were projected in all directions, and even backwards, destroying all the *personnel* not under cover. The rest of the projectile was reduced to metallic powder, penetrating all surrounding objects. To these effects are to be added those of the explosion, which is local, but which has great energy. If it is produced while the projectile is passing through the side, holes of 59 inches diameter are formed; when occurring near the decks they are destroyed by fracture of beams, bolts and planks. It may also set fire to them, as was

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* Recent Development of Armor and its Attack by Ordnance; Orde-Browne. "Proceedings," R. A. Institution. Vol. XX.

the case three times out of 12 rounds, on board the *Belliqueuse*. Lastly, the movement effected by the mass of gas has such force that it destroys to great distances the weaker structural parts of the ship." One must not forget what a mass of electric wires, speaking tubes, &c., are used in the handling of a modern ship of war.

Again, in the trials against the *Resistance*, at Portsmouth, in 1889, which unfortunately have not been published, the destructive effects of high explosive shells after penetration are known to have been terrible, while one of the most remarkable features was the smoke and fumes after each explosion, which set fire to the ship and prevented anyone approaching the spot, in some cases for twenty minutes after the shell had burst.

On the other hand, while great effects are produced in ships, the whole experience gained at Lydd is said to* point to the fact that no increase of results can be obtained against earthworks.

The "armor-piercing" common shell are to have the same penetration as Palliser chilled-iron shot, † but against this advance it is said that the "Harvey" process of hardening so increases the resistance of armor, that it may lead before long to the re-introduction of the broadside battle-ships, or at anyrate enable considerable protection to be given to the secondary armament, either of which changes will make much shorter ranges possible, and greatly improve the relative power of ships against many existing shore defenses, though the invulnerability of properly placed forts will be as great as ever.

Whatever changes take place, however, in the relative power of ships and forts, the issue will still depend on the power of the guns to inflict injury on the *personnel* and material, the injury to the latter being of importance according to the degree it affects the former.

Coast defense vessels with ramming power may render blockade difficult, but cannot well take much part during a bombardment, except as floating batteries without masking the forts. An

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* Fortification; Clarke. 1890.

† Recent Development of Armor and its Attack by Ordnance; Orde-Browne. "Proceedings," R.A. Institution. Vol. XX.

example was given at Cherbourg during the French Naval Maneuvers, 1892.*

Torpedo boats and other floating defenses have the same drawback, and meeting them with their like will only form incidents of the battle.

Submarine mines and dirigible torpedoes will only be met with in ~~channels~~ and somewhat enclosed waters, or, if an attempt is made to employ them in the open they will only affect the question of range and anchoring. The case of Charleston, where submarine mines were used in front of the forts, is no exception, because the long bar gave the approach to the harbor all the characteristics of a channel.

It may be safely asserted that no serious bombardment of properly grouped, gun-ed, and garrisoned forts is possible without especially constructed vessels and much preparation, including the seizing of a suitable base of operations at no great distance. In the American War, for the attack of Charleston, the monitors had to be built, and Port Royal seized as a base. In the Crimean War the only effective action against forts was that of the specially built French ironclads, which reduced the casemated fort at Kinburn.†

Such a preparation involves complete command at sea. Without this condition the attack is limited in its nature by (1) Time; (2) Coal; (3) Ammunition; and it is only likely to be undertaken by a small squadron.‡

It is limited by time, because it is clear that the attack must be free from interruption, as was illustrated at Lissa, in 1866.§

It is limited by coal because the ships must be able to reach a depot, or colliers must be free to reach them.

It is limited by ammunition as its supply is what is carried, and sufficient must be kept for the naval action which is more or less certain. When Rooke took Gibraltar, which was only garrisoned by 150 men, he so far depleted his ships of ammunition that he actually risked the loss of the battle of Malaga which

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* French Naval Maneuvers, 1892; Garbet. R.U S. Institution Journal. Vol. XXXVI.

† Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

‡ Naval Prize Essay, 1892; Craigie. R.U.S. Instition Journal. Vol. XXXVI.

§ Attack on Lissa, 1866; Lewis. R.E. Occasional Papers. Vol. IX.

followed.[*] The Italian fleet would have been in far better a position to meet the Austrian at Lissa if it had not been engaged previously in a two days' bombardment of forts.[†]

Colonel J. B. Richardson, R.A., in a recent lecture[‡] said:—"It may, however, I think, be accepted that under existing conditions Coast Fortresses, which are known to be reasonably ready, will not be exposed to an Artillery engagement other than at quite long range, partaking of the nature of a reconnaissance to ascertain their preparedness. If found in a really bad state of preparation, such as might be expected quite at the beginning of a war, ships which have no hostile fleet behind them may attempt the bombardment of Coast Fortresses to cover an attack on the dockyard, &c., which they guard. During such a bombardment they may attempt to ascertain the position of or destroy mines, and prepare the way for passing forts, or they may rush torpedo boats through to destroy shipping in harbor, blow in dock gates, &c."

Whether the attack is of the nature of a reconnaissance or a determined effort to destroy the defensive power of the fortress, and whether it is made by a small squadron or by an especially equipped fleet, the tactics pursued must in principle be the same, their application being modified to suit the circumstances.

It seems convenient to discuss the tactics under the following heads:

1. The ranges at which the bombardment will take place.
2. The maneuvering of the ships during the engagement.
3. The formation of the attacking force.
4. The most suitable time for an attack.

1. *The Ranges at which the Bombardment will take place.*

Admiral Sir A. Cooper-Key, G.C.B., has said:[§] "I hope no one will think that I am an advocate for timidly attacking forts by ships."

Colonel Lewis, R.E., writes:[||] "I have hardly ever heard a

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[*] Naval Prize Essay, 1892; Craigie. R.U.S. Institution Journal. Vol. XXXVI.

[†] Attack on Lissa, 1866; Lewis. R.E. Occasional Papers. Vol. IX.

[‡] Defense of a Coast Fortress; Richardson. "Proceedings," R. A. Institution. Vol. XX.

[§] Bombardment of the Forts of Alexandria; Walford. R.U.S. Institution Journal. Vol. XXVII.

[||] Fortification for English Engineers; Lewis.

different opinion than that they (Naval Officers) would get as close as possible and pour in as heavy and rapid a fire as they could." And reviewing the lessons of Alexandria: "There is nothing in this action to disturb the opinion that ships attacking a properly built and manned fortress must fight at short ranges to obtain decisive results." And again, "It is only at short distances that the fire of a ship can be directed with sufficient precision to have any approach to certainty of striking the small area which is vulnerable in a barbette battery of the present day."

"The *Inflexible*[*] engaged Oom-el-Kabebe at a range of 3800 yards. Her practice is described on all hands as admirable. As the fort was only 80 feet above the sea, and was protected by a parapet 8 feet high, her shell struck with a descending angle, and had some searching power. As a result one S.B. gun was disabled, and this gun was not in action, while the damage to the parapet could have been repaired in a short time. So much for the effect of slow fire from heavy guns at long range."

As before remarked, short ranges are necessary for the auxiliary armament to be of use.

At Sebastopol, on 17th October, 1854, the main body of the Allied Fleets engaged, at ranges of from 1600 to 3000 yards. Three guns dismounted and 35 casualties were the result in the Quarantine Fort, mounting 58 guns *en barbette*, after a bombardment of some hours. Four two deckers and one frigate quickly silenced Fort Constantine, with casemates, at ranges of from 800 to 1500 yards.

At Port Royal, 7th November, 1861, Fort Walker was silenced at ranges of from 600 to 800 yards.

At Charleston, 7th April, 1863, the monitors engaged at ranges of from 500 to 1000 yards.

At the shelling of Fort Wagner, preparatory to the land assault on 18th July, 1863, the fort maintained its fire from 12.30 to 4 p.m. while the range was 1200 yards, but was at once silenced when the ships moved in to 300 yards.

At Fort Fisher, in January, 1865, the ranges varied from 800 to 2400 yards.

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[*] Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

It must be remembered that in examples from the American War the ironclads were impenetrable at the ranges, and that the broad-side ships had an overpowering superiority in mass of fire to the forts, which were all on low sites. When things were more equal it did not pay to get too close, as the river flotilla found at Fort Donelson, on 13th February, 1862, after its success at Fort Henry, eleven days before.

We may assume that the ranges will be as short as they can be without incurring too great injury to the effective target; and these ranges will probably be far less than might be supposed from formulæ for penetration, and the theoretical perfection of range-finding instruments. Annoyance and moral effect will generally be the aim, and long ranges will be used rather for the searching effect they give to the projectiles than for avoidance of injury to the ships.

The amount of injury it is allowable to incur depends on the distance from the fleet's base, whether the ship or ships can be spared for the necessary time of repair, and the prospects of a naval action to follow. More might have been attempted on the Atlantic coast in the American Civil War if it had not been necessary to maintain the blockade. At Lissa, the disablement of the *Formidable* contributed to the Italian defeat.

Colonel Lewis remarks* regarding Alexandria: "Long ranges were used probably because it was desired to keep the ships ready for subsequent action, and the possibility of silencing the guns at them, in consequence of the known bad quality of the gunners."

At Alexandria it may be questioned whether less injury would not have been received if the outside squadron had been taken early to shorter ranges, for the in-shore squadron had the fewer hits.

It can seldom, in a bombardment, be worth while to expose the ships to very great injury, because the results obtainable are too small.

At Fort McAllister,† 3rd March, 1862, 209 heavy shell were

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* Fortification for English Engineers; Lewis.

† The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

fired; 2 guns were dismounted and large craters cut in the parapets and traverses, "but still no injury was done that could not be readily repaired during the night." At Charleston,* on 7th April, 1863, 43 shot and 96 shell only produced 14 casualties although the works were struck 69 times. On this occasion 5 out of 7 monitors were disabled, and the iron ship *Keokuk* received 90 hits, of which 19 were penetrations on or below her water-line, which caused her to sink as soon as there was any sea on. On the 7th September, 1863, Fort Sumter† is said to have resembled a steep sandy island, not a fort; on the 8th, a landing party was repulsed. In December, 1864, the Federal fleet is said‡ to have thrown 15,000 projectiles into Fort Fisher, and on the 13th, 14th and 15th of January, 1865, 21,000; but an assault on the sea face was repulsed with loss on the last day. The fort appears to have had only 22 guns bearing on the ships, which had 405, and could bring at least 275 to bear at a time. At the French bombardment of Sfax "after a remarkably deliberate fire of 2002 projectiles delivered under peace conditions, the 'defensive power' of the place is reported to have been 'practically uninjured.'"§ At Alexandria, Fort Mex, which has been described as a "prehistoric work," was attacked at short range by the in-shore squadron, assisted by the *Temeraire* outside the Corvette Pass. "In view of the tremendous fire to which Fort Mex was subjected, and the comparative short range at which all the ships except the *Temeraire* engaged it, it is impossible to believe the fact that not a single gun here was dismounted or disabled during the action proper. . . The 8-inch gun . . . was bowled over by the *Penelope*, long after the fort had ceased firing, and from a distance stated to be about 300 yards." "So says Captain Goodrich in his official report on the action."||

No particular ranges can be assumed as probable, for independently of the hydro-graphic conditions of each locality, the permissible ranges for individual ships will vary according to

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* The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

† The Navy in the Civil War 3 vols. Soley, Ammen, Mahan.

‡ The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

§ Fortification; Clarke. 1890.

|| Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

circumstances. For instance, many battle-ships afford protection to their secondary armament by the armor protecting their primary armament when fighting end-on, and consequently if it is not necessary to use the former they can go in much closer than when they have to present their broadside to the fort.

2. *The Maneuvering of the Ships during the Engagement.*

The most important point under this head is whether the ships shall be anchored or kept in motion.

Captain Jackson, R.N., says:* "Without anchoring, experience has shown that the greater part of their fire is thrown away."

"The bombardment of the forts of Alexandria gave an excellent opportunity of comparing different methods of maneuvering ships when attacking batteries. The *Invincible* and *Penelope* remained at anchor during the whole engagement; the *Monarch* steamed backwards and forwards in a line parallel to the shore. The *Sultan*, *Alexandra* and *Superb*, at the beginning of the action, engaged under weigh, steering an elliptical course past the lighthouse batteries at a distance of 1500 yards. After passing the batteries twice in this manner they anchored, shifting their positions as requisite. This plan was also followed by the *Temeraire*. The *Inflexible* dropped a small buoy at a known range, and steamed up to it to deliver her fire. . . . . The plan of fighting a ship under weigh was evidently the worst of the many adopted. Sir W. Hunt-Grubbe, who commanded the off-shore squadron, only tried the elliptical course in line ahead twice. He then anchored his squadron to get more accurate shooting."

Lieut. Colonel Walford† was told that most of the hits on the off-shore squadron were received while in motion.

Colonel Clarke, R.E.,‡ "It is quite useless for ships to engage earth batteries by circling in front of them. They must either anchor or steam up to a buoy to fire, and the elliptical course, which theory has delighted in preserving, must be utterly given up where coast defenses cease to proffer a target."

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* Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

† Bombardment of the Forts of Alexandria; Walford. R.U.S. Institution Journal. Vol. XXVII.

‡ Fortification; Clarke. 1890.

Lieut. R. Hyde Smith, R.N , referring to howitzers:[*] "Ships could not remain at anchor where such ordnance was mounted, and no distant bombardment could be effective without their being so."

Admiral Right Hon. Sir J. D. Hay:[†] "Captain Walford laid down rather hard-and-fast rules that for the future it would be better for ships, in all cases, to engage batteries at anchor. I should be very sorry to hear that made an invariable rule of naval tactics. It is quite true where you have not much sea-room, or where there is much motion, it would be the better plan to adopt; but where there is perfectly smooth water and you have plenty of sea-room, I think there may be occasions in which it would be better to attack with the fleet in motion than at anchor."

The *Monarch*, under weigh, at Alexandria, received no hit, while the *Penelope* was struck eight times and the *Invincible* eleven.

At Port Royal and the first attack on Charleston the ships were under weigh, but at the subsequent bombardments of Forts Wagner and Fisher they anchored.

Admiral Porter, U.S.N., has written regarding keeping the ships in motion:[‡] "The plan has the advantage of bothering the enemy's gunners, as the ships are constantly changing their range; but it tends to lengthen out an engagement. At Hatteras, what should have been finished in six hours took twenty-four hours to accomplish." On which Captain Jackson remarks: "In these days, when the shore gunner has efficient range-finders while the sea gunner has none, which is the more likely to be bothered by change of range?"

Movement of the target or the gun generally renders the use of shrapnel with time fuzes almost impossible, which may be a disadvantage to the ships, but is not of much importance to the forts, because the upper works and unarmored portions of the ships form excellent bursting screens, and shrapnel with percussion fuzes may be expected to be very effective.

[‡] Naval Essay, 1892; Hyde Smith. R.U.S. Institution Journal. Vol. XXXVI.

[§] Bombardment of the Forts of Alexandria; Walford. R.U.S. Institution Journal. Vol. XXVII.

[‖] Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

From the Defense point of view there seems to be a decided advantage to be gained by the ships in moving, because (*a*) the "error of the day" varies with range; (*b*) an alteration of speed varies the allowance for time of firing; (*c*) alterations of direction upsets "predictions" and often varies the deflection required; and (*d*) the necessity of frequently changing the assignment of targets to the forts or "groups" may very well produce confusion unless the officers of the Defense have had much more practice than is at all likely.

Steaming up to a buoy at a known range, though as far as the Defense is concerned it is much the same as anchoring, may be the better method for some ships. Captain Jackson says:* "In the absence of means of quickly ascertaining and communicating the range, any rapid movement on the part of the attacking ships is out of the question, or if carried out, must entail bad shooting and waste of ammunition. The numerous instances already given show that to maintain an effective fire a ship must be at anchor. The excellent practice made by the *Inflexible* at Alexandria may be quoted in opposition to this theory, but the peculiar armament of that ship must be taken into account. The *Inflexible* carried four 16-inch R.M.L. guns, and eight 20-pr. R. B.L. guns. The lighter guns were therefore wholly insignificant in comparison with the heavier. The ship carried no secondary armament, in the sense in which the term is now understood. The four heavy guns took some time to load, and their fire was naturally delivered in salvos, with considerable intervals. The policy of keeping the ship moving, and steaming to an ascertained position to fire, seems to have been the natural outcome of her armament. Such a plan would probably not have been followed had she had a secondary armament of 6-inch guns, such as is now usually carried by battle-ships."

Weighing the evidence, it seems probable that unless the Defense is known to be bad in material or *personnel*, a bombardment will be begun with the ships under weigh, and that if it appears possible to silence the forts, then to do that the ships will go in to short ranges and anchor.

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* Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

Of course, when co-operating with a land force, as will usually be the case, there can be no particular object to be gained by silencing the guns on the sea faces. It will be sufficient to annoy the gunners on the land faces, who will then be taken in flank or rear, or to sweep the ground outside the works in order to prevent sorties. Under these circumstances great accuracy of fire is not necessary, and it is unlikely the ships will either anchor or close to short range, unless they have an overwhelming superiority in mass of fire.

Another point in connection with the maneuvering of the ships under fire is the position individual ships should place themselves with regard to the trajectories of the guns they are engaging.

Rear Admiral S. Long, R.N., in a recent lecture* said: "In many cases of actions between single ships and of ships engaging forts there would be an advantage open to one opponent by maintaining the position as much as possible in which he presented an oblique target to his enemy, and this especially at the beginning of an action, when all guns are intact and fire a maximum." He founded this theory on the increased resistance of armor if struck aslant.

Vice Admiral Sir E. Fremantle agreed with him: "The position of 45 degrees . . . . was one which was especially favorable as enabling you to use all your guns on one broadside, whilst at the same time not being placed in a position normal to that of the enemy."

But Captain May, R.N., replied with much force: "Now-a-days that we have so much curved armor, turrets, barbettes, redoubts, and the much abused conning tower, I do not think the oblique direction is so important. If a shell comes in on the bow, 45 degrees from the keel, and bursts, the splinters will diverge another 45 degrees, and will rake the deck, going nearly fore and aft, whereas if the shell comes in directly abeam, you only get your angle 45 degrees, and probably only one gun on the fighting side injured. I think that is important, and we cannot afford to disregard it."

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* Probable Influence of Quick-firing guns on Naval Tactics and Construction; Long. R.U.S. Institution Journal. Vol. XXXVI.

Tables might be given to show the increase of resistance given by the variation of the angle of impact, and it may be conceded that in some ships an oblique position of the keel may cause the emplacements of the primary armament to afford considerable protection to the secondary armament; but with a properly arranged and properly fought fortress, the ships will be dealt with in succession and assailed with a converging fire, which will defeat such a maneuver.

Under this head, too, may be included the nature of the fire. Whether the fire of the fleet shall be concentrated on works in succession or spread depends on their arrangement. If the batteries can be approached in succession, Sir Howard Douglas' plan, as quoted by Captain Bridge, R.N.,* is obviously the best: "Isolated points of defence mutually protecting each other, should be attacked in detail, and successively reduced, after which the fleet may arrive at and attack the main position." But if they do mutually protect each other, it is not clear how they can be approached in succession, and seeing how little material damage can be effected by ships' fire, it would appear that it must be generally advisable to, as far as possible, engage all guns bearing on the ships, in order to lessen the accuracy of their fire.

Under nearly all circumstances common shell appears to be the best projectile, but as exceptions may be noted—(*a*) The case of open works, when the range is known and facilities for observing the fire are good, in which shrapnel with time fuzes having some searching power may be better; (*b*) and perhaps, the chilled iron forts to be found† on the French, German, Russian, Danish, Spanish and Portuguese coasts, which might be best dealt with by salvos of armor-piercing shot. But even against armored casemates common shell will generally have the best effect, because the burst affects the *personnel* morally, the observation of fire is easier, and guns may be put out of action by their mountings being jammed by *debris* or pieces of shell.

As a rule percussion fuzes to burst on graze are best, though if

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* Naval Attack of a Fortress; Bridge. R.E. Occasional Papers, 1877.

† Attack of Armor-clad Vessels by Artillery; Orde-Browne. R.U.S. Institution Journal· Vol. XXVI.

masonry has to be attacked a delay-action fuze, permitting of some penetration, will enable a better result to be obtained from accurate hits.

Admiral Porter's orders at Fort Fisher were:* "Fire to dismount the guns and knock away the traverses." "All firing against earthworks, when the shell bursts in the air is thrown away. The object is to lodge the shell in the parapets and tear away the traverses in which the bomb-proofs are located. A shell now and then exploding over a gun *en barbette* may have good effect, but there is nothing like lodging a shell before it explodes."

Observation of fire may be assisted by sending out vessels for the purpose to a flank of the attack, as was done with three gunboats at Fort McAllister† or by the use of balloons, which the French have proved‡ practical.

3. *The Formation of the Attacking Force.*

Where it is possible it would seem that there is an advantage in ships, having end-on fire, approaching fortifications in line abreast, because it may to a certain extent prevent them being dealt with successively. The river gunboats on the Mississippi, acting together, survived many encounters with forts, but when the *Cincinnati* ventured to make a reconnaissance by herself at Vicksburg on 27th May, 1863, she was very quickly sunk.

Very often, however, if not in the majority of cases, hydrographic conditions will make such an advance very difficult or impossible.

Rear Admiral Long (speaking, it is true chiefly of purely naval combats), says:§ "The formation in line ahead is that ordinarily used for navigation, especially in circumstances of difficulty, and when it is considered that the maintenance of any other formation involves the use of the compass, which is likely to be shot away in action; it seems probable that its advantages as regards facilities of maintenance will outweigh any disadvantages it may

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* Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

† The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

‡ Balloons for Naval Purposes; Daniell. R.U.S. Institution Journal. Vol. XXXV.

§ Probable Influence of Quick-firing guns on Naval Tactics and Construction; Long. R.U.S. Institution Journal. Vol. XXXVI.

have from other points of view." And: "The distance apart at which ships of a squadron are to keep station affects the question of artillery support. Two cables (400 yards) appears to be accepted generally as the most suitable, and, considering the result of damage to communications or steering gear in action, no less distance is likely to be accepted on the open sea."

The concussion of the guns has been said to render the compass useless.

The intervals between ships may of course be affected by local conditions. Thus Sir G. Hornby has stated* that in the Dardanelles the water being very deep it is necessary to go close to the shore to anchor, and that consequently to bring a superior force of guns to bear on a fort from anchored ships, they would have to be very close together. His idea had been in such a case to put them one cable apart.

At Port Royal† the ships moved up in two colums; the main column at distances of a ship's length, with the flanking column of gunboats at the same distance on the starboard (off-shore side).

At Charleston the monitors went into action in line ahead.

During the French Naval Maneuvers of 1892,‡ when Cherbourg was attacked, the fleet steamed past the breakwater in line ahead, sending out its torpedo boats to deal with those of the defense.

At Alexdria the off-shore squadron, before anchoring, moved on an elliptical course in line ahead, at intervals of about one cable, with a speed of about five knots.

At Sfax§ the French had boats at a "few hundred yards," gun-vessels at about 2300 yards, and iron-clads at from 4300 to 7000 yards.

In several instances during the American Civil War the lighter vessels armed with long-range guns were employed outside those with heavier armament.

Something like the following plan seems probable:—

The ships intended to take an active part in the bombardment

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* On Naval Tactics; Dowell. R.U.S. Institution Journal. Vol. XXV.

† The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

‡ French Naval Maneuvers, 1892; Garbet. R.U.S. Institution Journal. Vol. XXXVI.

§ Fortification; Clarke. 1890.

will be divided according to their vulnerability, and will steam up, at a moderate speed from one flank of the works, in columns of divisions in line ahead at intervals in each column of about 400-yards. The distances between the columns will depend to a great extent on the difference in vulnerability, but it will be sufficient to allow each column describing an elliptical course, until it is decided to close in and either anchor or steam on a buoyed course.

The fleet may be divided, in the first instance, into squadrons to deal with different parts of the fortress; one division of a squadron may anchor while the other keeps in motion, and the peculiarities of some ships may cause the commander to use them more or less independently.

Gun-vessels, and cruisers too weak to subject themselves to the fire of shore defenses, will be employed on the flanks to observe the fire, or if opportunity offers to land small parties to surprise isolated batteries, which really appears the only possible method of silencing vertical fire batteries and guns mounted on the "disappearing" principle.

Torpedo boats will seek shelter on the off-shore side of the inner divisions, and be ready to deal with any attempts of craft of their own class.

If the Defense has controllable torpedoes, or batteries of Whiteheads like Germany and Italy, they will have to be avoided by motion or be dealt with by the torpedo boats if that is possible. Torpedo nets cannot be used under weigh, and in any case cannot be put out in action,* as if struck by shot or shell they would give dangerous splinters and fragments.

4. *The Most Suitable Time for the Attack.*

There can be no doubt that, except for annoyance or attracting attention from an attempt to penetrate the water area of a fortress with torpedo boats, a bombardment at night is perfectly useless, and the expenditure of ammunition will always prevent one; though such a maneuver is a pretty sight and will often form a part of peace exercises.

The earlier in the day a serious bombardment is commenced

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* Submarine Mines; Clarke. "Proceedings," R.A. Institution. Vol. XVII.

the better, because it will always take a considerable time to produce any effect, and if the garrison is worth anything, the task, if not finished, will have to be begun afresh next day. The ships will always be able to retire when they desire.

Tidal currents may affect the exact hour, as a strong one setting in towards the forts might carry a temporary disabled ship into a position she could not get out of. Besides some ships can fight better bow on and this would be difficult on the flow. At the attack on Grand Gulf, Mississippi, on 29th April, 1863, the gun boats actually ran past the batteries at very short ranges in order to gain the advantage of fighting with their heads up stream.*

Smooth weather is necessary for the ships' fire to have any accuracy, and is moreover desirable because, as the Director of Naval Construction has pointed out,† a ship rolling heavily may be struck below her armor.

A light breeze blowing landwards is favorable as long as ordinary powder is used, because the smoke will bother the fort gunners, and to some extent the ships will escape from the interference of each others' smoke.

FORCING A PASSAGE.

This, as Captain Jackson has noted,‡ does not mean forcing the entrance of a harbor, the inner waters of which are under the fire of the defenses, for in that case the ships would gain nothing; and the risk of their defeat and capture in their cramped position would make such an enterprise unjustifiable.

But if there is undefended water beyond the defenses as at Mobile Bay, the aim may well justify the risk, for it is pretty certain that no number of shore batteries will alone be able to prevent the ships passing.

It may be urged that no example, since the introduction of range and position-finders, quick-firing guns, electric lights, and means and methods of fire control, exists; but it is clear that the only way artillery can prevent a ship's passage is by injury to

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* The Navy in the Civil war. 3 vols. Soley Ammen, Mahan.

† Attack of Armor-clad Vessels by Artillery; Orde-Browne. R.U.S. Institution Journal. Vol. XXVI.

‡ Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

her engines or steering gear, and the chances of a ship escaping such injury are very great, and in most cases they may be made greater, or the effects of the injuries neutralized by proper arrangements.

The example of the *Keokuk* at Charleston shows how hard it is to sink or stop the weakest of ships. At Mobile the disabled *Oneida* was carried past the fort by the gun-boat lashed alongside of her.

Such being the case it is clear that the conditions are very different to those governing the conduct of a bombardment, but the tactics to be pursued can be discussed under similar heads, with the addition of a fresh one, which requires to be taken first, viz.:

1. *The Dealing with Obstructions.*

Unless the attack has recent and reliable information, it will be necessary to closely reconnoiter a channel before making an attempt to force it, because even a slight check to the leading ship may cause great confusion, if not disaster. Of this there was a clear illustration at Mobile Bay, 5th August, 1864, where the stopping of the *Brooklyn* would have blocked the channel, and probably have put the fleet at the mercy of the Confederate ram *Tennessee*, but for the coolness and courage of Admiral Farragut, who took his ship, the *Hartford*, out of the column and over the submarine mines.

The reconnaissance will undoubtedly have to be carried out in boats under the cover of darkness, unless the forts are [illegible] and so badly manned that their fire can be completely silenced by a bombardment delivered from outside the channel, and even then if the channel be narrow musketry fire will make a daylight reconnaissance impossible.

Obstructions vary from simple entanglements like those at the entrance to Charleston north of Fort Sumter, to sunken ships, as at Sebastopol, or they may be submarine mines.

Some may be impassable or only removable with an [illegible] of considerable time, in which case the forts must be captured and the operation ceases to be one of simply forcing a passage.

Others it may be possible to get through, and in these cases may be included submarine mines. This will be considered [illegible] and the examples of the *Patapasco*, the *Tecumseh*, and other ships sunk by mines in the American Civil War will be quoted, but all these cases were those of weakly built hulls without water-tight compartments, and their bottoms were actually blown in. With modern ships and mines, the effect *expected* is the disablement of the machinery by the shock, and not the actual sinking of the ship, but even this is doubtful when it is remembered that such weak constructions as the *Weehawken* at Charleston, and the *Montauk* at Fort McAllister, were actually lifted by the explosion of mines without injury. There appears to be no example of ships being injured by a simple shaking.

The British Navy has an elaborate system of counter-mining, but no other has,* and as such an operation undoubtedly requires much preparation, including the establishment of a base in the vicinity of the place attacked, it is unlikely to be undertaken.

Submarine mines are generally credited with exerting a great moral effect, even when the local conditions are most unfavorable to their use, but this will be worth nothing at all if a Farragut commands the attack.

2. *The Range at which the Ships will Engage.*

This will usually be decided by the conditions of navigation. But, if there is a choice, the nearer the ships can pass the forts the better, because the arcs of fire of the guns will be more quickly got through, and the ships will derive the full benefit of their secondary and and auxiliary armaments, while the danger to the "vital target" is not great enough to outweigh these advantages.

3. *The Formation of the Passing Fleet.*

There appears to be only one formation for navigating a channel, viz.: that of line ahead.

Even at New Orleans, where forts on each side had to be engaged and were assigned to different divisions, the fleet was formed in a single column.

At Vicksburg, on 28th June, 1862, the gun-boats formed a separate column on the outside of, and covering the intervals of, the the main one; but at Port Hudson, on 15th March, 1863,

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* Submarine Mines; Clarke. "Proceedings," R.A. Institution. Vol. XVII.

Farragut, with his previous experience, formed the two columns into one by lashing the gun-boats to the ships, which were slightly in echelon to facilitate end-on fire as the batteries were approached.

At Mobile, it is true, the monitors formed a separate column between the fort and the other ships, which were arranged as at Port Hudson, but it is certainly an open question whether it would not have been better to have had them at the head of the main column. They would have been in a better position to deal with the *Tennessee*, and the other ships would have had more room in the channel.

For the sake of mutual support the closest order admissible will generally be adopted. Rear Admiral R. V. Hamilton, C.B., says:* "In attacking forts under weigh very close order must be kept." Farragut passing Vicksburg remarks: "If the ships had kept in close order in all probability they would have suffered less, as the fire of the whole fleet would have kept the enemy from his gus a longer space of time, and when at his guns his fire would have been more distracted."

The arrangement of lashing the smaller vessels on the outside of the larger ones greatly lessens the chance of the important ships being stopped, and leads one to ask if colliers and other comparatively cheap vessels could not be lashed on the fighting side, or both sides if required, to act as bursting screens for the projectiles of the defense?

Could not such ships be also used as "forlorn hopes" to clear the way through mine-fields at night? If built with water-tight compartments, or especially prepared, they would not sink before they had been moved out of the way of the following warships.

4. *The Maneuvering of the Ships During the Passage.*

Under this head there are two points, the speed and the nature of the fire.

As to speed, the highest compatible with the safe navigation of the channel and the co-operation of the ships seems to be the

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* Naval Operations during the Civil War in the United States; Hamilton. R.U.S. Institution Journal. Vol. XXII.

best, but the qualification is very necessary for the examples of the Mississippi and Mobile Bay clearly show that the dangers from navigation and confusion in the squadron far exceed those from the action of the Defense.

It is worthy of note that at the Devonport Court-martial on the stranding of the *Howe* some officers expressed the opinion that large ships with twin screws can be more safely navigated in narrow waters at a speed of four or five knots than at a faster.

Uniformity of speed is to be expected, as any change is likely to produce confusion.

As to the nature of fire; the immediate object being to avoid injury to the ships, and the best method of attaining it being to keep down the fire of the forts, the secondary armament, and the auxiliary, if the ranges are suitable, will be used.

If the passage is made under cover of dusk or darkness and the fire of the forts is ineffective, it may often be better not to fire at all, because the smoke may increase the difficulties of navigation as was the case at Port Hudson;* but in other cases the veil of smoke may be of great use in hiding the vessels.

5. *The Most Suitable Time for the Passage.*

Captain Jackson on this says,† "Admirals Farragut and Porter evidently considered that ships had a better chance of slipping past in the dark, and to obtain the immunity from the enemy's fire which obscurity afforded, were ready to encounter the risks to navigation, which are unavoidable in a night action. . . . Yet the results of their action show that the passage of a narrow channel in the dark was a mistake. The case of a broad channel, which presents no difficulties of navigation, is different. . . . Here, if a ship or squadron wished to force a passage, darkness or fog would be chosen. In clear daylight there would be a chance of passing without being hit. In even moderate mist, still more in darkness, there would be a certainty of passing without injury. Now on the other hand, consider a position like Vicksburg fortified according to modern ideas . . . . No water battery would be found unless it were a dummy erected for

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* The Navy in the Civil War. 3 vols. Soley, Ammen, Mahan.

† Ships *versus* Forts; Jackson. R.E. Occasional Papers, 1889.

the purpose of diverting the fire of the ships from more important objects. Along the shore would be placed numerous electric search-lights, which would brightly illuminate the passing ships, dazzle the eyes of their Captains, and at the same time render the guns on the heights above invisible. The search-lights on board the ships would only add to the confusion. Without exaggeration, it is not improbable that the search-lights, judiciously used, might alone prevent the passage of the ships, and that the latter would devote themselves, as a preliminary operation, to extinguishing the lights by machine gun fire. Under these circumstances would not an Admiral prefer daylight to darkness? Would it not be better to expose ships to the enemy's fire than to the risk of grounding under the batteries? Farragut's squadron in the battle of Mobile Bay, suffered little from the fire of Fort Morgan, though he passed it in daylight. . . . However, looking at the matter from the Artilleryman's point of view, no general rule can be laid down as to the probable time for an attempt of this nature. The passage of a clear channel, however strongly defended by batteries, may be effected at all times of day and night and in any sort of weather. Ships can only be stopped by obstructing a channel to such an extent as to delay them under fire."

In fog dirigible torpedoes cannot be used, and in darkness their effective use is uncertain, which sometimes may be of very great importance to the attack.

LANDINGS, TORPEDO-BOAT RAIDS, &c.

If the foregoing deductions concerning the attack and passing of forts by ships are correct, it is clear—the offensive powers of the ships being so small and their risks of disablement so large—that some form of land attack in co-operation will nearly always be made, if the capture of the forts is the object in view or is necessary to ensure success.

This form of attack remains much the same as when so often practiced in the West Indies* and elsewhere in the last century, for, as Rear Admiral P. H. Colomb† has pointed out, steam

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* Annual Registers.

† Military and Naval Operations; Colomb. Lecture 34, Aldershot Military Society, 1891.

though it may shorten the passage of the boats from the ships to the shore, has not otherwise altered the conditions of the enterprise.

Although in some cases where the heavy broadsides of the ships were able to silence the weak shore batteries, landings were made close to the works, the lesson we received at Camaret Bay,* near Brest, as far back as 1694 holds good, and is strengthened by the relative power of ships and forts at the present day. A landing cannot take place in a defended area.

Sheltered landing places are necessary, for an open beach presents too many risks, because a very slight surf may make disembarkation impossible. The army was landed in the Crimea on an open beach, but the operation was one contrary to the teaching of experience, and itself illustrated the risks incurred.

When the attack is on a large scale, directly the land forces are in a position to act, the ships play a secondary *rôle.* They complete the investment and give such assistance with their guns as the circumstances admit.

Small parties may be landed either as a preparatory measure (Hatteras Inlet) or incidentally during the attack (Alexandria), but in either case surprise is necessary for success, unless the troops of the Defense are very bad or have been thoroughly demoralized. A check to the attack generally means disaster. Louisburg, Cape Breton, in 1745, Petropaulowski in the Crimean War, Peiho River, in 1859, Fort Sumter, 8th September, 1863, and later the French abortive action at the mouth of the Tam Sui, are perhaps sufficient examples.

This necessity for surprise appears to limit such attempts to very small dimensions, and to render the often-suggested enterprises with landing parties about 2000 strong extremely improbable, if not impossible, because (*a*) few modern ships of war can carry troops; (*b*) none have men to spare from their crews, when they themselves are to be engaged; (*c*) the presence of transports will at once put the defense on the alert; (*d*) the landing of such a force will take a considerable time; (*e*) if such a force is landed, its relation to the ships is the same as if it was a large

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* Military and Naval Operations; Colomb. Lecture 34, Aldershot Military Society, 1891.

one, but as its self-contained power is smaller, its chances of getting away again are also much smaller, for embarkation is well-nigh impossible if the enemy cannot be kept out of range.

At Aboukir Bay,* in 1801, the marshaling of the boats conveying the first detachments numbering about 2000 men, took many hours, although the fleet and troops had had far more practice than is ever probable in future. At Lissa,† in 1866, the attempt to land 2200 men took many hours to prepare and was then abandoned before the Austrian fleet was signaled.

Torpedo boat raids to destroy shipping, dock gates, &c., are perhaps the most probable of all forms of attack, because the size and speed of the boats render injury to them improbable unless they are stopped by obstructions in narrow waters defended by quick-firing ordnance.

No exact form of attack can be predicted. It is not likely that more than one or two boats will be employed at a time. Their aim will be to reach their objective unobserved, and the method of effecting this must vary with local conditions.

There is one other form of attack which should be noticed, because bases of supply, such as Cardiff, where the object would be to destroy dock gates and so impede shipments, are liable to it, viz., the use of high explosives conveyed in trading vessels. This will be prevented if all ships are compelled to anchor outside of the defenses for examination, and each ship's agent at the port is made responsible for her.

In fog neither can torpedo boat raids be stopped, nor vessels carrying high explosives prevented reaching the vicinity of dock gates, without the defense has an efficient organization of swift guard-boats.

CONCLUSION.

To sum up.—

In forcing a passage the risks include the possible loss of a ship or perhaps more. On the other hand it is almost certain that some of the ships will get past though their injuries will be severe and the probability of [illegible] them will increase from year to year.

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* Military and Naval Operations [illegible]

† Attack on Lissa [illegible] Lewis [illegible] Professional Papers [illegible]

In a bombardment there is a risk of serious injury to all the ships engaged, but a small one of actual loss. There is, however, a certainty of an enormous expenditure of ammunition with no lasting result, unless the fortress is badly constructed *and badly manned.*

Command of the sea is necessary before any serious attack on a sea fortress can be undertaken, because time, free communication with the base, and the co-operation of land forces are requisite.

A naval force cannot alone capture or destroy land defenses except in circumstances that should be exceptional.

The lessons for the defense:—

1. If the fortress' charge can be injured by distant bombardment a *few* heavy guns and a *few* heavy howitzers will be sufficient in advanced positions to keep the ships moving and so prevent accuracy of fire.
2. But it is best to concentrate the main defense on narrow waters, where navigation is difficult and ranges short.
3. A through channel, or the approach to the fortress' charge if it can be injured by torpedo boats, should be obstructed sufficiently to delay the passage of ships or boats; and the obstruction so defended that it may be safe from boat reconnaissance and attack.
4. Guard-boats are required for use in fog, when batteries are useless.
5. The material and the men should be prepared, remembering that simplicity of arrangement with the former, discipline *and localization* with the latter, are the chief essentials.
6. Some officers, of Garrison Artillery or attached to it, should have sufficient naval training to understand the probable actions of the enemy.

If these lessons are acted on, Coast Defense will be doubly strong at half the expense; and the naval assaillants will more than ever feel that "*Le coût fait perdre le goût.*"

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NOTES ON ARMOR.*

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I.

INTRODUCTION.

There is no question connected with the work of coast artillery of greater importance than that of armor. War ships in the future will carry armor covering a larger area of their sides than ever before, and the latest phase of the question, introduced by the employment of shells carrying within them bursting charges of high explosives, makes the armor on many old-type vessels of more service, relatively, than it was ten years ago. It is easy to understand, for example, that a ship of the *Hercules* type (1866) is better able to meet the fire of 8-inch guns and smaller calibers firing shells with gun-cotton charges than one of the *Impériuse* type (1881).

At all events, the targets to be fired at in time of war are of primary interest to the coast artillery. What will be the character of these targets? How do the powers of resistance of

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* It is the intention of the writer, after a brief review of the subject of armor in general, to present in the *Journal*, from time to time, such facts and information pertaining to armor as may come to his notice and be suitable for publication. To the end that the notes may be full, he asks contributions from all those who may be interested. Information in this line addressed to him at Fort Adams, Newport, Rhode Island, U. S. A., will be gratefully received and duly ackhowledged. E. M. WEAVER.

the sides of armored battle-ships compare with the penetrating powers of our sea coast guns? These questions must always be up before us as perhaps the most fundamental and practical ones we have to deal with.

It is desired in this series of notes to traverse the ground covered by these questions, indicating the leading features of the targets presented in the sides of the type ships of the principal naval powers, and considering the powers of resistance offered by these ships to the attack of our 8-inch, 10-inch, 12-inch and 16-inch B. L. sea-coast guns.

A brief review of the gun-armor question may be given here with advantage:—

THE GUN-ARMOR CONTEST.

For almost forty years this contest has been going on. The advent of modern armored ships may be considered to date from the bombardment of the Kinburn forts by the French men-of-war in 1854. In this action the iron-clads *Lave*, *Devastation* and *Tonnante* took a leading, if not decisive part, and their success on this occasion determined the future use of armor protection on war vessels. France was led to lay down her first armor-clad battle ship, the *Gloire*, in 1858; England followed with the *Warrior* in 1859; Italy, with the *Formidable*, in 1860; Russia, with the *Petropalovski*, in 1861, and, finally, our own country with the *New Ironsides* and the *Monitor* in 1861. These ships, respectively, constituted the germs of the great fleets that to-day sail the seas under the flags of these countries. With the appearance of iron-clad war vessels began the struggle between armor and artillery.

The advantage in this competition has oscillated from the gun to armor and back again so often that it has been difficult to predict at any one stage the character of the next one. At no time during the entire period has the rivalry been more keen than during the past two years, and at no time has the advantage appeared to be more positively on one side than it does at present on the side of the plate. Yet, in view of what has heretofore happened, it would be a rash thing to say that the prolonged contest has at last been brought to an end. The entire metallurgical horizon is being scanned with a watchful eye by projectile makers, and any new promising process, or principle, or treatment introduced in iron or steel manufacture will be seized upon by them and tested to the fullest extent with a view to restoring to the projectile the leading position from which it now appears to have been displaced.

The train of improvements which has led up to the present status of the relation between the plate and the projectile was initiated about 1875. The contest previous to this had been between wrought-iron armor, on the one hand, and cast-iron projectiles on the other. A short time before, the cast-iron projectile had been improved by chilling the ogive in casting; but, with this exception, there had been no material innovation in the manufacture of projectiles since the introduction of rifled projectiles.

Step by step, however, guns had been increasing in caliber and power. The only way wrought-iron armor could meet this increased power of the attack was by increasing the thickness of armor to correspond with the increased power of the guns. In this way, little by little, the thickness of armor increased on the sides of battle-ships until, finally, this phase of the contest may be said to have terminated with the twenty-four inches of armor placed along the water line of the English ship *Inflexible*, in 1874.

In 1875 the French designed the *Furieux* to carry steel armor. The Italians two years before had planned the *Duilio* to have steel armor, and this ship, launched in 1876, was the first battleship to float steel armor. In the same year the Wilson patent for compound armor was taken out. Two new types of armor, thus, made their appearance at about the same time. Both gave much higher powers of resistance than wrought-iron and this fact enabled war ships to reduce the thickness of armor carried by them, and, with the same relative defensive powers, gave them greater buoyancy and allowed more space between decks—considerations which were of great importance because of the encroachments that had been forced by the necessity of carrying great thicknesses of wrought-iron armor.

A contest at once sprang up between the compound plate made in England, chiefly, and steel armor made principally in France.

This battle of the plates was fought out on the testing grounds of Europe with varying advantage. As long as chilled-iron projectiles were used the compound plate had the better record in that it broke up in better form iron projectiles, but, with the appearance of the steel projectile, the weak point of the compound plate—the weld between the face and body—began to become apparent, and the steel plate, after this, was considered the better type. The rivalry continued however very warm down to the Annapolis and the Ochta trials of 1890. After these trials there remained no doubt as to the supremacy of the Schneider all-steel plate over the compound plate of the English manufacturers. But these same trials, which established the superiority of the all-steel plate, also marked its downfall in the introduction of an alloy of nickel and steel as armor-plate metal.

In consequence of the fact that cast-iron projectiles were broken up with ease by both steel and compound plates there arose a lively competition among European metallurgists in efforts to produce an efficient armor-piercing projectile. Krupp, Armstrong, Firth, Whitworth, the Terre Noire works, the St. Chamond works, Hadfield, Holtzer and others gave the matter close study and worked diligently to arrive at a solution. Forged-steel, cast-steel, specially treated steel and alloys of steel were all tried as projectile metals in many competitive tests in the period between 1882 and 1886. The results of the tests established in a definite way the superiority of the projectile made by Holtzer in France and Hadfield in England of an alloy of chromium and steel.

These chrome-steel projectiles were first developed in France by M. Brustlein, the metallurgist of the Holtzer Company. M. Brustlein had noted as far back as 1875 the success that had attended the efforts of Mr. Julius Baur, of New York, in the manufacture of chromium-steel for commercial purposes. Based on Baur's work he began experiments in France with projectiles made of this alloy, and ultimately succeeded in producing the now famous Holtzer armor-piercing shell, which has become the standard projectile, the world over, for attacking armor. In England, the projectiles made by the Firminy process, and those made by Hadfield, both understood to be chrome-steel alloys, possess about the same qualities as the Holtzer projectiles.

These projectiles have remarkable hardness associated with a high measure of tensile strength. To such a degree do they possess these properties that, as a rule, they are not disintegrated by impact against ordinary steel or compound plates, even with velocities above 2000 f. s,, and often they undergo impact without material deformation. By thus holding together they expend the full amount of their energies in producing changes in the plate, *i. e.*, in penetration, cracks, etc. There is on record the performance of a 6-inch Hadfield projectile which was fired three times from the same gun against armor,—the first time, it perforated a 9-inch compound plate and its backing; the second time, it perforated, similarly, a second 9-inch compound plate; the third time, it was fired at a specially treated plate which broke it up. When fired at simple steel or compound plates chrome-steel projectiles, with rare exceptions, either perforate without deformation, or rebound entire from the plate, or remain in the plate unbroken gripped by the metal.

The introduction of these projectiles had the effect of restoring the attack to the same relative position it held ten years before when cast-iron projectiles were pitted against wrought-iron armor; the increase in gun-power that had occurred in the meantime made about the same calibers effective against the same thicknesses of compound or steel armor as formerly obtained with cast-iron projectiles against wrought-iron armor.

This improvement in projectiles gave an impetus to the arguments of a certain class of officers abroad who advocated the abandonment of vertical armor. At first armor covered the entire hull of the ship as in the case of the *Gloire* and *Formidable*, but, in order to keep pace with the increased powers of the attack, it became necessary to make side armor thicker and thicker until, about 1865-7, when six to eight inches of wrought-iron were found to be insufficient, tonnage considerations placed a limit to this manner of meeting the attack. At this stage naval constructors were forced to leave certain portions of ship's sides uncovered in order that the requisite thickness could be placed along the water line and in the wake of the vital parts of the ship. England and Italy led the way in this movement as evidenced, for example, in the *Inflexible* and *Duilio*.

It was claimed by the anti-armor school that ships could fight and live even though projectiles should pass with freedom through the unarmored parts; that while, of course, it would be desirable to keep them out, if possible with a moderate thickness of armor, this could not be done, and, therefore, it would be better to have the increased flotation and interior ship space than the incomplete protection of the armor, especially as this armor, while failing to stop the projectiles, would, through the resistance offered, develop in blind shells sufficient heat to explode the charge between decks, which, if the armor were not there, would probably pass through these parts without exploding. It was further claimed that it would be better to give attention to increasing the flotation power of the ship by providing a belt of light elastic material like cork or cellulose along the water line, which, while permitting projectiles to pass, would, to a certain extent, close after them, and prevent the ingress of water, and, also, by employing many water-tight compartments in the structure of the ship's bottom filled with this same material, the effect would be to give the ship what was called a "raft body" and make her practically unsinkable; furthermore, that the development of the ram and the torpedo threatened to make all armor above water useless.*

These views were making great headway in naval circles and it seemed at one time that coast defenders might see all vertical side armor vanish, and that our sea-coast armament would have to deal chiefly with "wooden walls" again. But, at this epoch, an event occurred which arrested at once all progress in this direction, and caused a complete cessation to this line of argument.

Originally armor was placed on ships to keep out explosive projectiles, but as the resistance offered by armor became greater, the walls of the shell had to be made thicker. In course of time these conditions reduced the explosive charge within the shell to almost insignificant proportions. About 1880-5, however, it was shown by experiments that gun-cotton and other

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* It is probable that the sinking of the *Victoria* will revive some of these arguments.

explosive nitro-compounds could be fired with safety in shells with high velocities, and it was further revealed, especially by the experiments on the *Resistance* at Portsmouth, England, in 1889, that the destructive effect of shells so charged was appalling. "None but those who had witnessed the trials could picture the wholesale destruction caused by these shells. Of dummy men, scarcely one in the vicinity of a bursting shell escaped; but one of the most remarkable features was the terrible smoke and fumes after each explosion, which set fire to the ship and prevented any one approaching the spot, in some cases for twenty minutes after the shell had burst."* Also the use of forged steel shells enabled thinner walls to be used and thus increased the charge capacity of armor-piercing shells.

It is now generally admitted by all powers, including England and Italy, that it is absolutely necessary to keep these shells from entering to the interior of war ships. Practically, therefore, the same conditions obtain, at present, in this matter, as existed in 1854-5 in consequence of the introduction of the first explosive projectiles by General Paixhans of the French service, and we find in the latest designed ships a reproduction of the distribution of armor found in the *Gloire* and *Formidable*, as, for example, in the new *Dupuy de Lôme* French ship (named suggestively after the constructing engineer of the *Gloire*) and the modified design of the Italian war ship *Re Umburto*. Designers of war ships now provide, therefore, not only a belt of water line armor and turret armor but also arrange to have the entire midship section, where is placed the secondary battery of smaller caliber guns, covered with four to six inches of steel armor, with a view to excluding shells with high explosive charges from the fighting portion of ships.

But, to return to the plate, we have seen how, in the Annapolis and Ochta trials of 1890, the supremacy of the homogeneous steel plate was established over the compound plate with steel face and iron body, and reference was made to the introduction of an alloy of nickel and steel as a metal for armor. This was the first public test of a plate of this character and of a thickness as great as 10½ inches. The plate was the product of the

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* Lord Brassey's Annual for 1892, p. 309.

works of Schneider and Company, of France. Its performance was so promising, especially in the manner in which it took up the striking energy of Holtzer projectiles without cracking, that other tests were instituted by the ever watchful and progressive Bureau of Ordnance of the Navy Department, using American made plates of nickel-steel.

These tests were made at Annapolis and at the new naval proving ground at Indian Head. So emphatically did the tests confirm the behavior of the nickel-steel plate first tried, that the Navy Department at once decided to have all future armor for our war ships made of this alloy. This introduction of nickel-steel armor was a long step forward for the plate, and the credit of it rests first, with Schneider and Company, and secondly with Ex-Secretary of the Navy Tracy and Captain Folger, Ex-Chief of the Bureau of Ordnance of the Navy.

Almost simultaneous with this improvement occurred another of even a more striking nature and far-reaching in its effect on the armor question.

It has been noted that the hard steel face of the compound plate caused the old chilled-iron projectiles to go to pieces on impact. The principle involved in this action of the compound plate is, in theory, that the hard face of the compound plate, by presenting a hard rigid surface to the projectile at the very inception of its attack, prevents the point of the projectile from even entering the surface of the face of the plate, and the point being thus kept out at a critical instant, the ogive of the projectile receives no support from the metal of the plate, and, as a result, great reactionary stresses are developed throughout the projectile, tending to cause rupture; the effect is the same as if the projectile were at rest standing on its base and received on its point a blow from some huge hammer, in which the energy of the blow was equal to the energy of the projectile on striking the plate. In short, the object of the plate is to make the projectile do its work in breaking itself up, instead of doing work of penetration in the plate. For, if the point of the projectile is able to enter the plate far enough to secure a firm support for the ogive, the metal of the plate tends to keep the projectile together and to promote penetration. After the introduction of the Holtzer projectiles the points of armor-piercing projectiles had no difficulty in entering compound and steel plates and after overcoming thus the resistance associated with the first stage of impact, the subsequent course of the projectiles through the body of the plates was comparatively easy, especially with the soft iron body of compound plates.

The latest phase of the armor question has had for its object the destruction of chrome-steel projectiles in the same manner as chilled-iron projectiles were formerly broken up by compound armor. Plate makers have endeavored to increase the hardness of the faces of plates so as to keep out the points of chrome-steel projectiles. This involved, of course, giving to a surface layer of the face of the plate not only great hardness but at the same time preserving a high degree of tensile strength and toughness. All this appears to have been accomplished in a wonderfully successful manner by Mr. H. A. Harvey of the Harvey Steel Works of Newark, N. J., and to a less perfect degree by Captain T. J. Tresidder, late of the Royal Engineers. Each invention consists of subjecting the armor plate made in the usual way to a certain final treatment. The processes will each be explained in detail in connection with the consideration of the different types of armor which is to follow.

The Ordnance Bureau of the Navy deserves great credit again for its action in connection with the development of the Harvey process. The value of the invention was at once appreciated and thorough tests made at Indian Head, applying the process to both all steel and nickel-steel armor, with the result, that, employed with nickel-steel, the Harvey process has given us the highest measure of armor stength ever attained, and, in truth, some of the recently tested Harveyized nickel-steel plates have given almost ideal results.

II.

WROUGHT-IRON ARMOR.

While wrought-iron is no longer considered a suitable metal for ship armor, and has not been used for some years in new constructions, it is still of considerable interest, from a ballistic point of view, by reason, partly, of the fact that there are afloat at present many powerful battle-ships, launched before the advent of steel and compound armor, which are still in good fighting condition and will remain in commission for some years to come, and also, because the resistance offered by wrought-iron to the passage of projectiles through it has been made the subject of much study and extended experiments, and, with some authorities, it is regarded as the standard metal for ballistic comparisons of projectiles and all kinds of armor.

It is unnecessary to give a detailed account of the manufacture of wrought-iron armor. It is sufficient to say that the iron is reduced from the pig-iron by the usual commercial process and is given its proper plate form by forging under hammers or presses or passing between rollers.

Its characteristic features as an armor metal are its great ductility and uniformity of physical properties. Compared with other armor metals it is soft and yielding under impact, flowing readily from before the projectile in its passage through the plate after having exerted its full measure of resistance. The effect of impact, due to this last property, is limited almost strictly to the pathway of the projectile.

Its uniformity has led many to regard it as the proper standard of comparison for projectiles and steel armor. Often the resistance of steel armor to the attack of projectiles is expressed in terms of the thickness of wrought-iron the projectiles used would have perforated. The effect of the projectiles on wrought-iron of the same thickness as the plate under test is calculated by the formulas for perforating wrought-iron and to the results thus obtained a certain percentage is credited to the steel or compound plate. This percentage is an arbitrary factor based in each case on the experience or opinions of the experimenters. Krupp puts it at 10 to 20 per cent. for projectiles that remain unbroken. Others have placed it at 25 to 30 per cent. Recent experiments would require that the factor be as high as 50, 60, and, in one or two cases, as high as 100 per cent. But it may be doubted whether this is a proper way to measure the strength of steel armor. Steel is so radically different in its properties as armor from wrought-iron it may well be questioned whether there is any such direct and simple relation between the measures of their strengths. It would appear to be more scientific and logical to seek a formula for steel based upon experimental data. This will be considered again under the head of steel and compound armor.

Resistance to Penetration.

In view of the long period wrought-iron occupied the field unchallenged and of the many experiments made to determine its powers of resistance to the attack of projectiles, and, also, of the uniformity of its physical properties, it would be naturally taken for granted that the law of its resistance had been definitely determined, and that there would be, as a result, one formula accepted by all artillerymen as giving accurate expression to this law. This is not the case, however. In truth one of the most striking aspects of this portion of the subject is the wide variations in the interpretations of the law of resistance that have from time to time been enunciated by investigators. A review of the subject reveals a different interpretation by each of the first-class powers, and even these are not satisfactory to individual authorities in each country, and so other private formulas are advanced.

It will be a matter of some interest to glance at a few of these formulas and to endeavor to compare them, with view to bringing out wherein they are different in their respective interpretations of the law of resistance.

We may take, as among the most prominent, the following: in which t represents the thickness of plate, d the diameter of the attacking projectile, v the striking velocity, w the weight of the projectile, and E the striking energy:

$$t^{0.65}=0.002401\,\frac{w^{0.5}v}{d^{0.75}}\ \text{(de Marre's)}$$

$$t=\frac{2}{608.3}\left(\frac{w}{d}\right)^{\frac{1}{2}}-0.14d\ \text{(Maitland's)}$$

$$\frac{E}{\pi\left(\frac{d}{2}\right)^2}=100\left(\frac{t}{d}\right)^{\frac{1}{3}}t\ \text{(Krupp's)}$$

$\frac{E}{\pi d}=34.98t^{1.868}$ (Muggiano Commission's, for plates between 30 and 55 cm.)

$\frac{E}{\pi d}=15.72t^{2.085}$ (English Admiralty for plates between 10 and 20 inches)

$\frac{wv^2}{d}=2265464t^{1.4}$ (Gâvre)

$\frac{wv}{d^2}=400(t+1.5)$ (Froloff's, for plates more than 2½ inches thick)

$\frac{wv^2}{d}=62334(5t+2d)$ (Inglis')

$\frac{wv^2}{d^3}=437500\frac{t}{d}+161810\frac{t^2}{d^2}$ (de Brette's)

$\frac{E}{\pi d}=kt^2$ (Fairbairn's)

It is generally agreed at the present time that the problem of impact of a projectile against an armor plate involves nothing more than a proper accounting for the various transfers of the energy of the projectile that take place.

Under ordinary conditions the transfers of energy will take one or more of the following forms:

1. Producing change of form in the plate, that is penetration, cracking, bulging, etc.
2. Producing change of form in the projectile.
3. Heating the plate.
4. Heating the projectile.
5. Moving bodily the plate.
6. Moving the projectile in rebound.

With hard faced armor, such as steel and compound, the total energy as a rule is distributed in appreciable proportions among all of these divisions, but with soft wrought-iron armor it is chiefly confined to the first. In considering the resisting capacity of a plate we may for all practical purposes express the total loss of projectile energy in terms of the first.

For the purpose of convenient comparison let us solve the above equations with respect to the total energy of impact, and let us write for the numerical coefficient in each case the letter C. We shall have the following:

$E=Cd^{1.5}t^{1.3}$ (de Marre's)
$E=C(0.14d+t)d$ (Maitland's)
$E=Cd^{\frac{5}{3}}t^{\frac{4}{3}}$ (Krupp's)
$E=Cdt^{1.868}$ (Muggiano Commission)
$E=Cdt^{1.645}$ (English Admiralty)
$E=Cdt^{1.4}$ (Gâvre)
$E=Cvd^2(t+1.5)$ (Froloff's)
$E=Cdt(d+2.5t)$ (Inglis')
$E=Cdt(t+2.7038d)$ (de Brette's)
$E=Cdt^2$ (Fairbairn)

It is evident that the law of resistance as given by each of these formulas is determined by the relations existing among t, E and d, and we may change the value of C without affecting the law proper.

Let us impose the condition that C shall have such a value in each, as shall give the same value for E when $d=10$ and $t=10$. We shall have the following:

$E=5.8168d^{1.5}t^{1.3}$ (de Marre's)
$E=32.21(0.14d+t)d$ (Maitland's)
$E=3.672d^{\frac{5}{3}}t^{\frac{4}{3}}$ (Krupp's)
$E=4.9852dt^{1.868}$ (Muggiano Commission)
$E=3.3938dt^{2.085}$ (English Admiralty)
$E=14.619dt^{1.4}$ (Gâvre)
$E=3.34d^2(t+1.5)$ (Froloff's; v taken constant)
$E=1.04914dt(d+2.5t)$ (Inglis')
$E=0.99144dt(t+2.7038d)$ (de Brette's)
$E=3.672dt^2$ (Fairbairn)

Starting with the values $d=10$, and $t=10$, let us first assume t constant and assign to d values from 10 to 18, and deduce, for each formula, the corresponding values of E; then assume d constant, make t to vary and deduce values for E in the same manner. The results may be tabulated as follows:

TABLE I.

Showing law of resistance of wrought-iron armor to perforation by projectiles, as given by various formulas. First: for a constant thickness of plate and variable diameter of projectile. Second: For a constant diameter of projectile and a variable thickness of plate.

KRUPP.				GAVRE.				DE MARRE.				MAITLAND.				ENGLISH ADMIRALTY.				FROLOFF.			
$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.		$t = 10$ inches.		$d = 10$ inches.	
d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.
in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.
10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672
11	4304	11	4170	11	4039	11	4196	11	4234	11	4154	11	4089	11	3992	11	4039	11	4458	11	4443	11	4006
12	4975	12	4683	12	4406	12	4739	12	4824	12	4653	12	4515	12	4316	12	4406	12	5309	12	5288	12	4340
13	5686	13	5210	13	4774	13	5302	13	5440	13	5162	13	4950	13	4638	13	4774	13	6261	13	6206	13	4673
14	6433	14	5751	14	5141	14	5881	14	6080	14	5684	14	5395	14	4957	14	5141	14	7282	14	7197	14	5007
15	7217	15	6305	15	5508	15	6478	15	6742	15	6217	15	5846	15	5282	15	5508	15	8380	15	8261	15	5349
16	8037	16	6873	16	5875	16	7090	16	7428	16	6761	16	6288	16	5605	16	5875	16	9600	16	9398	16	5675
17	8891	17	7455	17	6242	17	7718	17	8134	17	7316	17	6763	17	5927	17	6242	17	10811	17	10608	17	6009
18	9780	18	8051	18	6610	18	8361	18	8863	18	7880	18	7259	18	6250	18	6610	18	12144	18	11891	18	6343
Formulas.	$E = Cd^{\frac{5}{3}}t^{\frac{4}{8}}$			$E = Cdt^{1.4}$				$E = Cd^{1.5}t^{1.3}$				$E = Cd(0.14d + t)$				$E = Cdt^{2.085}$				$E = Cvd^2(t + 1.5)$			

TABLE I (CONTINUED).

MUGGIANO COMMISSION.				INGLIS.				DE BRETTE.				FAIRBAIRN.				BY PRINCIPLE OF THE RESISTING DISK.			
t = 10 inches.		d = 10 inches.		t = 10 inches.		d = 10 inches.		t = 10 inches.		d = 10 inches.		t = 10 inches.		d = 10 inches.		t = 10 inches.		d = 10 inches.	
d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.	d	Perforating Energy.	t	Perforating Energy.
in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.	in.	ft.-tons.
10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672	10	3672
11	4039	11	4390	11	4155	11	4328	11	4334	11	4148	11	4039	11	4443	11	(1) 4235 (2) 4272	11	(1) 4059 (2) 4163
12	4406	12	5162	12	4656	12	5036	12	5050	12	4644	12	4406	12	5288	12	(1) 4792 (2) 4887	12	(1) 4449 (2) 4611
13	4774	13	5994	13	5183	13	5796	13	5819	13	5160	13	4774	13	6206	13	(1) 5345 (2) 5508	13	(1) 4842 (2) 5113
14	5141	14	6885	14	5728	14	6609	14	6642	14	5696	14	5141	14	7198	14	(1) 5882 (2) 6131	14	(1) 5240 (2) 5626
15	5508	15	7836	15	6294	15	7474	15	7518	15	6252	15	5508	15	8263	15	(1) 6383 (2) 6749	15	(1) 5641 (2) 6157
16	5875	16	8847	16	6882	16	8391	16	8488	16	6828	16	5875	16	9402	16	(1) 6883 (2) 7356	16	(1) 6046 (2) 6718
17	6242	17	9917	17	7491	17	9360	17	9431	17	7424	17	6242	17	10614	17	(1) 7346 (2) 7947	17	(1) 6453 (2) 7278
18	6610	18	11032	18	8121	18	10381	18	10468	18	8040	18	6610	18	11900	18	(1) 7767 (2) 8519	18	(1) 6865 (2) 7877
Formulas.	$E = Cdt^{1.868}$			$E = Cdt(d + 2.5t)$				$E = Cdt(2.7038d + t)$				$E = Cdt^2$				$E = C(nd)^2 t$. $(A) n = 1.52 + 0.003(T - 10d)$ $(B) n = 1.346 + 0.024(0.6T - d)$ t = depth of penetration. T = thickness of plate attacked.			

These results are further illustrated graphically in plates I and II, which bring out in striking relief the wide range covered by the formulas. For $d = 18$ and $t = 10$, plate I shows a variation in E of from 11891 foot-tons as given by Froloff's formula to 6610 foot-tons as given by the Gâvre and other formulas containing d to the first power. In the same manner plate II shows a variation of E, when $t = 18$ and $d = 10$, of from 12144 foot-tons, as given by the English Admiralty formula to 6250 foot-tons as given by Maitland's.

It will be observed that while de Marre's, Krupp's and de Brette's formulas occupy a mean position in both plates I and II, there is a radical change in the position of others. For example, Froloff's passes from the extreme right in plate I to the extreme left in plate II; on the other hand, the English Admiralty, Muggiano Commission, and Fairbairn formulas pass from the extreme left in plate I to the extreme right in plate II. The Inglis and Gâvre formulas give evidences of the same tendency, while de Brette's shows a slight swing from right to left, like Froloff's. Maitland's, though standing apart from the de Marre and Krupp formulas, like them shows no marked angular change.

The more distinct groupings of the curves in plate II than in plate I is evidence that there is closer agreement in the interpretation of the law for d constant and t variable than for t constant and d variable. The formulas of the group on the right in plate II are apparently based on the assumption that penetration is proportional to the energy per unit of length of circumference of the cross-section of the projectile. The middle group makes it proportional to the total energy. Froloff's assumes it to be proportional to the first power of the velocity—to the momentum instead of energy. The first assumes penetration to be similar to the action of a punch, the second assumes it to be similar to the action of a wedge, the third similar to the impact of elastic bodies. The first is now generally abandoned; the third is not known to be accepted by any authority except General Froloff. Only the second assumption is believed to be entitled to confidence.

Taking the loss of energy by the projectile in passing through a plate as a measure of the work performed by it, this, in turn, may be taken as a measure of the resisting capacity of the plate. The resistance offered is due to the cohesive forces which bind together the molecules of the metal and thereby make up the mass of the plate. These forces resist not only rupture, but also any force tending to cause a relative change in the original positions of the molecules. We may conceive, as a fundamental idea, two or more molecules bound together at a definite distance apart by elastic forces which oppose displacement in all directions within certain limits. The mass of metal is made up of an innumerable number of such groups. The projectile in entering and penetrating the plate encounters opposition from these forces continuously along its path within the plate; along the path it overcomes them causing rupture among the molecular aggregations, and beyond the limits of actual path it strains the molecular systems some within the limits of their elasticity and some beyond the elastic limit. In short the resistance of the plate is due to the reaction of the molecular forces which oppose the separation, displacement, or disturbance of the ultimate particles of the metal. We cannot deal with the fundamental forces existing between two molecules to obtain a unit of measure, nor can we determine specifically a measure of the force associated with the cold flow of the metal from before the projectile in its passage through the plate, but it is possible by experiment to obtain a value for the integrated effect of these small differential quantities of force, in terms of the projectile energy expended in producing a total observed effect.* This expended energy may then be made the first

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* The fundamental consideration to be kept in mind in future experiments should be *the loss of energy* by a projectile which passes completely through a plate. If this be ascertained for a series of projectiles having a uniformly graded difference of diameters, attacking a series of plates of different thicknesses, all data would be had which are necessary for preparing a trustworthy formula of perforation. It would seem to be a comparatively simple matter to determine this loss of energy, experimentally, quite accurately. It is suggested that a system of ballistic screens in circuit with the usual ballistic machine for determining velocities could be arranged *behind* the plate so as to register the velocity of the projectile at a given point in rear after it had perforated the plate. Having the velocity at this point it would be a simple problem in exterior ballistics to determine what velocity the projectile had on leaving the rear face of the plate. From the striking velocity and leaving velocity we could pass to the corresponding energies, and the difference between these two would be the loss of energy due to the resistance of the plate.

member of an equation expressing the strength of the plate; when confirmed by many experiments, and properly equated with functions of t and d, it expresses the law of resistance. In this manner Krupp's and de Marre's formulas, and others based on the assumption that penetration is proportional to the total striking energy, have been written out.

Reasoning along this line it has seemed probable to the writer, that the resistance offered by a plate of wrought-iron to the attack of any projectile should be confined to the comparatively small mass of metal pushed aside or cut out by the projectile in its passage and a further small mass immediately about the shot hole; that is to the mass in which there is any molecular disturbance, in contradistinction to the movement of the plate as a body. If it be assumed that the metal per unit of weight offers an intrinsic resistance to the passage of a projectile, it follows that the measure of strength of the plate will be proportional to the weight of the limited mass of metal above defined. The volume of this mass will be that of a cylindrical disk having the thickness of the plate for its altitude, and for its cross-section a circle which will be a function of the diameter of the projectile. If d represent the diameter of the attacking projectile and t the thickness of the plate, the volume of the resisting disk will be expressed by $\pi(nd)^2t$, in which n is a constant to be determined by experiment, and expresses the ratio of the radius of the resisting disk to the diameter of the projectile, therefore nd is the radius of the resisting disk. Taking the weight of one cubic inch of wrought-iron to be 0.28067 pounds the weight of the resisting disk in tons will be given by:

$$w = 0.000393364(nd)^2t \quad . \quad . \quad . \quad . \quad . \quad . \quad 1.$$

The resistance of the molecules to separation and disturbance may be expressed in the form of the energy per ton of the resisting disk that the projectile must carry to produce any given change in the position of the molecules, as, for example, that caused by the passage of the projectile through the plate. This will, of course, be constant for the same kind of metal.

It is evident, if we can obtain a value for this constant, that the energy necessary to perforate the plate will be had by multiplying the weight of the resisting disk in tons by the constant of resistance. If E represent the projectile energy required, and C the constant of resistance for wrought-iron, and w the weight of the resisting disk. in tons, we shall have the expression:

$$E = Cw \quad . \; . \; . \; . \; . \; . \; . \; . \quad 2.$$

We now assume a value for n in equation 1; then, by experiment, determine a value for E, whence, from equation 2, the value for C may be deduced. Let us assume, for example, that when d is equal to ten inches and t is equal to ten inches n is equal to 1.25,* and let us take the same value for E under these hypotheses as prescribed for the several formulas above, viz: 3672 foot-tons. We shall then have for the weight of the resisting disk:

$$w = 0.000393\,64(1{\cdot}25d)^2 t = 0.61507 \text{ tons.}$$

Hence: $E = 3672 = C0.61507$.

Hence: $C = \frac{3672}{0.61507} = 5970$.

That is, under this assumed value for n, we must credit to wrought-iron a resisting capacity of 5970 foot-tons per ton of metal disturbed by the passage of the attacking projectile, and every ton of wrought-iron has the power, through the operation of its molecular forces, to absorb 5970 foot-tons of projectile energy if all the molecules participate in the work.

Substituting this value of C in equation 2, we shall have:

$$E = 2.3501(nd)^2 t \quad . \; . \; . \; . \; . \; . \; . \quad 3.$$

In which E expresses in foot-tons the amount of energy which must be carried by a projectile having a diameter of d inches, to perforate t inches of wrought-iron.

The radius of the resisting disk (nd) will vary with the form of the head of the projectile, and with t and d.† For projectiles with ogives struck with a radius of from two to two and one-half calibers we may write:

$$n = 1.52 + 0.003(T - 10d) \quad . \; . \; . \; . \; . \quad \text{A.}$$

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* This is done by inspection of the plate *immediately* after it has received the blow of the projectile. With soft metals n will approach unity, and with hard elastic steels it will be greater than unity, running up to 3½ and perhaps 4 for $d = 10$, and $t = 10$.

† It will also vary with the striking velocity, but, for wrought-iron, this variation may be neglected without material error within the limits of practical velocities.

and for projectiles with ogives from one and one-half to two calibers we may write:

$$n = 1.346 + 0.0024(0.6T - d) \quad . \quad . \quad . \quad . \quad \text{B.}$$

In which T represents the thickness in inches of the plate attacked. For complete perforation T is equal to t in equation 3; for incomplete perforation t is less than T.

This formula has been incorporated in the table on page 507, in order that it may be compared with the other formulas, and is plotted on plates I and II for both values of n as given by equations A and B. For a constant diameter and variable thickness of plate, plate II shows that for values of n from equation B, the formula gives results similar to those of the middle group, being almost identical with those given by de Marre's formula, while values of n from equation A are practically a mean between Maitland's and de Marre's.

Plate I shows a marked difference however in the interpretation of the law of resistance for a constant thickness of plate and variable diameter between this formula and the others. It will be observed that whereas all the other formulas give either straight lines or lines convex toward the axis of diameters, this formula gives a line slightly concave towards this axis. The interpretation as given by the right line is, that the resistance of a plate of constant thickness increases directly with the increase of diameters; for the convex lines, that it increases more rapidly than the increase of diameters; for the concave, less rapidly. It would seem that this point might readily be determined by experiment and yet we note the wide range of interpretation of this point as evidenced in plate I. The last interpretation is believed to be supported by both *a priori* reasoning and experiment. It is to be noted that, under the assumption of a limited "resisting disk," an increase of diameter increases two dimensions of the attacking projectile but only one of the resisting disk. For example, the increase of two inches, in passing from our 10-inch to our 12-inch army projectiles, increases the weight, and therefore, for a constant velocity, the striking energy seventy-five per cent.; whereas the increase of plate metal disturbed, corresponding to this increase, is only forty-four per cent. It is well known that the striking velocity necessary for perforation decreases with the increase of diameter, much more then should the energy, which varies as the square of the velocity, decrease. Experimenters have observed that large projectiles stand up to their work better than smaller ones, especially in the case of hard armor. This is ascribed to the fact that there is less tendency to deformation, and the ogive is forced more readily into the face of the plate and then receives support from the metal of the plate. Krupp, in this connection, states that "the strain upon the metal of the projectile increases with the value of the ratio of the thickness of the plate to the diameter of the projectile." It is believed, therefore, that the rate of falling off of energy necessary to perforate is greater than has heretofore been allowed, and that the formula herein proposed gives more adequate expression than the others to the observed fact that larger projectiles are relatively more efficient than smaller ones.

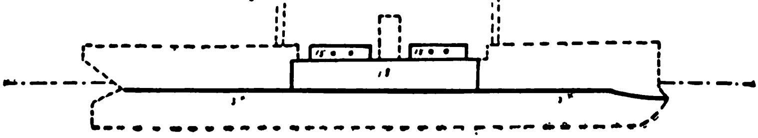
Finally, it is believed that this brief review of the subject of the ballistics of penetration of wrought-iron shows it to be in a most unsatisfactory state. If this metal is to be taken as the standard for ballistic comparisons of armor and projectiles it is important that a correct and universally accepted interpretation of the law of resistance be arrived at. As the question now stands there is ample justification for the recent assertion of an English authority that it is "a disgrace to science."

IRON-CLAD BATTLE SHIPS.

The characteristic features of the principal battle ships now afloat clad with wrought-iron are given herewith. The outline drawings of ships are intended to present those points of most importance, regarding the ships as targets. The armored parts are included within full lines. The unarmored parts are bounded by broken lines. The thickness of armor is given on each drawing in inches; the numbers with a cross to the right and above indicate the thickness of the horizontal protective deck armor. The drawings are not made accurately to scale; they do indicate, however, approximately, the sizes of ships and the dimensions of parts. They have been sketched from the plates given in Lord Brassey's Annual, Ordnance Note No. 337, King's War Ships, and the Naval Intelligence Annual for 1889. The descriptive parts have been taken from these same sources in part, and in addition from the "Report of the Board on Fortifications or Other Defenses." It has been the aim to give those characteristics which would be of service to the sea-coast artilleryman in recognizing a war ship, determining the kind and weight of fire necessary, and the parts of the ship to which each kind of fire should be directed. The vessels of each country are arranged in alphabetical order.

ENGLAND.

Ajax and Agamemnon



These are sea-going turreted battle ships, having a central citadel, or redoubt, enclosing two turrets placed obliquely across the ship. The sides of the citadel extend down below the water-line and form a partial belt, leaving the fore and aft parts unprotected against direct fire. A horizontal protective deck three inches thick passes from front to rear on a level with the lower part of the belt armor. The principle of the "raft body" is applied in these ships, the bottom having many water-tight compartments, and the water-line regions have a cork belt. The coal bunkers are arranged so as to give coal protection to the boilers and machinery. They carry two signal masts. They were launched in 1879 and 1880.

The armor would be perforated by our 8-inch, 10-inch, 12-inch, and 16-inch guns at the following ranges:

Turret Armor.

8-inch: would not perforate at muzzle.
10-inch: would perforate up to 3488 yards.
12-inch: would perforate up to 6000 yards.*
16-inch: would perforate up to 6000 yards.

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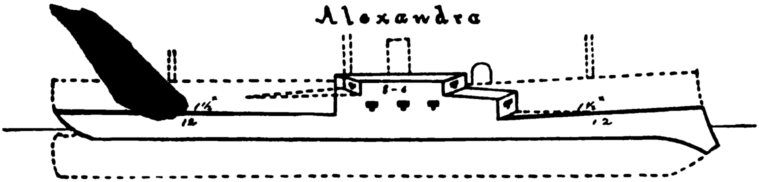
* Ranges beyond 6000 yards not considered.

Redoubt Armor.

8-inch: would not perforate at muzzle.
10-inch: would perforate up to 1314 yards.
12-inch: would perforate up to 4806 yards.
16-inch: would perforate up to 6000 yards.



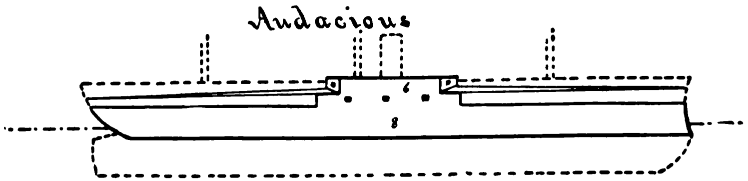
This is a full-rigged casemate battle-ship, having a central casemate with a double tier of guns for fore and aft fire. Protective deck over belt from one inch to one and one-half inch thick. Complete belt of water line armor twelve inches thick. Casemate armor from six to eight inches thick. The ship was launched in 1875. The limits for armor perforation by our guns are as follows:

Water-line Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

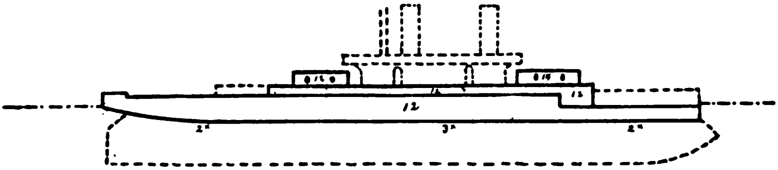
Casemate Armor.

	6-inch.	8-inch.
8-inch:	up to 5802 yards.	3944 yards.
10-inch:	up to 6000 yards.	6000 yares.
12-inch:	up to 6000 yards.	6000 yards.
16-inch:	up to 6000 yards.	6000 yards.



This is a central casemate ship with two tiers of guns, the upper tier arranged for fore and aft fire. The armor is distributed similarly to that of the *Alexandra.* The belt armor is eight inches thick and the casemate armor is six inches thick. The ship is bark rigged. She was launched in 1869. The limits for armor perforation are the same as for the casemate armor of the *Alexandra.*

Of the same type are the *Invincible,* launched in 1870: the *Iron Duke,* launched in 1870; the *Swiftsure* and *Triumph* also launched in 1870.



Devastation and Thunderer

These are turreted sea-going battle ships. There is a complete water-line belt twelve inches thick enclosing a midship breast height of 12-inch armor, which, in turn, encloses the turrets. The turrets are placed on fore and aft line and have 14-inch armor on forward turret and 12-inch on after. There is one signal mast. A protective deck of two to three inches thickness covers the below water regions. An unarmored superstructure rises between the turrets giving a characteristic appearance to the ships. They were launched in 1871. The limits for perforation are:

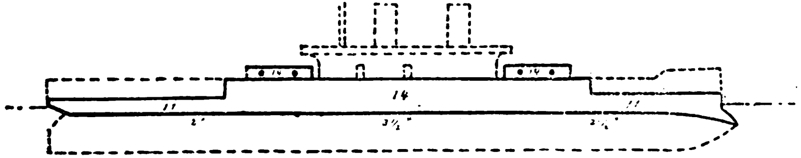
The 12-inch Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

The Forward Turret Armor.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Dreadnaught



This ship is in general appearance similar to the *Devastation* and may be considered a modification and improvement of that ship. It differs from the *Devastation* principally in that the belt rises amidship to form the sides of the central breast-height. The turret armor and midship belt armor is fourteen inches thick. The protective deck armor is from two and one-half to three and one-half inches thick. The ship was launched in 1875. The limits for armor perforation are:

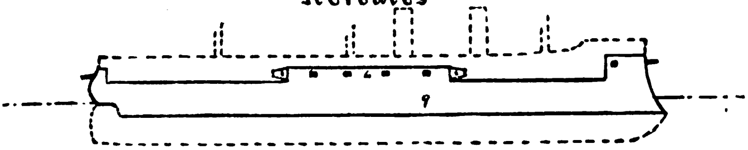
For the 11-inch Armor.

8-inch: up to 1835 yards.
10-inch: up to 5507 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

For the 14-inch Armor.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Hercules



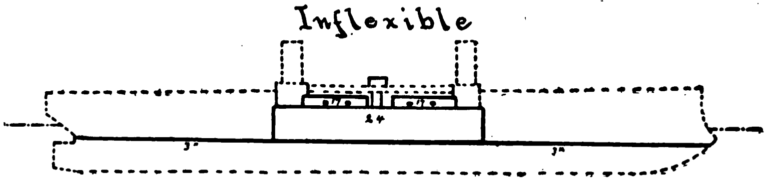
This is a casemate battle ship, having casemates forward, aft and amidship; the midship casemate is also arranged for fore and aft fire. It carries 9-inch belt armor and 6-inch casemate armor. It is full rigged. The limits of armor perforation are as follows:

9-inch Armor.

8-inch: up to 3175 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

6-inch Armor.

8-inch: up to 5802 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



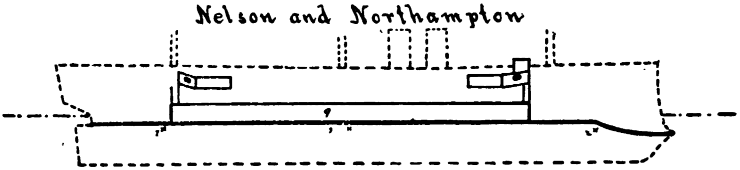
Similar to the *Ajax* and *Agamemnon*, but larger and more powerful. Citadel armor twenty-four inches thick; turret armor seventeen inches thick. 3-inch protective deck. Launched in 1876. Sides of central citadel pass down below water-line forming partial belt. Ends of ship unprotected. Turrets placed obliquely within citadel. Two signal masts. Cork belt, coal protection and "raft body," as in *Ajax*. Armor perforation as follows:

Turret Armor.

8-inch: cannot perforate.
10-inch: up to 1813 yards.
12-inch: up to 5377 yards.
16-inch: up to 6000 yards.

Citadel Armor.

8-inch: cannot perforate.
10-inch: cannot perforate.
12-inch: up to 1679 yards.
16-inch: up to 6000 yards.



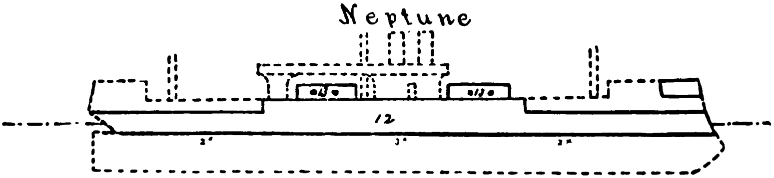
These are belted cruisers; belt 181 ft. 9 inches long; protective deck from three to two inches thick; bulkheads forward and aft with wings protecting chase guns and from raking fire; unprotected broadside; belt armor nine inches thick; bulkhead armor six inches. These ships are bark rigged and were launched in 1876. Limits of armor perforation as follows:

Belt Armor.

8-inch: up to 3175 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-incn: up to 6000 yards.

Bulkhead Armor.

8-inch: up to 5800 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



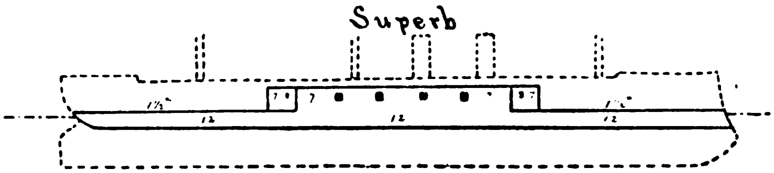
This is a turreted battle ship with forward casemate. It carries a complete water-line belt twelve inches thick and eight feet wide rising amidship to eleven feet above the water-line, forming a citadel enclosing the two turrets and protecting the vital parts. Turret armor thirteen inches thick; protective deck three to two inches thick. It has a superstructure similar to the *Devastation* type springing over the rear turret. The ship is bark rigged and was launched in 1874. The limits of armor perforation are as follows:

Belt Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Turret Armor.

8-inch: up to 693 yards.
10-inch: up to 4118 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



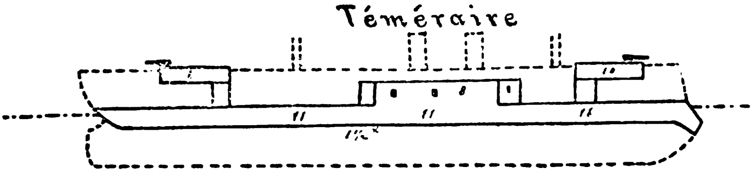
This is a casemated battle ship having a central casemate and carrying a complete water-line belt which rises amidships forming sides of the casemate; the casemate is arranged for fore and aft fire. Belt armor twelve inches thick; casemate armor seven inches thick. Protective deck over belt one and one-half inches thick. The ship is ship rigged and was launched in 1875. Limits of armor perforation as follows:

Belt Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 4875 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



This is a casemate battle ship having a central casemate arranged for broadside and ahead fire; a complete water-line belt, and two pear-shaped barbette towers, one forward and one aft, with armored loading cylinders; the guns in towers are mounted on disappearing carriages. There is a protective deck one and one-half inches thick. Water-line armor eleven inches thick, casemate armor eight inches thick, turret armor eight to ten inches thick. The ship was launched in 1876 and is brig rigged. Limits of armor perforation as follows:

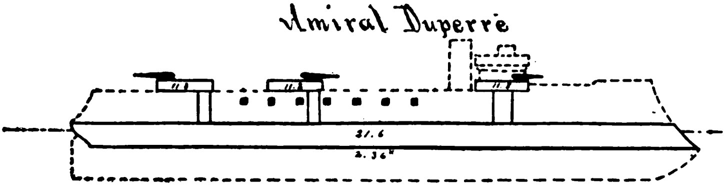
Belt Armor.

8-inch: up to 1835 yards.
10-inch: up to 5507 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate and Turret Armor.

8-inch: up to 2474 (10-in.) and 3944 (8-in.) yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

FRANCE.



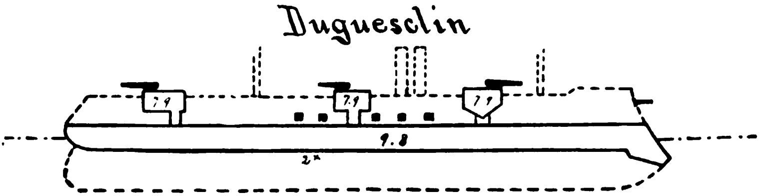
This is a battle ship having four barbette towers; two a little in front of the smoke pipe, one in the waist, and one aft. It has a complete belt along the water-line, and armored loading cylinders pass from the towers to the level of the belt. The belt armor is 21.6 inches thick, the tower armor 11.8 inches. There is a protective deck 2.36 inches thick. There are three masts with fighting tops. The water-line section is larger than those above it, giving a characteristic fish-back appearance to the ship, a feature shared by a number of French war ships. The broadside is entirely unprotected. The ship was launched in 1879. Limits of armor perforation as follows:

Belt Armor.

8-inch: could not perforate.
10-inch: could not perforate.
12-inch: up to 3000 yards.
16-inch: up to 6000 yards.

Tower Armor.

8-inch: up to 1200 yards.
10-inch: up to 4700 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.


Duguesclin

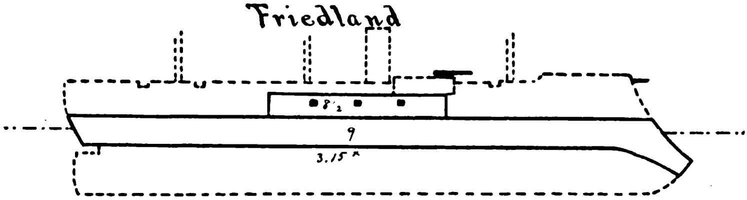
This ship is classed as an armored cruiser but with the exception of the thickness of armor she has many of the features of a battle ship. The distribution of armament and armor is similar to that of the *Amiral Duperré*. There are two smoke pipes, and she is ship rigged. The ship was launched in 1883. The *Vauban* launched in the same year is a sister ship. Both the *Duguesclin* and *Vauban* are patterned after the *Turenne* launched in 1879. The *Bayard*, launched in 1880, is a sister ship of the *Turenne*. The main difference between these is, that the two former are built of iron and the two latter of wood. The belt armor is 9.8 inches, the tower armor 7.9 inches, the protective deck two inches. Limits of perforation as follows:

Belt Armor.

8-inch: up to 2500 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Tower Armor.

8-inch: up to 4000 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



This is a casemate battle ship having a central casemate covered with eight and one-half inches of iron and a complete water-line belt nine inches thick. There are two unarmored barbette towers a little forward of the smoke pipe. Protective deck 3.15 inches thick. The vessel is ship rigged and was launched in 1873. The *Trident* and *Colbert* are similar to the *Friedland* except they have no protective deck and the belt armor is eight and one-half inches and casemate armor six and one-third inches; they were launched in 1876 and 1875. The *Richelieu* is also similar to the *Friedland* except there are four armored barbette towers, one over each corner of casemate, the belt and casemate armor same as on the *Trident* and *Colbert* and the protective deck is 4.36 inches thick. They were launched in 1873. The armor is the same thickness as on the *Trident* and *Colbert*. Limits of armor perforation as follows:

Belt Armor of Friedland.

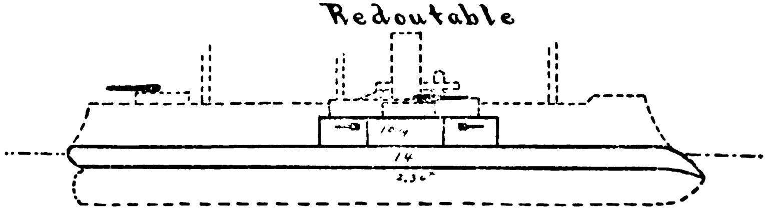
8-inch: up to 3175 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor of Friedland and Belt Armor of Trident, Colbert and Richelieu.

8-inch: up to 3400 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch. up to 6000 yards.

Casemate Armor of Trident, Colbert and Richelieu.

8-inch: up to 5700 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



The *Redoutable* is a belted battle ship with central casemate and has two unarmored barbette towers abreast of the smoke pipe and one aft. It has a complete armor belt of iron fourteen inches thick; the casemate armor is ten and one-fourth inches thick. The *Devastation* and *Courbert* are similar to the *Redoutable* except they have no barbette tower aft, the water-line armor does not extend to the stern but stops twenty-eight feet short of stern and the belt armor is fifteen inches thick and casemate armor eight and two-third inches. The *Redoutable* was launched in 1876, the *Devastation* in 1879, the *Courbert* in 1881. All these are ship rigged. The *Friedland* class differs in outward appearance from the *Redoutable* class chiefly in that in the latter the stern at water line projects beyond all parts above it, whereas in the former there is a very slight over hang; also in the latter there are two guns in each broadside while in the former there are three. The limits of armor perforation are as follows:

Belt Armor of Redoutable.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor of Redoutable.

8-inch: up to 2000 yards.
10-inch: up to 5800 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

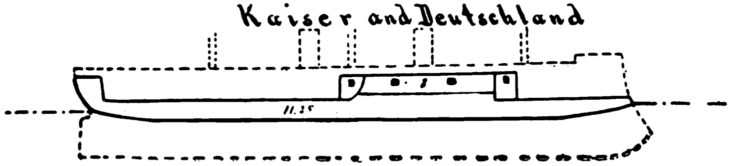
Belt Armor of Devastation.

8-inch: could not perforate.
10-inch: up to 2893 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor of Devastation.

8-inch: up to 5700 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

GERMANY.



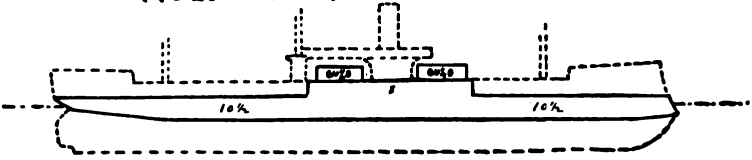
These are casemate battle ships with complete belt and armor rising in rear as protection for stern guns. Casemate is rectangular and situated a little forward of middle, has two guns arranged for fire ahead, two for broadside on each side, and two for stern fire. Belt armor is 11.25 inches thick; casemate, eight inches. Launched in 1874. Ship rigged. Limits of armor perforation as follows:

Belt Armor.

8-inch: up to 1700 yards.
10-inch: up to 5300 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 3944 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.


Preussen and Frederich der Grosse

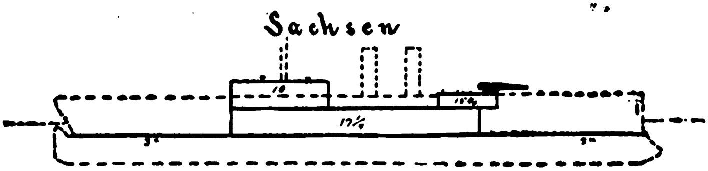
These are turreted battle ships of the British *Monarch* type. except there is no stern casemate. Two turrets placed midship on fore and aft line within a breastwork ninety feet by fifty-three feet. Complete belt. Turret armor ten and one-fourth inches thick. Belt armor ten and one-half inches thick. Launched in 1873 and 1874, respectively. Ship rigged. Limits of perforation as follows:

Belt Armor.

8-inch: up to 2154 yards.
10-inch; up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Turret Armor.

8-inch: up to 2314 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.



This is a barbette battle ship. Forward guns in pear-shaped barbette tower, after guns in rectangular overhanging redoubt, 2-inch iron hurricane deck over them. Main protective deck three inches thick. Belt only partial, amidship, in the wake of machinery and magazine. Only one mast, with military top. The armor is put on in "sandwich" form and is seventeen and one-fourth inches thick on belt; fifteen and one-fourth inches thick on forward tower; ten inches thick on redoubt. The ship was launched in 1877. The *Bayern* and the *Wurtemburg* (1878) and the *Baden* (1880) are sister ships to the *Sachsen*. Limits of perforation:

Belt Armor.

8-inch: could not perforate.
10-inch: up to 1700 yards.
12-inch: up to 5200 yards.
16-inch: up to 6000 yards.

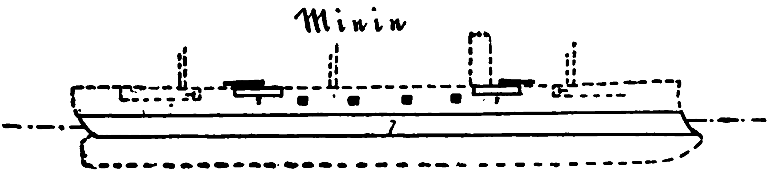
Forward Tower.

8-inch: could not perforate.
10-inch: up to 2400 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Redoubt Armor.

8-inch: up to 2474 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

RUSSIA.



The *Minin* is an armored cruiser, but of sufficient power to merit special description. She carries a complete belt of 7-inch armor, and four barbette towers covered with 8-inch armor, one each side forward and one each side aft. The broadside battery is unprotected. She was launched in 1878, and is ship rigged. Perforation limits as follows:

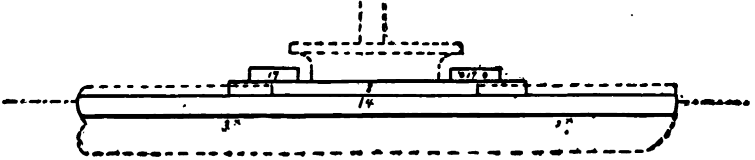
Belt Armor.

8-inch: up to 4875 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Tower Armor.

8-inch: up to 3944 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Peter the Great



This is a turreted battle ship built by the Russians to cope with the English *Devastation*. It is similar in general appearance and distribution of armor to the latter. The armor, which is "sandwich," is fourteen inches thick in the belt, eight inches thick in the breast-height enclosing turrets, and seventeen inches thick on turrets. It was launched in 1872. Perforation limits as follows:

Belt Armor.

8-inch: up to 182 yards.
10-inch: up to 3488 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

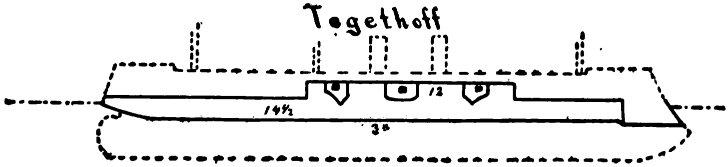
Turret Armor.

8-inch: could not perforate.
10-inch: up to 1813 yards.
12-inch: up to 5377 yards.
16-inch: up to 6000 yards.

Breast-work Armor.

8-inch. up to 3944 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

AUSTRIA.



This is a central casemate battle ship; two guns with bow and beam fire, two with beam fire and two with stern and beam fire. Belt fourteen and one-half inches thick stops short of bow thirty-three feet. Protective deck three inches thick. Casemate armor twelve inches thick. Launched in 1878. Ship rigged. Perforation limits as follows:

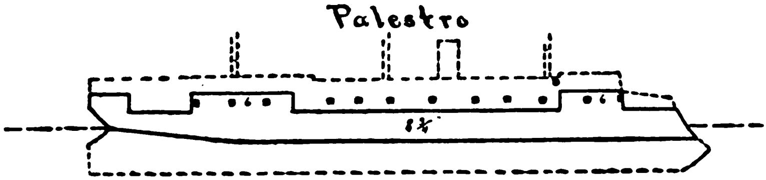
Belt Armor.

8-inch: at muzzle.
10-inch: up to 3200 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
12-inch: up to 6000 yards.

ITALY.



This is an old type battle ship with two casemates, one forward and one in the waist. There is a complete belt which rises at the stern to protect a gun. Belt armor is eight and three-fourth inches thick; casemate armor six inches thick. Launched in 1871, and is ship rigged. The *Principe Amadeo* is a similar ship. Perforation limits as follows:

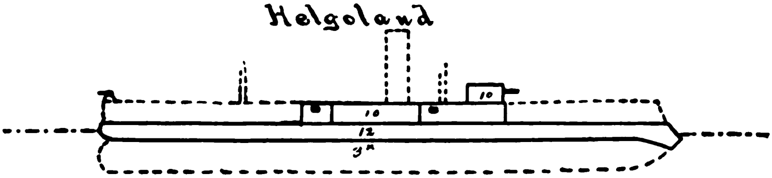
Belt Armor.

8-inch: up to 3300 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate Armor.

8-inch: up to 5800 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

DENMARK.



This is a casemated and turreted battle ship. One turret a little forward of midship. Complete belt of 12-inch armor. Casemate and turret armor ten inches thick. Two masts with military tops. Protective deck three inches thick. Launched in 1878. Perforation limits as follows:

Belt Armor.

8-inch: up to 1240 yards.
10-inch: up to 4786 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

Casemate and Turret Armor.

8-inch: up to 2474 yards.
10-inch: up to 6000 yards.
12-inch: up to 6000 yards.
16-inch: up to 6000 yards.

TABLE II.

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
ENGLAND.				
Téméraire	11	10 (fore) 8 (aft)	8	Iron; sheathed; launched in 1876; battle and cruising ship; complete belt; redoubt midship; two fixed turrets, one forward, one aft, pear shape; guns mounted on disappearing carriages; protective deck 1''.5; brig rigged.
Devastation . . . . *Thunderer*	12	14 (fore) 12 aft	12	Iron; 1871; high free board battle ship; two turrets on fore and aft line; armored breast-work including turrets; one mast; protective deck 3'' to 2'' thick.
Dreadnought	11	14	14	Modified and improved type of *Devastation*; protective deck 3''.5, 2''.5, and 2'' thick; central citadel armored rising from water, forming sides of ship up 12'; belt armor 5' below water.
Neptune	12	13	12	Iron; sheathed; 1874; battle and cruising ship; two turrets; casemate; protective deck 3'' to 2''; water-line belt 8' wide, at middle armor rises 11' above water, forming citadel enclosing turrets and protects vital parts.
Inflexible	24	17	24	Iron; 1876; battle ship; central citadel, sides of citadel forming partial belt; citadel encloses two turrets placed obliquely; unprotected ends; cork belt; two masts; protective deck 3''; turrets compound; coal protection.
Ajax . . . . *Agamemnon*	18 "	15 "	18 "	Iron; 1880-79; similar in type to *Inflexible;* protective deck 2'' and 3''.
Alexandra	12		8	Iron; 1875; battle ship; full rigged; protective deck over belt 1''.5—1'' thick; complete water-line belt; central casemate with two tiers of guns.
Superb	12		7	1875. Battle ship. Ship rigged. 1½'' deck over belt. Belt. Casemate battery armored 111'.

Where thickness of armor is variable only the maximum thickness is given. The dates are those of launching.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Audacious	8		6	1869. Battle ship. Complete belt. Bark rigged. Casemate 59′ on gun deck, 32′ 7″ on spar deck.
Invincible	“		“	1869. “
Iron Duke	“		“	1870. “
Swiftsure	“		“	1870. “
Triumph	“		“	1870. “
Sultan	12		6	1870. Battle ship. Ship rigged. Complete belt. Casemate 84′ 4″ on gun deck, 32′ 3″ on spar deck.
Belleisle	12		6	1876. Small type battle ship; brigantine rigged. Belt. Casemate 45′ long.
Orion	“		“	1879. “
Northampton	9			1876. Belted cruiser. Sides unprotected. Protected from raking fire by bulkheads with wings. Bark rigged. Protective deck 3″.2 thick. Belt 181′.
Nelson	“			
Shannon	“			1875. Belted cruiser. Ship rigged. Belt from 60′ abaft stem to stern. Protected by bulkheads from raking fire.
Rupert	12	14	12	1872. Turret coast defense ship; schooner rigged; breast work turret; ram; one turret forward; complete belt.
FRENCH.				
Friedland	9		8½	1873. Battle ship. Complete belt. Casemate. Unarmored barbette towers. Protective deck 3″.15 thick. Barbette towers abreast and forward of smoke pipe. Elliptical half-towers. Ship rigged.
Trident	8⅝		6⅓	1876. Similar to *Friedland*, but no protective deck. Two barbettes abreast of smoke pipe on each side.
Colbert	8⅝		6⅓	1875. “

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Redoutable	14		9½	1876. Similar to *Friedland.* Protective deck 2″.36.
Devastation	15		9½	1879. Similar generally to *Friedland.* Belt stops 28′ short of stern. Deck armor 2″.36.
Courbet	"		"	1881. "
Richelieu	8⅔		6.3	1873. Battle ship, belt, casemate, armored barbette towers. Protective deck 4″ 36. 4 barbettes, one on each corner of casemate.
Amiral Duperré	21.6			1879. Battle ship. Complete belt. 4 armored barbette towers. Unprotected broadside. Protective deck 2″.36. 3 masts, armored tops. Barbette towers one aft, one in waist, one on each side forward of smoke pipe.
Tonnerre	13	11.8	9⅞	1875. Mastless turret battle ship. Armored breast work 9⅞″, surmounted by unarmored superstructure. Armored deck 2″. Belt entire length. One turret in forward end of breast work.
Fulminant	"	"	"	1877. "
Duguesclin	9.8	7.9		Armored cruiser with complete belt and four barbette towers similar to *Amiral Duperré.* Sides unprotected. Armored deck 2″. Ship rig.
Vauban	"	"		
Turenne	"	"		
Bayard	"	"		
La Galissonnière	5⅞		4¾	1872. Armored cruiser. Casemate and barbette towers. Ship rigged. Complete belt. Barbettes forward of smoke pipe on each side.
Victorieuse	"	4.7	"	1875. "
Triomphante	"	7.9	"	1877. "
Thétis	"	"	"	1877. " Smaller than above three.

TABLE II (Continued).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
ITALY.				
Palestro	8¾		6	1871. Old type battle ship. Belt and two redoubts. Ship rig. Belt complete. Two casemates: one forward, one aft.
RUSSIA.				
Peter the Great	14	17	8	Battle ship. Belt complete Breastwork 160′ long. Two turrets: one forward, one aft. Unarmored superstructure between turrets. Mastless. Protective deck 3″. Armor, sandwich.
General-Admiral	7		6	1873. Armored cruiser. Complete belt. Low rectangular redoubt over which the guns are mounted in barbette. Ship rig.
Gerzog-Edinburgski	"		"	1875. "
Minin	7	8		1878. Armored cruiser. Complete belt. Four armored barbette half-towers: one each side forward, one each side aft. Ship rig. Unprotected broadside.
GERMANY.				
Preussen	10½	10¼	8	1873. Battle ship of British *Monarch* type. Complete belt. Two turrets, one fore and aft. Breastwork 90′ 6″ × 53′ 6″. Ship rig.
Friederich der Grosse	"	"	"	1874. Sister ship to *Preussen*.
Kaiser	11¼		8	1874. Battle ship. Broadside casemate; rectangular. Complete belt. Ship rig.
Deutschland	"		"	1874. Sister ship.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Sachsen	17¼	10	10	1877. Battle ship; guns in barbette, barbette tower and redoubt; forward gun in pear-shaped tower. After guns in rectangular overhanging redoubt, 2-inch iron deck over them. Main protective deck 3-inch iron. One mast, military top. Derricks for handling boats. Belt 135 ft. 4 in. long in wake of machinery and magazine only. Sandwich armor.
Bayern (1878)	"	"	"	
Würtemberg (1878)	"	"	"	
Baden (1880)	"	"	"	
Hansa	6		6	1872. Armored cruiser. Complete belt. Double decked casemate. Ship rig.
SPAIN.				
Sagunto	5.9		5.9	1869. Old type broadside battle ship. Complete belt. Side armor in wake of battery. Armored short central casemate on upper deck. Ship rig.
Numancia	5			Old type broadside armored ships. Low speed. Condition of all poor.
Vitoria	"			
Zaragoza	"			
Mendez Nunez	"			
AUSTRIA.				
Kaiser	6¼	5½	5½	1871. Old type casemate battle ship. Ship rig. Complete belt. One three-port turret each side upper deck.
Custoza	9		7	1872. Old type battle ship; double deck casemate Sides cut away fore and aft to allow for bow and stern fire. Ship rig. Complete belt.
Erzherzog Albrecht	"		"	1872. Similar to last. Sides cut away for four guns bow fire and two guns stern fire.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
Tegetthoff	14½		14	1878. New type casemate battle ship. Ship rig. Protective deck 3 inches. Belt to 32 ft. 10 in. of bow. Armored bulkhead. Two guns in forward compartment of casemate have bow and beam fire; four guns in after compartment have stern and beam fire.
Don Juan de Austria	8		6	1875. Armored cruiser. Ship rig. Casemate armored. Complete belt.
Kaiser Max (1875)	"		"	"
Prinz Eugen (1877)	"		"	"
HOLLAND.				
Konig der Nederlanders	8	12		1874. Turreted· cruiser and battle ship. Ship rig. Complete belt, Two turrets.
DENMARK.				
Helgoland	12	10	10 .	1878. Battle ship. Casemate and turret. Two masts, military tops. Deck 3 in. Complete belt.
TURKEY.				
Messudieh	12		10	1874. Broadside casemate battle ship. Complete belt. Casemate 135 ft. long. Ship rig. Protective deck 1 inch. Sister ship to the English ship *Superb*.
Hamidieh	10		6	1885. Broadside casemate battle ship. Complete belt. Ship rig.
Idjilalieh (Majestic)	6	4½	4½	1870. Armored cruiser. Armored casemate surmounted by barbette towers. Complete belt. Brig rig.
Feth-i-Bulend	9	6	6	1870. Armored cruiser; old type; complete belt; casemate; ship rig. Sides cut away for fore and aft fire.
Mukadim-i-Hair	"	"	"	Sister ship to *Feth-i-Bulend*.

TABLE II (CONTINUED).

PRINCIPAL IRON-CLAD BATTLE SHIPS.

Name.	Thickness of Armor, inches.			Description of Ships.
	Belt.	Turret.	Casemate or Side.	
PORTUGAL.				
Vasco da Gama	10		10	1876. Armored cruiser. Overhanging central casemate. Barkentine rig.
BRAZIL.				
Javary	12	13		1875. Sea going monitor. Two turrets on fore and aft line. Two signal poles.
Sete de Setembro	4½		4½	1874. Cruising iron-clad old type. Belt. Redoubt. Schooner rig.
CHILI.				
{*Almirante Cochrane*	9		8	1874. Armored cruiser. Complete belt. Overhanging casemate. Cut away for fore and aft fire. Bark rig.
{*Blanco Encalada*	“		“	Sister ship.
Huascar	4½	5½		1864. Low free board. Single turret. Complete belt. Brigantine rig. Cut away for fore and aft fire.
JAPAN.				
Fu-Sô	7		9	1877. Armored cruiser. Complete belt. Armored casemate. Ship rig.
{*Kin-go*	4½			1877. Armored cruiser. Belt runs nearly to bow and stern. Armored bulkhead. Bark rig. Are not armored ships in usual sense of the term. No armor against end-on fire and no armored deck.
{*Hi-yei*	“			

RANGE TABLE FOR THE 8-INCH B. L. RIFLE. (STEEL).

By Captain JAMES M. INGALLS, First Artillery, U. S. A.

Weight of projectile = 300 lbs. Log $C = 0.71670$. $\frac{\delta_1}{\delta} = 1$.

Coefficient of reduction = 0.9 *M. V.* = 1950 f. s. Wind, none.

Range in yards	Angle of departure (ϕ)	d	$\Delta'\phi$	$\Delta''\phi$	Time of flight in seconds	Drift in yards	Angle of fall	Striking velocity in f. s.	Thickness of steel shot would penetrate in inches
	° ′	′	′	′			° ′		
500	0 23.0	4.5	0.1	1.1	0.78	0.1	0 23	1872	15.0
600	0 27.5	4.6	0.1	1.3	0.94	0.1	0 28	1857	
700	0 32.1	4.7	0.1	1.4	1.10	0.1	0 32	1842	
800	0 36.8	4.7	0.1	1.6	1.27	0.2	0 37	1827	
900	0 41.5	4.8	0.2	1.8	1.43	0.2	0 43	1812	
1000	0 46.3	4.9	0.2	2.0	1.60	0.3	0 48	1797	14.2
1100	0 51.2	4.9	0.3	2.2	1.77	0.3	0 54	1782	
1200	0 56.1	5.0	0.3	2.4	1.93	0.4	0 59	1768	
1300	1 01.1	5.1	6.4	2.6	2.10	0.5	1 05	1753	
1400	1 06.2	5.1	0.5	2.9	2.28	0.6	1 11	1739	
1500	1 11.3	5.1	0.6	3.1	2.45	0.7	1 17	1725	13.4
1600	1 16.4	5.2	0.7	3.3	2.62	0.8	1 23	1711	
1700	1 21.6	5.3	0.8	3.6	2.80	0.9	1 29	1697	
1800	1 26.9	5.4	1.0	3.9	2.98	1.0	1 36	1683	
1900	1 32.3	5.4	1.1	4.2	3.16	1.1	1 42	1670	
2000	1 37.7	5.5	1.2	4.5	3.34	1.2	1 49	1656	12.6
2100	1 43.2	5.5	1.3	4.7	3.52	1.3	1 57	1643	
2200	1 48.7	5.6	1.4	5.0	3.71	1.5	2 02	1629	
2300	1 54.3	5.7	1.6	5.3	3.89	1.6	2 09	1616	
2400	2 00.0	5.8	1.7	5.5	4.08	1.8	2 17	1603	
2500	2 05.8	5.8	1.9	5.8	4.27	1.9	2 24	1590	11.9
2600	2 11.6	5.8	2.1	6.1	4.46	2.1	2 31	1577	
2700	2 17.4	5.9	2.2	6.3	4.65	2.3	2 39	1564	
2800	2 23.3	6.0	2.4	6.6	4.84	2.5	2 47	1551	
2900	2 29.3	6.1	2.6	6.9	5.03	2.7	2 55	1539	
3000	2 35.4	6.2	2.8	7.2	5.23	2.9	3 03	1526	11.2
3100	2 41.6	6.2	3.0	7.5	5.43	3.1	3 11	1513	

ing as the variations which produced them, diminish or increase the range, and can easily be determined in each case. The other columns of the range-table are sufficiently described by their captions.

The use of the table can best be indicated by a few examples.

EXAMPLE 1.—What is the angle of elevation for a range of 3964 yards; conditions normal, jump 6′? We have

$$\text{angle of elevation} = 3° \; 33'.2 + .64 \times 6'.86' = 3° \; 37'.6.$$

EXAMPLE 2.—What is the angle of elevation for a range of 6827 yards; temperature of the air 90°, barometer 30.16 inches, and muzzle velocity 1924 f. s.?

From Table III of Handbook we find $\frac{\delta_1}{\delta} = 1.054$, and, therefore, the variation of ϕ for the given atmospheric conditions is .54 times the tabular value of $\Delta'\phi$. To get the variation of ϕ due to the variation of the muzzle velocity we take $\frac{26}{50} = .52$ of the tabular value of $\Delta''\phi$. We therefore have

$$\varphi = 7° \; 26'.4 + .27 \times 9.'5 - .54 \times 19'.7 + .52 \times 22'.3 = 7° \; 30',$$

and

$$\text{angle of elevation} = 7° \; 30' - 6' = 6° \; 24'.$$

EXAMPLE 3.—Suppose that in Example 2, the actual range with an angle of elevation of 7° 24′ was only 6754 yards. What should be the angle of elevation for the next shot?

The angle of departure was 7° 30′, and for this angle we have $d = 9'.5$, which is the variation of the angle of departure for a variation of 100 yards in the range. Therefore for 6827—6754 = 73 yards, the variation in the angle of departure will be $.73 \times 9'.5 = 7'$. The gun should therefore be laid with an angle of elevation equal to

$$7° \; 30' + 7' - 6' = 7° \; 31'.$$

ARTILLERY DIFFICULTIES IN THE NEXT WAR.

BY FIRST LIEUTENANT JOHN W. RUCKMAN, FIRST ARTILLERY, U. S. A.

[CONCLUDED.]

III. MATERIAL CONSIDERATIONS.

When the organic and educational condition of an artillery reaches its highest state of perfection, difficulties may still remain. These new difficulties will chiefly be of a material nature, many of which may already be in view and steps taken towards their removal, more just appearing and others still below the horizon. Poor or inadequate material only may be found at a fort, rendering a thorough administration and drill impossible. When however this condition exists in connection with bad organization and instruction, a combination results in which inefficiency is at its worst and the consequences may be most awful. In a given well-organized and instructed garrison the defense will mainly depend upon the character of the guns, and sufficiency and adaptability of auxiliary appliances.

GUNS.

As the guns we expect to have for our future defense promise to compare favorably with any guns which are likely to be brought against them it will not be necessary to discuss their relative values. It must be added however, that as they, when mounted, will doubtless be required to protect the country for many years, this equality will probably not always exist.

CARRIAGES.

In future the gun-carriage will play a part equal in importance to that of the gun. The fact that the carriage must be something more than a necessary evil tolerated simply to support the gun seems not to have been appreciated in our army. Notwithstanding this it must become a part of the gun and be able to develop its full power and accuracy. Made in future not merely to hold the gun and check its recoil, but also with a view of giving the gun life and mobility undreamt of in the past. The carriage must be strong, carefully made, and capable of fulfilling all work that may be required of it. The upper carriage should return after each discharge to the same place on its chassis. This condition is essential to indirect fire.

The value of the preceding remarks is apparent; for it will be of little moment to reduce the gun's error to zero and allow that of the carriage to be hundreds of yards. Artillery work from this time forward will require that gun and carriage shall be constructed with equal care and accuracy and that the whole system shall be consistently well made. It will not be the future policy of artillerists to use costly guns upon inexpensive poorly designed carriages. In all cases it will be better to cut down the number of guns one-half and put the remainder into carriages suited to the work, than to be limited to such designs as have prevailed until now.

The next artillery war will impose the condition that our guns *shall be aimed with quickness, precision and continuity.** This condition we believe will tower above all others and that failure to attain it will mean defeat. Sighting devices whatever their nature, must be constructed with respect to these considerations. Ammunition is now too costly, and in future battles time will be too valuable to risk useless waste. Endeavors must be made to send every shot to its mark. Books and papers are now full of descriptions of quick-firing guns; quick-aiming guns would be much more to the point. Unaimed fire for coast-defense, except in very special cases, will be worse than useless.

While all apparatus connected with a modern gun must be efficacious it must be as elementary as possible consistent with this result, and while the necessary machines may be more or less complicated *their operation must be simple.*

Disappearing carriages have been advocated for the following reasons:

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* Since this was written the following article illustrating present tendencies has appeared: "Appariel auxiliaire permettant le pointage et le chargement simultanés et augmentant ainsi considérablement la rapidité du tir des pièces."—*Revue Maritime et Coloniale*, Mai 1893.

1. Their guns can be silenced only by a direct hit.

2. The greater part of the personnel is permanently under cover.

3. No satisfactory reconnaissance of the position can be made by the enemy.

First.—It may be said in reference to these arguments that those familiar with target practice from a solid platform know the difficulty of obtaining a "direct hit" even at short ranges. It would seem that the chances of disabling a gun, for the time at least, would be greatly enhanced by putting the gun in a deep emplacement behind a high parapet such as are required for this class of carriages. The enemy's projectiles striking a high parapet, it would seem, will throw down large fragments upon the guns and detachments. Barbette guns and a low parapet, we believe, will reduce this danger to a minimum. This is especially important in view of the probable use of long howitzer shells carrying heavy bursting charges of high explosives which are certain to be used in future bombardments.

Second.—In consequence of recent adoption of vertical fire these carriages no longer afford the detachment the shelter claimed for them and their advocates are supplying them with shields to protect from this kind of fire. These shields can as well be applied to barbette guns.

Third.—The question of reconnaissance scarcely needs consideration when we remember that it is not the policy of our government to maintain secrecy in regard to our defenses and that all enterprising nations will always know as much, if not more, than we do about the position and interior arrangement of our defenses. In such cases reconnaissance of our positions would be clearly superfluous. Moreover, if there be any virtue in this claim, barbette guns could be artificially disguised in a few minutes. The above claims doubtless have some merit in them, but we believe they ignore the most important element in the question. In a well equipped fort ships, we believe, can be made to fight at a distance, notwithstanding the present tendency of naval tactics to close with shore batteries. If this be true, the probability of disabling a gun by a direct hit from an unstable platform need scarcely be taken into account.

As with field artillery, we believe the defense should overwhelm the assailant from the first. Whenever the enemy attempts to close to obtain an effective range he should receive a well directed, deliberate, but rapid fire, whose effect should reveal to him the nature of his antagonist. If the first shots are true and terrible in their results it may be doubted if he will make good practice that day. Some of our guns may and probably will be dismounted, but it will also be a question of *dismounting the enemy's guns.* For him to anchor within effective range should mean his destruction. The barbette gun pointing above the parapet and covered with a suitable shield, would always be in position to pour forth its missiles upon him. We, as artillerymen, cannot very graciously object to having our emplacements made safe and comfortable, but when these attentions tend to make it safe and comfortable for the enemy, it is time to stop. There is something, we believe, in always being in place and ready to defy the assailant. Give us fewer complicated devices for hiding from him and the difference in better means of controlling our fire and the enemy will not be so anxious to see us. It will in the first place be a question of guns and in the second place the amount of metal accurately delivered in a given time. The former will influence the enemy's determination to attack, the latter his determination to persist. *The battle must ultimately turn on the damage we can do him, not on the amount we keep him from doing.*

The future carriage must be constructed with regard to the above-mentioned conditions of loading and aiming. From the nature of the case it is evident that they will not permit the use of a large number of men wasting their time with handspikes. In the first place this will be ineconomical, in the second impossible. All heavy work and much light work must be done by machinery. It is objected by a certain class of writers that these ideas will introduce complicated machinery into our work, but we need not be alarmed; for the history of war material is full of such solicitude, since the days of the club, the sling, and the spear. During all the past ages the same fears have been urged with the same *anxiety*, *fervor* and *reason.* We shall need for our own carriages, already accurate, equally accurate mechanism to control them. The mechanism will possess the necessary strength, be sensitive to the touch and prompt in obeying the will of the operator, so that the carriage, as if endowed with life and sense, may move from one side to the other, forward or backward, at the wish of the gunner. This will be essential in future gun tactics and fire control. In the din and confusion of future battle, when commands cannot be heard, the movement of the attendant heavy masses must emanate from a single mind conversant with his work. In all cases in history where ships have run past shore batteries within effective range old methods of handling the guns prevailed. In future new methods will obtain. The effect of these changes remains to be developed. War has been truly denominated a rough business, but it will be none the less rough *on the enemy* if our aiming mechanism be efficacious, our gun and carriage precise, and our sights true. All parts will be strong but refined in their nature. There will be no delicate pieces of mechanism in the whole system, so we need not distress ourselves with regard to our cannoneers smashing them with handspikes, since this relic of bygone ages will be excluded from the gun's equipment.

ELECTRIC MOTORS.

For many reasons we believe that the electric motor is, *par excellence*, the machine best adapted to the transformation of energy into artillery work. To obtain full effect the gun must be arranged to load, aim and fire while in motion. These objects can be obtained by use of the electric motor with the greatest facility, with the additional advantage of being capable of control from any point in the circuit. This latter consideration is important in connection with present tendencies, which are towards entire control from central stations. Again the angular motion of a moving ship with respect to the gun can be produced and maintained in the battle and the gun kept pointed always on the enemy. The same may be said of the elevation and other movements. These tactical advantages, added to those of economy and simplicity, at least render this motor worthy of exhaustive trial.

AIMING.

The aiming will require the most careful attention. No problem in gunnery to-day affords so much room for improvement as this one in our service. A range dial connected with the elevating mechanism should be simple and practicable. There is no good reason for introducing degrees of elevation into any of our practical work. They are only useful to the computer and the sight-maker. For direct fire a suitable well mounted telescope will answer for aligning. Indirect fire will be done with the vernier and azimuth circle.

TRANSMISSION OF ORDERS AND INTERIOR TRANSPORTATION.

A method of transmitting orders in a fort seems to have been ignored in our works. A more necessary portion of a well-equipped place could scarcely be omitted. While a system of transmitting orders may not, in the past, have been necessary, all may depend on an efficient system in future. Whatever we may adopt, we believe the following conditions must be fulfilled:

Quick delivery of a written or printed message at the required point. Pneumatic tubes or electrical typewriters may afford a means of solution.

Interior transportation is in its worst possible condition. A suitable scheme can only be worked out by ourselves after long experience.

POSITION FINDING.

To save time and ammunition position finding will be used to locate the exact position of the enemy. In cases where this cannot be done with reasonable correctness, firing will probably be withheld.

Among the first efforts at position finding may be named the "method of squares." It forms in the historical development a connecting link between the old, where accurate ranges were thought to be useless refinements, and the new, where the range is considered essential. The harbor was divided into a large number of squares whose centers were located by their distances and azimuths from the gun. The object had to be located [illegible] triangulation and the number of the square whose cent[illegible] nearest, was sent to the gun. The distance and azimuth of the center were found from prepared tables and the gun laid accordingly. The first efforts were exceedingly crude and unsatisfactory. This method was adopted for our coast artillery in General Orders No. 108, Headquarters of the Army, Adjutant General's Office, 1888. The side of a square was prescribed as 100 yards. The distances and azimuths of all squares within a radius of three miles were to be computed and tabulated. The tables when made out were enormous and impracticable. The polar coördinates thus tabulated gave data for points varying from 100 to 140 yards apart depending on the direction in which the object was moving. It is also evident that any given observation would on arriving at the gun always be several squares behind the ship's true place. By decreasing the size of the squares the tables become more cumbersome but the tabulated results when applied should be more accurate. Finally at the limit a ship's path would be made up of points whose distances and direction would be known. This is the result which will be obtained by the coming position finder which, without any cumbersome tables, or any other of the numerous objections to the squares, will trace upon a map the path of a hostile vessel. The system of squares had so many insurmountable obstacles wrapped up in it that it has long been discarded. Although the system was obsolete when adopted by us, and barren of practical results, its adoption was a great step forward. It was a move to obtain some kind of a system where none had existed. It produced in the country study and discussion which we believe not only demonstrated its utter impracticability, but put the question in its true light and developed a sentiment which is gradually evolving the correct solution.

Although there are at present many kinds of position finders in the field they all have the same object in view. They are divided into two principal classes as they depend upon a horizontal or vertical base. Those using the horizontal base require two observers and stations, may use any length of base, adapt themselves to any site, and are open to the objection that the observers may be observing different objects.

Those using the vertical base are called depression instruments and are applicable only where considerable elevation exists. They require fine mechanism, are liable to be less accurate, and require but one observer. The nature of our coast will make the use of both classes advantageous. They should, we believe, be used in combination wherever practicable. On account of the confusion which may arise from two observers watching different ships, some precaution must be taken to prevent it. This may require an auxiliary finder. A depression instrument when present would answer this purpose. The more accurate these instruments become, the better. In striving to reduce errors efforts must be made all along the line. The probable error in the range finder is as important as that in the gun; both must be reduced as much as possible. The future range and position finder will trace the path of a vessel continuously upon the map of the harbor. Unless placed at the gun-battery, the plotting apparatus must operate in connection with another device for sending range and direction to this point. The elements transmitted must be independent of measurements made on paper. An inexpansive range-scale passing over the map will obviate this difficulty. In regard to the value of the path of the vessel, there seems to be a difference of opinion, but we believe it will be essential to the best results. It will reveal an enemy's rate and direction at all times, betray circle sailing and other tricks to which he may resort, many of which would otherwise escape detection; allow the batteries to take him in disadvantageous positions, and will aid materially in ascertaining his tactics and intentions.

For direct fire ranges may be received from a central station. A small pointer moved by the plotting mechanism may be super-imposed upon the range dial already mentioned. The two pointers being supported as the hands of a clock. That one urged along by the position finder will always show the range; coincidence of the two will show that the gun is elevated. For indirect fire an identical device will show azimuths of the gun and object. In both cases it will probably be found as easy to transmit motions to the gun as to the pointers, in which case the gun would be both elevated and oriented from the central station.

In conclusion we may say that by the time our emplacements are constructed and the guns mounted, that position finders will be at hand suited in all respects to the work before them. We are now behind in fortifications, guns, range finders, and all war material, but we are also far, *far behind in the spirit of artillery science.* We are behind in the sentiment, methods and realization of that unceasing toil which to some is drudgery, that must be performed in order to make these future instruments possible. We have yet to be trained in these processes and specially educated up to their successful operation.

GRAPHIC REPRESENTATION OF DEVIATING AGENTS.

In the central station of the battery or fort will be a diagram over which a pointer will move and point out at all times the direction and intensity of the wind with its two components. This will be large enough to show all values from a distance. In a similar manner variations in barometer and thermometer will be computed and allowed for. These results will also be on diagrams so that no computations will ever be necessary within the station. The anemometer will stand at an elevated distant point and represent as nearly as possible the area covered by the guns.

SMOKE.

We read that the recent changes in powder will revolutionize warfare. It will be remembered that changes and improvements in powder and other war material have been revolutionizing warfare for the last thousand years and this revolution is still progressing. We doubt if war will ever be completely changed in a day, a year, or a whole period of years. It evolves its principles from conditions and adapts itself to its environment just as all other social movements. We must therefore question the correctness of the prediction that the advent of smokeless powder is going to overturn all military principles and enforce new ones of its own. We still cling to the idea that a great change in these things will work itself out slowly and steadily during a long period of years. It may yet be a long time before smokeless powder comes into general use and by that time we shall probably take it as a matter of course, and may be surprised to see how similar the old and the new methods will seem. So long as common powder is used smoke will be incident to the battle and will favor sometimes one side and sometimes the other, depending entirely on circumstances. It may be reasonably assumed that when smokeless powder replaces the present powder smoke will still be produced by either side whenever its presence will serve a definite purpose.*

A fleet may envelop itself in smoke and enter a harbor, but such action imposes the condition of slow and uncertain movement and exposes the vessels to the danger of successful attack by torpedoes and torpedo boats. The value of such an attempt would certainly depend upon the surrounding circumstances. A well posted line of offensive sentinel boats would easily discover an enemy thus attempting to enter a harbor. In cases where the fleet could be seen from observing stations it can be located and met with indirect fire, in which case the smoke becomes an advantage to the defense. Again, until the era of smokeless powders, both sides may have to suspend firing on account of smoke, or both sides may use it to cover their operations. As matters now stand it is impossible to predict what effect its presence or absence will have on future artillery operations. The question of any great change in artillery methods due to its presence or absence may well be doubted. Since it has been reported that fleets enshrouded in smoke have entered ports, it is reasonable to suppose that this will be tried again, and the prevention of such enterprises remains for the consideration of the defenders. This stratagem, with use of darkness and fogs, renders a perfect system of patrol and sentinel duty with swift offensive boats more important than ever. On account of the accuracy of future artillery fire in daylight, night will be a favorable time for the enemy to make his dispositions and destroy passive obstacles. In view of this fact it is quite probable that

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* *La fumée artificielle.*—Conformément à la demande de M. l'ingénieur mécanicien Oriolle, de Nantes, des expériences ont été faites à Toulon pour l'utilisation de la fumée opaque comme moyen de soustraire un bâtiment à la vue d'un ennemi supposé ou véritable ou de protéger une attaque. Le torpilleur *128* était désigné pour ces expériences; d'autres torpilleurs, postés à la distance de 400 mètres et formant le cercle, veillant sur lui. Le *128* a fourni son nuage artificiel et a franchi le cercle à la faveur de ce rideau. Un rapport officiel mentionnant les résultats exacts sera addressé au Ministre de la marine.—*La Marine Française*, 15 Mars, 1893.

desperate night encounters will take place in the vicinity of mine fields and other obstacles. These attacks will give rise to developments of counter defensive weapons such as the search light, submarine boat, torpedo boat and dirigible torpedo. In future, so much will depend on surprise and initiative, that the assailant will make every effort to conceal himself until the moment of attack. Modern naval tactics incline to short ranges, and if hostile ships reach a suitable position unobserved or unmolested their chances of silencing shore batteries will be greatly enhanced. *Therefore every defensive weapon and apparatus which will conspire to prevent this must be brought into play and used with vigilance and skill.* It is imperative that the weapons be extremely offensive in their character and always ready to strike home on the slightest opportunity.

The obstacles will be protected by the guns as at present. They, like all passive obstacles, simply detain the enemy under fire and, like all passive defenses, must ultimately give way if resolutely and persistently attacked.

Submarine mines operated from the shore will be especially vulnerable to submarine boats acting around the flanks and in rear. For such boats to cut the main cables will be but a simple matter. Mines can also be destroyed with certainty by dynamite guns projecting large charges of high explosive. With these weapons in possession of an enemy, we have little to hope from our submarine mines; they will delay but they cannot prevent the final moment.

THE CONTROL AND CONCENTRATION OF FIRE.

Much will depend, we believe, upon the manner in which the fire is concentrated and delivered. Batteries using direct fire will be laid upon a given point of the hostile ship. In indirect fire simplification will result if all guns of a battery can be given the same azimuth. To do this and avoid the errors caused by aiming along parallel lines a special device is necessary. Such a device may be obtained from a consideration of the following equation: $\theta = \frac{d \sin(\alpha + y)}{\rho}$ in which θ is the angular correction to be made in the vernier; d the distance between the gun of reference and any gun considered: α a constant angle; γ the variable azimuth of the reference gun, and ρ the range. The second member is a function of γ and ρ and therefore represents a surface. This surface may with a simple mechanical device be used as a cam which will shift the vernier a distance δ, and so adjust all verniers. Thus with a constant azimuth from the position finder the guns of a battery may be made to converge upon the point whose coördinates are γ and ρ.

Vertical fire with mortars will probably begin at long ranges. When vessels are concealed by smoke or other causes it may be necessary for advanced sentinel boats to plot their position and transmit it to the mortar batteries. The present scheme of sixteen mortars arranged in sub-groups of four in the corners of a square contemplates volley firing. The mortars will be aimed and fired along parallel lines. It has been shown by mathematical investigation that this scattering effect is, under present conditions, the most advantageous for mortar fire. This investigation is based upon data now on hand. A general solution of the problem would show that other conditions of observation and fire would demand divergent or convergent lines of fire for maximum results. In other words, the question will reduce to our ability to group our shots closely around a given point and to place that point near the target. For a certain mean absolute deviation from the center of impact and a given distance of this point from the target the converging and parallel methods should give the same results. For shorter distances of the center of impact from the target the converging method should give best results; while for greater values of this distance a diverging fire would excel. The upper currents of the air, it has been argued, will be so strong and variable that it will be useless to attempt to concentrate on a given point; but this reason may be urged against concentrated fire of any kind. The following facts bear upon this difficulty, if it really be a difficulty:

1. The effect of wind on a projectile is most important in the first portions of the trajectory.

2. The wind currents of high altitudes are usually stronger but also more uniform in velocity and direction.

3. In the higher portions of the trajectory the retardation and consequently wind effect will tend towards a minimum.

4. Investigations of the relation between the wind of the lower and higher altitudes can be made.

In fact every element which affects the problem must be carefully investigated, and every effort made to bring the target and center of impact into coincidence. The true artillerist, while drawing all possible advantages from the past and the present and availing himself of their teachings, must remain ever awake to their shortcomings and keep his mind ever turned to progress and the future. Therefore, the application of probabilities to future data must be constantly made and rules for future operations constantly developed. It must be observed that whatever rules apply to the past, the next war will exact methods of the future. The pointing of *guns* in parallel should in no case be permitted, for such practice can scarcely be anything but deliberate waste of ammunition and assumes that it is useless to try to improve our aiming. No effective fire can result from a *scattering principle* and the *chance* of obtaining a hit. All such schemes are confessions of weakness dangerous to accept and which no true artillerist should be willing to make. Finally, in this connection, it may be stated that all scattering methods are erroneous in principle.

GENERAL PRINCIPLES OF THE DEFENSE.

Having considered the preceding problems we may now pass to the means of putting the different parts into operation and using them to the best advantage. As said before, the plan of defense should always be on hand and ready to be put into execution. Each officer must thoroughly understand its general scope and the particular part he is to play in its development.

A battery, we believe, should always concentrate its fire on a particular object. Groups of batteries in like manner should concentrate upon a prescribed vessel or vessels. Finally, such communication must exist between the central station and all batteries that the commanding officer can quickly and simultaneously direct all or any portion of his guns upon a given point or object. He would thus, so far as the application of tactics is possible, be able to use any kind of tactics suited to the defense, and concentrate all his guns upon any vessel he wished to overwhelm and destroy. In fact with suitable devices and facilities he could, we believe, so control and concentrate his fire as to draw a veritable "dead line" upon the water.

In the general case an enemy would have in view not the destruction of the forts so much as the menace or destruction of more vital interests behind them. In such cases he would while trying to clear the passage, be compelled to engage the forts. During this preparation of the way, the hostile vessels should not be permitted to anchor or sail slowly for an instant. If thus prevented, he will but waste his ammunition. The necessary experience and accuracy to accomplish this can only be obtained by a painstaking and persistent course of target practice. During the first stages of the attack our fire should be rapid, but above all it should be efficacious and overwhelming. No pains should be spared either during peace or in battle to make shots tell in the beginning. It will be to the enemy's advantage on account of his smaller calibers and unstable platforms to close with the batteries. The batteries should be able to keep him at a distance and leave him the alternative of great disadvantage or destruction. The action of the batteries as a rule should be concerted and convergent. This operation, if judiciously carried out, would greatly delay and possibly prevent his removal of the obstructions.

The attack, however, if persistent, will probably make this only a question of time; when this result is obtained the critical moment will be at hand. It will be to his advantage to make the passage as soon after the opening as possible. Estimating the run under an effective fire at three miles and the speed at ten miles, he would be exposed to fire for eighteen minutes. When it becomes evident that a ship is going to run the batteries, the latter, while engaging the remainder of the ships up to the last moment, should stand ready to concentrate their fire upon and destroy it. This will be a period for stratagems on the part of both sides, and each may endeavor to envelop the other in smoke. The side which accomplishes this earliest or most effectually will obtain an advantage. Passing these diversions, we will notice the actual effort of the ship to pass the fire of the defenders.

Eighteen minutes may seem a very short time indeed, but when judged by the amount of iron that could, with suitable arrangements, be rained upon a vessel, the interval might be reckoned in years. During this time we believe that every available gun should *appear* and *remain* above the parapet and put in the maximum number of shots at short range. If ever this stage is reached in a future attack there will be no time for losing sight of the enemy by receding behind the parapets to reload. It will not be a time for skulking or crawling into holes. As in the future infantry battle the assailant must come out and show himself in his onward rush, and as at the same moment the defender must come out from his cover and face the opponent at any cost, so will the time come in an artillery duel when the assailant will attempt his rush and the defense must bring their guns to the front and keep them there. Some of the guns may be destroyed, but they must take that risk. Some would better be destroyed than that all should spend half their useful time behind the parapet, out of sight of the enemy. *It must be remembered that protection is a means, not an end, and, as in other conflicts, must be abandoned under the demands of necessity.* In most of our harbors running the batteries would have to take place within short range of the guns. Harbors in future will be protected by heavy, quick-firing, and dynamite guns. These, when furnished with a suitable training apparatus and acting together to concentrate their fire upon a given ship would compel it to move through a hail-storm of projectiles of all sizes capable of killing its crew, dismounting its guns, perforating its armor, and blowing it out of the water. Based upon past experience, the principle is now accepted that ships unobstructed by passive obstacles can force a passage in spite of shore batteries. Future conditions especially with respect to volume, accuracy, rapidity and power of fire, cannot be compared to those of past examples, and we must be cautious in deducing cast-iron rules from such experience. The above principle has been demonstrated beyond question under the old conditions, but the value of this fact for the future remains to be seen. No ship or ships of the past have ever been, even for a short period, subjected to a concentrated fire of guns of the above-mentioned character, all trained with modern machines and capable of being continuously aligned while delivering their fire. The next war promises conditions so different from those of the past that we may withhold judgment as to the success of operations based upon any precedents. Had former fleets been subjected to such guns and concentration of fire as will obtain, henceforth, history might have told other stories, and the fate of Lissa, Hilton Head, and even Alexandria, been different. It will be remembered that by thorough organization, study, and preparation beforehand, and persistent offensive action in 1870, the German field artillery reversed all accepted rules for its employment and created for itself an offensive and defensive rôle undreamt of before. In like manner it may not be too much to hope that the future heavy artillery which is skillfully, boldly and fearlessly handled will establish its superiority over all opponents and demonstrate to the world that if it will not it cannot be beaten. Such a result however can be reached, we believe, only by the complete removal of the difficulties already pointed out and by a realization of that mobility and offensiveness outlined in the preceding discussion. In addition to the difficulties already mentioned, others, on account of changing conditions, will arise from time to time and some will appear on the day of battle. Thorough study and inquiry during peace and the habit of treating important questions at short notice must form our main reliance in such cases.

We must be prepared to dispose of them as an experienced engineer meets an unexpected difficulty. To push investigations far into future artillery problems, to foresee, suggest, and correct when possible, and to be watchful and ready for all questions, will be the true course of the future artillery soldier.

Organization and instruction in keeping with future developments are the prime essentials to artillery success. Following these come the ability to ascertain and understand new considerations with promptitude and energy and the genius to satisfy them from available resources.

An artillery combining these requirements will, we believe, experience few difficulties in future wars, and under reasonable circumstances cannot be defeated.

NOTES ON CONFEDERATE ARTILLERY INSTRUCTION AND SERVICE

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Had all parties been willing, the good results of our civil war might have been more satisfactorily accomplished by peaceful means with less expenditure of money and without any suffering. If, then, the war is not to remain an unmitigated evil, it becomes us, before it is too late, to try to reap from it some useful fruits. Now if the improvement of our relative status as a military power is not one of the results of the war, we may well despair of finding any good in it. That war gave birth to the epoch-making iron-clad vessel; but this result can be, and has been, utilized by other nations as readily and effectually as by us; and the same may be said of all improvements that have followed in the *matériel*. Any *advantage* to be derived by us must be some lesson which we stand in special need of learning, or which, when learned, will specially benefit us. Such special need, if it exists, must be due to some condition peculiar to us. What, then, are our peculiarities? It is sufficient for the present purpose to mention just one: The proportion of our population adequately acquainted with the art of war, will, under our system, always be much smaller than in the case of any other great power. At the close of the civil struggle we had great experience in practical warfare; but that generation is passing away, and it may be assumed that even the survivors have not all learned every lesson the war taught. One observes one defect, another observes another; one has discovered what he considers an improvement upon existing means and methods, while another has done the same in another direction, or has discovered another improvement in the same line. A comparison of experiences, therefore, is of the first importance; and this would be equally useful to those who did not take part in the war, but will be entrusted with the organization and training, if we ever take the field with a large army.

These considerations have induced me, though a civilian pursuing a vocation far removed from war, to yield to the request of the editor of this *Journal*, and state some of the experiences of the artillery service in the Confederate army. In doing this I am greatly embarrassed by several facts. The chief of these is that some things which it will be necessary to say will seem to be reflections upon the officers under whom I served; but such is not the intent. It is simply impossible to write intelligently on the subject without mentioning errors of omission or commission on the part of officers, and an article excluding mention of these errors would be useless. Another is the necessity I am under, not only of speaking in the first person, but also of stating facts the very mention of which savors of egotism. Then one feels a natural aversion to telling what he found to be the best way to kill people. Finally I feel that it is presumptuous in one who only held the rank of sergeant in the Confederate army and is disqualified to hold a higher rank in the United States army, to offer any remarks on a military subject. Still I have overcome all these scruples through the hope that some good may possibly result.

It is to be hoped that if our country ever becomes engaged in war, the operations will be confined to the sea or at least the seacoast. For such warfare this article could certainly not be of any service. But there is a possibility of our becoming involved in a struggle that would require the employment of an immense army of volunteers on land. We should not have enough trained and educated military men to officer such a force; and even if we had them, it would be unwise to fill all the offices by appointment of men who are strangers to those under them. Volunteer commands are gotten up in great measure by the exertions of influential patriotic men; and the prospect of some recognition of their special efforts must in many cases be an incentive that should not be withdrawn. Moreover, our self-governing citizens would feel it to be their right, as citizen-soldiers, to have some voice in the selection of their immediate commanders. In short, we should find the general conditions very much as they were in 1861, when whole batteries and (in the South, at least,) whole battalions of artillery went into active service without a single man, whether officer, non-commissioned officer, or private, who knew anything about artillery. In view of these facts it may be useful to record some of the difficulties such organizations experienced, the errors they committed, the progress they made, etc., even when it is certain that our trained artillerists would not learn from this source anything new in their profession. It is important that experts should know the shortcomings of others, that the needful steps may be taken to prevent their repetition. It is, therefore, chiefly the wants and defects of a volunteer force that this article is intended to illustrate, and it will have accomplished its purpose if it contributes anything to the elimination of these faults in the future; but at the same time the possibility, however remote, that some of our experiences might prove useful to artillerists as such will be kept in view.

The infantry of the Confederacy was provided with instruction and training in the manual and use of arms and in elementary evolutions. For this purpose cadets of military schools were detailed as drill-masters. But I have never heard of any such provision being made for artillery, except in isolated cases where the men composing a company secured the services of experts before they organized and entered the army. Possibly the Federal artillery was more fortunate. Certainly there ought to have been, and ought to be again under like conditions, systematic instruction of as practical a nature as possible, and this instruction should be given to officers especially. There might be organized a special camp of instruction for them, where they would have practice in actual firing. But it is not my purpose to point out how the needs of raw artillery may be met: if they are known, a way to meet them can be devised.

Both on account of the revolutionizing improvements that have been made in cannon since the war, and because the Confederate artillery and ordnance supplies were inferior even to the Federal of that time, it might seem utterly useless to take any account of the Confederate experiences. But it has been shown repeatedly in this *Journal* and elsewhere, that experiences acquired with the poorest guns, especially if those experiences reveal erroneous methods, can be utilized in serving the best guns, and that the better the gun the better it must be served to secure the same ratio of the maximum possible efficiency.

This article deals only with light field artillery ("mounted," *i. e.*, with the cannoneers *not* mounted on horses,). There is reason to believe that the sea-coast guns were, as a rule, in more experienced hands than the field guns, or at least that, for some reason, they were more systematically served. With the horse artillery I had no experience.

The whole ground is immense. Among the special subjects, on which our experience had a bearing, are the following:

The necessity, in making up an artillery command, to have an eye to securing willing and competent drivers.

The selection and training of horses and their management and treatment in winter quarters, in camp, and on the march.

The preservation and actual (not formal) inspection of the *matériel.*

The training of men to handle and maneuver guns (manual of the piece, maneuvers of the battery, march, etc.).

The general disposition and maneuver of guns in the face of the enemy.

The special details of coming into action, and the disposition of limbers and caissons.

The selection of the exact location with reference to the general topography of the field and the immediate contour of the ground.

When, what, at what, how, and how often to fire.

How to hit.

The last named of these subjects should be the beginning, middle, and end of all artillery training, and the present article will be confined to it and its collaterals. To hit an object at the first round, one must know the distance and the elevation his gun requires for that distance; but neither of these is usually known with any degree of exactness, and often the distance can be only roughly approximated, and may be very erroneously estimated. Consequently, while how to estimate distance is an important part of the subject, a still more important one is how, after firing, to correct the error. Then again the mere process of directing the line of sight upon a distant object offers physical difficulties familiar to everyone who has aimed guns without telescopic sights. Such, then, are some of the collaterals of the question how to hit.

The battery whose experiences are to be discussed was formed when the Confederate army was reorganized before the opening of the second campaign, and was in active service until after the surrender at Appomattox. It originally had six guns, but was reduced to a four-gun battery at the opening of the Valley campaign of 1864. Up to that date the pieces had included 6-pdr. smooth-bores, 12-pdr. howitzers, 3-inch rifles, 10-pdr. Parrott guns, and 20-pdr. Parrott guns. The battery had all these pieces at the same time except that the last 6-pdr. was given up when the first 20-pdr. Parrott was received. When the battery was reduced to four pieces, these were all 3-in. rifles, but they were of different kinds with different ranges and degrees of accuracy, so that each gun always had to find its own, even approximate, range. During the campaigns of 1862 and 1863 the battery served usually with detached brigades in a mountainous region; but in 1864 it was incorporated into a battalion and served in a large army. Its two best guns were at the same time its worst, a steel 3-in. rifle, weighing only about 500 lbs., which often broke its carriage when fired, and a 20-pdr. Parrott, weighing nearly 2000 lbs., which the horses were often unable to pull up a hill or on soft ground. The present article, however, will not deal with the relative merits of old-fashioned guns.

The organization of the company was as follows: A captain, four lieutenants, an orderly sergeant, six sergeants, twelve corporals, a quartermaster (sergeant), a commissary, a wagon-master, three artificers, and about 110 men—drivers and cannoneers. Three of the lieutenants were each a "chief of section" (two pieces), and the fourth lieutenant was "chief of caissons." Each of the six sergeants was a "chief of piece," or "detachment," six of the corporals were "gunners," and each of the remaining six was a "chief of caisson." By "gunner" was meant the man whose duty it was to aim or lay the piece (we usually called it "pointing"). It was always the privilege, however, of an officer or a sergeant to perform this duty and the sergeants as well as the corporals were regarded as gunners. In fact the line was very vaguely drawn between sergeants and officers on the one side, and between sergeants and corporals on the other. The organization was scarcely ever intact. It frequently happened that a corporal acted as chief of piece, and a sergeant as chief of section, or chief of caissons; and in 1864-5 a sergeant often commanded the battery itself (sometimes even in battle), took his turn as "officer of the day" for the battalion, commanded the caissons of the whole battalion in time of battle, and performed all the duties of a commissioned officer.

The company was chiefly made up of men reared in small towns or in the country. Very few of them were wholly illiterate, and still fewer possessed more than a good common school education. None had received any military instruction or training before the war began, though several had served in infantry from the beginning of the war to the organization of the battery. The writer had been attending a college which suspended all other studies and took up infantry tactics, field-fortifications, and gunnery, in the spring of 1861. The gunnery taught, however, was purely theoretical and altogether unavailable for any practical purpose. With this exception no member of the company had any knowledge of artillery worth mentioning. There were only four men in the company, so far as I can recall, who knew any mathematics beyond elementary algebra and geometry, and none of these were commissioned officers; and there were but two that had even the slightest knowledge of the calculus. The writer was familiar with the lower branches of mathematics, and had a special fondness for descriptive and analytical geometry; but had studied very little calculus.

The men were carefully and regularly drilled from the start. They were first taught the manual of the piece with the necessary detachment drill; then were added the evolutions of the battery, sometimes with the pieces drawn by horses, sometimes with the men alone. In the latter case the evolutions were not unlike those of an infantry battalion of six companies. In short, we were taught everything except the one thing that all else was a preparation for—the art of hitting. Our drill included much more, even, than is required in actual service. It cannot be asserted, however, that the excess was useless. The training prepared the men to meet unexpected emergencies, and sometimes we found occasion to perform some particular evolution that one would not have expected ever to be required. Once, for instance, it became necessary under a heavy fire in a contracted space to "change front to fire to the right, left wing to the rear," and immediately afterwards to return to the original position. On another occasion a gun weighing about 1000 lbs., at a very important crisis, when engaged with infantry about 400 yds. distant, leaped from its carriage, the keys of the trunnion-caps having come out. The gun was remounted, the keys secured with the sergeant's shoe-string (the pins ordinarily used being found missing), and the gun was fired again not more than one minute (as estimated at the time) after the discharge that had dismounted it. Hence there is nothing to be said against the thoroughness of the drill; but the failure to instruct in gunnery (or the art of pointing) becomes all the more striking by contrast.

The battery had been organized about six weeks when the first intimation of anything like gunnery was made by an officer; and as this was the *only* intimation I ever heard, it may be worth while to record it. We were drilling at the pieces, at that time 6-pdr. smooth-bore guns, the shells of which had circular metallic fuses up to five seconds. The officer drilling us suddenly suspended the drill and asked each gunner in succession: "At how many seconds would you cut your fuse for 800 yds." One made one guess, another made another. According to my diary I guessed "two seconds," estimating that at 800 yds. the projectile ought to be about with the sound. The officer then said with a sneer, "It would require the *full five seconds!*" Our guns at this time were not supplied with tables of ranges.

Nor was this fault confined to our officers. To the end of the war the text-books accessible to us, though they had a few remarks on gunnery (chiefly nomenclature), treated the subject as one of entirely secondary importance, and offered scarcely any information of practical value. In one of these books is found, indeed, the suggestion that "artillerymen should be frequently practised in estimating distances by the eye alone, and rectifying the estimate afterward, either by pacing the distance, or by actual measurement with a tape-line or chain," which is well enough but for the fact that it is slow and tedious to step off or measure with a chain now a thousand yards or a mile in this direction, then a mile and a half in that direction. About a year before the end of the war the non-commissioned officers were required to study and pass an examination on artillery tactics, and the sergeants were required as a part of their examination, to give the commands on the field necessary to change the battery from positions it occupied to other designated positions; all of which was proper enough, but our manual taught us nothing about how to attain the ultimate object of all those evolutions. No instruction in gunnery was ordered until June, 1864; and as it devolved upon me to give this instruction, I must, with renewed apologies for seeming egotism, speak of my own attitude in the course of our experiences.

I had selected the artillery service because I imagined I should be fond of gunnery, and though only seventeen years old had stipulated with the recruiting officer and prospective captain, that I should be made a gunner. Having been appointed "first gunner," I procured from time to time such helps as I could in the way of books, and devoted much time and labor to a vain attempt to solve the problem of a projectile moving in a resisting medium, and to reduce the results to practical form. The only work I had in which this problem is treated was Boucharlat's Mechanics. But I found that among the men, and to some extent even among the officers, there was a positive prejudice against "theoretical" gunnery. It was by the slowest degrees that this prejudice disappeared. It was only through the aid of almost incredible good luck in practice that I induced men to believe that there was any good in gunnery. And it must be confessed that, as they conceived it, they were not far wrong. It seemed to be the prevalent notion that a "scientific gunner" professed to arrive at all his results by pure mathematics. This misconception was never wholly removed, but the prejudice well-nigh disappeared before 1865. The men who at first had the greatest contempt for "theory" were the gunners themselves. About these and others who acted in that capacity, a few remarks may not be amiss.

All commissioned officers were elected by the members of the company. During the first year most of the sergeants also were elected, but a few were appointed. Later the sergeants, and from the beginning the corporals, were all appointed by the commanding officer of the battery. To what extent fitness for the place was considered by the men when voting, it would be unsafe to say; but that such fitness was not the prime consideration in some instances was perfectly obvious. Even the appointments did not always appear to be made with a view to efficiency; and when they were so made, the qualities sought in the early period were not always the most important. Among our original gunners were some almost illiterate men, selected because they had great reputations as marksmen with the mountain rifle,—men who could "hit a squirrel's head fifty yards," or who had been known to "kill a deer two hundred yards." Now a good eye is, indeed, a necessity, and the ability to align sights at a near object is certainly of some use to a gunner; but these qualifications alone amount to very little. One man was urged by many for appointment because he could "drive the center every time" and "*had but one* eye" so that when aiming he did not have to shut the other one. And yet, when once we were estimating the distance to two trees, respectively about 600 and 800 yards distant, that one-eyed man insisted that the nearer tree (which was the smaller) was further away than the other. He, it is just to say, was not appointed. In the course of time we learned that general intelligence and the ability to estimate distances with some accuracy (which latter implies a good eye) were much more important than skill with a squirrel gun. According to my own experience the aiming of a cannon was more nearly related to directing a surveyor's compass,—a thing in which I had had some practice, which certainly was beneficial. But all of us had to learn (though some, I fear, never did) how to direct the sights of a cannon at a distant small object. The difficulty of doing this needs no emphasis: all artillerists must be familiar with it. To what extent this practical difficulty has been, or, in case of war, would be eliminated by the use of telescopic sights, I am not prepared to judge; but it was with us a greater obstacle to successful firing than some people would ever suspect. There are men of intelligence who lack the ability to comprehend some of the simplest optical phenomena, and seem unable to perform the most elementary experiments with their own eyes, such as looking at one thing while they *observe* another. When I had occasion to train men in the use of the eye, I found that some could not look at a near object with both eyes and *observe* at the same time that more remote small objects were seen double, and *vice versa*. The first thing I did in this case was to train them to do this, and then to use one eye in the same way and observe that the objects were *not* doubled. I could then feel some assurance that they were capable of looking at the sights and observing the object, and *vice versa*.

As has been already intimated, it began gradually to devolve on me in a manner to instruct others in gunnery. At first a few of those concerned conferred with me of their own motion and, so far as I ever knew, without any suggestion from the officers; and I merely explained to them how I estimated distance and how I proceeded in getting the range of an object, and practiced them in the actual estimation of distances. The commanding officer, however, in the course of time began to require me to correct tables of ranges, or, when these were lacking, to prepare tables, for new guns after a few experimental shots. Finally, when in June, 1864, our battery was reduced to four 3-in. rifles and my 20-pdr. Parrott was given up, I was required to retain the rank of sergeant, and it was made my duty, as "chief gunner" (a specially created function), to superintend the firing of all the guns to the extent of seeing that they obtained and kept the range, and to instruct others in practical gunnery. The ensuing campaign proved so active that neither of these duties was systematically performed. Though nominally a supernumerary sergeant, there was but one engagement (and that a small one) in which I did not have a temporary vacancy to fill either as gunner, chief of piece, chief of section, chief of caissons, or even as commander of the battery; and much of the time I acted as orderly sergeant, and was detailed as "officer of the day" just as if I had been a lieutenant. Moreover, so far as I knew, no order was ever given the gunners to be instructed; so that the matter was entirely voluntary, and not all of them ever attended the few formal lessons I tried to give, though at least one (a sergeant) from another battery attended.

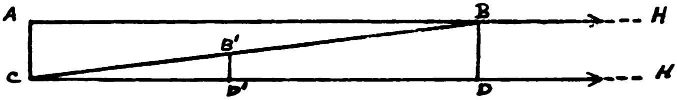
I now proceed to give my experience in the work above named along with an account of the development of gunnery in the battery. No systematic presentation will be attempted.

Every artillerist knows that he must feel his way when the range has not been measured or previously obtained by firing; but the nearer he can guess it before his first experimental shot, the better. Hence the first thing was to learn to estimate distances. Here two cases arise: first, when one is familiar with a locality, or can distinctly take in the topography with the eye, as when looking over a plain from an eminence; and secondly, when neither of these conditions is fulfilled. The means that have to be adopted in the second case are equally applicable to the first; but is desirable to be able without them to form some idea of distance by simple, direct contemplation; that is, one should know what a mile, for instance, is, when he sees it. For the first case we simply guessed at distances and then measured them. We on one occasion carefully measured several stretches with a tape-line, and also stepped them. In this way we learned how to step yards, or to convert our natural paces into yards. After that we satisfied ourselves with pacing. The tediousness of this method proved a serious obstacle to adequate practice; but where our battery served, it was usually impossible to find enough smooth level ground to lay off a base for triangulation. Near our winter-quarters during the winter of 1862-3 was a small level area from which a good deal of the surrounding country was visible. On this space we laid off a square with as great precision as possible, by geometrical means, marking the sides with a cord and the corners with wire pins. Having estimated the distance to a selected object, each participant writing down his own guess without conference, we would sight at the object from the ends of one side of the square and mark the points where the vertical planes of sight cut the opposite side, prolonged if necessary. Having now measured the distance between these two points and between one of them and the pin from which it had been located (sometimes this line was a side of the square already measured), we had the means of determining the distance by simple proportion. This method, without instruments, seems very crude; but the results (which I found it necessary to verify occasionally by actual measurement with a tape-line, to keep up confidence) proved surprisingly accurate. When a little boy I had often amused myself by measuring distances in a somewhat similar way and had sometimes calculated the elevation of hill tops, the height of trees, etc.; so that I had some experience in devising substitutes for instruments. These it is needless to describe. It will be observed that by the practice just described we were learning, not to measure distances (I did the measuring myself), but to estimate distances, the measurement being merely a test of the accuracy of the guesses.

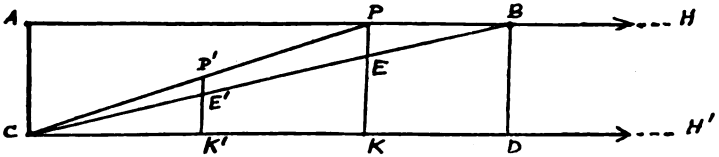
Usually, however, when a battle came off, we were unfamiliar with the ground, and there were undulations or groves or other obstacles to a direct contemplation of the intervening space. The difficulties confronting the gunner in this case constitute one of the most important subjects connected with the field artillery service. Of course those who operate the great stationary guns of our forts know the distances to all fixed objects in their view, and have at hand the means of promptly locating any new object that may appear and the point where a shot strikes; but our field artillery lacked all these advantages, and I have not only known men to greatly underestimate or overestimate the distance to a hostile battery and waste much time in getting the range, but I have seen them actually fire for hours under the impression that they had the range, when in fact the projectiles were striking the top of a hill a quarter of a mile short of the enemy's position, or the side of a hill a quarter of a mile beyond. Those who have received a military education may consider such a blunder too absurd for serious consideration; but it is a blunder that was by no means rare in our civil war, and would no doubt be committed again by uninstructed volunteers. The battery which I saw do the undershooting mentioned was a Confederate battery, and the Federals that day won a victory almost entirely by the superiority of their artillery. The converse case occurred between the same forces two weeks later; and this time it was the Federal artillery that proved inefficient, and the Confederates were victorious almost without the use of infantry. On this occasion a battery of four guns secured a position which enabled it to enfilade the Federal artillery. This position was on a low, treeless ridge, and behind it was a higher ridge with scattering trees on its top. At first four, then a larger number of Federal guns, were turned upon this battery, and though the distance was not more than half a mile, they shot over the heads of the Confederates from early in the forenoon till late in the afternoon, and failed to inflict the slightest damage on man, beast, or gun, while they themselves suffered severely and were eventually silenced. It is evident that the Confederate battery was supposed to be on the hill that was behind it, and the existence of the depression between the hills was probably not suspected. The remote hill was constantly struck. The error was the more natural because we did have on the farther hill a line of infantry, which withdrew behind the hill when the artillery duel commenced. Is it possible, it will be asked, that officers in the fourth year of the war could allow such blunders? One might answer by enumerating many still more unaccountable errors.

Two means were employed in estimating distances under the circumstances named; and though in the future range-finders will no doubt be provided, it may be worth while to describe our methods. These means were, first, the distinctness of vision and the apparent size (visual angle) of known objects near the target, and, secondly, the parallax of the target caused by moving laterally near the gun. The former means it was difficult to apply. The visual angle subtended by a man's body, for instance, could not be measured; and the distinctness of vision depends much upon the condition of the atmosphere, the time of day, the direction with reference to the sun, the relative color of objects and of the back-ground, etc, Moreover, everyone must learn rules for himself. I found that my eye was quite exceptional, and that consequently my experience was useless to others. On one occasion a line of battle running through the woods on the side of a mountain (before the leaves were fully out: May 9, 1864) was pronounced a brush-fence by everyone near me, and yet I could distinctly see the men's legs as they stepped. But, although this method of estimating distance is very uncertain, it is not entirely useless; for close attention to the appearance of men, horses, gun carriages, and the like, will in the course of time enable one to avoid enormously erroneous estimates of distance; but the rules sometimes laid down are of little value except as general hints how to utilize the appearance of things. As stated before, each one must practice his eye and form special rules for himself.

The second method, unless instruments are used, is not much more accurate; but it will always prevent blunders such as those described above, and enable one to find the range more promptly with the gun. It has always seemed to me that in many cases which arose instruments might have been used to advantage, though I have never seen them used in the field. I cannot say we did not have them. Our battery once hauled around for several months (sometimes with the cooking utensils) a fine theodolite in its original case. It was captured by our men at Gauley Bridge, W. Va., in 1862, and if I remember correctly was labeled "Theodolite No. 10, United States Topographical Bureau." But we never made any use of it. One of its levels was at last removed and fastened to the axle-body of the little steel rifle by means of nails driven in and bent over it. Whether the axis of the level was parallel to that of the trunnions, nobody knew or cared; nor did it make any difference, since we could not get the bubble to stand in the middle by leveling the ground under the wheels, and the first time the gun was fired the glass was shivered and the alcohol scattered in the air. After this occurrence the theodolite disappeared, and I never learned what became of it. I tried to extemporize crude devices for prompt measurement of parallax; and in this, as in most analogous attempts, the immediate result was of little practical value except as preventing enormous errors, but the theory and repeated attempt to apply it tended to cultivate a useful habit of observation and to develop the faculty of drawing intelligent conclusions from phenomena. I did not attempt to measure angles directly, but adopted the following plan. Let A be a point near the gun,



and B the object whose distance is desired. From A carefully note the point (H, H') in which AB prolonged (or the vertical plane containing AB) cuts the horizon. (Usually the point A may be selected *near* the gun, so that some distinguishable object will mark H.) Now step off AC perpendicular to AB, and from C observe the relative positions of B and H. The latter will appear in the direction CDH', and if AC is small (say 100 yds.) and the horizon is at all distant the point (H,H') on the horizon may be regarded as the true vanishing point, or, in other words, AB and CD are virtually parallel. If the horizon is not remote in comparison with AB and AC, the line CDH' should be directed towards a point situated a distance AC to the right of H. This distance AC on the horizon must, indeed, be estimated by means of surrounding objects or derived directly from AH, if this is approximately known; but an error in this estimation only affects a fraction of the general result. Draw BD parallel to AC in the figure; connect C and B, and draw B'D' parallel to BD. Now stand at C and hold a graded rule in the position B'D' and read off the length B'D'. Sometimes, when practicing, I used a measured rule (Gunter's) for CD', and adopted various devices for observing and measuring B'D' across the end of the rule; but in the face of the enemy, if I took any measurement at all, I held a little pocket rule at arm's length, having learned by practice to hold it twenty-eight inches from my eye. I carried in my head the various lengths of B'D' when AC was 100 yds. and AB varied from 500 to 2500 yds.; but the computation in any case required only a few seconds of mental operation. The difficulty of making the observation is very much the same as that of aligning the sights of a gun at a distant object, only the eye serves as the rear sight, simplifying the case, which is at the same time complicated by the necessity of observing simultaneously two objects. But the chief difficulty is to keep the object marking the vanishing point fixed in the memory. In fact it is best to watch it as you move, and to do this it may be more convenient to step off AC first, and from C project B upon the horizon; then, watching this point on the horizon, go back to the gun (walking by faith). In the face of the enemy, however, it frequently was impracticable to attempt any definite measurements; but almost always, not only before aiming the first time, but especially after the gun was laid, and when the first shot was about to be made, I stepped far enough to one side to be able to draw some inference from parallax, the significance of which I had learned by experience. Often the firing of other guns rendered the identification of my shot difficult, and sometimes I was interfered with by officers and ordered to my "post." The method just described relates solely to the distance of the object to be hit, and was applied before laying the gun. When the effect of one round has been observed the method is the same in principle, and will be made clear by a glance at the annexed figure. The lettering is, in the main, as before. Suppose a *line* shot has hit at P. The rule held before the eye is in the position P'E'K'; and it is obvious that P'K':P'E'::PK:PE: AB:PB, so that K'E'P' is a miniature of APB, viewed from the side. In battle I never attempted more than a rough estimate in this way; but a rough estimate is vastly better than unconsciousness of the very existence of an error, which unconsciousness is liable to occur if no observation of the sort named is made. The method of correcting the error of the first shot will be stated in its proper place in the account of our experiences, which will be given presently.



Some of our pieces were provided each with a tangent scale held firm in its socket with a thumb-screw, while others had each a movable pendulum hausse. These rear sights were at the centre of the breech on top, the front sights being on top of the muzzle. The notches in the breech sights, and especially the edges or points of the muzzle sights, were usually very coarse. The object of this I never could conjecture. The first thing I always did on being assigned to a new piece was to sharpen the sights. Some of our pieces (chiefly captured Parrott guns, I think) had the front sights on the trunnions and the tangent scales on the side of the breech. Even the captured guns, by the way, had those same coarse sights that rendered accuracy of aim impossible. During our war I never saw telescopic sights or sights that could be adjusted laterally.

Our ammunition was inferior to that of the Federal artillery. This fact became conspicuously obvious sometimes when (as at Bell Grove, October 19, 1864) Federal ammunition fell into our hands. The worst of it was that there was great lack of uniformity in the strength of the powder, and seemingly in the time of the fuses. No reflection on the Confederate ordnance department is implied by these remarks. With the means at their disposal their achievements were amazing; but the indisputable fact remains that our ammunition was in every way inferior to that of the Federal army. The supplies received at different times often differed very much in power, and sometimes we inadvertently mixed different supplies in our boxes, or had to change from one to the other in the heat of battle. At one engagement which I recall the Federal accounts represented us as having used pig-iron as projectiles. This, of course, was a mistake; but it was a natural one. There was some pig-iron scattered over that battle-field (how it got there, I do not know); and our ammunition was particularly bad and lacking in uniformity. At one time during the battle I had an opportunity of using case-shot from a 12-pdr. howitzer on a mass of men not more than 800 yds. away, and it became obvious that the shot did not kill. The (paper) fuses were in the form of a frustum of a cone, and the fuse-plugs were of wood. The tapping of the fuse with the mallet drove the plugs partly into the shells, and frequently, when the piece was discharged the plug jumped entirely into the shell or else let the fire pass it: at any rate the shell often exploded in the bore, or at the muzzle of the piece. It was also on this occasion that some guns never found out which ridge the hostile artillery was on. Hence, while the statement that we used pig-iron was not correct, the mistake was natural enough. But what was, perhaps, worst of all about our ammunition was that we usually had only a limited supply of it. Consequently we were rarely allowed to practice except in testing new guns; and in battle we sometimes were forbidden to fire at anything but masses of infantry. Hence our opportunities for practice in firing at a small object, such as a target or a hostile gun, were limited.

The pieces themselves were often very inaccurate. We had to use guns after they were really worn out, and sometimes our new pieces were defective. For two years we had a beautiful bronze 3-in. rifle, which was very untrustworthy in comparison with the Federal iron 3-in. rifles, some of which we afterwards used. Its caliber seemed to be a little too large, and often (possibly, however, from stripping) the projectiles failed to take the grooves. For a short time we had also a 20-pdr. Parrott, beautifully finished inside and outside, which we used in one engagement; but the shells did not once fail to strip. I tried hammering the rim to fit the grooves, and wrapping the whole projectile with twine; but all to no purpose. I made careful measurements, and could detect no difference between its caliber and that of another 20-pdr. Parrott (Federal), which, though not so smoothly finished inside, was an excellent gun but for occasional stripping. I threw light into its bore and carefully inspected it, but never detected the fault. I now *suspect* that the grooves had uniform twist, or at least began with too much twist. One of our guns, as already stated, was a steel 3-in. rifle, weighing only about 500 lbs., which was said to be a French experimental gun that had run the blockade. It was remarkably accurate and long-ranged. The barrel was longer than that of our other guns of the same caliber. It was a muzzle-loader: in fact, though there were a few in the Confederate army, I never saw a breech-loader during the whole war. The gun in question, however, gave us infinite trouble by kicking its carriage to pieces, breaking out of its bronze cap-squares, or in some way disabling itself. If nothing else happened, it would get choked. From all this it will be seen that not much can be expected from a discussion of our experience in trying to hit; but as this article deals rather with *corrigenda* than with positive results, such a discussion may prove not wholly useless.

Under the circumstances one would naturally suppose that when we did fire our guns, we took care to learn as much as possible from every round; but this was far from being the case. We sometimes fired seemingly idle salutes with blank charges. On one occasion, when our battery, being by accident far away from all other forces, arrived at a village after dark, we fired several rounds and actually threw a shell with uncut fuse toward the side of an uninhabited mountain. Moreover, in the early part of the war, when we practiced, it was done without any system whatever, and seemed to have no definite purpose. Much of the firing was simply at the trunks of trees, that is, at vertical lines, and the distance was either ignored entirely or guessed. Not only was no attention paid to the thermometer or barometer, but no one seemed to be aware that ranges obtained where we were, 2000 feet above the sea, would not hold good for every elevation above the sea. As time went on there was considerable improvement. Late in the fall of 1862, when the active campaign was evidently over and we were constructing winter-quarters, an officer discovering that my works on artillery and other books containing formulæ and tables of logarithms were in my limber-chest, threw them out on the ground in a heavy rain, because the "regulations" forbade carrying in the chests anything but "ammunition and artillery implements." I knew nothing of his act till next morning when I found my books utterly ruined. And yet, one year after this the non-commissioned officers of our battery were all required to procure and study a work on artillery tactics. From the latter time on our battery officers classed works on artillery as "implements" or "equipments;" but a field officer, in July, 1864, when we were in Maryland, inspected our battery and threw my book out on the ground. There was no other means at hand of carrying it, and our battery was on the rear-guard, pretty closely followed by a regiment of Federal cavalry; so, labeling the book as "abandoned for want of transportation," I fastened it to a thorn-bush by the road-side. But again, in the winter of 1864-5, when our battalion had fired its last round, we were required by field officers to study artillery tactics, and I was highly complimented for a "perfect recitation" on the duties of No. 1 in loading the piece! In all this there is evidence of individual progress, though some of it was a trifle late.

Let us return to 1862. Our original guns had been "turned over," some of them to the Confederate ordnance department, the rest to George Crook; and we were supplied with six new pieces. Some of these had tables of ranges pasted in the limber-boxes. These tables were not only printed and uniform for all guns of the same caliber without reference to the pattern, but some of them seemed to be, not theoretical, but what might be called conventional: the elevation, range, and time of flight were all three given in round numbers. This was probably the best our ordnance department could do; but it was our place as artillerymen to modify these tables to suit ascertained facts, and to construct tables for the pieces that had none. But at our first trial of the guns, as has been stated, we shot at a *vertical line, distance unmeasured.* The officers did nearly all the pointing, and no notes whatever were taken. At the close of the practice each gunner (corporal) was allowed to make a shot with a 6-pdr. bronze smooth-bore. The tree, distant less than 800 yards, had been struck once by the little steel rifle; but at what point and with what elevation it had been aimed seemed to concern no one. All the other shots had missed the tree and nobody cared where they struck. But at last, when the gunners' turn came, I ventured to ask at what point we should try to hit the tree. A point was designated, and some shots were made, missing the tree. When the gunner who immediately preceded me had aimed, I looked through the sights and received from him the pendulum hausse just as it was. The projectile struck very close to the right of the root of the tree. When I was about to aim, a device occurred to me which is so simple and self-evident that I hesitate to state it, and yet I never met with any one that used it, and I subsequently found difficulty in getting some to grasp it. I placed the unchanged hausse in its seat and aimed the gun exactly as it had just been aimed, that is, *at the same point* and *with the same elevation:* if fired in that position it ought to strike about the same place it did before. Next, leaving the gun unmoved, I ran the slide of the hausse up until the line of sight was brought down to where the shot struck (the line passed a little to the left of that point). Finally, assuming practical rigidity of the trajectory I raised the muzzle of the gun with the elevating screw until the new line of sight was brought to bear upon the point to be hit. The slight lateral correction was estimated: in fact, the sights were so coarse that it was merely a question which part of them the line presented by the tree should pass through. There was considerable murmuring at my slowness, and even some of the citizens, many of whom, male and female, were present, joined in and offered some witticisms. But fortune came to my rescue: a 6-pdr. smooth-bore did for once make two consecutive somewhat similar shots, and mine was the second of these shots. The projectile struck almost exactly as was intended, and knocked a large block of wood out of the tree. The only credit I claim for that shot is that I made the accident possible by placing the target within the limits of dispersion. The tree was not hit any more, and nothing had been learned, except in the vaguest way, about the range of our guns.

Not long after this we practiced again ; but most of the shooting was still at the trunks of trees, though some of it was at stumps. One case-shot was fired at a large hawk sitting on the top of a dead tree. No distances were measured and no notes taken by those conducting the practice. The objects fired at, however, were on inclined ground, rising to a considerable height beyond the targets, so that it was easy to observe where the projectiles struck, or the apparent point of explosion as viewed from the piece. I undertook to utilize as many of these shots as possible by applying the principle on which I had pointed the gun a short time before. When a shot had been fired, I got permission to point the gun in exactly the same way again, and then change the sights so as to bring the line of sight upon the point struck, or the point at which a shell seemed to explode (the actual point projected upon the background). Subsequently I measured the distance to as many of the points struck as I could identify. The observation of exploding shells gave the time of flight corresponding to the elevation in each case. From these data the range was calculated approximately, on the assumption that the time of flight was equal to the time required for the projectile to fall through the air a distance equal to the range multiplied by the tangent of the elevation (this was a few weeks before my books were destroyed). The strong prejudice existing at this time against "theorizing" deterred me from making any suggestions, and the only part I took in the practice was, just before each discharge, to predict what the projectile would do when a serious error seemed to me to have been committed in pointing. One of the lieutenants remarked to me on the comparative uselessness of firing at a vertical line without taking any note of the drift or deflection; but he made no protest so far as I know. We had no more field practice that fall and winter, except when we tried the steel rifle with the level from the theodolite attached to its axle. On this occasion only two or three rounds were fired, one from the rifle, the rest from a howitzer. The distance was not measured nor any notes taken.

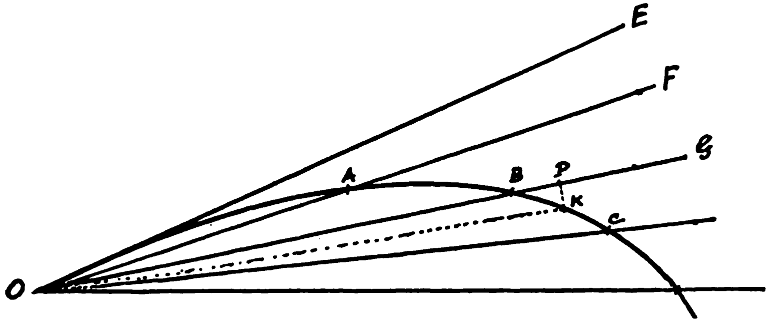
During the winter of 1862–3 four batteries, including ours, were formed into a battalion, under a field-officer. At the opening of spring some of the guns were fired at a selected object,—a stump, I think. No measurements were made and no notes were taken. Moreover, the object selected was on the opposite side of a river. Nothing could be gained by laying off a base and calculating the distance, as there was no record of the elevations used nor any means of identifying different shots. Of course a sergeant (I had been promoted to that rank) did not presume to open his mouth in the presence of a major and several captains.

During the campaign of 1863 the batteries of our battalion were again distributed among detached brigades, operating in the same department but independently of each other, and for the most part widely separated. Our battery was in remarkably few sharp engagements; but on several occasions we used our guns in skirmishes and in one artillery duel of twenty-four hours' duration. We practiced a little twice, once with a detached section and once when the battery was all together. In the case of the detached section some beautiful firing was done with the steel rifle, at a stump more than a mile away on the side of a steep hill. I utilized all the shots fired. The other piece was a bronze 12-pound howitzer, recently supplied with fresh ammunition which proved almost worthless. The rounds we fired indicated that the very maximum range attainable could hardly have exceeded a mile, while the range of the five second fuse was hardly ordinary musket range. Whether any report of this fact was made I never knew; but we had to use up the ammunition. When the whole battery practiced, the captain caused men to remain in the vicinity of the targets and mark where every shot struck. I was permitted to take an active part in supervising the practice, and after the firing was over measured the distances. It was found that the ammunition of two pieces (iron 12-pounder howitzers) was composed of two kinds, the range of one kind, to put it roughly, being nearly twice that of the other.

During the winter of 1863–4 we procured a 20-pounder Parrott gun and some other new pieces. These were tried in my absence (I was detached with the horses). For the first time various distances were measured before the practice began. The results were reported to me with instructions to prepare tables of ranges from them. The target in each case had been fired at until it was considered as virtually hit, and note was taken only of that round. Of course all the other rounds might have been utilized as well. After this we never again practiced at targets. Beginning with May 9th and closing with November 22nd, our battery was engaged twenty times. On some occasions we fired only a few rounds, while in one battle we fired from ten different positions an aggregate of 804 rounds with three guns, my piece firing 363 times.

It was usually supposed by members of our company that tables of ranges were calculated by some mysterious mathematical process, known as "scientific methods." I did not have even empirical formulæ, though I sometimes interpolated by an empirical process of calculation. Usually, however, I determined the ranges and elevations by graphic methods, and calculated the time of flight, first theoretically, $t=\left(\frac{2\,r\tan\alpha}{g}\right)^{\frac{1}{2}}$; then I modified the results after the analogy of previously determined tables, and our own actually observed shots. The uncertainty of our fuses and the absence even of stop-watches, rendered the time column in the tables inaccurate; but the approximation was sufficient to prevent gross errors at the beginning of an engagement. The ranges and elevations were obtained by drawing two lines perpendicular to each other, and marking points corresponding to ranges treated as abscissas and the elevations treated as ordinates (measured from the origin downward), and drawing a line (I can hardly call it a curve) through these points and tangent to the axis of abscissas at the origin. This line in some instances made it obvious that the data were not consistent with each other; so I sometimes tried to strike an average in the graphic process, but I did not dare to alter any observed figures in the tables prepared. This led to still more glaring inconsistencies in my tables, so that I had to *temper*, as it were, my own results before furnishing them to the respective gunners. Of course when we had used two kinds of ammunition, differing in power, I guarded against combining their results in the same table. Had I not taken this precaution, my "graphic curve" would have had some loops in it. As already intimated, I assumed that every shot utilized in forming a table of ranges had struck the centre of impact; and I departed from the data only when their incongruity was conspicuous.

The method, previously mentioned, of correcting the error of an experimental shot so as to hit the required object at the second round, is directly applicable only when the point struck is at the same distance as the point to be hit. In battle this hardly ever happens except in the case of lateral deflections, such as are due to wind, to rotation of the projectile (drift), the rotation of the earth or less obvious causes. Still it happened on several occasions that our battery was confronted by guns placed on bluffs so steep that the residual error was very slight after one correction, and sometimes our own guns were on the brow of a cliff or very steep hill; so that the direct application is sometimes practicable. But if the slope is gentle or the ground level, the method must be supplemented by other devices. When, therefore, under these circumstances a shot had been fired and the point struck had been noted, the question arose, how much the elevation of the gun must be changed. To form even a vague estimate it was necessary to know the form of the trajectory. This knowledge is also needed in the use of case-shot. As this was my favorite ammunition except when trying to dismount a gun, I gave the subject much thought and of course saw that the projectile should explode, not directly between the gun and the enemy, but on a trajectory passing through the enemy's position. It was my practice, however, to use the case-shot as shell or even solid shot until I got the range. In fact the safest plan seemed to be first to use it as solid shot, then as shell, then shorten the fuse a little (the same amount no matter what the distance). The inexperienced are sure to think that case-shot correctly used is going too high if the range is considerable. To determine, then, the form of the trajectory, I assumed its "rigidity," and projected the curve by drawing from a point O a series of lines OE, OF, OG, etc., so that the angles between OE and each of the other lines were equal respectively to the angles of elevation in the table of ranges, and then marking points $A_{,}$, $B_{,}$ etc., on these lines so that OA, OB, etc., should represent the ranges corresponding to the elevations, and finally drawing a curve, tangent to OE at O, and passing through $A_{,}$, $B_{,}$ etc. In the figure the angles are made too large, so that the other dimensions may be reduced without confusing the figure. If a shot fired at



P strikes *B*, the additional elevation (of the piece) needed is, of of course, *P O K*, *P K* being an arc with its centre at *O*.

In determining graphically the table of ranges and in plotting the trajectory, I took no account of the change of the law of resistance within the "ballistic bad limits." I knew only that when the velocity of a projectile exceeds that of air rushing into vacuum or that of sound, the resistance is greatly increased. One serious difficulty presented itself; most of our tables assigned a considerable range to 0° elevation. This I found by careful measurement to be partly due in some instances to the fact that the muzzle-sight did not quite compensate for the dispart; but towards the end of the war it became clear to me that the projectile did not start on the line fixed by the axis of the gun before firing. I do not think any of my books could have said anything about "jump," for I shared the opinion which seemed to be universal, that a gun could not change its position, or at least the direction of its axis while the projectile was still in the bore. But on the 20th of May, 1863, a howitzer which I was firing in an artillery duel got to making perfectly wild shots, the errors being chiefly deflections to the right or left. Afterwards in field practice it did the same thing and was condemned. When we were removing it from the army I observed that the whole framework that supported the trunnions was loose in its joints. Afterwards another howitzer commenced making similar shots and was found to be in the same condition. I tightened the loose parts by screwing up the taps and at once the piece resumed its usual degree of accuracy. It was this that led me to the belief that the reaction from the vent, or some other influence, caused the gun when fired, to suddenly press so hard upon the trail as to bend it before the projectile left the bore. Whether the theory was correct or not the fact was obvious; but I never attempted to determine with any precision the angular value of the jump.

From all that has been said it will be seen that our practical gunnery may be formulated as follows:

1. Estimate the distances, both directly and by concisely considering the distinctness and apparent size of things, and, if necessary by observing the parallax resulting from a lateral movement.

2. Point the piece with great care directly at the object, using (as a rule) an elevation slightly less than that required by the estimated distance.

3. Fire the piece, the corporal observing the effect from the piece and carefully noting the deflection if there is any, the sergeant stepping to one side and observing.

4. Aim the gun exactly as before, and then change the breech sight so that the artificial line of sight shall pass through the point actually struck. (In field practice, record this new elevation, and the measured distance to the point struck.)

5. If this point is at about the same distance as the object to be hit, merely bring the new line of sight to bear upon the object by elevating or otherwise moving the gun ; but if the object is at a different distance, consider the form of the trajectory and the observations (3) and estimate the correction needed for the elevation. It may be advisable in this case to dispense with rule four. Also circumstances may render it wise to try to hit, or even to slightly overshoot, at the first round.

Many other little devices adopted, especially in connection with the time of flight, and the relation between the distance and certain phenomena of sound (such as the time between the firing of the gun and the return sound of the impact or explosion, or the time between the flash of a shell or a hostile gun and the report) were of little practical value for want of stop-watches. The effect of the rotation of the earth also occurred to me, and I calculated its value for different ranges, times of flight and latitudes; but at first, committed the error of supposing it was influenced by the direction with respect to the points of the compass.

It is not easy to determine how successful we were in applying the crude methods described. In my own case it is certain that improvement resulted from the repeated attempts to apply the methods, and in some instances their direct application was in some degree successful. Others who were instructed in the methods, it may be safely stated, had their faculty of observing and interpreting phenomena more fully developed. Still it is true that some men seemed naturally to comprehend any situation, and made good gunners without any instruction that came to my knowledge. This was true of at least one in our battery who became a gunner in 1864; while on the other hand, a sergeant belonging to another battery, who acquired considerable distinction as a gunner in 1864, ascribes his greater success in that campaign entirely to instruction he heard given in our battery, although he admits he was strongly prejudiced against "theoretical gunnery," and attended the first time in a purely critical spirit. Others again seemed to be little benefited by any theoretical knowledge. They would explain methods, and go through the motions of obtaining the range and correcting errors in assumed cases; but when it came to actual firing in the face of the enemy, they would cast all that to the winds, and begin to fire with nervous haste, taking careless aim and guessing haphazard at the necessary correction, so that they were liable after one error to err the next time as much or more in the opposite direction. These men were not cut out for gunners, and it is possible that no instruction or experience could ever have made gunners of them.

Enough has been said to show that our condition was sad. In presenting our experiences, I have carefully guarded against confounding what I have learned since the war with what I knew during the war. This it has not been easy to do, as my diary kept during the war is silent as to details of this kind, confining itself rather to *what* was done than telling *how* it was done. I think, however, that nothing of any significance, except part of the nomenclature, has been infused into the treatment from subsequently acquired knowledge. The recent graphic works on ballistics I have not seen. Captain Ingalls' work would have been literally a joy to me had it existed and come into my hands during the war; but there is no need to give assurance that it has not influenced me in what I have said in this article.

To what extent our battery was typical I am not prepared to say. Some batteries were certainly in no better condition than ours. Very few were commanded by artillerists. General Johnston, while speaking of the surprising efficiency of the Confederate artillery at First Manassas, says "we had but one educated artillerist." This artillerist was educated at West Point, went out as a captain, and became brigadier general and chief of artillery in Lee's army. His original company furnished forty commissioned officers during the war. This may however, have been due to the fact that the company was made up at an important seat of learning, and was largely composed of highly educated and influential men. Though well acquainted with our chief of artillery for years after the close of the war, I have never learned anything from him about any attempts to instruct men himself or have them instructed by others; but I never asked him the direct question. I was also in almost daily intercourse with General Lee until his death, but I never heard him mention the subject. The only allusion to this subject I remember to have encountered in our war literature is interesting, and will be suitable as a close to this tedious article.

In a biography of the above named artillerist is published a letter written by him while commanding a battery. In this letter, speaking of what seems to have been the first action participated in by his battery (on this occasion only a single six pounder smooth bore being present), after mentioning the opening of the Federal fire, he says: "We however, quietly took our position and awaited the best moment for opening fire with our single gun. That moment arrived when I saw a body of horse, which seemed to be a squadron of cavalry about to charge, on the turnpike about a half-mile in front of our position. At that body I instantly had the gun directed with careful instructions how it should be aimed. In another instant the messenger of death was speeding on its way. The effect was obvious and decided. Not a man or a horse remained standing in the road nor did we see them again."

On this passage the biographer, who had exceptionally good opportunities of learning the facts, makes the following comment:

"The 'instructions' for aiming the gun on this occasion were: 'Steady, now; aim at the horses' knees.' Nor was this first lesson on the importance of firing low lost upon the men who afterwards proved themselves such efficient artillerists."

On other occasions reference is made to his directions how to aim, but what the directions were is unhappily not stated.

HADFIELD'S MANGANESE STEEL AND CHROMIUM STEEL PROJECTILES.

By Captain EDMUND L. ZALINSKI, Fifth Artillery, U. S. A.

The advances made in the manufacture of steel armor have given it a momentary supremacy over the gun. The best made so-called armor-piercing projectiles are frequently shattered as if made of glass when striking the Harveyized plates. The very high velocities now attainable are of no avail in the absence of suitable projectiles.

Unless an overwhelming energy with reference to the resisting ability of the plate is developed, perforation is out of the question. Failing to perforate, we must resort to smashing it by tremendous blows delivered from guns of very large caliber.

For either work a projectile must be provided which, whilst very hard, must have an enduring toughness.

Such have not yet been evolved. The most successful ones have been made of alloys of manganese and chromium with carbon steel.

We are indebted to the investigations of Robert Hadfield for manganese steel, and to his son R. A. Hadfield for its development, and a more definite knowledge of its properties as well as those of silicon, aluminum and chromium steels. Of these alloys, it appears that only chromium and manganese steels are of direct interest to the artillerist for the manufacture of projectiles. The most successful of the projectiles of the present are either of chromium steel or a combination of chromium and manganese. Both manganese and chromium steel contain carbon, and their characteristics are largely influenced by the percentage and character of the latter present. Manganese steel has from about seven to twenty per cent. of manganese. It has a variable effect on the characteristics of the alloy. With 1.5 per cent. manganese steel is brittle, with further increase from 4 to 6.5 per cent. it is so brittle that it may be pulverized under the hand hammer; but when the manganese rises above 7 per cent. the ductility of the water-cooled metal increases in the most striking way, till the manganese reaches 13 per cent. to 14 per cent. When the manganese exceeds this the ductility falls off abruptly, the strength remaining constant till it passes 18 per cent., when this also diminishes suddenly. It is generally free from blow-holes, has good tensile strength and astonishing ductility in combination with great hardness. The hardness is such, however, as to make it difficult to machine by ordinary methods. It yields quite readily however to the emery wheel. It is very hard to ordinary abrasion. Water cooling increases the hardness but slightly, if at all, whilst it increases ductility greatly. Annealing does not materially reduce its hardness. Whilst manganese steel cannot be made as hard as the hardest carbon steel nor as tough as the best soft carbon steel, it can be made to combine a greater hardness with a greater toughness than is obtainable with carbon steel.

A singular feature of its ductility is that, in being stretched, as in tests for elongation, it stretches nearly uniformly throughout its length (outside of the jaws of the testing machine), leaving the reduced part of nearly uniform cross-section, instead of reducing nearly tapering to the plane of fracture, as is the case with ordinary steel. It is practically unmagnetizable when it contains 13 per cent. manganese.

It has not yet been made into armor-piercing projectiles, except in combination with chromium. It possesses qualities which may make it useful in compound or built-up projectiles which will be referred to later. Its qualities should make it suitable for armor. With a higher percentage of carbon and Harveyized, or correspondingly treated, it should offer great resistance to penetration or crushing. Should it not be possible to bring its face to a sufficient degree of hardness a compound all-steel armor might be devised, the main part being of manganese steel and the face being of carbon steel of the thickness and carbon suitable for the greatest resisting hardness. The treatment which would harden the carbon steel face would only serve to toughen the manganese steel backing. The greatest objection to its use for armor is the difficulty of machining. But this may be overcome, if it is found by experiment that it possesses superior resisting qualities. An ingot of manganese steel has been sent to the United States to be rolled into an armor plate and tested for penetration. If properly treated there are reasons for expecting notable results.

The differences and similarities of the conduct of manganese and carbon steel, when suddenly cooled, are shown in the following table: *

Properties.	Effects of sudden cooling.	
	Carbon steel.	Manganese steel.
Hardness:	Enormous increase.	Slight increase.
Percentage of carbon in hardening state:	Very great increase.	Moderate increase.
Density:	Decrease.	Usually no change, but continue slight increase.
Size of grain:	Nil, or decrease.	Increase.
Separation of components:	Decrease.	Increase.
Ductility:	Enormous decrease.	Enormous increase.
Tensile strength:	Increase.	Increase.

The most remarkable feature of manganese steel is the great increase in ductility when cooled suddenly; this effect being directly opposite to that produced on carbon steel similarly treated.

CHROMIUM STEEL.

The simple addition of chromium to carbon steel serves to harden the metal whilst adding to its tensile strength. The alloy is susceptible of being tempered so as to obtain greater hardness than is possible with carbon steel, whilst retaining great tensile strength and some ductility. The alloy does not weld readily. The magnetic properties remain about the same as of carbon steel.

Tables II and V from Mr. Hadfield's paper on chromium steel present interesting comparisons between aluminum, silicon and chromium steel.

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* I am indebted to the various papers of Mr. Henry M. Howe, of Boston, Mass., for tables and information as to manganese steel. E. L. Z.

TABLE II. *Comparison Table of Tensile and Bending Tests of Forged Chromium, Silicon, and Aluminium Steels, all the Materials having been annealed.*

	Per Cent.				Limit of Elasticity in Tons per sq. inch.	Breaking Load in Tons per sq. inch.	Extension per Cent. on 2 inches.	Reduction of Area per Cent.	Bending Test of Annealed Forged Bars.	Remarks.
	C.	Si.	Al.	Cr.						
Si. steel **A** .	.14	.24	. . .	. . .	15.17	25.00	37.55	60.74	Bent double cold	
Al. steel **A** .	.15	. . .	.38	. . .	20.00	26.00	40.35	60.74	Bent double cold	
Cr. steel **B** .	.16	. . .	. . .	.29	17.00	25.00	45.55	65.90	Bent double cold	
Si. steel **B** .	.18	.73	. . .	. . .	19.00	29.50	34.02	52.66	Bent double cold	
Al. steel **C** .	.18	. . .	.66	. . .	18.00	27.00	33.00	52.14	Bent double cold	
Cr. steel **E** .	.12	. . .	. . .	.84	19.00	28.00	42.50	61.20	Bent double cold	
Si. steel **C** .	.19	1.60	. . .	. . .	25.00	33.00	35.10	54.52	Bent double cold	
Al. steel **F** .	.21	. . .	1.60	. . .	13.00	26.00	36.35	67.00	Bent double cold	
Cr. steel **G** .	.21	. . .	. . .	1.51	19.00	33.50	38.07	55.88	Bent double cold	
Si. steel **D** .	.20	2.18	. . .	. . .	25.50	34.00	36.50	59.96	Bent double cold	
Al. steel **H** .	.24	. . .	2.24	. . .	18.50	28.50	33.00	48.62	Bent double cold	
Cr. steel **H** .	.39	. . .	. . .	2.54	24.50	44.00	24.50	33.84	Bent double cold	
Si. steel **H** .	.26	5.53	. . .	. . .	25.00	25.00	0.37	2.00	Would not bend	
Al. steel **I** .	.22	. . .	5.60	. . .	27.00	36.00	6.45	6.16	16° broken	
Cr. steel **J** .	.77	. . .	. . .	5.19	20.00	55.00	8.20	6.88	Bent double cold	Carbon in chrome sample too high to make direct comparison.

TABLE V.—*Comparative Hardness of Chromium, Silicon, and Aluminium Steels (all unannealed).*
These tests were made by Professor T. TURNER, *Mason College, Birmingham, with the Sclerometer.*

SILICON STEEL.					ALUMINIUM STEEL.						CHROMIUM STEEL.						Remarks.
No.	Analysis per Cent.			Relative Hardness in Turner's Scale.	No.	Analysis per Cent.				Relative Hardness in Turner's Scale.	No.	Analysis per Cent.				Relative Hardness in Turner's Scale.	
	C.	Si.	Mn			C.	Si.	Mn	Al.			C.	Si.	Mn	Cr.		
898 A	.14	.24	.14	20	**1167 A**	.15	.18	.18	.38	20	**1176 B**	.16	.07	.18	.29	22	Relative hardness of other substances:— Lead . . . . . 1 Copper . . . . 8 Softest iron . . 15 Very hard white iron. 72
898 B	.18	.79	.21	20	**1167 B**	.20	.12	.11	.61	21	**1176 E**	.12	.08	.18	.84	21	
898 C	.19	1.60	.28	24	**1167 D**	.17	.10	.18	.72	20	**1176 F**	.27	.12	.21	1.18	24	
898 D	.20	2.18	.25	24	**1167 F**	.21	.18	.18	1.60	21	**1176 H**	.39	.14	.25	2.54	24	
898 E	.20	2.67	.25	26	**1167 G**	.21	.18	.18	2.20	21	**1176 J***	.77	.50	.61	5.19	55	*This has been partially hardened by heat treatment. In Nos. 1176 J, K, and L, the carbon necessarily present explains the hardness. Judging from the behaviour of B, E, F, and H, there is no reason to doubt the possibility of obtaining a soft 5.6 or even 9 per cent. chromium steel, provided the carbon is under .50 per cent.
898 F	.21	3.46	.29	30	**1167 H**	.24	.18	.32	2.24	20	**1176 K**	.86	.31	.29	6.89	38	
898 G	.25	4.49	.36	33	**1167 I**	.22	.20	.22	5.60	22	**1176 L**	.71	.36	.25	9.18	43	
898 H	.26	5.53	.29	36													

The results obtained in some English tests of Hadfield chromium steel projectiles are given in the following extracts from the same paper:*

"In 1882, the writer's firm supplied chromium shells to the English Government, one of which, a 6-inch, successfully penetrated an 8-inch wrought iron plate, and was so little injured that it could have been fired again; also about the same time a 9.2-inch projectile, which penetrated a 16½-inch wrought iron plate and 8½ inches into a second plate placed behind. The same firm has since been successful in passing considerable numbers into the English service. A short resumé of their latest tests may be of interest. By kind permission of the War Office, the results are illustrated by photographs of the plates and projectiles used.

"Although principally makers of smaller calibers, as regards 'armor-piercers,' one of those experimental shells, 13.5 inches, weighing 1120 lbs., fired from the 63-ton breech-loading gun at a velocity of 1950 feet per second, penetrated an 18-inch compound plate, a 6-inch wrought iron plate, 20 feet of oak backing, a further 10½-inch wrought iron plate, and was then found broken beyond a 2-inch wrought iron plate—that is, a total penetration of 36½ inches of armour plating. This projectile was believed by the Ordnance Committee to pass *whole* through the 18-inch compound and 6-inch wrought iron plates. Fig. 3 shows the penetration effected.

"One of their reception lots, viz., 300 6-inch projectiles, from which two were selected by the Government Inspector, gave the following results (Figs. 4 to 8 show the results of the tests).

"Each shell was fired against a separate 9-inch compound armour plate, with a striking velocity of 1825 feet per second, and a striking energy of 2250 tons. The faces of these plates contained 1.25 per cent. of carbon, so that the tests were severe.

"No. 1 projectile (round 2553, Figs. 4, 5, and 8) penetrated the plate to the eighth layer of oak backing. It was whole, showed no cracks, and very slightly altered in shape.

Diameter of body before firing, 5.963 inches; after firing, 5.974 inches = +.011 inches.
Length before firing. 16.68 inches; after firing, 16.47 inches . . = —.210 inches.

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* "Alloys of iron and chromium." by R. A. Hadfield: *Journal of the Iron and Steel Institute*, No, II for 1892.

"No. 2 projectile (round 2554, Figs. 6, 7, and 8) gave the same penetration, was also whole, showed no cracks, and altered in diameter of body .013 inches, and shortened .210 inches.

"Thus the above shells were only altered one-hundredth of an inch in diameter, and a little over two-tenths in length. (Figs. 4 to 8).

"The following results are, however, probably still more remarkable. A Hadfield 6-inch projectile was fired through a 9-inch compound plate. Being uninjured, it was ground up, fired a second time, and again penetrated another 9-inch compound plate. It was ground up and fired a third time at a 9-inch plate, when it broke up. It is, however, only fair to the projectile to state that the third plate was an experimental one, in which the face had been hardened by special tempering methods. Probably the projectile would still have been whole if fired at an ordinary compound plate. This projectile, after being fired twice, is shown in Fig. 9.

"Another remarkable result is that of a 6-inch bursting shell made by the same makers. This shell was the usual service weight, 100 lbs., but had a core of about double the capacity of an ordinary armor-piercing projectile (the latter are usually termed "shot"), and consequently its walls were of much thinner section and of less strength. This was fired at a 6-inch compound plate, which it penetrated, and was found uninjured 2000 yards (or nearly a mile and a quarter) on the other side. Beyond a slight chip off the point, the shell was unaltered in form, free from cracks, and could have been fired again. This shell is indicated by Fig. 10. The broken shell (Fig. 10^a) subjected to the same test was by another maker. The result with the latter shows that a steel shell, if not properly prepared, is little better than a cast iron projectile.

"An exceptionally severe set of trials is that shown in Figs. 11 to 13. The projectiles were selected at random from ordinary service supplies. The ordinary reception trial is to fire a 6-inch projectile against a 9-inch compound plate, but in this trial the compound plate was 10½ inches thick. As will be seen, notwithstanding the severe test, the four projectiles were practically uninjured, having neither set up nor broken. If the armour had been attached to the side of an ironclad, a few feet higher velocity would have resulted in a complete penetration into the interior of the ship. In other words, at short ranges, with the comparatively light 6-inch breech-loading gun, giving a velocity of say 2000 feet per second, all, excepting the largest modern ironclads, are easily vulnerable at point-blank range. (Figs. 11 to 13).

"In recent American trials it is reported that French-made projectiles, of 6 inches diameter, fired against 10½-inch nickel steel plates penetrated from 9.70 inches to 26 inches, the average penetration being 15 inches. In the case of the Hadfield projectile, fired against a 10½-inch compound plate, the penetrations averaged 26½ inches. It must be remembered that in the American trials, while the nickel steel plates offered greater resistance, the velocity and striking energy, 2075 feet and 2989 foot-tons, respectively, were much higher than those used in the English tests, viz., 1830 feet and 2200 foot-tons. Therefore, whilst the results cannot very well be compared, it will be seen that the English projectiles, with a lower velocity and striking energy gave excellent results. Probably with the same striking energy as at the Annapolis tests they would have penetrated uninjured a 12-inch compound plate."

Mr. Hadfield states that the chromium steel shell contains from 1¼ to 2 per cent. of chromium. The proportion of carbon is not mentioned, nor is it stated whether other elements such as manganese may not be used.

The Hadfield processes have been adopted by the Taylor Iron and Steel Company of Highbridge, New Jersey. They are now manufacturing shell according to Hadfield methods for the United States Navy. The results obtained by the Hadfield projectiles are therefore of direct interest to us. Whether they will succeed in producing armor-piercing shell able to cope with Harveyized plates remains to be seen. But so much has been accomplished by skillful combinations and treatment that there are fair promises of favorable results.

An analysis of the Holtzer projectile gave the following results:

	Point of projectile.	Body of projectile.
Silicon	0.822 per cent.	0.419 per cent.
Phosphorus	0.011 per cent.	0.044 per cent.
Manganese	0.306 per cent.	
Chromium	1.69 per cent.	2.28 per cent.
Copper	0.121 per cent.	trace.
Carbon	1.32 per cent.	1.26 per cent.

The analysis of the material of a projectile, however, conveys but little as to the mode of casting or the after treatment. The best combination of materials, etc., can only be arrived at by long continued patient investigation and usually many disappointments. A portion of the ingredients put into the melting pot become oxidized or otherwise transformed and disappear in the slag and do not appear in the resulting alloy. Such disappearance seems to be unavoidable and experience alone can indicate the proportions required to produce any desired alloy. The investigator cannot always trust to reasoning by analogy in shaping the direction of his experiments. He meets with apparently anomalous results at every step. Success may be found within very narrow limits, on either side of which appear utter failures. A very slight change of composition or of treatment produce markedly different results.

It now appears as if the metallurgist has done his utmost in the production of a simple bolt to perforate armor and, for the moment, has been foiled. It is obvious that the maximum hardness is requisite, but with it there must be sufficient toughness to hold the mass of the projectile together until it has expended its energy on the plate. As it is now, the sharp point used brings a concentration of the shock on a small portion of the projectile; it is broken off and a beginning is made of rupture of the shell, inviting further disintegration. The energy of the projectile is largely expended in its own destruction. Experiments are required to determine that form of head best suited to overcome the hardened resistance of the Harveyized plate, it being assumed that the projectile is of as hard and *tough* material as is attainable and it is propelled with the maximum velocity. Increase in sectional density may aid in the punching effect desired, if a sufficiently stiff metal may be found to resist the tendency to upset. The point may be made considerably blunter without increasing materially the resistance of the air. But should it be found necessary to give the front of the projectile a shape which largely adds to the resistance of the air, it may be desirable to add a point of soft metal or of a thin shell, easily crushed and not affecting the power of impact of the bolt.

Should we fail in producing a sufficiently hard and tough simple bolt of one piece of metal, it would then be advisable to try a built-up projectile of a striking core of very hard material with a jacket shrunk on having great tensile strength. The artillerist cannot afford to accept his defeat as final.

SHRAPNEL FOR FIELD ARTILLERY.

PAR LE COLONEL LANGLOIS, *Professeur à l'Ecole Supérieure de Guerre.*

TRANSLATED AND COMPILED BY LIEUTENANT WILLIAM W. GIBSON, ORDNANCE DEPARTMENT, U. S. A., FROM *L'Artillerie de Campagne en liason avec les autres Armes* (Paris, 1892).

In the Franco-Prussian war of 1870, the shrapnel could not be considered a practicable projectile. The initial velocities of the French and German rifled guns of that period were very feeble, were lost rapidly and the effective ranges were short—1300 meters at most in the French artillery.

Time fuzes were still irregular in their action, not suitably graduated* and the troops were not properly instructed in using them. In 1870 the shrapnel question was not yet mature. After this war improvements in field artillery resulted in securing high velocities, and the question of time fuzes was also satisfactorily settled. It was then recognized that shrapnel was the future projectile for field artillery.

A single difficulty arose, that of obtaining sufficient resistance to support the shock of discharge in the modern field gun, in which the initial velocities are considerable. In regard to this two elements are to be considered, the balls, and the case. At the shock of discharge the balls are violently crowded back toward the rear of the projectile, and tend to crush each other. They ought then to possess great hardness. Pure lead which resisted feeble velocities will no longer answer as the material for the balls. Lead hardened by adding a little antimony has been substituted, but this results in a serious disadvantage, loss of density (10.65 in place of 11.35), which, however, is unavoidable.

As regards the shrapnel case, two distinct efforts are to be

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* The fuzes for French shrapnel, in 1870, were capable of but two settings, one for 1450 meters and the other for 2850 meters.

resisted. 1st, the push of the powder gases at the moment of firing, an effort directed from rear to front longitudinally, and 2nd, the outward thrust of the balls.

This last effort is developed on the one hand because of the crowding of the mass of bullets toward the rear end of the case, and on the other on account of the centrifugal force due to the motion of rotation. The outward push is especially great a short distance in front of the band, and tends to swell the projectile at this point, or to break it. The resistance to expansion seems more difficult to obtain than the longitudinal resistance.*

It is thus seen that the efforts to be supported by the shrapnel increase with the initial velocity, and with the velocity of rotation. These conditions tended to increase the thickness of the walls of the shrapnel, and consequently to decrease the interior capacity, and the number of balls in the case. But the fragments furnished by the rupture of the case in firing have very little effect compared to that of the balls. The weight of the case then can be considered as a dead weight, serving merely as a vehicle to transport the *useful weight*, which is that of the "mitraille" (balls simply, or balls and separator plates provided with lines of rupture to give useful fragments).

One of the problems to be solved was the reduction in weight and thickness of wall of case, to increase as far as possible the *interior capacity*. This result was secured by the adoption of steel cases, one of the most important improvements in the organization of shrapnel. The enlarged capacity and consequent increase in the number of balls at the expense of the case has the effect of increasing the density of the projectile, an important advantage.

The necessary solidity is obtained by giving sufficient thickness to the steel case.† In the United States electrically welded

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* The United States specifications for shrapnel provide for rejection of all shrapnel after proof firing which bear such traces of the rifling as to indicate a deformation or upsetting of the shrapnel due to the above causes.—[TRANSLATOR.]

† The solidity of shrapnel is not fully assured by this method, and special arrangements are made in different types of shrapnel to stiffen the case, as in the electrically welded shrapnel for the United States 3.2-inch rifle and also in the Hotchkiss shrapnel. In the former, the cast iron powder tube connecting head with base powder chamber and resting against the diaphragm covering powder chamber, serves as a back-bone, by making the diaphragm, which is of wrought steel, carry weight of head and fuze. The diaphragm is supported by a cast iron tripod in powder chamber. In the Hotchkiss and also F. A. shrapnel the separators contribute to the resistance of the shrapnel.—[TRANSLATOR.]

shrapnel for the 3.2-inch B. L. steel rifle, a thickness of wall of .2125 inch has been found ample, except at the base, where it is .352 inch in thickness in the vicinity of the powder chamber and rotating band.

In France, studies have been directed toward assuring the shrapnel great resistance against breaking up before bursting, on striking hard rocky ground. For this purpose it is sought to make the "mitraille" itself contribute to the resistance of the projectile. It is formed of cast iron separator plates and balls. These plates are superposed and are intended to assure the projectile a resistance almost equal to that of a solid projectile.* Lines of weakness in the plates assist in their fragmentation, in unequal pieces it is true, but varying the least possible from the spherical form.

Recesses in the plates afford seats for the hardened lead balls. The plates, which are in contact, fit the balls quite accurately, and protect them from deformation so that they exercise no lateral push on the walls of the case.

We thus have two types of shrapnel, one type in which the "mitraille" is composed exclusively of hardened lead balls, and the French type in which the "mitraille" is composed of cast iron separator plates and hardened lead balls.

NATURE, FORM AND WEIGHT OF SHRAPNEL BALLS.†

Destructive Zones.

Shrapnel balls should be made of the densest metal possible. The maximum effect then results for the following reasons:

First.—The greatest possible density of the projectile best preserves its velocity to point of burst.

Second.—The densest balls best preserve their velocity after bursting.

Third.—The denser a ball, the more its weight can be reduced while preserving its destructive qualities, consequently a greater number of balls can be accommodated in a shrapnel of determined weight.

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* Considerable resistance against breaking up on striking can be obtained without using separator plates and reducing consequently the number of balls, as in 3.2-inch electrically welded shrapnel.—[TRANSLATOR.]

† See Table I.

For these reasons the first shrapnel balls were made of pure lead, but the velocities of the present guns require the use of a harder material to resist the shock of discharge. Lead hardened by the addition of antimony is employed at the present time. The spherical form is preferable to any other on account of the less resistance it offers to the air. The nature and form of the balls being determined, it remains to fix the weight of each ball.

This consideration ought to guide, in fixing the weight: the ball must be destructive in its action over all its trajectory from the point of bursting to its point of striking the ground, that is to say, its weight should be such that the extent of the destructive zone would be equal to the depth of the cone of dispersion up to the effective battle ranges (3000 meters at least).

It is important then to know the extent of the destructive zone for each projectile according to the velocity with which it is actuated at the moment of bursting. This would be simple if we knew what velocity is essential for balls of a given weight in order that they shall produce sufficiently destructive effects. Here the question arises as to what can be called a sufficiently destructive effect. What would be sufficient against men probably would not be so against horses.

Upon this point there is a great difference of ideas, and this lack of precision accounts for the different solutions of the problem of the weight of ball. Thus in France the weight of ball is 15 grammes, in Germany 13, in Russia 10.7, though the remaining velocities of the projectiles at the same ranges differ little in these artillery systems.

From experiments made by firing spherical balls from hunting guns at animals of different weights, it has been demonstrated that the living force necessary for the balls to pierce the skin and penetrate the flesh some little distance, what we would consider a wound sufficient to disable a man or horse, is proportional to the weight of the animal and to the section of the projectile.

Starting from this basis it is easy to determine what velocity a ball of given weight and density should possess, to give it the necessary living force, and consequently a sufficiently destructive power. The extent of the destructive zone of the ball for a determined remaining velocity of projectile is easily deduced. It is the space traveled by the ball in passing from the remaining velocity at the point of bursting, to the minimum velocity sufficient to produce destructive effect.

The following table shows extent of the destructive zones for balls of different weights:

TABLE I.

	Remaining Velocity of the Balls.	Extent of the Destructive Zones for Balls of Hardened Lead weighing,—		
	Meters.	11 gr.	13 gr.	15 gr.
		Meters.	Meters.	Meters.
(a) Wound sufficient to disable a man.	500	591	643	680
	400	559	605	642
	300	499	548	579
	250	456	500	531
	200	384	422	451
	150	271	302	326
Remaining velocity necessary . .		81	79	77
(b) Wound sufficient to disable a horse.	500	257	299	308
	400	222	252	270
	300	165	191	207
	250	123	146	160
	200	51	69	80
Remaining velocity necessary . .		175	169	166

It would not do, we think, to rely upon the figures of the first part of the table in the determination of the weight of balls necessary in firing against men. A just estimate of the destructive zone ought to be comprised between (a) and (b), approaching the figures given in the latter. At the present time at the range of 3000 metres the remaining velocity of the field projectile is about 250 meters.

With time fuzes some balls are thrown a distance of 200 meters at least from the point of bursting. It seems proper then that the weight of balls should be such as to insure a destructive zone of at least 200 meters for the remaining velocity of 250 meters, consequently a weight of ball equal to 15 grammes does not appear excessive, a ball of this weight not always having great effect against horses.

The German and Russian balls, 13 grammes and 10.7 grammes, appear insufficient in weight, though it is compensated for to a certain extent by the increase in velocity due to the rear position of bursting charge.

For the same remaining velocity of projectile the difference between the velocity of the French shrapnel balls and foreign can be evaluated at the maximum as 25 meters for German shrapnel, and 40 meters for the Russian shrapnel.

Table I (b) will show us if this compensation is sufficient.

Take the point where the destructive zone of the French balls is about 200 meters. (Remaining velocity of balls 300, zone 207 meters.) To have the same destructive zone the German ball should have a velocity of 325 meters (difference +25) and the Russian ball a velocity of 365 meters (difference +65). For the same remaining velocity of projectile, the Russian ball has an inferior zone to the French, the German an equal zone; but as for the same range the remaining velocity of the French projectile is superior, the French have an advantage which is not negligible particularly in the artillery struggle where the disabling of horses is of great importance.

An examination of the table shows how rapidly the destructive zone diminishes with the remaining velocity. The artillery ought to be impressed with this idea in order not to attempt firing at too great ranges whatever be the results of firing on the practice ground against targets.

POSITION OF THE BURSTING CHARGE.*

The bursting charge may be at the center of the projectile, at the front, or at the rear. Nearly all artillery systems except the French have adopted the rear position for the charge.

Central Bursting Charge.

This has the advantage of economizing space, but it increases the dispersion of the balls and diminishes the useful effect of the shrapnel.

Rear Charge.

This position possesses a great advantage. At the moment of bursting, the gaseous products act somewhat as in a cannon, to

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* See Table II.

which the case would correspond, and of which the "mitraille" would be the projectile. The velocity and murderous force of the balls is thus increased. Now if the charge is large, the density of the projectile is reduced and the dead weight* increases. The loss of density prevents the velocity of the projectile from being so well maintained, so that at a certain range the advantage of the rear charge may disappear entirely.

The increase of dead weight is accompanied by a reduction in the number of balls, and by a decrease of interior efficiency and effect.

This fact is rendered apparent by a comparison of the "interior efficiency" of the German and Russian shrapnel, Table II, which differ essentially only in the weight of the interior charge. Due to the rear position of the charge, the increase of the velocity of the balls in the Russian type would be about 25 meters; it must be quite feeble in the German shrapnel.

The rear charge renders the organization of the projectile more difficult in necessitating a long communicating tube between the fuze in front and powder chamber in rear, which takes up considerable space and increases the dead weight with a corresponding reduction in the weight of the "mitraille."

Front Charge.

This position facilitates the organization of the projectile and economizes space. It diminishes the chances of failure to burst, as it brings fuze and bursting charge closely together, and tends to insure greater regularity in points of bursting.

It has the disadvantage of diminishing the velocity of the bullets at the moment of bursting by a value which is not negligible, and may amount to as much as 15 meters.

WEIGHT AND NATURE OF BURSTING CHARGE.

This has been greatly varied by different authorities,† from the inferior limit necessary to insure the explosion of the shrapnel up to the superior limit compatible with its organization,

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* Weight of case, etc., in contra-distinction to useful weight "mitraille."

† See Table II.

that is, the maximum amount of powder, compressed or otherwise, that it will receive.

A feeble bursting charge is particularly necessary in shrapnel with front charge to avoid reduction in velocity of the balls at the moment of bursting. But if the charge is too much reduced the regulation of percussion fire becomes impossible, because the point of fall becomes invisible. Time fuze fire also becomes difficult to observe. We need to employ then a powder producing considerable smoke. Sometimes a very dense body furnishing a great deal of smoke by its combustion is added to the bursting charge.

INTERIOR EFFICIENCY OF SHRAPNEL (OR *RENDEMENT*).

The principal factors in the effect of a shrapnel against animate objects are, the number of fragments, their size, density, and velocity.

Considered from the stand-point of the organization of the shrapnel exclusively, we will compare the *rendement* or interior efficiency of different types of shrapnel.

The values of the "interior efficiency" do not give exact terms of comparison when the "mitraille" is composed of elements of different nature. The fragments of the separator plates, due to their irregular shapes, rapidly lose their velocity and are much less effective than the balls.

[The numbers of fragments of the 3.2-inch Hotchkiss and Frankford Arsenal shrapnel given in table are such as have been obtained in actual firing and are subject to variations. They are greater than was anticipated in the designs of these shrapnel. The numbers given for the French shrapnel are probably those for which the shrapnel were designed, and would be much less generally than obtained in actual firing.—TRANSLATOR.]

TABLE II.

Projectiles.	Weight of shrapnel.	Weight of bursting charge.	Position of bursting charge.	Number of balls and fragments.	Weight of each ball and fragment.	Total weight of "mitraille."	Interior efficiency.
	P	p		n	w	$W' = nw$	$\frac{W'}{P}$
	grm.	grm.			grm.	grm.	
French, 80 mm.	6300	90	Front.	balls 120 frags. 42	15 26	2890	0.459
French, 90 mm.	8700	100	Front.	balls 160 frags. 77	15 28	4550	0.523
German, 78 mm.	5530	19	Rear.	160	13	2080	0.376
German, 88 mm.	8150	22	Rear.	260	13	3380	0.415
Russian, light, 87 mm.	6860	60	Rear.	165	11	1760	0.259
Russian, H'vy, 100 mm.	12500	110	Rear.	340	11	3630	0.291
Italian, 70 mm.	4470	50	Rear.	109	13	1417	0.317
Italian, 90 mm.	6960	80	Rear.	176	13	2288	0.328
U. S. 3.2-in.: Elec. weld*	6122	67	Rear.	170	13.3	2261	0.370
Hotchkiss*	6122	85	Front.	balls 162 frags. 82+	11.4 variable	2990	0.488
F. Arsenal*	6122	78	Front.	balls 162 frags. 104+	11.1 variable	2699	0.440

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* By translator.

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THE ARTILLERY-FIRE GAME.

BY H. ROHNE, COLONEL, COMMANDING THE SCHLESWIG FIELD ARTILLERY REGIMENT NO. 9.

TRANSLATED BY FIRST LIEUTENANT JOHN P. WISSER, FIRST ARTILLERY, U. S. A., 1892.

[CONCLUDED.]

IV. APPLICATION OF THE GAME IN TESTING PARTICULAR FIRING REGULATIONS.

The fire-game can, however, also be used for testing firing regulations. Although it is an accepted fact that firing regulations cannot be based on theoretical considerations alone, irrespective of the results of practical experience, yet, on the other hand, mere experience alone is not in itself sufficient, since it cannot point out possible causes of failure in the firing regulations themselves. We shall illustrate the application of the game in such a case.

I. OPENING SHRAPNEL-FIRE AT THE SHORT-FORK RANGE.

Our firing regulations have become in the course of time more and more simple; mainly in that the smaller corrections—in case of percussion shell of 25 m., in case of shrapnel of 50 m.—have become less and less important and necessary, and the opening of shrapnel fire at the short-fork range has become the rule. It may, however, be questioned whether in the endeavor to open the shrapnel fire early we have not gone a little too far. The object is not to fire the first shrapnel early, but simply and solely to have an *effective* shrapnel fire established as quickly as possible. A single fork shot, falsely observed or directed, may have as its consequence that all the shrapnel burst behind the target or else far in front of it, and may thereby endanger the existence of the battery in the highest degree, unless such an error can be quickly detected and rendered without effect.

It is a matter of some interest to determine how often such a false establishment of the fork is liable to occur. We will consider here only firings in which the cause of the error is false observation.

Errors due to inaccurate pointing may be regarded as practically excluded, on account of the present careful training of our gunners. The cases in which they cause a firing to fail can be shown to be exceedingly rare. False elevations—and these alone can come under consideration, since simple inaccurate pointing is never of very great effect—are only possible when the chiefs of piece and of section, as well as the gunner are in error. A battery, in which such grave violations of firing discipline and instruction are possible, is beyond hope anyway and has deserved its fate. But with false observations it is quite different. By continual practice they may be reduced in number; but no one has as yet succeeded in avoiding them entirely. In my work "The firing of Field Artillery,"* I have stated (page 27) that in a course of firing at the firing school, out of one hundred observations, *referring only to shots used in establishing the fork*, sixty-two were correct, thirty-one doubtful and seven false. I do not know whether such investigations have been carried on elsewhere or not, but, judging from my experience, no *very* different result will probably be obtained in the near future. For, even if on the one hand the art of observation should make further progress, the use of the ground on the other hand will receive greater and greater attention, and thus make observation more and more difficult.

If we assume, therefore (a slightly more favorable case), that for every sixty-three correct observations there are seven false ones, it is the same as saying that in every ten observed fork shots one will be observed falsely. For the establishment of a short fork at least four observed shots are required, for that of a long fork two. From which it follows that as an average, two-fifths of all short forks and one-fifth of all long forks are incorrectly determined.†

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* "Das Schiessen der Feld-Artillerie."

† The latter assertion is not entirely free from criticism. Indeed it is probable that the number of incorrectly established *long* forks is smaller. If the above mentioned investigations had been limited to shots used in establishing long forks, the result would probably have been much more favorable.

In case the short fork only is incorrectly established, the error is not very great; but in case one of the two shots limiting the long fork is falsely observed, there is no knowing at all how great the error may be. When it happens that the long fork has been incorrectly established, we will always have,—supposing that a second shot was observed falsely, which according to the probabilities, will happen twice in a hundred times,—after the fork has been narrowed down to 50 m., at least one shot in front of the target and three behind, or the reverse. For this reason, it is well in all such cases to proceed with care and caution, not to say doubt and distrust as to the reliability of the data; and it would be advisable, as previously recommended, to obtain in any way possible satisfactory evidence that the fork has been correctly established, before proceeding to shrapnel fire. This may be done in a great variety of ways. Which method should be adopted in any given case may perhaps be determined by means of the fire game; at any rate, the latter can furnish a perfectly clear picture of the progress of events under each method.

The following four methods proposed will probably comprise all that are liable to be used:

1. To endeavor, after establishing the short fork, to obtain more accurate information in regard to the real target distance by continuing the firing with percussion shell.

2. To check (or verify) that shot of the long fork, the correctness of the observation of which is rendered doubtful by the fact that it was observed as deviating largely from the other three that were used in establishing the short fork.

3. To check (or verify) both the shots forming the short fork in the manner explained in the pamphlet "*Was bringen die neuen Schiessregeln der Feld-Artillerie?*" (Berlin, E. S. Mittler & Sohn, 1889.)

4. To *always* check the long fork before proceeding to narrow it down.

If in cases 2, 3 and 4 it appears that the fork was incorrectly established, it must be re-determined.

The method of checking (or verification) consists in every case in firing another shot at that particular range. If this is observed to be like the first one it is considered correct. But if it turns out different two more shots are fired. According to the character of the observation of these last two shots, either the first or the second is regarded as the correct one. Should the observation of the last two shots give them positions on opposite sides of the target, so that on the whole two shots have been observed in front of the target and two beyond, the range may be taken as the true target distance.

Let us compare, by means of the fire game, these four proposed methods with the method prescribed by the firing regulations.

For this purpose the following assumptions are made:

Target distance, *first*, 1870, *second*, 2330 m.

In the first case the short fork shot, in the second the long fork is assumed to be falsely observed. All other observations are assumed to have been made correctly, because otherwise too great an influence would be allowed to mere chance, moreover, with continual false observation *no* rule or method can lead to any practical result.

In order to have in shrapnel fire as many shots capable of observation as possible, it will be assumed that the fuses burn too long by 20 m. The mean point of bursting will then be lowered about 2 m., and there will not be too many ground hits. In this way about the same result is obtained, as if it had been assumed that points of bursting up to 5 m. in height could be observed with the same degree of certainty as percussion shell bursting on striking, an assumption, it must be acknowledged, certainly more than favorable for shrapnel, so that the method of the firing regulations will appear in the most advantageous light.

For determining the positions of the ground hits and the points of bursting, one and the same record of drawing of lottery numbers is used for all cases; and in order not to have the effect of the element of chance too great, small deviations (column A, Appendix 1) are assumed.

A.—*Record of drawing for percussion shell.*

Current number. 1.	Lottery number. 2.	Deviation m. 3.	Target distance (1870 m.) minus deviation. m. 4.	Target distance (2330 m.) minus deviation. m. 5.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance (1870 m.) minus deviation. m. 4.	Target distance (2330 m.) minus deviation. m. 5.
1	78	+15	1855	2315	10	68	+10	1860	2320
2	42	− 5	1875	2335	11	14	−25	1895	2355
3	6	−35	1905	2365	12	86	+25	1845	2305
4	36	−10	1880	2340	13	7	−35	1905	2365
5	67	+10	1860	2320	14	20	−20	1890	2350
6	44	− 5	1875	2335	15	79	+20	1850	2310
7	17	−20	1890	2350	16	25	−15	1885	2345
8	76	+15	1855	2315	17	3	−45	1915	2375
9	24	−15	1885	2345	18	57	+ 5	1865	2325

B.—*Record of drawing for shrapnel.*

Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.
1	79	$\frac{+20}{-2}$	7	37	$\frac{-10}{\pm 0}$	13	98	$\frac{+50}{-6}$
2	53	$\frac{\pm 0}{-1}$	8	67	$\frac{+10}{-2}$	14	16	$\frac{-25}{+4}$
3	58	$\frac{+5}{\pm 0}$	9	63	$\frac{+10}{+1}$	15	22	$\frac{-20}{+2}$
4	3	$\frac{-50}{+6}$	10	25	$\frac{-15}{+4}$	16	53	$\frac{\pm 0}{-1}$
5	14	$\frac{-30}{+1}$	11	85	$\frac{+25}{-4}$	17	59	$\frac{+5}{-1}$
6	35	$\frac{-10}{+1}$	12	42	$\frac{-5}{+1}$	18	14	$\frac{-30}{+1}$

Position of the mean point of bursting for the target distance

1870 m. 2330 m.

with elevation and fuse setting 2000, at $\frac{+100}{+3}$; 2300, at $\frac{-60}{+4}$.

1900, at $\frac{\pm 0}{+3}$; 2250, at $\frac{-110}{+4}$.

1850, at $\frac{-50}{+3}$; 2150, at $\frac{-210}{+4}$.

Of the following five extracts of firing records the first four relate to the previously mentioned four proposed methods of procedure, while the fifth is in conformity to the firing regulations. The shot, just before which the order is given to pass to shrapnel fire, increasing gradually by steps (50 or 100 m. at a time) is marked with an asterisk (*); at this instant it is assumed that there are four guns still loaded with percussion shell.

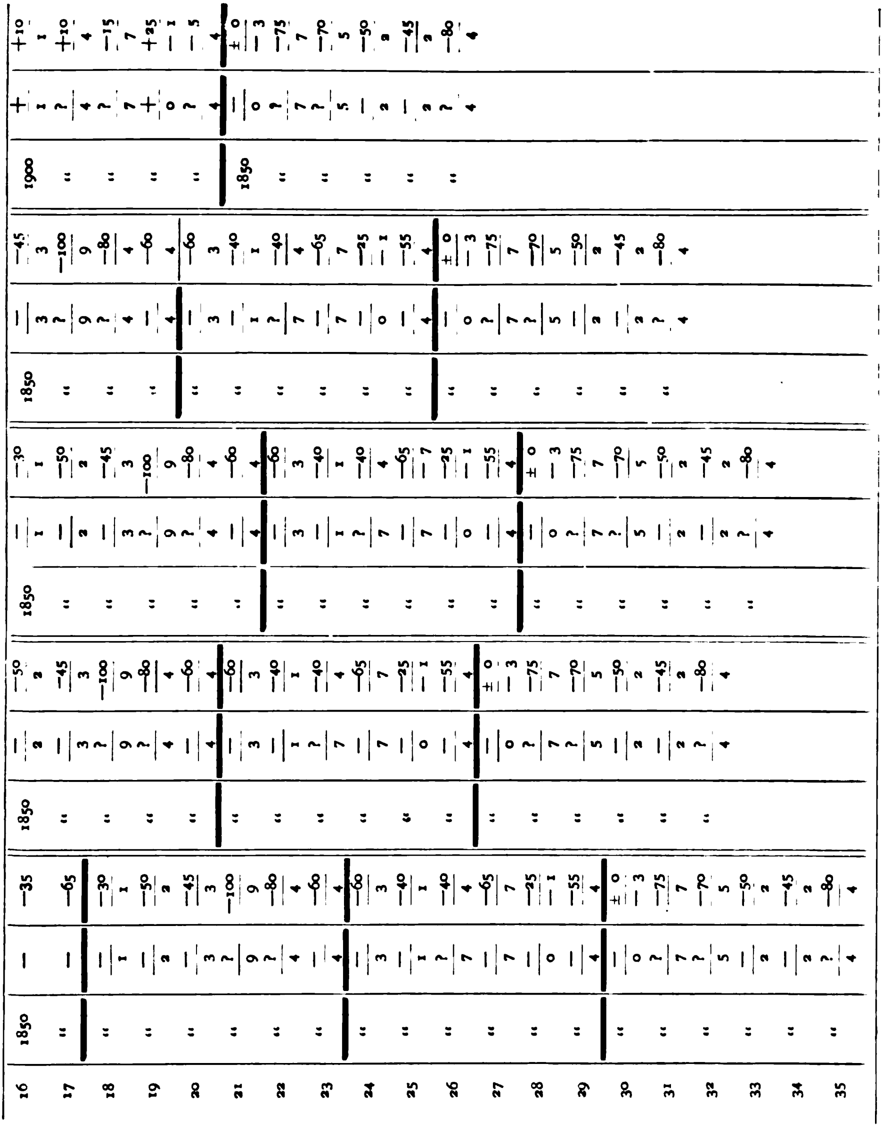
In case of the firing records 1 to 4, the battery commander may be blamed for not finding more accurately the distances of the points of bursting in front of the target, in as much as all the percussion shell fired at 2300 m. were observed to strike in front of the target. On the other hand, it is to be remarked that in actual firing—and that alone is here considered—the action of the shrapnel, whether effective or ineffective, would very soon be apparent. Moreover, in case of a larger deviation, one or more percussion shell would very likely have fallen beyond the target.

If we compare these five firing records for both target distances, we shall see that the method prescribed by the firing regulations, *i. e.*, the passage to shrapnel fire immediately after the establishment of the short fork, does, indeed, allow the opening of shrapnel fire the earliest, but, on the other hand, the first *effective* shot is in this case delayed the longest. The first shrapnel shot by this method precedes that by the other methods by 9, 6, 7 and 5 shots respectively, in case the short fork shot was falsely observed; and by 8, 6, 7, 4 shots respectively, in case this happened with the long fork shot. On the other hand, the first *effective* shrapnel is behind hand by 3, 6, 5, 7 shots respectively, in case the short fork shot has been falsely observed; and as much as 11, 13, 12, 15 shots respectively, in case the long fork shot has been observed falsely.

The best method according to this, seems to be number four, *i. e.*, checking (or verifying) the limits of the long fork before proceeding to narrow it down; next stands method number two —checking (or verifying) that particular long fork shot, the observation of which gave rise to doubt as to its actual position, followed by the checking of the short fork; while method one—continuation of the firing with percussion shell according to the

A.—*Target Distance 1870 m.*

Current number.	1.			2.			3.			4.			5.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	—	+ 145	2000	—	+ 145	2000	—	+ 145	2000	—	+ 145	2000	—	+ 145
2	2200	+	+ 325	2200	+	+ 325	2200	+	+ 325	2200	+	+ 325	2200	+	+ 325
3	2100	+	+ 195	2100	+	+ 195	2100	+	+ 195	2200	+	+ 295	2100	+	+ 195
4	2050	+	+ 170	2050	+	+ 170	2050	+	+ 170	2000	+	+ 120	2050	+	+ 170
5	2000	+	+ 140	2000	+	+ 140	2050	+	+ 190	2000	+	+ 140	2000*)	+	+ 140
6	2000	+	+ 125	2000	+	+ 125	2000	+	+ 125	2000	+	+ 125	"	+	+ 125
7	2000	+	+ 110	2000	+	+ 110	2000	+	+ 110	1800	—	—90	"	+	+ 110
8	1950	+	+95	1800	—	—55	2000	+	+ 145	1900	+	+45	"	+	+ 145
9	1950	+	+65	1900	+	+15	1800	—	—85	1850	—	—35	"	+ 1	+120 1
10	1950	+	+90	1850	—	—10	1900	+	+40	"*)	—	—10	"	+ 2	+100 2
11	1800	—	—95	"*)	—	—45	1850	—	—45	"	—	—45	"	+ 3	+105 3
12	1900	+	+55	"	+	+ 5	"*)	+	+ 5	"	+	+ 5	"	? 9	+50 9
13	1850	—	—55	"	—	—55	"	—	—55	"	—	—55	"	? 4	+70 4
14	1850*)	—	—40	"	—	—40	"	—	—40	"	— 1	—30 1	"	? 4	+90 4
15	1850	+	± 0	"	— 1	—30 1	"	+	± 0	"	— 2	—50 2	1900	— 3	—10 3


1900
1850
16
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35

B.—*Target distance 2330 m.*

Current number.	1.			2.			3.			4.			5.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered, m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	—	— 315	2000	—	— 315	2000	—	— 315	2000	—	— 315	2000	—	— 315
2	2200	+	— 135	2200	+	— 135	2200	+	— 135	2200	+	— 135	2200	+	— 135
3	2100	—	— 265	2100	—	— 265	2100	—	— 265	"	—	— 165	2100	—	— 265
4	2150	—	— 190	2150	—	— 190	2150	—	— 190	"	—	— 140	2150	—	— 190
5	"	—	— 170	2200	—	— 120	"	—	— 120	"	—	— 120	" *)	—	— 170
6	"	—	— 175	"	—	— 125	2200	—	— 125	2400	+	+75	"	—	— 175
7	2200	—	— 150	"	—	— 150	"	—	— 150	2300	—	—50	"	—	— 200
8	"	—	— 115	2400	+	+85	"	—	— 115	2350	+	+35	"	—	— 165
9	"	—	— 145	2300	—	—45	2400	+	+55	2300*).	—	—45	"	$\frac{-}{2}$	$\frac{-190}{2}$
10	2400	+	+80	2350	+	+30	2300	—	—20	"	—	—20	"	$\frac{-}{3}$	$\frac{-210}{3}$
11	2300	—	—55	2300*)	—	—55	2350	—	— 5	"	—	—55	"	$\frac{?}{4}$	$\frac{-205}{4}$
12	2350	+	+45	"	—	— 5	2300*)	—	— 5	"	—	— 5	"	$\frac{?}{10}$	$\frac{-250}{10}$
13	2300*)	—	—65	"	—	—65	"	—	—65	"	$\frac{-}{2}$	$\frac{-40}{2}$	"	$\frac{?}{5}$	$\frac{-240}{5}$
14	"	—	—50	"	—	—50	"	—	—50	"	$\frac{-}{3}$	$\frac{-60}{3}$	"	$\frac{?}{5}$	$\frac{-220}{5}$
15	"	—	—10	"	$\frac{-}{2}$	$\frac{-40}{2}$	"	—	—10	"	$\frac{?}{4}$	$\frac{-55}{4}$	2250	$\frac{?}{4}$	$\frac{-120}{4}$

16	2300	—	—45	2300	— 3	—60 3	2300	— 2	—40 2	2300	? 10	—100 10	2250	— 2	—100 2
17	"	— 2	—40 2	"	? 4	—55 4	"	— 3	—60 3	"	? 5	—90 5	"	? 5	—100 5
18	"	— 3	—60 3	"	? 10	—100 10	"	? 4	—55 4	"	? 5	—70 5	"	? 8	—125 8
19	"	? 4	—55 4	"	? 5	—90 5	"	? 10	—100 10	"	? 4	—70 4	"	— 0	—85 0
20	"	? 10	—100 10	"	? 5	—70 5	"	? 5	—90 5	"	— 2	—50 2	"	? 5	—115 5
21	"	? 5	—90 5	"	? 4	—70 4	"	? 5	—70 5	"	? 5	—50 5	2400**	+	+55
22	"	? 5	—70 5	"	— 2	—50 2	"	? 4	—70 4	"	? 8	—75 8	2300	—	—40
23	"	? 4	—70 4	"	? 5	—50 5	"	— 2	—50 2	"	— 0	—35 0	2350	—	— 5
24	"	— 2	—50 2	"	? 8	—75 8	"	? 5	—50 5	"	? 5	—65 5	2300*	—	— 5
25	"	? 5	—50 5	"	— 0	—35 0	"	? 8	—75 8	"	— 0	—10 — 2	"	—	—65
26	"	? 8	—75 8	"	? 5	—65 5	"	— 0	—35 0	"	? 8	—85 8	"	—	—50
27	"	— 0	—35 0	"	— 0	—10 — 2	"	? 5	—65 5	"	? 6	—80 6	"	—	—10
28	"	? 5	—65 5	"	? 8	—85 8	"	— 0	—10 — 2	"	— 8	—60 3	"	— 0	—10 — 2
29	"	— 0	—10 — 2	"	? 6	—80 6	"	? 8	—85 8	"	— 3	—55 3	"	? 8	—85 8
30	"	? 8	—85 8	"	— 3	—60 3	"	? 6	—80 6	"	? 5	—90 5	"	? 6	—80 6
31	"	? 6	—80 6	"	— 3	—55 3	"	— 8	—60 3				"	— 3	—60 3
32	"	— 3	—60 3	"	? 5	—90 5	"	— 3	—55 3				"	— 3	—55 3
33	"	— 3	—55 3				"	? 5	—90 5				"	? 5	—90 5
34	"	? 5	—90 5												

** At this shot (21 of firing record number 5) percussion shell fire was resumed, according to paragraph 64 of the firing regulations, in order to re-determine the fork.

firing regulations stands last and gives the poorest results. This last method required in both cases four more observed shots than method four.

Without a full and complete test, however, I would not care to advocate the above method. In all those cases where the short fork is established by two shots observed to strike in front of the target and two beyond, the checking of the long fork shots may be dispensed with; for in that case the narrowing down of the fork serves exactly that very purpose. On the other hand, this method—the checking of the long fork *before* proceeding to narrow it down—has, however, the great advantage that we still have a safe basis for the opening of shrapnel fire even if for any reason the narrowing down of the fork does not succeed, and we are compelled to fall back on keeping the entire space between the two limits of the fork under shrapnel fire, increasing or decreasing by successive steps of 50 or 100 m. at a time.

It remains to be determined what delay in the opening of shrapnel fire will be caused in case the checking of the limits of the fork should turn out to be superfluous, in consequence of the fact that the fork has already been correctly determined. With this object in view, we will compare the five firing records under the supposition that the fork has been correctly determined. Let the target distance be 2020 m. The record of drawings of lottery numbers on page 612 will be used again, but of course column three only can be used. On the assumption that the fuses burn 20m. too long, the mean point of bursting, for elevation and fuse 2000 m., will be at $\frac{-50}{3}$. See page 620.

The fact that the method prescribed by the firing regulations is the most expeditious, in case the checking of the doubtful shot turns out to be superfluous is not surprising; indeed, it is more surprising to see what little time is saved, amounting at times to only one or two shots, and, if the firing of percussion shell is continued as prescribed by the firing regulations, rising to but five shots. While, therefore, under favorable circumstances, by opening shrapnel fire at the short fork range without verification or checking, we *may* have effective shrapnel fire one or two shots earlier, we are always running the risk of not reaching that point by some fifteen shots later, and then only in case the enemy does not make use of the advantage he thereby has gained.

In my opinion the choice of method cannot for a moment remain in doubt. I consider the opening of shrapnel fire *without verification or checking* of the distance, at *mean* ranges, permissible only when in the establishment of the short fork it becomes evident that no important error has been made, *i. e.*, in case two shots have been observed in front of the target and two beyond. If we cannot decide on checking both long fork shots *before* proceeding to narrow down the fork,—the reasons *pro* and *con* have been discussed above,—then it appears best, after narrowing the fork, to check that shot which was observed as deviating widely from the other three.

2. FIRING WITH TORPEDO-SHELL ON COVERED TARGETS.

In the two examples of firing with torpedo shell which were given above (pages 279 and 389), the mean point of bursting at the end of the preliminary firing to determine the range and fix the point of explosion, notwithstanding the fact that it was conducted strictly according to the firing regulations and only correct observations were made, was found to be in such a disadvantageous position with reference to the target, that an effective action of the firing was not to be expected. It may, therefore, be considered an open question whether the results were accidental or legitimate,—in accord with the law applying in such cases.

The methods prescribed by the firing regulations are briefly as follows: Determining the range with percussion shell c/82 with all possible accuracy,—neglecting corrections as small as 25 m.,—accurately fixing the distance of the point of bursting in front of the target by increasing or decreasing by steps (50 or 100 m. at a time) with torpedo-shell furnished with time-fuses, in such wise that points of bursting are obtained in front of the target as well as beyond it; and finally, raising the point of bursting to a height of 10 or 15 m.

The first and last operations involve not the slightest difficulty, moreover it is quite immaterial whether the first succeeds or not, since the process of more accurately locating the points of bursting in front of the target would correct any error which might

Current number.	1.			2.			3.			4.			5.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	—	—5	2000	—	—5	2000	—	—5	2000	—	—5	2000	—	—5
2	2200	+	+175	2200	+	+175	2200	+	+175	2200	+	+175	2200	+	+175
3	2100	+	+45	2100	+	+45	2100	+	+45	"	+	+145	2100	+	+45
4	2050	+	+20	2050	+	+20	2050	+	+20	2000	—	—30	2050	+	+20
5	2000	—	—10	"	—	—10	"	+	+40	2100	+	+90	2000*)	—	—10
6	"	—	—25	2000	—	—25	2000	—	—25	2050	+	+25	"	—	—25
7	2050	+	+10	"*)	—	—40	"*)	—	—40	2000*)	—	—40	"	—	—40
8	"	+	+45	"	—	—5	"	—	—5	"	—	—5	"	—	—5
9	"	+	+15	"	—	—35	"	—	—35	"	—	—35	"	— 1	—30 1
10	2000*)	—	—10	"	— 1	—30 1	"	—	—10	"	—	—10			
11	"	—	—45		etc.		"	— 1	—30 1	"	— 1	—30 1			
12	"	+	+5					etc.			etc.				
13	"	—	—55												
14	"	— 1	—30 1												
15	Etc. Mean distance of the points of bursting in front of the target. —50 3														

have been made, assuming of course, that this *latter* operation is actually successful. But just herein the real difficulties of the case lie, and it is not saying too much to assert that in most cases an accurate fixing of the points of bursting is not practicable, merely because the assumptions which must be made are not true.

In every firing the tacit assumption is made that all shots not observed are distributed in front of and beyond the target, in the same way as short shots and over shots in general. Should this assumption prove untrue, we cannot of course, get a correct idea of the position of the mean point of bursting from our observations, and *must* be led to adopt altogether false measures. But this is exactly the case in attempting to fix the distances of the points of bursting of torpedo-shell in front of the target.

If we inspect the two diagrams—Appendix 2—the matter becomes clear at once. If we assume, for example, in the diagram that the mean point of bursting lies at $\frac{\pm 0}{+4}$ with reference to the target, it is readily seen that, although one-half of all the points of explosion lie in front of the target, the other half beyond, only an *insignificantly small number* of the points of explosion lying *in front of* the target can be observed at all, while *almost* all points of explosion or ground hits lying *beyond* the target will be observed. From Appendix 1, column E, it is seen that in this case forty-two points of explosion cannot be observed on account of having too great a height of explosion (over 4 m.*); but of *these, thirty-nine are in front of the target and only three beyond;* eight points of explosion lie just over the target, and only fifty shots are capable of observation. *Of these last only seven lie in front of the target and forty-three* (including fifteen ground hits) *beyond the target.* The chances are, therefore six to one that the battery commander, on the strength of his observation, will come to the conclusion that his points of explosion lie beyond the target, and that he will consequently go back 50 m. There he will naturally obtain only points of explosion in front of the target, and will alternate between these two ranges (paragraph 73 of the firing regulations) and thereby sacrifice nearly half the effective action.

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* Should, under particularly favorable circumstances, points of explosion lying higher than this admit of observation, the actual numbers will, indeed, be altered somewhat, but the relative numbers will still remain the same.

For the range 3000 m. this applies with particular force. With the same position of the mean point of explosion there will be, out of one hundred shots, forty-five points of explosion, forty-two *in front of* the target and three *beyond*, not admitting of observation on account of having too great a height of explosion; eight points of explosion have a distance in front of the target equal to zero. Forty-seven points of explosion admit of observation, four of which lie *in front of* the target, forty-three *beyond* it, the latter including twenty-six ground hits. The chances are, therefore, ten to one that the battery commander will attempt a false mode of correction.*

To these modes of procedure it may be objected that a height of explosion of 4 m. is too great, as it gives too few points of bursting admitting of observation. I am of that opinion myself and believe too that in practice we will generally be concerned with lower points of explosion. Let us see, therefore, how the matter appears in case of a mean height of explosion and distance from the target of zero. A glance at Appendix 2 shows that in this case the number of points of bursting *beyond* the tar-target, admitting of observation, becomes exceedingly small, while that of those lying in front of the target becomes greater. However, a careful study of columns E and F of Appendix 1, is of especial interest in this connection, and may throw light on the subject of the probable causes which led to the failure of getting the correct effective range in the examples above.

At the distance of 2000 m. we obtain in one hundred shots nine, the height of explosion of which is over 4 m., and which, therefore, do not admit of observation (lottery numbers 1 to 6, 8, 11 and 15), four shots give ground hits exactly at the target (lottery numbers 49 to 52). Twenty-nine points of bursting, having a height admitting of observation, lie *in front of* the target (numbers 7, 9, 10, 12 to 14, 16 to 18, 20 to 30, 32 to 36 and 39 to 42); two points of bursting *directly over* the target (numbers 47 and 48) and three *beyond* the target (numbers 55, 63 and 70).

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* It is hardly necessary to call attention to the fact that all the numbers possess but a limited degree of reliability. Should the deviation, or the height up to which the position of the points of bursting still admit of observation, or the angle of fall, change, these numbers will also naturally change.

Of *ground hits in front of* the target, as is clearly apparent, there are eight to be expected (numbers 19, 31, 37, 38 and 43 to 46). Furthermore, by the application of the formula on page 137 in case of those shots which, with points of explosion lying *beyond* the target, have a negative height of explosion, we find that twenty-seven more shots make ground hits *in front of* the target (numbers 53, 54, 59 to 61, 67 to 69, 73 to 76, 80, 81, 84 to 86, 88 to 90, 92, 93 and 95 to 99). Only eighteen ground hits lie *beyond* the target.

Should the battery commander fail to discriminate between ground hits and low points of bursting—in my opinion he cannot distinguish between them at all—he will observe sixty-four bursting clouds in front of the target and twenty-one beyond. The chances are therefore three to one that, in case the distance from the target and the height of the points of explosion are both zero, he will increase by 50 m., instead of retaining the time of fuse burning, which is already greater than necessary or desirable. Should he succeed in distinguishing the points of bursting from the ground hits the trouble would only be magnified; because, for the twenty-nine points of bursting in front of the target he would have but three beyond. Should, however a sandy soil and dry weather favor in an exceptional manner the observation of very high points of explosion, then his observations, quite correct in themselves, will all the more certainly lead him to make a false correction; because, for thirty-eight points of bursting in front of the target he will observe but three beyond.

That these errors will grow if the point of explosion is lowered, is readily perceived. And yet it is generally impossible to avoid this. At 3000 m. we will probably have the choice only between points of bursting at a height of from 6 to 7 m., which will very likely give but a very few points of bursting admitting of observation, and those at a height of from minus 3 to minus 4 m. The most advantageous mean height of + 2m. can be obtained only in the rarest cases.

The cause of all these phenomena is the fact that the trajectory is not horizontal. Were this the case the points of bursting in front of the mean point of bursting and those beyond would equally admit of observation, and the ground hits would lie in exactly the same relative positions in front of and beyond this point. The fact that the fixing of the position of the points of bursting in front of the target is possible in case of shrapnel fire, but almost impossible in case of torpedo-shell, is due to the fact that in the former no accurate fixing of this distance is required; it is sufficient to have the mean distance between 25 and 100 m., whereas, the very nature of the torpedo-shell requires an *accurate* fixing of this point.

Having thus, in my opinion, clearly shown the inadequacy of the method prescribed by the firing regulations, I feel compelled to submit propositions of a more practically useful nature. We will concede that the method proposed must be perfectly simple and follow the rules for shrapnel firing as clearly as possible.

If we have determined the effective range *exactly* by means of percussion shell, and then pass to torpedo-shell—with time fuses —at a range greater by 50 m., then, in case of fuses which burn correctly, the mean point of bursting will lie directly over the target, provided the trajectories of the percussion shell and the torpedo-shell coincide. But, since the torpedo-shell have a trajectory from 10 to 20 m. shorter, the mean point of explosion will also lie from 10 to 20 m. in front of the target, and will therefore have the most favorable position that could be desired. By inserting plates the proper height of explosion may be obtained. For ranges of from 1600 m. (short of which it would hardly become necessary to fire on shelter trenches, etc.) up to 2500 m. one plate is required. For greater ranges *such* high points of explosion are obtained (about 9 m.), that any further raising will put the point of explosion too high. (At 2600 m. the insertion of one plate produces a change of about 8½ m. in the height of explosion.

If the determination of the range and the attainment of effective fire were always successful, and the fuses always burned correctly, there could hardly be anything simpler than firing with torpedo-shell. We must, however, investigate what will be the effect of unavoidable errors and how these are to be met. According to the firing regulations we may regard the range as determined and the firing as effective when from one-third to two-thirds of all shots are observed as lying in front of the target.

If we assume mean deviations (25 m. mean probable longitudinal deviation), then the centre of impact, in case one-third are short shots, will lie about 15 m. *beyond*, in case two-thirds are short shots the same distance *in front of* the target. With fuses which burn *correctly* the mean point of explosion in the most unfavorable case will therefore be transferred to 5 m. beyond the target in the first case, or 36 m. in front of it in the second. It therefore still lies so that every correction of 50 m. will only make the position of the point of explosion worse. Smaller corrections—of 25 m.—which are often spoken of as desirable in our firing, I regard as useless in actual field service. The reason is that delicate corrections have a meaning only when we have accurate data as to the exact amount of the error to be corrected. But this necessary information can hardly be obtained in the face of the large deviations that will occur, and the more or less uncertain character of the observations. We can convince ourselves of this very readily by taking examples in illustration from the fire game. Example number one (page 264), indeed, is very instructive on this point. I would recommend to all doubters that they work this example out once more, and that under the assumption of greater deviations and more unfavorable observation relations.

Furthermore, we must take into consideration points of explosion, which, in consequence of the behavior of the fuses, deviate by as much as 25 m. from the normal distance in front of the target, without our having been able to bring about by means of any correction a more favorable position. Should these *most unfavorable* circumstances happen to *combine* and add their effects together, the mean point of explosion may possibly, without any blame attaching to the battery commander, lie as much as 60 m. in front of the target or 30 m. beyond it. In this case, at 2000 m. (assuming our previously adopted deviation) only nine per cent. of effective shots is to be expected, not a very large amount to be sure. Such relations, which can only be brought about by a *concurrence* of the most unfavorable circumstances, will on that very account be of very rare occurrence.

There will be cases no doubt, in which, in the determination of the range with percussion shell one elevation will furnish too many short shots, and another 50 m. greater, too many over shots, or, in which at *both* elevations the ratio of short to over shots is a proper one for effective fire. In both these cases the *greater* range is to be selected and taken as a starting point; but we must alternate in firing, with one still greater by 50 m.

In case the behavior of the fuses is not normal, *i. e.*, should they burn too long (which fact may be recognized by the large number of ground hits made) or too short (in which case the height of explosion will become too great), we must bring the point of explosion to the right point in height by raising or lowering (as the case may be) the trajectory by means of plates. *Every such raising or lowering, the object of which is to produce a normal height of explosion* (about $\frac{1}{300}$ of the range), *corresponding to a correct behavior of the fuse, must be accompanied by a corresponding going back or ahead.*

In the *later* raising of the trajectory, the only object of which is to bring the height of explosion up to the desirable mean of 12 m., there is of course no accompanying decrease, as the distance of the point of explosion in front of the target is already fixed. Whether this difference in the methods to be pursued after the insertion of the plates will not open the way to errors in practical field firing, only a long continued trial with troops can determine. Should this prove to be the case, then we must find some way, by giving a different command or by some other means, to avoid mistakes. In such a case I might even advocate a direct correction in the fuse setting, which method I am not ordinarily very enthusiastic about.

The following examples are given to illustrate the foregoing propositions and to show their practicability. The same lottery drawing list is used in all the examples, all observations are regarded as correct, and it is assumed that the torpedo-shell has a range 10 m. shorter than the percussion shell c/82.

Five examples are here given, the following assumptions being made in the different cases:

1. Target distance, 1950 m., fuse normal.
2. " " 1965 m., " "
3. " " 1935 m., " "
4. " " 1965 m., fuse burning 25 m. too short.
5. " " 1935 m., fuse burning 25 m. too long.

In examples four and five the most unfavorable circumstances are combined.

The mean point of explosion, with elevation and fuse-setting as indicated, is located as follows:

1. 2000 m. at $\frac{-10}{6}$, $\underline{2000}$ m. at $\frac{-10}{12}$, 1950 m. at $\frac{-60}{6}$, $\underline{1950}$ m. at $\frac{-60}{12}$.
2. 2000 m. at $\frac{-25}{6}$, $\underline{2000}$ m. at $\frac{-25}{12}$, $\underline{2050}$ m. at $\frac{+25}{12}$,
3. 2000 m. at $\frac{+5}{6}$, $\underline{2000}$ m. at $\frac{+5}{12}$, 1950 m. at $\frac{-45}{6}$, $\underline{1950}$ m. at $\frac{-45}{12}$.
4. 2000 m. at $\frac{-50}{8}$, $\underline{2000}$ m. at $\frac{-50}{15}$, $\overline{2050}$ m. at $\frac{\pm 0}{2}$, 2050 m. at $\frac{\pm 0}{8}$,
5. 2000 m. at $\frac{+30}{3}$, $\underline{2000}$ m. at $\frac{+30}{9}$, $\underline{\underline{2000}}$ m. at $\frac{+30}{16}$, 1950 m. at $\frac{-20}{3}$, $\underline{\underline{1950}}$ m. at $\frac{-20}{16}$.

Lottery-drawing List.

Percussion-shell.						Torpedo-shell.					
Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.	Current number. 1.	Lottery number. 2.	Deviation. m. 3.
1	89	+45	13	44	−5	1	24	$\frac{-20}{+1}$	13	61	$\frac{+5}{-1}$
2	57	+5	14	86	+40	2	44	$\frac{-5}{\pm 0}$	14	94	$\frac{+40}{-3}$
3	49	± 0	15	60	+10	3	76	$\frac{+15}{-4}$	15	3	$\frac{-50}{+6}$
4	78	+30	16	12	−45	4	58	$\frac{+5}{\pm 0}$	16	14	$\frac{-30}{+1}$
5	98	+75	17	72	+20	5	30	$\frac{-15}{+1}$	17	6	$\frac{-40}{+5}$
6	86	+40	18	42	−10	6	82	$\frac{+25}{\pm 0}$	18	79	$\frac{+20}{-2}$
7	11	−45	19	96	+65	7	5	$\frac{-45}{+5}$	19	35	$\frac{-10}{+1}$
8	25	−25	20	13	−45	8	46	$\frac{-5}{-1}$	20	70	$\frac{+15}{+1}$
9	20	−30	21	73	+20	9	97	$\frac{+45}{-6}$	21	48	$\frac{\pm 0}{+1}$
10	36	−15	22	48	± 0	10	86	$\frac{+25}{-5}$	22	20	$\frac{-20}{+4}$
11	67	+15	23	92	+50	11	38	$\frac{-10}{-1}$	23	54	$\frac{\pm 0}{-2}$
12	76	+25	24	28	−20	12	55	$\frac{+5}{+1}$	24	15	$\frac{-25}{+5}$

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			5. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered, m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	1800	—	— 105	1800	—	— 120	1800	—	—90	1800	—	— 120	1800	—	—90
2	2000	+	+ 55	2000	+	+ 40	2000	+	+70	2000	+	+ 40	2000	+	+70
3	1900	—	— 50	1900	—	— 65	1900	—	—35	1900	—	— 65	1900	—	—35
4	1950	+	+ 30	1950	+	+ 15	1950	+	+45	1950	+	+ 15	1950	+	+45
5	1900	+	+ 25	1900	+	+ 10	1900	+	+40	1900	+	+ 10	1900	+	+40
6	"	—	— 10	"	—	— 25	"	+	+ 5	"	—	— 25	"	+	+ 5
7	"	—	— 95	"	—	— 110	"	—	—80	"	—	— 110	"	—	—80
8	"	—	— 75	"	—	— 90	"	—	—60	"	—	— 90	"	—	—60
9	"		— 80	"	—	— 95	"	—	—65	"	—	— 95	"	—	—65
10	1950	—	— 15	1950	—	— 30	1950*)	?	± 0	1950	—	— 30	1950*)	?	± 0
11	"	+	+ 15	"	?	± 0	"	+	+30	"	?	± 0	"	+	+30
12	"	+	+ 25	"	+	+ 10	"	+	+40	"	+	+ 10	"	+	+40
13	"	—	— 5	"	—	— 20	"	—	—50	"	—	— 20	"	—	—50

14	1950	+	+40	1950	+	+25	1950	$\frac{?}{7}$	$\frac{-65}{7}$	1950	+	+25	1950	$\frac{-}{4}$	$\frac{-40}{4}$
15	"	+	+10	"	−	− 5	"	$\frac{?}{6}$	$\frac{-50}{6}$	"	−	− 5	"	$\frac{-}{3}$	$\frac{-25}{3}$
16	2000*)	+	+ 5	2000*)	−	−10	"	$\frac{-}{2}$	$\frac{-30}{2}$	2000*)	−	−10	"	$\frac{-}{0}$	$\frac{-5}{-1}$
17	"	+	+70	"	+	+55	"	$\frac{?}{6}$	$\frac{-40}{6}$	"	+	+55	"	$\frac{-}{3}$	$\frac{-15}{3}$
18	"	+	+40	"	+	+25	1950	$\frac{?}{13}$	$\frac{-60}{13}$	"	+	+25	"	$\frac{-}{4}$	$\frac{-35}{4}$
19	"	+	+115	"	+	+ 100	"	$\frac{?}{8}$	$\frac{-20}{8}$	"	+	+ 100	"	$\frac{+}{3}$	$\frac{+5}{3}$
20	"	$\frac{?}{7}$	$\frac{-30}{7}$	"	$\frac{?}{7}$	$\frac{-45}{7}$	2000	$\frac{?}{17}$	$\frac{-40}{17}$	2000	$\frac{?}{9}$	$\frac{-70}{9}$	2000	$\frac{?}{14}$	$\frac{-15}{14}$
21	"	$\frac{?}{6}$	$\frac{-15}{6}$	"	$\frac{?}{6}$	$\frac{-30}{6}$	"	$\frac{?}{11}$	$\frac{\pm 0}{11}$	"	$\frac{?}{8}$	$\frac{-55}{8}$		$\frac{?}{8}$	$\frac{+25}{8}$
22	"	$\frac{+}{2}$	$\frac{+5}{2}$	"	$\frac{-}{2}$	$\frac{-10}{2}$	"	$\frac{?}{6}$	$\frac{+50}{6}$	"	$\frac{-}{4}$	$\frac{-35}{4}$		$\frac{+}{3}$	$\frac{+75}{3}$
23	"	$\frac{?}{6}$	$\frac{-5}{6}$	"	$\frac{?}{6}$	$\frac{-20}{6}$	"	$\frac{?}{7}$	$\frac{+30}{7}$	"	$\frac{?}{8}$	$\frac{-45}{8}$		$\frac{+}{4}$	$\frac{+65}{4}$
24	2000	$\frac{?}{13}$	$\frac{-25}{13}$	2000	$\frac{?}{13}$	$\frac{-40}{13}$	"	$\frac{?}{11}$	$\frac{-5}{11}$	"	$\frac{?}{9}$	$\frac{-65}{9}$	2000	$\frac{?}{15}$	$\frac{+20}{15}$
25	"	$\frac{?}{12}$	$\frac{+15}{12}$	"	$\frac{?}{12}$	$\frac{\pm 0}{12}$	"	$\frac{?}{12}$	$\frac{+10}{12}$	"	$\frac{?}{11}$	$\frac{-25}{11}$		$\frac{?}{17}$	$\frac{+35}{17}$
26	"	$\frac{?}{17}$	$\frac{-55}{17}$	"	$\frac{?}{17}$	$\frac{-70}{17}$	1950	$\frac{?}{11}$	$\frac{-40}{11}$	2000	$\frac{?}{20}$	$\frac{-95}{20}$	1950	$\frac{?}{15}$	$\frac{-15}{15}$

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			6. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range' ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
27	2000	?/11	−15/11	2000	?/11	−30/11	1950	?/9	− 5/9	2000	?/14	−55/14	1950	?/13	+20/13
28	"	?/6	+35/6	"	?/6	+20/6	"	?/18	−95/18	"	?/9	− 5/9		?/22	−70/22
29	"	?/7	+15/7	"	?/7	± 0/7	"	?/13	−75/13	"	?/10	−25/10		?/17	−50/17
30	"	?/11	−20/11	"	?/11	−35/11	"	?/17	−85/17	"	?/14	−60/14		?/21	−60/21
31	"	?/13	− 5/13	"	?/13	−20/13	"	?/10	−25/10	"	?/16	−45/16		?/14	± 0/14
32	"	?/11	− 5/11	"	?/11	−20/11	2000	?/13	− 5/13	"	?/14	−45/14	2000	?/17	+20/17
33	"	?/9	+30/9	"	?/9	+15/9	"	?/13	+20/13	"	?/12	−10/12		?/17	+45/17
34	"	?/18	−60/18	"	?/18	−75/18	"	?/13	+ 5/13	"	?/21	−100/21		?/17	+30/17
35	"	?/13	−40/13	"	?/13	−55/13	"	?/16	−15/16	"	?/16	−80/16		?/20	+10/20
36	"	?/17	−50/17	"	?/17	−65/17	"	?/10	+ 5/10	"	?/20	−90/20		?/14	+30/14
37	"	?/10	+10/10	"	?/10	− 5/10	"	?/17	−20/17	"	?/13	−30/13		?/21	+ 5/21
38	"	?/13	−20/13	"	?/13	−35/13				"	?/16	−60/16			
39	"	?/13	+ 5/13	"	?/13	−10/13				"	?/16	−35/16			
40	"	?/13	−10/13	"	?/13	−25/13				"	?/16	−50/16			
41	"	?/16	−30/16	"	?/16	−45/16				"	?/19	−70/19			
42	"	?/10	−10/10	"	?/10	−25/10				"	?/13	−50/13			
43	"	?/17	−35/17	"	?/17	−50/17				"	?/20	−75/20			

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			5. Target distance 1935 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	$\frac{?}{7}$	$\frac{-30}{7}$	2000	$\frac{?}{7}$	$\frac{-45}{7}$	1950	$\frac{?}{7}$	$\frac{-65}{7}$	2000	$\frac{?}{10}$	$\frac{-70}{10}$	1950	$\frac{-}{4}$	$\frac{-40}{-4}$
2	"	$\frac{?}{6}$	$\frac{-15}{6}$	"	$\frac{?}{6}$	$\frac{-30}{6}$	"	$\frac{?}{6}$	$\frac{-50}{6}$	"	$\frac{?}{9}$	$\frac{-55}{9}$	"	$\frac{-}{3}$	$\frac{-25}{3}$
3	"	$\frac{+}{2}$	$\frac{+5}{2}$	"	$\frac{-}{2}$	$\frac{-20}{2}$	"	$\frac{-}{2}$	$\frac{-30}{2}$	2000	$\frac{-}{0}$	$\frac{-35}{-1}$	"	$\frac{-}{0}$	$\frac{-5}{-1}$
4	"	$\frac{?}{6}$	$\frac{-5}{6}$	"	$\frac{?}{6}$	$\frac{-20}{6}$	"	$\frac{?}{6}$	$\frac{-40}{6}$		$\frac{-}{3}$	$\frac{-45}{3}$	"	$\frac{-}{3}$	$\frac{-15}{3}$
5	"	$\frac{?}{7}$	$\frac{-25}{7}$	"	$\frac{?}{7}$	$\frac{-40}{7}$	"	$\frac{?}{7}$	$\frac{-60}{7}$		$\frac{-}{4}$	$\frac{-65}{4}$	"	$\frac{-}{4}$	$\frac{-35}{4}$
6	"	$\frac{?}{6}$	$\frac{+15}{6}$	"	$\frac{?}{6}$	$\frac{\pm 0}{6}$	"	$\frac{?}{6}$	$\frac{-20}{6}$		$\frac{-}{3}$	$\frac{-25}{-3}$	"	$\frac{-}{6}$	$\frac{+5}{6}$
7	"	$\frac{?}{11}$	$\frac{-65}{11}$	"	$\frac{?}{11}$	$\frac{-70}{11}$	"	$\frac{?}{11}$	$\frac{-90}{11}$	2050	$\frac{?}{7}$	$\frac{-45}{7}$	2000	$\frac{?}{8}$	$\frac{-15}{8}$
8	"	$\frac{?}{5}$	$\frac{-15}{5}$	"	$\frac{?}{5}$	$\frac{-30}{5}$	"	$\frac{?}{5}$	$\frac{-50}{5}$	"	$\frac{-}{1}$	$\frac{-5}{1}$	"	$\frac{+}{2}$	$\frac{+25}{2}$
9	"	$\frac{+}{0}$	$\frac{+35}{0}$	"	$\frac{+}{0}$	$\frac{+25}{0}$	"	$\frac{?}{0}$	$\frac{\pm 0}{0}$	"	$\frac{+}{0}$	$\frac{+45}{-4}$	"	$\frac{+}{0}$	$\frac{+75}{-3}$
10	"	$\frac{+}{1}$	$\frac{+15}{1}$	"	$\frac{?}{1}$	$\frac{\pm 0}{1}$	"	$\frac{-}{1}$	$\frac{-20}{1}$	"	$\frac{+}{0}$	$\frac{+25}{-4}$	"	$\frac{+}{0}$	$\frac{+55}{-2}$

Current number.	1. Target distance 1950 m.			2. Target distance 1965 m.			3. Target distance 1935 m.			4. Target distance 1965 m.			5. Target distance 1935 m.		
	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.	Range ordered. m.	Observation. batt'y	Observation. target.
11	2000	? 5	—20 5	2000	? 5	—30 5	1950	? 5	—35 5	2050	— 1	—10 1	2000	+ 2	+20 2
12	"	? 7	— 5 7	"	? 7	—20 7	"	? 7	—40 7	"	+ 3	+ 5 3	"	+ 4	+35 4
13	1950	? 5	—55 5	2000	? 11	—20 11	2000	? 5	+10 5	2050	? 7	+ 5 7	2000	? 8	+35 8
14	"	— 3	—20 3	"	? 9	+15 9	"	+ 3	+45 3	"	? 5	+40 5	"	? 6	+70 6
15	"	? 12	— 110 12	"	? 18	—75 18	"	? 12	—45 12	"	? 14	—50 14	2000	? 22	—20 22
16	"	? 7	—90 7	"	? 13	—55 13	"	? 7	—25 7	"	? 9	—30 9	"	? 17	± 0 17
17	"	? 11	— 100 11	"	? 17	—65 17	"	? 11	—35 11	"	? 9	—40 9	"	? 21	—10 21
18	"	— 4	—40 4	"	? 10	—45 10	"	+ 4	+25 4	"	? 6	+20 6	"	? 14	+10 14
19	1950	? 13	—70 13	2050	? 13	+15 13	2000	? 13	— 5 13	"	? 13	—10 9	1950	? 17	—30 17
20	"	? 13	—45 13	"	? 13	+ 0 13	"	? 13	+20 13	"	? 10	+15 9	"	? 17	— 5 17
21	"	? 13	—60 13	"	? 13	+25 13	"	? 13	+ 5 13	"	? 10	± 0 9	"	? 17	—20 17
22	"	? 16	—90 16	"	? 16	+ 5 16	"	? 16	—15 16	"	? 13	—20 12	"	? 20	—40 20
23	"	? 10	—60 10	"	? 10	+25 10	"	? 10	+ 5 10	"	? 7	± 0 6	"	? 14	—20 14
24	"	? 17	—85 17	"	? 17	± 0 17	"	? 17	—20 17	"	? 14	—25 13	"	? 21	—45 21

On the firing records, numbers one, two and four, there are no special remarks to be made. In firing record number three, although 1900 m. seemed at the beginning to be the approximate distance for percussion shell, c/82., the firing was continued with torpedo-shell by alternating between the ranges 1950 and 2000 m., because the battery commander drew the conclusion from shots 10 to 13 that the target must lie between 1900 and 1950 m.—Firing record number five gave the most unfavorable results; the fact that the fuses burned longer than the normal time was not recognized in the first fuse-setting, because only one ground hit occurred.

But the most interesting point is the question as to what would have been the result, under exactly the same conditions, which, for the method proposed by me in examples number four and five are as unfavorable as they can possibly be, had the rules of the firing regulations been strictly followed. Since the firing with percussion shell in the two methods would have proceeded in exactly the same way, and the differences only become apparent in the firing of torpedo-shell (with time fuses), we need consider in the firing records only the twenty-four torpedo-shell (see pages 631 and 632).

A comparison of the firing records shows that three times (in examples number three and number five) the result is exactly the same, whether the firing is conducted according to the firing regulations or according to my proposed method. But while the principal part of the measures taken for obtaining effective fire,—the determination of the proper length of fuse,—is in my proposed method, practically accomplished when the last percussion shell is fired, in the method prescribed by the firing regulations this operation is then just beginning. Aside from the fact, however, that effective fire is obtained later in every case, a higher demand is also made on the judgment and intelligence of the battery commander. In example number one, in which, by following my proposed method the most favorable position imaginable for the point of explosion, $\frac{-10}{12}$, is obtained, by following the firing regulations we are compelled to alternate between two ranges, whereby the effect is reduced by nearly one-half. The same may be said in regard to example number two, in which the position of the point of explosion is not, indeed, the most favorable imaginable, but perhaps under the circumstances the best. Only in example number four is a better result obtained. By following my proposed method the mean point of explosion in this is at $\frac{-50}{15}$, by following the firing regulations at $\frac{\pm 0}{9}$. The former promises about 16 per cent.,* the latter 31 per cent.** effective shots. While therefore, in two cases the result was the same for both methods, it was twice worse and once better when the firing regulations were applied. It must be noted, however, that examples number four and five illustrate in my proposed method, a most unfavorable combination of the position of the target and the behavior of the fuse, whereas in the firing according to firing regulations, we have in both cases for the purposes of observation almost the most favorable mean heights of explosion of + 2 and + 3 m., respectively.

Furthermore, I would recommend the working out of all the examples in firing . . . . according to my proposed method. Any one will then be convinced how smoothly the firing progresses, how rapidly effective fire is attained, and what favorable positions of the mean point of explosion are obtained.

It remains now only to show how the firing shapes itself in its progress when the fuses burn so much too long or too short that the correct relation must be restored. We will select for this purpose example number one, in which the target distance was 1950 m., and will assume that the fuses in the first place burn 50 m. too long, and in the second place 50 m. too short, and construct firing records one and two to correspond to my proposed method, and three and four to correspond to that of the firing regulations. We will commence at once with torpedo-shell (with time-fuses).

Mean position of the point of explosion with an elevation and fuse.

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* Appendix 1, column E, lottery numbers 82 to 97.

** Appendix 1, column E, lottery numbers 15 to 46, excepting 19, which shot has too small a height of explosion.

Firing records 1 and 3.	**Firing records 2 and 4.**
of 2000 m. at $\frac{+40}{0}$;	of 2000 m. at $\frac{-60}{11}$;
of $\underline{2000}$ m. at $\frac{+40}{7}$;	of $\overline{2000}$ m. at $\frac{-60}{5}$;
of 1950 m. at $\frac{-10}{0}$;	
of $\underline{1950}$ m. at $\frac{-10}{7}$;	at 2050 m. at $\frac{-10}{11}$;
of $\underline{\underline{1950}}$ m. at $\frac{-10}{13}$;	at $\overline{2050}$ m. at $\frac{-10}{5}$.

In this case as before, comparison entirely favors my proposed method. In the firing records numbers two and four the final result is, indeed, the same exactly; except that my proposed method again accomplishes the object sought more quickly than the firing regulations. While in firing record number one an exceptionally favorable position of the point of explosion is obtained, in the third firing record the *correct* observation of the shots at the second elevation and fuse setting, leads to the adoption of an alternating fire between the ranges $\underline{1950}$ m. and $\underline{2000}$ m., *i. e.*, the target is under the fire of but half of all the shots. It may be held that it was wrong at the first elevation and fuse setting after the second ground hit, not to insert a plate. But I do not admit this. It is however, very interesting to note how entirely different the character of the observation at the second elevation and fuse setting would have turned out had a plate been inserted after shot three. In that case all the shots, except nine and ten would have been observed as doubtful, and these two not now *in front of* the target but *beyond* it. In consequence of which it would have become necessary to go back to 1900 m., and finally to alternate between $\underline{1950}$ and $\underline{1900}$ m. The effect however, would not have been increased at all, since the trajectory at the latter elevation would have been located entirely in front of the target, and not a single fragment of a shell would have reached the target.

Current number.	1. Target distance 1950 m.			2. Target distance 1950 m.			3. Target distance 1950 m.			4. Target distance 1950 m.		
	Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.		Range ordered. m.	Observation.	
		batt'y	target.		batt'y	target.		batt'y	target.		batt'y	target.
1	2000	$\frac{+}{1}$	$\frac{+20}{1}$	2000	$\frac{?}{12}$	$\frac{-80}{12}$	2000	$\frac{+}{1}$	$\frac{+20}{1}$	2000	$\frac{?}{12}$	$\frac{-80}{12}$
2	"	$\frac{+}{0}$	$\frac{+35}{0}$	"	$\frac{?}{11}$	$\frac{-65}{11}$	"	$\frac{+}{0}$	$\frac{+35}{0}$	"	$\frac{?}{11}$	$\frac{-65}{11}$
3	"	$\frac{+}{0}$	$\frac{+55}{-4}$	2000	$\frac{-}{1}$	$\frac{-45}{1}$	"	$\frac{+}{0}$	$\frac{+55}{-4}$	2000	$\frac{-}{1}$	$\frac{-45}{1}$
4	2000	$\frac{?}{7}$	$\frac{+45}{7}$	"	$\frac{?}{5}$	$\frac{-55}{5}$	"	$\frac{+}{0}$	$\frac{+45}{0}$	"	$\frac{?}{5}$	$\frac{-55}{5}$
5	"	$\frac{?}{8}$	$\frac{+25}{8}$	"	$\frac{?}{6}$	$\frac{-75}{6}$	"	$\frac{+}{1}$	$\frac{+25}{1}$	"	$\frac{?}{6}$	$\frac{-75}{6}$
6	"	$\frac{?}{7}$	$\frac{+65}{7}$	"	$\frac{?}{5}$	$\frac{-35}{5}$		$\frac{+}{0}$	$\frac{+64}{-4}$	"	$\frac{?}{5}$	$\frac{-35}{5}$
7	1950	$\frac{?}{12}$	$\frac{-55}{12}$	2050	$\frac{?}{16}$	$\frac{-55}{16}$	1950	$\frac{?}{5}$	$\frac{-55}{5}$	2000	$\frac{?}{10}$	$\frac{-105}{10}$
8	"	$\frac{?}{6}$	$\frac{-15}{6}$	"	$\frac{?}{10}$	$\frac{-15}{10}$	"	$\frac{-}{0}$	$\frac{-15}{-1}$	"	$\frac{-}{4}$	$\frac{-65}{4}$
9	"	$\frac{+}{1}$	$\frac{+35}{1}$	"	$\frac{?}{5}$	$\frac{+35}{5}$	"	$\frac{-}{0}$	$\frac{+35}{-6^{*})}$	"	$\frac{-}{0}$	$\frac{-15}{0}$
10	1950	$\frac{?}{8}$	$\frac{+15}{8}$	"	$\frac{?}{6}$	$\frac{+15}{6}$	"	$\frac{-}{0}$	$\frac{+15}{-5^{*})}$	"	$\frac{-}{1}$	$\frac{-35}{1}$

*The ground hits on both these cases lie *in front of* the target.

11	1950	?/12	−20/12	2050	?/10	−20/10	1950	—/0	+20/−1	2000	—/4	−70/4
12	"	?/14	−5/14	"	?/12	−5/12	"	—/1	−5/1	"	?/6	−55/6
13	"	?/12	−5/12	"	?/10	−5/10	1950	?/6	−5/6	2050	—/4	−5/4
14	"	?/10	+30/10	"	?/8	+30/8	"	+/4	+30/4	"	?/2	+30/2
15	"	?/19	−60/19	"	?/17	−60/17	"	?/13	−60/13	"	?/11	−60/11
16	"	?/14	−40/14	"	?/12	−40/12	"	?/12	−40/12	"	?/6	−40/6
17	"	?/18	−50/18	"	?/16	−50/16	"	?/16	−50/16	"	?/10	−50/10
18	"	?/11	+10/11	"	?/9	+10/9	"	?/7	+10/5	"	+/3	+10/3
19	"	?/14	−20/14	"	?/12	−20/12	2000	?/8	+30/8	2050	?/12	−20/12
20	"	?/14	+5/14	"	?/12	+5/12	"	?/8	+55/12	"	?/12	+5/12
21	"	?/14	−10/14	"	?/12	−10/12	"	?/8	+40/8	"	?/12	−10/12
22	"	?/17	−30/17	"	?/15	−30/15	"	?/11	+20/11	"	?/15	−30/15
23	"	?/11	−10/11	"	?/9	−10/9	"	?/5	+40/5	"	?/9	−10/9
24	"	?/18	−35/18	"	?/16	−35/16	"	?/12	+15/12	"	?/16	−35/16

3. DIRECT AND INDIRECT CORRECTION OF THE LENGTH OF FUSE.

In the same way we might investigate by means of the fire game the question as to whether the direct or the indirect method of correcting the length of fuse deserves the preference in shrapnel fire. This question, discussed so energetically in the "Archiv" some two years ago has lost much of its interest, and to bring it up again in this connection would lead us too far astray. To those who are interested therein this reference may be sufficient to induce them to consider it from this point of view.

POSTSCRIPT.

Those of my respected readers who have followed me to this point, have probably been conscious of the utility of the fire game for the officer serving with troops and the teacher at the military schools, as well as for the development of the art of artillery fire. It will be a simple matter to propose an unlimited number of problems in firing and to solve them, or to have them solved by means of the fire game.

The fact that there are still some weak points in the game, no one can be more thoroughly convinced of than the author; but in time we will probably succeed in perfecting it. The careful reader will not have failed to observe that all the examples in which the firing was conducted with time fuses were selected for ranges lying near 1000, 2000 or 3000 m. The reason is that for these ranges only are the tables, relating to the dispersion of the points of explosion and represented in the vertical side elevation, constructed. Should the game be generally adopted, as I hope it may be, it will be no great matter to construct tables for the intermediate ranges—1500 and 2500 m.—by which it would become possible to represent firing at *any* desired range. It would then also be possible to combine the fire game with Kriegsspiel, and have the artillery combat, which is now generally decided at the pleasure of the director, or in favor of the battery which arrives first on the field, or by mere numerical superiority, brought to an issue by means of the fire game. That this is possible only in a Kriegsspiel involving but small subdivisions of troops, and which can be worked out to the minutest details, is self-evident.

Much more important and much simpler appears to me the possible combination of the fire game with fortification Kriegsspiel. That for this purpose certain alterations and adaptations must be made therein, which will represent a very comprehensive amount of labor, is evident. But it also appears to me quite certain that thereby fortification Kriegsspiel will itself become more interesting and instructive.

FIRE-MANOEUVRES OF ARTILLERY MASSES, AND THE INSTRUCTION TO BE DRAWN THEREFROM.

Revue d'Artillerie for November, 1892. By Lieutenant Colonel COHADON, Second Regiment of French Artillery. (Officially designated to attend the artillery mass manœuvres at Chalons, in August, 1892.)

Translated by First Lieutenant CHARLES W. FOSTER, Third Artillery, U. S. A.

It is not intended, in this article, to relate in regular order the operations of the artillery brought together in the camp at Chalons, August 1st to 14th, 1892, and to give a full detailed account of the same, but simply to show how these manœuvres were conducted, and to indicate them as a whole. Afterwards, the conclusions drawn from the circumstances observed during these manœuvres will be stated, together with the reflections suggested by them.

General Character of Mass Manœuvres of Artillery.—These, as is known, are the manœuvres as a whole, of the artillery units (batteries and ammunition trains) which accompany an army corps. This considerable force of artillery manœuvres independently of troops of the other arms, and when it takes a combat position, instead of firing blank cartridges, opens a real fire upon objectives which from their position, shape, and number, simulate, as completely as possible, an actual enemy. Such manœuvres are therefore absolutely distinct in character from the autumn manœuvres, and constitute, so to speak, the crown of technical and professional instruction for artillery officers. Moreover, very great interest attaches to them from the fact that instruction is then imparted by the highest officers of the French artillery.

Their Aim and Utility.—Their aim is to indicate how to manage the large artillery units; and, in this respect, they are the school of the colonels and generals of this arm. But, aside from these larger lessons, they are also the source of much information of a minor cast, but which is nevertheless extremely interesting and useful, and which may be reflected upon with advantage by artillery officers of all grades.

Again, they serve to resolve certain practical tactical or technical questions which could not be experimented upon did the batteries manœuvre with the other arms.

Composition of the Artillery which executed the Mass Manœuvres of 1892.—The artillery troops brought together in 1892, at the camp at Chalons, in order there to execute mass manœuvres under direction of the Division General, President of the Artillery Committee, comprised seven groups distributed into divisional and corps artillery as follows: The artillery of two divisions, composed in each case of two groups of three mounted batteries each (9 cm. guns), and two ammunition sections; the corps artillery, composed of a group of three mounted batteries (9 cm.), a group of three horse batteries (8 cm.), a group of two horse batteries (8 cm.), and two ammunition sections.

The artillery staffs of the army corps and the divisional and corps artillery were constituted according to regulation methods.

General Prescriptions.—At the outset, the following prescriptions were ordered:

1st: The various elements of the batteries will march in the order set down in the *Regulations of December 28, 1888, for Field Batteries*, which should be consulted in all matters of detail.

2nd: Batteries and ammunition sections, in column upon the roads, will occupy the places assigned them in the Staff Officers' Campaign Hand-book (3rd Edition, May 1, 1890).

3rd: For the execution, regulation, and conduct of fire, and the replenishment of ammunition, the ministerial orders in force will be conformed to.

Manœuvres of the first week.—During the first week, each force of divisional artillery and the corps artillery manœuvred separately; then each divisional force, reinforced by one or two groups from the corps artillery.

The different schemes for the manœuvres of this first part may be presented under the following general form:

"*A division covered by a normal advanced-guard (a group of batteries) or a reinforced advanced-guard (two groups of batteries) is marching upon . . . . by the road from . . . .*

"*It receives orders to deploy in order to meet an attack coming from . . . . The artillery of the advanced-guard establishes itself at . . . to fire upon the enemy's artillery posted at . . . . The batteries of the main body go to the support of the advanced-guard artillery, and take position at . . . . The enemy is repulsed; the infantry moves forward; the artillery, in order to support the movement, advances to a second position where it continues the action against the hostile artillery, opposes itself to counter-attacks of the adversary, and, finally, paves the way for the assault of the infantry by concentrating its fire against the point of attack.*"

In the first combat positions, the artillery opens fire against the enemy's batteries at distances varying from 2500 to 3500 metres. The distances from the first to the second positions varied from 1200 to 1800 metres. The latter were so chosen that the artillery was able to co-operate during the entire development of the combat, up to and including the preparation for the assault, without being obliged to shift its position. The range was never less than 1200 metres.

Manœuvres of the second week.—During this period, the various parts of the artillery of the army corps manœuvred together.

Following is a general type of the scheme for these manœuvres:

"*The army corps is moving in two columns from . . . . to . . . . the first division on the . . . . . road; the second division and the corps artillery is following the . . . . . road. (Generally the advanced-guard of this second column will be reinforced, and its artillery will be composed of two groups of batteries.) At the moment the heads of column reach . . . . . (or arrive upon the line of . . . . .), the enemy is observed at . . . . . (Details upon the position and strength of this enemy.)*

"*The corps commander gives orders for the deployment of the first division (or the second with the corps artillery, or the entire army corps) upon the position . . . . . facing towards . . . . . .*"

For the execution of each manœuvre, the scheme indicated the hour at which each artillery grand unit was to occupy certain prescribed positions of rendezvous.

To the scheme for each manœuvre was joined an order for its development, which comprised three or four phases.

The artillery of a division engaged first of all, and was then successively reinforced by the other groups, the whole of the artillery of the corps thus deploying upon a first combat position. The fire, with rare exceptions, was directed against the enemy's artillery.

Upon the supposition that the infantry had in the meantime gained ground, the artillery was then to support this movement, by pushing forward in fractions of greater or less size for the occupation of a new position from which the artillery combat could be brought to a decisive issue. The objectives, as has just been intimated, were first of all the enemy's batteries; but, during the fire, some of the groups were directed to train their guns upon the hostile infantry. Superiority over the adversary's artillery having been obtained and the moment for the decisive attack approaching, the entire artillery concentrated its fire upon the point to be assaulted, in order to pave the way to success; and finally, the attack having succeeded, a group of horse artillery sprang forward at a gallop to occupy the conquered ground and to oppose itself to any counter-offensive thrusts that might be attempted.

The ranges at the first positions were from 2800 to 3000 metres, on an average, and the front of the deployed artillery was generally from two to three kilometres.

The distances from the first to the second positions varied from about 1000 to 2000 metres.

At the second positions, the ranges were from 1000 to 1500 metres. Against infantry, rapid and salvo fire were several times employed, particularly for the fire of concentration.

The second positions were so chosen that the batteries without changing their posts, could take part in the combat during its entire development, and, for the most part, co-operate in the fire of concentration.

Such, in general outline, were these mass manœuvres. It would be departing from the end here proposed to enter more in detail into their preparation and execution.

After this general exposition of the manœuvres at the camp at Chalons in 1892, we come to a consideration of the instruction that the writer drew therefrom; and the clearest and simplest method of presenting the same appears to be to group the remarks to be made in the order in which the events themselves were unrolled during the development of the combat.

Agents de Liaison.—But first of all, it is well to speak of the agencies through which the command is exercised, for absolute silence in this respect might excite surprise.

It was not possible to form a clear and accurate idea of the rôle of *agents de liaison*, of the advantages and inconveniences incident to their employment, or of other agencies that might be substituted for them. Indeed, in order to obtain a just view of the questions to which the exercise of command gives rise, it is not enough to have beheld the commander for a few hours and at a distance; it is necessary to have actually commanded oneself, in order to be really acquainted with the material difficulties which arise upon the manœuvre ground or the field of battle in consequence of the distance of the point at which the order is to be executed, the greater or less intelligence with which it will be transmitted, and the events liable to happen during the time of its transmission.

However, it is proper to state that no criticism on the employment of *agents de liaison* was made, and that apparently no great embarrassment was experienced in the exercise of the command.

Marches near the Enemy.—The regulation prescriptions relative to the way in which the battery shall march, and the arrangement to observe in each of its elements, respond well to the exigencies of actual service. However, it may be asked if when the carriages of mounted batteries in the field are in column of files, it would not be preferable to adopt the following as the normal order of march, as is the case with horse batteries: The six pieces of the battery, then the three caissons under charge of the chief artificer. But this question is of little importance.

It is known that the battery combat trains have sometimes been the cause of false movements, on account of their not being formed in time. The assembling of the combat trains of three batteries of a group is not always easily effected; moreover, it should be remarked that when these trains are brought thus temporarily together, they do not constitute a sufficiently homogeneous whole, and cannot be as effectively commanded as could be desired, especially with the new current of ideas which assigns to the major the duty of watching the expenditure of ammunition and assuring its replenishment. These trains ought then to be absolutely in his hands, and be taken entirely from the control of the battery commanders. Therefore, it appears to me to be preferable, if it is possible to do so, to consolidate these trains, thus forming of them a new unit of supply,—the group combat train, under the direct authority of the major.

This modification appears to me to have the following advantages:

1st: Lightening of the battery in the field, so that in case of need it could be reduced to the battery of fire and its regimental train.

2nd: Lightening of the entire group, the carriages of which could be somewhat reduced in number: it is evident that the combat train of the group—the organ of replenishment for the three batteries taken as a whole—will not require the total of the trains necessary for the batteries acting separately.

3rd: The service of supply will be better assured and better directed: it will be entirely in the hands of the major, who will be responsible for this service.

4th: Simplification in marches and manœuvres. This rule may be set down as fixed and absolute. The group combat train will always march immediately after the three batteries of the group in movements to the front and immediately before them during retreats.

The limits of this study will not permit a deeper examination of this question, which, moreover, presents certain difficulties, though of a nature foreign to the considerations with which we are here concerned.

Positions of Rendezvous and of Waiting.—A distinction is made between these, although they are frequently confounded in practice.

The position of rendezvous is that assigned to a force at the beginning of an operation or manœuvre; in the field it is the position in which, in certain cases, a force is halted preparatory to deploying. The position of waiting is that taken up by a battery, when, having arrived near its combat position, it is desirable to remain concealed from the enemy before coming into action.

Here are, according to my experience, the considerations which should be presented upon the selection and occupation of these positions. The rendezvous position should generally be at quite a distance from the enemy, and be screened from his view and sheltered from his blows. The troops there should assume the formations best suited to the character of the ground; and it is there that the combat trains should be formed, if this has not been done previously. The preparatory combat dispositions should also be there made, if it does not seem practicable afterwards to take up a position of waiting.

The position of waiting, when it ought to be or can be taken, should be in as close propinquity as possible to the combat position. It is essential, in every case, that it be out of view of the enemy, and that the batteries be able to reach it unseen by him.

All prescriptions relative to secrecy with respect to positions and marches deserve great consideration, for it is an established principle that surprise of the adversary is one of the best guarantees of success in artillery engagements.

In the position of waiting, the batteries usually are formed in mass or in line, with open or closed intervals, facing the combat position which they are soon to occupy. The choice of formation depends especially upon the character of the terrain and upon tactical conditions; but it should never be lost sight of that the formations with closed intervals necessitate subsequent rather long spreading-out movements, which may, moreover, lead to uncertainties and irregularities in coming into battery.

The batteries should make preparatory dispositions for the combat,. if this has not already been done. As it is of extreme importance to open fire as quickly as possible after the pieces are in battery, it is well to prescribe that they be loaded as a part of the preparatory preparations. This measure has hitherto been sometimes employed. It is one that has never presented inconveniences, and it is expedient to make its employment general.

Selection of the First Combat Position.—This position, as respects artillery, will usually be a crest, behind which the batteries will be established, so far as possible unknown to the enemy. The slope upon which they are installed should not be so steep as to render it too difficult to place them there; yet, on the other hand, if the incline be too gradual, the batteries, in order to be put in place without being seen, must be moved by hand a considerable distance, and when the nature of the soil is unfavorable, such an operation will necessarily be performed with great slowness. The direction of this crest should not be too oblique with respect to the line of fire. During the manœuvres at the camp at Chalons, this obliquity was the cause of much embarrassment to the officers who had not taken sufficient account of it. It produced regrettable confusion in the objectives; and several times necessitated partial movements of the batteries, occasioning thus a tardy opening of fire, and a faulty disposition of the caissons and limbers with respect to the line of fire of the adversary, who was able to enfilade them.

For the purpose of reducing the effects of the enemy's fire to the minimum, and also to facilitate supervision in the battery and the service of it, it is recognized that in the order in battery, the limbers and caissons should be in prolongation of the piece carriages. If, therefore, the crest to be occupied is not perpendicular to the line of fire, and if (as will naturally happen unless care is exercised) the battery is moved up in a direction nearly normal to the crest, a vicious disposition of its elements will necessarily result, or if it is thought proper to bring the battery into a regular formation, it will be necessary to move guns, limbers, and caissons,—a matter that may involve serious consequences. The disposition by which fire would be opened with the pieces placed obliquely with respect to the front of the battery and with the limbers and caissons obliqued so that their axes would be parallel to those of the gun-carriages (these various elements remaining practically on their own ground), would be an insufficient palliative, because in the trace of each gun-carriage would be the limber or caisson of another section, and this disposition would result later in confusion and disorder.

Other opportunities will present themselves for returning to this very important question.

The plan of taking position behind the crest has been erected into an absolute principle. The facility with which batteries formerly moved beyond the crest is thus suppressed,—a disposition made use of on account of the possibility of obtaining a better view and of abolishing the dead angle beyond the front.

The rigor of this rule implies that the artillery shall be protected from all enterprises on the part of hostile infantry and cavalry on its front and also upon its flanks. This security is obtained by the concurrence of the other arms, which should, under all circumstances, aid and protect the artillery in their vicinity. However, it may, without rashness, be said that a strict application of the principle of putting the artillery in position behind the crest, must lead to the revival of the old question relative to artillery supports.

Notwithstanding all that may be laid down on the subject, it will sometimes be absolutely necessary to take post beyond the crest. It appears to me then essential that the battery should see well the objectives and the surrounding terrain, and have a clear field in its front,—in a word that it profit from its position to develop its offensive qualities, while at the same time it should, if possible, endeavor to conceal itself from view. In the latter respect, and leaving out of consideration the cover afforded by the terrain occupied, the mass manœuvres we are considering showed that artillery is little visible when placed in front of a wood, as in this case it projects itself upon it; that the position upon the crest itself is less defective than it appears to be at first sight, because the estimation of the range is often erroneous, and the long shots of the adversary will furnish no clew for its correction; and that such a position is always to be preferred when the ground is of a light hue, either naturally or on account of the vegetation covering it.

Again, it was attempted at the camp at Chalons, to take post within the border of the wood. This position, when it is possible to assume it, may be very advantageous, especially with the employment of smokeless powder.

Reconnaissances.—A good reconnaissance of an artillery position requires that it be made with discretion, and that it be complete. These are the essential characteristics. Moreover, the reconnaissance should be made rapidly, and, under some circumstances, this requisite outweighs all other considerations.

Discretion should be exercised in making reconnaissances to the end that the attention of the enemy may not be drawn to them and the advantage lost of an unexpected coming into battery and opening of fire.

Reconnaissances should be complete in order that the batteries as soon as they arrive may be perfectly well acquainted with the position, and thus avoid all hesitation and confusion and everything tending to delay their movements and their fire.

In order that a reconnaissance may be discreetly made, the party engaged should be small, and the movement should be as much disguised as possible. In consequence, only the personnel strictly necessary should be employed (the staff officers and the orderlies not essential in executing the work, being left at some distance in rear of the crest), and the reconnaissance should be made on foot, if the condition relative to rapidity will permit.

Here is the complete mechanism of the reconnaissance of a battery position. It is a type which should be approached as nearly as the conditions of a particular case will permit; but it should be understood that there is nothing of an absolute character in what is to be stated, and that the reconnaissance is, above all, subordinate to the exigencies of the combat.

The reconnaissance of battery sites should be made by the commander of the divisional or corps artillery, the group commander and the battery commander. These three successive reconnaissances are made from different points of view, according to the functions and duties of each of these officers.

The reconnaissance of the first bears at the outset upon the part of the hostile position that is to become his target, and upon the extent of front that his groups are to occupy. These points having received his attention, he calls up his group commanders and indicates to them the portion of the opposing lines that is to become the objective of the batteries of each, and distributes between them the front to be occupied by the artillery. These are two essential prescriptions, and negligence in their application is likely to involve either an imperfect distribution of fire or great disorder in coming into battery, arising from the fact that the group arriving first will take the most plainly visible objectives or will not think to leave sufficient space in the line for the succeeding groups.

After giving these directions to the majors, the colonel commanding the artillery continues his study of the terrain, having in view the subsequent steps of the combat and the movements which he will have to order later.

It is evident that, in the majority of cases, the colonel, but he only, will be obliged to show himself. This will be done without inconvenience, for the presence of a single horseman upon a crest will not seem to the enemy an indication of any importance. When the colonel is joined by the group commanders, the party thus formed, if seen, is likely to arouse the suspicions of the adversary; it is therefore necessary that these join him covered from hostile view.

The reconnaissance of the major should, at the outset, be for his batteries, what that made by the colonel was for the groups, that is to say, his first care should be to select each battery's objective and to fix for each the extent of front it is to occupy. This reconnaissance will be less summary than the preceding. If the direction of fire is oblique to the crest, the major will precede his batteries into place, and indicate the dispositions to be made in order to obviate this inconvenience. Depending upon the character of the terrain and the degree of obliquity of fire, he will prescribe that the batteries establish their fronts respectively parallel to the crest, the limbers and carriages being in the track of their respective guns; or that the batteries place themselves in echelon, their fronts perpendicular to the direction of fire, one of their wings resting on the crest; or he will direct such other dispositions as the circumstances of the particular case suggest to him.

It is recommended to the major to estimate as exactly as possible the distance of the points to be aimed at, and, to this end, to make use of all means at his disposal, including the range-finder, if the group staff possesses one. This is an evident means of accelerating the regulation of the fire, and of rendering it quickly efficacious.

After these matters have received attention, the major will concern himself with the places to be occupied by the combat trains.

When all these various questions have been decided, the major calls up the battery commanders to give them their instructions. To each is indicated the objective of his battery, the formation to assume, the extent of front to be occupied, and the position of the reserve ammunition caissons.

After having thus instructed his battery commanders, the major continues his study of the terrain with reference to the approaches to the position, the more or less dangerous dead angles which may be on the front or the flanks of his group, and the means of remedying defects in the position and of avoiding surprise. He establishes relations with the commanders of the neighboring troops, in order to assure himself of their support in case of need. He devotes himself particularly to the means to be adopted to change the position of his batteries, either to the front or to the rear, without discovering their movements to the enemy.

The battery commander makes reconnaissance of the ground assigned to his battery. This should always be executed on foot, and to this end he halts with the mounted men who accompany him, far enough in rear of the crest to avoid being seen from the front, and he and those with him who are to take part in the reconnaissance, dismount.

The reconnaissance on foot is indispensable, not only from the point of view of discretion, but also in order to assure the prompt opening of fire by the avoidance of all useless movements of the guns by hand. The captain should, as it were, trace the line on which the wheels of his gun-carriages are to stop, and for this it is necessary that he be dismounted and that he stoop to the front as does the gunner in laying the piece in order to assure himself that the objective will be seen from each gun. It is essential that he indicate clearly to his lieutenants and even to his chiefs of sections, if not the ground to be occupied by each piece, at least the positions where the extreme pieces are to be located, and even, although this may seem a superfluity, the interval between pieces. Also, he ought to indicate and even to actually mark out, in the center of the battery position, the direction of the line of fire.

The captain is left to decide, according to the circumstances of a particular case, as to who should accompany him in reconnoitering. On the one hand, there is an evident advantage in restricting the size of the party to the minimum; but, on the other, it is well that the greatest possible number of officers and non-commissioned officers of the battery should receive directly from the captain, upon the very ground to be occupied, all details relative to coming into battery there and to the fire of the battery. Experience in the mass manœuvres we are considering clearly showed the exceptional importance of a well-conducted reconnaissance, the results of which are well known in advance by all, especially as a means of assuring a proper direction to the carriages in coming into battery.

Occupation of the First Combat Position.—All preliminary dispositions are made; everything is prepared for coming into action. It is essential to prolong the enemy's ignorance up to the last moment and to strike him with great suddenness and at the same time as effectively as possible. These are the conditions which render all the preliminaries so important, and which make the favorable occupation of the combat position and its concealment from the enemy, one of the surest elements of success, as well with respect to material effects as to the moral influence arising therefrom.

Here, still, everything depends upon the ground, the weather, and the enemy. If absolute rules cannot be fixed, one may at least affirm that this is the moment when it is more than ever necessary to act quickly and to the purpose. It is well here to recall and to practice the advice of a celebrated physician who, when about to perform an operation in the presence of his students, in an urgent case, said to them: "At such a time we must act quickly, but let us not hurry."

Experience at the camp at Chalons demonstrated that a precipitate coming into battery was generally faulty, notwithstanding the terrain was singularly favorable to rapid gaits, and batteries which assumed this formation in a methodical way after due preparation had been made and with a slowness apparently inadmissible, were seen to open fire before those that came into battery at a rapid pace.

In this connection, I cannot but express regret at the suppression, in the regulations relative to mounted batteries, of the method of coming into battery at a walk. The general practice of the battle field, which will seldom permit a faster gait at this time, is thus sacrificed to a vain parade display on the manœuvre field. Lack of excitement as respects men and horses, the preservation of order during the movement, and precision in halting, make for more than a rapid gait in insuring a quick coming into battery and opening of fire.

The first question which presents itself is, Who is to lead the battery to its position?

The captain is already there, the Regulations even assign him a place; the battery is in its position of waiting, which is at a greater or less distance to the rear; is the captain to go there to seek his battery while stationing someone else at his regulation post, or will he send his first lieutenant the necessary order for conducting the battery to its assigned position? Here again there are no fixed and absolute rules. My opinion is that the captain should be left free to act according to the distance, the character of the terrain, and the orders relating to details which he finds it necessary to prescribe. It will be sufficient in every case, that accuracy and promptness in coming into battery be assured.

At the camp at Chalons, the most varied dispositions were employed by the batteries in reaching the first combat position and coming into battery. I shall here set them forth, at the same time giving some information relative to the conditions of their employment. Each of the methods tried has advantages in particular cases, and it will be useful to officers who may be called upon to execute such operations, to have the benefit of the experience resulting from the manœuvres in question.

Among the regulation methods the most frequently employed for coming into battery, may be cited the deployment of the column of platoons, and immediate coming into battery; and the same deployment followed by a march in line with full intervals, and a subsequent regular coming into battery. I take occasion here to express regret that in the Regulations, the formation formerly known as column of attack has been suppressed.*

The center platoon being at the head of the column and each of the wing platoons being in column of sections in rear of the nearer section of the leading platoon, line is formed by deploying the sections of the wing platoons to the right and left. The reasons which led to the rejection of these movements are of secondary importance in comparison with the advantages which they present, especially in the case of actual evolutions. This formation, indeed, furnishes the most rapid mode of forming line of columns and of masses, at the same time that it permits the most rapid deployment of these two formations and upon ground of minimum depth.

The column of attack presents still another advantage from the point of view of coming into battery. As is known, and as has already been insisted on in this article, the captain, during his reconnaissance of the terrain, should indicate in the plainest manner possible the point where the center of the battery is to rest, and the direction to be taken by the carriages in reaching their places. With the column of attack, the chief of the center platoon, marching at the head of the battery, will evidently have every facility for properly guiding himself by the indications furnished by the captain, since he has only to follow a line actually marked out, and to halt at a well defined point. This is only a detail, but a detail that nevertheless has its value.

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* In the new manœuvre regulations for the German field artillery, of June 27th, 1892, we find a method of ploying the battery into column of platoons with the center platoon in advance, and a corresponding deployment to the right and left on the head of the column. —Editor *Revue*.

The following methods were also employed during the manœuvres: Upon favorable ground, the battery marched in line with open intervals, and then went into battery in the regulation manner. Again, it marched in line with closed intervals, taking open intervals as it approached the designated position, and then went regularly into battery. In the latter case, it was necessary to see to it that the carriages were properly dressed, and that they marched in parallel directions, before giving the command to form in battery, under penalty of bringing the battery into position in disorder. This manœuvre requires ground to a great degree open, and of considerable extent, between the position of waiting and that of combat.

Concerning the regulation method of coming into battery, the following inconveniences, in the light of present ideas upon the manner of engaging artillery, may, in general, be noted.

1st: The piece before being brought to a stand upon the position in which the gunner will be as little exposed as possible in pointing, will, with the limber and its teams, arrive too near the crest, will sometimes, indeed, even pass it, and thus the battery will be unmasked before the opportune time. It is proper to remark also, that this inconvenience is still further aggravated by the mistake which is almost always made by the limbers in moving more or less to the front before making their two successive wheels to the left to gain their places in battery. This serious fault results from the fact that the drivers are instructed to move off abruptly at a trot from a walk in wheeling to the left, a thing that is generally impossible. To remedy this, it should be prescribed to the lead and swing drivers to turn their horses with force to the left without tightening the traces, immediately after the carriage is halted; and for the wheel drivers, after the piece is unlimbered, to do likewise, turning the limber thus to the left without advancing; the pairs being again in column of files, the limber will then make its second left wheel in order to move to its place in battery, taking up the trot if this increase of speed be necessary.

2nd: The pieces moving at a trot do not halt exactly upon the designated battery front. As a rule they go beyond it, and there result useless by-hand movements, and a premature disclosure of the battery position.

3rd: When marching at a trot, especially on difficult ground, the carriages do not always preserve a good direction; in consequence the limbers and caissons cannot put themselves in the track of their pieces, and the in-battery formation is so far defective.

The methods we are considering were also employed with the following modification, which served to prolong the invisibility of the battery. The pieces were halted in rear of their position in such a way that the personnel remained completely concealed, and were then unlimbered and run by hand to the front to their respective positions, the other elements of the battery taking their proper places in battery. This is an excellent mode of operating when the form and nature of the ground are such that movements by hand do not become too prolonged and laborious.

At other times, in order to render the movement less exposed to view, the drivers and chiefs of section were dismounted, and the teams led to the battery position.

Under still other circumstances, the guns may come into battery, with closed or open intervals, in rear of the real position to be occupied; every one is then dismounted; the chiefs of section go forward to the points where the wheels of their piece carriages are to rest; the piece teams are then led to the front by the drivers, who cause the pieces to execute a wheel to the right or left, and to halt upon the line marked for the front of the battery, the carriage wheels close to the chiefs of section; the pieces are then unlimbered, and come into place no longer by an about but by a simple turn to the right or left; the limbers take their posts, and the caissons close up.

This method will be advantageous under many circumstances, particularly on heavy soil, where movements by hand would be very difficult.

If the character of the ground lends itself thereto, the same method may be employed with the drivers mounted.

The manœuvre is more simple with open intervals; and in all cases care should be exercised during the movement that the caissons do not become too far separated from their pieces.

The manœuvre will be still further facilitated if the guns can be led into battery, not from a point behind the position actually to be occupied, but from one a little in rear of one of the flanks of this position.

When the guns have come into battery and opened fire, the sheltering of the limbers may be ordered. The commander of the artillery is alone competent to give directions for this, because only he has sufficient information to judge whether or not it is advisable. To shelter the limbers is to produce the serious inconvenience of rendering the battery stationary, leaving it thus in a critical position while exposed to the hazards of a battle field.

It has been recognized as dangerous to shelter the caisson teams. By not unhitching from the caissons, the inconveniences attending the *eloignment* of the limbers are in part made up for. Let us suppose, for example, that cavalry, by a fortunate dash, is on the point of over-running the battery. The limbers and caissons will be able to beat a retreat, and the pieces remaining in place cannot be used by the enemy in default of ammunition nor be removed for lack of teams.

In concluding this important question relative to the occupation of the first combat position, a word remains to be said upon the place of the combat trains. These have almost always been placed in rear and outside of one of the flanks of the group. This position is, in principle, good, although it renders replenishment of ammunition in the opposite wing somewhat slow, and obliges the caissons executing this work to make flank marches in rear of the guns, over ground covered by the enemy's fire. But is there not still another inconvenience to be feared? The intervals left between the artillery groups are spaces reserved to the other arms and to the auxiliary services.—Will such ground therefore be at the disposal of the artillery? For these various reasons, I prefer to assign to the combat trains a sheltered position in rear of the center of the group.

[TO BE CONTINUED.]

NOTES ON ARTILLERY.

Long Guns. Translated and summarized by Lieutenant Cornélis DeW. Willcox, 2nd Artillery, from *La Marine de France*, Vol. I, No. 6.

For many years, investigators of explosives have sought to reduce rapidity of combustion. The efforts made have resulted in an increase in the length of guns and hence in the muzzle velocity.

Four or five years ago, a length of 35 or 36 calibers was considered very great. In 1889 and 1890 the French Navy constructed pieces of 40 and 45 calibers, while the Canet guns of those dates were longer yet.

We are naturally led to dwell upon the latter, for they were the first built and installed on board ship, and they have always, both in France and abroad, formed the basis for discussion in respect of length.

In 1889, M. Canet built guns of 32 cm., L/40., giving a M. V. of 730 m. to a projectile of 450 kg. In 1889 and 1890, he experimented with guns of 10 cm., 12 cm., and 15 cm., L/48, giving a M. V. of 880 m. with high pressure, and of 800 m. in service, without exceeding 2400 atmospheres. Always advancing, he has since built guns of 70 and 80 calibers, with a M. V. of 1000 m. and over.

Various objections have been made to long guns.

I. *Resistance of the piece.*—In the first place, it has been argued, that the chase of a long gun is inherently weak. To this it may be replied, that the vibrations of the metal and of the piece do not affect the life of a long more seriously than that of a short gun, so long as permissible service pressures are not exceeded. And similarly of erosion. The vibration of the gun is hurtful in direct proportion to the number of elements of which it may be composed, and not in proportion to the length.

II. *Deflection of the muzzle.*—As regards the rigidity of the chase, it is a fact, that in certain navies even medium lengths have been found imperfect. Thus certain guns, L/35, furnished to Russia by Krupp, have revealed after being fired, a permanent droop varying from 3 to 13 mm. Such deviations of the axis, when permanent and exceeding certain limits, affect accuracy of fire, and may produce accidents, in consequence of the jamming of the projectile. In any case, the balloting and friction injure the rifling.

Deflection may be due, however, to causes other than repeated vibrations. For example, and especially in the case of older guns, the chase bends often under its own weight. After noting a very slight deflection in one direction, one in the opposite may be noted if the gun be turned through 180°.

We must guard, here, against confounding elastic with permanent deflection. The former manifests itself in all guns: it cannot be avoided, but must be reduced to a minimum by a *tracé* rationally investigated. The thinner the tube, and the more it is loaded with hoops, the greater the tendency of elastic deflection to display itself. Hence the unhooped tube of the Canet system, and of the new navy guns.

Vibrations have a permanent effect upon the chase proper, apart from the dislocation of hoops, only when the metal itself has been subjected to irregular initial tensions. The consequent defects, therefore, depend directly on the mechanical treatment of the metal itself. This question affects long guns only in so far as their greater length imposes greater difficulties of treatment, and furnishes no reason in itself against their existence. If the metal be defective, the gun rapidly deteriorates, but this is absolutely independent of the length of the gun. Hence special precautions are necessary in the manufacture of very long guns.

The present tendency is to lengthen guns. The French navy is building them 45 calibers long, up to a caliber of 30 cm. Colonel de la Roque, the present director of artillery has ordered from Canet pieces 55 calibers in length. At Ruelle a piece of 15 cm., L/90, has been successfully tried. Krupp has got up to 40 calibers, and will probably go further. Elswick has gone up to 100 calibers, but this piece, composed of parts screwed together end to end is hardly a service gun.

It appears that in the future, great length will be the rule.

III. *Installation on board ship.*—This question involves serious difficulties. Taking actually existing ships, it is no easy matter to equip them with very long pieces. If installed, they are hard to work. A solution may be reached by substituting pieces which, while of inferior caliber, have counterbalancing advantages. Evidently, however, the question of emplacement will have to be investigated from the point of view of the gun—that is, if the expression may be allowed, the ship must fit the gun, and not the gun the ship.

IV. *Advantages of great length.*—The disadvantages are far outweighed by the advantages of great length. We have first a notable increase in muzzle velocity and hence in energy, perforating power, and flatness of trajectory. For the same angle of projection, the range is greater, as well as the dangerous zone. If fire be opened on a target 6 m. high, with a 57-mm. gun, M. V. 1000 m., projectile 2.7 k., there will be first a dangerous zone from the muzzle to the point of fall for the trajectory whose maximum ordinate is 6 m. This zone is 1524 m. wide. Next there will be a second zone up to the point of fall for the trajectory whose ordinate is 6 m. at the end of the first trajectory, with a width of 1806 m. For a freeboard of 2.5 m. (torpedo-boat), the extreme points of the corresponding trajectories will be distant 1101 m. and 1403 m., respectively. If we suppose two sight-notches, answering the one to the first, and the other to the second trajectory, the latter will be used from 1800 m. (target 6 m. high), and from 1400 m. (target 2.5 m.). Supposing the target to approach 200 m., the gunner will use the first notch, after running the slide down by a simple pressure of the hand. Point blank fire is thus up to 1500 m. and 1100 m. completely, and up to 1800 m. and 1400 m., satisfactorily, realised. This result is of great importance.

For the 10-cm. Canet, L/80, projectile 13 k., M. V. 1000 m., we have:

6-m. target. 1st dangerous zone, 1835 m.
2nd dangerous zone, 2240 m.
2.5-m. target: 1st zone, 1262 m.
2nd zone, 1761 m.

This gun at the muzzle will pierce 50 cm. of wrought iron.
at 1500 m. will pierce 30 cm. of wrought iron.
at 2500 m. will pierce 20 cm. of wrought iron.

This piece, therefore, all things considered, is superior to those [of the same caliber] firing a heavier projectile with a smaller M. V.

Passing by the increased accuracy resulting from increased velocity, we may finally note the importance of rapidity of fire. A great deal has been already accomplished by simplifying the service of the piece. But the gunner must be enabled to follow the target by simple changes in azimuth and in angle of sight. In particular must he be freed from adjusting the sight to the varying range. In other words point blank fire must be approximated to as closely as possible, thus minimizing the importance of the sight, and making it almost unnecessary under 1800 m. This is the important result of increased velocity. The considerations given, viz.: increase of power, accuracy and efficacy, special facilities in aiming, emphasize the significance of muzzle velocity, and justify all efforts made to increase it.

From my diary: Memoirs of the siege of Diedenhofen in November, 1870. Translated and summarized by Captain William A. Kobbé, 3rd Artillery, from *Jahrbücher für die deutsche Armee und Marine*, October, 1892.

Diedenhofen (Thionville) was a fortified town astride the Moselle about 20 miles north of Metz and 15 from the neutral frontier of Luxemburg. The place had 8000 or 9000 inhabitants and a garrison of 4000 regular troops. The works consisted of an elaborate bastioned enceinte by Vauban and Cormontaigne and belonged, therefore, to the "cut and dried systems of fortification" which, according to Major Clarke, "have no longer any place in military science." They were, moreover, tactically indefensible; for, while they commanded the railway and valley, they were, in turn, commanded by the hills on both sides,—some good artillery positions being within 1500 meters. After the battle of August 6th had uncovered the fortress, "a few weak and insufficient detachments of landwehr" promptly (August 8th) occupied these hills to "observe" it. Later, especially when it seemed likely that Bazaine might attempt to break through in that direction, the observing force was strengthened until it consisted of five regiments of cavalry, three landwehr battalions and one horse battery. To these, early in October, two infantry battalions of the line were added and in one of them the anonymous diarist served as a subaltern. About the middle of November a division of regular infantry was available, the place was closely invested and, finally, bombarded for 52 hours from 128 siege guns and 30 mortars, when it surrendered with 120 officers, 4000 men, 187 guns, together with depots of munitions of war,

&c. About 9000 hostile shell had been flung over the ramparts with the accuracy born of deliberation and leisure.

The operation thus slightly sketched merits no other mention than the page or two it receives in the German official account. It was the merest episode in an epoch. Not so, however, with the soldierly, lifelike and altogether charming narrative, made up from notes jotted down from day to day by this young officer bivouacking in the mud of interminable rains. All that can be done here, however, is to give a few extracts from them and to express eternal regrets that the whole art of war cannot be re-written in the light of notes of this kind, whether they cover a reconnaissance, a campaign, or, as do those of de Marbot, a lifetime in the field.

> "We were excessively bored; for there was little of honor or glory to be had from outpost duty in mud and rain, especially as the enemy, immediately after our arrival, took back some broken heads from a sortie made against us, and left us thereafter entirely alone. After this lesson any investing troops wearing the helmet were unmolested while, for the same reason, the landwehr men, who wore forage caps, were incessantly harassed, &c."

And thus the Prussian helmet was of some service, after all. Solitary instance!

Thereafter, whenever a sortie seemed imminent, the helmets were quickly transferred to the point where it was expected.

> "And wonderful to relate! wherever troops of the line took position there reigned the most profound tranquillity: we slept at night as if in Abraham's bosom and during the day had only to look out for the shells which the French fired at us with great regularity once after each meal,—apparently to amuse the ladies of the garrison, who, with the aid of a field-glass, could be seen, looking on."

Some days were noisier in the fortress:

> "With the dawn began the continuous drumming and bugle-blowing which had puzzled us the whole previous afternoon. One 'call' followed another: one could even hear the words of command, the driving of nails, the noise of falling boards in the work of constructing bomb-proof shelter. They make a devil of a racket, these French! What a contrast to the stillness at our outposts, where no 'calls' are allowed in active service "

One night there was an alarm and the troops stood to their arms:

> "About 8 o'clock in the morning we went back to quarters, after standing three hours in the cold grumbling and swearing."

Just like the human beings they were and like the American volunteers,—which they were not.

When all was ready for the bombardment the diarist's company and another were assigned to the support of a battery, their only available shelter being a masonry garden wall directly over which the hostile shells would pass:

> "This wall concealed us; but in order to protect the men from indirect fire they were placed in one rank behind it and ordered to sit with their backs close against it. Only those fragments might hit which were driven backward or which had a large angle of fall. My own company was the more exposed as, from lack of room, it was obliged to sit, mostly, in double rank. The sticky, ankle-deep mud made any movement difficult, but during the night we had emptied the barns of straw and had strewn it thickly all along the line. * * Of course our two infantry companies caught everything that went over the guns. Such a hail of fragments, humming like bees, I never saw before, even at Königgratz. * * * The most interesting part of a newspaper which I was reading was torn out by a piece of

the wall driven through it and I was expressing my annoyance when the man next to me jumped up crying: 'Herr Lieutenant! I'm hit!' 'Have the goodness to keep your seat, it probably don't amount to much,' I replied, pulling him down by his coat at the same time. 'Where's the trouble?' 'I don't know sir, but I felt a powerful blow in the back.' 'Off with your knapsack—let's examine into it!' I ordered. Then I found the whole upper part of the knapsack torn, and a fragment of shell, still hot, lying between shirt and undershirt. * * The man was uninjured."

Later on the lieutenant was ordered, with his platoon, to occupy a large village near the glacis,—which, in spite of infallible German maps, he had much difficulty in finding:

"I had great trouble in keeping the men up to their work, for they were worn out with fatigue, short rations and lack of sleep. * * * It will give an idea of their exhaustion. to state that I was obliged, personally, to fetch every relief of patrols and sentinels and post them, no non-commissioned officer being able to keep awake. I could not even rely on their vigilance if they were left without supervision * * and I have spent the whole night between posting reliefs and actually standing guard with the sentinels."

Finally the fortress capitulated, the first duty of the new German garrison being the protection of the inhabitants from the drunken and demoralized French soldiery.

"There were but few noticeable traces of the effect of the bombardment on the works * * and but few damaged guns. * *

Of all the 8000 *or* 9000 *inhabitants,—men, women and children,—not one was injured. The loss of the* 4000 *troops of the garrison was* 17, *including the wounded.*

Ce n'est pas magnifique, mais c'est la guerre.

Mathematical Aiming, by Contre-Amiral Reveillère. Translated from *La Marine Française*, December 4, 1892, by Lieutenant Charles C. Gallup, 5th Artillery.

The article, "Future War," which appeared in the publication by the German General Staff, contains this phrase: "France has reached the limit of her military power, every Frenchman being summoned to and trained in the service."

This is not exact. Certainly, in war matériel, man surpasses all, but capital must not be forgotten. Money is also a military force, because it is that which assumes the form of the most perfect armament, which is always expensive.

Now, of all the instruments of warfare, the most perfect, the most expensive, but also the most powerful, is certainly the man-of-war. The ship is, *par excellence*, the weapon of industrial and wealthy nations.

We must not lose sight of the fact that if we were able to prolong the war of 1870 with certain honor, it was only because we were masters of the sea.

It is necessary to admit frankly, as the Germans say, "that on the frontier the struggle is uncertain." We must hope for the victory, we must even believe it, but we must act as if the chances were equal, as our adversaries also affirm.

Now, if the chances are equal, superiority at sea assumes immediately an importance of the first rank. With a doubtful struggle on the frontier, and conquerors on the sea, we remain masters of the situation.

[illegible] land [illegible] is the [illegible] it is much more so at sea. The empire of the sea can only be acquired by the perfection of personnel and material, a perfection always progressive.

We must acknowledge that at any given instant, the sea may be our best stronghold, but we must also acknowledge that the sea power is expensive.

On the other hand, it is evident that a nation [illegible] will soon succumb under the weight of its armament, as a [illegible] in heavy armor.

It is for parliament to decide how much may be devoted to armament without exhausting the nation. It is for the experts to [illegible] this armament. Number is important, but quality more so. [illegible] hesitate to prefer quality to number. If we are not rich enough to have many ships, let us have few ships, but the greatest [illegible] ships.

It is in artillery above all, and in its manner of employment, that we must strive to reach the maximum. Without disparaging the torpedo, [illegible] always remain the main weapon of the man-of-war.

Such as it is, has the rapid fire gun said its last word? No, if the rapidity of fire is not accompanied by a corresponding accuracy.

If there exists a more accurate system of fire, expensive or not, we [illegible] adopt it with the shortest delay; because on the day of battle, it will [illegible] more costly to have magnificent ships armed with admirable cannon which have but one defect: missing the target. Tireless study and the [illegible] perfection in the numerous details can alone give us the victory over our competitors who, in this epoch of transition, start free of the weight of old things: matériel, personnel, ideas. While admiring an honorable past, we cannot persist in wishing to live amongst the dead, we must have our [illegible] in new creations and in a forward movement.

The optical sight of Commandant de Fraysseix is a beautiful example of the result of persevering study. To replace rapidity of fire by accuracy of fire, has been his object.

That is to say, to replace the apparent rapidity by the true rapidity, since in the same time more hits are made although firing fewer shots. It is then with rapid fire guns and small arms, that optical fire or accurate fire is the most necessary.

Do we imagine that we can frighten our enemy by deafening him with a useless noise? Unfortunately we have before us adversaries who do not tremble so easily.

A ship can only carry an extremely limited quantity of ammunition; rapid fire without accuracy will empty the magazines with as much promptness as uselessness.

Do not forget that with the present system, it is exceedingly difficult to fire accurately, and the proportion of hits to shots fired is very small.

To limit the use of optical fire to closed turrets, is to underrate the limits of the new invention. The use of the optical sight must be generalized as soon as possible.

I repeat it, because the importance of the subject excuses the repetition: what is rapid fire without accuracy, if not the waste of ammunition.

With the new system we will be able, as it appears, to form excellent gunners in a few weeks, a result that we do not obtain at present in many months. This is not a small advantage. Because, if being able to aim accurately does not suffice to make a true gunner, it is certainly the most difficult quality to acquire. The old procedure demands a long and costly education. and exceptional abilities; the new method can be promptly put into use by the first comer.

The optical sight, already adopted in principle for closed turrets, can, slightly modified, be applied to all arms. The question may be put thus: which system is preferable, the one where the individual faculties play a preponderant part or the mathematical and mechanical system leaving almost nothing to personal qualifications? Without a doubt, skill and instruction will always be necessary, but here the inherent fitness is not necessary. Pointing becomes a scientific question.

The Italians, according to the reports of a very intelligent officer, just returned from a visit to our neighbors, have already applied optical fire to their closed turrets; that was all he could ascertain, because our adversaries hide their proceedings with a jealous care.

On the other hand, Captain Akland of the R. A., has taken out a patent on optical fire and doubtless will soon supply all Europe. As has happened with us many times, after having been the first to invent, will we be the last to apply the invention?

Is it worth the trouble to apply the principle of optical fire to all arms, especially small arms? We think so, but it is after all only a belief based on the great possibilities. It is for experience to solve the question finally.

The question is worth the effort of solving and solving in such a manner as to leave no doubt. It is necessary to proceed without delay with a conclusive experiment. What can this experiment be?—Evidently to equip completely without exception all the arms of a man-of-war of the first rank according to this system and compare its fire to that of a similar ship under present conditions.

Suppose that the experiment pronounces in favor of the present armament, nevertheless, it will have been an excellent exercise profitable to all and, therefore, it will not be money badly employed.

It will be in any case an excellent subject for work, and it is very rarely that serious work is totally lost.

Gun trials of the Battleship *Ramillies*. From *Engineering*, August 25, 1893.

The new battleship *Ramillies*, which is being completed as the flagship of the Commander-in-Chief of the Mediterranean Fleet, and which has been fully described in *Engineering*,* has this week completed her gunnery trials with results eminently satisfactory, alike to the several constructors of the guns and the builders of the ship and engines—Messrs. J. and G. Thomson, Limited, Clydebank. In the first place, the diameters of the circles turned by the vessel were measured under various conditions of helms and propelling power, the ship being steered round a buoy, angles being taken at every four points turned by observers stationed at the bow and stern, using the known length of the ship as a base line. The gunnery trials were proceeded with on Wednesday. The main armament of the *Ramillies*, it may be said, consists of four 13½-in. 67-ton guns, Mark III. The secondary and auxiliary armaments comprise ten 6-in. 100 pounder quick-firing guns, sixteen 6-pounder and nine 3-pounder quick-firers, eight machine guns, and a couple of 9-pounder field-guns—an aggregate about 500 tons heavier than the secondary armaments carried by battleships of the *Trafalgar* class. The 6-in. quick-firing guns are mounted in a central battery, and are double-banked. Four are disposed on the main deck within armour casemates 6 in. in thickness at the face, and having athwart screens for the protection of the gun crew. The forward guns are arranged to train 60 deg. ahead, and the after guns 60 deg. astern. The four 67-ton guns, which are of the same pattern, though constructed by different manufacturers, are mounted in pairs in a couple of barbettes erected at each end of the secondary battery, and consequently well apart. Although they tower to a height of not less than 23 ft. above the water line, their tops protrude only 2 ft. 9 in. beyond the level of the upper deck; and as the structures are screened by the top sides of the ship, they present an indifferent target to an enemy. The axis of the guns when laid horizontally is about a foot and a half higher than the parapets of the redoubts, or a total height of 4 ft. 6 in. above the deck, which is believed to be sufficient to preserve it intact when the guns are fired direct ahead. The guns have a total length of 36 ft 1 in., with a length of bore of 405 in., equal to 30 calibers, while the rifling extends throughout a length of 333.4 in. The powder chamber is 18 in., the jacket 57 in., and the chase at the muzzle, which has a slight bulge, 23.4 in. in diameter. The full charge fired weighed 630 lb., S.B.C. powder, and the reduced charge 472½ lb., while the projectile had an approximate weight of 1250 lb. The general details of the hydraulic machinery and arrangements are precisely of the same character and design as those employed on board the *Royal Sovereign*, it having been found impossible to improve upon them. The great object aimed at has been to combine quickness of fire with perfect safety in the working. The hoists are loaded with shot and powder from different sides simultaneously. This economises time in feeding the guns; but as the path from the bogey to the lift has an upward inclination corresponding with the plane of the guns when the breeches are depressed for loading, the new system also offers additional security against accident, as there is no danger of the projectiles taking

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* *Engineering*, vol. liv., pages 197 and 412; vol. lv., page 716. See also *Ibid.* vol. li., pages 251 and 283; vol. liii., pages 287 and 530.

charge when being forced up the gradient and striking the stops against which they are to rest. It may be interesting to state that each of the 67-ton guns forming the main armament costs 13,000*l*, exclusive of its mounting, and that every shotted round fired represents an expenditure of 114*l*. The whole of the hydraulic machinery was designed, manufactured, and fitted on board by Sir William Armstrong, Mitchell, and Co., of the Elswick Ordnance Works.

Firing, according to the *Times* report of the trials, commenced with the machine, Hotchkiss, and 6-in. quick-firing guns on the upper deck. Fifty rounds were discharged from the first-mentioned in pulls of five each, four 7¾-oz. charges from the 6-pounders, four 6⅜-oz. charges from the 3-pounders, and two charges of 13 lb. 4 oz. each from the 6-in. quick-firers. The mountings withstood the strains perfectly, and it is only necessary to record with respect to this part of the programme, that cordite was exclusively used for the quick-firing guns. The trial of the 67-ton guns afterwards took place. The following is a tabulated record of the order and conditions of firing, with the recoils of the guns for each round:

After Barbette.

Gun.	Rounds.	Charge.	Elevation.	Bearing.	Recoils.	
			deg.	deg.	ft.	in.
Left gun	1	Reduced	5 elevation	Port beam	2	3½
	2	Full	5 "	10 before beam	4	1
	3	"	Horizontal	10 abaft "	4	1
Right gun	1	Reduced	"	Port beam	2	3
	2	Full	5 elevation	10 before beam	4	0
	3	"	Horizontal	10 abaft "	4	0
			Fore Barbette.			
Left gun	1	Reduced	Horizontal	Starbo'd beam	2	8½
	2	Full	Extreme elevation	10 before "	3	5
	3	"	5 elevation	10 abaft "	3	3
Right gun	1	Reduced	Horizontal	Starbo'd "	2	10½
	2	Full	10 elevation	10 before "	3	2
	3	"	5 "	10 abaft "	3	7½

The hydraulic connections were worked at a pressure of 1000 lb., and it was understood that the maximum pressure in the recoil presses was about 2700 lb. The third rounds from the guns in the after barbette were fired simultaneously, and the whole of the others independently. The second round from the left gun in the fore barbette was fired with extreme elevation for the purpose of determining the maximum recoil. This was reported to be 41 in. The recoils were, on the whole, eminently satisfactory, those of the guns in the after barbette uniformly so. There were no accidents of any kind, and with the exception of the breaking of a few panes of glass no damage was inflicted upon the ship's fittings by the heavy concussions. The hydraulic machinery proved [illegible] under the [illegible] it, and showed no signs of distress. The [illegible] guns [illegible] were subsequently fired. The guns, in consequence of their great length, are fitted with an arrangement for running them in and out [illegible]. The gear was not tried, but previous experiments had shown [illegible] beneath deck can be disconnected, suspended and brought [illegible] minutes or seconds.

American High Velocity Shooting. From *The Engineer*, September [illegible]

At Sandy Hook, in August [illegible], a [illegible] *New York Herald* to have been made with the following results. [illegible] experimental wire gun [illegible] long, was fired with the [illegible] smokeless powder. In all, thirteen rounds were fired, beginning with [illegible] and increasing [illegible]. With [illegible] the muzzle velocity was [illegible] second. The last round was fired with a projectile [illegible] charge, when a muzzle velocity of [illegible] ft. per second was obtained. [illegible] result is described as a "record breaker," and it is [illegible] the charge is increased until the pressure of [illegible] the velocity will be in excess of anything yet achieved. [illegible] foot-seconds obtained by the experimental Elswick [illegible] calibers. Very probably the result above reported is [illegible] it may be observed that not only is the velocity very high [illegible] calibers long, but the projectile is unusually heavy, [illegible] weight of the service projectile for the English gun [illegible] of a wire gun and smokeless powder charge is that which [illegible] expected to give the highest result, but it is satisfactory to [illegible] appears to have been a comparatively low pressure. [illegible] these matters, however, and we may naturally raise the question, [illegible] the high result due? The wire gun supplies the strength, and the powder is the element to which we must look for the high velocity. If the pressure [illegible] low throughout, then it follows that the gun might have been a gun of [illegible] strength. The value of the combination of powder and wire gun [illegible] brought out by the development of such energy as is only to be [illegible] pressure which is too great for ordinary guns. We are not told the exact pressure recorded on this occasion, but it appears to be assumed that it was very much below the 22.3 tons, which it is hoped may increase the velocity by more than 846 ft. This would at first sight look as if, so far, the power of the wire gun had not had much to say to the matter. This does not follow, however, for the pressure was probably kept up to an unusual extent, and thus the forward part of the gun exposed to a strain which may well have called for special strength. The question is, what will happen when the charge is increased? Before the additional 850 ft. is obtained, the forward pressure in the gun will be necessarily very great, and it is also possible that with a piece of this length so much of the powder will be blown out unburned that disappointment may be experienced. Supposing, however, that success is achieved in the measure that is looked for, it is much to be hoped that the conditions may not be left in the obscurity that has already done mischief with pieces firing slow powder, but that means may be taken to investigate exactly what pressures fall on the forward parts of the gun, the maximum, which acts at the strongest part of the gun, being in such a case only one element, and very likely not the one of greatest importance. While looking forward with much interest to future results, we are unable to regard the question as having yet got beyond the region of experiment. Erosion is a very serious matter with smokeless powder, and under the conditions above, if it is such as can be ordinarily incurred on service, we think that the Leonard powder ought to have a great future before it. Of this, however, we know nothing at present.

Tests of the Brown Wire Segmental Gun, by the Engineer of the Company.

Assuming that some record of the test of the 5-inch Brown segmental wire gun will be of interest to the readers of the *Journal*, herewith a synopsis of the first one hundred rounds fired from the gun is given.

Twenty-six rounds have been fired from the gun with service pressures of 40,000 lbs. per square inch, or thereabouts.

Twenty-five rounds with pressures of 50,000 lbs. per square inch, and four rounds with pressures exceeding 70,000 lbs. per square inch.

The maximum record of pressure ever obtained in the gun being something over 75,000 lbs. per square inch.

The gun has stood the test in an entirely satisfactory manner, and as stated in a report in the *Army and Navy Journal*, the last star gauging showed not the slightest enlargement of the bore of the gun.

Probably the most interesting data will be that obtained with the Leonard smokeless powder on August 18th.

The first point of interest will be the peculiar shape of the grain used in this experiment. Each grain was a round rod of smokeless powder ⅝ inch in diameter, and 40 inches long; being about the length of the powder chamber. These grains were tied up in bundles like a fascine. Through the center of each bundle was placed an igniter of black powder, that is a tube 40 inches long filled with rifle powder. The object being to produce instantaneous ignition throughout the entire length of the cartridge. The following table shows the report of the firing:

Weight of Charge, lbs.	Weight of Shot, lbs.	Instrumental Velocity, ft. sec.	Muzzle Velocity, ft. sec.	Pressure, lbs. per sq. in.
11	62	1,965	1,981	20,900
13	"	2,197	2,236	28,700
15	"	2,368	2,399	32,850
17	"	2,490	2,523	35,100
19	"	2,770	2,807	46,500
21	"	2,839	2,875	46,800

The last shot gave a muzzle energy of 3,557 ft. tons, or 857 ft. tons of energy per ton of weight of gun, or 169 ft. tons of energy per pound of powder. This, it may be stated, exceeds any record yet obtained for any gun or powder.

BOOK NOTICES.

Construction der Gezogenen Geschuetzrohre, by Georg Kaiser, K. und K. O. Professor am Höheren Artillerie-Curse. *Mittheilungen über Gegenstände des Artillerie- und Genie-Wesens.* **Price from publishers, 6 fl.; from book sellers, 10 fl.**

An indication of the contents of this book is best given by the author's preface,—"This work is composed of some of my lectures on the study of gun construction delivered before the classes taking the higher artillery course. In preparing these lectures I believed, in order to thoroughly understand the present mode of gun construction, it to be necessary to have a preliminary knowledge of the early construction of rifled guns. I began, therefore, by giving such details of construction, as were first made use of and which sometimes are very primitive; then I pass on to the various improvements that were gradually made, ending with the details of the construction as now adopted and which have undergone the various trial tests. I made an exception in regard to the breech mechanism, because to dwell on all heretofore constructed breech mechanisms would fill a book by itself. I confined myself to those breech mechanisms that are now actually used, simply preceding them by a description of the breech mechanisms of Wahrendorff, Cavalli and Schenkl-Saroni, because the principles involved in the construction of these hold good for all succeeding ones. I did not take cognizance in this book of the latest and most important breech mechanisms of the rapid firing guns, as I expect to publish a separate pamphlet on this subject.

"In regard to the manipulation of the material, I closely followed the information as laid down in so many good books on the manufacture of machinery. Wherever possible, I have made use of measured dimensions, because they make the beginner in gun construction familiar with important points; in such cases where obsolete or condemned measurements are given, those now applied may readily be substituted. All theoretical and empirical formulæ are based on practical application and have been upheld by actual experiment, so that the strength and the life of a gun tube can be figured out with great accuracy. As the construction of the bore depends on the kind of projectile to be fired from it, Appendix 'A,' which treats of the dimensions of armor piercing projectiles and shrapnel, is added.

"In regard to the rifling and the twist it is important to understand the resisting forces brought into play in giving the rotary motion, and Appendix 'B' dwells at length on these resisting forces.

"Books containing only technical information soon get out of date owing to the rapid advance made nowadays in technology and the great endeavor made to bring forth new and better arrangements. In order to keep this book up to date, I shall publish in the *Mittheilungen ueber Gegenstände des Artillerie- und Genie-Wesens* any new developments that may be reported on gun construction."

The book is divided into fifteen chapters and has two appendixes.

Chapter I treats of the subject of the determination of the caliber and discusses the different kinds of guns and the classes into which their use divides them. The author then goes into detail regarding each of the three classes, viz.—Field artillery, sea-coast and water-battery artillery, and siege artillery.

Chapter II treats of the different kinds of rifling and goes into detail in the description of the following systems: 1st. When the rifling is made effective by means of a band of softer metal around the projectile making the diameter greater than that of the bore; 2nd. Where studded projectiles are used; 3rd. The expansive system; and, 4th, the polygonal system. The first system, embracing modern modes of procedure, is very interesting. In it are shown how deep the grooves should be, their number and their form. The other systems are the older ones, including those employed in the United States; the description of many other forms is of interest only to the beginner who is not already thoroughly acquainted with the old systems.

Capter III treats of the size of the chamber.

Chapter IV treats of the form of the chamber of breech-loaders and muzzle-loaders.

Chapter V considers the determination of the length of the bore. Here the author enters into a general discussion and determines mathematically the best length to be employed. Use is made of Erb's and Sarrau's formulæ for velocity.

Chapter VI treats of "twist." A general discussion is given similar to that in our modern text books; it includes the subject of rapidity of twist and the use of either uniform or increasing twist.

Chapter VII. The theory regarding the elasticity and rigidity of all tube-like bodies is here discussed. It includes a thorough discussion, both general and mathematical, of the elastic strength of guns. It involves the same theories and discussions as are laid down in our own pamphlets on gun construction used in the artillery course at the Artillery School.

Chapter VIII describes the built-up guns composed of concentric cylinders shrunk one on the other and also the system of concentric cylinders assembled without shrinkage. The mathematical discussion of both systems is complete and illustrates how closely the methods employed in Germany resemble our own.

Chapter IX treats of the different metals employed in gun construction and starts out by defining the properties which a metal must possess in order to be fit for use as gun material. Full details are given and the completeness of

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[illegible] a great deal of useful and necessary [illegible] The book contains in addition [illegible] advance and rear guards the manual [illegible] truce, the U. S. signal and [illegible] code, and [illegible]ation not suggested by the title. The

the chapter on the subject will be fully understood when it is mentioned that the following gun metals and subjects bearing thereon are discussed and described:—Gun bronze, Lavroff's compressed bronze, Lâveissière's method of casting bronze, phosphor-bronze, steel bronze (hard bronze), cast iron, wrought iron, puddled, crucible, Bessemer and Martin steel; Whitworth's homogeneous iron, the hardening of steel and steel free from air holes before being worked. In the production of this last steel two methods are mentioned, the first of which refers to the addition of ferro-manganese with a certain per cent. of silicon and the second to the addition of "aluminum iron."

Chapter X treats of the construction of gun tubes. A theoretical discussion of the subject is interwoven with a description of the actual manufacture of tubes of different kinds—simple and built-up tubes. In describing the different systems employed, that of the Spanish navy guns (Hontoria tubes) appears to be quite different from those of other nations. Considerable space is devoted to the subject of wire wound guns and the chapter ends with a comparison between the wire wound and the built up systems.

Chapter XI treats of vents and primers. The subject of vents is discussed theoretically as to direction and size; also as to the necessity for bushings in some constructions. Primers of various kinds are described, including Krupp's, those used in the Austrian service, the French percussion, the De Bange, those of the English artillery and those of the Swiss 8.4 cm. guns.

Chapter XII contains a thorough description of gas checks, fermetures and the locking mechanism of different systems. The chapter starts out with a discussion of the advantages and disadvantages of breech-loaders and states the conditions that must be fulfilled in order to obtain the necessary breech mechanism. The subject of gas checks is gone into at length. As with other subjects a theoretical discussion precedes the whole and the different methods employed to obtain obturation are discussed both as to advantages and disadvantages. Finally, those used in different services are mentioned and discussed. The information given in this chapter on the subjects involved is probably as complete as can be desired and forms interesting reading to all students of modern artillery.

Chapters XIII, XIV and XV are short; in them are discussed mathematically the determination of the weight of the gun tube and the strength and dimensions of the trunnions; the procedure in making the calculations for the tube of a gun is then given.

Finally, there are two appendixes and, as already stated in the author's preface, the first discusses the subject of armor piercing projectiles and the second is a discussion of the resistances offered to projectiles by the rifling of the guns.

The book is accompanied by fourteen large plates and throughout the text reference is made to numerous illustrations which are both clear and accurate and of great assistance to the student.

HERMAN C. SCHUMM,
2nd Lieutenant 2nd Artillery.

The Present Development of Heavy Ordnance in the United States, by W. H. Jaques, Ordnance Engineer. Reprinted from the *Journal of the Franklin Institute*, July, 1893.

A lecture delivered before the Franklin Institute, January 6, 1893, in which the lecturer illustrated his discussion by lantern views. He confines his remarks to the period since the organization of the gun foundry board. It appears that no important change in gun construction has been made since this board made its report, except that of increasing the size of the parts of the gun, which brought with it a consequent reduction in the number comprising a gun. In this lecture the author restricts himself to the built-up forged steel gun, since he is convinced that it "can be made a perfect machine" and, while not dampening the enthusiasm of advocates of other systems, he regards this type of gun as safe and not liable to do "more harm to its friends than to its enemies." The sentiment here is decidedly in favor of the steel built-up gun as against other designs now struggling for recognition. Since this lecture was delivered events have been moving forward and develments within the last eight months would indicate that there is, at least, a reasonable chance of the built-up forged steel gun being superseded by wire-wound guns within a few years. Details of casting and forging are given and the successive processes of obtaining the finished parts from the ore are clearly presented. Following the construction and assembling of the gun comes a consideration of the breech mechanism.

The writer places himself on the side of large guns and considers the defects of the English 110-guns as merely mechanical. In advocating guns of this size he places himself in direct opposition to present practice of European navies and especially the recent decision of the English Admiralty. In connection with these large guns it may be suggested that there may be tactical objectious to the use of such heavy guns and that, after all mechanical difficulties are removed, it is quite possible that tactical questions may be as important as weight and velocity of projectile.

In the closing pages the author gives some space to torpedo apparatus and its construction, wire guns, and very interesting data upon armor tests, and terminates the lecture with remarks upon the rapid growth of gun factories in the country. Numerous lantern views accompanied the lecture and greatly added to its clearness and value. J. W. R.

Duties of Outposts, Advance and Rear Guards, with manual of Guard Duty, U. S. Army. By Lieutenant W. P. Burnham, 6th Infantry. 171 pages. Published by C. W. Bardeen, Syracuse, N. Y. Price: bristol board, 35 cents; flexible cloth, 50 cents; leather, 70 cents.

The author has been able to put a great deal of useful and necessary information into a very small volume. The book contains, in addition to a complete manual of duty for outposts, advance and rear guards, the manual of guard duty, U. S. Army, flags of truce, the U. S. signal and telegraph code, and much other useful information not suggested by the title. The principal subject matter is illustrated by numerous plates and shows careful and intelligent work on the part of the author. C. T. M.

Naval Annual, 1892. Edited by T. A. Brassey, B. A., F. R. G. S., 1892. Portsmouth: J. Griffen & Co., 2 The Hard.

It is hardly possible that within convenient limits more or fuller information could be placed and it is so concise and well arranged as to be easily found.

Practically, all that can be given here is a synopsis of chapters and side notes or headings.

Chapter I gives the progress of the British navy, 1891-92, and shows number and description of vessels completed, launched or reconstructed both by the government and by contract, and the number retired. Under the head of personnel, the naval reserve and naval volunteers are discussed. Trials of Sims-Edison torpedo are given in full and the naval maneuvers touched upon.

Chapter II is introductory to the progress of foreign navies and includes these sub-heads: Rapidity with which a ship of war becomes obsolete. Objects of maintaining navies. Importance of rapidity of construction. Lessons of Chilian war. Improvements in armor and guns. Ships now demanded by navy. Admitted supremacy of British navy.

It then gives in a manner similar to that of England, the progress of the navies of France, Germany, Italy, Russia, Austro-Hungary, Denmark, Greece, Holland, Norway, Portugal, Morocco, Spain, Turkey, United States, Mexico, Argentine Republic, Brazil, Chili and Japan.

Chapter III treats of British naval maneuvers very fully.

Chapter IV: French, Russian, Austrian and German maneuvers.

These two chapters are very interesting to all artillerymen.

The following is a brief synopsis of these maneuvers. With the English the operations were tactical and as no instructions are given it is hard to judge of their results. The method of division was different from former years giving homogeneous commands. There were four fleets, the Northern, Western, Red and Blue, acting out two different plans. Northern and Western were iron-clads. The Northern was the more modern and faster. The principal point brought out was the difficulty of scouting, as is shown by the following: The Northern fleet was to prevent the Western fleet passing the Straits of Dover, and to do this established a scouting line of nine vessels seven miles apart, between the Isle of Wight and Cape Barfleur; three of the nine were in line south of the *Royal Sovereign* light ship, sixty miles behind the first line. As to the results, the following paragraph gives them; the *Immortalité*, *Medea* and *Tartar* being in the second line:

"The *Mersey*, at the Cape Barfleur end of the line, between 9 and 10 P. M. on the 31st of July, sighted five steamers coming down in two groups, which led to the belief that they might be a portion of the enemy's fleet. This was communicated to the *Medusa*. The latter closed and passed on the word to the senior officer in the *Aurora*, who, as soon as he could signal to her, sent the *Pallas* to communicate it to the *Immortalité* in the second line of scouts.

Later on, the *Aurora* sighted the *Iris* steaming fast to the eastward, apparently on the heels of the enemy's ships. The *Aurora* accordingly followed her, until the *Pallas*, returning from the *Immortalité*, was met with. The last-mentioned ship had received information from a German steamer that five men-of-war had been seen south of Brighton. The next intelligence was a report from the *Tartar* that four of the enemy's cruisers, one judged to be the *Narcissus* of the Western fleet, had passed to the eastward. The *Medea* had informed the *Tartar* that an enemy's cruiser had challenged her, and, as she did not answer, had put out her lights and had disappeared. Then came the *Pallas*, announcing that she had been sent by the *Aurora* to report that five steamers, believed to be the enemy, had passed between the southern scout and the French coast. Three independent sets of witnesses agreed that five steamers had passed going to the eastward." Thus it was reported to the admiral of the Northern fleet that the enemy had passed to the east of the scouts "nevertheless, there had been no cruisers except the Northern fleet's own scouts anywhere near."

The Red and Blue squadrons carried out the following program:

"(a) To ascertain the tactics which would probably be adopted by flotillas of torpedo boats stationed at several points on one shore of a channel in order to harass or destroy an enemy's ships, &c., operating in the channel, or lying at anchorages on the other shore.

"(b) To ascertain the measures which should be taken to give security against the attacks of these torpedo boats."

The results show that catchers are the best means of defense against torpedo boats, long days are unfavorable to them, also moonlight nights. Smooth water necessary for success.

The scheme of French maneuvers was as follows:

A, coming from Gibraltar, to pass between Spain and Balearic Islands to operate against coasts of France and Corsica. B covers French coast. B learns by telegraph of enemy's passing Cap de Gatte and proceeds to the west to intercept A between Majorca and Barcelona. A has advantage in speed. B in numbers and relative strength.

As to results, A slips past B. B pursues and follows sufficiently near to frustrate A's attacks on Corsican ports.

Russia's maneuvers were quite complicated and need to be read to give a clear idea of them.

Germany's consisted of a night naval attack on Kiel which was an utter failure and, as is aptly remarked, "similar attack impossible in real warfare."

Chapter V gives very full descriptions of the newer designs of vessels now building in England, France, Germany, Russia, United States, Brazil, Chili, and Japan.

Chapter VI is devoted to marine engineering, giving general descriptions of the newest and most powerful engines and boilers, trials, successes and failures. Only English make considered.

Chapter VII describes the naval exhibition.

Chapter VIII: the naval episodes of the Chilian civil war. This is divided as follows:

1. The *Blanco Encalada* and the forts.
2. The attempt on the *Imperial.*
3. Operations in the north.
4. The *Itata* affair.
5. The sinking of the *Blanco Encalada.*
6. The *Aconcagua* and the gun vessels.
7. The final operations.

Conclusions drawn from Chilian war:

"a. The value of speed and consequent mobility in warships of a certain class in certain circumstances.

"b. The importance of sea power.

"c. The difficulty of effectively using the Whitehead torpedo save when it is in the hands of people thoroughly familiar with it, and the untrustworthiness of the human element in torpedo warfare.

"d. The usefulness of the Whitehead torpedo when properly handled.

"e. The enormous waste of projectiles that may be expected in modern warfare.

"f. The destructiveness of good heavy shell-fire.

"g. The unsuitableness of torpedo gun-vessels for artillery action with other ships."

Next comes Part II which gives first in tabular form the class, name, tonnage, horse power, draught, length, beam, where built, maker of engines, date of completion, cost of hull, machinery, armor, backing, deck plating, armament, torpedo tubes, speed, coal capacity in tons and knots of all the vessels of Great Britain, Argentine Republic, Austria, Brazil, Belgium, Bulgaria, Chili, China, Denmark, Egypt, France, Germany, Greece, Hayti, Italy, Japan, Mexico, Morocco, Netherlands, Norway, Peru, Persia, Portugal, Roumania, Russia, Sarawak, Siam, Spain, Sweden, Turkey, United States, Uruguay and Venezuela.

Then come a series of 89 plates giving elevations and plans of the different classes of war vessels of the more important powers. These drawings are all to the same scale unless otherwise stated, thus giving an idea of relative size. They also show armor protection both in thickness and extent and location of guns. There are 10 plates descriptive of U. S. vessels. They comprise the *Atlanta*, *Baltimore*, *Charleston*, *Chicago*, Commerce Destroyers 12 and 13, *Maine*, *Monterey*, *Newark*, *Oregon* and *Texas* classes.

Part III. Armor and ordnance.

I. Armor and armor experiments.

Under this head comes the Japanese trial of attack on steel decks, showing them to be vulnerable to high angle fire from comparatively light guns. Working trials of Spezzia turrets. 111-ton gun's penetration of built-up target. American armor plate trials at Annapolis and Indian Head. French steel plate trials. Compound Brown-Tresidder plates tried at Brown's works and Portsmouth. Comparison of English and American plates. Resistance of new armor. Armor piercing projectiles. Rule of thumb for penetration of armor for normal impact and for oblique impact. Diagrams showing penetration of British M. L. and B. L. guns and French and German B L. guns up to 3000 yards. These penetrations are for wrought iron and this work gives steel the advantage of 5 to 4.

II. Ordnance. This begins with a discussion of the relative powers of primary guns and the quick firing armament of a ship; then comes accidents and casualties occurring with guns. Life of a heavy gun. Maxim on erosion. Krupp, Canet, and Armstrong guns. Heavy guns *versus* light. The working of heavy guns. Engagements between ships and coast batteries. Trials of shell effect on H. M. S. *Resistance*. Effect ot position finder on coast defense. High explosives tested in the U. S.

III. Quick-firing guns. Introduction of quick-firing guns in French Navy. Relative power of quick-firing guns. New tables of same. High velocities and variations in different formulæ for penetration. Rate of fire. Energy of quick-firing guns. Canet quick-firing guns. Detailed descriptions, with drawings, of the mechanism of the Canet 12 and 15-cm., 45 cal. long, very instructive. Personnel required for their service. Characteristic features and construction of Canet system. Initial velocities not up to date. Breech mechanism. Advantages of screw over wedge. Canet carriage. Canet coast defense quick-firing guns. Tables of naval ordnance: British rifled, Austrian, British, Dutch, French, German, Italian, Russian, Spanish, Sweden and Norway, United States, Elswick quick-firing, Canet, Krupp.

Tables of pressure, weight, energy and perforation; showing conversion to and from English to metric.

Part IV. Statistics, official statements and papers.

I. Statement of First Lord of the Admiralty explanatory of navy estimates, 1891-92.

1. New construction. Contract and dockyard built ships. Dockyard work. New program. Torpedo boats and torpedo gunboats. Reconstruction. Renewal of engines and re-arming of old battleships. Stranding of *Victoria*. Summary.

2. Steam trials and machinery. Ship trials. Boiler troubles. Causes of same.

3. Naval Defense Act (its cost and results). Cost of boats. Objects of act. Cordite (no experiments given).

4. Armor plate experiments. Compound armor. Nickel steel armor.

5. New works. Portsmouth. Malta. Haulbowline. New magazines. New works proposed.

6. Mobilization and arrangements for increasing efficiency of Reserves. Ships mobilized. Reserve drawn upon. Naval volunteers. Reorganization of steam reserve, of personnel.

7. Personnel and condition of active list.

8. Past and future naval expenditure.

9. Report on Royal Naval Reserve.

II. Royal Naval Artillery Volunteers. Report on their employment.

IV. Navy estimates for 1892-93.

V. 1892-93. Program of works in progress on ships building &c., in H. M. dockyards and by contract.

VI. New construction. And 12 other tables of naval information on British navy. French navy estimates, German, Italian and Russian. Condensation of report of U. S. Secretary of Navy for 1891. Naval bibliography.

Part V. Chapter I. Manning and training. Naval education. Training at sea. Navigation and pilotage. Training in masted ships and flying squadrons. Advocates training in vessels provided with sail power.

Chapter II. Shipbuilding policy. 1. Battleships. Dimensions. Growth of. Moderate dimensions. 2. Coast defenders. 3. Rams. 4. Reconstruction and armament. 5. Cruisers. Dimensions. Value of sail power. 6. Machinery and boilers. 7. Torpedo cruisers. 8. Torpedo gunboats. 9. Torpedo boats.

Chapter III. Navy estimates.

The work is then completed by a very full index, by which any subject or vessel named can be immediately found.

There is much in the book of value to artillery officers and it will well repay those who have the opportunity, to go over it. The plates showing disposition of armor on vessels may give some suggestions in regard to coast defense.

CHARLES C. GALLUP,
2nd Lieutenant 5th Artillery.

War Series No. IV. Information from Abroad. The Chilian Revolution of 1891, by Lieutenant James H. Sears and Ensign B. W. Wells, Jr., U. S. N.

The report of Lieutenant James H. Sears and Ensign B. W. Wells, Jr. U. S. Navy, "prepared from personal observation, from the statements of participants, from official papers, and from presumably authentic publications," has recently been issued by the office of Naval Intelligence in the form of War Series, No. IV.

In a comparatively small compass the causes, progress and incidents of the recent revolution are reviewed, to which is added in the form of appendixes other valuable and pertinent information.

The ultimate success of the constitutional party was assured as soon as it secured the naval superiority which enabled it to secure its communication in rear, utilizing as it saw fit the various ports as bases of operations.

Of the various combats and skirmishes, both on land and sea, very little is added to the daily reports that appeared at the time.

From a naval and military point of view, however, two incidents mentioned are of special interest and worthy of study.

The first refers to the several reports from both sides on the subject of the sinking in Caldera Bay of the iron clad *Blanco Encalada* by the torpedo cruisers, *Lynch* and *Condell.*

The second relates to the use of the modern small caliber repeating rifle. At Concon, although the fighting was done at close quarters, of 1,057,700 rounds fired only about 2200 reached their mark as shown by the number of killed and wounded; or, in other words, but one hit was recorded for every 500 shots fired. The rifles used were Gras and Mannlicher.

At La Placilla, however, from the beginning of the fight "a veritable rain of fire" was poured into the ranks of the army of the Gobernistas.

In the first mentioned battle, the ranks of the constitutional army, a large proportion of which was armed with the new rifles, contained a large percentage of recruits who had not been instructed in the handling and use of their weapon, and who began firing before the enemy were within range, and finally became "carried away with this kind of hand-machine gun" and pumped away their ammunition without aim or reason.

At La Placilla, however, these same recruits having become somewhat accustomed to their weapon, and profiting from the experience at Concon, used their rifles with judgment and effect.

With each and every innovation in military and naval equipment, new and important conditions are introduced, and it behooves those upon whom the responsibility of success or failure will rest, when brought to the test, to study these conditions, and profit by the experience of our South American neighbors, and "in time of peace prepare for war." W. W.

SERVICE PERIODICALS.

Revue d'Artillerie.

JUNE.—General Eblé (continued). Note upon the organization of the inferior lists in batteries. Developments upon certain particular cases of the methods of fire of siege and position artillery,—IV. Placing of the shots by the observation of time fuze shell (continued).

Time fuzed shell, are advocated in the following particular cases:

1. The position of the object inaccurately known is visible from the battery or point of observation, but the percussion shells which fall in the region of the object are not visible from any available point.

2. The position of the object inaccurately known is invisible, but its place is indicated by smoke.

3. The object's position known is invisible and the points of fall of percussion shell are not visible from any available position.

The article is treated under the following heads: Principle of the method. 1st Case. Lateral point of observation. a.—Determination of the first event in the development. b.—Rules to follow for lowering or raising the point of burst. c.—Rules of the fire as soon as the range of a time fuzed shell has been observed. d.—Examples. 2nd case, The observation made from a point without the battery. Cuts given showing method. The paper is illustrated in each case, making the different processes clear.

A new ballistic table.

The essential difference between this table and preceding ones is that it is extended to include the problems resulting from the high velocities which have been recently obtained. The table computed is a double entry table with arguments α and V and corresponds to the double entry table, *Auxiliary A* in the *Handbook of problems in direct fire* by Captain James M. Ingalls, 1st U. S. Artillery. $\alpha = \frac{X}{C}$ varies by steps of 200 from 0 to 8000. V varies by differences of 10 m. from 1100 m. to 150 m.

JULY.—The determination of a portable reconnaissance instrument.

This article deals with the subject of field reconnaissance and shows plans, etc., of an instrument which is designed to fulfill the following requirements: Scales for the purpose of reading maps of foreign countries. The compass card and needle. The measurement of horizontal angles and bringing forward the distances. Measurement of vertical angles and heights and differences of level. Measurement of distances vertical and horizontal. Picturesque sketch, perspective picture and reduction of angles to the horizon. Solution of problems.

The German field artillery regulations.

II. School of the battery. III. Group school. Part IV. The combat.

Developments upon certain particular cases of fire methods for siege and position artillery.

AUGUST.—Study upon the efficacy of time fuze fire.

This consists of a discussion of the efficacy of shrapnel fire. The writer considers the efficacy of a single shot and then proceeds to the consideration of any number of shots. In treating the subject the writer shows how to ascertain the useful shots, points out the difficulty of applying theories to the subject and endeavors to lay down a method for calculating the efficacy of a regulated fire. He also considers the influence of the probable deviation in direction, the influence of the probable deviation in height and the influence of the curvature of the trajectory and loss of velocity in the fragments. The writer assumes the three ranges, 1500, 2000 and 3500 metres, works out the probable deviations for these ranges and determines the probable efficiency.

Methods and formulas of experimental ballistics.

Experimental methods. (1) The establishment of a programme of experiments. The writer considers the advisability of determining a few points in a trajectory with a large number of shots in preference to many points with a few shots, when ammunition is limited. He lays out tables giving ranges etc., to be determined in experimental ballistics. (2) *Execution of the experiments.* Determination of the initial velocity. Measure of the angle of departure. Measure of the resistance of the air. The discussion closes with two notes, one upon the determination of the experimental functions between given limits, and the other upon the use of acoustic interrupters.

General Eblé. J. W. R.

Revue Militaire de l'Etranger.

JUNE.—The new project of maneuver regulations for the German cavalry. The present situation of the railroads of the Ottoman empire.

JULY.—The new military law of Germany. The great maneuvers of 1892 in Italy.

AUGUST.—Instruction upon the work in the field for the German cavalry.

The principal additions to these new instructions are: (1) With respect to the use of explosives for the destruction of bridges, railways, works of all kinds, and guns; (2) The passage of streams by any means whatever. The article is a review or resumé of the German instructions and covers the heads; General principles, Method of practical instruction, Instruction material, Supply of boats and engines of destruction, Passage of water courses (swimming and with regimental material and improvised material), Passage upon ice. The German regulations hold that their cavalry should be self-supporting under all circumstances and capable of doing all kinds of work such as constructing field works, bridges, roads, telegraph lines, etc., even in contact with the enemy and likewise capable of destroying all kinds of obstacles and constructions. To aid in the work of destruction each regiment carries with it 32 cartridges in packages of four, in a leather sack, also 40 strings of slow match composition and 40 fulminate caps. The most careful instruction in swimming etc., and all other means of crossing streams are given.

The great maneuvers in Italy in 1892. The new fire manual for the German field artillery.

The adoption recently of new regulations for maneuvering field artillery in Germany necessitated a change in their firing manual. Since the adoption of the old firing manual their material has undergone many modifications. The common shell with percussion fuze has been dropped from the ammunition supply. A new shrapnel has been adopted and the artillery has been furnished with a new apparatus for indirect laying (*Richtfläche*). The article proceeds to give the reasons for the adoption of the new fire manual which is to be made the subject of reports during next year's exercises, which are to be submitted before 1st of December, 1894. The review compares the new with the old and brings forth the defects of the old system and enters exhaustively into Colonel Rohne's book, *Das Artillerie Schiessspiel*, and his criticism of the firing regulations. The treatment of the questions of torpedo-shell fire and indirect fire are interesting.

The augmentation of the lists of the Austro-Hungarian infantry reserve battalions. J. W. R.

Revue du Génie Militaire.

May–June.—Tactics and fortification,—ideas of an engineer officer in 1774. Note upon Duportail. Railway curves of small radius. An account of an experiment of breaching walls by mines, executed at Arras in 1892.

The experiment here described is a valuable one, since it furnishes data upon sloping revetment walls, that is, upon walls which are drawn well back from the vertical towards the top. The experiment was made with view of obtaining information upon the destruction of such walls. The great value of the results rests upon the fact that this kind of wall is frequently used in modern methods of fortification. The experiment is described under the following heads: (1) *Description of the revetment.* The revetment consisted of a retaining wall 13.5 m. above the bottom of the ditch with vaults in rear 4.35 m. center and 9.50 m. depth. The arches rested upon piers 1.65 m.

thick, with the exception of the two vaults adjacent to the left abutment, which had 5.80 m. centers and piers of 2.55 m. thickness. Over the vaults a gentle slope of earth was placed and the main parapet reduced in width and drawn back so as to be no longer supported by the revetment. From the foot of exterior slope proper to the face of the scarp revetment a thick layer of asphalt had been placed to prevent infiltrations into the casemates. (2) *Scheme of demolition adopted.* The mines could not be placed too near the scarp on account of the small resistance that would obtain. It was finally decided to place the charges in the piers about two-thirds the distance from the scarp. The charges were located about .30 m. above the level of the foot of the scarp, so as to avoid loss in the galleries or vaults. The object was to destroy the piers and cause vaults and parapet to fall in upon the broken walls. The abutment being a mass of masonry 12.4 m. wide, 9.5 m. deep and 14 m. high, was mined in its center. Mines were placed under the piers 1, 3, 5, 7, etc., from the left abutment. There being 20 vaults, 11 mines were established. They were on the average 5.20 m. below the floor of casemates. (4) *Determination of the charge of the mine chambers.* The charge was determined from the formula $C=2.4(5.3)^3$. 2.4 being a coefficient for the earth beneath the casemate and 5.3 the line of least resistance. This gives in round numbers 350 kg., and for the abutment $C=1.5(6.5)^3=412$ kg., in round numbers 400. In the 1st and 3rd, each 400 kg.

In the	1st and 3rd, each	400 kg.
"	6th, 7th and 8th,	325 kg.
"	6 others,	350 kg.

(5) *Establishment and priming of the mine chambers.* Two methods of placing the charges could be followed. They could be inserted through galleries run under the work from the ditch or through holes sunk within the casemates. The latter was followed, since it offered the advantage of a closed cavern into which the explosion could take place. The holes leading to the chambers formed double elbows, thus adding greatly to the strength of tamping and compensating in a degree for the reduced length of tamping, which is only equal to the line of least resistance. The priming was in wooden boxes containing 3 to 4 kg. The charges were also in wooden boxes. To each priming box were connected two lines of detonators. The two lines branched from a main line running along the gallery and turning back from the end mines joined at the central one and then connected to an electrical firing machine. Each mine was doubly primed. (6) *Personnel and time employed.* The work was done by 26 sappers, not thoroughly skilled in such work, working 29 sessions of 3 hours each, which includes all transportation of material; rest and time of going and coming to the work is deducted. This work was done under the greatest difficulties and discouragement. (7) *Effects of the explosion.* The whole wall was thrown into the ditch; with its fall came a large portion of the ramparts and parapet. The breach was 132 m. long, but was practicable only at the extreme left and for a distance of 20 m and near the center over a distance of from 10 to 15 m. The whole breach however could soon have been made practicable. Only a light trembling was noticed by people

within 100 m. of the mines and no pieces were thrown into the air. That no parts of the parapet masonry should be projected into the air was one of the conditions to be fulfilled.

An account of the operations of rescue of a detachment of men imprisoned in a mine executed at Chalillon-in-Dunois in January, 1893. The fortification of Spezzia. The wells of Ouargla. J. W. R.

Revue Maritime et Coloniale.

June.—Essay with respect to the left bank and the navigability of the middle Me-Kong. Essay upon the research for the best order of combat. Indication and control of the course by means of a compass with luminous marks,—description of a new compass. The circulation of the winds and rain in the atmosphere. Historical study of the military marine of France.

July.—General considerations upon the electrical installations on board war-ships. The ministry of marine of the Duke de Choiseul and the preparation of the ordinance of 1765. A study upon the organization of the defense of the United States.—Sea-coast guns and steel armor. Mechanical theory of marching and running. Congress of the French association for the advancement of science. Study upon the civil and military organization of China and upon the province of Kwang-Si. The inaguration of the statue of François Arago at Paris, June 11, 1893.

August.—A vocabulary of powder and explosives. Study upon the organization of the defense of the sea-coast of the United States.

This is a note appended to the same subject discussed in the preceding number of this *Revue* and relates directly to the ballistic power of guns. The following are the principal divisions of the discussion:

1. Measure of the ballistic power of guns. Simplification of the formula of Jacob de Marre.
2. Considerations upon the progress of artillery.
3. Penetration in oblique fire.

Celestial mechanics.—Note upon the invariable plane of the solar system, Method of pointing sea-coast guns in order to use to the greatest advantage the instantaneous indications of the range-finder. Historical studies upon the military marine of France. J. W. R.

Revue du Cercle Militaire.

JUNE 4.—The new regulations of maneuver for German cavalry. The Italian army and the review of Centocelle in 1888 (continued).

JUNE 18.—The new maneuver regulations for the German cavalry (continued).

JULY 2.—Notes upon the mobilization of the Italian army.

JULY 16.—The friendly coöperative association of the officers of land and sea.

JULY 30.—The events in Siam. Project for the reorganization of the Italian army (continued). The bridge material for the German cavalry.

AUGUST 13.—The normal caliber of the infantry gun (continued). War dogs in the German army (continued).

AUGUST 20.—The Vosges army in 1871. The new portable tent of the Austro-Hungarian army.

AUGUST 27.—Ricciotti Garibaldi in the Cote-d'or. The schools of instruction at Paris and in the provinces.

SEPTEMBER 3.—New firing instruction for the Italian artillery. The field kitchen of Colonel Alexieff.

La Marine de France.

JUNE 4. The loss of *La Bourdonnais*. The armament of the *Capitan Prat.*

JUNE 11.—The native troops in the colonies. The armament of the *Capitan Prat* (concluded).

The conclusion of the article is treated under the following heads: Electrical maneuvering of the turrets. I. Lateral pointing. II. Shot-hoist. III. Distribution of electricity. General considerations.

A few notes upon the best order and the most accurate method of reconnoitering for cruisers.

JUNE 18. The teachings of a dead man. The discussions of the society of naval architects. In march upon Tchad (continued).

JUNE 25.—The directing policy of the Admiralty.

The writer discusses the maritime position of France in Europe and brings forth a strong plea in favor of a strong navy. Five propositions are made with respect to the question. 1. The torpedo. 2. France and the offensive role. 3. Sufficient ships to remain masters of the Mediterranean in case of conflict with the Triple Alliance. 4. The loss of the Mediterranean would entail the loss of Corsica, Algeria and Tunis. 5. The criminality of not constructing the requisite number of cruisers.

Divisions d'Aventure.

Treats of the necessity of organizing into divisions, the torpedo boats which accompany a squadron. Considers the day combat and the night combat, and general considerations affecting both. The idea is to have the torpedo boats organized to maneuver as a body and move quickly and lightly to the attack. The writer shows that these boats as now controlled are useless appendages to a ship.

JULY 2.—The navy and parliament (continued). Discussion of the naval budget in the Italian chamber.

JULY 30.—The French naval maneuvers in the Mediterranean (continued).

AUGUST 13.—The trials of the warship *Magenta.* Recent progress of the navy.

AUGUST 20.—A last word.

Relates to a discussion of a previous article entitled *Essai de stratégie navale* and the application of principles there enunciated to the recent French naval maneuvers.

The maneuvers of the north.

SEPTEMBER 3.—The truth with respect to the role of the cruisers of the Gadaud division. J. W. R.

Journal de la Marine, Le Yacht.

JUNE 3.—Our naval forces outside of Europe. The commission for the safety of navigation.

JUNE 17.—The French squadron on the coast of Gallicia. The cruiser *d'Entrecasteaux.*

This cruiser will have a speed of nineteen knots with medium draft. It will be constructed at La Seyne by the Forges et Chantiers de la Méditerranée after the designs of M. Lagane, the constructor of the *Pelayo* and the *Capitan Prat.*

Length between perpendiculars, 117 m.; length at water line, 120 m.; maximum width, 17.85 m.; mean draft, 7.15 m.; displacement, 8114 tons; engines, 14,000 H. P.

Armament.—Two 24-cm., 40-caliber, cannon; twelve 14-cm. rapid-firing cannon; twelve 47-mm. rapid-firing cannon; four 37-mm. rapid-firing cannon; two submarine torpedo tubes; five torpedo tubes above water line.

Two of the torpedo tubes above water are in the stern. All auxiliary apparatus is sheltered under the armored deck and everything will be maneuvered by electricity. The 24-cm. guns are in closed towers, bow and stern, and protected by 250 mm. of steel. The towers are designed after Lagane's equilibrium system and maneuvered by electricity. The other guns are arranged so as to obtain the maximum fire in any desirable direction. This ship will be the largest of the French cruisers and has nearly the same tonnage as the *New York.* The protection for each gun is complete in itself and all arrangements are studiously designed to reduce damage from hostile shot to a minimum.

June 24.—The great maneuvers of 1893.

Article which gives a statement of the program for the naval maneuvers of the coming month. The plan of operations for both the Mediterranean and Channel squadrons.

July 1.—The loss of the *Victoria* (continued). The stability and flotation of armored ships.

July 15.—The marine budget in the Chamber.

July 22.—The great naval maneuvers. The Paknam affair.

July 29.—The English naval maneuvers (continued). The raising of the English man-of-war *Howe.*

August 5.—Our naval maneuvers. The Siamese conflict. The cruisers of the 2nd class.

August 26.—The trials of the *Mousquetaire.* The aluminum yacht *Vendenesse.* The French armored ship *Le Charles Martel.* The launching of the *d'Iberville.* J. W. R.

Revue d'Infanterie.

June.—History of infantry in France (continued). Infantry instruction (continued). Infantry fire (continued). Analytical tactics for infantry (continued). The mounted infantry in the colonial wars (continued).

July.—The Spanish model of the 7-mm. Mauser gun.

August.—A single rule for infantry instruction. The hygiene of European troops in the colonies and colonial expeditions. A methodical exposition and summary of infantry tactics in connection with artillery in the offensive defensive combat.

Revue Militaire Universelle.

July.—Tactics applied to the terrain. Regulations for cannon fire of the foot artillery in the German army, The influence of religious ideas upon the military state. General study upon the contemporaneous geographical movement. Algerian souvenirs.

September.—The service of the engineer troops in armies.

The invasion of 1815. The siege of Mézières. The war of secession. Acts to preserve the civil interests of military men in the army. General study upon the contemporaneous geographical movement. Colonel de Monteyrémard.

Le Génie Civil.

AUGUST 12.—Electric crucible with controlling magnet for laboratories.

This is a description of an apparatus to be used for fusing substances. A strong current is passed through two suitable carbons which in all respects are similar to the carbons of the arc light. The apparatus contains a directing magnet which regulates the operation of the crucible. By the arrangement the arc can be brought gradually upon the matter in the crucible.

Telephotography.

SEPTEMBER 2.—The launching of the *Suchet*.

J. W. R.

Mémoires de la Société des Ingénieurs Civils.

Revue Militaire Suisse.

JUNE.—Administration of the military department in 1892. Critical remarks upon the Swiss Infantry organization. The day of October 31, 1870, at Paris.

AUGUST.—Critical observations upon the organization of the Swiss infantry. The question of the hour during the Franco-German war of 1870-1871.

Revue de l'Armée belge.

MAY.—Considerations with respect to the fundamental principles of different projects presented in Austria for the organization and use of the troops and general staff of the engineers. Study relative to the influence of new engines upon the fortification of the field of battle.

The writer considers that new engines of warfare will produce important changes in field fortifications, and proceeds to ascertain these changes.

I. Small caliber rifles and smokeless powders.—The small caliber bullet has such increased penetration that old dimensions giving security will no longer do so. Sand and earth parapets must be doubled at least and the penetration into wood is so great that its use is practically impossible except for revetting etc. Palisades will require greater thickness than before. Smokeless powder will render firing undiscoverable, since it cannot longer be seen clearly outlined by puffs and lines of white smoke and the feeble sound can be heard at a distance of 300 m. only under favorable atmospheric conditions. Ricochets and hits upon trees may in some cases indicate the direction of the enemy. This condition of affairs the writer considers is so advantageous to the defender that every possible effort should be made to preserve it. Hence, so construct the field works as to render them as indistinct as possible. This will be accomplished by the following means: 1. Give as small relief as possible. 2. Avoid commanding emplacements. 3. Give emplacements to such works only when the latter are not projected against a clear sky. 4. Avoid angular forms. 5. Preserve in front bushes, trees and grain such as do not interfere with the fire. 6. Re-cover the parapet with sod, straw, and boughs, in keeping with the surrounding ground. Avoid the use in front of any auxiliary defense which may be recognized from afar.

II. The use of violent explosives.—This part of the article is occupied in the discussion of effects of using violent explosives as bursting charges for shells on the battle field. The great difficulty in treating this subject is the secrecy with which all experimental results with torpedo-shells are guarded. From data obtainable and certain hypotheses the writer endeavors to give an idea of the effect these shells will have on the battle field and on works of various kinds. These shells are longer and contain more explosive than ordinary shells of the same caliber. It is assumed that of the different explosives used by different nations equal charges will give equal results and that each nation in selecting a particular substance has done so because it is considered safest for use. We learn that the French charge their shells with cresylite or nitrated melinite, the Germans now use picric-acid in place of paraffined gun-cotton formerly, the Austrians ecrasite, and that Belgium will soon experiment with tonite. The French torpedo-shell is carried with the 88-mm. gun: length 4 calibers, weight 8 kg., charge 1.4 kg. of cresylite; delay action percussion fuze: intended for action only against passive objects and with mine effects. The German has the same caliber: weight 7 kg. bursting charge not known: double action fuze apparently for use against living objects. Time fuze is used up to distances which exclude shrapnel fire, after which percussion fuzes are used.

To study the different effects of these two shells upon field fortifications, the writer proceeds to study the two roles assigned to these two shells using percussion and time fuze fire respectively. In considering the question of the mine effect the writer holds that the explosive burns at the same rate under all circumstances [?] and that the shell will therefore absorb but little of the energy developed. This is not the case with common powder. The mine produced by the *poudre brisante* is regarded as differing from the crater formed by ordinary powder in that the radius of the maximum crater is more than three times the depth of the charge, three times this depth being the radius of maximum crater with ordinary powder. According to the results of experiments made in Belgium with ordinary and *brisant* powders the former clears away more earth than the second whilst the results correspond to under-charged, ordinary or over-charged mines. For a less depth it appears that the *brisant* powder produces effects superior to those of the brown powder. These two conclusions are drawn from the discussion:

(1). The depth of explosion in earth with torpedo-shells ought to be comparatively small in order to obtain maximum clearing effects. (2). It is not sufficient to augment the charge nor to substitute *brisant* for common powder in order to produce the greatest destruction in parapets; it is still necessary to regulate in consequence the depth at which these projectiles burst in the earth. Can this be done? Assuming that the clearing effect is proportional to the respective bursting charges in the common and torpedo-shell the French shells give a ratio of 1 : 5. Considering the chances of successful shots with ordinary shell the artillerist cannot produce much effect upon a work of weak profile especially one whose parapet is low and nearly or quite invisible at ordinary battle ranges, without an enormous expenditure of projectiles. This difficulty is exaggerated in the use of torpedo-shells whose fire is less accurate owing to the great length of projectile. Experiments in England have shown that at 1100 m. 50 projectiles per running meter of parapet were required to destroy a parapet 2.65 m. high and 3.65 m. thick. Assuming effective fire and a comparative efficiency of fire for the torpedo-shell, 10 per meter of parapet would be necessary to produce the same effect. Considering the difficulty of a battery maintaining itself at 1500 m., obliquity to parapet in many cases, and inaccuracy of torpedo-shell fire, 15 shots per meter at least will be necessary and this is *certainly* much below the truth. The whole supply of an army corps would be necessary to produce a sensible result and then the cover would probably exist more or less and would probably be manned by infantry at the final moment. Torpedo-shells therefore cannot be regarded as the proper engine to destroy earthen parapets. It now becomes a question of the effect of these shells upon improvised shelter constructed of wood, trees, etc., obtained in vicinity of the works. It is concluded that shells arriving at smaller angles than 15° will ricochet and burst in air while others which happen to lodge in the over-head cover will do little damage to the work. It becomes a question of determining the minimum height of cover etc., which will afford protection to the defender. This is found to be about 1.5 m. Considering the penetration of shells into sand, average earth, etc., it is concluded that the thickness of the side exposed to the fire should not be less than 3.6 m. The conclusions show that torpedo-shells will render the construction of field works more difficult and will require more time and material than formerly. There will be no difference in their effect upon abatis from that of common shell.

Conclusions with respect to the destruction of all other obstacles are reached similar to those just given for breaching the parapet. Great expenditure of projectiles will be necessary. With respect to thin walls, it is held that the torpedo-shell will pass through before explosion will take place. That this may also happen with thick walls but that when explosion occurs within masonry the destruction will be very great, effecting the fall of the wall. All however will be accomplished only at great expense of projectiles. Passing to the effect of torpedo-shells upon the defense it will be observed that the shell will be broken into very small pieces, thrown at high velocity but losing it quickly. According to one, these pieces will not kill at distances greater than 10 to 15 m.; according to another, at about 75 m. These fragments will not be so effective as shrapnel. They will kill only a few men near the burst who will be riddled with missiles. The burst of a torpedo-shell at rest a little above the ground, on account of its comparatively weak sides and strong head and base, will cause the fragments to form upon the ground an ellipse with the transverse axis perpendicular to the line of fire. With a shell in motion it is different, the head only will be thrown forward, the base will be thrown backward with a velocity equal to the velocity impressed by the explosion diminished by the remaining velocity. The lateral fragments describe a cone of revolution whose vertex angle for range of 2500 m. is 95°. Shots falling short will do no harm, those striking the parapet and ricocheting will explode above and will do effective work with their lateral fragments, while those bursting just beyond will be dangerous on account of the pieces thrown backward. The writer furnishes sections of parapets, etc., with the effect which will be produced upon them by the torpedo-shell. In one case is shown a double parapet for purpose of protecting from the rearward action of shells which burst beyond the line of works. The conclusions are that this kind of shell will be more deadly than any other in searching out men behind walls, etc., but it will be necessary to have the explosion take place very near the object. In firing upon buildings explosions within rooms or confined space will be terrible, rendering their occupation impossible.

III. The field mortar.—Mortars and howitzers will in future be used upon the battle field. The advantages allowed in use of mortars are, their use up to the last moment before the assault, the moral effect of the shells upon the defenders, the correction of the fire will be aided by the large quantities of smoke produced, the explosions in the earth of parapets will overturn bomb proofs and other protection, and the use of mortar shrapnel by which the balls will have great dispersion and will descend at such an angle as to reach all points in the defense. To counteract these advantages we find the following considerations: It will in general be difficult to obtain the best results from time fuze mortar fire since greater deviation will result from greater irregularity in burning of fuze on account of longer times of flight; on account of these deviations great care must be taken at the time just before the assault; the correction in range will be difficult on account of long times of flight; and the size of the mortar shell will restrict the shots to a few.

The Russians have already introduced this weapon into their service. Experiments at polygons have indicated that this kind of fire will be extremely murderous and that they destroy the parapets without completely destroying the defensive cover. These experiments were made against defenses visible from a distance, and under conditions much more favorable than those of actual service.

IV. Insufficiency of materials.—The defense has imposed upon it the problem of creating stronger works than formerly from insufficient means, but the defense may be able to make such dispositions that the attacking artillery can produce insignificant effects. It becomes essential that the position and character of the work be concealed. Low relief and all other means that will conduce to this end must be used. The former importance of the ditch is now replaced by a volume of fire and the ditch will no longer be used as an obstacle. The parapet will no longer form an obstacle to the assailants and accessory defenses from 30 to 50 m. in advance of the works will be depended upon to break the force of the assault.

Historical, political, and military history of Constantinople, and the peninsula of the Balkans. Offensive combat of the army division. Rapid-fire cannon of 7.5 cm. of Nordenfelt system. The revision of the regulations and unification of the instruction in the German field artillery. The new military hospital of Madrid. The nation and the Russian army.

J. W. R.

Memorial de Artilleria.

MAY.—Note referring to the cylindrical shells used in the 16th century. Rapid-firing cannon 42 mm., Sarmiento system.

This is a gun with a new breech mechanism. The description, illustrated by two plates, is treated under the following heads: the piece; the breech mechanism; manner of operating the mechanism; and recoil mount.

The automatic repeating rifle. Marches and fire exercises of the third battery of the fifth battalion of fortress artillery.

This is a continuation of exercises already mentioned. Second exercise: Indirect breaching fire. Third exercise: Bombardment fire. Fourth exercise: Night firing. The means of correcting the fire, using tables and find-the target are given: also the results of the exercises with tables of deviation in each case.

The progress of ærial navigation.

JUNE.—Proof of a 14 cm. gun at the Nervon ship-yards. Study upon a special plan for hollow projectiles.

This is a continuation of the subject begun several months ago. The discussion is analytical and seeks the best form of head and body, also the best dimensions and shape generally, for a projectile. The present discussion relates to the spherical and ogival forms.

A compromise solution.

Relates to a preceding decree re-organizing the field artillery. The author proposes several combinations of guns and carriages with permanent batteries of different strengths and points out a solution best suited to the circumstances.

The relative value of the present small caliber guns. An important discovery,—note referring to the chase of a culverin belonging to the first half of the XV century; found in the fortress of Segovia. Points upon the military organization of Great Britain in 1893.

JULY.—The equipments of the first section of the siege train.

First part.—The first section of the siege train as now organized consists of 68 pieces divided into 13 batteries. The division consists of light and heavy guns equal in number, the light pieces to form a reserve of field artillery. The writer shows that it will not be possible, on account of the large number of wagons required, to mobilize heavy siege guns with 200 rounds per gun and that 100 must suffice; the remainder must be carried in the movable park of the army similarly to the case of ammunition for light field batteries. The light batteries also would be mobilized with 100 rounds. It is estimated that at least 800 rounds for the heavy and 1000 for the light guns, per gun, will be necessary for the reduction of a place. Following this introduction are tables giving in detail the parts, equipments and necessaries of the train. The scheme is worked out with the greatest care.

Applications of electricity to artillery.

Projectors.—The writer recognizes two different conditions to be fulfilled in use of projectors for sea-coast work. 1. The recognition of distant points. 2. The illumination of extensive zones at short distance. The first requires great concentration, and the second dispersion of the light. The structure of the projector will depend upon which of these uses will be required. The former should be placed upon great elevations, the latter as nearly as possible on level with the sea. This separation of the projectors into different groups for different purposes imposes the necessity of directing the movement of each from a point distant from both. In this manner alone can the projectors be made independent of each other and can be directed from a central station although they may be placed in positions difficult of access. It has been proposed to signal to an operator of the projector what movements should be made; control from a distant point will remove all this dependence. The advantages of such a combination are the following: (1.) The focus of the light can be placed in the most suitable advanced position and manipulated without any exposure. (2.) The responsibility for direction lies in a single hand which can change objects at will. (3.) The projector can be located in places where by other methods it would not be possible to place them. (4.) The persons employed are reduced to a minimum and chances of error reduced. It is proposed to drive the projector with a small dynamo [motor] with the necessary switches and resistance boxes in the central station. Following this is a discussion relating to the different arrangements and uses of projectors with many valuable suggestions. The article is illustrated by three large folded plates showing different kinds of lights and the mechanism which operates them. One of the most interesting of these machines is one mounted on a kind of electric car which travels on an iron track. The operator sits upon the car and controls the light at will.

J. W. R.

Revista Cientifico Militar.

JUNE 1.—The military problem. Armament for our infantry. Armored infantry (continued).

JUNE 15.—The self-administration of armed bodies. The health of the soldier. The force of an empire. Review of the press and military progress.

JULY 15.—The self-administration of armed bodies.

Revista General de Marina.

JUNE.—The voyage of the *Santa Maria.* Cruisers: their functions and the conditions which they ought to satisfy. Arsenals and fleet of Japan. Vocabulary of modern powders and explosives (continued). Abacus for the determination of the position at sea. The important modifications which have been introduced into the Whitehead-Schwartzkopff torpedo. Trials upon the art of submarine navigation (continued).

JULY.—Spanish cosmography. Notes referring to the voyage of the caravels from Havana to New York. Manner of determining the position of the vessel by the methods of the new astronomical navigation.

Boletin del Centro Naval.

MARCH.—Project of a rapid cruiser (continued). The recent armor plate trials in the United States. Forms of musket balls. Bellville boilers.

APRIL.—The naval school and the fleet. The Argentine cruiser *Nueve de Julio.* Proposition to exchange the artillery of the Argentine cruisers.

The proposition relates to a replacement of the 28-cm. Armstrong muzzle-loaders by 15-cm. breech-loading rapid-fire guns. A ballistic comparison between these guns shows that the former has an initial velocity of 399 meters whilst the latter has 597 meters and that other elements are in favor of this exchange. A tactical comparison shows the rate of firing as 1 to 4. A statistical memoir accompanies the proposition showing weights, etc., and confirms the preceding arguments with figures.

Technical section of artillery.

A proposition to create a technical department of artillery. The writer claims that in their squadron artillerists no longer are found, and gives two reasons for this decline. 1. Officers are not sufficiently prepared. 2. The subalterns are a heterogeneous and unstable set, due to desertion and casualties. To remove these defects in the personnel he proposes to establish a technical section which will collect and study data and develop the most suitable means of preserving and operating the material.

The role and use of torpedo vessels according to English ideas. The Spanish-American military congress.

JUNE.—Court martial defense. The island of the States. Study of navigation. The hydrographic service of England.

J. W. R.

Circulo Naval, Revista de Marina.

APRIL.—Comparative study of rapid-fire cannon. Nets for defense against torpedoes. The application of electric motors on board war-ships.

This article deals with the introduction of electricity on board ship. It comprises a complete review of the subject from its beginning to the present time. Gives the kind of equipment of the *Capitan Prat* with the electrical arrangements on the ship. Describes the electrical installations upon our own ships giving in each case the kind of engines, dynamos and motors, and illustrates the wiring of circuits by cuts. The currents, voltages, and windings are given making the whole a very valuable contribution to the literature on the subject.

A reply to the pamphlet published by Messrs. Armstrong & Co., November, 1892, with respect to rapid-fire cannon. A vocabulary of powders and explosives.

MAY.—A course of selection in the naval school. Organization of the rowers in the galleys. Vocabulary of powders and explosives. Coral formations. The eclipse of the sun on April 16, 1893.

J. W. R.

Revista Militar.

JUNE 15.—The army and country. The theory and the practice of war. Infantry and its battle trenches (continued).

JUNE 30.—A selection of formations of the army (continued).

JULY 15.—Breaches of discipline and punishment. Scientific military expeditions of Portugal in Brazil (continued).

AUGUST 15.—Smokeless powders (continued).

AUGUST 31.—The army and the country. Practical school for infantry.

Revista Maritima Brazileira.

April.—The autobiography of a Whitehead torpedo (continued). Powders and explosives. Naval maneuvers in 1892. The German war marine in 1892.

May.—Torpedo guns.

This is a brief review of the subject of ærial torpedo guns. The principal ones mentioned are that of the Pneumatic Dynamite Gun Co., that of Graydon and Reynolds. Only a short description is given of each.

Naval maneuvers in 1892. A plan for the distribution and equipment of the meteorological stations necessary to a new organization of our meteorological service. The United States navy. Instrument for the determination of the variation and declination of the needle with view to correcting the compass.

J. W. R.

Revista da Commissao Technica Militar Consultiva.

March.—Uniformity of munitions for the arming of infantry and cavalry. Notes on artillery aluminum articles. German cupolas and armor. The present state of the war marine. The new Krupp artillery.

Revista do Exercito e da Armado.

July.—The bayonet and the resolution to attack (continued). Architects and Portugese military engineers in the service of Portugal (continued). Colonization (continued).

August.—The engineer practical school exercises in the spring of 1893. Our army in the eastern colonies. Fire exercises. Tactical problems.

Revista di Artiglieria e Genio.

June.—History of siege warfare from the adoption of fire arms to the end of the year 1892 (continued). The elastic surface of metallic plates subjected to bending forces. Electrical illumination of works of fortification. The development of the kind of gaits of horses from the foot-prints left upon the ground.

July-August.—The school of fire for the German field and foot artillery. Proposition for a new width of tent copied from the regulation tent adpating it for four soldiers. The new fire regulations for the German field artillery.

Allgemeine Schweizerische Militaerzeitung.

JUNE 10.—The Austro-Hungarian war budget for 1894.

JUNE 24.—News from the French army.

JULY 8.—Heavy and light "tubular" projectiles.

JULY 15.—France's conflict with Siam.

JULY 22.—The Von Krnka "miniature gun." With respect to the plans and execution of the maneuvers.

AUGUST 5.—The new German reinforements.

AUGUST 12.—Military report of the German empire.

AUGUST 19.—The steel "tubular" projectile.

AUGUST 26.—The garrison of Paris.

SEPTEMBER 2.—The new German cavalry regulations.

Allgemeine Militaerzeitung.

JULY 2.—A few thoughts on the future infantry fire improvement.

JULY 8.—The French cavalry of to-day.

JULY 12.—The results of the French and the German army organization.

JULY 15.—The law against the betrayal of military secrets.

JULY 19.—The improvement of cavalry in pioneer service.

JULY 22.—The German and the French army.

JULY 29.—The impending increase in the German field artillery.

Die Reichswehr.

Kriegswaffen.

Razviedtchik.

No. 138.—Hesitation before smokeless powder (continued).

No. 139.—The new Austrian gun.

No. 140.—Preparation for fire.

No. 141.—The establishment of the sight in guns by three lines model 1891.

No. 142.—The new regulations of fire instruction, edition 1893.

No. 146.—Are guns necessary for sappers?

No. 147.—The corps of Turkish officers.

No. 149.—Increase of the military forces of France of 1892 over 1891 and its cost.

Russkii Invalid.

No. 123.—The conditions of mobilization of the German army.

No. 128.—Note upon the mobile field kitchen.

No. 165.—Instruction with the lance in the cavalry.

No. 176.—The passage of the Vistula by the Cossacks of the Don.

No. 182.—The field artillery maneuvers at Chalons.

Nos. 186, 187, 188.—The present state of tactics of the three arms in the principal European armies.

No. 188.—Labors of the telegraph detachment upon the Pavier.

Journal of the Royal United Service Institution.

JUNE.—Military organization best adapted to Imperial needs. The art of marching. Volunteer transport. Cruisers: their role and the conditions they should satisfy. Recent progress in marine machinery. Russian naval maneuvers of 1892.

JULY.—The military organization best adapted to Imperial needs. The best type of field gun for the British service, including the question of Q. F. guns. [Captain J. Headlam, R. A.]

The following is the author's synopsis of the article:

Part I. Introduction. How many natures are required: Uniformity of caliber. Tactical considerations. 1. Weight behind splinter-bar. 2. Number of rounds per gun.

Part II. Guiding principles in the choice of a type:

A. The gun.
B. The shell. 1. General requirements. 2. Considerations of shell in use.
C. The carriage. 1. Gun carriages. 2. Ammunition carriages. 3. Shields.

Part III. Quick-firing guns. 1. Definition. 1. Ammunition supply. 3. Rapidity of fire.

The mobilization of the volunteers. Battleships of England. A foreign notice of Mr. Williams. The steam navy of England.

AUGUST.—Universal compulsory service for the United Kingdom. On the photography of flying bullets by the light of the electric spark.

A lecture by C. V. Boys, Esq., F. R. S., on the photography of a bullet in flight. He enters into a discussion of the duration of light in order to photograph rapidly moving objects and explains the apparatus and points out some of the possible discoveries which may result from this kind of investigation. The wave lines in air in advance of the projectile are considered, with differences under different circumstances.

How best to secure continuity in the effective service of modern ships of war. An 18th century Thermopylæ. Submerged discharge for Whitehead torpedoes. J. W. R.

Journal of the United Service Institution of India.

APRIL.—The modern literature of cavalry tactics. Notes on convoy duty. Musketry training and its value in war. [Captain James Parker, 4th U. S. Cavalry; reprinted from the *Journal of the Military Service Institution.*] Russia and the invasion of India. The question of cavalry firing when mounted.

MAY.—The double company system. Economy in the management of the soldier's ration. A geography of the Turkestan country.

The Military Society of Ireland.

NOVEMBER 16, 1892.—The battle of Tashkessan.

DECEMBER 15.—Villars.

JANUARY 11, 1893.—The Rochelle expedition of 1627.

JANUARY 18.—The offensive tactics of infantry as exemplified by the battle of Spicheren.

FEBRUARY 1.—The ordnance survey.

FEBRUARY 24.—The American civil war, 1861-65.

MARCH 15.—The supply of water to troops on the march.

MARCH 22.—The supply and transport on active service.

APRIL 5.—Military topography.

APRIL 24.—Cavalry and horse artillery on the march and in the field.

The Aldershot Military Society.

XLI.—Wood operations. The battle of Gettysburg. Smokeless powder and its probable effect upon the tactics of the future.

Proceedings of the Royal Artillery Institution.

JUNE.—Memoirs, historical and biographical (continued). A method of concentrating the fire of a group of guns laid for direction by graduated arcs. Extracts from the diary of Lieut. Ingilby, R. H. A., during the Waterloo campaign. The artillery of the three armies.

JULY.—The attack of a coast fortress.

Three prize essays which treat of the subject of the attack of sea-coast fortresses.

AUGUST.—Remarks on making and breaking. The "lining plane" of the German field artillery. The Spanish gun factory and arsenal of Trubia. The value of mobility for field artillery.

J. W. R.

Engineering.

JUNE 16.—Portable engine fitted to burn liquid fuel. The Krupp pavilion at Jackson Park.

The Krupp exhibit at the Columbian exhibition is dwelt upon. The relation which Krupp holds to the ordnance world is briefly considered, and the buildings containing the exhibit described. The 42-cm. (16¼") gun is the largest gun ever brought to an exhibition. This gun is described, but it is sufficiently well known. The next gun considered is the 30.5-cm. (12".01) which is mounted, with all its appliances, upon a turret carriage. It has been fired 98 times. Its projectile weighs 1000 pounds, is fired with 226 pounds of smokeless powder, and attains an initial velocity of 2290 f.s. The 28-cm. (11".02) with its mountings, which are the very latest type, is mentioned; also the 24-cm. (9".45) is noticed. The 21-cm. coast-defense gun is represented and described. Smaller guns, R. F. guns, and siege and field artillery are noticed.

The first-class twin-screw cruiser *Gibraltar*. The fuel supply of warships. New smokeless powder. New torpedo craft. The new second-class cruiser *Fox*.

JUNE 23.—Model of 125-ton steam hammer by the Bethlehem Iron Co. The French navy program. The hardening of steel. H. M. Torpedo Gunboat *Speedy*. The manufacture of small-arms.

JULY 7.—The model Battleship *Illinois*. Transmission and distribution of power by compressed air.

JULY 14.—The Japanese cruiser *Yoshino*.

JULY 28.—The Pennsylvania Railroad exhibit at Chicago.

This article includes a description of the Krupp 120-ton gun and railway carriage upon which it was taken to Chicago.

150-ton electric traveling crane at Creusot. The naval maneuvers.

AUGUST 18.—The test of a Bethlehem armor plate.

This article gives details of test of 17″ plate at Indian Head July 11, 1893, with photograph showing effect of the shots.

AUGUST 25.—Gun trials of the battleship *Ramillies.* The Engineering Congress at Chicago. On the electric light of light houses.

SEPTEMBER 2.—The navy estimates. J. W. R.

The Engineer.

JUNE 16.—Armor question puzzles.

A comparative notice of the Harvey and Tresidder plates, with comments upon the renewed proposal to cover the heads of armor piercing projectiles with wrought iron. The same scheme was tried in England in 1878 but failed: the proposition now comes from Russia.

German armor constructions and French imitations. Launches and trial trips.

JUNE 23.—Launches and trial trips.

JUNE 30.—The loss of the *Victoria.* The first-class cruiser *Grafton.* Her Majesty's ships *Camperdown, Collingwood, Anson,* and *Howe.*

JULY 7.—Chicago exhibition,—triple expansion engine and dynamos.

JULY 14.—The naval maneuvers. H. M. S. *Endymion.* Launch of the gunboat *Antelope.*

JULY 21.—The society of Naval Architects. Naval rams.

While regretting the loss of life and cost of the experiment it is urged that the loss of the *Victoria* be regarded as an experiment and that all circumstances relating to this great disaster be carefully studied and suitable lessons drawn therefrom. In reference to stability it is concluded that water-tight bulkheads cannot save a ship which has been rammed; and that her chances in such case are simply better than if she had none. Generally speaking stability in such cases will depend upon the absence of top weight and this object can be obtained by lowering her guns and thus making them less efficient. The alternative of this is to replace 100-ton guns with lighter guns. It is considered suggestive that at this moment two of the 100-ton guns on one of the largest iron clads of the Italian navy are being replaced by two 10-inch 25-ton wire guns. It appears also that the *Camperdown* came near going down. The argument is here to the effect that the ram of the *Camperdown,* though long enough to sink the *Victoria,* was not long enough to fend off the latter from the upper works of the former. French war ships have rams projecting a long distance under water, which will enable the ship ramming to do so without coming in contact with armor belt.

The naval maneuvers.

JUNE 28.—Trial of the American nickel steel plate.

An accurate account of the armor tests at Indian Head on July 11. The test of a 17-inch plate is considered a great step in advance. The trial is important in being made upon a plate which is practically the worst in the whole lot proposed for acceptance. The inspection branch of our navy have arranged to test chemically and mechanically the metal cut out of every bolt hole of every plate. The results of these analyses are recorded and the plate which shows the greatest irregularity is tested for acceptance. The series of trials are described and data in each case given. These plates had not been treated by the Harvey process, having been made in conformity with orders for nickel plate previous to the development of Harvey's discovery. The resistance to perforation was in all cases good and with respect to fracture perfect. All the plates were accepted, but without premium.

The naval maneuvers.

A brief description of the plan of the maneuvers and the rules for government of the same. The umpires this year will remain on shore and hear and decide all contentions after the termination of the exercises.

Trials of the Japanese cruiser *Yoshino*.

AUGUST 4.—Heat transmission through metal plates The Naval Annual for 1893 (final notice). The naval maneuvers. The U. S. battleship *Massachusetts*.

AUGUST 11.—The naval maneuvers. Bacteriological purification of a sewage.

AUGUST 18.—A new rifling machine. Lessons from the naval maneuvers.

AUGUST 25.—Lessons from the naval maneuvers (continued). -II. The new French battleship.

Relates to the proposition contained in the French naval estimates for 1894 to add thirty-two new vessels to their navy. Amongst these vessels of various types are to be three battle ships of 12,000 tons; the propelling machinery to be triplicate—driving three screws giving a speed under forced draught of 18 knots. The hulls to be protected with an armored belt of maximum thickness of 17½ inches. Instead of an ordinary splinter deck below an armored one, a second armored deck of lighter scantling is to be introduced. The armament will consist of 11″.7 guns in the central batteries and 6.5 and 3.9 quick firing in the auxiliary batteries. The two turret system, one fore and one aft, will be used for the heavy guns and all movements will be given by electricity as in the *Capitan Prat*. The smaller guns will be placed singly behind shields 2″.8 thick.

SEPTEMBER 1.—Ship building in America. The new battleships *Majestic* and *Magnificent*. The naval estimates. American high velocity shooting. J. W. R.

Engineering Review.

The United Service Gazette.

JUNE 17.—The new defenses of France. The artillery of three armies. Infantry efficiency. The coal endurance of warships.

JUNE 24.—The French naval estimates. Army mobilization.

JULY 1.—Coast artillery practice. Coast defense.

JULY 8.—The Duke of York from a naval standpoint. The new defenses of France. A compass card marked in degrees only. Skeleton exercises and their teaching.

JULY 15.—The relative strength of our navy. The value of the volunteer force.

JULY 29.—The French cavalry: its present organization, strength, and distribution. The *Victoria* court martial. The value of skeleton exercises.

AUGUST 5.—The naval maneuvers. Recruiting in the French army. A tremendous indictment.

An indictment or charge made by Sir Thomas Symonds against the British nation for so neglecting the requirements of the navy as to endanger the safety of the country. The admiral of the fleet in an article contributed to the *Fortnightly* presents a formidable array of facts and figures to prove that in *matériel* and personnel the nation is not prepared to meet its probable requirements. One of his claims of inferiority in the English ships is the unarmored ends, a fact which is strongly sustained by the *Camperdown-Victoria* affair. To help overcome this defect in comparison to foreign warships which are armored from end to end, he suggests the construction of six rams of 6000 tons displacement as strong as steel can make them and of great speed. The writer then goes on to show that England's sea power has relatively diminished from about 240 battleships to Europe's 180, in 1807, to 77 battleships to-day against 116 possessed by France and Russia. The writer holds that the country instead of insuring a coal supply is neglecting the matter; the armament of British ships does not compare favorably with these other nations. In reference to the *personnel* it appears that the navy is short of officers by at least 300. In numbers we find a total of 99,000 against France's total of 131,000 and Russia's 54,000.

British Federalism.

AUGUST 12.—The naval maneuvers (the Red side). With the coast of Ireland squadron. The Krnka "tubular" projectiles (continued). Naval maneuvers and their teaching. Gunnery, past and present.

AUGUST 19.—A Crimean reminiscence. The naval warrant officers. Army medical report.—I (continued). The army autumn maneuvers.

AUGUST 26.—The recruiting question. The naval expenditure of maritime powers. The relative strength of our navy.

SEPTEMBER 2.—The late naval maneuvers. The navy estimates' debate. The health of our troops serving in India. Rum in the navy.—I. The relative strength of our navy.

J. W. R.

The Army and Navy Gazette.

JUNE 1.—The naval mobilization. The education of officers.

JUNE 24.—The new infantry drill. Russian cavalry regulations. The corps of commissionaires.

JULY 1.—The new infantry drill—II. Artillery organization.

JULY 15.—Mobilization for home defense.

JULY 22.—The German army bill. The Anglo-Egyptian question. The employment of reserve men.

JULY 29.—Coast defense. Drill and discipline. France, Siam, and England.

AUGUST 5.—Fire tactics. Egypt. Lord Roberts on "India for the Indians." France and Siam. The naval maneuvers.

AUGUST 12.—The lessons of the naval maneuvers. The naval maneuvers (the Red side). Non-commissioned officers' education.

AUGUST 19.—Our naval supremacy. The volunteers at Aldershot. India between two fires. Musketry in India. The Aldershot command.

AUGUST 26.—Army entrance examinations. Army medical efficiency. The French shipbuilding programme of 1894. The Italian naval maneuvers. The manufacture of cordite. The pell-mell firing line. The promotion examination. India under two fires.

SEPTEMBER 2.—Non-combatants and the General-staff. The *Victoria's* stability. Artillery achievements. The French naval maneuvers. The services in parliament. The new first-class cruisers. Our naval literature. The rules of the late French naval maneuvers. The Indian army as it is. Smokeless powder. Education of non-commissioned officers.

Journal of the Military Service Institution.

JULY.—Military sanitation. Army regulations. The three battalion organization. Company papers. Organization of the armies of Europe The past the guide for the future. Drill. Some suggestions in regard to arms, etc. Comment and criticism. Reprints and translations.

SEPTEMBER.—Recruiting and desertion. Army organization. Annotations by General Sherman. Small arms firing. The Bear, the Lion, and the Porcupine. A special service corps for the Quartermaster Department. Practice *versus* theory in army training. Comment and criticism. Reprints and translations.

Journal of the U. S. Cavalry Association.

The Army and Navy Journal.

SEPTEMBER 2.—Army recruiting. Rifle competitions.

SEPTEMBER 16.—Torpedo boats. Formula for pitching tents. The question of small arms. Rifle competitions.

The Army and Navy Register.

Cassier's Magazine.

JUNE.—The life and inventions of Edison (continued). The blower system of heating and ventilating. Leading American engineers. Waste furnace heat under steam boilers. Steam engines at the World's Fair (continued). Progress in heating by electricity. Fast trains of England and America. Modern gas and oil engines (continued). The future of cast steel.

JULY.—From mine to furnace. Recent developments in power transmission.

Article treats of modern transmission in shops and factories. The use of the electric motor is shown in operating looms, lathes, and other small or individual pieces of machinery. The writer informs us that the uses of electric motors in connection with the transmission of power are becoming more widely extended all the time, and illustrates by the installation of the Page Belting Co., at Concord, N. H., where the power is distributed throughout their extensive new establishment by means of electric motors. The electricity for them is generated at works. According to the statement of the president of this company the whole cost was 20 per cent. less than for a steam plant for the same capacity. A valuable comparison with respect to shafting in the two cases follows which in all aspects indicates the great value of the new means of transmission over the old. The use of electric motors for driving printing machines is considered and the great value of this motor established. In conclusion it appears that the whole tendency at present is toward the successful use of large motors.

The life and work of Gustav Adolph Hirn, 1815-1890. Safety devices on railroad cars.

August.—From mine to furnace. Boilers at the World's Fair. Collection of dust in workshops. The life and inventions of Edison. Semi-portable engines in England. Modern gas and oil engines. Anhydrous ammonia gas as a motive power. The Buckley water tube boiler. Copper mining in Nevada. The Glasgow and west of Scotland technical college.

J. W. R.

Hammersley's United Service.

September.—I. The geographical knowledge of the Atlantic in the time of Christopher Columbus.

III. Great Britain as a sea power. IV. The epidemic of militarism in Europe.

The Iron Age.

July 27.—Shipping armor plate. Fast foreign cruisers. The estimation of chromium in steel and iron.

August 24.—Brown wire gun and smokeless powders.

The Scientific American.

July 1.—Proposed submarine boats. The sinking of the British warship *Victoria.*

July 15.—The Krupp traveling crane.

September 2.—Military ballooning in France. The great German search light at the World's Columbian Exposition. The new U. S. S. *Detroit.*

September 9.—The latest armor trial at Indian Head.

Engineering Magazine.

July.—The financial situation. Limits of the natural gas supply. Sculptors of the World's Fair. Development of the modern steam pump. Weak points in trade unionism. Coke manufacture in the United States. International Engineering

Congress. Steam locomotion on common roads. Mechanical aids to building. The safety car coupler problem.

SEPTEMBER.—Some facts about the silver industry. A scientific analysis of money. The real condition of the farmer. The fallacy of municipal ownership. Steamboating in the west and south. Growth of commerce on the lakes. Need of uniform building laws. The development of the nickel-steel armor plate.

This is a valuable article on the subject of armor, taking one through the numerous tests which have developed the most recent types of armor. The article is well illustrated and brings the question up to date.

Electricity and electric generators. Distance not a factor in the cost of railway traffic. J. W. R.

The American Engineer and Railroad Journal.

JULY.—The U. S. protected cruiser *Olympia.*

SEPTEMBER.—The U. S. cruiser *Minneapolis.* 12-inch breech loading rifle mortars.

The Engineer, N. Y.

A new electric locomotive. An extraordinary armor plate and shell test.

The Electrical Review.

The Technology Quarterly and Proceedings of the Society of Arts.

APRIL.—The course in naval architecture at the Institute of Technology. The manufacture of heavy ordnance, with special reference to wire construction.

This paper, by Mr. W. H. Jaques, Ordnance Engineer, consists of a historical sketch of heavy gun construction and then devotes the principal part of the lecture to wire gun construction. This part of the paper relates principally to a short history of the development of the principles embraced in this system of gun construction and the difficulties to be overcome and defects of guns already tested. The Woodbridge and Crozier guns are considered and special space devoted to the Brown segmental wire gun.

Fire proof construction. High frequency electric induction [by Elihu Thomson]. Electrolytic reduction of nitro-benzene in sulphuric acid solution. Excursions of the diaphragm of a telephone receiver. J. W. R.

Jahrbuecher fuer die deutsche Armee und Marine.

June.—The efficiency of the cavalry in battle. Review of the field of military science and literature.

July.—The German-French controversy on armored turrets. The present standpoint of field-fortification, and the "Manual of Field-fortification." The rules of war. The draft of a law concerning the national rifle-club and the military training of the young in Italy.

August.—The history of the small-caliber quick-firing field-pieces. The re-organization of the army in Spain. The method of attack of the Russian infantry.

Organ der Militær-Wissenschaftlichen Vereine.

No. 7.—The use of infantry or sharpshooters in the skirmish-duty of cavalry. Russian ideas on firing from horse-back.

Schweizerische Militærische Blætter.

June.—The new system of the Swiss artillery. Establishment of an artillery proving station at Thun.

July.—Artillery as a principal arm. The new German military problem and its causes.

Internationale Revue ueber die Gesammten Armeen und Flotten.

June.—The nature of modern war and the military problem. Naval armor and artillery, and marine artillery material.

July.—The manual of field-fortification.

Mittheilungen aus dem Gebiete des Seewesens.

Nos. 4 and 5.—Hydraulic gun-appliances in the French navy.

Nos. 6 and 7.—Naval landing-operations.

ERRATA—PAGE 542.

Eighth line, read "angle of elevation $= 3° 33'.2 + .64 \times 6'.8 - 6' = 3° 31'.6$."

Nineteenth line, read "angle of elevation $= 7° 30' - 6' = 7° 24'$."

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VERTICAL FIRE.

BY BREVET BRIGADIER GENERAL HENRY L. ABBOT, U. S. ARMY, COLONEL,
CORPS OF ENGINEERS.

The early completion of the new mortar batteries at Sandy Hook, Davids Island, Boston and San Francisco, the successful development of the new carriage, and the rapid fabrication and delivery of the pieces themselves will soon bring the weapon prominently to the attention of artillery officers, and the time therefore seems appropriate for presenting a paper upon the subject promised some months ago to the Editor of the *Journal of the U. S. Artillery*.

It is to be noted that although precision of fire has been wonderfully increased by rifling, and other modern improvements of construction, it must still be admitted as the result of careful analysis of recent practice with a 9-inch mortar that the chance of hitting a stationary target with vertical fire at ranges from one to four miles is only about half of that with guns of like calibre. This defect is in part due to the longer flight and less velocity of the projectile, which prolong the disturbing effect of the wind, and in part to the fact that the trajectory (often rising more than a mile above the ground) traverses atmospheric conditions wholly different from those at the surface, and therefore impossible to predict.

For this reason I have never advocated the general use of mortars against ships in rapid motion. Experience at Alexandria demonstrated that, to secure satisfactory gun practice, ships must anchor; or, as was done at Port Royal, circle in a manner to return to a fixed position. Under such conditions, even at a range of five or six miles, there is no reason why, if used with skill and good judgment, the inherent defects of vertical fire should not be overcome.

On the other hand mortars in coast defense possess incontestible advantages. (1) The blow is delivered precisely where armored protection is least effective, and in a direction which threatens danger to the magazines, the engines, the boilers and the other vitals of the ship covered against horizontal fire by the water and heavy armor; and even if these vitals are not reached by the projectile the explosion of its charge of 100 pounds of high explosive will occur in the shell-trap above the protected deck where the secondary armament and the bulk of the crew are fully exposed. (2) The mortar battery may usually be located where it is concealed from the enemy, and where no effective reply is practicable. This so materially reduces cost that the number of the mortars may be multiplied without extravagant outlay and their comparative lack of precision thus be corrected. (3) Another merit of vertical fire is that the force of the blow increases with the range instead of diminishing, as in horizontal fire,—the vertical velocity within ordinary limits of practice being measured by the square root of twice the acceleration of gravity into the fall. The latter may be taken roughly at one-fourth of the range for an angle of elevation of forty-five degrees. At sixty degrees of elevation the fall is one-half greater (and the range one-tenth less), and at seventy-five degrees elevation the fall is four-fifths greater (and the range one-half less) than at forty-five degrees. These vertical velocities unfortunately are not great, being below 1,000 feet, and hence the energy required for penetration must be obtained by using large calibres with their considerable weights of projectile. With our new 12-inch mortars these weights range from 625 to 1,000 pounds.

It may be noted in this connection that experience at Sandy Hook has shown that with elevations exceeding about sixty-five degrees there is difficulty in causing the axis of the projectile to remain parallel to the trajectory, and hence the use of higher angles is not favored. It is also found that the service of the piece is facilitated by selecting one of five fixed charges of suitable grades of powder, and regulating the range by slightly varying the elevation between forty-five and sixty-five degrees, rather than by the old method of depending wholly upon a variation of the charge.

The extensive use of vertical fire in the siege of Petersburg by the volunteer artillery troops under my command, as well as the previous preparatory training the regiment received when stationed in the defenses of Washington, first drew my attention strongly to this kind of fire. The results achieved proved the mortar, even in the crude form then in service, to be one of the most effective weapons on the lines of the army; but experience equally demonstrated that it required careful treatment to bring out its good points. Improved modes of pointing over that prescribed in the text books, systematic mixing of the powder for the day's firing to obtain uniformity of action, equalizing the weights of the shells, and many other points no longer necessary to mention in connection with the modern type proved to be essential to satisfactory service. One practical difficulty however was found to be inherent to the system, and it impressed itself upon my mind as something which should be corrected even with the large targets usual in field service, before all the efficiency possible could be secured. For use against so small a target as a ship this difficulty would become still more important; it is simply the impossibility of regulating the pointing by individual gunners when many pieces are directed at the same object. In gun practice the short time of flight enables each gunner to perceive where his own projectile strikes, and to regulate his pointing accordingly. With the long times of flight characteristic of vertical fire this is no longer the case. Shells are falling so thickly around the target that with a flight of many seconds he can no longer distinguish which is his own shot, and his aim may thus remain uncorrected because he

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imagines that he is doing much better than is really the case. Where, as in the case of a siege battery, the target remains immovable this difficulty may in a measure be overcome by determining and recording for future use the pointing of each piece separately; but against a target shifting position like a ship, I am satisfied that no dependence can be placed on individual pointing. One man must regulate the firing of a whole group of mortars to secure satisfactory results.

These considerations suggest how the engineer may assist the artillerist materially by designing the battery so that the fire of many pieces can be controlled as a unit by a single officer, stationed where he can observe the impacts. The problem is simple, and has been solved to develop this principle.

For example, suppose say sixteen mortars are grouped in a single square pit in close juxtaposition. Evidently all of them would call for a common pointing, which may be given mechanically by the gunners with the aid of a horizontal azimuth circle on each platform, with the lines connecting the zero and 180 degree points all parallel to each other, use being made of course of identical elevations and charges. Such a battery would fulfill the purely theoretical conditions of the problem, but any artillerist will see that its service would be impracticable, because the needful magazines and bomb-proofs and routes of supply for the ammunition would be lacking.

Next let us see if the tables of practice, giving the rectangles of mean dispersion in longitudinal and lateral directions, will not justify so separating the mortars in groups of four as to provide room for these magazines, bombproofs, and routes of supply in a central position without so far separating the pieces as to demand individual pointing for each. The following tables contain such data of this character for heavy rifled mortars as I have been able to collect.

Tables of this kind are often misunderstood, and a few words upon them may be not out of place. In preparing them the firing for each group of shots is conducted under as nearly identical conditions as possible. Whether there be a target or not is unimportant. The *mean range* is found by dividing the sum of all the ranges by the whole number of shots. The difference of each range from this mean range, without regard to sign, is taken, and the sum of these differences divided by the whole number of shots gives the *mean longitudinal dispersion*. By the law of error this latter quantity multiplied by 1.69 gives the width of the transverse zone which will include fifty per cent. of all the shots. In like manner is found the *mean lateral dispersion;* and this quantity multiplied by 1.69 gives the width of the longitudinal zone which will contain fifty per cent. of all the shots. Representing these zones upon paper, by two sets of double parallel lines at right angles to each other and of indefinite length, the included area common to both will receive fifty per cent. of fifty per cent., or twenty-five per cent. of all the shots. This rectangle is sometimes known as *the twenty-five per cent. probable rectangle*, and serves to compare relative accuracy of different pieces, firing at different ranges, etc.

The error of supposing that these probable rectangles afford the means of estimating the probable chance of hitting a target at which the piece may be pointed in artillery practice, is apparent. They take into account no mechanical errors of pointing whatever, no errors in the assumed range, and no atmospheric conditions different from those affecting the experiments from which they were derived. Their proper use is relative, not absolute; but together with zones of other percentages of probability, which may be derived from those for the fifty per cent. zones by the use of tables based on the general law of error, they are very helpful in discussing problems like the present. The following are the tables of data referred to above.

The first exhibits eleven records with the 28-centimetre (11.2-inch) mortar, made at the Krupp range at Meppen at various dates from March 14, 1879, to July 14, 1888.

The second table exhibits nineteen records at Meppen, made with the 28.55-centimetre (11.4-inch) mortar in September, 1889. It will be noted that only four shots were fired for determining each mean, and that the results are more discrepant than the preceding.

TABLE (1).

No. of Shots.	Elevation. Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
5	45	476	9	1600	1.6	36.4	58	26
5	45	476	40	8369	15.2	39.6	602	700
5	45	476	62	10781	11.0	23.5	259	1162
10	60	476	40	6859	13.9	39.6	550	471
10	45	761	13	1691	2.6	27.4	71	29
7	60	761	40	5170	17.7	27.1	480	268
5	58	506	13	1993	2.7	20.1	54	40
5	58	759	19	2158	5.6	9.1	51	46
8	58	759	33	4019	7.9	22.0	174	162
10	45	475	42	8513	7.6	59.2	450	725
10	45	475	62	10787	17.6	61.2	1077	1162
		Sums - - - - -			103.4	365.2	4326	4791

TABLE (2).

No. of Shots.	Elevation. Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
4	45	511	57.2	10000	23.8	60.1	1430	1000
4	45	660	17.6	2591	4.0	20.3	81	67
4	45	660	25.3	3994	3.2	7.4	24	159
4	45	660	57.2	9105	10.4	53.9	561	829
4	55	660	17.6	2355	4.6	27.1	125	56
4	55	660	50.6	7412	8.3	49.2	408	549
4	55	660	57.2	8385	12.0	18.8	226	703
4	60	660	25.3	3379	27.8	23.1	642	114
4	60	660	40.7	5361	19.4	80.1	1554	288
4	65	660	33.0	3939	38.8	20.7	803	155
4	65	660	50.6	5787	18.5	27.8	514	335
4	65	660	57.2	6644	25.9	83.8	2170	442
4	45	935	17.6	1906	2.7	25.4	69	36
4	45	935	25.3	2958	1.3	49.6	64	88
4	45	935	33.0	4038	5.6	11.5	64	163
4	55	935	17.6	1798	7.8	14.8	115	32
4	60	935	25.3	2476	21.2	38.8	823	61
4	60	935	40.7	4210	5.9	73.1	431	177
4	65	935	33.0	2938	24.1	53.6	1292	86
		Sums - - - - -			265.3	739.1	11396	5340

The third table exhibits six records of Russian practice made in 1885 with the 11-inch mortar. The details are reported with less completeness than at the Meppen firing, but it appears that the table is a consolidation of the results of about 600 rounds. If so, it is entitled to much more weight than any of the others.

The fourth table exhibits eleven records of Italian practice designed to develop experimentally their 28-centimetre (11.2-inch) mortar, and made between the years 1881 and 1884. The first two rectangles were made in deciding upon the best powder; the next eight, in determining whether a uniform or increasing pitch should be adopted for the rifling (the former received the preference); and the last one with the piece as finally adopted. The number of shots fired to determine these rectangles is reported only for the last one, but it is probable that the same number (10) was used for all the rest. The weight of the projectile is also somewhat in doubt, not being reported for each rectangle in detail.

The fifth table contains eight 10-shot rectangles, the first five with the 12-inch mortar rifled with uniform twist and the last three with an experimental 12.2-inch mortar rifled with an increasing twist-all obtained at Sandy Hook in 1888-90. Although the carriage was of an antiquated pattern, which probably impaired the accuracy of the firing, the precision exhibited is highly gratifying; it is understood that similar trials will be repeated with the new carriage at an early day. The increasing twist was adopted for the cast-iron pattern hooped with steel, as a result of these experiments.

TABLE (3).

No. of Shots.	Elevation.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longitudinal dispersion.	Observed.	By Eq. (1).
	° ′							
	43 30	477	36.1	5668	7.4	40.6	300	321
	43 30	477	46.9	7412	11.0	47.8	526	549
	43 30	559	18.0	2343	5.6	29.7	166	55
	43 30	559	27.1	3597	3.7	22.3	83	129
	43 30	559	36.1	5014	5.6	38.8	217	251
	43 30	559	45.1	6431	7.4	44.3	328	415
		Sums - -		- -	40.7	223.5.	1620	1720

TABLE (4).

No. of Shots.	Elevation Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longi-tudinal dispersion.	Observed.	By Eq. (1).
	45	496 ?	31.9	6766	7.4	48.3	357	458
	45	496 ?	35.2	6802	10.2	86.5	882	463
	60	496 ?	41.8	7005	8.5	42.3	359	491
	60	496 ?	41.8	6910	23.8	46.5	1107	478
	45	496 ?	27.5	6127	11.5	33.4	384	376
	45	496 ?	27.5	6203	12.7	50.9	646	385
	45	496 ?	22.0	4960	8.5	23.0	195	246
	45	496 ?	22.0	4896	7.4	30.9	229	240
	45	496 ?	11.0	2194	5.0 ?	27.8	139	48
	45	496 ?	11.0	2217	8.6	34.2	294	49
10	45	496 ?	44.0	8522	9.1	65.9	560	726
		Sums - - - - -			131.9	489.7	5152	3960

TABLE (5).

No. of Shots.	Elevation. Degrees.	Weight in lbs.		Mean Range. Yds.	50 per cent. zones in yds.		25 per cent. probable rectangle in square yards.	
		Shell.	Charge.		Lateral dispersion.	Longi-tudinal dispersion.	Observed.	By Eq. (1).
10	60	620	33	3913	15.2	59.0	897	153
10	60	627	33	3906				
10	60	627	32	4024	4.7	38.5	181	162
10	60	624	30	4032				
10	45	630	80	10480	70.8	105.6	7476	1098
10	45	669	75	9683	1.9	75.2	143	938
10	60	664	27	4532	6.8	35.5	241	205
10	60	665	17	1950	7.6	22.6	172	38
		Sums - - - - -			107.0	336.4	9110	2594

These tables give fifty 25 per cent. probable rectangles well distributed between ranges of 1500 yards and 10,500 yards, and are sufficiently numerous and accurate to justify an attempt at analysis. It appears that with these large mortars the longitudinal averages about three and a quarter times the lateral dispersion; and that the area of the 25 per cent. probable rectangle in square yards is about 0.00001 times the square of the range in yards. That is, denoting by A the area in square yards of the 25 per cent. probable rectangle; by W, its width in yards; by L, its length in yards; and by R, the range in yards; we have:

$$(1)\quad A = WL = 0.00001\ R^2$$

$$(2)\quad W = 0.0018\ R$$

$$(3)\quad L = 0.0058\ R$$

While great accuracy is not claimed for these formulæ, the discussion shows that precision of fire (measured by the reciprocals of the 25 per cent. probable rectangles) is inversely proportional to the square of the range, or thereabouts. The weight of evidence supporting this law may be seen by comparing the last two columns of the tables, which show that the largest discrepancies from it occur where different similar records diverge most widely from each other. These rectangles also give an approximate idea of what is to be expected from carefully conducted mortar fire *when the target lies at the mean point of impact;* but it is well to remember that this assumes absolute perfection in pointing, which is unattainable in service.

A better idea of the precision to be expected in firing at a stationary object may be formed from some practice in Japan, at a range of two miles, on March 19-20, 1891. The target represented part of a modern armored deck, and had a length in the plane of fire of 59 feet, and a width of 17 feet. It was composed of three sheets of Creusot steel deck armor, properly riveted and jointed, which had a total thickness of about three inches. This was supported by 9-foot steel beams spaced about four feet apart. The firing was with a 28-cm. (11.2-inch) howitzer of modern type, made in Japan from Japanese materials; powder charge, 20.9 pounds; shell, 477 pounds, carrying a bursting charge of 20 pounds; elevation, 58 degrees; range, 3773 yards. Thirty unloaded shell were fired with two hits, and fifteen live shell with one hit, giving an average of seven per cent. of hits. The mean error in range was 134.5 feet; and in direction, 26.2 feet. If the firing had been made under absolutely unvarying conditions, without correcting the pointing for errors noted, the 25 per cent. probable rectangle should have been 142 square yards by formula (1).

The trials also included firing at the same target with a 24-cm. (9.5-inch) mortar, of Japanese construction upon approved modern types; powder charge, 11 pounds; shell, 268 pounds, carrying a bursting charge of 13 pounds; elevation, 60 degrees; range, 3554 yards. Forty-three unloaded shell were fired with three hits, and thirty live shell with one hit; giving an average of five per cent. of hits. The 25 per cent. probable rectangle at this range by equation (1), should have been 129 square yards. The actually observed mean error in range was 131.2 feet, and in direction 49.2 feet.

Lord Brassey remarks: "It will be seen from the drawing that if the target had been a ship's deck, instead of only a portion of it, the number of hits under actual conditions would have been twenty-three, making a percentage of twenty on the whole number of rounds. This is about the same result, as at the Bucharest trials some years ago, where the percentage under the same conditions was twenty-two."

The target (3-inch steel) was curved in form like a real deck and of more than the ordinary strength. The projectiles were of chilled cast-iron. Every shell went clean through, and buried itself deeply in the ground. Two of the hits were with live shells, and both exploded after penetration.

An inspection of these 50 per cent. zones makes it plain that the dispersion in the direction of the trajectory is much more than at right angles thereto, and that to avoid a central sector of comparative safety, our four mortar pits should be placed at the angles not of a square but of a parallelogram with the longer sides directed toward the position most likely to be occupied by the enemy. A careful study of the requirements for magazine space, bombproofs, connecting passages, ample thickness of cover to keep out projectiles, and other engineering details, has led to the conclusion that, with the four pits placed so that the pintles of the outer mortars are on the circumference of a circle 150 feet in radius, and at positions which make the distances between these outer pintles 140 feet in a transverse direction, and 265 feet in a longitudinal direction, all the needful engineering requirements will be fulfilled.

It remains to consider how such a battery would fulfill the artillery conditions. These are of two kinds, ballistic and tactical.

The ballistic conditions may be studied graphically, by the aid of the rectangles showing the probable dispersion of fire from such a battery in zones of different percentages overlapping each other. This was carefully done some years ago when the typical battery was projected.* A range of 4.5 miles was selected, and use was made of the tenth shot of the first table and of the second shot of the third table—the best data available at that date. They indicated for the mean 50 per cent. zones containing half of the projectiles of a single mortar, widths of 28 feet laterally and 162 feet longitudinally. The discussion, taking into account overlapping zones as affected by the partial dispersion of the mortars, showed that a space of 800 feet long and 300 feet wide is covered so effectively that, assuming the battery to be fired by volleys once in ten minutes, a battle-ship having the dimensions of the *Inflexible* would be struck from two to nineteen times per hour according to the position occupied in this space. For the average position about ten per cent. of the projectiles fired would take effect. Ordinary service projectiles for the 12-inch mortar have an energy of impact at this range of about fifty foot-tons per inch of the circumference, while about thirteen to fifteen foot-tons are required to penetrate a 3-inch wrought-iron deck. Hence one hit would end the battle.

In actual firing from a group of mortars it is quite certain that the dispersion of the projectiles would differ from that indicated by these computed rectangles, inasmuch as the different mortars could never be served so as to give identical trajectories parallel to each other; but the greater and more irregular dispersion resulting from this cause would be of immense benefit, because the overlapping of the different zones would be disposed in a manner to cover more ground and with more uniformity. The great practical difficulty in all firing is to make the center of impact coincide with the target, and this is to a measure overcome by the certain wandering of the shots from their theoretical

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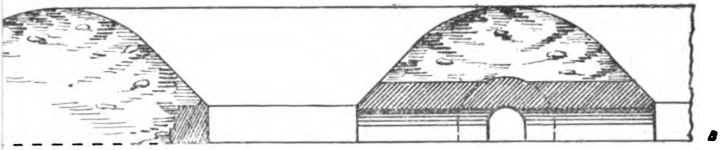
* See plate.

positions. Assuming that the pieces are well served with the assistance of modern position finders, these figures make it evident that no ship could remain at anchor at this range (4½ miles) with impunity.

But certain conditions other than ballistic are demanded to enable the gunners to properly perform their duties; these are met as follows in the batteries under construction: (1) There must be ample room about each mortar for loading; this is secured with the adopted carriage when the four pintles of each pit are placed at the corners of a square twenty feet on the side. (2) Bombproof cover must be furnished to protect the men from the blast at firing, and for passages for conveying the ammunition in safety from the magazines to the mortars; this is provided to the extent of over 350 running feet ten feet wide. (3) Convenient magazine accommodation must be given; there are two, each with a floor space of 580 square feet, disposed at right angles to the long gallery, and with anterooms and entrances so placed that two adjacent pits can be served independently of the other two, without requiring the different detachments to pass each other in the gallery. Capacity for over 100 rounds is provided, the shells (loaded but without fuzes) being stored chiefly along one side of the long gallery. (4) The ammunition will be served on truck cars running on tracks, with overhead facilities for loading. (5) The whole interior will be lighted by incandescent lamps, run by a small dynamo under bombproof cover. (6) All firing of course will be done by electricity; and (7) where arrangements for resisting attacks by boat parties are necessary they will consist of a counterscarp fifteen feet high, with a ditch thirty feet wide flanked by counterscarp galleries at two angles diagonally opposite to each other. Two machine guns in casemates will thus sweep each of the four ditches. Musketry fire over the approaches will be obtained by field intrenchments on the top of the central covering mass, prepared by the garrison after the outbreak of hostilities.

To secure the highest possible accuracy with this system, care should be taken by the Ordnance Department to insist on well graduated azimuth and vertical circles, and any failure in this respect should cause instant rejection of the defective work.



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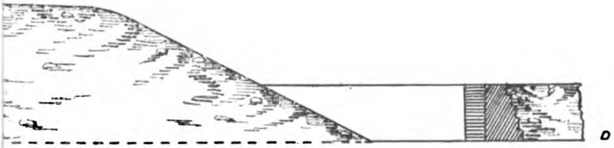

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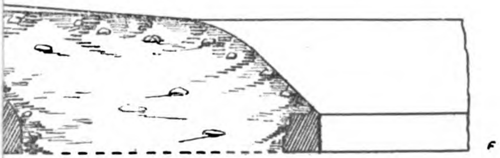

n E-F

Plan.

tions.

MORTAR BATTERY,

DEFENSE.

The engineer cannot be too careful to place all the platforms horizontal, with the lines connecting the zero and 180 degree marks truly in the meridian. Of course any other position for these lines would serve equally well for a single battery, so long as they are parallel to each other; but the true meridian is named in the instructions of the Chief of Engineers in order to assist the commanding artillery officer at a central station where the position of the enemy is supposed to be known, to designate the first trial azimuth to be used at any mortar battery in the harbor.

One of these batteries can be served either by volleys of sixteen mortars, by volleys of four mortars, or by single pieces. The latter method will naturally be used in obtaining the exact range and azimuth after the position of the enemy is approximately determined by the position finder. The effect of the conditions existing in the upper atmosphere will thus be determined by actual trial, and the commanding officer will have every detail under his control, and will be enabled to bring into play the highest professional skill and good judgment. It is to be hoped that at an early day the completion of several of these batteries will permit regular practice to be had by the artillery troops stationed in the neighboring fortifications, and that by this means the entire system may be put to a practical test. Practice over a land range would afford data of extreme value, as by marking the projectiles with a cold chisel, as was done in the preliminary training of my regiment in the Defenses of Washington, it would be possible to discuss the trajectory of each piece separately, and thus obtain precious information respecting group firing which can no where be found in existing records. Indeed, experimental investigation in this new field can hardly fail to lead to useful conclusions as to the best modes of serving modern mortars.

THE ARTILLERY OF THE U. S. NATIONAL GUARD.*

By First Lieutenant ELISHA S. BENTON, Third Artillery, U. S. A.

OHIO ARTILLERY.

Ohio has taken the initiative in forming a regimental artillery organization; this, the only regiment of light artillery in our national guard, occupies therefore a distinctive place in the volunteer establishment.

By General Orders No. 7, from General Headquarters State of Ohio, Adjutant General's Office, Columbus, Ohio, May 6, 1886, all the artillery organizations in the state, consisting of eight four-gun batteries, were consolidated into a regiment designated as the First Regiment of Light Artillery, Ohio National Guard.

This regiment has a colonel, a lieutenant colonel, two majors, an adjutant, a quartermaster, a surgeon and an assistant surgeon, and a chaplain—besides, the usual non-commissioned staff.

Each battery has a captain, one first and two second lieutenants, an assistant surgeon with the rank of a captain; one first, one quartermaster, one veterinary and four line sergeants, eight corporals and from forty to sixty privates.

The regiment has also a band of about twenty-five musicians.

The regiment, when full, therefore has, 9 commissioned officers field and staff; 40 commissioned officers attached to batteries; 480 privates in batteries and 25 in band; an aggregate of about 550—these numbers of course vary from time to time.

The batteries are stationed and armed as follows:

Battery "A," Cleveland, organized in 1872, 4, 3-inch rifles.

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* It is proposed to continue these papers descriptive of the Artillery of the National Guard until that of all the states has been considered. Afterwards it is hoped that the opinions of prominent officers in this service will be presented touching organization armament, drill, instruction and all other questions which relate to the subject of efficiency. In this manner defects and points of excellence will be drawn out to the view of all. Such discussion should analyze methods and suggest improvements, and constantly collect good practical ideas for the use of all.—Ed. *Journal.*

Battery "B," Cincinnati, organized in 1882, 4 Gatling guns, cal. .45, 1883.
Battery "C," Zanesville, organized in 1886, 4, 3-inch rifles.
Battery "D," Toledo, organized in 1866, 4 Gatling guns, cal. .45, 1883.
Battery "E," Springfield, organized in 1881, 2, 3-inch rifles, 2 Gatling guns. cal. .45, 1883.
Battery "F," Akron, organized in 1877, 4, 3-inch rifles.
Battery "G," Marietta, organized in 1877, 4 12-pdr. Napoleons.
Battery "H," Columbus, organized in 1884, 2 Gatlings model 1891, 2 breech-loading 3".2 rifles.

There are no traveling forges and battery wagons with these batteries, but each of the pieces is supplied with a good limber and caisson. Each of the Gatling guns is fully supplied with the necessary tools.

Each officer has a full outfit of horse equipments. The uniform, both dress and fatigue; the blankets, haversacks, canteens, sabers, etc., are the U. S. army regulation.

The men are required to buy their dress uniform and the officers are required to buy their own uniform and equipment throughout.

The regimental colors and battery guidons are also in accordance with the U. S. army regulations.

Officers are elected by the votes of the men. After election the officer goes before the regimental examining board and if he passes a satisfactory examination, he is recommended for a commission and receives one, for five years, from the governor.

This system of examination for commissioned officers keeps the standard of this regiment high. All the officers, or nearly all, have seen long previous service as enlisted men, either as non-commissioned officers or as privates, or as both, and have not only become familiar with their duties in that way, but many of them have studied the theory of artillery and are somewhat versed in the science of their profession.

The enlisted men are between the ages of sixteen and forty-five. The ranks of this regiment are recruited from the best walks of life; the men being nearly all young, vigorous, and active in the cause.

There seems to be a marked military courtesy which extends throughout the regiment—there is a prompt and cheerful obedience to orders, and a self-respecting and prompt response to the requirements of military courtesy. By such a spirit as this the regiment has been brought to a high state of efficiency.

Officers on duty receive the pay of officers of like grade in the army, while in camp they receive half pay; men on duty receive two dollars a day for thirty days and then one dollar a day—while in camp they receive one dollar a day. All are allowed forty cents a day in camp for subsistence.

Batteries "A," "B," "C" and "D" have very fine armories with very large drill floors and all facilities for instruction, the other four batteries also have good armories but are not so well fitted up.

The batteries drill once a week with special drills for recruits besides. These drills are usually standing gun drill, or marching drill in the school of the battery dismounted. These batteries are drilled well and understandingly, but have little mounted drill, with perhaps the exception of Battery "E" which nearly always marches to the annual regimental encampments. In those cases, however, in which the batteries march to camp they are kept well in hand on the journey and brought into camp in good condition.

In some of the camps, notably that of 1887, the regiment had some target practice. In the case mentioned the record of firing, at 1000 yards, was very creditable.

All the batteries are accustomed to participate in local celebrations and thus always get some mounted drill.

The regiment usually encamps every summer for about eight days—this time is always crowded with instruction—drill follows drill, and inspection follows inspection.

This regiment has the peculiar advantage that being wholly artillery the entire course in camp is artillery instruction. In many batteries in other states, associated as they are with infantry in their camps, the instruction received during this most valuable time is much of it applicable only to the infantry.

Each of the batteries has a fairly complete messing outfit.

The usual battery and regimental record books are as a rule well kept and there seems to be a fairly good idea of the "paper work" necessary to a good organization which is usually lacking among militia organizations.

In addition to the inspections in camp by U. S. army and regimental officers, each battery is occasionally inspected in its armory by a regimental officer detailed for that purpose.

Several of the batteries have seen active duty and each time acquitted themselves well.

In 1884 Battery "A" figured conspicuously in the Cincinnati riots. Anticipating orders, the captain had his battery assembled at the armory; the battery was on the train, guns and baggage loaded, and was leaving the station thirty-five minutes after the order was received.

Since its organization this battery has fired 25,000 rounds at target practice and in the way of salutes without an accident of any kind.

Battery "B" has seen more service than any of the others; it was on duty during the Cincinnati floods of 1883 and 1884, during the Cincinnati riot of 1884 and the labor troubles of 1886. This battery won the first prize for machine gun drill at Washington in May, 1887.

Battery "D" was organized in 1866 by the surviving veterans of Battery "H," First Ohio Volunteer Light Artillery, for the purpose of perpetuating their record and history. This battery has seen much active service snce the war; notably in the labor troubles in Toledo in 1877, and in 1887 at the Paulding county reservoir against the "Dynamiters."

This regiment stands upon a fairly good war footing to-day--it can be assembled in Columbus in ten hours, some of the batteries getting there in half that time. In large cities, where there is a riot alarm, it takes but a few minutes to get the men to their armories. In other places it is only the work of an hour or so to notify all the men.

Many examples could be given of the zeal and enthusiasm of the men. In loading for the trip to New York to participate in the celebration of the centennial of Washington's inauguration, April 30, 1889, Battery "A" succeeded in getting its four guns, four caissons, harness and horse equipment into one car.

In the same trip Battery "B" was subsisted from Cincinnati to New York by provisions purchased before, and by aid of an oil stove in one end of the car the men were supplied with hot coffee.

These examples show that this regiment could be very quickly placed in condition for active service. The various officers of the army who have inspected this regiment have spoken in the highest terms of its condition.

At the time the regiment was organized it was commanded by Colonel Louis Smithnight, of Cleveland, who had been for many years the captain of Battery "A." He resigned June 11, 1891, followed by the regrets of the entire regiment, by whom he was beloved for his kindly yet firm character. The present colonel is Edmund C. Brush of Zanesville; he is an enthusiast upon the subject of his regiment and works continually for its good. In a letter to the writer he says:

"The general government should arm the militia and take a more active part in its affairs. The armament should be the same as that of the U. S. army, so that the two organizations could take the field and be supplied by the same ammunition train.

"The organization of the guard into regiments and larger units should correspond to the U. S. army, so that there would be no confusion in case the organizations were brought together.

"The uniformed and equipped militia should be called the 'National Volunteers,' as for instance, the 'Ohio National Volunteers.' The oath administered to officers and men should so read as to swear to obey orders from the President of the United States, &c. He has the power to call for the militia, let the militia include in the oath the above."

"I believe that the education given by the U. S. government at West Point, to the young men, is for the good of our country first and for the young men next. Give these young men a chance to impart their knowledge gained at West Point to the national guard. It would benefit the guard and the regular service by keeping officers interested and up in the art of war."

"For a state the size of Ohio let two or three educated military men be detailed to visit every armory monthly and deliver a series of talks on practical subjects of use to the guard. The regular and militia forces each have a mission to fulfill; let each understand its position, throw aside all feelings but one—the good of our country—and elbow to elbow try to be the best military organizations in the world. Men who are in the army and guard, through motives of pure love for country, are ready to do this."

He further adds: "The magazine being published at the U. S. Artillery School should be found in every guard battery's armory and should be devoted to the interests of the regular and militia artillery. Make the militia feel that the regulars take an active interest in its welfare. Have artillery officers at every camp of militia artillery, and militia officers of artillery with regular artillery on practice marches and camp tours. Get the two organizations together—encamp them together."

The other officers are as follows:

Lieutenant Colonel E. O. Dana, Cincinnati.
Major Owen J. Hopkins, Toledo.
Major Joseph C. Ewart, Akron.
Surgeon Willis W. Hall, Springfield.
Assistant Surgeon Henry M. Clewell, Cleveland.
Quartermaster C. V. Shryock, Zanesville.
Adjutant C. T. Atwell, Zanesville.
Chaplain, Rev. L. B. Moore, Cambridge.
"A," Captain George T. McConnell, Cleveland.
"B," Captain Fred. J. Herman, Cincinnati.
"C," Captain Henry A. Leslie, Zanesville.
"D," Captain George V. Roulet, Toledo.
"E," Captain John G. Kennan, Springfield.
"F," Captain James D. Chandler, Akron.
"G," Captain David Dow, Marietta.
"H," Captain W. N. P. Darrow, Columbus.

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MASSACHUSETTS ARTILLERY.

The field artillery of the Massachusetts Volunteer Militia consists of three batteries. The first, Battery "A," Light Artillery, is attached to the Second Brigade: the other two, Batteries "B" and "C," are formed into a battalion called the First Battalion of Light Artillery, with field and staff, and attached to the First Brigade.

The battalion mentioned above is commanded by a major, who has a staff as follows: an adjutant, a quartermaster, a surgeon (major), an assistant surgeon, a veterinary surgeon and a paymaster.

Battery "A" is located at Boston; Battery "B," organized May 10, 1869, at Worcester, and Battery "C," organized May 10, 1886, at Lawrence.

Each of the batteries has a captain, two first and two second lieutenants; one first, one quartermaster and six line sergeants, one guidon (corporal), twelve corporals, two buglers and eighty-four privates—making a total of 112.

The uniform both dress and undress is the same as the regular army and consists of great coat, dress coat, trousers, white and black helmets, forage cap and blouse. The entire state troops have been recently furnished.

The officers are elected by the enlisted men, but are examined by a board of officers, convened for that purpose, in regard to their military and general knowledge; they hold commissions for life.

Privates are enlisted for three years and, after serving one term, may re-enlist for a period of one, two or three years. When young men present themselves and desire to enlist they are questioned as to their taste for military life, their character is investigated and, after being properly vouched for, they are put into squads and drilled. If found apt, they are accepted. The men are from all professions and trades, clerks, etc.

Each battery has four three-inch rifles and two Gatling guns. Each rifle and caisson has two teams, making eight horses, the Gatlings take only two horses each; so that the batteries require thirty-six draft and sixteen saddle horses. Red blankets are used for draft horses and the red saddle cloths for saddle horses. The batteries have the regulation belts, sabers, canteens and haversacks.

The officers receive the same pay as officers of like grade in the regular army when called to perform duty, as follows: invasion or insurrection, tumult, riot or mob, fall drill five consecutive days in camp, escort and other duty.

Enlisted men at all times are paid two dollars a day. For all horses four dollars a day is paid. Food for officers. men and horses must be provided out of pay.

The armories in large cities in Massachusetts are built by the state and are very good buildings. That of Battery "B," Worcester, cost about $100,000, and is well arranged. The drill room is 150 x 75 feet, besides good large company room, officers' room, harness room, store room, lavatories and all possible conveniences.

At the risk of taking up too much space I will describe the new armory of the Lawrence battery, which also contains the headquarters of the 1st Battalion of Light Artillery. This armory cost $90,000 and is built to accommodate four infantry companies and the battery.

The main body of the building is one large drill shed 68 x 125 feet, at one end of which is the head house so called, and at the other end the gun room.

The battery occupies the lower floor of the head house, which is 58 x 74 feet. There is one room for battalion staff 19 x 8, one for battery officers 19 x 8, one for non-commissioned officers 14 x 26, one for privates about 26 x 40, one for uniform (full dress) 16 x 25, two for storage, in basement.

The gun room is 25 x 70 feet—in this room there are six harness racks, built on trucks, which can be moved about like any other carriage. The armory contains elaborate toilet rooms and a boiler room with a sixty horse-power boiler, etc.

Everything is finished in ash, with light finish of filling. The furniture furnished by the state will cost about $2200; besides which, the furniture of battery rooms will be old oak at a cost to the battery of about $1000. The state builds these armories and the city pays annually the interest and one-thirtieth of the bonds, so that in thirty years the armories become the property of the city.

The batteries have one drill a week and also some non-commissioned officers' meetings and drivers' drills. These drills are usually given out beforehand, by paragraphs, and the non-commissioned officers and drivers are instructed orally and by blackboard. In camp they usually have one day of mounted drill; the drivers are permanent men in the company and from a class that have to do with horses.

The permanent camp is at South Framingham, and Battery "B" always marches to camp, a distance of twenty-five miles. Battery "C" frequently has marched, but the distance, thirty-five miles, is too far for one day and therefore impracticable. The batteries seldom, if ever, get any target practice.

The batteries are quite fully equipped for field service and could be placed in Boston within six hours after receipt of order. There are however some things lacking for immediate field service, such as tentage, cooking utensils, etc., besides which there is but very little if any ammunition kept on hand, except for the Gatling guns.

The battery at Worcester has always had a very high reputation for excellence. The captain, Lawrence G. Bigelow, writes as follows:

"I think the militia a very necessary institution, and everything that it is possible to do to make it more effective in time of need should be done. For instance, more money spent in arming, equipping and in armories; also, better care of property and more care in selecting officers. I would like regular army officers detailed to instruct militia officers in their more particular duties by lectures and examples. Have the two go to camp together and the one try to learn the teachings of the other."

Captain L. N. Duchesney, of the Lawrence battery, is an old soldier and saw four years service during the war from 1861 to

1865; serving three months in 6th Massachusetts Infantry, three years and six months in 1st Massachusetts and 26th New York Cavalry, from private to captain, including sixteen months in Libby and Salisbury prisons. He writes as follows:

"The greatest difficulty in the artillery is in regard to the horses. If it were possible to have the state buy horses and so arrange to have stables in close proximity to armories, and under the careful management of some competent man have the animals employed sufficiently to pay expenses and to replace those lost by death or by becoming unfit for artillery work, it would solve the problem; this is the only obstacle in the way to insure for the militia artillery the greatest possible success."

"The very best of our young men would flock to our ranks, and, it may be my fanciful idea, but I would be willing to risk my reputation in predicting a popularity for the artillery which would be irresistable."

"I have a scheme, and I think every other militia artillery officer has, to form stock companies for this very purpose, to secure at all times a sure and perfect supply of ready trained animals and permanent drivers, so that the battery would become as proficient when mounted as on foot or gun drill."

"In reply to the question as to what could be done, it is hard to state. I am sorry to say that too many of our leaders in the militia do not appreciate the value of the light artillery service for future wars, and to advance ideas for the betterment of the interest of this branch of the public service, with no hope of doing anything in the enactment of laws to increase its efficiency, is like writing a romance without a hero. We need the coöperation of the general government--the forts in Boston harbor should be at the disposal of the artillery for the purpose of target practice, and ammunition should be furnished by general government and regular officers detailed to instruct the officers and men of the state artillery."

"Occasional batteries of regulars and militia should be joined in route marches for instruction in the bivouac, care of horses, selecting camping grounds, to teach men to care for themselves in cooking and everything that men should know in case they were called to active service."

"I believe that the battles of the future will be fought at long range so that the artillery thus demanded for them will be greatly increased as shown by the experiences of the late war. I appreciate everything in the advancements made in the regular army and navy, in improved guns and projectiles, etc., since the war and now under way and it is galling to an old soldier who loves the service as I do not to be able to see these improvements going on and not to have the opportunity to practice and keep up with the times. You will readily see that the only thing which the poor batterymen of the national guard need is 'an appropriation of money with which to thoroughly equip themselves. We are millions who are willing to train so as to be ever ready, if need be, to battle for our country.'"

Major George S. Merrill, who also served during the war in the Massachusetts Volunteers, commanding the First Battalion Artillery, M. V. M., writes at length and very thoughtfully upon the artillery question; I can only quote his closing sentences.

"The need of the artillery to-day is actual target practice, it is in all other respects well drilled and ready for efficient service. I, last year, after several personal suggestions of a like character, sent to the Adjutant General a communication asking that instead of the one day annual drill, which with untrained horses is of very little advantage to the artillery, I be permitted to take my battalion to Fort Warren, in Boston Harbor, the consent of the government being obtained for its use, and that there under the direction of the regular artillery officers it have a day of actual target practice."

"Unfortunately such extensive repairs were being made in the fort that it was found impracticable to carry out this suggestion at that time, but I hope in the immediate future that this will be adopted and this branch of the service be given, as is the infantry, one day each year of target practice."

"One other need of the militia of this commonwealth, and that I think will be remedied in the immediate future, is the providing of cooking utensils to each organization and a change in the system so that each company may have the experience during five days of encampment, which they would so much need in the field, in preparing and serving their own rations.

This would not only very materially reduce the expense to the men, as the rations are provided out of the pay allowed by the state, but it would be of advantage in case any portion of the militia was suddenly called upon for actual service. The need of this was strongly illustrated when a portion of the New York national guard was called out during the strike at Buffalo."

TEXAS ARTILLERY.

The Texas Volunteer Guard has three batteries of field artillery, known as the First Battalion of Artillery.

Battery "A," of Galveston, organized in 1839, contains about 100 men; Battery "B," of Dallas, organized in 1879 and contains about 60 men; Battery "C," of Brenham, was organized June 17, 1887, and contains about 41 men.

The uniform is the United States army regulation: the Dallas artillery has adopted a braid on the coat and a red trimmed cap, while the Galveston battery has both a dress and undress uniform. All the batteries are obliged to purchase their uniforms, as the state has never provided them. The average cost of the undress uniform is about twenty dollars, while the dress uniform costs something more.

Each battery has one captain and three lieutenants; these officers are elected by the votes of active members in good standing, and, by recent orders, must pass a compulsory examination. Those of Batteries "A" and "B" have held office for one year and those of Battery "C" for three years, but the term is now fixed at three years. The qualifications necessary are military and always have been shown by previous service in the battery; they may be briefly stated as follows: Proficiency in the manual of the piece, school of the battery, such rules and regulations as are necessary for the discipline of a camp of instruction, a sufficient knowledge of the articles of war as is applicable to the national guard, courts-martial, military courtesy, ability to handle and instruct men, and a knowledge of the militia laws of Texas.

The privates are enlisted for three years and sworn into the state service, but have the privilege of resigning at any time

They are obtained as a general rule by their own choice, they join because of the social features connected with such organizations and from patriotism, and are generally obtained from the young men of the country who are fond of military display, possessed of courage, and a desire to serve their state if needed.

In most cases enlistments are voluntary, without solicitation. The members of the battery vote on each and every application, three black balls usually rejecting, and good substantial young men are generally obtained. In the Brenham artillery nearly every man is a business man and man of family.

The armament of Battery "A" consists of two 12-pounder Napoleon guns, two 3-inch rifles, four mountain howitzers and one .45 cal. Gatling gun; that of Battery "B" is one .45 cal. Gatling gun, recent model, and one 12-pound bronze gun, together with some few sabers, etc; that of Battery "C" is two .45 cal. Gatling guns, with harness for eight horses together with revolvers and sabers.

The pay allowed by the state is that of U. S. army. Enlisted men one dollar per day. No pay is allowed in camp, but at this time commutation is allowed at the rate of fifty cents per man, with an allowance of one dollar per day for horses.

The state allows no money for rent or purchase of armories, but, notwithstanding this fact, all these batteries have fine armories which are owned by or in the battery.

Battery "A" has a large two-story building suitable for military purposes, very well arranged and handsomely fitted up. The value of the armory and furnishings is about twenty-three thousand dollars.

Battery "B" has a fine armory, worth about ten thousand dollars; this building is 130 × 60 feet, standing on a lot 100 × 228 feet, drill room on ground floor 60 × 100, large company room, rooms for saber rack, store room, etc.—the upper story has a large ball room.

Battery "C" has also a fine armory sufficiently large to comfortably house the guns and harness, the latter is carefully cared for.

The batteries are all very proficient at dismounted drill, usually drill once a week or oftener, but as the state provides no horses and the harness is nearly all unserviceable it is almost impossible to get any mounted drill—they always have a little practice during their annual encampment, but not much.

The Brenham battery is, however, an exception to this; during the summer months they usually have one mounted drill per week: the members of the company own their horses and they are used in the battery drills free of charge. The drivers are selected from among the members, those best fitted are picked out and change about riding lead and wheel teams; they are exempt from payment of dues, etc.

The benefits enjoyed by the members of these batteries are, exemption from road duty, jury duty and the payment of poll taxes—counting the probable time that would be served on jury duty this amounts to about ten dollars per year. The individual expenses incurred by the members are much greater than this each year.

The only active service seen recently by Battery "A" has been two days in strike of 1886. Battery "B" also served at this time, and, reporting with one 3-inch gun, was obliged to improvise its own ammunition by filling oil cans with buckshot after knocking off the spouts. Battery "C" has never been ordered out.

These batteries camp each year for about ten days at the permanent state camp established at Austin, Camp "Mabry," named after the present adjutant general of Texas. All these batteries have been frequently complimented on their drilling. Battery "C" usually goes into camp mounted.

All the batteries have had target practice with Gatling guns, with most satisfactory results.

The condition for active service of the Brenham battery is very good, since they have horses and men already well up in mounted drill; but the condition of the other two batteries is not so good. This is owing entirely to their poor equipment, however, since the men could be readily assembled. The Brenham battery could take the field at once, while the others would be obliged to get nearly all the necessary field equipment before moving.

The Dallas battery is exceptionally well drilled and has drilled in prize drills as follows: At Austin in May, 1888, they took second place; at Nashville, the following week, they were fifth in a field of six batteries; at Galveston, in 1889, they won first prize; at Indianapolis in July, 1891, first prize in a field of four batteries; at Omaha, Nebraska, in June, 1892, second, three batteries competing.

These batteries have had the good fortune during their last three or four annual encampments to encamp with Light Battery "F," 3rd U. S. Artillery, on which occasions the officers of the army have been untiring in their efforts to aid them.

The following opinions of the captains of the different batteries will be of value, as showing the needs of the militia artillery.

Captain S. L. Crawford, of Galveston, writes as follows: "I do not consider the Gatling gun as belonging to our branch. We cannot practice with the 3-inch rifles as the state persistently refuses to furnish us with the necessary ammunition, and the military organization that furnishes its own uniforms, pays its own armory rent, and keeps its arms in good condition, must draw the line of expense somewhere. I might mention that this lack of interest, in both state and national government, is causing a very lukewarm feeling to enter the mind of the militiaman. As to our condition for active service, it is a hard question to answer frankly. As you know, our drill is the dismounted drill; we could assemble a battery for same in defense of this city in less than one hour, and serve our guns, provided we had the necessary ammunition. But when you ask me how soon my battery could assemble equipped for the field, horsed, with the necessary drivers, artisans, etc., I must say 'I give it up;' although, should a crisis require it, I think that we could get into shape quicker than our unorganized condition would indicate.

"As the militia are proficient with the dismounted drill, handling of the piece, etc., it may be a good idea for them to continue in that line: for the regulars excel in handling the horses and driving. Could we meet at our annual state encampments and combine forces, I think that it would do us decidedly more good than our present mode of drilling, for it seems to be out of the question for us to receive horses or ammunition with which to practice."

"If the regulars and militia would devote a week or ten days to this joint drill, and be on the move part of the time, with target practice, etc., I think that we would derive as much experience in ten days as we would in ten years of our present mode of doing business. Of course, this would be all for our benefit."

"We need from the government, uniforms, money to pay armory rent, and ammunition for practice, none of which we receive. I will say this, that batteries in sea-coast towns, which towns should all have some *stationary guns* of defense, should be manned by cannoneers who, from constant practice, have become familiar with their range, etc. As the defense of one's town naturally stirs up the patriotism of a man, I think that there would be no trouble in arousing interest in said work."

Captain F. V. Blythe, of Dallas, writes as follows: "That a well armed and disciplined national guard is absolutely necessary to the maintainance of law and order, has been so clearly demonstrated in the last few months that no doubt on that point exists in the minds of any but the fanatical so-called friends of the working classes and demagogues pandering to the same class with an eye single to their own glory and future political advancement."

"This force must be free from all political influence, and, regardless of class or prejudice, be prepared to repel any assault against the laws or established authority."

"The civil authorities, fearful of losing place and influence, will too often parley with men whose incendiary and unlawful conduct has placed them outside the pale of the law, and only the strong arm of those whose training has taught them that law and order are of the first importance, regardless of class or party or the effect it will have on the next election, will suffice to undo the harm such weak and vacillating officials may cause. Pennsylvania, in my opinion, has solved the problem, and the magnificent manner in which her force was concentrated at Homestead last July shows what may be done with the national guard when under the command of able men and backed by a patriotism that does not stop to count the cost in dollars and cents when the necessity is shown to exist for the maintenance of such a force."

"The legislation necessary to place the force in this state on an effective footing would call for the framing of an entirely new militia law, the one under which we are organized not contemplating any financial assistance for the volunteers."

"Every dollar of the expense connected with the service comes from the individual members, and the artillery branch of the service must provide ammunition for target practice, must pay all repair bills on ordnance which is issued to them in unserviceable condition, and if they have a mounted drill it is a considerable expense for horses."

"Men should be uniformed and equipped for actual service; armory rent, lights and janitors' wages should be provided for; ten days in annual encampment should be compulsory with pay for such time, and this time should be spent in practical instruction in field exercises, target practice, marching, camping, guards and outposts, and the handling of the men in the enemy's country. Systematic target practice during the year should be provided for and required. We have none of these nor will have under the present law."

"I am of the opinion that a national militia law, making the guard a national force in fact, would be better than the present method."

Captain C. F. Herbst, of Brenham, writes as follows: "In my opinion the militia service can only derive the greatest benefit from being thrown in contact with the regular army forces at the various annual state encampments, the example set by them has had a wonderful effect on the volunteer guards. In order to have a thoroughly drilled and equipped militia force in our state a great deal of friendly legislation is necessary. So little is done for the men who voluntarily enlist for the good of their state that in my opinion the increase of the militia forces, or even the keeping of them at a proper standard, is out of the question. The state furnishes absolutely nothing except arms, accoutrements, and rations at the state encampments. It certainly would be a credit to the United States should the national congress pass such laws as would not only encourage the military spirit but aid the volunteer forces materially by large appropriations of funds for the purchase of uniforms, for defraying the expenses of armory rent, loss of time, etc., to be regulated by the executives of the different states.''

"I think that a union of interest and duty between the U. S. army artillery service and the national guard or state troops could be brought about by a uniform armament, by placing modern guns (not old, dilapidated, worthless, condemned ordnance) in the hands of volunteer artillerymen, such as Gatling or breech-loading rifled guns; by establishing a system of instructions through competent army men, commissioned and non-commissioned, at convenient times at the different towns and cities where enough interest is taken by the state organizations.''

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Captain F. V. Blythe, Dallas,
ex-Captain A. P. Wozencraft, Dallas.

KANSAS ARTILLERY.

The Kansas national guard has only one battery of light artillery, Battery "A;'' this battery is divided into two platoons, the first stationed at Wichita consists of one captain, one first lieutenant, one second lieutenant and thirty non-commissioned officers and privates. The second platoon is stationed at Topeka and consists of one first and one second lieutenant, and thirty non-commissioned officers and privates. The present organization is dated from July 16, 1888.

The uniform is the same as U. S. army, with the white helmet for summer wear.

Commissioned officers are elected by men and commissioned for five years. The privates are recruited from young men of good physique, less than six feet tall; the battery is always full of the best material and always has a great many applicants to select from.

The battery is armed with four bronze cannon and one Gatling gun—the brass guns are very old, some of them cast in 1842 and are perfectly useless; they were a part of the 2nd Kansas Artillery during the war. The battery has artillery sabers and belts, canteens, haversacks, blanket bags, ponchos, with 9×9 wall tents for men and 10×12 for officers, The battery is also armed with .50 cal. Sharp's carbines and slings and belts.

The same pay is allowed the officers as in the regular army, but only when ordered out by governor or sheriff of county.

The state allows $50.00 to each platoon each quarter, for rent. The platoons each have good drill halls with large rooms attached for commissioned officers, etc.

The battery drills twice a week the year round, usually dismounted drills with pieces; they drill enough with carbines to learn how to handle them well; the percentage of attendance at these drills is about seventy-five. There is also mounted drill five or six times a year; the drivers are cannoneers who volunteer to drive.

The battery was ordered to Stevens county seat war for four weeks in 1884 with Gatling guns, and again for six weeks in fall of same year and has been turned out to guard the county jail several times. Although no appropriations have been made by the state for camping since 1886, the battery has camped five times a year with the G. A. R. on the average at the state reunions and various county reunions, and is well known in the state for discipline and proficiency in drill.

Captain Willis Metcalf, of Wichita, writes as follows: "I have been in the national guard of this state for twelve years and think the service the best possible place for young men. It sets them up, gives them a better carriage and teaches them something that some day will be of use to them and the state that is doing so little for them now. I want to see the U. S. army officers and national guard officers stand together, organize and make an assault upon congress this fall and obtain what legislation we need; for in case of crisis you will look to us to organize armies, etc., and the better the shape in which you find us the better service we can accomplish.

"If we could encamp or go on a practice march with the battalion at Fort Riley thirty days each year, we could learn more than in ten years in the armory. But of course it is hard to get men who can give up thirty days without great loss to themselves. I think that one officer from each battery in the national guard should be sent to some artillery school similar to the one at Fort Riley, for six months, then they will be in shape to practically instruct recruits. They will then be something near the standard of the U. S. Army, at least be instructed by officers of the regular army."

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RHODE ISLAND ARTILLERY.

The light artillery of Rhode Island consists of a Gatling gun battery and a light battery, both of which are in Providence.

The light battery, designated as Battery "A," was organized in 1801 and chartered by the state; it is the oldest artillery organization in the United States. It consists of one captain, two first lieutenants and one second, and the usual non-commissioned officers; the aggregate is about sixty. The Gatling gun battery was reorganized July 31, 1891, by act of legislature and consists of one captain, one first and one second lieutenant, one first, one quartermaster and four line sergeants, four corporals, one musician, one guidon and twenty-eight privates; an aggregate of forty-three.

The uniform is patterned after the United States service and consists of dress and undress, with overcoat.

The officers are elected for a period of three years and are commissioned after passing the prescribed examination. The men enlist for the same period. The enlisted men are mechanics, clerks, accountants and horsemen. Many of the machinists in the light battery are familiar with guns, as they work on the Martini rifle, the breech-loading mortar, Howell torpedoes, etc.

The Gatling gun battery is a four gun battery without caissons. The light battery is armed with six 6-pdr. bronze guns with caissons, and two 3-inch rifles. The men have canteens, haversacks, rubber and woolen blankets; sergeants only are armed with saber.

The officers, when on duty, receive pay at same rate as in the regular service; men receive one dollar and a half a day.

The armory for the light artillery is owned by the state, is built of stone, and is in good condition, but not as convenient as some more modern in construction; the armory of the Gatling gun company is leased by the state.

Drills are held about twice a week and are usually confined to the standing gun drill, mechanical manœuvres, school of the battery dismounted and squad drill for recruits. There is also a school of instruction for officers and non-commissioned officers. The batteries go to camp each year at Oakland Beach, for a period of five days; they are also horsed at other times during the year for parade. Drivers at mounted drills are men who handle the same horses in their regular business.

The light battery could be manned and horsed in twelve hours or less notice, and could go into the field with personnel well clothed and with sufficient camp equipage. Has battery wagon and forge and the battery does its own horse shoeing in camp.

Light Battery "A" has quite a distinguished history. It was first paraded as a light artillery organization in May, 1848, and was the first light battery in the volunteer service. Rhode Island's famous war governor, William Sprague, resigned his commission as commander of the battery to accept the position of governor during the war. This battery sent out, or were instrumental in sending out, during the war, eleven light batteries numbering some two thousand men. More than fifty of the men whose names may be seen on the signature book held commissions from brigadier general down. Among the most prominent are: Brevet Brigadier General Charles H. Thompkins, Chief of Artillery, 6th Army Corps; Brevet Brigadier General Francis F. Lippitt; Brevet Brigadier General John G. Hazzard, Chief of Artillery, 2nd Army Corps; Lieutenant Colonel J. Albert Monroe, Chief of Artillery, 2nd and 9th Army Corps, and commander of Camp Berry school of instruction for batteries, Washington, D. C.; Colonel Henry T. Sisson, 5th Heavy Artillery;

Colonel George L. Andrews, 10th Missouri and Lieutenant Colonel 17th U. S. Infantry; Lieutenant Colonel William H. Reynolds, 1st Rhode Island Light Artillery, and Major J. B. Patch, 1st Rhode Island Infantry.

Captain E. R. Barker, commanding Battery "A," although not a veteran of the war, has seen continuous service in the Rhode Island militia, both infantry and artillery, since 1878. He is an enthusiastic artillerist and writes as follows: "I believe that the volunteer service will compose the greater portion of any army of size that the United States government will put in the field in future wars, as in the war of the rebellion; that it has made great improvement and advancement in drill, discipline and equipment in the last ten years; and that in many states it is prepared for and should have better facilities, in theoretical and practical study, in the use of instruments, a general knowledge of chemistry and explosives, which knowledge I believe should be imparted at the expense of the general government.

"I believe the national government should own lands and buildings in each state, where there could be constructed proper appliances for study and instruction. Until then, I believe that the best results would be obtained by detailing officers to the United States schools and coast garrisons for a period of weeks and then sending them back to their commands. There should be furnished to each officer, through the adjutant general of states, publications of high character, such as the *Journal of the Military Service Institution.*"

THE FORAGE RATION FOR HORSES OF FIELD ARTILLERY AND CAVALRY.

BY FIRST LIEUTENANT EDWARD E. GAYLE, SECOND ARTILLERY, U. S. A.

The relation which the food of man bears to his useful work has been under investigation since scientific knowledge first afforded a means for its determination, and, at the present day, modern methods have established it with a degree of accuracy but little short of perfection. As a result of these investigations we know that a soldier's ration, in order that he may retain good health and be able to perform moderate work, should contain certain nutrients in definite proportions, and to enable him to perform hard work they should bear different relations to each other.

While this is true of man it is equally true of the horse, and, if it be economical to adjust the food of the former to suit different grades of work, it is reasonable to infer that the same should be done for the latter.

To a clear understanding of the close relationship existing between the animal body and food it may be well briefly to consider the composition of each. This may seem superfluous, since it is a matter of every day knowledge, but its intimate connection with our subject justifies its repetition.

While the animal body is a complex machine whose intricate workings have not yet been fully mastered, we do know that it is built up as the result of digestion and assimilation of food and that the character of the food may be such as to hasten or retard that which we wish to produce—muscle, bone, fat, &c. For present purposes it may be reduced to four substances, namely: protein (lean flesh), fat, water, and ash or saline materials. The amount of water varies from about forty to sixty per cent. and ash from about two to five per cent. of the live weight. The latter consists mainly of lime, phosphoric acid, potash, soda, magnesia and small quantities of sulphuric and muriatic acids which, in point of quantity, rank about in the order given.

By analyzing lean flesh (protein) and fat we find they are made up of four chemical elements in certain definite proportions. The protein consists of carbon, oxygen, hydrogen and nitrogen and the fat of the first three only. It is not necessary to point out the relative amounts of these elements in the two tissues, but it should be noted that the chief difference between them consists in this: that the former contains nitrogen while the latter does not.

These tissues are constantly undergoing waste and require constant renewal, the material for which is supplied by the food.

Turning to the food materials we find that they are composed of the same elements and in the same combination as those found in the body. While this is true, feeding stuffs may differ from each other on three very important points, namely: quality, quantity and digestibility of the nutrients contained in them. When we speak of a food as being more or less digestible, we mean simply that the animal has the power of appropriating more or less of the nourishment which it contains. Chemical analysis will reveal the exact amount of nourishing elements bound up in a food; but of two foods of the same composition one may be more digestible than the other. Some are completely, others only partially, digestible. The grains, hay, straw, &c., contain a certain amount of nourishment which cannot be appropriated; the animal body has not the power of extracting all of it. This is important, because in compounding a ration it is only on the *digestible portion* that we can count. Every one is aware that feeding stuffs differ in the quantity of their nutrients; grain contains much more nutrition in a given bulk than straw or hay or any of the so-called coarse fodders. The most important point in a feeding stuff is its quality; that is, the absolute and relative amounts of the nutrient elements which it contains. These nutrients are protein, or albuminoids, the substance which contains nitrogen; it differs greatly in quantity in different materials as may be seen by reference to the table of analysis of feeding stuffs. It is the only substance from which flesh can be formed, rapid growth and development of muscle being impossible when food is deficient in protein. It is the most important and indispensable element in all food; indispensable because an animal would starve to death on a food such as starch or sugar, which contained no protein.*

The carbo-hydrates are next in importance; they consist chiefly of starch, sugar, fibre and gum, are present in relative abundance in ordinary feeding stuffs, and are utilized as fuel to supply the body with heat.

Fat, the third nutrient, is essentially of the same character as the fat of the body, is present only in small quantities in feeding stuffs suitable for the forage ration, and goes to the formation of fat in the body; it is not, however, its only source, the other nutrients aiding to some extent in this regard.

Other things being equal, that feeding stuff is of the best quality which is richest in digestible albuminoids.

Based upon these facts of animal nutrition experiments have established other facts in regard to the economic use of feeding stuffs with a view to diminishing the waste of nutrients and to getting the greatest production of muscle, &c., for the food consumed. They are the ratio which the albuminoids and carbohydrates must bear to each other, called the nutritive ratio; and the quantity of these nutrients required by an animal under different conditions of work.

The results of these experiments have been reduced to figures and tabulated under the name of Feeding Standards, and although they have been compiled by German experimenters, they are as applicable in this country as in Germany. The results represent averages of a large number of experiments with horses, cattle and other animals under various conditions of work, weight, age and growth. Regarding their practical value there can be no question, as they are in daily use by intelligent and progressive stockmen, dairymen and farmers for the fattening of stock, the production of milk and for various other purposes, and have thus been subjected to the test of experience.

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* This word is used to represent the essential nitrogeneous constituent of food.

"Horses doing hard work will require food containing a large proportion of both nitrogenous and non-nitrogenous principles. Not only is the waste of the various tissues accelerated by long continued exertion, but chemical combustion takes place more rapidly.

"If the nitrogenous elements [protein] are not supplied in quantities sufficient to repair the waste the animal will fall away in muscle.

"If the non-nitrogenous elements [carbo-hydrates and fats] are not supplied in quantities sufficient to compensate for the chemical combustion, the fat stored up in the various parts of the body will be called upon to supply the deficiency and the animal will become thin."—Fitzwygram.

It is proposed to apply data taken from the table of Feeding Standards to the regulation forage ration for our horses of field artillery and cavalry, to point out certain deficiencies existing in it and to suggest the means for their correction.

Paragraph 1142 A. R. gives as the forage ration for a horse, fourteen pounds of hay and twelve pounds of oats, corn or barley. In special cases of hard service the grain ration may be increased not to exceed three pounds. We thus have six distinct rations.

Paragraph 1127 A. R. requires that the minimum and maximum weights of artillery horses shall be 1050 and 1300 pounds respectively.

From the table of Feeding Standards we get the following: A horse weighing 1000 lbs. requires per day:

	Total organic substance.	Protein.	Carbo-hydrates.	Fats.	Total Nutrients.	Nutritive ratio.
Under moderate work - -	22.5	1.8	11.2	.60	13.60	1:7
Under hard work - - -	25.5	2.8	13.4	.80	17.00	1:5.5

Adjusting this table to the weights of our artillery horses by increasing the numbers in each column by five per cent. for the minimum and thirty per cent. for the maximum, we have the following:

TABLE I.

	Total organic substance, lbs.	Protein, lbs.	Carbo-hydrates, lbs.	Fats, lbs.	Total nutrients, lbs.
For moderate work:					
Weight of horse, 1050 - -	23.62	1.89	11.76	.63	14.28
" " 1300 - - -	29.25	2.34	14.56	.78	17.68
Average weight in battery, 1105 - -	24.80	1.98	12.37	.66	15.01
For hard work:					
Weight of horse, 1050 - -	26.77	2.94	14.07	.84	17.85
" " 1300 - - -	33.15	3.64	17.42	1.04	22.10
Average weight in battery, 1105 - -	28.17	3.09	14.80	.88	18.77

An examination of the weights of horses in Light Battery "A," 2nd Artillery, shows, with the exception of two unusually tall and heavy horses—which are thought to be unfit for the service—that the difference between the minimum weight as authorized by regulations and the heaviest horse in the battery is about 150 pounds; while the average weight, including the two above mentioned, is 1105 pounds. This is the average weight for which calculation is made in the above table.

For purposes of comparison it is necessary to compute the amount of digestible nutrients contained in the six forage rations: three for ordinary or moderate work, in which the grain allowance is twelve pounds, and three for hard work, in which it is fifteen pounds; the weight of hay being the same in all.

The result is embodied in the following:

TABLE II.

	Total organic substance, lbs.	Protein, lbs.	Carbo-hydrates, lbs.	Fats, lbs.	Total nutrients, lbs.	Nutritive ratio.
Moderate work:						
14 lbs. Hay (mixed grasses) - -	11.17	.448	5.628	.126		
12 lbs. Oats - - -	10.33	1.176	5.760	.468		
12 lbs Corn - - -	10.50	1.002	7.800	.505		
12 lbs. Barley - - -	10.40	1.164	7.440	.204		
Hay and Oats - - -	21.50	1.624	11.388	.594	13.606	1:8
Hay and Corn - - -	21.67	1.450	13.428	.631	15.509	1:10
Hay and Barley - -	21.57	1.612	13.068	.330	15.010	1:8.5
Hard work:						
14 lbs. Hay - - -	11.17	.448	5.628	.126		
15 lbs. Oats - - - -	12.91	1.470	7.200	.585		
15 lbs. Corn - - -	13.13	1.252	9.750	.631		
15 lbs. Barley - - -	13.00	1.455	9.300	.255		
Hay and Oats - - -	24.08	1.918	12.828	.711	15.457	1:7.6
Hay and Corn - - -	24.30	1.700	15.378	.757	17.835	1:10
Hay and Barley - -	24.17	1.903	14.928	.381	17.212	1:8.3

We are now ready to compare our rations with those required by the Feeding Standards. Before doing so it is well to state that the hay selected as forming a part of the ration in the above calculations is that given in the table of analyses of feeding stuffs as "mixed grasses." This selection was made because the per cent. of digestible nutrients given for it is about equal to that of timothy hay and, in all probability, equal to that of any hay likely to be issued as part of the ration. Also because the name would indicate a near approximation to the hay used at this post, with the exception, however, that no mention is made of weeds of which we have an abundance. In consequence of this the ration is considered under the most favorable circumstances, as far as its nutritive qualities are concerned.

We will first consider the ordinary or moderate work ration. Referring to tables I and II, ration hay and oats, we note the following:

For horse weighing 1050 pounds, the organic substance is deficient by 2.12 pounds, protein 16 per cent., carbo-hydrates 3 per cent., fats 6 per cent.

For horse weighing 1300 pounds, organic substance deficient by 7.75 pounds, protein 44 per cent., carbo-hydrates 27 per cent., fats 32 per cent.

For horse weighing 1105 pounds, organic substance deficient 3.3 pounds, protein 22 per cent., carbo-hydrates 8 per cent., fats 12 per cent.

Ration hay and corn.

For weight 1050 pounds, organic substance deficient 1.95 pounds, protein 30 per cent., carbo-hydrates in excess 14 per cent., fats about normal.

For weight 1300 pounds, organic substance deficient 7.58 pounds, protein 61 per cent., carbo-hydrates 8 per cent., fats 23 per cent.

For weight 1105 pounds, organic substance deficient 3.3 pounds, protein 36 per cent., carbo-hydrates in excess 8 per cent., fats deficient 5 per cent.

Ration hay and barley.

For weight 1050 pounds, organic substance deficient 2.05 pounds, protein 17 per cent., carbo-hydrates in excess 11 per cent., fat deficient 90 per cent.

For weight 1300 pounds, organic substance deficient 7.68 pounds, protein 45 per cent., carbo-hydrates 11 per cent., fats 130 per cent.

For weight 1105 pounds, organic substance deficient 3.23 pounds, protein 23 per cent., carbo-hydrates in excess 5 per cent., fats deficient 100 per cent.

Considering the hard service ration we find as follows:

Ration hay and oats.

For weight 1050 pounds, organic substance deficient 2.69 pounds, protein 53 per cent., carbo-hydrates 9 per cent., fats 18 per cent.

For weight 1300 pounds, organic substance deficient 9.07 pounds, protein 89 per cent., carbo-hydrates 35 per cent., fats 46 per cent.

For weight 1105 pounds, organic substance deficient 4.09

pounds, protein 60 per cent., carbo-hydrates 15 per cent., fats 23 per cent.

Ration hay and corn.

For weight 1050 pounds, organic substance deficient 2.47 pounds, protein 72 per cent., carbo-hydrates in excess 9 per cent., fats deficient 10 per cent.

For weight 1300 pounds, organic substance deficient 8.85 pounds, protein 114 pec rent., carbo-hydrates 13 per cent., fats 36 per cent.

For weight 1105 pounds, organic substance deficient 3.87 pounds, protein 82 per cent., carbo-hydrates in excess 2½ per cent., fats deficient 15 per cent.

Ration hay and barley.

For weight 1050 pounds, organic substance deficient 2.6 pounds, protein 54 per cent., carbo-hydrates in excess 6 per cent., fats deficient 121 per cent.

For weight 1300 pounds, organic substance deficient 8.98 pounds, protein 91 per cent., carbo-hydrates 16 per cent., fats 172 per cent.

For weight 1105 pounds, organic substance deficient 4 pounds, protein 62 per cent., carbo-hydrates about normal, fats deficient 131 per cent.

By examining these results it will be seen, in the light of the Feeding Standards, that all of the rations are deficient in organic substance between the limits 1.95 pounds and 9.07 pounds; that in carbo-hydrates they approach nearest the normal, though in some cases the deficiency and in others the excess in this nutrient is marked; that in fats the deficiency for the heaviest horse is large throughout, and in the ration in which barley is an ingredient it is exceedingly large, amounting in one case to 172 per cent.; that in protein, the most important and indispensable nutrient, the deficiency obtains throughout, varying, for all weights, between the limits 16 per cent. and 114 per cent., and for the average horse, in the ration hay and oats, its shortage is 22 per cent. and 60 per cent. for moderate and hard work respectively.

From this our conclusion must be that the ration is sadly deficient in that most essential nutrient, protein, or muscle making food: in other words, it cannot supply the necessary material to renew the wear and tear of muscular fiber because it does not contain it and, as a necessary consequence, our horses under moderate work and particularly under the hard work incident to active service, would show fatigue and distress sooner than they would under more favorable conditions of feeding.

It is stated by those who are well informed on the subject that cavalry will be able to make twenty-five miles, day in and day out; hence horse artillery will have to do the same, or travel eight hours per day at three miles per hour. For this time and rate a horse can, according to Aide Mémoire R. E., exert a useful tractive force of 125 pounds, which would give as a measure of his day's work 15,840,000 ft. lbs.

This is without doubt hard service for artillery horses and will require for its successful performance all the aid to be derived from the hard service ration, that is 17 lbs. of digestible nutrients as given in the Feeding Standards. Moderate work, for which there is required 13.6 lbs. of digestible nutrients, will therefore be that represented by a day's work of 12,672,000 ft. lbs., which is very nearly the work performed by artillery accompanying infantry at the ordinary rate, the number of ft. lbs. being 12,790,000. The proportions of digestible nutrients for the hard and moderate service rations have already been determined; we will now determine them for—we will call it—the garrison ration. It is assumed that the exercises of field artillery in garrison will consume two hours per day at the rate of six miles per hour. This is a little in excess of that actually determined at Fort Riley, Kansas, by one of the batteries stationed there. It is stated—Trautwine, Handbook of Civil Engineering—that if the number of hours remain constant tractive force varies inversely as the speed, and speed remaining constant it varies inversely as the time. While this is not strictly true for the time and rate assumed, the slight error is in favor of the horse. We thus have for the assumed time and rate a tractive force of 250 lbs., for which the corresponding load is 2036 lbs. The present light field carriage, without ammunition, with three men, the usual number mounted on it at drill, weighs 3539 lbs., or 885 lbs. per horse, the corresponding tractive force for which is 108 lbs. Since the team consists of four horses with drivers on two of them the tractive force of 250 lbs. is reduced for effective hauling to 148 lbs., a loss of 40 per cent., and as the 108 lbs. above is that available for actual hauling the total will be 180 lbs.; giving as a day's work 11,404,800 ft. lbs., which requires a ration containing 12¼ lbs. of digestible nutrients.

There is still another ration to be determined, for which, however, there is no immediate need, since the carriage for which it is calculated does not exist in our service, and when it is constructed the preceding ration may be abandoned. The proper weight for the light field carriage should be about 4432 lbs., deducting weight of ammunition and retaining weight of three men we have 3218 lbs. as the load in garrison service for four horses, with a tractive force for all purposes of 163 lbs. per horse, giving as a day's work 10,327,680 ft. lbs., which requires a ration containing 11 lbs. of digestible nutrients.

It is interesting to note, in passing, the amount of work our horses are at present required to do in actual service. Horse artillery under these conditions have, for hauling, an available tractive force of 65 lbs. per horse, which corresponds to a load of 530 lbs.; the present caisson completely equipped weighs 4753 lbs., 792 lbs. per horse, which requires under same conditions of time and rate a tractive force of 97 lbs. for hauling, or 186 lbs. for all purposes. This gives for the day's work of one horse 23,570,000 ft. lbs., which requires, to supply the corresponding wear and tear of tissue, a ration of more than 50 lbs., which the horse is not capable of consuming. This would indicate that the caisson is too heavy by 32 per cent. In the event of a light battery being ordered into the field, with its present organization, fully equipped for active service, we would have as a load for four horses a caisson weighing 5713 lbs. or 1428 lbs. per horse. This requires a tractive force of 175 lbs. available for hauling, or 333⅓ lbs. for all purposes, which would give as the measure of a day's work per horse 26,400,000 ft. lbs. and requires a ration of 56½ lbs.

Paragraph 1126 A. R. states that the weight of the cavalry horse "must not be less than 900 nor more than 1200 pounds."

Based upon the opinion of well informed officers of cavalry it is assumed that 1025 pounds will be a fair representative of the weight of an average cavalry horse, while an inspection of the weights of horses of a troop of the 7th Cavalry shows that the difference between this assumed weight and the average of those within regulation limits is but three pounds.

Adapting the Feeding Standard table, as before, to the required and assumed weights, we have the following:

	Total organic substance.	Protein.	Carbo-hydrates.	Fats.	Total nutrients.
Moderate work.					
Weight of horse, 900 lbs. -	20.25	1.62	10.08	.54	12.24
" " 1200 lbs. -	27.00	2.16	13.44	.72	16.32
" " 1025 lbs. -	23.06	1.85	11.48	.62	13.95
Hard work.					
Weight of horse, 900 lbs. -	22.95	2.52	12.06	.72	15.30
" " 1200 lbs. -	30.60	3.36	16.08	.96	20.40
" " 1025 lbs. -	26.13	2.87	13.73	.82	17.42

Comparing these with the digestible nutrients contained in the forage rations as given by Table II, we note as follows:

ORDINARY WORK.

Ration hay and oats.

Weight of horse 900 lbs., protein normal, carbo-hydrates and fats in excess 11 and 9 per cent. respectively.

Weight 1200 lbs., deficiency in protein 33 per cent., carbo-hydrates 18 per cent. and fats 21 per cent.

Weight 1025 lbs., protein deficient 14 per cent., carbo-hydrates nearly normal, fats deficient 4 per cent.

Ration hay and corn.

Weight 900 lbs., protein deficient 12 per cent., carbo-hydrates and fats in excess 25 and 14 per cent. respectively.

Weight 1200 lbs., protein deficient 50 per cent., carbo-hydrates normal, fats deficient 12 per cent.

Weight 1025 lbs., protein deficient 27 per cent., carbo-hydrates in excess 11 per cent., fats normal.

Ration hay and barley.

Weight 900 lbs., protein normal, carbo-hydrates in excess 22 per cent., fats deficient 63 per cent.

Weight 1200 lbs., protein deficient 34 per cent., carbo-hydrates normal, fats deficient 118 per cent.

Weight 1025 lbs., protein deficient 14 per cent., carbo-hydrates in excess 12 per cent., fats deficient 87 per cent.

HARD WORK.

Ration hay and oats.

Weight 900 lbs., protein deficient 31 per cent., carbo-hydrates and fats about normal.

Weight 1200 lbs., protein, carbo-hydrates and fats deficient 70 per cent., 33 per cent. and 35 per cent., respectively.

Weight 1025 lbs., protein, carbo-hydrates and fats deficient 50 per cent., 7 per cent. and 15 per cent., respectively.

Ration hay and corn.

Weight 900 lbs., protein deficient 48 per cent., carbo-hydrates and fats in excess 21 and 5 per cent., respectively.

Weight 1200 lbs., protein, carbo-hydrates and fats deficient 97 per cent., 4 per cent. and 26 per cent., respectively.

Weight 1025 lbs., protein deficient 68 per cent., carbo-hydrates in excess 10 per cent., fats deficient 87 per cent.

Ration hay and barley.

Weight 900 lbs. protein deficient 32 per cent., carbo-hydrates in excess 20 per cent., fats deficient 88 per cent.

Weight 1200 lbs., protein deficient 76 per cent., carbo-hydrates 8 per cent. and fats 152 per cent.

Weight 1025 lbs., protein deficient 50 per cent., carbo-hydrates in excess 8 per cent., fats deficient 115 per cent.

In a word, the same state of affairs is shown to exist for cavalry horses as has been pointed out for those of artillery.

To determine the proper ration for service conditions we will assume that cavalry will be able to make twenty-five miles a day six days in the week at the rate of three miles per hour, and that each horse will carry as a maximum weight 280 lbs., which we find from Aide-Mémoires R. E. he can do without over-exerting himself, and from the same authority that this weight is equivalent to a tractive force of 125 lbs. for same time and rate. A day's work would therefore be represented by 15,840,000 ft. lbs., and being hard service, would require the seventeen lbs. of digestible nutrients of the Feeding Standards. A day's work which will require the moderate work ration will be 12,672,000 ft. lbs., equivalent to the horse carrying a weight of 224 lbs., for eight hours at three miles per hour, or 280 lbs. for 6½ hours at same rate.

For data upon which to compute the proportions of nutrients for the garrison ration we will assume that drill and other mounted exercises consume 2½ hours a day at an average rate of eight miles per hour. This is supported by the opinion of cavalry officers at this post—Fort Riley—and is believed to be a sufficiently high limit to cover all cases. The weight of rider, equipment, arms, &c., will in round numbers be 200 lbs., as is shown below:

	lbs.	oz.
Saddle (complete) - - - - - -	18	08
Saddle blanket - - - - - - -	4	10
Bridle and bit - - - - - - -	3	01.5
Spurs and straps - - - - - - -	0	12
Surcingle - - - - - - -	0	13
Carbine and 20 rounds - - - - - -	10	07
Pistol, holster and 12 rounds - - -	3	10
Sabre and knot - - - - - - -	3	15
Cartride belt - - - - - - -	0	12
Sling-belt and swivel - - - - - -	1	04.5
Average cavalryman - - - - -	155	00

The weights of the equipment were obtained by weighing the articles.

The day's work under these conditions would be 9,504,000 ft. lbs., which would require a ration containing 10.2 lbs. of digestible nutrients.

Calculating by means of the Feeding Standards the amounts of protein, carbo-hydrates and fats required for the two garrison rations for artillery and one for cavalry, we find them to be as follows:

	Protein.	Carbo-hydrates.	Fats.	Total nutrients.
Horse weighing 1105 lbs., Artillery .	1.60	10.00	.53	12.13
" " " " "	1.79	11.14	.59	13.52
" " 1025 lbs., Cavalry . .	1.38	8.61	.46	10.45

Having the proper proportions of digestible nutrients for all the rations, to compound them is, with the tables at hand, a question of but a few moments. Before selecting our feeding stuffs for this purpose three conditions must be fulfilled: first, we must be able to get the materials when required; second, they must be sufficiently cheap, and, third, they must be such as the horse will eat. The result is given below:

ARTILLERY.

	Total organic matter, lbs.	Protein, lbs.	Carbo-hydrates, lbs.	Fats, lbs.	Total nutrients, lbs.
Horse weighing 1105 lbs.					
Garrison ration, proper carriage, requires . .	19.55	1.60	10.00	.53	12.13
12 lbs. hay, 10 lbs. oats, 1 lb. beans contain . .	19.70	1.59	10.12	.51	12.22
Garrison ration, present carriage, requires . .	21.04	1.79	11.14	.59	13.52
14 lbs. hay, 11 lbs. oats, 1 lb. beans contain . .	21.37	1.75	11.41	.57	13.73
Moderate work, or field ration, requires . .	24.80	1.98	12.37	.66	15.01
14 lbs. hay, 13 lbs. oats, 1 lb. beans contain . .	24.42	1.95	12.37	.64	14.96
Hard work, or active service ration requires .	28.17	3.09	14.80	.88	18.77
14 lbs. hay, 15 lbs. oats, 5 lbs. beans contain .	28.20	3.06	15.33	.78	18.18
CAVALRY.					
Horse weighing 1025 lbs.					
Garrison ration requires	17.27	1.38	8.61	.46	10.45
12 lbs. hay, 8 lbs. oats, 1 lb. beans contain . .	17.29	1.39	9.15	.43	10.97
Moderate work ration requires	23.06	1.85	11.48	.62	13.95
14 lbs. hay, 12 lbs. oats, 1 lb. beans contain . .	23.70	1.85	11.88	.61	14.34
Hard service ration requires	26.13	2.87	13.73	.82	17.42
14 lbs. hay, 16 lbs. oats, 4 lbs. beans contain .	28.23	2.87	14.50	.79	18.16

These are as near the standard rations as they can be made with the feeding stuffs selected and are near enough for all practical purposes.

It thus appears that there should be three distinct rations for horses of field artillery and three for those of cavalry corresponding to the grades of work they are required to perform. Should it become necessary to reduce the ration in consequence of less exercise than that assumed above for garrison work, the reduction should be made in the proportions .6, .3, and .1 for hay, oats and beans respectively.

An estimate of the comparative cost of the regulatiion ration and that suggested for garrison service based upon prices of the St. Louis market shows that for the cavalry and light artillery service for one year the difference would be $84,315.00 in favor of the latter.

At what time the present ration was adopted, or upon what principles, if any, its component parts were adjusted, cannot be ascertained. It is a fact that it has existed for many years, that it has served its purpose without serious criticism and that it will probably remain as it now is, defects to the contrary notwithstanding. If, however, with it our horses have accomplished so much it is reasonable to infer that with rations properly compounded and graded they would accomplish more. A simple statement that it is sufficient for all purposes, though supported by an experience of many years, is not a final answer to the question, for the foregoing conclusions are based upon facts which are the results not of theory but of carefully conducted experiments and are entitled to more than a passing notice.

A CONTRIBUTION TO THE INTERIOR BALLISTICS OF SMOKELESS POWDERS.

BY FIRST LIEUTENANT LUCIEN G. BERRY, FOURTH ARTILLERY, U. S. A.

PART I.

So long as the smokeless powders were uncertain in their action, it is evident that any attempt to apply to them the principles of thermodynamics must have given confused and unreliable results. At present this uncertainty no longer exists, as is shown in the very interesting study recently published in the *Journal of the United States Artillery* of the effects of smokeless powders in a 57-mm. gun, by Mr. Lawrence V. Benét, Artillery Engineer of the Hotchkiss Ordnance Co., Limited, Paris.*

The results of the comparison of the data there given with certain theoretical deductions may be of interest to some of the readers of the *Journal.* We assume the following notation:

$E =$ A general expression for the kinetic energies of the projectile, powder and piece at any instant.

$\Sigma pv =$ The sum of the products arising from multiplying each pressure by the volume of gas at that pressure at the same instant.

$f =$ The force of the powder, a quantity which is expressed in units of energy.

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* This article originally appeared in the *Journal* (No. 3, July, 1892.) It has since been the subject of considerable discussion in both this country and Europe. It has also received the very high compliment of having been officially noticed and reprinted, by the Chief of Ordnance, U. S. Army, in the form of an Ordnance Construction Note (No. 61, 1892). While appreciating the compliment, and at the same time being willing to further the dissemination of professional information in any way possible, it is greatly to be regretted that no credit was given to the *Journal* as the original publisher of this article, since to those not acquainted with the circumstances the *Journal* is placed in the doubtful position of having plagiarized the article from a subsequent Ordnance publication. The act of reprinting an original and copyrighted article without authority and without even an acknowledgement of its origin was wholly unnecessary, since a request to reprint it would have been most cheerfully granted.—[EDITOR *Journal.*]

y = The weight of powder burned at any instant in kilograms.
W = Weight of the projectile in kilograms.
$\tilde{\omega}$ = Weight of the charge in kilograms.
z_0 = Initial space behind the projectile not occupied by the charge, divided by area of cross-section of bore in decimetres.
u = Length of travel of projectile, in decimetres.
δ = Density of the powder.
ω = Cross-section of the bore, in square decimetres.
g = Acceleration due to gravity, in metres.
V = Velocity of the projectile, in metres.
A = A constant depending on the conditions of loading, see Part II.
W_1 = Weight of gun in kilograms.
p = Pressure on the base of the projectile in kilograms per square decimetre.

Neglecting the passive resistances we have from the principles of mechanics, using metric units;

$$E = \int_{v_0}^{v} p\,dv$$

if the expansion is adiabatic

$$p = \frac{p_0 v_0^{1.41}}{v^{1.41}}$$

hence

$$E = \int_{v_0}^{v} p_0 v_0^{1.41} \frac{dv}{v^{1.41}} = \frac{p_0 v_0}{.41} - \frac{p_0 v_0^{1.41}}{.41\,v^{.41}} = \frac{p_0 v_0}{.41} - \frac{pv}{.41}$$

placing $p_0 v_0 = fy$ we have

$$.41 E = fy - \Sigma pv$$

The kinetic energy of the projectile is $\frac{WV^2}{2g}$,

That of the charge is $\frac{WV^2}{2g}\left(\frac{\tilde{\omega}}{2W}\frac{1}{A} - 1\right)$ (See Part II),

That of the gun is $\frac{WV^2}{2g} A_1^2 \frac{W}{W_1}$ (See Part II),

The value of Σpv is $\frac{\tilde{\omega}}{2W}\frac{1}{A} p\omega \left(z_0 + u + \frac{y}{\delta\omega}\right)$ (See part II).

Neglecting the kinetic energy of rotation of the projectile we have:

$$.41\,\frac{WV^2}{2g}\left(\frac{\tilde{\omega}}{2W}\,\frac{1}{A}+A_1^2\,\frac{W}{W_1}\right)=fy-\frac{\tilde{\omega}}{2W}\,\frac{1}{A}\,p\omega\left(z_0+u+\frac{y}{\omega\delta}\right)$$

Neglecting $A_1^2\,\frac{W}{W_1}$, dividing through by $\frac{\tilde{\omega}}{2W}\,\frac{1}{A}$, and placing

$f'=\frac{f}{\frac{\tilde{\omega}}{2W}\,\frac{1}{A}}$, we have:

$$.41\,\frac{WV^2}{2g}=f'y-\omega p\left(z_0+u+\frac{y}{\omega\delta}\right)$$

or

$$p=\frac{f'y-.41\,\frac{WV_2}{2g}}{\omega\left(z_0+u+\frac{y}{\omega\delta}\right)}\qquad\text{- - (1)}$$

f is a constant for a given powder if the products of combustion are constant. f' is a constant for the same powder and conditions of loading.

Under the suppositions made

$$p=\frac{W}{2g}\,\frac{d(v^2)}{du}$$

substituting in (1) and integrating between the limits $z_0+\frac{y}{\omega\delta}$ and $z_0+u+\frac{y}{\omega\delta}$ for u we have, since $\frac{2}{.41}=4.9$

$$V^2=4.9gf'\,\frac{y}{W}\left\{1-\left[\frac{z_0+\frac{y}{\omega\delta}}{z^0+u+\frac{y}{\omega\delta}}\right]^{.41}\right\}\qquad\text{- (2)}$$

It now remains to determine the amount of powder consumed at any time. If we take Sarrau's expression for black powders as a tentative expression for the law of burning of smokeless powders, we have,

$$\frac{dl}{dt}=\frac{l_0}{\tau}\left(\frac{p'}{p_0}\right)^{\frac{1}{2}}$$

in which $l_0=\frac{1}{2}$ of the mean least dimension of the grains of which the charge is composed, and l the length burned in the time t under a variable pressure p', $\tau =$ the time of total combustion in air under the atmospheric pressure p_0*

Taking as a mean value of p', $A_1\,p$, we have

$$dl^2 = \left(\frac{l_0}{\tau}\right)^2 \frac{A_1}{p_0}\, d^2u$$

integrating twice

$$l^2 = \left(\frac{l_0}{\tau}\right)^2 \frac{2A_1}{p_0}\, u$$

or

$$\frac{l}{l_0} = K_1\, u^{\frac{1}{2}}$$

It can be shown that the amount of powder burned when a length l is consumed is

$$y = \tilde{\omega} a \frac{l}{l_0}\left(1 - \lambda \frac{l}{l_0} + \mu \frac{l^2}{l_0^2}\right)$$

in which, if we represent by α β and γ the three dimensions of the grain, α being the least,

$$a = 1 + \frac{\alpha}{\beta} + \frac{\alpha}{\gamma},\ \lambda = \frac{\frac{\alpha}{\beta} + \frac{\alpha}{\gamma} + \frac{\alpha^2}{\beta\gamma}}{1 + \frac{\alpha}{\beta} + \frac{\alpha}{\gamma}},\ \mu = \frac{\frac{\alpha^2}{\beta\gamma}}{1 + \frac{\alpha}{\beta} + \frac{\alpha}{\gamma}}\ \dagger$$

Substituting for $\frac{l}{l_0}$ its value $K_1 u^{\frac{1}{2}}$, we have

$$y = \tilde{\omega} a K_1 u^{\frac{1}{2}}\left(1 - \lambda K_1 u^{\frac{1}{2}} + \mu K_1^2\, u\right) \quad - \quad (3)$$

We then have for the equations expressing the value of the pressure on the base of the projectile, velocity and weight of powder consumed, Equations (1), (2) and (3).

When the units of the English system are used, that is, when u, z_0, V and g are expressed in feet, W, y and $\tilde{\omega}$ in pounds, ω in square feet, p in lbs. per square foot, f' in ft. lbs., the formulas become:

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* Ingalls' Interior Ballistics, p. 66.

† Ingalls' Interior Ballistics, p. 64.

$$p = \frac{f'y - \frac{WV^2}{2g}.41}{\omega\left(z_0 + u + \frac{y}{\omega\delta 62.4}\right)} \quad - \quad - \quad (4)$$

$$V^2 = 4.9 g f' \frac{y}{W}\left\{1 - \left(\frac{z_0 + \frac{y}{\omega\delta 62.4}}{z_0 + u + \frac{y}{\omega\delta 62.4}}\right)^{.41}\right\} \quad - \quad (5)$$

$$y = \tilde{\omega} a K_1 u^{\frac{1}{2}}\left(1 - \lambda K_1 u^{\frac{1}{2}} + \mu K_1^2 u\right) \quad - \quad - \quad (6)$$

f' and K_1 being obtained by trial will have the values appropriate to the system of measures in which the data are given.

In order to apply these formulas it will be necessary to know the rate of burning of the powder used. Since the velocity is a function of the amount of powder burned, and not of its rate of burning; if the powder be entirely consumed, the velocity will not differ whatever be the point of completed combustion. By taking one charge sufficiently small to insure complete combustion and measuring the velocity, all other quantities being known, we may find f', and from the conditions of loading, f. Since f is constant for the same powder we may now find f' for any charge. If we take the charge sufficiently large so that all of the powder will not be consumed in the gun then the value of y can be found by solving (2) by trial; having found y and knowing the dimensions of the grain we may find K_1 and hence the amount of powder consumed at any point in the projectile's travel *under the assumed law.* With this value of y we may from (2) find the corresponding value of V and having these two we may find the pressure on the base of the projectile from (1). It will be observed that these formulas will require modification if, as in the case of small arms, the powder does a large amount of work in compressing the projectile, and that they will apply only when the products of combustion are measurably constant.

Let us consider the application of these formulas to the data given by Mr. Benét. He, in effect, determined the velocity at eight points along the bore with two different charges and kinds of powder. If the powder was not wholly consumed at any point of the bore, the quantity $4.9 g f' \frac{y}{W}$ would vary from that point to the point of complete combustion; but if at any point the powder is wholly consumed, then from that point on this quantity should be a constant, and V in (2) should vary only with u.

Assuming the powder all burned at the muzzle and computing the velocities at the other points along the bore under the same supposition, we have the following table:

Weight of Projectile 2.72 kg. Weight of Charge .46 kg. BN$_1$ Powder. Velocity in Metres.			Travel of shell, decimetres.	Weight of Projectile 2.72 kg. Weight of Charge .4 kg. BN$_{144}$ Powder. Velocities in Metres.		
Observed.	Computed under the supposition that the powder is all burned.	Diff.		Observed.	Computed under the supposition that the powder is all burned.	Diff.
682.1	682.1	0.0	28.45	632.8	632.8	0.0
648.3	651.7	+ 3.4	20.20	600.7	604.6	+ 3.9
636.5	640.1	+ 3.6	17.92	591.0	593.8	+ 2.8
622.3	626.1	+ 3.8	15.64	573.5	580.8	+ 7.3
612.6	614.2	+ 1.6	13.93	565.0	569.8	+ 4.8
595.0	599.9	+ 4.9	12.22	553.1	556.6	+ 3.5
574.4	582.9	+ 8.5	10.51	534.9	540.8	+ 5.9
543.1	561.9	+ 18.8	8.80	503.7	521.3	+ 17.6

These results show conclusively that the powder was all consumed at a point in the bore corresponding to a travel of about 10.5 decimetres, and that the subsequent increase in velocity was due to the adiabatic expansion of the powder gases.

If we assume the combustion completed at the point $u = 10.5$ we have under the assumed law for rate of burning, for BN$_{144}$ $\omega = .4$, $a = 1.41$, $\lambda = .29$ and $\mu =$ a negligible quantity, $K = .308$, which give for $u = 8.80$, $y = .378$ and $V = 508.2$, a difference of 4.5 from the observed. In the same way for BN$_1$ we have $\omega = .46$, $a = 1.36$, $\lambda = .267$, $\mu =$ a negligible quantity and $K_1 = .310$. For $u = 8.80$ we find $y = .424$ and $V = 542.3$, which is a difference of $-.8$ from the observed. While these results are not sufficient to enable us to draw any absolute conclusions with respect to the law of combustion, they tend to confirm the correctness of the assumed law.

There is one deduction which can be clearly made, that is, that the limit of progressiveness with the smokeless powders had not been reached in this case. The main question, the rate of burning of smokeless powders, remains still to be solved. Mr. Benét is entitled to credit for what he has done and for the honesty and care with which he has recorded it.

The formulas here deduced have been applied to several examples and seem to give very good results. In the case of brown powder, also, it has been observed that the velocity is more nearly a function of the one-half power of the weight of the charge, than of the five-eighths power. This is to be expected, since it is known that the brown powders give little residue.

PART II.

Let us suppose that we have given the pressure on the base of the projectile at any point of its travel along the bore of the gun, and *let it be required to find the pressure at any point of the bore in rear and at any point of the powder chamber.* Let

p_u = pressure on the base of the projectile,

p = pressure at any point in rear of the base of the projectile.

u_0 = the length of the powder chamber, assuming that it has the same diameter as the rest of the bore.

c = a constant for any given position of the projectile.

s = a variable coordinate equal at the base of the projectile to u_0+u but which is supposed to have values from o to $u+u_0$ for any given position of the projectile.

Other symbols as before.

Then the increment of pressure between any two sections is equal to the mass between the sections multiplied by its acceleration and divided by the area of the section. The mass between any two sections is equal to the volume multiplied by the density; if we suppose the temperature to be uniform behind the projectile the density $= cp$. The acceleration varies with the acceleration of the projectile multiplied by the ratio of their distances from the bottom of the bore, or

$$dp = \left(\frac{\omega ds}{g}\right) cp \left(\frac{dv}{dt}\,\frac{s}{u+u_0}\right)\frac{1}{\omega}$$

$$dp = \frac{cp}{g}\,\frac{dv}{dt}\,\frac{sds}{u+u_0}$$

In this equation s and p are the only variables, u and $\frac{dv}{dt}$ becoming for the instant constants, hence placing

$$A = c\frac{dv}{dt}\,\frac{u+u_0}{2g}$$

we have

$$\frac{dp}{p} = A\,\frac{2sds}{(u+u_0)^2}$$

integrating between the limits s and $u+u_0$ for s corresponding to p and p_u we have

$$\log_e\left(\frac{p}{p_u}\right) = A\left(1 - \frac{s^2}{(u+u_0)^2}\right)$$

or

$$p = p_u\, e^{A\left(1-\left(\frac{s}{u+u_0}\right)^2\right)}$$

It is evident that the weight of powder consumed and unconsumed must equal the weight of the charge, hence

$$\int_0^{u+u_0} \omega cpds = \bar{\omega}$$

or substituting for p

$$\bar{\omega} = \int_0^{u+u_0} \omega cp_u\, e^{A\left(1-\left(\frac{s}{u+u_0}\right)^2\right)} ds$$

$$\text{but } \omega cp_u = \frac{2W}{2g}\,\frac{dv}{dt}\,c\,\frac{u+u_0}{u+u_0} = \frac{2WA}{u+u_0}$$

$$\text{and placing } A\left(\frac{s}{u+u_0}\right)^2 = x^2,\quad dx = \frac{A^{\frac{1}{2}}}{u+u_0}\,ds$$

$$\bar{\omega} = 2WA^{\frac{1}{2}}\,e^{A}\int_0^{A^{\frac{1}{2}}} e^{-x^2}\,dx$$

$$\text{or}\quad \frac{\bar{\omega}}{2W} = A^{\frac{1}{2}}\,e^{A}\int_0^{A^{\frac{1}{2}}} e^{-x^2}\,dx$$

The definite integral $\int_0^{A^{\frac{1}{2}}} e^{-x^2}\,dx$ is a well known elliptic integral whose values have been tabulated. Hence we might form a table giving for all values of $\frac{\tilde{\omega}}{2W}$ the corresponding value of A. We may obtain a sufficiently close approximation in the following manner: for all values of x between 0 and .5 the curve whose equation is $y = e^{-x^2}$ is practically coincident with the parabola whose equation is $y = 1 - .924x^2$, hence substituting for e^{-x^2} this expression $1 - .924x^2$ we have

$$\frac{\tilde{\omega}}{2W} = A^{\frac{1}{2}} e^{A} \int_0^{A^{\frac{1}{2}}} (1 - .924x^2)dx \quad \text{integrating}$$

$$\frac{\omega}{2W} = A^{\frac{1}{2}} e^{A} \left(A^{\frac{1}{2}} - .308 A^{\frac{8}{2}} \right)$$

$$\text{but } e^{A} = 1 + A + \frac{A^2}{2} + \frac{A^8}{6} + \&c \quad \text{hence}$$

$$\frac{\tilde{\omega}}{2W} = A(1 + .692A + .192A^2 + .012A^8) \text{ or}$$

$$\frac{\tilde{\omega}}{2W} = A(1 + .232A)^8$$

As the value of A is always less than .25, its value can be easily determined by one or two approximations; first assuming a value for A within the brackets and finding the corresponding value for A outside of the brackets, then substituting this last value for A in the brackets and solving again.

We have then for the pressure at any point,

$$\log_e p = \log_e p_u + A\left(1 - \left(\frac{s}{u + u_0}\right)^2\right)$$

for the breech, place $A = \log_e A_1$ then $p_1 = A_1 p_u$

These formulas explain why the smokeless powders give greater velocities, with no greater pressure, than the black or brown powders. For example, take the case of the Canet 32-centimetre gun constructed for the Japanese government, and compare these shots:

Wt. of charge.	Wt. of projectile.	Initial Velocity.	Maximum Pressure.
255 kg. of PB$_1$	451 kg.	718 metres.	2866 kg. per cm^2
144 kg. of BN$_1$	450.5 kg.	727 metres.	2553 kg. per cm^2

In the first case $A = .24$, in the second $A = .1452$, which give values for A_1 of 1.27 and 1.15 respectively; which would indicate that the pressure in the first case should be about ten per cent. greater than in the second, which was fully verified by the indications of the pressure gauge.

In this respect the nitro-glycerine powders are superior to the gun-cotton powders. They give less pressure at the breech and less recoil for equal pressures on the base of the projectile.

To find the kinetic energy of the powder and gun.

The weight of any elementary section of powder gas and unconsumed powder is $cp\omega ds$; its velocity is $\frac{s}{u+u_0}$, hence we have, representing the kinetic energy of the powder by E

$$E=\int_0^{u+u_0} \frac{cp\omega}{g} ds \left(\frac{s}{u+u_0}\right)^2 \frac{V^2}{2}$$

$$E=\int_0^{u+u_0} MV^2 \frac{A}{u+u_0}\, e^{A\left(1+\left(\frac{s}{u+u_0}\right)^2\right)} \left(\frac{s}{u+u_0}\right)^2 as$$

placing $x=A^{\frac{1}{2}}\frac{s}{u+u_0}$

$$E=MV^2\frac{A^{\frac{1}{2}}}{u+u_0} e^{A}\int_0^{A^{\frac{1}{2}}} e^{-x^2} x^2 dx$$

Integrating by parts, remembering that

$$A^{\frac{1}{2}} e^{A}\int_0^{A^{\frac{1}{2}}} e^{-x^2} dx=\frac{\tilde{\omega}}{2W}$$

we have

$$E=\tfrac{1}{2}MV^2\left(\frac{\tilde{\omega}}{2W}\,\frac{1}{A}-1\right)$$

For the breech we have

$$p_1=A_1 p$$

whence we have

$$M_1 V_1=A_1 MV$$

and

$$\tfrac{1}{2}M_1 V_1^2=\tfrac{1}{2}MV^2A_1^2\,\frac{W}{W_1}$$

To find the sum of the products arising from multiplying each volume by the pressure of the gas which it contains.

The powder gas is all contained in the volume $\omega\left(z_0+u+\frac{y}{\omega\delta}\right)$ and its pressure varies in this volume according to the law

$$p=p_0\, e^{A\left\{1-\left[\frac{s}{z_0+u+\frac{y}{\omega\delta}}\right]^2\right\}}$$

hence

$$\Sigma pv=\int_0^{z_0+u+\frac{y}{\omega\delta}}\omega p_0\, e^{A\left(1-\left(\frac{s}{z_0+u+\frac{y}{\omega\delta}}\right)^2\right)}ds$$

placing $x=A^{\frac{1}{2}}\frac{s}{z_0+u+\frac{y}{\omega\delta}}$

we have

$$\Sigma pv=\int_0^{A^{\frac{1}{2}}}\omega p_0\left(e^{A}\right)\frac{\left(z^0+u+\frac{y}{\omega\delta}\right)}{A^{\frac{1}{2}}}\,e^{-x^2}dx$$

but

$$\int_0^{A^{\frac{1}{2}}}e^{-x^2}dx=\frac{\tilde{\omega}}{2W}\;\frac{1}{A^{\frac{1}{2}}e^{A}}$$

hence

$$\Sigma pv=\omega p_0\left(z_0+u+\frac{y}{\omega\delta}\right)\frac{\tilde{\omega}}{2W}\;\frac{1}{A}$$

NOTE.—The writer wishes to acknowledge his indebtedness to Lieutenant C. DeW Willcox, 2nd Artillery, for assistance in the way of computations and valuable suggestions.

A NEW POWDER.

THE PRESENT PHASE OF SMOKELESS COMPOUNDS.

By First Lieutenant WILLOUGHBY WALKE, Fifth Artillery, U. S. A.

During the earlier stages of the development of modern smokeless powders, the most important feature was clearly shown to be the stability of the compounds, and the principal tests to which they were subjected sought to establish or disprove their power to resist the extreme changes, climatic and atmospheric, to which they would naturally be exposed under the ordinary conditions of service. Under these tests the majority of the new powders failed. The causes that led to their rapid deterioration and decomposition are now too well known to be dwelt upon, and the question of stability may be considered as settled.

In its stead, however, a far more serious, and as yet more difficult problem has appeared, that is the control of the enormous pressures developed by the new powders when burned, exploded or detonated in the bore of a gun.

These pressures result from the thermo-chemical conditions inherent in the powders, especially those which obtain at the instant of decomposition, and secondly from the rate of this decomposition or transformation, which determines the character of the phenomenon, whether it be a simple combustion or a detonation.

The heat of formation of the explosive itself, the temperature of explosion, the chemical composition of the products of explosion, and the specific heats of these products are factors which may be partly calculated according to well established physical and chemical principles, and partly measured at the instant of explosion.

These conditions are determined absolutely by the chemical composition of the explosives. Therefore for a given temperature of combustion, the pressures developed will vary directly with the rate with which the gases are produced within the containing volume, and the amount of gas already evolved. The problem as presented then resolves itself into the control of this rate of combustion or detonation.

Up to the present time the attainment of this object has been sought by introducing into the powders various salts which offer physical rather than chemical obstruction to the spread of inflammation, or introduce a physical interference to the propagation of the explosive wave.

With the introduction of foreign substances, however, which as a rule, do not enter into chemical union with the explosive constituents of the compound, not only is the mode of action changed, but the entire character of the powder is transformed.

Of the original powders it may be said that they were true chemical compounds, whereas, in their modified form, they have become to a greater or less extent mechanical mixtures, and, as such, subject to the usual difficulties in the way of securing homogeneity in the final result.

In microscopic examinations of several of the new powders, the almost total lack of uniformity discovered between separate grains of the same powder, would alone explain the anomalous results frequently obtained of late from the same powder under practically the same conditions, upon the assumption that in the manufacture of the individual cartridges, the actual composition of the explosive has varied between very considerable limits. The great difficulty in securing uniformity of incorporation in these powders is due to the inherent danger attending this stage of their manipulation, and to it largely is to be attributed the irreconcilability of the ballistic results obtained.

Thus from the records of the official tests of the more prominent powders we note the following results; the conditions, ballistic and atmospheric, being as nearly as possible identical for the same powder, which however is to be considered independently of the others:

Poudre BN: Initial velocity, 1765 to 1944 feet per second: pressure, 39,400 to 62,400 pounds per square inch.

Cordite: Initial velocity, 1876 to 2040 feet per second; pressure, 49,500 to 59,000 pounds per square inch.

Maxim: Initial velocity, 1910 to 2076 feet per second; pressure, 44,000 to 63,200 pounds per square inch.

Wetteren: Initial velocity, 1916 to 1992 feet per second; pressure, 46,700 to 62,700 pounds per square inch.

Ballistite: Initial velocity, 2004 to 2296 feet per second; pressure, 57,000 to 73,500 pounds per square inch.

These results were obtained with small arms having an average calibre of 0″.30, and beyond a reduction in granulation, the powder was similar to that used in guns of heavier calibre (field and rapid-fire) for which it was originally designed, and in which far more satisfactory results were obtained.

Thus in the mad haste with which experimenters have plunged into this new line of investigation, the well established principle that the powder must be fitted to the gun, which had been so thoroughly developed with the old compositions, was entirely lost sight of, and in so far has the growth of the new powders been seriously impeded. That the increase in pressure referred to is not only out of all proportion with the corresponding increase in velocity, but also beyond the limits allowable in guns of small calibre is manifest.

In support of this assertion, it is not necessary to enter into an elaborate calculation involving the consideration of the elastic strength of the rifle barrel and the expansive force of the confined gases. That the small-arm rifle barrel can withstand these strains has been demonstrated theoretically and proven practically. There are however other parts to the modern rifle, and with the universal demand for magazine arms, the intricacy and delicacy of the parts which go to make up the whole are greatly multiplied, in spite of all efforts to simplify the mechanism as much as possible.

The question at present is no longer confined to the strength of the barrel; but can this complicated machine, the modern magazine rifle, with its carefully constructed cams, its accurately calibrated springs, its bolts and pins, resist the terrible strain to which it is subjected at each discharge?

We find an answer to this query in the numerous reports of injuries to small-arms during the field manœuvres in recent years. During the manœuvres of 1891, we find that, of the magazine rifles in which the new powders were used, from 35 to 50 per cent. were rendered unfit for service, and, in the majority of cases, before ten rounds had been fired. These accidents were at first attributed to imperfect workmanship; but the real cause of the trouble became known only after searching investigations, and was summed up in an official report which stated "*that the gun was not designed for the increased pressures produced by the smokeless powders of the day.*" It is to be noted that in no instance above referred to did the rifle barrel burst or even become swelled; it was the breech and magazine mechanism that became jammed or was broken, and rendered the arm for the time being a worthless encumbrance. We are thus confronted with what is believed to be the latest phase in the development of the new powder which has been already alluded to, but which, by reason of its vital importance may be emphasized in the question "Can the enormous pressures developed by the modern smokeless powders be brought within the limits of the magazine small-arm, and controlled?"

A careful consideration of the facts above stated, accompanied by thorough analyses of the powders themselves, indicate that the difficulties heretofore encountered in efforts to solve this problem can be entirely overcome, and during the past eight months a systematic investigation has been carried on in the Chemical and Explosive Laboratory of the U. S. Artillery School, with results pointing to ultimate success. It would be inexpedient at the present stage of the investigation to more than indicate the methods pursued, and state the results obtained.

Stability under climatic extremes and during long storage was recognized as the absolute *sine qua non* of a service explosive, and imposed the first condition to be fulfilled by the new powder. So far as laboratory tests can be assimilated to the actual atmospheric and climatic conditions of service, this object appears to have been attained, although the storage test can be decided absolutely only after lapse of time.

An important factor considered in the determination of the theoretical composition of the powder, was the work required in order to obtain the following ballistic results, viz: bullet; calibre, 0''.30, weight, 230 grains; powder; weight of charge, 36 to 40 grains; muzzle velocity, 2000 feet per second; pressure, not to exceed 45,000 pounds per square inch. An analysis of the first twenty shots fired indicated the necessary modification of the theoretical powder, and a new lot was made accordingly and tested. As a result of the second firing, the actual composition of the powder was determined, and also the method of manipulation with a view of controlling the pressures developed, so that with but a single change in the relative proportions of the ingredients, for the same muzzle velocity, the pressure was reduced 43,400 pounds per square inch.

To subject this method of controlling the pressures to as rigid a test as possible, from the same incorporation, several lots of powder were subjected to varying degrees of the same general method of manipulation, and subsequently made up into cartridges. In every instance did the pressure respond to the treatment, ranging for the same charge of 42 grains from 25,500 to 47,800 pounds per square inch.

As was expected the velocities varied correspondingly, but one appeared invariably a direct function of the other, so that the operator at the rifle upon reading the pressures, knew immediately the velocity within ten feet per second, and conversely the operator at the chronograph knew the pressure within 100 pounds per square inch, as soon as he took from the tables the velocity corresponding to the reading of his instrument.

Not the least encouraging feature of these experiments has been the remarkable uniformity in the action of the powder, that has obtained throughout the trials. After the final proportions of the ingredients were determined and the methods of manipulation adopted, scarcely a shot was fired the result of which could not have been foretold. In the few instances of what might possibly have been classed as abnormal results, the causes leading thereto were readily discovered, and were directly attributable to the difficulty attending the manufacture of the powder by hand.

In all the trials for velocity two chronographs arranged in independent circuits were used, and the pressures were checked by alternating the copper pressure discs. One set of the latter together with the corresponding pressure curve was obtained from the Ordnance Bureau of the U. S. Navy, and the other made from a different lot of copper was furnished with the maximum, minimum and mean compressions by the Ordnance Department of the Army.

It is proposed to continue this investigation, the results of which as indicated encourage me to look for greater success than that already attained. In the meantime the following results observed and calculated for some of the better known foreign powders, are tabulated for comparison with the results actually obtained with the experimental powder, which for the present is designated * 3 P.P.G.

Table I contains data actually obtained from experimental firing.

Table II is calculated from data contained in Table I, upon the hypothesis that the chamber of the rifle remains constant and that the density of loading varies with the charge, being unity for the given service charge (Table I).

Table III is calculated from the same data, upon the hypothesis that the volume of the chamber varies with the charge, so that the density of loading is constantly equal to unity.

In the case of the powder under investigation (* 3 P.P.G.), the results were actually obtained on the firing ground, and are repeated in Tables II and III so as to be more readily compared.

TABLE I.*

Powder.	Rifle.	Weight of charge.	Weight of bullet.	I. V. f. s.	P_0 lbs. per sq. in.
Smokeless, No. 6, P.	Mauser—0''.3012.	37 grains.	216 grains.	2139	44128
Smokeless, BN.	Lebel—0''.3149.	43.2 "	231.5 "	2073	. . .
Smokeless, G. C.	Mannlicher—0''.3110.	42.43 "	223.7 "	2034	47040
Ballistite.	Mannlicher—0''.2569.	30.5 "	162 "	2296	73472
Cordite.	Lee 0''.3030.	30.5 "	215 "	2000	33600
Smokeless.	Krag-Jorgensen—0''.3149.	33.9 "	238 "	1968	33810
* 3 P. P. G.	Expr.—0''.300.	38 "	230 "	2026.25	31775
" " " "	" "	40 "	" "	2216.25	33517
" " " "	" "	42 "	" "	2367.50	35325

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* For assistance in the computation of these tables, I desire to acknowledge my indebtedness to Captain James M. Ingalls, 1st Artillery, Instructor Department of Ballistics, U. S. Artillery School.

TABLE II.

Powder.	Rifle.	Weight of charge.	Weight of bullet.	I. V. f. s.	P_0 lbs. per sq. in.
Smokeless, No. 6 P.	Mauser—0''.3012.	38 grains.	230 grains.	2108	46968
		40 “		2176	51379
		42 “		2244	55959
Smokeless, B. N.	Lebel—0''.3149.	38 “	“ “	1918	. .
		40 “		1981	. .
		42 “		2042	. .
Smokeless, G. C.	Mannlicher—0''.3110.	38 “	“ “	1872	39055
		40 “		1933	42723
		42 “		1993	46531
Ballistite.	Mannlicher—0''.2569.	38 “	“ “	2211	117830
		40 “		2283	128900
		42 “		2354	140390
Cordite.	Lee—0''.3030.	38 “	“ “	2219	50207
		40 “		2291	54921
		42 “		2362	59817
Smokeless.	Krag-Jorgensen—0''3149.	38 “	“ “	2150	40932
		40 “		2220	44776
		42 “		2289	48767
* 3 P.P.G.	Experimental—0''.3000.	38 “	“ “	2026.25	31775
		40 “		2216.25	33517
		42 “		2367.50	35325

TABLE III.

Powder.	Rifle.	Weight of charge.	Weight of bullet.	I. V. f. s.	P_0 lbs. per sq. in.
Smokeless, No. 6 P.	Mauser—0''.3012.	38 grains.	230 grains.	2094	45732
		40 "		2134	47525
		42 "		2174	49297
Smokeless, B.N.	Lebel—0''.4149.	38 "	" "	1982	. .
		40 "		2021	. .
		42 "		2058	. .
Smokeless, G.C.	Mannlicher—0''.3110.	38 "	" "	1912	43024
		40 "		1949	44711
		42 "		1985	46377
Ballistite.	Mannlicher—0''.2569.	38 "	" "	2093	94577
		40 "		2134	98287
		42 "		2173	101950
Cordite.	Lee—0''.3030.	38 "	" "	2100	40297
		40 "		2141	41878
		42 "		2180	43438
Smokeless.	Krag-Jorgensen—0''.3149.	38 "	" "	2090	36515
		40 "		2130	37948
		42 "		2170	39362
* 3 P.P.G.	Experimental—0''.3000.	38 "	" "	2026.25	31775
		40 "		2216.25	33517
		42 "		2367.50	35325

THE ARTILLERY-FIRE GAME.

BY H. ROHNE, COLONEL, COMMANDING THE SCHLESWIG FIELD ARTILLERY
REGIMENT No. 9.

TRANSLATED BY FIRST LIEUTENANT JOHN P. WISSER, FIRST ARTILLERY,
U. S. A., 1892.

[CONTINUED.]

III. EXAMPLES IN APPLICATION.

The rules and principles of the fire game having been discussed and established, a few examples illustrating its application under different circumstances are added.

I. FIRING AGAINST ARTILLERY AT LONG RANGE.

Assumptions made by the director:

Target:—A firing battery of 6 pieces at 3180 m.
Dispersion:—Great.
Observation:—Lottery numbers 1 to 43, correct (43 per cent.);
Lottery numbers 44 to 93, doubtful (50 per cent.);
Lottery numbers 94 to 100, false (7 per cent.).
Shrapnel fuses burn 10 m. too long.

Mean point of bursting with 3100 m. elevation and fuse, $\frac{-120}{9}$;

Mean point of bursting with 3200 m. elevation and fuse, $\frac{-\ 20}{10}$;

Mean point of bursting with 3300 m. elevation and fuse, $\frac{+\ 18}{10}$.

Record of lottery numbers drawn and their signification.

Number. 1.	Lottery number. 2.	Deviation. m. 3.	Tar. dist'nce minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 1.	No. on the firing record 2.	Lottery number. 3.	Deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	4	—100	3280	56	?	25	18	50	± 0 0	57	?
2	11	— 65	3245	34	c	26	19	6	—45 +10	5	c
3	71	+ 30	3150	72	?	27	20	36	—10 + 3	89	?
4	23	— 40	3220	26	c	28	21	48	± 0 + 1	35	c
5	20	— 45	3225	30	c	29	22	69	+15 — 2	21	c
6	88	+ 60	3120	28	c	30	23	10	—40 + 3	76	?
7	56	+ 5	3175	64	?	31	24	95	+45 —10	79	?
8	45	— 5	3185	72	?	32	25	51	± 0 0	27	c
9	85	+ 55	3125	61	?	33	26	6	—45 +10	41	c
10	59	+ 10	3170	81	?	34	27	98	+60 —15	30	c
11	84	+ 50	3130	97	f	35	28	41	— 5 + 3	6	c
12	6	— 85	3265	10	c	36	29	80	+25 — 3	40	c
13	76	+ 35	3145	78	?	37	30	21	—25 + 3	17	c
14	77	+ 35	3145	61	?	38	31	55	+ 5 + 3	1	c
15	37	— 20	3200	18	c	39	32	42	— 5 + 2	38	c
16	10	— 70	3250	26	c	40	33	57	+ 5 ± 0	84	?
17	79	+ 40	3140	17	c	41	34	27	—20 + 1	49	?
18	1	—140	3320	93	?	42	35	89	+35 — 7	74	?
19	40	— 15	3195	15	c	43	36	42	— 5 + 2	78	?
20	73	+ 30	3150	16	c	44	37	13	—35 + 5	24	c
21	61	+ 15	3165	63	?	45	38	72	+15 — 5	34	c
22	22	— 40	3220	19	c	46	39	96	+50 —10	3	c
23	3	—105	3285	67	?	47	40	40	— 5 — 4	97	f
24	11	— 65	3245	89	?	48	41	11	—35 +12	37	c

Firing record.

No. of gun.	COMMAND.	No. of shot.	Fuse. Elevation. m.	OBSERVATION.	
1.	2.	3.	4.	batt'y. 6.	target. 6.
I.	P. s. dir. f. batt'y in woods, 4th p., 2800, r. fl. F. ![*]	1	• 2800	?	—480
II.	. . . .	2	"	—	—445
III.	. . . .	3	3200	?	+ 50
IV.	. . . .	4	"	—	— 20
V.	. . . .	5	3600	+	+375
VI.	. . . .	6	3400	—	+280
I.	. . . .	7	3300	?	+125
II.	. . . .	8	"	?	+115
III.	. . . .	9	"	?	+175
IV.	. . . .	10	3200	?	+ 30
V.	. . . .	11	"	—	+ 70
VI.	. . . .	12	3400	+	+135
I.	C. f. sh. t. f., by steps, (50 or 100 at a t.) F. at w ![†]	13	3300	?	+155
II.	. . . .	14	"	?	+155
III.	. . . .	15	"	+	+100
IV.	. . . .	16	"	+	+ 50
V.	. . . .	17	"	+	+160
VI.	(Discharge loaded pieces !)	. .	. . .	. . .	. . .
I.	(Shr. t. f. !)	18	3300	$\frac{?}{10}$	$\frac{+80}{10}$
II.	. . . .	19	"	$\frac{?}{20}$	$\frac{+35}{20}$
III.	. . . .	20	"	$\frac{?}{13}$	$\frac{+70}{13}$
IV.	. . . .	21	"	$\frac{?}{11}$	$\frac{+80}{11}$
V.	. . . .	22	"	$\frac{?}{3}$	$\frac{+65}{8}$
VI.	New elevation and fuse, 3200 !	23	"	$\frac{?}{13}$	$\frac{+40}{13}$
I.	(New fuse setting !)	24	3200	$\frac{?}{0}$	$\frac{+25}{0}$
II.	. . . .	25	"	$\frac{?}{10}$	$\frac{-20}{10}$
III.	. . . .	26	"	$\frac{?}{20}$	$\frac{-65}{20}$
IV.	. . . .	27	"	$\frac{+}{0}$	$\frac{+40}{-5}$
V.	. . . .	28	"	$\frac{?}{13}$	$\frac{-25}{13}$
VI.	New elevation and fuse, 3200 !	29	"	$\frac{?}{7}$	$\frac{+5}{7}$

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[*] "Percussion shell, directly on firing battery in the woods, 4th piece, at 2800 m., from the right flank, Fire!"

[†] Cease firing, shrapnel, time fuses, by steps (50 or 100 m. at a time), Fire at will!

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. elevation. m. 4.	OBSERVATION.	
				batt'y. 5.	target. 6.
I.		30	3200	$\frac{?}{13}$	$\frac{-45}{13}$
II.		31	"	$\frac{?}{13}$	$\frac{-15}{13}$
III.		32	"	$\frac{?}{12}$	$\frac{-25}{12}$
IV.		33	"	$\frac{?}{10}$	$\frac{-15}{10}$
V.	New elevation and fuse, 3200 !	34	"	$\frac{?}{11}$	$\frac{-40}{11}$
VI.		35	"	$\frac{?}{3}$	$\frac{+15}{3}$
I.		36	"	$\frac{?}{12}$	$\frac{-25}{12}$
II.		37	"	$\frac{?}{15}$	$\frac{-55}{15}$
III.		38	"	$\frac{?}{5}$	$\frac{-5}{5}$
IV.		39	"	$\frac{+}{0}$	$\frac{+30}{0}$
V.		40	"	$\frac{?}{14}$	$\frac{-25}{14}$
VI.		41	"	$\frac{?}{22}$	$\frac{-55}{22}$

The assumption that the dispersion (double the deviation) is large in this case is correct, although it is as much as three times as great as that given in the ordinary firing table. As a matter of fact, probable longitudinal deviations of 35 m. in actual fire under war conditions, are not uncommon. The assumed observation conditions must be regarded as hardly more than favorable ; nevertheless, much more difficult ones will often be met with at such long ranges. The character of the observations as entered in the firing record conforms very closely to such conditions and circumstances as occur in actual firing.

At 3300 m. as many as five shots were not observed ; it may be supposed, for instance, that they fell on ground particularly unfavorable for observation ; only after the fire was dispersed did the character of the observation improve, In actual firing doubtful observations will occur, especially at the first range, but often later on also, in consequence of lateral deviation, which will make the determination of the short fork very much more difficult than was the case here.

The three shots not observed (numbers 7, 8 and 9) decided the director to give up trying to narrow down the short fork any further. He wished to take the space from 3200 to 3400 m. under shrapnel fire, but before doing so desired to determine whether the fork had been correctly established. This method is to be recommended. A fork of 200 m. that is established with *certainty* is preferable to one of 50 m. that is uncertain. In spite of this endeavor the fork limit of 3200 m. was not correctly determined, at least not with perfect certainty. *Both* shots fired at 3200 m. were observed *in front of* the target, although the actual distance was 3180 m. Shot four had a deviation of 40 m. short, shot eleven was falsely observed. It was a very extraordinary and unfortunate circumstance that this particular shot, the *only* one of seventeen, should have been observed falsely. Still, the error was not very great; for, had the fuses burned correctly, the probable mean distance of the points of explosion in front of the target would have been 30 m.

It may be asked whether in this case a volley would not have been in place. This question cannot be answered definitely in the negative; still, by this means the object would not have been accomplished any faster than it was by the method adopted. When black powder was still used in firing, the principal object of the volley was to facilitate the observation of the explosion cloud in the powder smoke surrounding the target (the enemy's firing battery). This object can no longer be attained in this way, therefore, in my opinion, the use of volleys will in future become less and less frequent.

After the limits of the fork of 200 m. as determined had been tested, the battery commander ordered the passage to shrapnel fire at the intermediate range—3300 m. Had he been so fortunate as to observe well the points of explosion of the shell set for this range, the limits of the space to be taken under fire could, at all events, have been reduced. In the present case three of the five shells were observed to burst beyond the target and more in front. The battery commander properly concluded that the points of explosion of all the shrapnel he might fire at

3400 m. would lie beyond the target, and could therefore limit himself to the ranges 3200 and 3300 m. Had the shells been all observed to burst *in front of* the target, the limit would of course have been advanced from 3200 to 3300 m.; had they been observed to burst partly in front of and partly beyond the target, 3300 m. would have been regarded as approximately the correct target distance, and the range would have been varied between 3250 and 3350 m.

On account of the great heights of explosion which normal fuses might give at long ranges, only a few explosion clouds are generally located at heights admitting of observation; at the first shrapnel range there were none at all.

At the next range two ground hits occurred, of which the first was observed doubtfully, the second as beyond the target. That the battery commander did not allow himself to be misled thereby and induced to insert a plate, was correct, for the other points of bursting at this range were none of them too low, and moreover, those of the preceding were either normal or else rather high. Furthermore, it was also quite correct, after observing shot 27 *beyond* the target, not to increase to 3300 m. On the other hand, neither did the fact of this observation justify the continuation of the shrapnel fire at 3100 m. Shot 27 was a *ground hit*, not a point of bursting in the air; but with the trajectory correctly placed ground hits must occur behind the target as well. Nevertheless, taken in connection with the shells fired at 3300 m., it had been made evident that even should 3200 m. be too short a range, the error could not in any case be very great. In the subsequent firing only one more point of explosion (number 35) was of such a height as to admit of observation, and only one more ground hit (number 39) occurred, but of these two only the latter was actually observed.

Whether the battery commander could conclude from this that he ought to go back from 3200 to 3100 m., or fire between these ranges as limits it is difficult to say, judging from the data of the firing record alone. It depends largely on personal impressions and judgment, and, in actual firing, it would depend on whether any definite effect on the target had been noticeable or not.

The shrapnel fired at 3300 m. were all without effect; of the 18 shots fired at 3200 m., on the other hand, shots number 26, 30, 32, 34, 36, 37 and 41, in sum total therefore seven, were, judging by the relation between height of explosion and distance in front of target, more or less effective. With all the other shots the effect, if any, was beyond the target proper, and may have come into play on the line of limbers or on the caissons. Any firing at long ranges, in which effective action can be expected from a third of all the shots must be regarded as decidedly successful. The mean point of explosion was at $\frac{-17}{10}$, certainly too near the target, so that the fragments even of the lower part of the cone of explosion of a shot of mean distance in front of the target, and mean height of explosion would pass entirely over the target.

In conclusion, be it remarked that had the firing with shell at 3200 m. been continued in order to determine the distance more accuratety, the result would probably have been the same. Since the distance was 3180 m., the probabilities were, as may be readily calculated, that two-thirds of the shots would be over and one-third short, and therefore this had to be regarded as the true distance. Indeed, 3200 m. is nearer the true target distance, 3180 m., than 3150 would have been. The fact that the fuses burned somewhat too long a time, of course, lessened the effective action considerably. Had the fuses burned correctly on the average, shots 25, 28 and 40 would also have been effective, hence, half the entire number.

2. FIRING WITH TORPEDO-SHELL AGAINST TROOPS OCCUPYING A FIELD FORTIFICATION.

Assumptions made by the director:

Distance—2870 m.

Trajectory of the torpedo-shell—about 20 m. shorter than that of shell c/82.

Longitudinal dispersion—medium.

Observation conditions— 1 to 60 correct (60 per cent.);
61 to 92 doubtful (32 per cent.);
93 to 100 false (8 per cent.).

The fuses burn about 30 m. too short (unknown to the battery commander).

Preparatory notes.

Position of the mean point of explosion of the torpedo-shell for elevation and fuse setting :*

$$2900\text{ m.}: \frac{-70}{16},\quad 2900\text{ m.}: \frac{-70}{7},\quad 2900\text{ m.}: \frac{-70}{3};$$

$$2950\text{ m.}: \frac{-20}{16},\quad 2950\text{ m.}: \frac{-20}{7},\quad 2950\text{ m.}: \frac{-20}{2};$$

$$3000\text{ m.}: \frac{+30}{17},\quad 3000\text{ m.}: \frac{+30}{8},\quad 3000\text{ m.}: \frac{+30}{-2}.$$

Record of the lottery numbers drawn for determining the range with percussion shell c/82.

Number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 1.	Lottery number. 2.	Deviation m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	86	+40	2830	3	c	10	26	—25	2895	76	?
2	4	—70	2940	17	c	11	60	+10	2860	41	c
3	5	—65	2935	53	c	12	28	—20	2890	12	c
4	92	+50	2820	16	c	13	57	+ 5	2865	73	?
5	48	± 0	2870	35	c	14	78	+30	2840	22	c
6	27	—25	2895	60	c	15	72	+20	2850	44	c
7	13	—45	2915	2	c	16	2	—85	2955	85	?
8	48	± 0	2870	21	c	17	93	+55	2815	35	c
9	79	+20	2850	70	?	18	60	+10	2860	86	?

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* With fuses that burn correctly, when in addition, there is no difference in position between the trajectories of the percussion-shell and the torpedo-shell, the point of explosion for elevation and fuse at 2900 m. would have been at $\frac{-20}{10}$; on account of the difference in position of the trajectories it is at $\frac{-40}{10}$; on account of the behavior of the fuses at $\frac{-70}{10}$.

1. Number.	2. Number on the firing record.	3. Lottery number.	4. Deviation. m.	5. Lottery number.	6. Observation.	1. Number.	2. Number on the firing record.	3. Lottery number.	4. Deviation. m.	5. Lottery number.	6. Observation.
1	18	31	−15 + 3	96	f	22	39	97	+55 −11	55	c
2	19	81	+25 − 6	27	c	23	40	5	−50 +10	75	?
3	20	3	−60 +15	19	c	24	41	59	+ 5 − 2	5	c
4	21	50	± 0 0	16	c	25	42	99	+65 −13	15	c
5	22	78	+20 − 9	61	?	26	43	37	−10 + 1	9	c
6	23	27	−20 + 1	17	c	27	44	48	± 0 + 1	82	?
7	24	23	−20 + 9	3	c	28	45	96	+50 −10	65	?
8	25	58	+ 5 − 1	7	c	29	46	54	± 0 + 3	98	f
9	26	75	+20 − 3	14	c	30	47	88	+35 − 4	97	f
10	27	90	+35 −12	9	c	31	48	18	−30 + 3	30	c
11	28	82	+25 − 8	35	c	32	49	3	−60 +15	95	f
12	29	71	+15 − 4	62	?	33	50	65	+10 − 3	44	c
13	30	13	−35 + 5	15	c	34	51	10	−40 + 3	10	c
14	31	23	−20 + 9	83	c	35	52	45	− 5 − 1	3	c
15	32	28	−15 + 7	35	c	36	53	29	−15 + 5	37	c
16	33	25	−20 + 4	1	c	37	54	66	+10 − 4	39	c
17	34	61	+ 5 − 4	90	?	38	55	41	− 5 + 3	27	c
18	35	48	± 0 − 1	39	c	39	56	59	+ 5 − 2	44	c
19	36	47	± 0 + 2	18	c	40	57	15	−30 + 9	25	c
20	37	13	−35 + 5	6	c	41	58	75	+20 − 3	40	c
21	38	84	+30 − 6	23	c	42	59	82	+25 − 8	83	?

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
I.	P. s., field int. on the green h't, quad. 2200, r. fl. F.!*	1	2200	−	−630
II.	. . . .	2	2600	−	−340
III.	. . . .	3	3000	+	+ 65
IV.	. . . .	4	2800	−	− 20
V.	. . . .	5	2900	+	+ 30
VI.	. . . .	6	2950	−	− 45
I.	. . . .	7	"	−	− 65
II.	. . . .	8	"	−	− 20
III.	. . . .	9	2900	?	+ 50
IV.	. . . .	10	"	?	+ 5
V.	. . . .	11	"	+	+ 40
VI.	. . . .	12	"	+	+ 10
I.	C. f., tor. s., t. f. by steps (50 or 100 m.), 2900, F. w.!†	13	"	+	+ 35
II.	. . . .	14	"	+	+ 60
III.	. . . .	15	"	+	+ 50
IV.	. . . .	16	"	?	− 55
V.	. . . .	17	"	+	+ 85
I.	(torp. s., t. f.	18	2900	? 19	−86 19
II.	. . . .	19	"	? 10	−45 10
III.	1 pl. l.!‡	20	2900	? 22	−130 22
IV.	. . . .	21	"	? 7	−70 7
V.	. . . .	22	"	? 0	−50 − 2
VI.	New elevation and fuse setting 2900!	23	"	? 8	−90 8
I.	A second plate lower!§	24	2900	? 6	−90 6
II.	. . . .	25	"	− 0	−65 − 4
III.	. . . .	26	"	− c	−50 − 6
IV.	. . . .	27	"	− 0	−35 −15
V.	New elevation and fuse-setting 2950!	28	"	− 0	−45 −11
VI.	. . . .	29	"	? 0	−55 − 7

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* Percussion shell, field intrenchment on the green height, quadrant, 2200, from the right flank fire!

† Cease firing, torpedo-shell, by steps (50 or 100 m. at a time), 2900, fire at will!

‡ One plate lower!

§ The command "one plate lower (or higher)" is not in the drill regulations. In the later firing regulations, however, it appears in place of the older form "one plate inserted (or removed)." Whether in the future the command "a second plate higher (or lower)" will be adopted, conforming in principle to the above, the author cannot say.

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
I.	(New fuse setting.)	30	2950	— 3	—55 3
II.	. . . .	31	"	? 7	—40 7
III.	. . . .	32	"	? 5	—35 5
IV.	. . . .	33	"	— 2	—40 2
V.	. . . .	34	"	? 0	—15 — 6
VI.	. . . .	35	"	— 0	—20 — 3
I.	New elevation 3000! (New fuse setting.)	36	3000	+ 0	+30 ± 0
II.	. . . .	37	"	— 3	— 5 + 3
III.	. . . .	38	"	— 0	± 0 — 8
IV.	. . . .	39*	"	+ 0	+85 —13
V.	. . . .	40	"	? 8	—20 8
VI.	New elevation 3000! Set all fuses at that.	41*	"	+ 0	+35 — 4
I.	1 plate higher!	42*	3000	+ 0	+95 — 5
II.	. . . .	43	"	? 9	+20 9
III.	. . . .	44	"	? 9	+30 9
IV.	. . . .	45	"	? 0	+20 — 2
V.	A second plate higher!	46	3000	? 14	+30 14
VI.	. . . .	47	"	? 13	+65 13

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* The positions of the ground hits in these cases were determined by the formula on page 137, and the corresponding entry made for observation in the battery.

No. of gun.	COMMAND.	No. of shot.	Fuse. / Elevation. m.	OBSERVATION. batt'y.	OBSERVATION. target.
1.	2.	3.	4.	5.	6.
I.	....	48	3000	$\frac{?}{20}$	$\frac{\pm 0}{20}$
II.	....	49	"	$\frac{?}{32}$	$\frac{-30}{32}$
III.	....	50	"	$\frac{?}{14}$	$\frac{+40}{14}$
IV.	....	51	"	$\frac{?}{20}$	$\frac{-10}{20}$
V.	....	52	"	$\frac{?}{16}$	$\frac{+25}{16}$
VI.	....	53	"	$\frac{?}{22}$	$\frac{+15}{22}$
I.	....	54	"	$\frac{?}{13}$	$\frac{+40}{13}$
II.	....	55	"	$\frac{?}{20}$	$\frac{+25}{20}$
III.	....	56	"	$\frac{?}{15}$	$\frac{+35}{15}$
IV.	....	57	"	$\frac{?}{26}$	$\frac{\pm 0}{26}$
V.	....	58	"	$\frac{?}{14}$	$\frac{+50}{14}$
VI.	....	59	"	$\frac{?}{9}$	$\frac{+55}{9}$

The character of the foregoing firing with torpedo shell on covered targets is not at all an uncommon case in practice. Whoever has been present at such a firing practice, or has looked over the firing record of any *long-continued* firing, will admit that the firing usually proceeds in the same general way as is here indicated.

The determination of the range by means of percussion shell was undoubtedly successful; it is perfectly certain that the target lies between 2850 and 2900 m. In the continuation of the firing not a single false observation was made (in the case of shots 18, 46, 47 and 49, for which the lottery numbers gave false observations, the points of explosion were so high that they could not be observed at all). Nor was there any apparent violation of the firing regulations. And yet the firing proved unsuccessful; indeed, it must be so considered, since, among the twenty-four shots fired with a 3000 m. fuse only three (shots number 37, 40 and 51), or only one-eighth were effective, and if we leave out the first two shots because they were fired at an elevation lower by $\frac{6}{16}^\circ$ than that at which the firing was afterward continued, only a single shot produced any effect.

The battery commander correctly opens the fire with torpedo-shell at 2900 m. The points of explosion lay too high for observation and were therefore lowered. Even normally burning fuses would have given points of explosion so high (10 m.) that observation was not to be thought of; and, as the fuses burn 30 m. too short the mean height of explosion rises to 16 m. Lowering by one plate is not sufficient to give points of explosion admitting of observation; the mean height of explosion is still 7 m. +, and only about one third of all the shots can be counted on to have points of explosion having heights under 4 m.; but a considerable number of these are useless for observation because they are ground hits. Of the four shots fired with the points of explosion lowered by one plate, three have too great a height of explosion and one is a ground hit. The battery commander therefore again lowers and at $\overline{\overline{2900}}$ m. obtains one point of explosion, too high for observation however, and four ground hits in front of the target. Strictly speaking the battery commander cannot use his observation of the ground hits at all for the determination of the proper fuse setting. But let us put ourselves in his place; he either gets points of explosion so high that they cannot be accurately observed at all, or else they lie very low and many of them appear to be ground hits. That these last are really ground hits he cannot know with certainty; he might just as well regard them as low points of explosion. If it is difficult in case of shrapnel to distinguish ground hits from low points of explosion, it is much more so in case of torpedo-shell. While the ground hit in case of shrapnel can still be recognized occasionally by the admixture of more or less sand and dust in the white explosion cloud, this means of recognition is entirely wanting in the black explosion cloud of the torpedo-shell.

It may be thought that the unfavorable result was due to the particularly unlucky numbers that were drawn in case of shots 30 to 35 and 36 to 41. But that this was not the case can readily be seen if we consider how the points of explosion would have been located had the lottery numbers come in just the reverse way, *i. e.*, those of shots 36 to 41 for shots 30 to 35 and the reverse. The points of explosion of the shots 30 to 35 at $\overline{2950}$ m., would have been in order, $\frac{-20}{0}$, $\frac{-55}{3}$, $\frac{-50}{8}$ (observed, therefore, $\frac{-}{0}$), $\frac{+35}{-11}$ (observed $\frac{-}{0}$, since the ground hit lies 20 m. in front of the target), $\frac{-50}{8}$, $\frac{-15}{-4}$. Evidently, no points of explosion beyond the target would have been obtained in this case either. By going up to $\overline{3000}$ m. the location of the points of explosion would have been as follows: $\frac{-5}{3}$, $\frac{+10}{7}$, $\frac{+15}{5}$, $\frac{+10}{2}$, $\frac{+35}{-2}$ (ground hit 25 m. beyond the target, therefore observed, $\frac{+}{0}$), $\frac{+30}{1}$ (ground hit 25 m. behind the target). Of these six shots the second and third, on account of the fact that their points of bursting were too high, were not observed at all, the first one was observed as at $\frac{-}{3}$, the others at $\frac{+}{1}$ and $\frac{+}{0}$, respectively. Therefore, in this case just as in the preceding one, the firing would have been continued with 3000 m. elevation and fuse.

The mean point of bursting was to be expected, as stated, at $\frac{+30}{17}$; but with such a position for it not more than 7 per cent. of the shots can be counted on as effective, as may be readily shown by means of the diagram of points of bursting, which may be easily constructed from the data of column F in the table, bearing in mind the fact that the angle enclosing the effective shots is determined and limited by lines making angles, respectively, of 22° and 72° with the horizontal (compare appendix 2).

By adopting the elevation and fuse-setting 2950 m., the mean point of bursting would have been moved to $\frac{-20}{16}$, and the number of effective shots would have risen to 33 per cent., *i. e.*, the effect would have been about five times as great as at 3000 m.

It is also worthy of notice that the determination of the range was not really completed until after the expenditure of some thirty torpedo-shells, from which it is apparent how little value can be placed on results obtained from but a few shots.

We will have occasion to refer to these evils again further on.

3. FIRING ON A BATTERY; PASSING TO A BATTERY APPEARING ALONGSIDE THE FIRST TARGET.

Assumptions made by the director:

Longitudinal distance—2230 m.; the second target stands echelonned 60 m. to the front.

Longitudinal deviation—medium.

Fuses—burning 80 m. (in range) too long.

Observation—Lottery numbers 1 to 66, correct (66 per cent.);
67 to 92, doubtful (26 per cent.);
93 to 100, false (8 per cent.).

Preparatory notes:

Position of mean point of bursting for	1st target.	2nd target.
with elevation and fuse 2200 m.,	$\frac{\pm 0}{-4}$	$\frac{+60}{4}$
$\underline{2200\text{ m.}}$,	$\frac{\pm 0}{+3}$	$\frac{+60}{+3}$
$\underline{\underline{2200\text{ m.}}}$,	$\frac{\pm 0}{+10}$	$\frac{+60}{+10}$
2150 m.,	$\frac{-50}{-4}$	$\frac{+10}{-4}$
$\underline{2150\text{ m.}}$,	$\frac{-50}{+3}$	$\frac{+10}{+3}$
$\underline{\underline{2150\text{ m.}}}$,	$\frac{-50}{+10}$	$\frac{+10}{10}$
$\underline{2100\text{ m.}}$,	—	$\frac{-40}{+3}$
$\underline{\underline{2100\text{ m.}}}$,	—	$\frac{-40}{10}$

Record of the lottery numbers drawn.

Percussion shell.

Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance minus deviation. m. 5.	Lottery number. 6.	Observation. 7.	Number. 1.	Number on the firing record. 2.	Lottery number. 3.	Deviation. m. 4.	Target distance minus deviation. m. 5.	Lottery number. 6.	Observation. 7.
1	1	59	+ 10	2220	74	?	9	9	77	+25	2205	79	?
2	2	100	+100	2130	13	c	10	10	52	± 0	2230	80	?
3	3	93	+ 55	2175	10	c	11		23	−30	2260	44	c
4	4	54	+ 5	2225	24	c	12		44	− 5	2235	69	?
5	5	56	+ 5	2225	68	?	13		47	− 5	2235	93	f
6	6	69	+ 20	2210	39	c	14		64	+15	2215	73	?
7	7	94	+ 55	2175	75	?	15		31	−20	2250	44	c
8	8	34	− 15	2245	35	c	16		10	−50	2280	46	c

Shrapnel.

1	11	27	−15 + 2		42	c	13	23	18	−25 + 2		42	c
2	12	93	+35 − 6		90	?	14	24	69	+10 − 4		57	c
3	13	51	± 0 0		3	c	15	25	16	−25 + 4		9	c
4	14	6	−40 + 5		85	?	16	26	80	+20 − 3		13	c
5	15	29	−15 + 1		73	?	17	27	94	+40 − 3		39	c
6	16	77	+20 − 1		35	c	18	28	38	−10 − 1		60	c
7	17	36	−10 + 1		15	c	19	29	73	+15 − 2		48	c
8	18	38	−10 − 1		70	?	20	30	61	+ 5 − 1		43	c
9	19	98	+50 − 6		4	c	21	31	12	−30 + 4		77	?
10	20	51	± 0 0		22	c	22	32	77	+20 − 1		84	?
11	21	64	+10 0		25	c	23	33	90	+30 − 5		38	c
12	22	2	−55 + 7		10	c	24	34	78	+20 − 2		90	?

Firing Record.

No. of gun.	COMMAND.	No. of shot.	Fuse.	OBSERVATION.	
			elevation. m.	batt'y.	target.
1.	2.	3.	4.	5.	6.
VI.‡	P. s., dir. on bat., l. of vil.. 2d p., 2000, l. fl. F.!*	1	2000	?	—220
V.		2	2000	—	—130
IV.		3	2200	+	+ 25
III.		4	2100	—	—125
II.		5	2150	?	— 75
I.		6	2150	—	— 60
VI.	C. f., shr., by steps, 2150, F. w.!†	7	2150	?	— 25
V.		8	2150	—	— 95
IV.		9	2150	?	— 55
III.		10	2150	?	— 80
II.	(Discharge loaded pieces.)				
I.					
VI.	(Shrapnel, time fuses.)	11	2150	$\frac{-}{0}$	$\frac{-65}{-2}$
V.		12	2150	$\frac{?}{0}$	$\frac{-10}{-10}$
IV.	1 plate higher!	13	2150	$\frac{-}{3}$	$\frac{-50}{3}$
III.		14	"	$\frac{?}{8}$	$\frac{-90}{8}$
II.		15	"	$\frac{?}{4}$	$\frac{-65}{4}$
I.	New fuse 2150, set all at that!	16	"	$\frac{-}{2}$	$\frac{-30}{2}$

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* Percussion shell, directly on battery to left of village, 2nd piece, 2000 m., from left flank Fire!

† Cease firing, shrapnel, by steps (increasing gradually, 50 or 100 m. at a time), 2150 m., fire at will!

‡ On account of the fire beginning with left piece. these numbers are reversed with respect to their original order [note by translator J. W. P.].

No. of gun.	COMMAND.	No. of shot.	Fuse. Elevation. m.	OBSERVATION.	
				batt'y.	target.
1.	2.	3.	4.	5.	6.
VI.	...	17	2150	$\frac{?}{4}$	$\frac{-60}{4}$
V.	...	18	"	$\frac{?}{2}$	$\frac{-60}{2}$
IV.	C. f., r., on the battery coming up, F. w.!*	19	"	$\frac{+}{0}$	$\frac{+60}{-3}$
III.	...	20	"	$\frac{+}{3}$	$\frac{+10}{3}$
II.	2100! ...	21	2150 2100	$\frac{-}{0}$	$\frac{+20}{-4}$
I.	...	22	"	$\frac{-}{3}$	$\frac{-45}{3}$
VI.	...	23	"	$\frac{-}{0}$	$\frac{-15}{-2}$
V.	...	24	"	$\frac{-}{0}$	$\frac{+20}{-8}$
IV.	(New fuse setting.)	25	2100	$\frac{?}{7}$	$\frac{-65}{7}$
III.	...	26	"	$\frac{-}{0}$	$\frac{-20}{0}$
II.	...	27	"	$\frac{?}{0}$	$\frac{\pm 0}{0}$
I.	...	28	"	$\frac{-}{2}$	$\frac{-50}{2}$
VI.	...	29	"	$\frac{-}{1}$	$\frac{-25}{1}$
V.	...	30	"	$\frac{-}{2}$	$\frac{-35}{2}$
IV.	...	31	"	$\frac{?}{7}$	$\frac{-70}{7}$
III.	...	32	"	$\frac{?}{2}$	$\frac{-20}{2}$
II.	...	33	"	$\frac{-}{0}$	$\frac{-10}{-2}$
I.	...	34	"	$\frac{?}{1}$	$\frac{-20}{1}$

* Cease firing; to the right on the battery coming up, fire at will!

DISCUSSION OF THE FIRING.

In determining the range with percussion shell the fork was not correctly established, because shot three in consequence of its large deviation struck far beyond the target. Since the target distance was 2230 m. and the elevation given to this shot was only 2200 m., it should have struck in front of the target. The short-fork distance became therefore, not 2200 (what it should have been) but 2150 m. As the short fork was established by three shots in front of the target and only one actually observed to fall beyond, it would have been better before passing to shrapnel fire to have fired a few more percussion shells at 2150 m.; then it would have become evident very quickly, as may be seen from the firing record, that 2150 m. was too short a range. That the passage to shrapnel fire in this particular case could follow without detriment immediately upon the establishment of the short fork, was due to the combination of two fortunate circumstances. In the first place 2200 m. was the actual approximate short-fork distance; the error made in its determination was *accidentally* not over 50 m.; it might have been however,—in consequence for example, of a false observation—very much greater. Moreover, the fact that the fuses burned 80 m. too long (in range) was exceptionally fortunate, since, after ground hits were avoided by inserting a plate, it so happened that perfectly normal distances of 50 m. in front of the target were obtained for the points of bursting. Had the fuses burned correctly bursting distances of 130 m. would have been obtained, and therefore certainly a very indifferent effect.

On passing to shrapnel fire the battery commander was soon obliged, on account of ground hits to insert a plate. In spite of the fact that the fuses burned 80 m. too long, it appeared as if the insertion of a single plate was sufficient to prevent ground hits. As a matter of fact the insertion of a plate increases the range by about 60 m.; the mean height of explosion would therefore be such as would correspond to fuses burning about 20 m. too long (about 3 m.).

As soon as the second target, the battery arriving on the right of the existing target, came up, the battery commander turned his fire in that direction. The first shot, a ground hit beyond the target did not as yet necessitate any correction, but upon observing in the next shot a point of explosion beyond the target the battery commander at once reduced the elevation by 50 m., *i. e.*, shrapnel with fuse set for 2150 m. were fired with an elevation of 2100 m. For this combination of elevation and fuse setting the director was not prepared. It is evident, however, that since the elevation 2100 m. is almost exactly the same as 2150 m., the position of the mean point of bursting for thse shots may be taken to be that assumed for 2150 m., viz: at $\frac{+10}{-4}$. These shots all lay in front of the target, those that gave ground hits as well as the one shot that burst in air.

From shot 25 on, when elevation and fuse setting were in accord again—2100 m.,—the first point of explosion was at 7 m., therefore somewhat above the normal height, and then followed two ground hits. The battery commander might have had another plate inserted at once. But, as the fuses of the shots fired against the first target burned approximately correctly, and the two ground hits (or possibly low bursting points) had been preceded by a high point of bursting, and as, moreover, he did not wish to leave a long interval before firing on the newly arrived target, he delayed inserting a second plate. The result justified his action; in the next seven shots there was but one ground hit, and he could hope, from the progress of the entire firing against this target, to obtain in a short time an annihilating effect.

4. FIRING AT A SKIRMISH LINE AT SHORT RANGE.

Assumptions of the director.

Target—skirmishers, kneeling, in open ground.

Distance—1170 m.

Fuses—burning 20 m. too long (in range).

Longitudinal deviation—medium.

Observation conditions—Lottery numbers 1 to 64 correct (64 per cent.); 65 to 91, doubtful (27 per cent.); 92 to 100, false (9 per cent).

Position of the mean point of bursting, with elevation and fuse 1100 m., at $\frac{-100}{2}$.

Record of lottery numbers drawn.

PERCUSSION SHELL.						SHRAPNEL.					
Number. 1.	Lottery number. 2.	Deviation. m. 3.	Target distance minus deviation. m. 4.	Lottery number. 5.	Observation. 6.	Number. 1.	No. on the firing record 2.	Lottery number. 3.	Deviation. m. 4.	Lottery number. 5.	Observation. 6.
1	34	—15	1185	56	c	1	9	23	—15 0	84	?
2	8	—55	1225	69	?	2	10	54	± 0 — 1	23	c
3	87	+40	1130	74	?	3	11	80	+15 — 1	63	?
4	86	+40	1130	7	c	4	12	91	+25 — 1	71	?
5	96	+65	1105	29	c	5	13	12	—20 + 3	2	c
6	79	+30	1140	73	?	6	14	34	—10 — 1	43	c
7	74	+25	1145	55	c	7	15	25	—10 + 2	24	c
8	45	— 5	1175	98	f	8	16	20	—15 + 1	55	c
9	69	+20	1150	36	c	9	17	81	+15 — 1	31	c
10	55	+ 5	1165	71	?	10	18	95	+30 — 1	54	c
11	40	—10	1180	82	?	11	19	50	± 0 0	48	c
12	75	+25	1145	29	c	12	20	54	± 0 — 1	60	c

Firing Record.

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. / Elevation. m. 4.	OBSERVATION. batt'y. 5.	OBSERVATION. target. 6.
I.	P. s., skirmishers on the main road, 1000!*	1	1000	—	—185
II.	....	2	1200	?	— 25
III.	....	3	"	?	+ 75
IV.	....	4	"	+	+ 70
V.	....	5	1100	—	— 5
VI.	C. f., shrapnel, 1100, F. w.!†	6	"	?	— 40
I.	....	7	"	?	— 45
II.	....	8	"	+	— 75
III.	(Shrapnel.)	9	"	? 2	—115 2
IV.	....	10	"	— 1	—100 1
V.	....	11	"	? 1	—85 1
VI.	....	12	"	? 1	—75 1
I.	....	13	"	? 5	—120 5
II.	....	14	"	— 1	—110 1
III.	....	15	"	? 4	—110 4
IV.	....	16	"	— 3	—115 3
V.	....	17	"	— 1	—85 1
VI.	....	r8	"	— 1	—70 1
I.	....	19	"	— 2	—100 2
II.	....	20	"	— 1	—100 1

* Percussion shell, on skirmishers on the main road, 1000 m.!
† Cease firing, shrapnel, 1100 m., Fire at will!

Determining the distance of a line of skirmishers at short range by means of percussion shell, is the exception rather than the rule in practice. More commonly it will be necessary to pass to them from targets at greater distances, against which the battery is at the time engaged in firing shrapnel. If this is to be illustrated in the fire game a supposition to that effect must be made, and also as to how many guns of the battery are loaded when a particular gun is fired immediately after firing which the passage to the new target is to be ordered. We will illustrate such a firing by an example. Let us take the battery of the preceding example, standing as it was under fire and firing on hostile artillery at 2100 m. At the moment when the skirmishers arrive at the distance of 1170 m., suppose the fourth piece has just fired, and that the fifth, sixth, first and second are again loaded with shrapnel, set at 2100 m. Let the record as given for percussion shell in example four hold true as regards deviation and character of the observation in the case of these shrapnel, which will burst as ground hits by percussion.

The firing will then proceed as indicated in the following firing record:

No. of gun.	COMMAND.	No. of shot.	Fuse.	OBSERVATION.	
			Elevation. m.	batt'y.	target.
1.	2.	3.	4.	5.	6.
V.	C. f., l. skirmishers, 1000, F. w.*	1	2100 1000	—	—185
VI.	. . . .	2	2100 1200	?	— 25
I.	. . . .	3	2100 1200	?	+ 75
II.	. . . .	4	"	+	+ 70
III.	(New fuse setting.)	5	1000 1100	? 6	—200 6
IV.	(New fuse setting.)	6	1200 1100	?	— 40
V.	. . . .	7	"	?	— 45
VI.	. . . .	8	"	+	— 75

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* Cease firing to the left on the skirmishers, at 1000 m., Fire at will!

No. of gun. 1.	COMMAND. 2.	No. of shot. 3.	Fuse. Elevation. m. 4.	OBSERVATION. batt'y. 5.	target. 6.
I.	(New fuse setting.)	9	1100 1000	—	—150
II.		10	"	?	—165
III.		11	"	?	—185
IV.		12	"	—	—145
V.	(New fuse setting.)	13	1000	$\frac{?}{2}$	$\frac{-215}{2}$
VI.		14	"	$\frac{-}{1}$	$\frac{-200}{1}$
I.		15	1000 1100	$\frac{?}{4}$	$\frac{-185}{4}$
II.		16	"	$\frac{?}{4}$	$\frac{-175}{4}$
III.		17	"	$\frac{?}{7}$	$\frac{-210}{7}$
IV.		18	"	$\frac{?}{6}$	$\frac{-215}{6}$
V.	(New fuse setting.)	19	1100	$\frac{-}{1}$	$\frac{-70}{1}$
VI.		20	"	$\frac{-}{1}$	$\frac{-100}{1}$

The comparison of these two firing records is very interesting. The first firing was quite successful; the last a complete failure. For, a battery which hurls its first effective shot at a line of skirmishers at *less* than 1200 m. distance, only after firing eighteen shots, *i. e.*, at the expiration of about five minutes, cannot certainly count on any effective result after that.

In order at the beginning to prevent any misunderstanding, it may be definitely stated that this was not due to any mismanagement in directing the firing. How the effects of good work are combined with mere luck in firing is very clearly shown in these two examples. Had shot two been *correctly* observed, the firing in *both* cases would have been a failure; for, in that case 1200 m. would have been the short fork distance, and the position of the mean point of explosion would have become ±0, as in the other case. It was, therefore, an especially fortunate circumstance—namely, that a shot with a particularly large deviation short of the target (—55 m.) was not observed—which permitted the first firing to succeed so well. In the second firing record shot five was not observed, and it could not, even had the battery commander been aware of the fact, as he probably was, that it lay short of the target, be taken into consideration any way. The position of its point of bursting in front of the target was entirely the result of the fuse setting (1000 m.). This shot only served to show, what was already well known, viz: that the target was farther off than 1000 m. Then shots six and seven were not observed at all, and shot eight falsely, just as in the first firing record. In the latter (the first) it was without significance, because the fork of 100 m. had been already established and the passage to shrapnel fire already ordered. But in this (the second) case it was of *decisive* importance and value; for the result of the false observation was that the shrapnel bursting in air by the action of the fuse had too great a distance for the point of explosion in front of the target. Although the error was noticed as early as the second projectile which burst in air, it was still necessary to fire four more shrapnel with this false fuse-setting.

Whereas, in the first firing record the first effective shot fired was the ninth, *i. e.*, after about three minutes of firing, the first effective shot in the second case was the eighteenth.

The example also shows, however, how entirely different an order of firing may result from a change in a single observation. To make such a change is to be recommended whenever there is not much time for preparation. If, in the preparatory record, in the case of one of the first shots that serve to establish the fork, a correct observation is changed to a false one or the reverse, an entirely different firing record will be obtained, and all the rest of the preparations can be fully utilized.

[TO BE CONTINUED.]

ON THE DETERMINATION OF THE COMBUSTION-TEMPERATURE OF EXPLOSIVES.[*]

By NIKOLAUS RITTER von WUICH, Lieutenant Colonel, Artillery Staff, Austrian Army.

Very few data connected with the theory of explosives up to date have been received with so much skepticism as the enormously high temperatures of explosion. For example, in accordance with the most recent experiments, that of black gunpowder lies between 3000° C. and 4000° C.; of gun-cotton, between 5000° C. and 6000° C.; and, finally, that of nitro-glycerine between 7000° C. and 8000° C.

The object of this investigation is to reduce on theoretical grounds, the temperatures of combustion of explosives to a trustworthy standard. For this purpose, in addition to the already existing black powder as standard of comparison, there will be considered besides nitro-glycerine, a few types of smokeless powders.

The most obvious objection to the high combustion-temperatures of powders depends on the consideration that these temperatures far exceed the melting points of the gun-metals, and that consequently guns ought to be destroyed far sooner than, fortunately, experience shows to be the case.

The above mentioned objection finds however in the extremely short duration of the influence of the glowing heated gases on the gun, an important if not complete invalidation, since to the exercise of this influence—here the alteration of the state of aggregation—a certain interval of time is necessary.

Accordingly, time for destruction is not given, in analogy with the idea first expressed by Rodman, that guns often withstand

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[*] Translated with the permission of the author, from *Mittheilungen über Gegenstände des Artillerie- und Genie-Wesens*, No. 2, 1891, by 1st Lieutenant C. DeW. Willcox, U. S. Artillery

very severe strains without bursting, because time therefor is not granted.

Naturally the greater the intensity of the cause of destruction, the shorter is the time unquestionably necessary for completing the destruction.

The molecular theory of gases has also a word to say, although its foundations are not yet so secure, as to beget absolute confidence in the results of its computation. In accordance with this theory, between 2500° C. and 2800° C. molecular cohesion ceases to exist; that is, the molecules must separate into their unstable atoms.

Theorists, guided by the conjecture that, in analogy with solid bodies, the specific heats of gases must increase with the temperature, have maintained that the real temperatures of combustion are *somewhat* smaller than the calculated. In the meantime, however, experimenters have already furnished results exciting less astonishment. Experiments with the melting of platinum in the flame of gunpowder have indicated a surface alteration of the state of aggregation. Inasmuch as the melting point of platinum is 1775° C., the combustion-temperature of black powder could be put down incidentally at 2000° C., reckoned from the melting point of ice.

From pressures in closed vessels, as furnished by experiments with crusher-gauge, Noble and Abel have, indirectly, determined the temperature. In regard to this, I refer to my investigations published in 1888, in the *Mittheilungen*, on "The pressure relations in respect of the combustion of powder in closed vessels," and particularly to the formula on page 383:

$$p = R_1 T \frac{\varepsilon a \sigma_g D_1}{1 - \frac{\sigma_g}{\sigma_p} D_1}$$

in which:

p = pressure in atmospheres.

R_1 = characteristic constant for the products of combustion in Gay-Lussac—Mariotte's law (according to Noble and Able, = 0·00229).

T = the absolute temperature of combustion.

ε = the weight of gas in 1 kg. of powder.

a = the weight of powder burned per kilogram. of the charge, here = 1.

σ_g = weight of the volume of powder (*Kubiergewicht*).

σ_p = the specific weight of the mass of powder.

D_1 = the density of loading, according to the definition of both experimenters; that is, the ratio of the volume of the powder plus interstitial spaces, to the volume of the powder chamber.

If in the formula above, we put

$$R_1 T\varepsilon\sigma_g = A$$

then

$$p = A \frac{D'}{1 - \frac{\sigma_g}{\sigma_p} D'}$$

in which A may be computed as a mean from the system of pairs of values of p and D; according to Noble and Abel, $A = 2340$.

The numerical value of A being deduced from the pressures, we have

$$T = \frac{A}{R_1 \varepsilon\sigma_g}$$

By this procedure the temperature of combustion is found indirectly to be 2100° C., computed from freezing point. While this temperature is far more trustworthy than the purely theoretical one, yet we cannot but ask whether the pressures deduced from the data of the crusher-gauge are the correct ones, in regard to which a good deal might be said.

Finally, it may be remarked, in respect of Gay-Lussac—Mariotte's law, that,

$$\frac{1 - \frac{\sigma_g}{\sigma_p} D'}{\varepsilon\sigma_g D'}$$

is the specific volume of the powder gases, the value of which corresponding to the investigation above mentioned, becomes

$$\frac{1 - 0.6 D'}{430 D'}$$

These considerations premised, I turn to the real subject of my investigations, and begin with a glance at the cardinal error of previous methods of determining the temperature of combustion. This consists in assuming the specific heat to be independent of temperature, and in taking into account the specific heat determined for freezing. It is evident however that simple logic based on the phenomena of nature must lead to the conclusion that thermal capacity, of which specific heat is the numerical expression, decreases as the quantity of heat in a given body increases. That is, more heat must be imparted to a body, in order for example to raise its temperature from 1000° C. to 1001° C., than to raise it from 0° to 1°.

If we call Q_r the quantity of heat which one kg. of a composition gives out on explosion, and c_0 the absolute specific heat at 0° C., agreeing in the case of gases (there being no internal work done) with specific heat at constant volume, then heretofore the temperature t of combustion, counted from 0° C., has been defined by

$$t = \frac{Q_r}{c_0} \quad - \quad - \quad - \quad - \quad (1)$$

As an example take the black powder experimented with by Bunsen and Schischkoff. For this, the quantity of heat Q_r was found to be 620 calories (using the kilogram and centigrade scale). This value was deduced both from a practical reaction, furnished by a chemical analysis of the products of explosion, and from the data of a calorimetric experiment. The experimenters above-named, relying on the reaction of decomposition, found as an average value for the absolute specific heat of the products of explosion $c_0 = 0.18548$. With these data, we have in round numbers for the temperature of explosion

$$t = \frac{620}{0.18548} = 3340^\circ \text{ C.}$$

With regard to this I remark that the quantity of heat, 620 calories, is decidedly greater than is accordant with the truth. It must be noticed in the next place, that chemical analysis is possible only after cooling takes place. In this process of cooling complicated combinations take place as subsequent reactions, that are not conceivable as occurring at the high temperature of explosion, but which nevertheless have been considered in the determination of the deduced quantities of heat.

Similarly, in calorimetric experiments time is given for subsequent formation of complex compounds, and for a partial change in the state of aggregation, giving rise to the emission of more heat, which has nothing to do with that given out at the moment of explosion.

Consequently, $Q_r = 620$ calories is far too great, and it is likely that the so-called theoretical formula of decomposition containing only simple combinations lies nearer the truth than those based entirely on chemical analysis.

The commonly given theoretical formula for the decomposition of black powder is as follows:

$$2KNO_3 + 3C + S = K_2S + 3CO_2 + 2N$$

to which corresponds $Q_r = 424$ calories.

The percentage composition of powder is in round numbers 75:13:12.

If we take the quoted value of Q_r as limiting value, then $\frac{620 + 424}{2} = 522$ may be regarded as a mean value lying nearer the truth.

To this mean value of Q_r we must also naturally join the mean value of c_0; and as, by my calculations $c_0 = 0.1282$ for the theoretical reaction, we have as mean for c_0:

$$c_0 = \frac{0.1282 + 0.18548}{2} = 0.15684$$

whence

$$t = \frac{522}{0.15684} = 3330^\circ$$

It is evident from this, that however the matter may be investigated, abnormally high temperatures are always obtained, as long as the specific heat is considered independent of the temperature. I shall therefore show how the temperature of combustion turns out, if we take the specific heat to be a function of the temperature.

In this matter, E. Wiedemann's experiments are of great value. According to these, we have for CO_2 at

	0°	100°	200° C.
the absolute specific heats	0.1394	0.1549	0.1705.

Whence, the specific heat increases 0.000155 for 1°. We may therefore write for CO_2

$$c = c_0 + 0.000155t \quad - \quad - \quad - \quad (2)$$

As nothing more suited to my purpose is available, and as the average behavior of the products of combustion is quite similar to that of CO_2 (see, the already quoted investigation, p. 346), I shall assume formula (2) throughout. It must however be borne in mind, that formula (2) offers only approximate results in the case of explosive compounds, particularly as I am applying to much wider temperature-limits, a formula applicable only to narrow (0°—200°) limits.

The question now is to determine the quantity of heat to be applied to unit-weight (1 kg.), in order to raise its temperature from 0° to t°.

If we put

$$c = f(t)$$

this means that to the mass of one kg., at the temperature t, must be imparted the quantity of heat $f(t)$ in order to increase the temperature by 1°.

Should the temperature be infinitesimally increased in a time dt,

$$cdt = f(t)dt$$

is the quantity of heat required.

Hence the quantity of heat, corresponding to t, absorbed by one kilogramme of the mass is defined by the equation

$$Q_t = \int_0^t f(t)dt = F(t)$$

and if, referring to (2), we write

$$f(t) = c_0 + at$$

then

$$Q_r = \int_0^t (c_0 + at)dt = c_0 t + \frac{a}{2} t^2 = F(t) \quad - \quad (3)$$

Hence, we have to determine the temperature of combustion

$$t = \frac{-c_0 + \sqrt{c_0^2 + 2Q_r a}}{a} \quad - \quad - \quad - \quad (4)$$

Substituting in this formula the values of c_0 and Q_r corresponding to the experiments of Bunsen and Schischkoff, and taking $a = 0.000155$, we have

$$t = 1874°$$

that is, a value in tolerable accord with the confessedly few results of experiment.

In round numbers then, we may take the temperature of combustion as 2000° C.

If one wishes to deduce the coefficients of t in (2) from experiments made with powder, it is recommended to use in the calculation the temperature deduced from Noble and Abel's experiments.

If in

$$Q_r = c_0 t + \frac{a}{2} t^2$$

we put $Q_r = 620$, $c_0 = 0.18548$, and $t = 2100$
then

$$a = 0.0001$$

and

$$c = c_0 + 0.0001t$$

I now pass to the determination of the temperatures of combustion for a few of the modern explosive compounds, whose chemical constitution and conjectural theoretical decomposition will be next given.

This preliminary fundamental work I have carried out at the instigation, and in accordance with the valuable suggestions, of Major Johann Schwab, of the Artillery Staff.

Let us now take up four nitro-cellulose powders, distinguished from one another chiefly by different quantities of nitrogen.

A.—Powder, consisting of one molecule of trinitro-cellulose and two of binitro-cellulose (collodion-cotton):

$$C_6H_7(NO_2)_3O_5+2C_6H_8(NO_2)_2O_5= CO_2+17CO+10H_2O+7N+3H.$$

B.—One molecule of trinitro- to one of binitro-cellulose:

$$2C_6H_7(NO_2)_3O_5+2C_6H_8(NO_2)_2O_5= CO_2+23CO+15H_2O+10N.$$

C.—Reverse of **A.**

$$2C_6H_7(NO_2)_3O_5+C_6H_8(NO_2)_2O_5=CO_2+16CO+11H_2O+8N.$$

D.—Pure trinitro-cellulose.

$$2C_6H_7(NO_2)_3O_5=3CO_2+9CO+7H_2O+6N.$$

Besides these nitro-cellulose powders, will be investigated:

E.—Noble's nitro-glycerine binitro-cellulose powder, for which Krupp offers the following reaction:

$$10C_3H_5(NO_2)_3O_3+9C_6H_8(NO_2)_2O_5= 26CO_2+58CO+61H_2O+48N.$$

Finally:

F.—Nitro-glycerine:

$$2C_3H_5(NO_2)_3O_3=6CO_2+5H_2O+6N+O.$$

In constructing these reactions—which may always vary under the conditions of the explosion—it was assumed as basis, that the *H* and *C* are as far as possible completely burned. In the following table are given the percentages of the elements contained in the respective explosives, as well as those of the products of explosion:

Explosive.	Element.				Products of Explosion.					
	C	H	N	O	CO_2	CO	H_2O	N	H	O
A[*]	26.97	2.87	(12.24)	57.92	5.5	59.4	22.5	12.2	0.4	
B	26.23	2.73	(12.75)	58.29	4.0	58.7	24.6	12.7		
C	25.53	2.60	(13.24)	58.63	10.5	52.9	23.4	13.2		
D	24.24	2.36	(14.14)	59.26	22.2	42.4	21.2	14.2		
E	22.21	2.69	(14.81)	60.29	25.2	35.8	24.2	14.8		
F	15.86	2.20	(18.50)	63.44	58.2		19.8	18.5		3.5

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[*] If we suppose that all the hydrogen burns to water, then the reaction for **A** is:

$$C_6H_7(NO_2)_3O_5+2C_6H_8(NO_2)_2O_5=17.5CO+11.5H_2O+7N+0.5C.$$

The percentages of the products of explosion then are:

$$CO:H_2O:N:C=61.2:25.8:12.2:0.8$$

In order to be able to compute the combustion temperatures corresponding to the explosive compounds, we must first know the reduced quantities of heat Q_r, and the (corresponding to 0°) average absolute specific heats c_0 of the products of explosion; or more exactly, the absolute specific heats of the mixture of these products.

If we represent in general a decomposition by

$$K = k_1 + k_2 + k_3 + \ldots\ldots$$

then to get Q_r, we must have the quantity of heat Q, due to the chemical processes involved, and then divide this by the weight of the body K in kilograms.

Taking the gram. as unit of atomic and molecular weights, then, according to the decompositions above given, we have for

	A	**B**	**C**	**D**	**E**	**F**
the weights	0.801	1.098	0.846	0.594	4.538	0.454 kg.

The quantity of heat Q will be obtained by subtracting from the heat of combination of the explosion-products k_1, k_2, k_3, that absorbed in the separation of the given substance K into its elements.

The following table* gives, for one molecule of the substance concerned, the unit being the gramme, the quantities of heat of combination (or of separation) in usual (large) calories (kilogramme-degree C.):—

Substance.	Quantities of heat.	
CO_2	94	calories
CO	25	"
H_2O	69	"
$C_6H_8(NO_2)_2O_5$	184	"
$C_6H_7(NO_2)_3O_5$	195	"
$C_3H_5(NO_2)_3O_3$	130.5	"

That is, in making 44 g. CO_2 94 large calories are set free; contrariwise, in separating 44 g. CO_2 into its elements, 94 calories are absorbed.

To illustrate the process of computing Q_r, we shall make the numerical calculation for compound A; as already pointed out, 0.801 kg. are taken into account.

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* From Berthelot.

1 CO_2 gives 94 calories $=94$

17 CO gives 17×25 calories $=425$

10 H_2O gives 10×69 calories $=690$

whence 1209 calories are set free.

Since in the decomposition of one molecule of trinitro-cellulose, and in that of two molecules of binitro-cellulose, 195, and $2\times 184=358$ calories, respectively, are absorbed, in all 563, we have for 0.801 kg. of the compound: $Q=1209-563=646$ calories available, whence for one kg.:

$$Q_r=\frac{646}{.801}=806 \text{ calories}^*$$

In this fashion I found for

	A	B	C	D	E	F
$Q_r=$	806	862	914	1010	1133	1427 cal.

It is now necessary to determine the specific heat c_0 of the products of explosion, i. e., the quantity of heat that—reckoning from the freezing point—must be imparted to one kilogram. of the products of explosion, in order to raise the temperature by 1° C. Supposing the weights a_1, a_2, ... of the products of explosion to be determined corresponding to one kilogram. of the substance considered (see table, p. 415), and calling c_0', c_0'', ... the absolute specific heats of the separate products of explosion, then in accordance with the law of nature that the absorption of heat always takes place in accordance with the condition of temperature equilibrium, we have,

$$c_0=a_1c_0'+a_2c_0''+\dots \qquad (5)$$

as the quantity of heat that will increase the temperature of the products of explosion by 1° C.

Below are given the absolute specific heats for the products of explosion considered:

Substances,	Sp. heat.
CO_2	0.1581
CO	0.1752
H_2O (vapor)	0.3432
N	0.1717

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* If we take the reaction giving *free* carbon, $Q_r=834$ cal.

O	0.1533
H	2.4046

The computation for preparation **A** is as follows:
From one kilogram. of the products of explosion we have:

CO_2	CO	H_2O	N	H
0.055	0.593	0.225	0.122	0.004 kg.

to which correspond the specific heats

0.1581	0.1752	0.3432	0.1717	2.4046

Multiplying, conformably to (5), the numbers in the upper by the corresponding ones in the lower line, we get (water-equivalents)

0.0087	0.1041	0.0772	0.0187	0.0096

whence by addition,

$$c_0 = 0.2183.$$

In this way I found for

	A	**B**	**C**	**D**	**E**	**F**
$c_0 =$	0.2183	0.2146	0.2121	0.2064	0.2110	0.1971

In conclusion, the temperatures of combustion will be computed according to the usual method, and then according to mine.

By formula (1) for

	A	**B**	**C**	**D**	**E**	**F**
$t =$	3692°	4017°	4309°	4893°	5370°	7240° C.

By formula (4)

$t =$	2110°	2234°	2329°	2516°	2697°	3005° C.

A few considerations may be added connected with the reduced quantities of heat, Q_r. Starting from these magnitudes, we may compute the energy E_r given up by one kilogram. of a (compound) substance—and this we may call the reduced energy. Since one calorie is the equivalent (using the kilogram. and the centigrade scale) of 424 kgm., or of 0.424 mt. (metre-tonnes), we may obtain the reduced quantity of energy, by multiplying the number given above by 424, and 0.424 respectively.

Hence for

	A	**B**	**C**	**D**	**E**	**F**
we get						
$E_r =$	341744	365488	387536	428240	480392	605048 kgm.
and						
$E_r =$	341.744	365.488	387.536	428.240	480.392	605.048 mt.

respectively.

The quantity of energy E_r is a fundamental magnitude in interior ballistics, since—briefly—the solution of the problem of the motion of the projectile in the bore of a gun consists in distributing the energy of the charge—the potential energy—according to the laws of mechanics. By bringing the deduced values of Q_r and of E_r into relation with the data of the table, p. 415, the conclusion is drawn that Q_r (or E_r) increases with the quantity of nitrogen as well as with the quantity of oxygen present. And it is interesting to investigate whether in bodies of the same kind, a numerical relation may be determined between Q_r and the nitrogen.

Let us consider for this purpose, the nitro-cellulose powders (that is, **A, B, C, D**,), of which a greater number is available.

If we take the differences ΔN of N; next, the differences ΔQ_r of Q_r, and then determine the increase in Q_r for $\Delta N = 0.1$ per cent., we get the following:

Substance	N per ct.	ΔN	Q_r	ΔQ_r	ΔQ_r for $\Delta N = 0.1$
A	12.24		806		
B	12.75	0.51	862	56	11
C	13.24	0.49	914	52	10.6
D	14.14	0.90	1010	96	10.7

We may accordingly say, that within the limits of the considered quantities of nitrogen, an increase of 0.1 per cent. in nitrogen increases the reduced quantity of heat by 11 calories, and hence the reduced quantity of energy by $11 \times 424 = 4664$ kgm. For oxygen, we have as increases in Q_r for an increment of 0.1 per cent. in the oxygen of the series, 15.1, 15.3, 15.2, or an average of 15.2 calories. If we know ΔE_r, we may by means of the useful effect η determine approximately the increment ΔV in the initial velocity.

Since η indicates what proportional part of the energy contained in the powder charge (weight $= p$) was transferred to the projectile (weight $= P$), we have

$$\frac{P}{2g} V^2 = \eta p E_r$$

whence

$$V=\sqrt{2g\eta}\sqrt{\frac{p}{P}}\sqrt{E_r}$$

and

$$\Delta V=\sqrt{2g\eta}\sqrt{\frac{p}{P}}\,\frac{\Delta E_r}{2\sqrt{E_r}}$$

If, for example, starting from A, we put in this equation, $\eta=\frac{1}{3}$, $p=2.75g$, $P=15.8g$, $\Delta E_r=4664$ kgm., then

$$\Delta V=7\text{m}.$$

From the last two equations we get by division for the relative variation in initial velocity,

$$\Delta V=\frac{\Delta E_r}{2E_r}\,V.$$

To get the reduced quantities of heat, Q_r, reckoned from absolute 0 ($-273°$ C.) we must add to Q_r the quantity corresponding to the absolute temperature of the substance before explosion.

As an approximation:

$$Q'_r=Q_r+c_0(273+t)$$

in which $t=$ temperature of the substance before explosion, reckoned from freezing point.

Neglecting t,

$$Q'_r=Q_r+273c_0$$

This determination is approximate, only because the temperature $-273°$ C. involves the assumption that Gay-Lussac—Marriotte's law holds good down to the absolute zero, while it is still further tacitly assumed that the specific heat suffers no change within the limit of negative temperatures.

For black powder $Q'_r=670$ cal., and for

A	B	C	D	E	F
866	920	972	1066	1190	1480 cal.

The quantity of heat Q'_r may be taken as the measure of the dynamic effect of a compound, since—leaving out losses of heat—the pressure p' depends only on Q'_r, and is directly proportional to it, if unit-weight (1 kg.) of the substance is burned in unit-volume (1 m^3); hence,

$$p'=mQ'_r$$

According to the mechanical theory of heat, and the molecular theory of gases, if p' is in atmospheres,

$$m = \frac{424}{10333}(k-1) = \frac{2}{3}\ \frac{424}{10333\beta}$$

in which

$k =$ ratio of specific heats at constant pressure and at constant volume.

$\beta =$ number by which must be multiplied the energy of the forward motion of the gas-molecules, in order to obtain the total energy. For perfect gases, $\beta = 1.625$.

With the known values of k, or β, tolerably plausible values may be obtained: it is more reliable to determine m from pressure-experiments. Taking those of Abel and Noble, and going back to the formula on page 410

$$m = \frac{p'}{Q'_r} = p\,\frac{1-0.6D'}{430D'Q'_r}$$

whence

$$m = \frac{2340}{430 \times 670} = 0.0081$$

This value of m may also be used in the determination of the values of k and β that are most likely to be true for the products of explosion; from the above formula,

$$k = 1.2, \quad \beta = 3.3$$

Since, as already pointed out in my investigations published in the *Mittheilungen* in 1888, the behavior of the powder-gases in guns lies between *isothermic* ($k = 1$), and *adiabatic* ($k = 1.2$), we have as a mean for k,

$$k = 1.1,$$

a value in remarkable accord with that (1.11) deduced by Krupp from velocity measurements.

NOTE.—I should like to express my thanks to 1st Lieutenant J. P. WISSER, 1st Artillery, for revising this translation.
C. DEW. W.

ARTILLERY DIFFICULTIES IN THE NEXT WAR.*

By First Lieutenant JOHN W. RUCKMAN, First Artillery, U. S. A.

INTRODUCTION.

The attempt to discuss the artillery difficulties of the next war must, from the nature of the case, savor of prophecy. Perceiving this fact at the outset, and the indefinite and unsatisfactory results of such discussion, we plead in vindication of the act, that notwithstanding the involved nature of the subject there exist to-day among artillerists certain well defined lines of thought and movement which point out the direction in which future artillery problems are tending, and which enable us to see that while most of the circumstances of the future artillery battle will be novel, they will in many cases have been foreseen.

The manufacture of longer guns, heavier projectiles moving with higher velocities, and accurate devices for aiming, indicate that artillery fire will be certain and efficacious.

The scientific and practical care given to instruction and preparation indicate that the commencement will be sharp and effective. On all sides we see tendencies from the old toward the new which point out certain general modes of operation.

It is evident in the beginning that much will depend upon time, place, organization, and degree of preparation for these new conditions and that some definite limits must be assumed. Not being able to predict the time and place and not having the means to forecast the future, and to ascertain the effect of inventions during the intermediate years an attempt to arrive at exact conclusions would be useless.

Since we must select a future battle ground and since the question applied to our own country is an important and interesting one, we will assume our country to be the defender

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* Read before the officers of Fort Monroe, Va., June 17, 1892.

in this hypothetical war, and as it, judging from the present outlook, promises to have many difficulties, the discussion may also be profitable.

There is a wide-spread sentiment throughout the country that a sea-coast artillery is superfluous and useless; and that in case of war we would make short work of a hostile army which would dare "to set foot on the sacred soil of this grand and glorious Republic. Doubtless France puffed up with the same feeling thought in 1870 that she could similarly despise an invader, yet one short month sufficed to reveal her mistake."

As in 1870, war promises to come in future like an avalanche upon the unprepared and overwhelm them in its course. From the nature of our country, its government, and the traditions of the people, it will always be difficult to establish the necessity for a reasonable sea-coast defense, but does this alter our needs?

However this may be, so long as we as a nation remain so thoroughly satisfied with ourselves, and the demagogue and charlatan continue to have more influence than the military expert, we shall have little to hope for in the way of sea-coast defense. It is not here the purpose to discuss sociological questions, but simply to direct attention to this particular weakness which in itself is an inherent obstacle to artillery progress.

History shows that war like other human institutions adapts itself to the surrounding conditions and that the principle of the "survival of the fittest" obtains in a marked degree. By study a nation can ascertain these conditions and so control her preparations as to march with them or neglect all and permit her military establishment to fall behind or directly oppose them. The former insures success; the latter defeat. Other things being equal, it may be stated with certainty that the nation which adapts itself, in organization and preparation for war, and most thoroughly avails itself of the world's intellectual and material resources, will be the stronger at the critical moment.

In a general sense an artillery difficulty may be defined as any condition, social, organic, educational, or material, which will prevent the artillery from obtaining the highest results in war.

It is apparent that the state of proficiency of an artillery command will depend upon its instruction in its duties and its familiarity with the work required. Again when these qualifications are perfect there may still remain certain organic obstacles in the way of the highest results. From these different factors which enter a modern or future artillery problem there appear three classes of considerations. Those affecting *organization*, *personnel*, and *matériel*.

I. ORGANIZATION.

Under this head will be considered those causes which act to destroy our health as a body.

1. A WEAK ORGANIC STRUCTURE.

The general subject may be compared to a man who has a piece of work to perform. If he be strong, healthy, has a good constitution, and is well skilled in the use of suitable instruments, he will do it with intelligence and comparative ease. Given the requisite health, vigor, food, and tools, with a clear insight into the duty repuired, and few difficulties will appear.

But poor tools produce delay and fatigue, poor skill produces inadequate results, poor food destroys the health; but organic disease destroys the life. In the latter case there is no hope for the patient except through its permanent removal. As with the sick man, so it is with our artillery. As one already having a constitutional weakness may by indulgence in improper food and neglect of exercise so pervert his system as to render him incapable of taking proper sustenance, so it is with our arm, which through time misapplied and energies misdirected is so run down that it turns from a correct diagnosis of its case and hesitates to accept the only remedy which will restore it to efficiency. Keeping this fact well in view, the first thing to be done in order to obtain a strong artillery is to create a sound organic structure. Having once achieved this we shall have removed one of the greatest artillery difficulties that now oppresses us and will have paved the way for the removal of most of the others.

2. THE ABSENCE OF A CHIEF OF ARTILLERY.

On emerging from the Civil War we were practically field artillery. Since that time our history has been one of aimless drifting from one thing to another, but in all the vicissitudes through which we have passed we have never struck upon our legitimate coast artillery duties.

A few years ago an appreciation of the country's defenseless condition brought about a kind of reaction, and for once in our history we found ourselves beginning to take an interest in artillery questions. The habits and methods of years, however, could not be left off in a day, so that now though progressing, the movement is slow. Each regiment, post, and battery is following its own independent line of operation without concerted action or system from which alone valuable results can flow. In this work we are drifting pretty much as before, and the fact that we are showing interest in our own professional work must be regarded as more or less accidental, since a change in the present administration of our affairs may cut it off at any time. We have not yet been long enough at the work to have become imbued with it and it is by no means popular or fashionable. So long as each officer in charge can carry out a scheme of instruction or practice in his own way, do it in a perfunctory manner and hurry through it to engage in more agreeable duties we can make but slow progress. The instruction of a battery at target practice for example should be made "popular and fashionable." All these "go as you please" methods should be bridled and brought in with a strong hand, and made to move with uniformity and singleness of purpose. This will be the work for a Chief of Artillery.

A chief would obtain suitable instruments, see that they were in order, and uniformly and intelligently used. He would lay out practical and theoretical instruction and by a systematical course of artillery inspections see that they were carried out and made efficient. He would prescribe experiments to be made from time to time, to obtain necessary or useful data, collect and classify the results and disseminate them amongst his corps. More generally speaking, he would supervise artillery work, study its needs, coördinate its methods, supply information and encourage and develop artillery enterprise. Thus keeping himself ever abreast of his profession and awake to the progress of his arm he would institute and administer a system of reform, gather about him a staff of energetic assistants through whom he would command and educate the arm and prepare it for any emergency.

There is in this country no field so unoccupied and yet so full of promise as that of future artillery.

To develop this field we need a man at our head who can grasp this fact and the far reaching effects of a proper organization, and who can direct our movement toward the great opportunities before us.

3. UNION OF COAST AND FIELD ARTILLERY.

The dual nature of our artillery is a third point of weakness in our system. Officers are periodically transferred from heavy to light and from light to heavy service without regard to fitness or preference. While the manifest object of this course is to give instruction in both branches of artillery, we believe that the opposite effect is produced. Two years is certainly a short time in which to learn light battery duties, while a lifetime is not too long for those of the coast artillery. The two years avocation in the life of the heavy artillerist is not however the principal disadvantage resulting from this practice. It unsettles each one in turn, not only in place but in thought. Investigations in subjects of one service are unexpectedly broken up and all interest in it practically destroyed. Such practice is contrary to that of all other institutions, not one of which could for any time withstand such draughts upon its resources. In our case, however, held together with the artificial forces of law we cannot go to pieces however far our efficiency may fall. Instead of having these disrupting forces in our combined services, would it not be better to introduce into each, separately, natural central forces, which, acting with the artificial ones present, would tend to make each an inherently strong and efficient body. All causes we believe, looking to the highest development of both, require their separation.

4. DIVIDED RESPONSIBILITY.

Passing now from our own arm to its relations with the other technical corps we find that the three departments are practically independent of one another. Having no direct responsibility to the others, each may prosecute its work along its own line without coöperation. This may some day lead to friction and want of adjustability.

Forts are now in progress of construction and guns will soon be placed on them, yet we as artillerists, who will use these guns, have no settled policy as to their grouping with respect to tactical considerations.

A tactical system of controlling the guns will have to be developed in future to suit whatever combination happens to be adopted in the construction of the forts; the opposite of this should obtain. The parapets and emplacements may be ready before the carriages and appurtenances have been officially adopted, and so on throughout the list. Our whole scheme for defense seems to be wanting in coherence, harmony and systematic action. The artillery has no effective means of making its needs felt and having them attended to. A machine, when tried under service conditions, may fail; the artillery can neither correct it nor have it corrected. The routine method is long and tedious and great injury to the service may result from delay.

To be an efficacious arm we must know at all times the value of our weapons, and whether our material is in good order and will stand the tests of war. This can be known only by using it. When a piece of apparatus is found to be defective the remedy should be prompt and decisive. The present state of divided responsibility may some day cause disaster. History already furnishes many instances of disaster in war due to this cause, and will doubtless furnish many more. In the case now in question, although central authority is behind all of them, it is, we think, too distant and indefinite to give prompt and decisive action. There must be but one commander-in-chief to give directions in emergency.

The three departments to which the country's defense is intrusted have a common aim and object and it is in the interest of all to work in closest touch with one another; the sentiment of unity of purpose should not be discouraged, but cultivated and strengthened by the freest discussion of all subjects relating to sea-coast defense. The present state of affairs is unfortunate; nobody is to blame; it is a bad system. If in future these three departments must remain independent, could not all questions affecting them collectively be disposed of by a representative board of officers whose action would be authoritative and final.

II. INSTRUCTION.

Judging from present signs, the future coast artillery will consist of a personnel thoroughly instructed theoretically and practically in all that pertains to the preparation and use of heavy artillery.

I. THEORETICAL EDUCATION.

To clearly grasp the detailed functions required of a sea-coast fort a thorough understanding of the general object of the place becomes necessary.

This object being to repel a naval attack the first lessons should be devoted to a careful study of the navies of the world; the means of recognizing them; the effective strength of each, and their methods of attack. Without some information on these subjects the defense will know nothing of the forces against them and be ignorant of their probable course. The instruction should if possible be carried still further, so as to obtain a clear idea of the nation's war policy and views of its leading men. This information should be utilized in studying modern sea-coast fortifications in their various forms and the conditions to be fulfilled by them; and a thorough analysis made upon modern basis, of the attack and defense of sea-coast works. This analysis being worked out for one or more of our important harbors would develop the fundamental principles involved. We have nothing touching these important subjects in our present instruction, and yet it cannot be denied that the want of familiarity with them is a serious omission. The want of acquaintance with modern naval tactics, sea-coast fortification, tactical organization suited to given conditions, and the means of administering suitable instruction and drill, indicate a want of appreciation of some of the most important considerations in our profession. If the necessity for acquaintance with them does not present itself now it may some day, when it will be too late. While we are neglecting them it must be remembered that the necessity for them remains and that time should be given them in proportion to their importance.

Next in order would follow a course of theoretical study of all the minor problems of gunnery and considerations relating to defense. This is especially important with respect to artillery, since many of its problems admit of exact solutions. In all such cases theoretical study will save great labor and expense. As these facts become more pronounced and appreciated our officers cannot but feel that their facilities for study do not keep pace with the demand, and find themselves from day to day engaged in a struggle to obtain the necessary books and information. Artillery posts, furnishing facilities for theoretical investigations, are rare and, as a rule, officers are thrown upon their own resources and compelled to work along without aid or encouragement. Professional books are expensive, and unless he makes unusual efforts the officer cannot keep pace with the advance around him. Here once more is an unfortunate state of affairs, the direct result of having no head and no system. While this condition is a bar to all uniform progress, its amelioration in a great measure seems but a simple matter and requires remedies well within the power of our authorities. Briefly stated, we believe the following policy would accomplish the greatest improvement in this direction:

First.—The establishment of an efficient bureau of artillery information at the *United States Artillery School.* Such a bureau could be developed and organized in a few years so that an officer at any post investigating a special subject could obtain all relevant information in the bureau without difficulty or delay. This department, if energetically handled, would soon contain all the important results of artillery development of recent years and distribute its collections throughout the service.

Second.—Aid and encouragement as far as possible in obtaining books and professional papers by the War Department.

Third.—An efficacious means of discussion and interchange of opinions on doubtful or unsettled subjects. This proposition, if carried into effect, would collect useful data and fill the arm with new life and hope.

Fourth.—The principle of the "division of labor" should be adopted and applied to our work. The present artillery requirements are so varied and exhausting that one mind cannot become proficient in all. In scientific and business professions no one attempts to master all branches; on the contrary, the above mentioned principle is carried to its limit. Little progress was made in civilization, science or art until it was followed. It pervades and rules every human institution except our army. Nevertheless, when we consider the subjects comprehended in an artillerist's profession, it seems clear this principle should find double application.

Modern artillery, in order to secure maximum efficiency, exhausts the domain of *mathematics* with its applications to mechanics, ballistics and thermodynamics; embraces all the principles of *engineering*, with its applications of the strength of materials and other innumerable considerations, to gun construction, electricity, metallurgy and steam; and elicits from *chemistry* results with respect to powders and explosives immeasurable in value. In fact all physical sciences must be studied and used, and as the present phase of artillery makes these demands extensive in comparison with the past, so will future requirements be so in comparison with present. In addition to the above mentioned sciences, and in direct touch with the artillery profession we find the subjects of the armaments of the world, naval tactics, attack and defense of places, siege operations, mines and torpedoes, organization and administration of fortress artillery, and many others which are artillery necessities. According to our present methods the artillery officer is also required to keep himself proficient in the art and science of war, reconnaisance, surveying, grand and minor tactics, drills of all arms, practical exercises and use of all kinds of instruments. One can scarcely hope to master this array. It should be remembered that an artillery personnel are only men after all, whose minds are not infinite and who cannot, with reason, be expected to master all the parts of a profession whose scope practically embraces all the arts, sciences and material considerations in existence.

As now pursued our instruction is merely a smattering, which is scarcely retained until learned, and produces no permanent good to the service. Our methods are contrary to the practice of all progressive institutions and the great principle which actuates the movements and resources of the world.

Judging from these and many other relevant facts, we are forced to the conclusion that a great part of our work should be done by specialists.

A man having signified his intention to pursue a certain course of study should, as far as possible, be aided and encouraged by his fellow-officers, his arm, and by all who may be interested in his work. In this age new and original work can be done only by specialists, so that if we in ourselves hope to increase our stock of knowledge this is the only way. We cannot go on copying ideas after our past practice, and maintain even our present place, we must create; we must be pioneers in the work or fall still further behind. Even a mediocre standard will never be reached by borrowing old or obsolete ideas.

So far we have referred to officers only. We question the necessity for giving non-commissioned officers and cannoneers theoretical instruction. In cases where it is to be given, it should be according to a system and with a definite end in view.

2. PRACTICAL EDUCATION.

This is beyond question the important part of the instruction of an artillery personnel. Theoretical and practical men have wrangled and are still wrangling over the values of their respective methods and usually each has missed the true function of the other's work. Theoretical investigations may be considered a means, the practical application an end. In artillery science the former is invaluable, the latter indispensable; the one an essential, the other a necessity. It is only by reducing our fund of information to blows that we can accomplish our object. The weight, accuracy, and rapidity with which we can deliver them, and the skill with which we can mass them on a given point will show how well we have learned the lessons of modern artillery war. A complete mastery of all theoretic principles and a thorough and judicious turning of them to practical account, is therefore the result to be striven for and its achievement will demonstrate our readiness for war.

(1) *Reduction of scientific data.*—The results of all scientific researches, generalizations, and deductions should be reduced to practical form that they may be used, when needed, with celerity and certainty. This reduction we believe essential to success; its importance cannot be estimated. Every course of instruction should lead either directly or indirectly *to the solution of the problems which will actually arise in war.* Until now our arm seems to have been afflicted with tangential tendencies, and has suffered from a chronic state of missing the main issues. These are the inevitable effects of any system which is wanting in strong central forces necessary to keep the component parts in their proper orbits. If we wish in future to become a progressive, living arm of our service and carry respect and influence with us we must leave off amusing ourselves with these side issues and go straight to the main ones before us. The small arm must be relegated to the shelf and the artillery be armed, equipped and drilled as artillery. Artillery work must take its place at the front without apology and stand out in relief in proportion to its importance.

At this point we will bring forward, as of first importance, the determination of essential data. Range-tables must be computed and kept on hand for emergency; suitable tactics must be developed and a thousand smaller matters settled during peace, or be ignored in war. This may be considered preliminary work, as it is simply accumulated for use in drill and combat. At present the results of such work, if any exist, are in a hopeless condition. There is to-day scarcely a reliable range-table for our guns in existence, and the same may be said of all other ballistic data.

(2) *An Artillery proving ground.*—The Ordnance Department has in the past furnished us tables in a few cases, but this department being strictly one of supply and construction, has justly held aloof from that which was beyond all question artillery work. Furthermore, their proving ground being fully occupied

in testing guns, carriages, and making other experiments in ordnance, they have not time, had they the inclination, to construct our tables for us. Here then is a field, until now neglected by us, which must be occupied energetically and permanently. We need to commence with an exhaustive course in the solution of practical ballistic problems.

We are constantly learning how to do such work but are never doing it. The question here confronting us is not to know how to do artillery work, it is to do it. This most desirable result can only be attained at a well equipped artillery proving ground. The want of such a ground now bars, and until obtained, will continue to bar artillery development.

A type gun having been tested at the ordnance ground should go directly to that of the artillery and there be fired until all useful elements of fire have been ascertained. In this manner all ballistic theories would be tested, and from the actual results measured on the range complete gunnery tables should be constructed and arranged conveniently for use. When a gun had passed through this process no information, with respect to it, should be wanting. A complete record of the gun and its action would form a part of the gun's battery equipment.

The ground would be commanded by an artillery expert and operated by a number of officers who would at the end of a definite term be replaced by others, and return to their batteries to put into application the information gathered from their experience at the proving ground. This policy would bring artillery officers into their true sphere of action, keep them in touch with scientific gunnery and introduce into the arm a vast amount of theoretical and practical information.

In addition to the preceding results all carriages and varieties of mechanism would go there and be thoroughly tried under service conditions and their suitability and efficacy determined before assignment to the troops. Gun tactics would then be developed at the ground and ready to put into execution at the earliest moment.

With these data on hand their application remains. This brings us to the last stage of the instruction and in touch with the gun.

The preceding work must be done in peace, or remain undone, for when once the battle is on it will be too late; this will not be the time to figure, but the time to fight.

In many experiments in the instruction of a battery, observations with nice instruments will be necessary. It must be clearly understood that they will not be used in time of attack. During drill, measurements of range, deviation, and other elements become essential to a complete study of results with view to future corrections, and mark an important distinction between *drill* and *war.*

(3) *New methods of drill.*—Our whole system of drill at the gun must be replaced by new methods. As now carried out, a great deal of time is spent in teaching the detachment nothing. The instructor prescribes with minute accuracy how the staff shall be grasped and inserted in the bore but he does not insist on its uniform insertion, to the same point. While the former is insisted on and the latter neglected, it makes comparatively little difference in a ballistic sense how the staff is put into the bore, provided it goes to the same place each time. Again our continued drilling without cartridge or projectile renders it impossible to attend to uniformity of loading and other important details. Every drill should be performed with a perfect cartridge and projectile and the greatest care given to the above considerations. Correct allowances for the day should be ascertained and made for the assumed range, and repeated until they can be made without hesitation. The exercise should include instruction in handling fuzes, powder and shot, and progress as if engaging the enemy. We must remember that "fancy movements" are very well in their place, but they form a very small part of the instruction of a battery. We must not drop the bone to grasp at its shadow. Æsthetic considerations of drill should be set aside for special occasions and so conducted that there would be no possibility of being mistaken for serious work. For, if, in this discussion, there is one thing that is clear to our mind, it is that the future successful soldier must put away his gay dress, quit posing for effect, take up the stern

realties of his profession and pursue them according to business principles. It cannot be too strongly emphasized that business with us will mean work and that our work is war.

(4) *Permanent assignment of batteries to guns.*—Batteries should during peace, be permanently assigned to particular groups, and platoons and detachments to particular guns. Excepting drills to familiarize cannoneers with the duties of other guns, all drills should take place at the guns assigned and the battery made thoroughly proficient in their use, since it would man these guns in time of war. In this scheme the cannoneers would be trained to fall in at their own guns ready for conflict at a moment's notice and exercised in target practice and battle exercises. In this manner the cannoneers would learn their guns as the infantryman learns his rifle. When this had been well mastered, further drill should be given with fixed numbers, with view to giving each *man the maximum preparation for his duties in emergency*. Each battery would care for its own material and be responsible for its condition at all times. Weekly and monthly inspections at the guns, advantageously replacing the present infantry inspections, would determine a battery's standing and elicit progress made.

As things now stand, were an alarm to sound, interminable confusion would prevail, orders would be given and countermanded, batteries would get in each others way and valuable time would be lost. This difficulty can be avoided by settling beforehand what must be done, in case of susprise, and doing it until each man knows his post and duties.

Portions of a harbor will be directly controlled by certain batteries and definite orders concerning them could be prescribed, for contingencies, and laid down in the general scheme of defense. This would enable the commander of a group of guns to make his general arrangements without further instructions. This implies on the part of the officer a thorough acquaintance with the harbor, the scheme of defense and the details of the part his guns are to play.

(5) *A definite scheme of defense.*—For a thorough and intelligent coöperation of the whole defense, all officers must understand the ultimate end to be obtained. To this end the commanding

officer should have the scheme of defense always on hand and instruct his command in its details. It should always be ready for study and criticism. So far, instruction in our army has been limited to lieutenants and non-commissioned officers. This is unquestionably a mistake, for in time of war captains, majors and colonels will have duties to perform, These duties should within limits be prescribed and considered by their respective grades. This system contemplates the theoretical and practical education of each officer in those duties which will probably be demanded of him in war. Thus would lieutenants be instructed in the duties of lieutenants, captains in those of captains, colonels in those of colonels, and generals in those of generals.

(6) *A thorough course of target practice.*—When the drill at the guns reaches the highest standard the command is ready for a thorough course in target practice. In this exercise we apply all our previously collected information and in its combination we ascertain our ability to hit. This is the branch of our work which must not fail. This practice, as far as possible, should be devoted to the ascertainment of rules and methods which will serve as future guides for the gunners. It should also be utilized in supplementing the proving ground work, especially with those guns which have not been tested. Too much time and attention is given to tentative methods of hitting the target, allowances being made first to one side and then to the other without any intelligent reason for doing so. It would be better to miss the target a score of times and learn the deviating causes, than to hit it accidentally. On account of this tentative method we have and shall continue to have practice without results. The main object of the practice—the determination of rules and processes to be used in war—seems to have been lost, and in its place spectacular effects are sought, it being considered of more importance to splash the target than to demonstrate a principle. To rush it through and pass to more agreeable duties seems to have been the order of the day. It is greatly to be regretted that this sentiment prevails and that in many cases it takes refuge under the pretext that it is useless to waste time in attempting to accomplish anything with our old guns and that it will be time enough to commence work when the new guns

arrive. This shows that we are not yet ready to give to our profession the plodding labor which it deserves and which it exacts for profitable returns. It was so when our present guns were new and will obtain in future with new guns, unless a complete change takes place first in the present conception of the object of target practice, and second in regard to the intelligence and motive with which it is carried out. We must not deceive ourselves into thinking that when we have new guns it will be an easy and simple matter to use them. The science of gunnery, like geodesy, requires the most painstaking attention to details, in order to secure valuable results. The prevailing sentiment until now pervading our work is wrong, and we here record an urgent protest against it. Gunnery is not changed by the kind of gun any more than astronomy by the kind of telescope. The principles of loading, aiming and firing remain the same whether the gun be a muzzle or breech loader. For the old guns the error will be greater and the target struck less often, but that is all. The above argument would disarm the infantry and stop all practice, because that arm expects soon to be armed with a small-caliber rifle. And yet, is not the continued practice with the old weapon preparing them for the use of the new? Will not the use of the old ammunition, after the adoption of the new, make these men better able to use their new gun effectively? These questions admit, we believe, of an affirmative answer only. If this answer be true for infantry it must be many times more true for artillery.

Our present scheme for target practice needs further extension and development.

Judging from present tendencies, the following conditions will be elicited in future war and should as far as possible be considered during peace and embraced in a well digested system of target practice:

a. Practice at fixed targets.

When ballistic machines are present *they should always be used* and data for the following exercises determined.

b. Practice at a target moving at different speeds, both in daylight and at night. For this work some kind of tracking instrument is necessary to show the continuous path of the moving object.

The observing telescopes of such an instrument, if furnished with an open sight alidade, will enable the observers to stop turning their telescopes as the shot strikes and plot it with the independent sights. The target's position being marked by the stopping of the path, the impact of shots can be plotted on the same map. A transit behind the gun, constructed for continuous motion and carrying a movable hair, would measure all deviations and check the preceding observations. The results should be carefully plotted on the original map and critically studied. This study should seek causes of error, defects in apparatus and suggest improvements. When this practice had been completely analyzed and mastered and methods corrected, all apparatus with view to preliminary instruction should be thrown aside and the experiment repeated as if in actual battle. In this case the instruments of battle only should be used, and the fact impressed upon all. Time spent on this drill will never be wasted. If it be impracticable to have such drill at all artillery posts the officers and non-commissioned, at least, should be annually concentrated at central points where the practice can be held.

c. Practice by indirect laying at fixed and moving targets.

In future this kind of fire must under certain circumstances be used, especially when the enemy can be seen from points of observation, but not directly from the battery. In such cases direct fire becomes impossible. Basing the statements on some experience, we believe that this kind of fire can be made more accurate and efficacious than any other and it should be developed to its extreme limit.

In the final adoption of a target system and other subjects connected with our theoretical instruction, it must be remembered that in regard to these questions there is no such thing as "peace footing." All movements during peace must look to ultimate war.

The preceding remarks in reference to organization and education we believe cover the most important considerations embraced under these heads. In the good organization the sick man is made well, in the proper education he obtains food which gives him the mental strength and will to grasp and handle his tools; the latter remain to be considered.

[TO BE CONTINUED.]

NOTES ON ARTILLERY.

The Angle of Jump and its Measurement, by Colonel Siacci, Royal Italian Artillery. Translated from *La Revue de l'Armée belge*, by Laurence V. Benét, Artillery Engineer, Hotchkiss Ordnance Company, Ltd.

I.

It is well known with all descriptions of guns, that the angle of departure does not coincide with the angle of elevation of the piece before firing. This was formerly attributed to the balloting of the projectile in the bore, but since the development of breech-loading guns and banded projectiles this explanation has lost all value, and the recoil is now indicated as the cause of the difference between the two angles. As a matter of fact, the recoil (by which we mean the complex motion of translation and rotation imparted to the gun and carriage by the discharge) commences while the projectile is still in the bore, and when it reaches the muzzle, the axis of the gun is no longer in its original position. It cannot be inferred, however, that the projectile leaves the muzzle in the direction of the axis of the piece at this instant, for although the center of gravity of the projectile describes a straight line along the bore, it actually describes a curve in space on account of the rotation of the gun, and leaves the muzzle in the final direction of this curve.[*] This direction corresponds to the resultant of the initial velocity, and the velocity of rotation of the axis of the piece at the moment the projectile leaves the muzzle.

In the case of small-arms, the difference between the angles of elevation and departure was, and is still attributed, to a certain extent, to the vibrations of the barrel.[†] In the case of artillery, however, such vibrations have never been observed, and if they do occur they cannot exert as great an influence as does the recoil. This is demonstrated by the fact that the greater the recoil, that is the greater the ratio of the weight of the projectile to that of the gun, the greater the angle of jump. The 15-cm. (Italian) shell, for instance, according as it is fired from the gun, howitzer, or mortar, gives angles of jump which vary between the respective limits of 5′ to 12′, 18′ to 23′, and 34′ to 57′.

The object of this paper is not, however, to explain the cause of the angle of jump, but to review the methods employed for its measurement, and to propose a new method which is more exact than those heretofore followed.

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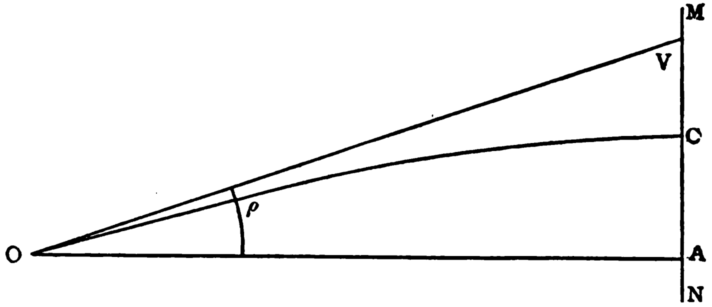
[*] See *Journal of the U. S. Artillery*, Vol. I, page 386.—EDITOR *Journal*.

[†] Didion, *Balistique*, 1860, page 389. See also *Memorial des Poudres et Salpêtres*. Vol. IV, Paris, 1891, page 79.—(Note of translator.)

II.

The method universally followed for determining the angle of jump is the following:



A number of rounds are fired at a vertical screen *MN*, and the distance of the center of impact *C*, from the point aimed at *A*, is measured A distance *VC* equal to the space through which the projectile would fall under gravity while transversing the distance *OA* is laid off above *C*, and the angle of jump is computed by the formula:

$$\tan \rho = \frac{AV}{OA}$$

It is readily seen that while this method is more or less approximate, it is not exact. As a matter of fact it supposes that when the projectile leaves the muzzle, the gun has not movéd, that is that the muzzle is still at *O* as before firing.

It is undoubtedly true, that in the very short time employed by the projectile to traverse the bore, the gun will be displaced by a very small amount, but however small this may be, the error arising from the supposition that the muzzle has remained at *O*, will be more or less negligible according to the distance *OA*.

The Prussian *Handbuch* says that this distance should be such that the blast will not damage the screen.[*]

The French *Aide-Mémoire* calls for a distance of fifteen metres.[†]

Colonel D. Diego Ollero, of the Spanish Artillery, proposes not less than 100 metres.[‡]

The French Marine Artillery employs from 400 to 500 metres,[§] but as at these distances the resistance of the air is already sensible, the measure of the angle of jump is combined with a special determination of this resistance.

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[*] *Handbuch für die offiziere der Königlichen preussischen artillerie. Zehnte Abtheilung*, page 16.

[†] *Aide-Mémoire à l'usage des officiers d'Artillerie.* Fourth edition, chapter XV, page 37.

[‡] *Balistica.* Madrid, 1890, page 415.

[§] Hélie. *Balistique expérimentale*, 1884, vol. II, page 265. In the trials of the Hotchkiss 10-cm. rapid firing gun at Gâvre, June 11th, 1889, the angle of jump was determined at a range of no less than 1325 metres.—(Note of translator.)

We have already recommended from 20 to 60 metres,* but in the presence of the distance employed by the French Marine Artillery, the former figure may appear too small, although greater than the distances proposed by the *Handbuch* and the *Aide-Mémoire*.†

III.

In order to obtain the angle of jump freed from the error which may arise from the displacement of the muzzle, the following method may be employed, which requires no special determination of the resistance of the air. This method is quite as simple as that usually followed, and utilizes the rounds fired for the measurement of initial velocity. It also affords a means of determining the amount of the displacement of the muzzle at the moment the projectile leaves the bore.

The gun being mounted for taking velocities, place a card-board target of convenient size close behind each of the velocity screens. Mark on these targets the points P_1 and P_2 where the natural line of sight intersects them, and fire.

Let x_1 and x_2 be the distances from the muzzle to the targets;

a_1 and a_2 the distances between the centers of impact O_1 and O_2 and the points P_1 and P_2;

V the instrumental velocity as given by the chronograph;

ρ the angle of jump;

b the vertical displacement of the center of the muzzle;

r the vertical distance of the line of sight from the axis of the bore.

Then we shall have:

$$\left.\begin{aligned} \tan\rho &= -\frac{g}{2V^2}(x_1+x_2)+\frac{a_1-a_2}{x_2-x_1} \\ b &= r-\frac{gx_1x_2}{2V^2}-\frac{a_1x_2-a_2x_1}{x_2-x_1} \end{aligned}\right\} \quad - \quad - \quad - \quad \text{(A)}$$

Demonstration:—Before firing (Fig. II), let A be the muzzle of the piece; P, P_1, P_2 the natural line of sight which we suppose parallel to the axis of the bore, and making an angle α with the horizontal. At the moment the projectile leaves the bore, let O be the muzzle of the piece, and O, O_1, O_2 the trajectory, and finally let Q_1, Q_2, and R_1, R_2 be the points in which horizontal lines through O and A would intersect the targets.

The distances x_1 and x_2 being very small, the trajectory O, O_1, O_2 will differ very little from a parabola having for its equation

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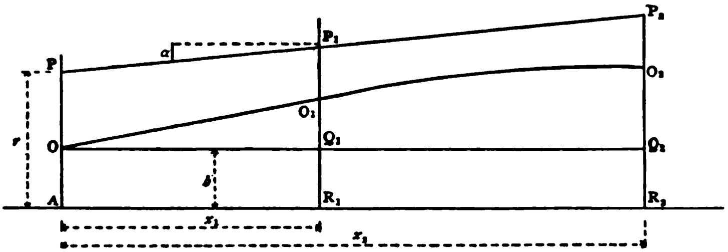
* *Balistica.* Turin, 1889, page 141.

† For the determination of the angle of vibration (*vibrations-winkel*) of small-arms, Mieg is satisfied with 10 metres (*Aussere Balistik*, Berlin, 1884, page 100). This officer makes the hypothesis that the barrel revolves as a rigid system about its rear end, and also that the bullet leaves the muzzle in the direction of the axis of the bore. We must observe, however, that the hypothesis of rigidity is in contradiction to that of vibrations of the barrel. In addition it cannot be admitted that the bullet leaves the bore in the direction of the axis. In reality, as we have explained, it leaves the muzzle in the direction of the resultant of the initial velocity and the velocity of rotation of the gun barrel.

$$y = x\tan\phi - \frac{gx^2}{2V^2} \qquad - \quad - \quad - \quad - \quad - \qquad \text{(B)}$$

wherein ϕ is the angle of departure. For the point O_1 we have from the figure:



$$y_1 = Q_1O_1 = P_1R_1 - P_1O_1 - Q_1R_1 = x_1\tan\alpha + r - a_1 - b$$

and for the point O_2

$$y_2 = Q_2O_2 = P_2R_2 - P_2O_2 - Q_2R_2 = x_2\tan\alpha + r - a_2 - b$$

Substituting for y_1 and y_2 their values from (B) we have:

$$\left.\begin{array}{l} x_1\tan\alpha + r - a_1 - b = x_1\tan\phi - \dfrac{gx_1^2}{2V^2} \\ \\ x_2\tan\alpha + r - a_2 - b = x_2\tan\phi - \dfrac{gx_2^2}{2V^2} \end{array}\right\} \qquad - \quad - \qquad \text{(C)}$$

α and ϕ being very small, we may write $\tan\phi - \tan\alpha = \tan(\phi - \alpha) = \tan\rho$, and from equations (C) we readily deduce the formulas (A).

The above method was tested last May at our School of Application for Artillery and Engineering, with the 12-cm. bronze B. L. gun ($r = 0.135$ metres), mounted on the light siege carriage. The following table gives the results of the experiments:

Charge.	Number of rounds.	x_1	x_2	a_1	a_2	V	ρ	b	ρ_1	ρ_2
kgs.		metres.	metres.	metres.	metres.	metres.		metres.		
0.500	8	11	23.1	0.112	0.131	143.6	22′	—0.020	16′	19′
0.900	6	11	31	0.119	0.131	217.2	13′	—0.013	9′	12′
1.700	7	11	41	0.075	—0.031	321.2	21′	0.000	21′	21′
3.600	6	11	56	0.092	—0.026	457.8	14′	0.000	14′	14′

The values of ρ_1 and ρ_2 in the last two columns are the angles of jump that would have been found had a single target been employed. These values of ρ are computed by means of the following equations:

$$\tan\rho_1 = \frac{gx_1}{2V^2} + \frac{r-a_1}{x_1}$$

$$\tan\rho_2 = \frac{gx_2}{2V^2} + \frac{r-a_2}{x_2}$$

From the experiments we find that in firing with the two lower charges, the muzzle of the gun was displaced downwards by twenty mm. and thirteen mm. respectively, small amounts it is true, but which cannot be neglected. If they were neglected as when the usual methods are followed, we would find angles of jump considerably below the truth, as is apparent from the table.

IV.

The displacements of the muzzle were so small, that it may be thought that they were more apparent than real, that is that they are numerical results due to an insufficiently exact measurement of the velocity V, or to leaving out of account the resistance of the air. This doubt is immediately dispelled, however, if we compute the errors we must admit in the measurement of V, to account for the displacements of twenty mm. and thirteen mm. found with the first two charges. It is only necessary to make $b = 0$ in equations (A) and determine the value of V; we find:—

$$V = \sqrt{\frac{\frac{1}{2}gx_1x_2}{r - \frac{a_1x_2 - a_2x_1}{x_2 - x_1}}}$$

whence we find for the charge of 0.500 kgs.:—

$V = 176.4$ instead of 146.3, a difference of 30.1 metres, and for the charge of 0.900 kgs.:—

$V = 269.6$ instead of 217.2, a difference of 52.4 metres.

The magnitude of the differences shows conclusively that whatever may have been the actual errors in V, the computed displacements of the muzzle cannot be attributed to them.

The displacements are therefore real; but how then explain the angle of jump? It is apparent that the downward displacement of the muzzle can only take place through a downward rotation of the chase, the more so if the carriage turns, as it apparently does, about the point of contact between the trail and the ground, the wheels rising and with them the axis of the trunnions. This downward rotation of the chase must therefore be due to the reaction of the elevating screw, when struck by the breech of the gun. But if the projectile left the muzzle while the chase was descending, or when it had its maximum displacement, the angle of jump would be negative. As it is on the contrary positive, we must conclude that the projectile leaves the muzzle while the chase is rising after its downward movement.[*]

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[*] If we admit that the axis of the trunnions has returned to its original height (from the ground) when the projectile leaves the muzzle, we may readily compute the vertical velocity of the latter. This velocity v will be given by:

$$v = V_0\left(\tan\rho - \frac{b}{l}\right)$$

V_0 being the initial velocity, and l the distance from the axis of the trunnions to the muzzle. In the experiments just cited, $l = 1.775$ metres, and we find for the four charges respectively $v = 2.5$ metres, 2.4 metres, 2.0 metres and 1.7 metres.

Whatever may be the explanation of the facts, it is certain that sensible movements of the muzzle take place, or may take place, and that consequently the old method of determining the angle of jump should be abandoned, or solely reserved for firings at considerable ranges wherein the resistance of the air is measured and taken into account. At all events the employment of two targets will always be more exact as well as simpler and more convenient. It gives in addition data (the displacement of the muzzle), which the old method cannot give, and which may throw some light on the obscure phenomena of recoil.

Report of tests of The Brown Segmental Tube Wire Gun.

Trustees Brown Segmental Wire Gun,
Gentlemen:

I have the honor to submit the following report of the preliminary firing, of the completed five inch B. L. Experimental Rifle.

The firing consisted of a private and a public test, at each of which three rounds were fired.

PRIVATE TEST, APRIL 12th, 1893.

First round.—Charge, 19.79 ℔s. of DuPont's Brown Prismatic Powder W. F., lot 2. Specific gravity, 1.810. Granulation, 24 to the pound., being 7 prisms of black and 468 prisms of brown powder. Weight of shot, 62½ ℔s. Pressure obtained, 26382 ℔s. per sq. in.

Second round.—Charge, 24.54 ℔s. of the same powder, being 7 prisms of black and 582 prisms of brown powder. Weight of shot, 62½ ℔s. Pressure obtained, 34,231 ℔s. per sq. in.

Third round.—Charge, 30.83 ℔s. of the same powder, being 7 black and 715 brown prisms. Weight of shot, 62½ ℔s. Pressure obtained, considerably in excess of 60,000 ℔s. per sq. in.

The coppers used had an initial compression of 40,000 ℔s. per sq. in. Estimating on the basis of the tabular difference for coppers of this initial compression, would indicate a pressure of 66,200 ℔s. per sq. in. Two gauges were used.

PUBLIC TEST, APRIL 15th, 1893.

First round.—Charge, 19.79 ℔s. of the same powder as in private test, 7 black and 468 brown prisms. Weight of shot 62½ ℔s. Pressure obtained, 25,200 ℔s. per sq. in.

Second round.—Charge, 24.54 ℔s. of the same powder, 7 black and 582 brown prisms. Weight of shot. 60 ℔s. Pressure obtained, 33,800 ℔s. per sq. in.

Third round.—Charge, 30.83 ℔s. of the same powder, 7 black and 715 brown prisms. Weight of shot, 60 lbs. Pressure so far above 60,000 lbs. per sq. in., that it was impossible to estimate its approximate value.

In order to give the artillerist an idea of the character of the phenomenal pressure obtained, I give the following extract from the pressure table furnished by the Ordnance Department from the Watertown Arsenal, also the record of the pressure gauges.

Lieutenant E. St. John Greble, 2nd Artillery, kindly consented to assist in making the test, and brought with him from Sandy Hook one of the government gauges. This gauge was used, together with one of our own at each discharge. The pressure records obtained by the two sets of gauges were practically the same, the pressure given in this paper being the mean of the two gauges.

PRESSURE RECORD OF LAST ROUND.

Three gauges were used. Gauge No. 1 contained a copper compressed to 40,000 lbs. per sq. in. Gauge No. 2 a copper compressed to 50,000 lbs. per sq. in. Lieutenant Greble's gauge, a copper compressed to 40,000 lbs. per sq. in.

	Gauge No. 1.	*Gauge No.* 2.
Initial compression	40,000 lbs. per sq. in	50,000 lbs per sq. in.
Original length	0''.3276	0''.2782
Final length	0''.1620	0''.1918
	0''.1656	0''.0864

The copper in the government gauge was so distorted that the compression could not be measured.

EXTRACT FROM PRESSURE TABLE.

Pressure.	Corrected Compressions.	
lbs. per sq. in.	I. C. 40,000 lbs. per sq. in.	I. C. 50,000 lbs. per sq. in.
59,000	0''.0812	0''.0333
59,200	0''.0818	0''.0339
59,400	0''.0823	0''.0344
59,600	0''.0828	0''.0349
59,800	0''.0835	0''.0356
60,000	0''.0841	0''.0362

It will be seen at a glance that the compression of the copper in gauge No. 1, 0''.1656 is nearly double the compression corresponding to 60,000 lbs. per sq. in. for a forty thousand copper. And the compression of the copper in gauge No. 2, 0''.0864 is more than double that for a fifty thousand copper for the same pressure. Therefore the pressure in the gun greatly exceeded 60,000 lbs. per sq. in.; how much, it is impossible to estimate.

I have, however, forwarded the compressed coppers, together with others, to the Chief of Ordnance, with a request that experiment may be made at Watertown Arsenal, in order to determine the probable pressure.

The copper in Lieutenant Greble's gauge also indicated a phenomenal pressure, although it could not be measured.

CONDITION OF THE GUN AFTER PRIVATE TEST.

After each round the gun was carefully examined. The only thing noticed was a slight movement of the liner, and movement of the chase jacket.

After the test was completed the gun was carefully examined and star-gauged. It was found that precisely as in the case of the test cylinder, the entire bore had become slightly smaller, due to the settling together of the segments; there had also been a slight movement of the liner, otherwise the gun was found intact and in splendid condition.

The movement of the liner had been expected; the same thing occurred in the cylinder and is of no consequence, as it can readily be prevented.

The movement in the chase jacket consisted of a very slight opening of the joints, which closed again as soon as the gun became cool.

AFTER PUBLIC TEST.

Nothing of importance was noticed after the first two rounds, except a slight movement of the liner and the opening of the chase jacket. At the last discharge a few unimportant bolts were broken in the hinge plate of the breech mechanism by the terrible shock, otherwise the gun appeared to be in good condition.

After the test the gun was carefully examined. *No enlargement* of the bore was detected, in fact, at one point the bore was found to be, if anything, perceptibly smaller.

The breech action worked well and was readily opened after each discharge.

A fact worthy of note is that the breech bushing was unscrewed with ease by one man after the public test.

The movement of the liner is entirely unimportant. It was assumed that the friction would be sufficient to hold it in place without other locking device. It will now be set home and locked before the gun is turned over.

The movement of the chase jacket is of a character to demonstrate the free action of one of the essential features of the system. The segmental core becoming heated, elongates; this opens out the several layers of wire like so many spiral springs, and as the several hoops of the chase jacket are shrunk upon the outer layer of wire, they necessarily move with the wire. The fact that they close as soon as the gun cools demonstrates how freely the several layers act in unison and resume their normal condition as the gun cools down.

THE PHENOMENAL PRESSURE.

It is a fact that every time an attempt has been made to obtain high pressures in our gun we have had phenomenal results.

On the first occasion with but a small charge of sphero-hexagonal powder, a pressure of 60,000 lbs. per sq. in. was obtained. This being incomprehensible it was attributed to the roughness of the bore.

At the private test, 30 lbs. of Brown Prismatic Powder gave phenomenal results. This was attributed to drying out of the powder. At the public test every precaution was taken. The cartridges were carefully loaded from a new lot of powder just received from the manufacturers, the copper bands were turned off reducing them 0''.02 in diameter, and great care was taken to wash out the gun after each discharge; nevertheless 30 lbs. again gave us phenomenal results.

The only explanation seems to be that for all powders there is a "*critical pressure*;" when this is reached the powder is rapidly converted into gas, and phenomenal pressures produced.

This has not been noticed before as no such pressures have ever been used in guns. In other words, it is probable that the enormous pressures used in our gun has developed a new principle, not before known.

In conclusion I would call attention to the fact that the phenomenal pressure obtained at the last discharge, was far beyond anything that has ever been thought of in a gun. It has in a most effectual manner demonstrated the truth of our claim as to elastic strength.

The three copper gauges used in the last discharge proclaim in a language far more powerful than any I can use, that the Brown Segmental Wire Gun is a phenomenal gun.

Very respectfully,
G. N. WHISTLER,
1st Lieutenant 5th Artillery,
Engineer for Trustees.

A New Torpedo Circuit Closer.*

Thornfield,
Bitterne,
Hants,
12 April, 1892.

To the Under Secretary of State for War.

Sir:

A foreign government torpedo department having enquired last December concerning the circuit closer with mechanical retardation designed by me and described on page 126 of my book on Submarine Mines and Torpedoes (London, 1889), I replied saying that I had designed an improved apparatus of the kind in which the glycerine cylinder and piston are replaced by a valvular air arrangement which is far simpler.

Having considered the matter during January and February, I sent the said department a design on 3rd March, which I shall now describe.

A is an india rubber pear-shaped chamber like the squirt which can be bought in any chemist's shop. It is closed at the top by an ebonite or bone mouth *M*, bored with a central hole in which fits the spindle *Y*, and this carries a contact-ring for connecting the springs *S S* electrically, and therefore the terminals *T T* to battery and fuze. A small vertical slot is cut in *Y* by which air can enter *A* gradually. The bottom of *A* is fitted with an india rubber flap valve *D*, which allows air to escape freely but not to return.. The cord *H* connects *Y* to a bridge of tape over the orifice leading to *D*.

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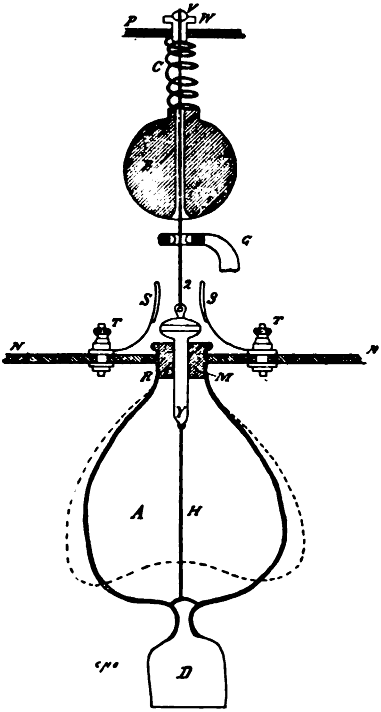
* Received through courtesy of Captain E. L. Zalinski, 5th U. S. Artillery.



A is fixed at *M* to the table *N N*, which also carries *T T*.

The action is as follows:

When the ship strikes the buoyant body carrying the apparatus, the inertia of *B* (which may be a ball of lead) causes it to swing aside on its hanging support *C* (a spiral spring) and thus to pull the cord *Z* vertically upwards through the guide hole in the arm *G*. *Y* is consequently raised also, and the cord *H*; the chamber *A* taking the shape in dotted lines, and air being expelled through *D*. The contact-ring is thus brought against the springs *S S* and remains there during the time air is leaking back into *A* by the vertical slot in *Y*, the length of the time of such retardation being regulated by the size of the said slot in *Y*.

Mines of secondary importance which it may not be convenient to fit with the elaborate electrical contrivances for electrical retardation, may thus be retarded mechanically by this pneumatic arrangement, and therefore be somewhat protected from counter-mining, as experts will understand.

This apparatus is now being manufactured by the torpedo department before referred to. The Royal Engineers may like to do so too.

Hence this letter.

I have the honor to be, Sir,
Your obedient servant,
J. T. Bucknill,
Lieutenant Colonel.

Trial of Armor Plates at Gâvre.

Trial of a Vickers Harveyized steel plate has been made at Gâvre in France, with results not equal to those obtained in England, the United States, and Russia. The plate in question was 26.8 cm. (10.55 in.) thick, and it was attacked by a chromatized steel projectile of 24 cm. (9.44 in.). It resisted the first shot, which had an initial velocity of 580 mètres (1,903 ft.), but was deeply cracked in three places. A second projectile, with a velocity of 700 mètres (2,296 ft.), however, perforated it, and buried itself at a distance of 1,300 yards beyond, and a third projectile, with a velocity of 650 mètres (2,132 ft.), also passed through, but its impact had been upon one of the cracks. Finally, a fragment of the plate showed better power of resistance to a projectile with 20 mètres less velocity, which broke up without injuring it. Whether the inferior results obtained by the plate in France were due to special defects or to superior hardness of the projectiles is difficult to determine. But it will be seen that the plate succumbed to the attack of projectiles with an initial velocity between 600 and 700 mètres; and, as M. Weyl points out in the *Débats*, France is about to mount naval guns with a velocity of 800 mètres (2,624 feet). This velocity has been reached by lengthening the gun, and by the employment of slow-burning powder. But, with a bound, a much greater success has been attained recently at Ruelle, where a gun of 16 cm. (6.29 in.), 90 calibers in length, has given a velocity of more than 1,200 mètres (3,936 feet). With this piece several hundred rounds have already been fired under satisfactory conditions, and we learn that it is now about to be despatched to Gâvre to be tried against Harveyized plates, so that we may expect further interesting particulars. Of course a gun 47 feet in length can be mounted only in a ship specially constructed.—*The Army and Navy Gazette.*

BOOK NOTICES.

The Influence of Sea-power upon the French Revolution and Empire. By Captain A. T. Mahan, U. S. Navy. Two volumes, Pp. xxii., 380, 428. Boston—Little, Brown & Co., 1892.

In these volumes Captain Mahan continues the labors begun by him in his "Influence of Sea Power on History," published in 1890. As this work was general in character, so is his later one special, in that it deals with a special period. But the one is the continuation of the other. Together, they constitute the most valuable contributions yet made to naval history. To regard them however as merely naval histories would be to lose sight of their chief value. For it may be justly said of these works, that whatever the point of view, whether of naval history, of strategy, or of history as a science, their importance is of the first order. There have been writers on naval operations, on sea wars, but until these works appeared, no writer had ever developed the *principles* of sea-power and assigned them their place in the system of forces, the resultant of which we see in the civilization of to-day.

So true is this, as to leave in the reader's mind the impression that Captain Mahan has discovered an unexplored field in the domain of history. And this will be found to be the fact. In most histories, land wars have ever been regarded as the chief factors in the development of modern history, so far as this is controlled by war. The results of naval operations, when taken into account, have been thought to be too scattered, too casual, if that expression may be used, to exercise a measured, not to say measurable, influence in shaping the destinies of the world. Of course the destruction of his fleet in Aboukir Bay made Napoleon's tenure of Egypt impossible. Of course the battle of Trafalgar rendered impossible his invasion of England. But if marked cases like these be excepted, the general proposition laid down will command belief, that until the publication of Captain Mahan's works, the influence of sea-power as a force of incessant application, was, if not unknown at least ignored, in those estimates and records of national effort that we call history. It is a matter of just national pride then, that an American naval officer should have filled up, as we now know that he has, a breach in the continuity of history. For rightly considered, Captain Mahan's works are positive contributions to the philosophy of history. This is saying a great deal, but it is not saying too much. Captain Mahan everywhere traces the influence of a force; he shows how the force is continually applied to secure definite results and how events shape themselves in consequence. The conclusion forces itself upon the mind that this force, dormant in peace, is bound up in the essence of a great nation's existence, and is to-day as much a factor in the possibilities of the future, as it was in the realities of the struggle that began at Valmy and ended at Waterloo. If such conclusions are not contributions to the philosophy of history, then there is no meaning in the term.

Limitations of which it is unnecessary to speak in detail, make it impossible to do full justice to the work, the title of which heads this notice. To give anything more than a brief statement of its scope would require an article foreign to the purposes of the *Journal.* The aim of Captain Mahan is perfectly described by the title he has chosen. Volume I covers the period between 1783 and 1800–01. From a sketch of the state of affairs in Europe after the treaty of Versailles, we pass to a description of the various European navies, and in particular of that of France. The chapter dealing with the causes that led to its ruin is one of the most striking in the whole work. Under the influence of revolutionary ideas discipline disappeared, and with it trained officers and men. To this disappearance may be attributed the disaster that finally overwhelmed Napoleon. The remaining chapters of this volume are devoted to the development of operations in the Mediterranean and in the Atlantic, on the coasts of France, and against Ireland. Volume II carries on the thread, discusses the proposed invasion of England, the events leading up to Trafalgar, the Trafalgar campaign itself, and the terrible struggle set on foot by Napoleon's continental system. The last chapter analyses the British policy during the Napoleonic wars. At the risk of repetition it must be stated that the point of view throughout is not that of naval operations as such, but of history as influenced, as controlled by naval operations. It is this point of view which, by its novelty and importance, lends such interest and value to Captain Mahan's labors.

We should, however, be unjust to the author if in this notice we omitted to mention the admirably clear accounts of the various purely naval events. No landsman need fear to read this work lest it should prove of too technical a nature. And in general praise is freely due, and will be freely given for the author's skill in marshalling facts, in assigning just weights to the conditions involved, in drawing conclusions and in estimating results. His skill in respect of these matters nowhere stands out more clearly than in his description of the confessedly intricate events growing out of the Orders in Council, and of the Berlin and Milan Decrees. On the same plan of excellence rests his analysis and defense of the British policy as shaped by Pitt. Nor must we fail to speak of the convincing argument against commerce destroying as an element of war, deducible from the losses of British commerce by French privateering. These for the whole war did not exceed two and a half per cent. of the capital invested.

We close this notice, not with the feeling that justice has been done to its subject, but with the hope that it may serve to bring to the attention of artillery officers a work, the value of which can scarcely be overestimated.

C. DEW. W.

Nouveau Dictionnaire Militaire, par un comité d'officiers de toutes armes. Pp. viii, 854. Paris, L. Baudoin, 1892.

The object of this work as set forth in the preface is two-fold. In the first place, there is to-day no encyclopædia that fully reports the progress made of late years in military science. In the next, such encyclopædias as do exist are so voluminous as to be found in general only in public libraries. Hence it has seemed to the authors "that a military dictionary containing all words whose military meaning should be accurately understood, and cast into such a form as to make a sort of *Aide Mémoire général* . . . . would satisfy a real need."

The authors are to be congratulated on the success of their efforts. They have compiled a work that cannot but be of great general utility. While omitting details, either as being too technical or as being out of place in a work of general application, *i. e.*, intended to meet the wants of all arms of the service,—they have yet treated the principal subjects concerned with a fulness sufficient for most purposes of reference. It must not from this be inferred that details are lacking; on the contrary many subjects are fully developed. What is meant is that the limits adopted have in some cases forbidden the introduction and description of all the component parts of the subject considered. To illustrate, only general considerations are given in respect of gun-carriages; a detailed nomenclature of the various types would have extended the work beyond the limit of general reference.

A feature of the work lies in the fact that questions of what may be called the archæology of the science of arms, hold an altogether subordinate place. It is upon the questions of the day, upon the present state of development of the art military, that the authors have fixed their attention. For example, the principal high explosives and small calibre magazine rifles using smokeless powders are described; other examples might be given. The advantage of having in one compact volume, data that otherwise must be sought in periodicals of many languages needs no comment. The subjects of administration of interior economy and of organization, are concisely and accurately treated. And these are just the matters in regard to which it is frequently so hard to get definite information without great trouble and even expense.

The make-up of the book is satisfactory. By using double columns, and type, which though small, is clear and easily read, the authors have compressed their work within 850 octavo pages. Figures to the number of 310 serve to illustrate the subjects that admit of illustration, while reference is made easy by heavy-faced type of different fonts for the various headings and their subdivisions.

C. DEW. W.

Handbook of the Hotchkiss 75-mm. Rapid Firing Field Gun. London: Harrison and Sons, 1893. Pp. 23, with plates.

Under this title the Hotchkiss Ordnance Company describes the latest product of its shops, a R. F. field gun. Like all of Hotchkiss' work, it is good. We do not agree with some artillerists who insist that high initial velocities giving tremendously long ranges are necessary for field artillery, for the reasons that the country ordinarily moved over would not admit of their use; neither would the eye, even with assistance, give the desired accuracy. The ammunition, hauled over the country at the expense of horseflesh, would be thrown away at such ranges only to be longed for when fighting at the closer ranges commenced.

We are of the opinion that the ranges at present accepted are amply sufficient: and while in the outer zone the ammunition could be expended with more than sufficient rapidity for accomplishing the desired work from the field guns now in use, there is no question but that at closer ranges the problem changes, and in order to keep pace with the infantry, the artillery must provide itself with a gun which will pour in such a dense fire that its work will be more rapidly and effectively done than with the present field gun for light and horse artillery.

It is at the shorter fighting ranges, and in cavalry combats, that the artillery must make its best effort, and the consumption of ammunition will be very great in order that the troops may be saved from decimation. It therefore behooves us to obtain a field armament fulfilling practical conditions that are possible, and which will best satisfy the requirements of the future.

Such a weapon must be within the limit of weight and at the same time capable of very rapid work when called on. We note the following extract from conditions contained in a pamphlet by Nordenfelt:

1. Fixed metallic ammunition will be used.

2. The breech mechanism must work rapidly enough not to cause more delay in the firing than the time necessary for preparing the fuze and aiming.

3. The breech mechanism must combine simplicity, security and facility of manipulation.

4. The carriage should be supplied for giving proper deviation and elevation.

5. The force of recoil must be so absorbed, as to avoid change of position of the carriage when the piece is discharged.

6. The weight of gun, carriage and limber must be so distributed that the limber will carry about fifty projectiles.

7. The total weight of the light field piece should not exceed about 3630 pounds, or about 605 pounds per horse.

Artillerymen have been longing for such a weapon for some time past: and now the Hotchkiss Ordnance Company puts forward its claim, after long study and careful practice, to having finally solved the problem.

We shall now give short descriptions of the principal parts of this weapon.

THE GUN.

As described in the pamphlet, the 75-mm. gun puts the total weight for each horse at 580 lbs. and permits a supply of forty-eight rounds to be carried in the limber chest. With a charge of French BN_4 smokeless powder weighing 1.76 lbs., the projectile of 13.2 lbs. weight has an initial velocity of 1740

f. s. and, at a range of 6000 yards, the remaining velocity is 668 f. s. The pressure obtained for the above I. V. is not indicated.

The shrapnel breaks into 231 pieces and the canister contains 200 balls.

Eight aimed rounds, and at short ranges fifteen unaimed rounds, may be fired per minute.

The body of the gun is built up of three forgings of oil tempered and annealed steel, and the breech-block is a hollow prismatic forging, with rounded corners, having a vertical movement in a mortise cut completely through the jacket.

The front face of the block is perpendicular to the axis of the bore, whilst the rear face is slightly inclined. The upper front corner is cut away to allow for the motion of the extractor; and the firing mechanism is contained in the hollow part of the block. The part of the breech-block which supports the head of the cartridge consists of a removable hard steel plate, which is dovetailed into the face of the block, and secured by two screws.

By means of a crank the breech-block is moved down or up, thereby opening or closing the breech, extracting the empty cartridge case and cocking the firing mechanism. The hammer of this mechanism is in the axis of the breech-block and carries a detachable point or firing-pin which acts on the primer of the cartridge through a hole in the face plate.

Without detailing the various parts of the mechanism we shall remark that "the extractor is a single piece of steel working in a longitudinal groove in the left cheek of the breech housing. Its forward end is formed into a hook to grasp the head of the cartridge."

Simple rules are given for mounting and dismounting the breech mechanism, and also for the care and preservation of the gun.

THE CARRIAGE.

The gun carriage is made of steel and is of the rigid type. It combines simplicity, lightness and resistance.

Lateral pointing is done by means of the trail handspike, instead of training gear. This avoids increased weight; and as with training gear the axis of the gun would generally make an angle with the axis of the carriage thereby disarranging the aim on the discharge of the gun, the method adopted seems satisfactory until the perfect rapid-fire gun is found. The trail consists of two brackets which are built up of steel plates and angles, and properly braced; a feature of the design being that a line drawn from the centre of the trunnions to the point of contact between the trail and the ground almost coincides with the axis of the trail.

The axle is a single forging of mild steel rectangular in section, but hollowed between the collars to reduce the weight; and the trail is attached to it by means of two strong steel castings, which are riveted on the inside of the brackets, and to the axle plates; and in these pieces are formed the trunnion beds.

The wheels are of the Archibald type. Recoil is checked by means of a powerful spade on the end of the trail, which is forced into the ground on firing. In general one or two rounds are necessary to give the spade a firm bearing, but after these have been fired the recoil is completely checked.

As the wheels leave the ground at each discharge, the carriage is simply fitted with one traveling brake on the left side; and the one indicated is not such as, in our opinion, leaves nothing to be desired. We cannot consider it as being a good traveling brake.

The elevating gear consists of a hollowed arc attached to lugs on the breech of the gun and gearing lodged in the elevating transom. It is worked easily and rapidly by means of a crank handle, and is relieved from the shock of discharge by a friction clutch.

THE LIMBER AND CAISSON.

The limber body is a rigid steel frame carrying a wooden ammunition chest covered with water-proof canvas and stoutly ironed. The chest opens to the rear and contains six compartments, in each of which eight rounds can be placed. The cartridges are carried horizontally, and are supported at the center of gravity of the projectiles and near the heads of the cases in loose racks fitted in the compartments, so that each cartridge is held securely irrespective of the number contained in the chest. The caisson, carrying ninety-six rounds of ammunition, consists of two limbers similar to the one described. On the rear one the pole is replaced by a stock, on which is secured the spare wheel.

Under the foot-boards are receptacles for the necessary stores and spare parts.

We do not like the position of the spare wheel, high in air: nor of the picket rope and prolonge, below the axle.

We would also substitute the canvas watering buckets, to be carried in some position above, instead of below, the axle. The total weight of the caisson is 3663 lbs., being 187 lbs. more than the weight behind the gun team.

The pole yoke and single-trees are of metal, and no double-tree is used, the single-trees being attached directly to the splinter-bar; a position which finds some advocates.

THE AMMUNITION.

The ammunition is assembled in a manner similar to that employed for small arms, and consists of a primed aluminum cartridge case containing the powder charge and a wad, in which is inserted the projectile.

The combination fuze, having a range of fifteen seconds, consists of four main parts, all of which are made of aluminum to economize weight.

The base percussion fuze is well known in our service.

There are also given a short drill for the gun detachment, consisting of six active and three reserve cannoneers: a range table, a table of weights and measures, several photographs and nine plates of drawings.

In conclusion we will call attention to the fact that our present light field battery on a war footing consists of six guns and nine caissons, thereby allowing 231 rounds of ammunition to each gun.

A four-gun rapid-fire battery, with twelve caissons, would call for one team more and would provide 336 rounds per gun.

Total number of rounds in first case 1586.

Total number of rounds in second case 1344.

We are however getting entirely beyond our limits in entering on the subject of ammunition supply and shall therefore close by calling attention to the fact that our Ordnance Department is now, we understand, either manufacturing, or contemplating the immediate manufacture of, metallic ammunition for our present light field piece.

A. B. Dyer,
1st Lieutenant 4th Artillery.

Aide-mémoire de l'Officier de Marine, by Edouard Durassier, chief of bureau to the Minister of the Navy, and Charles Valentino, late officer of the navy, librarian to the Minister of the Navy. Pocket edition. Address L. Baudoin, 30 Rue et Passage Dauphine, á Paris, France. One vol., 12mo, in English cloth: price, 3 fr. 50, postpaid 3 fr. 80.

This pocket companion is brought up to its sixth year. It opens with a table giving in net the force of the new naval structures of the maritime nations (with true French politeness arranged alphabetically, not in order of strength), classified by tonnage and speed.

It discusses maritime international rights; gives the grades of the different navies, with their pay. Here our own navy stands out remarkably: an American cannot understand how the European officers live on their pay; the only answer appears to be, they do not. Then follows a description in detail of the armored vessels of England, Germany, Austria and Italy; these are either those imposing special study on the French officer, or the only ones worth his study. Next comes a list of the war vessels of all nations, armored or plain: here is given the material of construction, length, breadth, draft, displacement, H. P., speed, number of propellers, coal capacity, thickness of armor, armament, style of armor, crew, torpedo arrangements, and date of launching.

The fourth chapter should be the most interesting to our arm. In the words of the prospectus, in it is given a descriptive nomenclature of the principal models of guns now in use, either for the armament of ships or for coast defense. It courteously gives the United States *a system*. It appears that we have breech-loading rifles in steel; breech-loading rifles in cast-iron; muzzle-loading rifles in cast-iron; and smooth-bores in cast-iron. In this chapter are given name, caliber, destination (ship or sea-coast), metal, length of bore in calibers, weight of gun, class of powder and weight of charge, weight of shell, initial velocity, energy by circumference of missile and of weight of gun, and penetration of armor at muzzle: it also gives the revolving systems, and the systems of small arms.

The succeeding chapters are on torpedoes, a navy list of the French navy, and a list of the submarine cables of the world.

Nothing in its space could be more complete than this work, perfected as it has been under the careful revision of so many years by men having every advantage and fully alive to progress and to the wants of every navy officer of the world. J. H.

Extended Order of Drill. An arrangement of rules prescribed in Infantry drill regulations, with explanations. By 1st Lieutenant John T. French, Jr., 4th Artillery, late Recorder of Tactical Board. 23 pages. Army and Navy Register, Washington, D. C. Price 25 cents.

This is a small pamphlet containing the general principles of the new infantry drill regulations with elucidation of many points relative to their practical application. The author's official connection with the tactical board renders him particularly qualified to treat of the subject, and one is thus enabled as it were to read between the lines of the regulations. It is safe to say that these explanations will be of great help to those who are studying the new drill regulations. J. W. R.

Alternating Currents of Electricity: Their Generation, Measurement, Distribution and Application. By Gisbert Kapp, C. E., with an introduction by Wm. Stanley, jr., 1893. The W. J. Johnston Co., Ltd., 41 Park Row, New York City. Price $1.00.

A small book of one hundred and fifty-six pages, reprinted from the *Professional papers of the Corps of Royal Engineers*, and devoted to the subject of alternating currents. Owing to the present and increasing importance of this subject the work is timely. The subject is treated in a clear and enticing style, and elucidates the elementary but fundamental principles of the subject. The author's name alone is sufficient recommendation for the character of the contents, so that it is only necessary in a brief notice to convey to the readers an idea of their scope.

Beginning with an introduction to the elementary conceptions of alternating currents, one is carried along through the chapter without much help from mathematics, except where equations are necessary to aid in grasping the relations existing between the quantities. The reader who is able to read the book intelligently will not fail with respect to the formulas. The measurement of pressure, current and power forms a chapter which deals with the necessary instruments involved, and leads up naturally to the subject of the condition of maximum power.

Having thus paved the way for the consideration of the generator, the author proceeds to the construction, advantages and disadvantages of the alternator, and briefly touches upon that of Ferranti, Westinghouse, Mordey, Kapp, Kingdon and Kennedy. The alternator being avowedly a high voltage machine, it is necessary for economical reasons to transform the current into one of suitable low voltage by means of *transformers*. These are clearly set forth in construction and principle. The part relating to central stations and their operation with the transformers, either in separate houses or in subtransforming stations, is probably one of the most useful to the practical man.

The advantage of using alternators in parallel is considered practically, and it is shown that a direct-coupled engine with even angular speed represents the condition for success. The remainder of the book contains chapters on *motors*, *self starting motors* and *multiphase currents*. Each of these subjects is so extensive that but little can be given under them. In connection with motors, the principal part of the chapter is given to necessity for and means of synchronizing, with some experience of the author. Under self starting motors we find Zipernowsky's motor mentioned. The closing chapter treats of multiphase currents, which is probably the most important subject treated in the book, since it relates directly to the construction of alternating current motors which have unbounded promise before them. Commencing with the discovery of Ferraris and Tesla, and its application to the production of rotary motion, we follow the writer through resulting motor development and its defects. Dobrowolsky recognized the cause of the defects, substituted three currents for the two in the Tesla-Ferraris motor, and finally "re-arranged the winding of the field in such a way as to attain the effect of six distinct currents, though still using only three wires in the line transmission." These developments are told in a way that holds the attention of the reader, and takes him through a remarkable period of electrical development.

J. W. R.

Index to the Literature of Explosives, Part II. By Charles E. Monroe, Baltimore Deutsch Lithographing and Printing Co., 1893. Price $1.00.

In publishing Part II of his index, Professor Munroe has given a valuable aid to those who are interested in the investigation of modern explosives. The literature on this subject is so widely scattered and is so constantly being added to, that without some such compendium, the effort to keep up with the development of the subject would be almost hopeless.

The value of the index would, however, be greatly enhanced by the addition of an index of subjects treated. As it now stands, in looking up a subject it is necessary to run through the entire pamphlet

W. W.

BOOKS RECEIVED.

Extended Order of Drill.—An arrangement of rules prescribed in infantry drill regulations, with explanations by *1st Lieutenant* JOHN T. FRENCH, JR., *4th Artillery*, late recorder of the tactical board. Army and Navy Register, Washington, D. C. Price 25 cents.

Electro-Chemical Effects due to Magnetism, by *Lieutenant* GEORGE OWEN SQUIER, Ph.D., *U. S. Army*. Reprinted from the London, Edinburgh and Dublin Philosophical Magazine, June 1893. Same, reprinted from American Journal of Science.

Aide-Mémoire de l'officier de Marine, by E. DURASSIER and C. VALENTINO L. BAUDOIN, Paris, 1893.

Course of Instruction for Artillery Gunners, prepared for publication under direction of *Major General* JOHN M. SCHOFIELD, *Commanding U. S. Army.* Artillery Circular. B—Gunpowder and high explosives, 1*st Lieutenant* WILLOUGHBY WALKE, 5*th U. S. Artillery.* D—The use of meteorological instruments, *Captain* CHARLES E. KILBOURNE, *Signal Corps, U. S. Army.* E—Range and position finding, *Lieutenant* HENRY L. HARRIS, 1*st U. S. Artillery.* Government printing office, Washington, D. C.

SERVICE PERIODICALS.

Revue d'Artillerie.

JANUARY.—The Souchier Prism-Telemeter.

This range-finder was adopted for the Russian Army after a competitive trial, in which many models of range-finders were considered. Each commandant of a company or troop will be provided with it. The description is illustrated and considered under the heads (1) Theory of the Apparatus, (2) Method of using it.

The fire of field artillery.

An abridged translation of article by Captain W. L. White, R. A. *Proceedings of the Royal Artillery Institution*, 1892, Nos. 4 to 8.

The Roknic apparatus for indirect field fire.

The instrument enables giving direction to pieces when other methods (procédés de repérage) are not applicable, as when the object is covered by woods, a farm, etc. The method is described in detail and results of the inventor's experiments given.

Mountain exercises executed in Switzerland.

FEBRUARY.—Methods and formulas of experimental ballistics.

Chapter III. Solution of problems of fire. Consisting of nine problems of fire; formula for correction and discussion of the drift of a projectile.

Field artillery fire. Schlæpfer system of automatic brakes (for field gun).

Treated under the heads of description, operation, advantages and disadvantages of the brake.

MARCH.—Artillery in the United States in 1892 (continued).

Description of the material and organization of our field and mountain artillery, illustrated by plates showing guns, fuzes, shells, primers, etc.

Methods and formulas of experimental ballistics (continued). Experiments made at Krupp's shops upon 6-cm. rapid fire field guns.

This is an analytical investigation of the experiments made with 6-cm. R. F. field guns of 30 and 38 calibers. The discussion consists chiefly of a comparison with the 8-cm. German field gun in regard to efficacy. Dimensions and weights are first given, with brief mention of new features in construction; after which comes a thorough review of the ballistic qualities of these new guns compared with the old German field gun. The projectile has great sectional density, so great in fact that the old range tables apply almost exactly. Shrapnel fire reaches 3000 m. Experiments were made upon three ranks of screens 2.7 m. high and 30 m. long, with intervals in depth of 20 m. The results are tabulated. The comparison of the two types of gun is carried out with respect to the following considerations: (1) The efficacy of the projectile considered separately.

a. The number of bullets contained within it.
b. Their force of penetration.
c. Flatness of trajectory (angle of fall).
d. Range interval covered by the burst.
e. Opening of the sheaf.

(2) Precision. (3) Rapidity.

Drill regulations for the German field artillery (continued).

A revision of the drill regulations of 1889 and known as those of 1892.

The Military Academy of West Point.

APRIL.—Principles of pointing in field artillery fire. The new magazine guns before the Chilian Commission. Developments relative to certain particular cases of the methods of fire of siege artillery.

MAY.—Exercise regulations for the German field artillery. Developments with respect to particular cases of the methods of fire of siege and position artillery. Warfare executed by a mixed detachment of the XIV German Corps. J. W. R.

Revue Militaire de l'Etranger.

JANUARY.—Tactical observations of General Dragomirov upon the maneuvers and exercises of the troops of his command. The mobilization of the English army. The war budget of Norway. The military utilization of a railroad in Spain.

FEBRUARY.—The recent armor plate trials in the United States. The new military law of Bulgaria. The Norwegian railway system.

MARCH.—Reorganization of the general staffs of the surrounding military frontiers in Russia. The new Krupp field artillery.

This article treats of the recent experiments at the shops of Krupp with respect to rapid fire guns. (1) Twelve guns have been constructed varying in caliber from 6 cm. to 8.7 cm.; they are probably nickel steel. All of these twelve types are intended for metallic cartridge cases. The wedge opens to the right. (2) The fermeture is an entirely new model. (3) The carriage of the 6-cm. is without recoil; that is, it is intended for rapid fire. To accomplish this it is divided into two parts, a small carriage carrying the piece and a large one carrying the whole. (4) Powder, projectiles, fuzes. The powder is C/89 smokeless. Three kinds of shells are used. The fuzes are discussed and illustrated by cuts.

Results of experiments with the 6-cm. rapid fire gun during 1891 and 1892 are given. Number and kind of shots are given, with the nature and dimensions of the target.

The railway troops of the Austro-Hungarian army.

APRIL.—Instruction of the German foot soldier in varied ground. Strong places and fortress troops in Russia. The new Spanish 7-mm. gun.

MAY.—The German war budget for 1893-94. The reorganization of the Swedish army. The combat and investment of Fredericia. Military news. J. W. R.

Revue du Génie Militaire.

JULY-AUGUST, 1892.—An application of graphical statics to the computation of the metallic arcs of the bridge of the Cerveyrette. Detachable constructions and their military uses. Experiments upon the rupture of metallic bridges. Apparatus for testing cements. Narrow-gauge railways.

SEPTEMBER-OCTOBER.—Upon the processes of construction employed in the dunes of El-Oued.

NOVEMBER-DECEMBER.—Note upon a new bridge material for advance guards. The conditions of visibility of two distant points. Military telegraphy and telephony. The Teilloux sounding call relay. General Faidherbe.

JANUARY-FEBRUARY 1893.—The fortress of Küstrin under the French occupation, 1806-1814. Upon a new system of rolling platforms for rapid transportation for docks, shops and arsenals.

MARCH-APRIL.—Lighting of barracks by electricity.

The subject is treated thoroughly; commencing with a statement of a few general principles the writer, Captain E. Dubois, of the Engineers, considers the following questions connected with the problem: I. Cost of present illumination. II. Net cost of a lamp-hour for electricity, gas and petroleum, in which it is concluded that when the troops occupying the barracks take charge of the plant and run it, electric light in France can be supplied cheaper than other illumination. III. Illumination necessary for the service, in which is found a detailed discussion and tabular estimate of the needs of barracks and auxiliary buildings. IV. Economical and practical conditions for electrical illumination of barracks, V. Cost of electric light. (a) Cost of installation. (b) Cost of maintenance. Conclusion.

Note relative to the size of gauge. for colonial railways. The fortifications of Sicily. The defense of the German coasts explained to the Reichstag. J. W. R.

Revue Maritime et Coloniale.

November, 1892.—The disembarkation of a body of troops. Balloons and the exploration of Africa. Vocabulary of powders and explosives. The German navy (continued). Former troops of the navy (continued). History of the French military marine (contiued).

December.—The civil war in Chili. Study upon the mechanical theory of heat. Coal in the extreme east. Ideas upon the Seine wave action.

January, 1893.—English war-ships. Experiments made on board the *Naiäde* upon the quieting effect of oil on waves. The cyclone of the 18th of August, 1891, at Martinique. Description of an apparatus for counting the number of turns and the direction of motion of a machine. The contemporaneous navies of European states--their elements of strength. Artillery and armor. The civil war in Chili in 1891. Succinct résumé of the results of the voyage of the despatch-boat *La Manche* to the island of Jan Mayen and Spitzbergen during the summer of 1892. Abacus for the determination of points at sea.

February.--Note upon a graphic representation of the diurnal movement of a chronometer. Canada and the French interests. A new system of mounting light weight compass needles. In the country of the Kanakas. The civil war in Chili. Mechanical theory of heat. Fishing section.

April.—English war-ships. Note upon a provisional installation of electric light made on board the *Japan.*

May.—Study upon the theory of the great war. Auxiliary apparatus permitting pointing and loading simultaneously.

This article gives a solution of the important problem in gunnery, of preventing any delay in aiming on account of the operation of loading, and thus enables the cannoneers to keep the gun constantly directed upon the enemy. Rapidity of fire will in this manner be enormously increased and at the critical moment may be the one important element of fire. The details are worked out with great care. The feasibility of adapting the apparatus for a fixed telescope and the Deport telemeter is considered.

Mechanical solution of navigation problems. The circulation of the winds and rain in the atmosphere. Note upon the *Capitan Prat*—the armored Chilian cruiser.

The note gives a complete history of the early negotiations which led to the order for the ship of the La Seyne works up to its completion. The dimensions, construction, system of protection, armament and all that relates to this remarkable ship are given. The electrical manipulation of the towers, means of signaling and transmitting orders, etc., are the most prominent of the many interesting features of the ship. J. W. R.

Revue du Cercle Militaire.

JANUARY 1.—The Army School of Portugal (continued). Archipelago of the New Hebrides (continued).

JANUARY 8.—The travels of Commander Monteil.

JANUARY 15.—War a hundred years hence (continued). Infantry combat.

JANUARY 29.—Field hospitals (continued). A new law proposed for recruiting in the Italian Army.

FEBRUARY 5.—The new decree upon the interior service of infantry (continued).

FEBRUARY 12.—The Military Society of Berlin.

FEBRUARY 26.—The war game and means of perfecting it. The new organization of the Spanish army.

MARCH 12.—Our regulations of maneuver and their application. Winter tents in the Russian army. The small arm of the future.

APRIL 2.—The arming of infantry according to the formula of Professor Hebler (continued). Italian railroads. The state of preparation of the Russian army for war.

La Marine Française.

JANUARY 8.—Admiral Saint-Bon. Tables of advancement.

JANUARY 15.—Short guns. The loss of the *Rosales*. A celebrated paper (continued).

JANUARY 22.—The new ministry.

JANUARY 29.—Discussion upon the naval budget.

FEBRUARY 5.—Recruitment of crews.

FEBRUARY 12.—Twenty years ago.

FEBRUARY 19.—The army and the colonial navy. Oceanic circulation. Administration and accounts of the crews of the navy.

FEBRUARY 26.—Discussion of the marine budget.

MARCH 15.—The navy and the great works (continued). Artificial smoke.

APRIL 15.—The senate and the navy. The chamber of deputies and the navy.

MAY 1.—The Bosphorus and the Dardanelles. The cannon of 90 calibres.

This is a 16-cm. cannon which has just been finished at Ruelle. It consists of four independent parts: the first 50 calibers, which is lengthened to 90 calibers by three sections being screwed on in succession. The reported initial velocity is 1,214 metres (3,983 feet) with a 45-kg. projectile. The gun is an experimental model, in which it is proposed to study ballistic advantages of long guns in addition to the mechanical problems involved. The gun is reported to be a success. J. W. R.

Journal de la Marine—Le Yacht.

JANUARY 7.—War navies in 1892 (continued). Technical Maritime Association—analysis of papers presented (continued).

JANUARY 21.—The national marine.

JANUARY 28.—The French torpedo vessel *Corsair*.

FEBRUARY 4.—The naval budget in the chamber of deputies. The Japanese armed coast guard ship *Itsuku Shima*. English naval constructions in 1892.

FEBRUARY 18.—The United States navy.

FEBRUARY 25.—Sailor's Home. Firing with heavy oils.

MARCH 4.—The English naval budget. The American ram *Katahdin* (continued). The Italian torpedo-cruiser *l'Aretusa*.

MARCH 11.—The actual condition of war navies. Foreign naval news.

APRIL 8.—The loss of the *Bourdonnais*. The application of low density aluminum alloys to naval construction.

APRIL 15.—The institution of naval architects in England.

APRIL 29.—Guns and armor.

A review of the recent achievements of guns as compared to former design, strength and velocity of projectile, and also considerations relative to improvements in armor. The writer looks forward to still greater improvements in guns and gunnery, greater speed for vessels and continued advancement in the resistance of armor.

MAY 13.—The Italian submarine boat *Audace*. J. W. R.

Revue d'Infanterie.

JANUARY.—Treatise on the exercises and maneuvers of infantry. History of infantry in France (continued). The Russian army—artillery (continued). Notes on combat formations and methods of instruction for infantry. The march from the military point of view. Manner of applying the rule for suppressing inconveniences inherent in the dispersed order in the combat of the battalion.

MARCH.—A page of history: defense of Châteaudun.

MAY.—Infantry fire. Infantry instruction.

Revue Militaire Universelle.

JANUARY.—Tactics applied to the terrain (continued). Explosives (continued). The Dahomeyan expedition in 1890 (continued). The Chaplain of Saint Cyr (continued). General study upon the contemporaneous geographical movement.

FEBRUARY.—The principal explosive factories.

MARCH.—The South Orange States.

APRIL.—Tactics applied to the terrain. The war of the future. Strategy and mobilization in Algeria.

MAY.—The two guns—the German model of 1888 and the French of 1886. Notes on smokeless powders.

JUNE.—German foot artillery regulations. The siege of Méziéres, 1815.

Mémoires de la Société des Ingénieurs Civils.

Revue Militaire Suisse.

JANUARY.—Complement of the mountain fortifications, especially that of the St. Gothard.

FEBRUARY.—Study upon the Swiss Landsturm: organization, employment and use. Society of officers of the Swiss Confederation.

MARCH.—The judiciary organization: upon the mode of punishment. The combat sword. The task and actual condition of the Swiss army.

MAY.—The German emperor and empress in Switzerland. Reorganization of the Spanish army.

Revue de l'Armée belge.

JANUARY.—Study of the defense of the lower Scheldt.

The writer, after laying down the general principles which should be applied to the problem, passes to the different subdivisions of the defense in detail. The history, efficacy, and present use of torpedoes is considered; also the control of fire, range-finding, and other considerations which pertain to the problem.

General Le Clément de Saint Marcq. Application of the processes of stationary and mobile ærial navigation to the art of war.

This discussion is a continuation of the subject begun in an earlier number and treats the subject of ærial navigation analytically, and considers the value and effect of the solution of this problem upon the art of war.

Note upon the formation of cannoneers in field artillery.

A careful, thoughtful argument in reference to the instruction of recruits: I. Instruction in the service of the piece. II. Pointing with the sight.

Historical, political and military study of Constantinople and the peninsula of the Balkans (continued). Note in reference to field artillery fire. Study upon powders and explosives considered from the point of view of military demolition. Second part.

The author deprecates the general tendency of men using explosives for destructive purposes to over-charge the mine or work to be destroyed, frequently wasting large quantities of precious explosive and also obtaining a result quite the contrary to what was desired. He argues for the use of these agents according to theoretical and experimental formulas, and with some intelligence as to what is to be done. Following these general remarks are several tables giving comparative data with respect to all the principal military explosives. These data refer to temperature, time and velocity of detonation and pressures produced compared to a standard powder. Formulas for computing these data are given. An appendix follows which contains all the most reliable practical formulas for destroying different kinds and shapes of material with the rules for their application.

Study upon the destruction of ice.

This study relates to the obstruction of rivers by ice and means of breaking and clearing it away.

MARCH.—The tactics of former times. Repeating fire-arms now in use. Souvenirs of Mexico. Study upon powders and explosives considered from the point of view of military destructions.

This article, in continuation of the subject, considers the following questions: § 3. General study of the effects of an explosion. (A) Upon the phenomenon of explosions—exterior effects. The first part of this section is devoted to the theoretical action of an explosive detonated in a uniform medium; after which comes the effect in media of limited dimensions and with results, such as the effect within the mine, the transmission of the wave and the crater formed. (B) Definitions and notation. Here are defined the terms used in practical mining. (C) Research relative to the form of intumescence produced by a charge of powder or explosive. This part of the paper consists in an analytical investigation of the intumescence of a mine, in which enter the elements of time, velocity and displacement of the particles in terms of known quantities. The formulas for maximum height and extension, etc., enable one to construct the sheaf point by point. Practical examples with computations follow the deduction of the formulas. The article is illustrated by photographs of land and water mines and by curves and plates showing the progress of explosion. J. W. R.

Memorial de Artilleria.

DECEMBER, 1892.—Combustion of grains of powder.

A discussion by Lieutenant Colonel Onofre Mata, Commandant of the Central School of Fire, Madrid, relative to the generality of certain formulas for the combustion of grains of powder given in his *Tratado de balistica interior*. The article is in the main a reply to the criticisms expressed by the *Revue de l'Armée belge* doubting the applicability of the formulas to all forms of grains. The first part is devoted to general reasoning in which is found an elucidation of mathematical principles involved. The volume of the grain burnt at any time is expressed by Al^3+Bl^2+Cl, in which l is the thickness of the grain burnt. A and B are functions of the primitive surface of the elementary pyramid considered and the radius of curvature of the normal section, and C is the primitive elementary surface of the grain. The first differential coefficient of this function becomes the burning surface for any given value of l.

The discussion and application of these formulas is exceedingly interesting. The paper closes with two tables which contain the values of A, B and C for all the ordinary forms of grain of smokeless and black powders.

A provisional system of projectors.

The author in advocating the installation of a plant for projectors does so, not so much with respect to its use in war as to the establishment of a provisional system for immediate instruction and drill. The argument which follows consists mainly in showing the advantages which would flow from a provisional system and the manner in which it can be cheaply constructed. The writer advocates the use of engines already existing in the artillery parks at Barcelona. The plan is thoroughly worked out and estimated cost given.

Military maneuvers in Spain (continued). Coast artillery, (warships continued). Material of the Schneider 45 caliber 15-cm. rapid-fire gun.

JANUARY, 1893.—Field harness. Experiments with smokeless powders in the factory of Granada.

This article gives the results of a series of experiments carried on at the factory with different kinds of smokeless powders. Tables giving conditions, velocitiies and pressures accompany the discussion.

Points upon the military organization of Great Britain in 1893 (continued). The progress of ærial navigation.

FEBRUARY.—Observations upon the rules of field artillery fire.

An analytical treatment of the subject under the following heads: 1. Upon fire by regular increments in elevation. This relates to the question of finding the range by firing successive guns with regular increments or decrements in elevation; it also covers the cases of depth and motion of target. 2. Upon shrapnel fire. (a) Laws of dispersion of explosions in which the principles of probabilities are applied. (b) Operations of correcting shrapnel fire, given in shape of six rules for procedure.

The form of small-arm bullets.

MARCH.—Treatise upon a special form of hollow projectiles.

An analytical discussion of the form and length of hollow projectiles.

Cartridges of the Lee-Metford gun. Modern fire-arms and their ammunition.

APRIL.—A proposed system of pack-saddles for mountain artillery. Marches and fire exercises executed by the third Battery of the fifth Battalion of fortress Artillery.

The march was from Pamplona to the Central School of Fire at Madrid. The events and experience of the march of sixteen days are given. The details of the fire exercises are interesting. The firing represented an attack upon a siege battery emplacement with traverses, parapets, etc. The first exercise was an indirect enfilade fire; the details, with plates representing the effect of a definite number of shots, are shown. The method of correcting for range and deflection are described and tables of deviations, etc., accompany the article.

Points upon the British militia organization. Military maneuvers. Coast artillery (warships).

J. W. R.

Revista Cientifico Militar [Barcelona].

JANUARY 1.—Lieutenant General D. Marcelo de Aycánaga as minister of war. The health of the soldier (continued). Importance of communications across the Pyrenees. The defense in military operations. Review of the press and of military progress (continued).

JANUARY 15.—The service of subalterns. The Spanish-American military congress (continued). The valley of Andorra.

FEBRUARY 15.—The military problem (continued). Nitramite.

MARCH 1.—Fortifications applied to the defense of Spain. Moral education of the soldier (continued). Work descriptive of an historical military episode.

APRIL 15.—The military problem. The small-arm for our infantry.

MAY 1.—Classification of belligerents and combatants in civil wars.

Revista General de Marina.

MAY.—The right of search. The actual condition of war navies. The hydrographic service of England. A vocabulary of powders and explosives. The voyage of the *Santa Maria.*

Boletin del Centro Naval.

NOVEMBER 1892.—Tactics of torpedo vessels.

DECEMBER.—Modern constructions—project of a rapid cruiser (continued). Naval school.

JANUARY AND FEBRUARY 1893.—The naval military school. Monitors considered as a coast guard. The recovery of wrecked boats in general (application to the *Howe*). Compendium of the instructions for the artillery and torpedo school boats in the Italian navy.

Circulo Naval, Revista de Marina.

DECEMBER 1892.—Discrepancy between the duties and pay of a few sea sergeants in our fleet. Cyclonic and anti-cyclonic storms in the southern hemisphere. European navies. Vocabulary of powders and explosives. The great war of 1892, a prophecy.

Revista Maritima Brazileira.

JANUARY.—Steel in France (continued). The battle-ship. Portable fire-arms. The naval maneuvers of 1892.

FEBRUARY. Autobiography of a Whitehead torpedo (continued). Powders and explosives. Naval maneuvers in 1892.

Revista da Commissao Technica Militar Consultiva.

JANUARY.—Repeating fire-arms—the new German and Belgian guns. Reorganization of the military schools. Artillery notes.

Revista Militar.

DECEMBER 15, 1892.—Questions of alimentation. Points in reference to the history of the arsenal of the army.

DECEMBER 31.—Service of information for cavalry.

JANUARY 15, 1893.—The army and politics. Instruction for companies. Notes upon the recent military and technical inventions and discoveries.

JANUARY 31.—The army officer.

FEBRUARY 28.—The army and the finances.

APRIL 15.—Reward and punishment. Excerpts of studies upon military education and organization. A military velocipede in Spain.

APRIL 30.—Military reforms. Infantry and field trenches of battle.

Rivista di Artiglieria e Genio.

JANUARY.—Present fortification—transformation of existing works. Miscellaneous notes.

FEBRUARY.—The progress of modern map making in Europe (continued). Instruction of the foot artillery of the German army. Considerations upon the probabilities of fire of coast and marine artillery (continued). Miscellaneous notes.

MARCH.—Method of indirect pointing for field artillery. Notes.

APRIL.—Brief consideration of the regulations for field artillery fire. Temporary fortification and the new means of offense. Fuzes and primers proposed for the German artillery service. Instruction for the execution of the school of fire.

MAY.—Minimum small-arm caliber. Temporary fortification and the new means of offense. Observations and remarks in respect of siege artillery fire. Proposed modification in the present attachment of the traces to the collar. Notes.

Archiv fuer die Artillerie- und Ingenieur-Offiziere.

OCTOBER-NOVEMBER, 1892.—The most recent photographic surveying instruments. Photographic record and theory of projectile-oscillation. Recent regulations for the Spanish artillery and engineer arms.

JANUARY, 1893.—The construction of tables for curved fire (translated from the Italian).

FEBRUARY.—The first quarter-century of the Engineer Commission.

MARCH.—Long-distance rides.

This is a sort of record of long-distance rides, both past and present. With the exception of one case, American examples are not reported.

Fortifications and field armies: considerations upon the campaigns of '48 and '68 in upper Italy, and upon the first operations of the last war with France.

APRIL.—A new French range-finder. Description of the Paschwitz telemeter.

MAY.—Practice against captive balloons.

Mittheilungen ueber Gegenstaende des Artillerie- und Genie-Wesens.

No. 11, 1892.—Summary of technological experiments. Summary of experiments in the domain of artillery and arms.

No. 12.—Theory of artillery practice.

No. 1, 1893.—Considerations on the theory of the behavior of projectiles (continued in No. 3). Conclusions respecting R. F. guns (continued in No. 2, 3; concluded in No. 5) More recent opinions on mountain fortifications.

No. 2.—Experiments on a new pole for field piece. Upon means of observing shots.

No. 4.—Artillery range-finders. On compressed air.

No. 5.—Experiments with explosives by the engineer regiment in 1892.

Jahrbuecher fuer die deutsche Armee und Marine.

November, 1892.—The maneuvering and fire of artillery in battle. Considerations on the behavior of the small-calibre bullet.

December.—Military reflections upon the suppression of riots in large cities. The recent Italian regulations in combat exercises.

January, 1893.—The fall maneuvers of the 9th against the 12th French Army Corps in Poitou, 1892 (continued in February). The French fleet maneuvers in 1892. Armor-plate fortification illustrated in its economical aspect by the examples of Liege and Namur.

March.—The employment of belt-roads for tactical purposes. The speed of modern armored ships. The care of our wounded in a future war.

April.—On the wounds caused by the small-caliber rifle.

May.—The land fortification of Switzerland. The history of siege warfare since the introduction of fire-arms until 1892.

Internationale Revue ueber die Gesammten Armeen und Flotten.

October 1892.—German armor-plate construction and French imitation. Germany's coast-defense.

December.—On the use of R. F. and machine guns in the field (continued in January, February and March, 1893).

March, 1893.—New small-arms, by General R. Wille (continued in April and May). Shall we build coast-defense ships, and of what kind (concluded in April)?

April.—Attack and defense of places (continued in May).

May.—American plan and policy of defense.

Marine-Rundschau.

January.—Prussian naval policy since 1836 (continued in February). English naval maneuvers, 1892.

April.—Russian fleet maneuvers in 1892.

Organ der Militaer-Wissenschaftlichen Vereine.

No. 1, 1893.—A word on the application of field artillery.

No. 2.—The work of the German general staff in 1870-71.

No. 3.—Moltke and his influence on the operations of 1864.

No. 4.—The field-gun of the future. The defense of the bridge-head of Presburg.

No. 5.—Cavalry to the front! a study in war history.

No. 6.—Infantry fire in battle. On the formation and leading of larger artillery masses in battle.

Schweizerische Militaerische Blaetter.

JANUARY.—The Swiss artillery. Trial of a 7.5 cm. R. F. Skoda gun. French battle tactics for artillery. Experiments with aluminum. The war of the future.

FEBRUARY.—Implement for setting time and double action fuses.

MAY.—Infantry against artillery.

Mittheilungen aus dem Gebiete des Seewesens.

No. 12, 1892.—Relation between offensive and defensive powers of state. R. F. guns of large caliber.

Nos. 1 and 2, 1893.—Fleet maneuvers in 1892.

No. 3.—On stability of rotation, with special reference to Howell torpedo.

Beiheft zum Militaer-Wochenblatt.

Nos. 8 and 9, 1892.—Remarks on the Russo-Turksh war, 1877-78.

No. 1, 1893.—My long-distance ride, Berlin-Vienna.

No. 2.—Epitome of the history of the Royal Prussian Engineer Committee, during the first 25 years of its existence.

No. 3.—Impressions of a military tour in the Caucasus and South Russia.

Militaer-Wochenblatt.

APRIL 26.—On the history of the German general staff, from 1806 to 1870 (continued).

Allgemeine Schweizerische Militaerzeitung.

February 11.—Attack and defense of modern armored forts (continued). Investigation of the tactical consequences of the introduction of the small-caliber rifle and of smokeless powder.

March 4.—Reorganization of our field artillery.

Allgemeine Militaerzeitung.

April 12.—Tactics of the three arms (continued).

May 27.—Charts and plans of the city of Metz.

Die Reichswehr.

April 23.—The ersatz-officers of Germany.

April 30.—The ram-cruiser *Maria-Theresa.*

May 20.—The naval review in New York.

May 26.—The Roumanian Mannlicher rifle, M. 1893.

Kriegswaffen.

Part 12, 1893.—Compressed air gun (pneumatic dynamite gun). Aiming contrivance for guns.

Artilleriskii Journal.

January, 1893.—Preparation of field artillery for war (continued). Manufacture and character of different smokeless powders and those of little smoke (continued). The measurement of high temperatures.

February.—Exercises with double-action fuzes. The artificer, the pointer and the chief of piece. The settlement of a few practical questions with respect to lighting by means of electrical projectors.

March.—The one hundred years existence of the Russian horse artillery. Notes upon the execution of field artillery night firing exercises. The apparatus adopted in Germany for masked field artillery fire.

Razviedtchik.

No. 122, 1893.—Organization and service of velocipedists in foreign armies (continued).

No. 127.—The lance in the German cavalry.

No. 128.—Individual instruction of the new soldiers of the guard.

No. 133.—What are our neighbors doing?

No. 136.—The Chicago exposition.

Russkii Invalid.

No. 29, 1893.—Review of artillery in foreign armies in 1892 (continued).

Nos. 41 and 42.—War fire maneuvers with masses of artillery.

No. 58.—A few remarks on the organization of the order for combat.

No. 59.—Smokeless powder viewed as to the absence of danger, —fire and transportation.

No. 71 —Notes on small-arms.

Nos. 72 and 73.—The means of lighting, taking care of, and maintaining communications upon the battle-field.

Nos. 90, 91 and 92.—Special works of the engineer field troops in 1891-92.

Nos. 102 and 103.—Summer exercises for the troops in 1893.

No. 107.—Summer work for the field engineer troops in 1893.

No. 108.—Instruction as to the classification of the sick and wounded in war.

Norsk Militaert Tidsskrift.

PART 1, 1893.—The society for voluntary assistance of the sick and wounded in the field. The attack of the enemy by an infantry battalion, armed with the small-caliber rifle and smokeless powder.

PART 3.—Smokeless powders and small-calibers.

PART 4.—Fire discipline and fire leading.

Militaert Tidsskrift.

PARTS 1 AND 2, 1892.—Military retrospect for 1891.

PART 3.—Military sanitation.

PART 6.—The soldier's moral training. The fall maneuvers of 1891 and the report of the Minister of War made up from reports on the maneuvers.

PART 1, 1893.—What has been the role of the lance in cavalry during different periods (continued in part 2).

Artilleri-Tidskrift.

PART 1, 1892.—Field artillery firing over its own troops. About the deviation (scattering) of projectiles. The fire of field artillery at concealed objects (with plates). The reorganization of the German field artillery firing school. Rapid-fire cannon in comparison with ordinary field guns. Notes about the manufacture of cannon in America. Notes from foreign countries: Reorganization of the German field artillery material; a new field gun in France; effects of the new ammunition in Italy; experimental firing at captive balloons in Russia; Maxim's automatic rapid-fire gun; aluminum bronze as a material for cannon and small-arms; from the 9th German field artillery's history. Announcement: "Fire game for the field artillery."

PARTS 2 AND 3.—The field gun of the future—a study. Schleswig's field artillery regiment No. 9 in the battle of Gravelotte-St. Privat. Fiske's range-finder—with plate. What value for war ought to be given to the present divisional exercise of the field artillery? Malmström's concussion fuze. Pressure gauge for muskets. Horse-shoes in the German army. News from foreign lands: Experiments with mortar batteries in Germany; experiments with observation ladders in Germany; reorganization of the English field artillery; changes in the Austro-Hungarian field artillery; a new rifle in Roumania; Graydon's torpedo gun; the newest artillery material in the United States.

PART 4.—Field artillery's advance guard duties. German field artillery firing school. Fire rules for the German field artillery. 6.5 mm. repeating rifle, Mannlicher's system.

PARTS 5 AND 6.—Our new army organization. Growth of field artillery in France. Notes on the pressures generated by some of the new propulsion agents (motors). Target practice of the three arms by the XIV German Army Corps. Attempt at firing regulations (firing instruction) for the German field artillery, 1892. A few American notes on the last German fall maneuvers. News from foreign lands.

The Journal of the Royal United Service Institution.

JANUARY 1893.—Ventilation of ships. Notes on infantry tactics. An old log. Army and Navy of Japan. Recent progress in marine machinery. Cavalry divisions and divisonal cavalry.

FEBRUARY.—The system of mounting and placing guns on board ships of the royal navy. Foreign war offices. Brief account of the return march to India of the army in Afghanistan under General Sir Donald Stewart, G. C. B. &c., in 1880. The Turkish Janissaries. France and her marine (mercantile and war). Recent progress in marine machinery. A Spanish view of the Spanish Navy. Moltke's tactical exercises, 1858–82.

MARCH.—Electric balloon signalling. Tactical employment of engineer field companies in combination with other arms. Different systems of signalling in the field. German field-artillery exercise. The Buonaccorsi Automobile torpedo. Bohmayer's electric bell. Electrical transmission and indicator for the movements of the tiller. The magazine rifle of 6.5 mm. caliber.

MAY.—The military organization best adapted to imperial needs. Modern warfare as affecting the mercantile marine of Great Britain. The contemporary navies of the world; their elements of power, guns and armor. Battle-ships of England. The Russian official report on the Ochta competition. Experimental firing with 6 cm. quick-firing guns at the Krupp works in Germany.

Journal of the United Service Institution of India.

AUGUST 1892.—On repairing and constructing war railways. The most effective tactical use that can be made of signalling on a modern battle field. A revised scheme for a government mule farm in the hills. Penetration and effects of magazine rifles.

SEPTEMBER.—Plevna with tactical considerations of defense. Revolver training. Jungle fighting. Suggestions on the train- of cavalry leaders and remarks upon pace in manœuvre, and the use of succor squadrons in battle. The volunteer force in India. The civil war in Chili, with special reference to the employment of small bore rifles. The combined tactics of infantry and artillery.

OCTOBER.—The bearing of recent developments in the means of destruction on the medical service in time of war. The bearing of cavalry for reconnaissance. Warfare in mountainous countries.

NOVEMBER.—A suggestion for the improvement of horse breeding in India. Smokeless powder as affecting tactics. Instructions for field firing of detachments of the three arms of the Russian Army, 1886.

DECEMBER.—Burma, 1885–1887.

JANUARY 1893.—The organization of the native cavalry. The armaments of the three arms and their effects in war. Continental regulations on attack and defense.

FEBRUARY.—An estimate of the probable losses in the frontal attack of infantry. The curved sword in the native cavalry. A tactical retrospect of the years 1859 and 1890 with special reference to infantry; see page 157.

MARCH.—Section columns from parade to battle. Infantry attack formations. A tactical retrospect of the years 1859 to 1890.

The Military Society of Ireland.

MAY 1, 1891.—Reconnaissance.

DECEMBER 8.—Slavish discipline.

JANUARY 6, 1892.—The physical training of the recruit and drilled soldier.

JANUARY 27.—Soldiers life in the army and how to improve it.

FEBRUARY 10.—Military horses and their management.

MARCH 2.—Barracks.

APRIL 13.—Woods: their tactical importance in battle.

NOVEMBER 2.—Mobilization for home defense.

NOVEMBER 16.—The artillery in 1870–71, from a general army point of view.

NOVEMBER 30.—Field manœuvres and camp of instruction.

JANUARY 4, 1893.—Army organization.

Aldershot Military Society.

NO. XXXIX.—Synopsis of lecture on the horse for military purposes.

No. XL.—The importance of the American war of 1861–65 as a strategical study.

No. XLI.—Lecture on modern infantry fire tactics (offensive).

No. XLII.—The command of the sea and its effect upon military operations [Vice Admiral P. H. Coulomb, R. N.].

Transactions of the East of Scotland Tactical Socicty.

1892–93.—Discussion on some needful reforms. Field firing of 5th V. B. R. S. at Camp Aberlady, 1892. Discussion on musketry instruction. "The Defense of the Forth." Scottish military bodies and their territorial traditions. Discussion Military Medical Organization. Suggested improved method for dismounting troops in the field. "Marching power." The effect of smokeless powder on the attack and defense.

Proceedings of the Royal Artillery Institution.

JANUARY 1893.—Achievments of field-artillery (continued). Defense of a coast fortress. Instructions for the conveyance of troops by rail on the field service scale. Recent development of armor and its attack by ordnance [continued].

FEBRUARY.—Soldiering and sport in Mashonaland. Saddlery.

MARCH.—Okehampton experience, 1892.

APRIL.—The strategical geography of Europe. Notes on optical instruments. The value of a high site for coast artillery.

MAY.—The effect of the rotation of the earth on the motion of projectiles. The modern batteries. Modern gun-powder and cordite.

Engineering.

JANUARY 13, 1893.—The gun trials of the armor clad ram *Libertad.*

JANUARY 20.—The strength of torpedo boats; the effect of a collision.

FEBRUARY 10.—Electric balloon signalling.

FEBRUARY 17.—The Dredge-Steward omni-telemeter. Gunnery trials of a battle ship. Ordnance manufacture in America. H. M. S. *Grafton.*

FEBRUARY 24.—The Argentine Cruiser *Neuvo de Julio.*

MARCH 24.—The position of cruisers in warfare.

Summary of subject matter of papers read before the Institution of Naval Architects, by Lord Brassey, Admiral Coulomb and others, the above and kindred subjects.

MARCH 31.—Quick-firing guns in the field.

APRIL 7.—The Institution of Naval Architects.

MAY 19.—The power trials of H. M. Battleship *Ramillies.*

MAY 26.—Explosions.

A review of Colonel Majendie's report on the subject of explosives for 1892.

The manufacture of small arms (continued).

JUNE 3.—The Russian Torpedo Cruisers *Wolwoda* and *Possadnik.* The engines of the first class cruiser *Crescent.*

J. W. R.

The Engineer.

JANUARY 6, 1893.—War material.

JANUARY 13.—Electricity in the United States. The gun trials of the twin-screw armor clad ram *Libertad.* Gas power for electric lighting.

JANUARY 20.—The Harvey plate trial.

JANUARY 27.—Engineers in the U. S. Navy. Mounting heavy guns afloat.

FEBRUARY 3.—Complication in gunnery.

FEBRUARY 10.—Harvey-Vickers plate. Cordite.

FEBRUARY 17.—The "*9 de Julio.*" Smokeless powders. Nickel steel.

FEBRUARY 24.—Armored cruiser *Brooklyn,* U. S. Navy.

MARCH 3.—Bridging the Bosphorus. The trial of H. M. S. *Hood.* Battleship *Iowa,* U. S. Navy.

MARCH 24.—The bearing of recent plate trials on future warfare. The Russian official report of the Ochta competition.

An illustrated article showing photographs of the recent armor trials, and the effect of the attack at each stage of the experiment.

MARCH 31.—The Russian barbette battleship *Sinope.*

APRIL 7.—The American Nickel Harveyized Plate trial.

APRIL 21.—The U. S. Dynamite Cruiser *Vesuvius.*

MAY 5.—Trials of H. M. S. *Ramillies* and *Alarm.*

JUNE 2.—The Naval Annual for 1893. The *Dimitri Donskoi.*

J. W. R.

The United Service Gazette.

JANUARY 7, 1893.—A calendar of British land victories. The reorganization of the French Army (continued). A French reply to Sir Thomas Symonds. The training of engineers and artillery. A naval retrospect, 1892. The army, 1892.

JANUARY 21.—Offensive tactics of infantry. Guns on board ship.

JANUARY 28.—Ammunition for field guns. Electric balloon signalling. Training troops for action. The next naval programme.

FEBRUARY 4.—Lord Roberts on artillery. Engineers in the field. Our naval supremacy.

FEBRUARY 11.—Sea power. Field maneuvers and camps of instruction.

FEBRUARY 18.—Army organization. II. Sea power. The battle of Gettysburg.

FEBRUARY 25.—Our swordsmanship. Lord Roberts on the duties of cavalry in the field. Egypt and the Red Sea.

MARCH 4.—The *Royal Arthur.* The navy estimates. Proper professional pride. Strategy in the American civil war.

MARCH 11.—The navy estimates.

MARCH 18.—The art of marching. The state of the navy.

MARCH 25.—French army maneuvers. The navy maneuvers of 1892—I. The manning of the navy.

APRIL 8.—Naval supremacy.

APRIL 15.—The value of the torpedo-boat. Imperial defense. Mobilization of the volunteers. Conscription statistics.

APRIL 22.—Our position in the Mediterranean. The invasion of England.

APRIL 29.—The future of the torpedo.

MAY 6.—Employment of artillery in masses. The new defenses of France. Our relative strength at sea. The function of artillery. Continuity of the effective service of war-ships.

MAY 13.—The personnel of the navy.

MAY 20.—Our naval strength. The new defenses of France. The eastern frontier—II. The phonograph and its military use.

MAY 27.—Our naval requirements. Our position in India.

The Army and Navy Gazette.

JANUARY 7.—Musketry in India. Our naval literature.

JANUARY 14.—The defenses of Constantinople. The reorganization of the yeomanry.

JANUARY 21.—The efficiency of the Italian army. Naval engineering.

JANUARY 28.—The armies of Europe. Sea power and the French revolution. Artillery fire. Electric balloon signalling.

FEBRUARY 4.—Quick-firing guns. The French navy in 1789. The tactical employment of the Royal Engineers.

FEBRUARY 11.—The yeomanry reorganization scheme. Army signalling.

FEBRUARY 18.—Cavalry and mounted infantry. The ventilation of ships.

FEBRUARY 25.—The army service corps. Young soldiers and enteric fevers. The shipbuilding programme.

MARCH 4.—Balaclava (continued). Sandhurst and Woolwich. The soldiers ration. The Military Society of Ireland.

MARCH 11.—The localization of the forces.

MARCH 25.—The state of the army. The Canadian Militia. Field guns.

APRIL 1.—A war cloud. The ordnance corps.

APRIL 8.—Cruisers, monstrous or otherwise (continued).

MAY 13.—State-craft and sea-power. Defenses of Constantinople.

MAY 27.—Cordite.

Review of paper by Orde Brown in the Naval Annual, in which he treats of cordite as compared to the black powders with tests as to its stability, made upon it in Canada and also in the hot stations.

JUNE 3.—Foreign policy and naval program. Our naval literature.

J. W. R.

Journal of the U. S. Military Service Institution.

JANUARY 1893.—Artillery service in the rebellion. Hot air balloons. Russian view of the Pamir question. Comments on military specialists. The knapsack. Musketry training. Place of the Medical Department in the army.

MARCH.—Prize essay. The army organization best adapted to a republican form of government. The evolution of modern drill books. Telegraph in war. Artillery service in the rebellion.

MAY.—The evolution of modern drill books. The knapsack and the army shoe. Military misconceptions and absurdities. The post mess. Cavalry drill regulations. The flag of truce. Apprentice schools for the army. Military uses of photography. Target practice.

Proceedings of the U. S. Naval Institute.

No. 64.—Naval signaling (A. P. Niblack, Lieutenant Junior grade, U. S. N.).

The author here adds a very interesting and valuable contribution to his previous investigations on the subject of signaling. The subject is considered from the present status of signaling and the different methods now in use. The following general heads indicate the nature and scope of the paper. Theory of signaling. I—Messenger service. II—Day and night squadron and distant visual signaling. III—Phonetic signaling. Under these heads are included sub-heads covering all kinds of signaling problems and the apparatus used in solving them. A discussion filling several pages follow the main article. The comments on the propositions of the paper are in general very complimentary to the writer and confirm his statements in reference to the signaling question.

Crusher and cutter gauges for explosives (W. R. Quinan).

This is an article of eighty pages and four large plates. The paper opens with the apparatus used by the author in his experiments. The most important machines described are the pressure gauge, foot pounds machine, calipers and lead cylinders. The author has taken a very prominent part in the development of these machines and their application to the measurement and test of explosives. He lays before the reader a vast amount of data of his own production, and with this and other data obtainable proceeds to an analytical investigation of the very questionable status of *crusher and cutter gauges*. In the beginning a step is taken with view to the determination of an expression for work in foot pounds in terms of known constants, and the amount of compression of the lead cylinders used.

It is inferable from the context that the writer does not consider the investigation entirely successful. It is impossible here to follow the steps in the analysis of the subject. It is found that the first formula deduced which results strictly from theoretical considerations does not agree with the results of experiment, and it becomes necessary to ascertain coefficients, exponents, etc., which will obviate the discrepancy. The reasoning then becomes a search for an empirical formula. The deduction and illustration of the final equation is interesting and well worth reading by all who may be interested in this part of the subject of high explosives. The principal points raised in this part of the paper is the shape of the cylinders after compression and the old question as to whether compression of lead causes any change in *density* and *volume*. In reviewing other experiments much attention is given to those of General Abbot who, it is safe to say, founded the present schools of research with reference to the physical properties of high explosives. Care is also taken to correct statements made in other magazines with respect to the direction of action of an explosion

Considerable space is given to discussion of the "anomalous sub-aqueous action of nitro-glycerine," as recorded by General Abbot. In this connection the writer considers the question of two waves the *explosive* and the *pressure* wave, which some hold, accompanies explosion. In attempting to follow the reasoning here, one soon gets into deep water—for example: "*The velocity of the pressure wave is simply the velocity of sound.*" Why? Does not the velocity of such a wave in its initial stages depend *entirely* upon the impulse behind, which is urging it forward. Is not the rate of elastic propagation an after and secondary consideration? Is this wave propagation likely to be greater in nitro-glycerine than the velocity of detonation, assumed as moving from one end to the other of an elongated charge. Briefly stated will nitro-glycerine under any circumstances transmit an elastic wave more rapidly than that of the detonation producing it? One of the most interesting suppositions connected with this discussion is that some of the nitro-glycerine may not have been exploded, which is supported by the author's own extensive experience in reference to nitro-glycerine explosions.

Under the head of *lead as a register of work* we find its advantages and disadvantages mentioned; and the form of compressed plugs for both soft and hard lead under explosive and impulsive forces. The statement as to the difference in time and action of these two kinds of forces involves some very nice physical problems which are not easily answered. That an *explosive force* ever begins its action at zero and develops to a maximum may well be questioned. May it not in many particular cases begin its action at its maximum intensity?

Copper as a register embraces quite an extended discussion covering the physical properties of this metal and the different methods of using it. The subject is treated both experimentally and analytically and great quantities of data presented. These data and in fact all those of the paper are shown graphically. It is impossible to mention even the various heads which are considered in this thorough and able paper. The subject of *Strength of Explosives* in itself demands extended study and thought. The same may be said of its application to High Explosives.

In his closing remarks he says that, "It is possible that no explosive used in fire-arms is capable of writing a record of work which will agree in two such instruments as the cutter and crusher gauges." The questions may also be asked in connection with his closing remarks on smokeless powders, are *they* high explosives and is the velocity of combustion independent of the pressure? Does the difference mentioned with respect to external reaction amongst molecules in case of gunpowder and internal reaction amongst atoms in smokeless powders really exist? The most recent experiments in these matters, it may be ventured, show no radical difference either in manner and rate of combustion, or in the reactions which result therefrom.

One of the most interesting and valuable parts of the paper is the clear way in which all the different problems and their attendant difficulties are brought to the surface and stated. The statistics also form an invaluable contribution to the subject. For all these parts to the general subject all interested in the physical problems treated will find the discussion most instructive and useful.

No. 65.—Automobile torpedoes.

Enters into a thorough discussion of the general uses of such weapons and their efficiency, the Howell torpedo and the probable type of the future torpedo cruiser and destroyer.

Chemical analysis of the three Corean guns. Notes on the literature of explosives. Naval signaling (discussion continued).

J. W. R.

Journal of the U. S. Cavalry Association.

MARCH.—Cavalry upon the field of battle. Smokeless powder in its relation to cavalry efficiency. Conversations on cavalry. Gaits and gaiting of horses.

Journal of the American Society of Naval Engineers.

FEBRUARY.—Method of running the lines for the shafting and boring out the stern tubes and brackets of the U. S. S. *Cincinnati*. Marine boiler furnaces. Steel castings. Economical speed and coal endurance of war vessels as affected by the relation of the coal expended for all other purposes. The contract trial of the U. S. S. *Monterey*. Commerce of the great lakes.

The Army and Navy Journal.

JANUARY 7.—Russian trial of armor plates.

MARCH 11.—The inaugural parade. The navy appropriation.

MARCH 25.—The effect of new army legislation.

The Army and Navy Register.

JANUARY 28, 1893.—Ranging the *Vesuvius*.
FEBRUARY 11.—Status of naval vessels building.
FEBRUARY 18.—Rifles in European armies.
FEBRUARY 25.—The army bill.
MARCH 11.—Report on the guns of the *Vesuvius*.

Cassier's Magazine.

JANUARY.—Life and inventions of Edison (continued). Three million horse power in winter. The governing of steam engines. Electric traveling cranes. Gauges for registering high pressures. The Canadian Society of Civil Engineers. Influence of patents on American industries. The steam engine in modern civilization. A new form of condenser. Notes on new and patented inventions (continued). Machine shop construction. Some interesting machines. The milling machine in place of the planer.

FEBRUARY.—Mechanical flight. Leading American engineers. Economy of a non-condensing engine. Electric transmission of power for mills. Steel for forgings. Some new pumping machinery. Heat movement in steam engine cylinders. Valuable speed power transmission. A new sectional water-tube boiler.

MARCH.—Electricity and our coast defenses. Long distance transmission of power. Modern gas and oil engines. A new method of storing power.

APRIL.—Traveling cranes. Power transmission for central stations.

This is a valuable paper added to the literature on electricity by Dr. Louis Bell. In it he discusses the general question of electrical power transmission under the following three heads: 1. The transmission of single units. 2. The transmission of power to a centre of supply from which point it is to be distributed. 3. The supply of power for light and motors throughout the transmission line. He then proceeds to discuss the special considerations involved in each of these classes. His remarks relating to incandescent lighting with multiphase systems deserve special notice. In this connection speaking from experience and in contradiction to the popular notion, says that lamps can be as successfully operated on multiphase systems, as on an ordinary single phase circuit, provided equal pains be taken with the distribution of the copper in the lines and the regulation of the voltage in the dynamos. The article is extremely interesting and valuable.

Modern gas and oil engines. Steam engines at the World's Fair. J. W. R.

Hammersley's United Service.

JANUARY 1893.—The National Guard of Iowa in 1892. A story of Gettysburg. The battle of Copenhagen.

FEBRUARY.—The rennaissance of war.

MARCH.—Ship canals. The Vermont National Guard.

APRIL.—Moltke.

MAY.—A new system of drill regulations for infantry. Oliver Cromwell as a soldier. Army clothing and equipage.

The Iron Age.

JANUARY, 1893.—U. S. armored cruiser *Brooklyn.* British naval forced draft rules.

JANUARY 26.—Machine for rolling electrically heated bars.

FEBRUARY 2.—The Shaw 80-ton Gantry transfer crane.

This crane is to be used in mounting, dismounting and transferring heavy guns at Sandy Hook.

FEBRUARY 16.—The small arms of the great powers. The development and transmission of power from central stations.

FEBRUARY 23.—New armor specifications. The new Edison Station, New York.

MARCH 2.—Unfreezable dynamite.

MARCH 9.—Hydraulic power plant for the U. S. coast-defense vessel *Monterey.* A new mitrailleuse for cavalry. Trial of the 14-inch Harvey plate.

MARCH 16.—Hydraulic machinery and heavy guns.

A quotation from the *London Times* with comments on the fact that the recent cold weather had very disastrous effects upon the hydraulic machinery for the heavy guns upon the *Benbow.* After discovery of the injury, a careful inspection of the machinery was made and the necessity for taking apart most of the machinery was reached. It became necessary to send it to the original makers for reconstruction and repair. The Admiral of the fleet, Sir Thomas Symonds, suggested in this connection. the possibility of the best English ships being unsuited for service in such waters as the Baltic.

Schneider gun mount. Machinists in the navy.

MARCH 30.—Trials of the dynamite gun-boat *Vesuvius.* Notes on British armor and ordnance.

APRIL 6.—The Merriam percussion fuse.

APRIL 13.—Car for conveying heavy guns.

APRIL 20.—The manufacture of rifles.

MAY 4.—The new Western Electric Generator and Motor.

J. W. R.

The Scientific American.

JANUARY 14, 1893.—The manufacture of small arms. Fast torpedo boats.

JANUARY 21.—The Russian Warship *Ruric.*

JANUARY 28.—Warship *Chicago.* Military cycling. The advance in armed cruisers.

FEBRUARY 4.—Snow-shoe exercise in the German army.

FEBRUARY 11.—Trial of an American armor plate at Portsmouth, England. Trial of the pneumatic cruiser *Vesuvius.*

FEBRUARY 18.—The harbor defense ram *Katahdin.*

MARCH 4.—The manufacture of dynamite.

MARCH 11.—The coming naval review. The Uniten States steamship *Iowa.*

APRIL 11.—An improved camera lucida.

APRIL 18.—Krupp's exhibits at the Columbian Exhibition. The first war steamer of the world.

Engineering Magazine.

JANUARY 1893.—The choice of an architect. The anthracite coal industry· Fire losses and the age of clay. Pan-American railway surveys. Liquid fuel in steam making.

FEBRUARY.—The World's Fair and industrial art. The great wall of China. Progress in pneumatic tube transmission. Railroad development in Africa. Practical farming by electricity. Fire proof buildings. Modern uses of windmills.

MARCH.—America's need of the Nicaragua Canal. Relation of architect and engineer. The increase of speed on railways. Locations for the pig-iron industry. American railway progress in 1892. Value of long distance telegraphing. American annexation of Hawaii.

The American Engineer and Railroad Journal.

JANUARY 1893.—The new Manlicher rifle. Naval notes.

FEBRUARY.—Recent inventions in armor. The Ochta armor trial. An English torpedo cruiser. The manufacture of rifles. Naval notes.

MARCH.—The trials of the *Vesuvius*. Trial of Harvey steel armor plate. The Ammen ram *Katahdin*. Naval notes. War ships under construction.

APRIL.—Shells and high explosives. Fletcher rapid fire gun mount.

The Engineer (N. Y.).

JANUARY 7, 1893.—Hot work in naval vessels.

JANUARY 21.—Krupp's steel works. Machinists in the navy.

FEBRUARY 18.—The *Ann Arbor* as a coast defense ship.

The Electrical Review.

JANUARY 28, 1893.—An electric torpedo detector. The naval search light.

MARCH 18.—Power transmission for central stations.

The Western Electrician.

JANUARY 7, 1893.—The 120-ton electric traveling crane at Watervliet.

FEBRUARY 18.—Electricity in the French navy.

MARCH 11.—Electric shot firing in mines.

Marine Review.

JUNE 22, 1893.—Plans for submarine boats.

This relates to a call by our navy for designs for a submarine torpedo-boat. It appears that George C. Baker and Captain McDougall will probably submit designs. The French it appears have taken the lead in submarine navigation, having built several vessels of this class recently. The *Gymnote* is now said to be successful and is attached to their navy. This vessel has remained below water forty minutes, and during early trials maintained a steady course eight metres below the surface for 500 metres at a speed of four knots. She is propelled by electricity and contains compressed air for supplying the crew. Spain has a similar boat, and Russia and Italy are experimenting in the same direction. The article closes with a summary of a recent report of our Navy Department with respect to the great value of such navigation in coast defenses.

J. W. R.

ANNOUNCEMENT TO VOL. II.

The establishment of the *Journal of the United States Artillery* in 1892, was felt by its projectors to be largely an experiment. While the idea of an artillery review for our service was not new, yet the idea itself had for various, and doubtless good reasons never been carried out. The benefit that would follow from a professional journal was acknowledged, but remained unreaped. Seed however had not been sowed in vain. The reasons advanced for the establishment of an artillery review increased in weight as years came and went, and as the importance of coast-defense and all related questions passed from the domain of theory to that of condition. The origin therefore of our present *Journal* is to be sought in the attempt made long since to set on foot a review devoted to the interests of our arm of the service. And if efforts to-day have met with success where before they encountered defeat, the reason lies ultimately in the changed environment of the artillery question. For that there is an artillery question, no clear-thinking man will to-day deny.

It is scarcely necessary here to review the results of the past year. In brief, a working plan submitted through the commanding officer of the Artillery School to its Staff, met with the approbation not only of the Staff, but of the artillery at large. Previous investigation had shown that for financial reasons alone, all others being disregarded, a review could not be maintained at any place other than Fort Monroe. But it is equally true that, however great the facilities at the school, these alone would not have sufficed. A professional review became a possibility only by combining the generous support of the artillery with the "wise liberality" of the School. The outcome of this combination is the *Journal* as it exists to-day. We shall leave the results accomplished to speak for themselves.

It may not be amiss, however, at the outset of a new year, to dwell for a moment upon the changes made necessary by the natural development of affairs. The original organization of the

Journal was avowedly temporary. The reasons for this consisted mainly in the exigencies of the service, and in the proper desire to acquire experience before proceeding to lay a permanent foundation. Difficulties had to be overcome and obstacles removed; many problems arose, the solution of which called for serious effort on the part of the projectors. To all the questions that came up, the temporary organization was found adequate. But it became at the same time increasingly evident that continuous results could be expected only from continuous effort, and that this in turn meant a permanent organization. The *Journal* will therefore in future be under the management of an editor, aided by a committee of general direction and publication. This committee will consist of the following officers who, having consented to act in this capacity, are designated by the Staff of the U. S. Artillery School:

Colonel Henry W. Closson, 4th U. S. Artillery,
Captain James M. Ingalls, 1st U. S. Artillery,
Captain E. L. Zalinski, 5th U. S. Artillery,
Lieutenant E. M. Weaver, 2nd U. S. Artillery,
Lieutenant George O. Squier, 3rd U. S. Artillery.

The editor is Lieutenant John W. Ruckman, 1st Artillery.

It is believed that this organization will receive the cordial approval and loyal support of all artillery officers. While it secures on the one hand, permanency and continuity of effort, on the other, it lends itself by its elasticity to the requirements of growing experience.

Having thus a strong and simple organization, the *Journal* renews with increased confidence, the assurances held out in the initial number. It feels that the experimental stage is passed, and relies for this feeling upon the intelligent interest of the arm of the service that it seeks to represent.

In relinquishing its charge, the temporary committee of 1892, desires here to make its appreciation of the encouragment with which its labors have been received. To say that under the new management this encouragement will grow in strength and purpose, is to say that the future of the *Journal* is assured.

JOURNAL

OF THE

UNITED STATES ARTILLERY.

VOL. II. NO. 1. JANUARY 1893. WHOLE NO. 6.

OUR ARTILLERY ORGANIZATION.

BY COLONEL JOHN HAMILTON, U. S. ARMY.

Whether it is that artillery being the latest arm of service or from the great differentiation of its duties, uniformity of opinion as to its proper organization appears to be impossible of attainment.

Of late our best writers on what field artillery wants, agree pretty well (Tidball, Birkhimer and Parkhurst) as to its needs in field organization. Whether this should constitute a separate arm from siege, or sea-coast artillery, may justify a good deal of thought.

Because all officers of our arm are not equally suited for all the duties of the arm, as actually organized, it should not necessarily require a re-organization to suit the personnel. Admitted that every captain of an artillery regiment be not fitted for a horse battery, still, under the present organization, enough are, and should extension be required plenty of senior first lieutenants are to be found for the places.

This, however, is merely saying that our condition is not lamentable, and does not bind the writer to an expression that our present system is the best fitted for nor the best to prepare us for war.

In fact all organizations, laws, and regulations made in time of peace are trimmed to suit actual necessities: the exigencies of war being in the dim distance are scarcely thought of in administration. What is best to be done now to insure safety, economy, and a mere existence, is the aim of popular government.

As to our arm, it is believed that had the old blood of the service done its duty in the past we would have been in a greatly advanced state of organization and status. But the old are conservative and inert, hence the young have been the only workers. These on the other hand have generally been too ambitious and have wished to reorganize by great leaps, which legislators have feared to take, seeing that the strongest part of the supporting arguments for the new order of affairs was the well arranged promotion which would result. Even these changes might have been good, but most of them excited antagonism from those of whom the scheme did not make field officers.

One point we believe is agreed on by all artillerists, that no change in the way of increase in regiments nor change of units can be of any permanent benefit to the arm without a Chief.

This is a question entirely independent of our numbers, or of bureau, corps, or "*department*" proclivities. We are a weak arm in numbers and in warlike prestige, owing to our duties, as translated and applied by infantry and cavalry generals, being considered as subsidiary to those of their battalions or squadrons. We are not considered in the same breath with those arms. *Vide* Hunt and Barry's claims for a brigadiership. Brilliant men, brainy men, but having no chance of recognition, though their practical infantry experience, as well as artillery and staff, had much antedated that of their successful rivals.

We all know the history of detachments of mixed commands. No artillery officer is ever sent in command of such. However true or untrue it may be, the artilleryman always complains that the infantry or cavalry commander gets into camp first, selects the best ground, wood, and water and the artillery is left to "hustle." Marches are fixed quite regardless of his comfort, and guard duties added to him for which his arm is not fitted and which become an extra onus on his men.

We remember an instance of mixed service worthy of note. Previous to the indian scare of 1868 on *the Republican*, Uncle Sam had made a worthy but unsustained effort to start a school of field artillery at Fort Riley. There were men in uniform and there were government horses, hence public clamor required that these should be sent to protect the settlers against the wild man. Had it not been for the serious injury it was doing to the arm and to the command, it would have caused a smile to see these men set forth on their 1200-pound horses to catch indians. Of course only captains could be sent out and on arriving at the field of operations they found a cavalry major there to direct them, and he did. His horses needed rest so the artillerymen were dispatched to all points of the compass to sight the indians, but on no account to engage them. The artillery "scout" was to hurry in to camp headquarters and report, so that the cavalry should go out and kill the savages. It never was known whether this order was given in the interests of the artillery men or of their horses. The major may not have wanted to lose the artillery men to the service, or he may have thought that the scouting was sufficiently hard on the horses without exposing them additionally to the enemy's bullets. On their return the horses were healthy enough, had lost a good deal of adipose, but were in no way bettered for artillery work.

In ye olden time when red-legged infantry was common on the plains and in the everglades and where its record does not place it second to any, a mixed detachment was ordered out in Texas. After the detail was made the detaching officer's attention was called to the fact that the artillery captain ranked. This would never do, so he was placed on some home special duty, and the command set out; the red-legged company commanded by an old lieutenant of the Florida wars. At the first camp the infantry captain selected his camp and directed the artillery lieutenant to fix himself in a certain position. The lieutenant replied that, No, he proposed to command this detachment on an old brevet that he had won in past indian battles, showed his commission and took command as regulations then stood, much to the dismay of the infantryman; but history does not record whether to the failure or success of the enterprise.

Though we cannot expect any well organized course of improvement either in organization or instruction in time of peace without a Chief, his existence in war is of still greater importance. We know how hard it was in the rebellion to break down the feeling of the cavalry and infantry generals that artillery's use was simply as a tail to a battalion's or at most to the brigade kite. This had arisen not from a study of European organizations but from our own wars, where, either through smallness of the numbers engaged, or at a more remote time, from the little development of the arm, masses of artillery were useless, or the field such that grand operations were out of the question.

Had a Chief existed at the beginning of our late struggle his dictum would never have been questioned, but when the generals had to have it argued into them by artillery majors, and where the brigadiers thought they saw in an artillery reserve a possible loss of strength to their brigade, or a loss of prestige to their commands they were found to be in active hostility to it.

The opposition to such an official (that of a major-, or even brigadier-general) from the Washington authorities was very natural. It would, did the office once obtain, not be broken up by a cessation of the war and then the existing departments would have a new problem of accommodation which they shrank from solving. 'Twere better to let the arm take its chances for good or evil rather than create another *Department*, that might rival the existing ones in its claims on congress, or intrude on the prerogatives of some, or have its duties that should conflict with old current geographical deparment routine to be adjudicated.

Whatever changes on present organization are made they should grow out of the experience of a Chief of Artillery. The idea of preparing for him his arm, completely organized by others, would strike one as an unnatural course of procedure. The great problem will be how he may fully and to the best advantage cultivate the artillery knowledge of his arm, and at the same time avoid any essential interference with the local administration of the generals commanding geographical departments. It is not believed that in the present feeling of the people, any important number of troops could be set aside as a body not liable to duty with the musket. And it is probably not desirable that there should be. Always, odd portions of time can be utilized in garrison to make fair infantry out of our artillerists and nothing will add more to their smartness of appearance than this training. Observe the few evenings per month that our national guardsman is exercised. The guard is composed of hard worked business and laboring men, yet they make a very effective infantry. Furthermore, could one work his men continuously at artillery labors it is undeniable that it would be done at great cost; for ropes, timber, ammunition, and all artillery supplies needed for exercise and instruction are very costly and are rapidly worn out. Our men should be supplied with the very best infantry arm. The carbine and musquetoon have had their advocates for artillery guard-duty service, but, arm a man with an inferior weapon and he loses his self-respect. The artilleryman has not the excuse of the cavalry soldier for carrying the carbine and it is doubted by many if the carbine be the best weapon for the horseman. Now, however, that the three-tenths rifle is coming to the front all troops will likely be armed with the same weapon.

We are so used to getting all our supplies from other departments, from the ordnance or quartermaster's, that few of us think how much this trammels our development. We should remember that in making his estimates for the action of congress, the Chief of Ordnance must look out for his own plants and the demands for his constructions and investigations. He is necessarily ignorant of what the demands of a manned artillery fort will or should be for the coming year and is in no condition to battle for increase of allowance. The artillery commander of a fort may be a very energetic officer or may have no interest in the specialties of his arm. He may prefer to spend all his force on a neat garrison, projecting improvements in gardening, painting, white-washing, and pipe-claying. The Chief of Ordnance cannot tell if he will mount, dismount, or fire a gun in the year. It is not known in any case where a Chief of Ordnance has urged an artillery commander to practice his specialty with the material that the Chief might be able to supply, nor is it known where the Chief has recommended activity in this direction to a department commander.

We do not bring this as a charge against this office of Chief of Ordnance but simply to show that said officer can have no interest in our improvement as an arm and that his own department is quite exacting enough to demand the exclusive energies of the most gifted man. Hence, all our estimates for material and for appropriations must be made by our own Chief based on work that he knows his own arm will have to perform, and which work he can exact from them. And above all to be able to go before congress with the right to say, Give me this and I will do that. No Chief of Ordnance can do this for us. More than that, no promise of this kind can be made by any existing authority which will bear uniformly on all the artillery. No two department commanders will take the same interest in our work, and it is human nature to direct us more for present convenience to those immediately concerned, than for prospective good to the arm.

There is another crying necessity for a Chief to our arm. To determine our armament. At the present time there is nobody to say what shall be our gun or equipment. We will be answered, Yes, the ordnance makes them and hands them over to you when ready. Just so, and here is the difficulty, that it is the ordnance that determines the necessity for the arm and equipment. An artillerist who doesn't know what he needs and how to demand it, is not an agressive nor even progressive soldier. Had we had a Chief of Artillery it is well recognized that the Ordnance Department would have seen the necessity for a 3″.2 (or 3″.25) field gun sooner. A Chief of Artillery would have been a stimulus in the production of many of the modern guns, a Chief of Artillery might even have procured modern ordnance for West Point, where now the practical instruction is limited to accustoming the ears of the cadets to a big noise. The Chief of Artillery might save the ordnance the responsibility of experimenting on unpractical improvements in harness, carriages, etc. If the service needed a mountain howitzer the Chief of Artillery should give the conditions it was to fulfil and have the officers and men ready to man it. This would not prevent, as in the Mexican war, the ordnance from running a side game of their own, but it would have been a stigma on a Chief of Artillery had he not foreseen a necessity for such an arm. If constructionists desire to ply a free lance as combatants they should not be obstructed. But should they keep back a proper armament from combatants that they themselves might use it, would it not be a *casus belli?*

Another matter in which there is no question the artillerist should be entirely free is that of selecting his ammunition and equipments. The Chief should be as free in such selection as the appropriations of congress will permit him to be. This would in no way conflict with the progress, experiments, investigations, and convictions of our most conscientious and talented construction departments.

The only difficulties that may arise for solution in the introduction of the new functionary, Chief of Artillery, would be those due to a conflict of claims on the artillerist for his specific professional duties, and those of his more general ones as required by his department commander. But the way to settle these is to settle them. Resumption they say was accomplished by resuming. By looking at difficulties from a distance they are magnified by their haziness; give us the Chief and let him "fix" things: there are plenty of us ready to grapple with the question. Of one thing however we may be sure as before referred to, whatever may be our unit of organization the public will require of such a large body of men fitness for general service, and immediate obedience to the department commmander. Many arguments could be well raised to continue the old regimental organization. 1. It is not so likely to be tampered with by legislation. 2. Till lately its legal organization preserved the officer from the chance of invidious selections against him; he was more entitled to the good luck of his promotions, to the changes of posts falling to him, &c. 3. It saved him from one man power idignities, thus giving him a higher bearing, and nobler motives for duty. As law stands now, however, we may properly look to a Chief as a protector, as an intermediate, to oppose against unfair selection, or a favoritism that even the highest human nature may be influenced by.

Few arguments can be adduced against a corps organization, other than the facility with which it can be legislated down. It is not seen how any change of minor units, either in their localities or in their instruction need infringe on their general routine duties outside of their specific armal pursuits. A reduction of corps in our country, to put it mildly, is not imminent. Our greater commercial complications with the world, our wealth, our weaknesses, the speed which is lending itself to modern war, all court aggression on our coasts. We have more to fear from having our cadres filled by overtopping rank from other arms being reduced than from danger of our own reduction.

Another minor point of improvement should be had in our arm. Though we deprecate turning the artillerist into a constructionist, still there are found men in our arm suited to mechanical investigation who when they have found "a good thing," should, on the approval of our Chief, have the best opportunities to investigate it to a practical conclusion. These opportunities should be reached through our ordnance or quartermaster's department or through the naval shops or even through such private *chantiers* as might liberally open their plants to such service; and there should in this be full reciprocity with the navy. Wherever the best opportunities offer let the aspirant be sent.

To render them more expert in the field and that they may learn all the most modern appliances of their profession, every young artillerist should spend a year in these shops before joining his regiment. The knowledge acquired by the officers of the line at Willet's Point will be of incalculable benefit to the service in case of war.

Esprit de Corps has been greatly used as an argument for regimental organization, but it doesn't appear to be very logical. There may be some adventitious courage or enterprise gained from the feeling of responsibility to one's immediate intimates, or in the support of a reputation for the organization, gained by past sacrifices; but other than regimental organizations have shown all this. It is probable that a man will fight and work as well for his arm as for a sub-division of it. In any case, had we a corps organization there would be plenty of prestige to stimulate us and plenty of reprehension to be feared for shortcomings. As we are, if *esprit de corps* had ever had any claims the regimental family should have always remained intact from cadet to colonel. But it was only cultivated through the company grades, and thrown to the winds with the field officers; there, individual claims were considered of more importance than *esprit de corps:* we are to be congratulated that justice has reached the young at length. It is believed that the enfranchisement of the subaltern, opening his whole arm to him, will in no way detract from his enthusiasm or pluck.

But what we need first, last, and middle, is a Chief.

1. If our arm needs development in instruction, organization, or unanimity of purpose, it can only be done through him.
2. If we want to be held to an immediate responsibility of advancement, he must be the exactor.
3. If we want to have the best appliances for effective work a Chief free from all other dependencies than the General of the Army and congress is necessary.
4. If we need a professional study of the harbors of our country, he alone can make it systematic and can equalize it through his arm.
5. A stable force should, like a stable government, grow into existence under its daily necessities: to direct this growth healthfully, we need a man at our head, whose whole heart is in his work. One who, however much he may be forced to "trim" to surrounding conflicting interests, will keep the good of the arm as the main object before his eye: at the same time it would be unjust to that man, to complicate his problem by previous hasty legislation.
6. Every *corps d'armée* in the field will need its chief of field, siege, or *pièce de place* artillery, and a Chief of the Arm is the only one that can secure this to the corps, protecting it against

the disintegrating process of frittering away in detachments to brigades, battalions, and pickets.

In selecting our Chief there should be no restriction. It would probably be safest to bet on his coming from the cavalry or infantry. He should not be an old man, out of whom all the work has been driven, or whose brain has been atrophied through disuse in other than attention to old fashioned elegant routine. He should not be too young, for if a mistake in selection be made death or retirement will be the only available remedy. Let not our artillery pride be an obstruction in the selection. Maybe it would be better to have him from the engineers or even the ordnance. Once placed at the head of our arm he would be loyal enough to it, and would not restrict himself in its enlargement. At the same time we have minds and energy in our own arm if petty jealousies might not mar the whole by opposition excited by individual claims.

In the worst case (like the old maid's selection of a poor husband, "He is much better than none"), we will have an excellent safeguard in our Chief's staff. The young, bright administrative staff he will gather around him will be a guarantee of work and progress.

Some things present themselves as lost to us up to the present for want of a Chief. Had General Hunt been made such during or after the war, we would have had a practice ground of from four to six miles in length along the Chattanooga where the artillery of the southern coast would have been gathered for summer work. Guns of every class could there have been practised with, and for winter work, the healthy season, the arm could have worked at everything involving the hydrography at their proper forts.

A study, in regular course, of theoretical armament of our sea-coast forts would have been instituted, involving, of course, an exhaustive instruction in their defense.

Let us have a Chief and organization will follow.

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THE ARTILLERY OF SIEGE WARFARE.

BY SECOND LIEUTENANT L. G. BERRY, FOURTH ARTILLERY, U. S. A.

A GLANCE AT THE MATERIEL.

The day has long since passed when a siege was the principal operation of a campaign. And, especially in our own service, there has been a tendency to conclude from the disastrous results of the sieges of Paris and Metz and want of results from the prolonged resistance at Plevna, that a force which allows itself to be besieged is beaten from the beginning. Hence it is not surprising that we find that there are in the artillery arm of the service many officers who are skilled in the use of field artillery, but comparatively few who have devoted serious attention to the subject of siege warfare.

Yet if we may judge from the contents of foreign periodicals it is a subject which is receiving great attention abroad, and it remains to be seen whether our situation is such that it would be profitable for us to follow this example.

If we assume the offensive as we we would be forced to do in case of a war with our next door neighbor and hereditary enemy, England, "Quebec is the most important objective; for its possession by us would prevent the naval or military reinforcement of the British armies or fleets above that point, and history proves that it is the key to the conquest of Canada." "The capture of Montreal is a necessary stepping stone to the reduction of Quebec." "At the first sound of war they (the garrisons of Forts Porter and Niagara) should be thrown across the frontier, seizing and holding the International R. R. bridge between Fort Erie and Buffalo, and the Rœbling, Keefer and Cantilever bridges below the falls of Niagara. Pushing on with the utmost celerity, they could then seize the Welland canal and blow up its locks." *

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* The Military Geography of Canada, by Captain *Arthur L. Wagner*, 6th U. S. Infantry, Journal of the Military Service Institution, May, 1892.

In the case of offensive operations by sea against us, "The same reason (to secure a base of supplise) would doubtless lead any nation intending serious operations against our sea-board, to seize points remote from the great centres and susceptible of defense, like Gardiner's Bay or Port Royal, which in an inefficient condition of our navy they might hold with and for their fleets." *

It would then be the duty of our own army to capture these places. If the country should be invaded either from the sea-board or from Canada owing to a temporary superiority on the part of the enemy, a delay would be of the greatest value to us. Captain Mahan very pertinently remarks: "How would a delay like that of Plevna have affected the fortune of war, had Turkey had any reserve of national power upon which to call?"†

It would seem that in case of hostile operations, either offensive or defensive, we would be compelled to undertake siege operations at the outset. The question then of the artillery of siege warfare should not be without interest to the artillery arm of the service.

A siege is "The placing of an army round or before a fortified place for the purpose of attacking it, and compelling a surrender, or the operation of attacking a fortified place under cover of earth thrown up from trenches."

The fortified places which will be besieged or defended by our armies may be divided into two general classes: 1st. Strategic fortifications, 2nd. Tactical fortifications; but without any distinct line of separation between the two classes.

Under the first class are included: (*a*) The fortifications of important strategic points erected in time of peace, sometimes called permanent fortifications, such as those of Paris. These will probably be made of granite, concrete, iron or steel, together with a certain amount of earth, or of earth alone.

(*b*) Similar fortifications erected on the outbreak of war, such as were the fortifications of Washington, and such as will probably be erected covering the locks of the Canadian canals. These consist of earthworks of strong profile and include block

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* Influence of Sea Power on History, *Mahan*, page 212.

† Influence of Sea Power on History, *Mahan*, page 16.

houses and similar constructions.

Under the second class are the earthworks of more or less strong profile, forming pivots for tactical wheels, protection for flanks, and generally defensive points on the field of battle, either constructed in advance or improvised.

As to the artillery for siege purposes, abroad "there appears to be a tendency to classify the artillery—so far as it is possible to draw a hard and fast line in this matter—into that required to deal with personnel and that to attack materiél."* The same idea was developed in our service during the war of secession.

General Abbot says in his report: "Without questioning the wisdom of composing each field battery of a single caliber and class of guns, as was always done after a little experience in Virginia, we found great advantage in placing a few smaller rifled guns in heavy batteries, where barbette carriages are required. Thus Battery Spofford, on James river, was composed of two 100-pounder and three 30-pounder Parrotts. It was subjected to a heavy fire of 7-inch and 8-inch Brooke rifles and 10-inch Columbiads, at a range of about 2700 yards. The enemy were so annoyed by the rapid practice of the 30-pounders at their embrasures as to make interrupted and wild firing, thus enabling the practice of the 100-pounders to be deliberate and effective. The 30-pounders played the part of sharpshooters, who can often destroy precision of fire in a field battery." †

We may then take it for granted that the artillery is to be considered under the aspects (1st) against materiél and (2nd) against personnel. Mortars are useful for both these purposes, but as they deserve separate consideration from direct and curved fire guns, we may form a third class: mortars.

"It is a mere truism to assert that, nowadays, events in war proceed with unexampled rapidity, but this assertion lies at the root of the matter. It is pointed out that the interval that must elapse between the investment of a fortress, and the arrival of the siege train requisite for its attack, according to the approved formal method, is very considerable, and is. in fact, so great as

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* Foreign views upon Siege and Fortress Warfare—Major *J. Wolfe Murray*, R. A. Proceedings Royal Artillery Institution, June, 1891.

† Professional Papers of the Corps of Engineers, No. 14, page 125.

to be inconsistent with the rapid march of events in modern warfare. Thus it is pointed out that, in order to satisfy the text-book conditions, which require the provision by the besiegers of an artillery at least equal in number to that of the besieged on the front attacked, probably at least a month would have passed before fire could be opened from the batteries of the first artillery position. Various suggestions have been made to curtail this period.

"Practical attempts at a solution of this problem have already been made by several European powers; they may be classified as follows:—

"(*a*) Partial equipment of the field artillery with mobile mortars, of large caliber, possessing great shell effect. *e. g.*, Russia.

"(*b*) Organization of the siege park in such a manner that certain units are armed with medium caliber guns, which can be readily brought to the front, *e. g.*, Russia, Germany.

"(*c*) Equipment of specially organized artillery units with guns of medium caliber possessing sufficient mobility to act in the field.

"Thus, it is clear that a tendency exists to attach to the army in the field an artillery of position capable of playing a twofold part, namely, either to act as a heavy field artillery in the attack of hastily entrenched positions, which will probably be met with more frequently in future wars, or to form an advanced light siege train in case works of a more permanent character are to be dealt with. The conditions to be met by this new development of artillery preclude the use of guns, and necessitate the employment of mortars or howitzers using curved fire." *

As to the heavier guns, the same reasons impose the condition of the utmost mobility consistent with a proper performance of their appropriate functions.

DIRECT AND CURVED FIRE GUNS FOR USE AGAINST MATERIEL.

Against works constructed of steel or iron.—This class of work resembles in its protection the armor clad ship and the same classes

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* Foreign views upon Siege and Fortress Warfare—Major *J. Wolfe Murray*, R. A. Proceedings Royal Artillery Institution, June, 1891.

of guns, *i. e.*, battering, will be used against each. For this class work naval guns or guns constructed for coast-defense would answer. The existence of works of this kind abroad forms the reason for the long guns still retained in the siege trains.

Against works made of concrete or granite, or earthworks of strong profile.—The experiments carried on abroad in recent years have demonstrated what the Germans knew and practiced in 1870, that against this class of works shell effect was immensely superior to the impact of projectiles. In the siege of Strasbourg the breaching was done by short 15-cm. guns firing, with a curved trajectory, special elongated shells. In the bombardment of Alexandria the English used only common shell, which is a shell of comparatively small capacity and they produced a correspondingly small effect. General Abbott says: "Earthen parapets of proper thickness cannot be seriously injured by the explosions of rifled shells of any caliber less than 6.4 inches; and not by these if the garrison is active in repairing damages."* Of course we must bear in mind that he refers to the shell of that day (1866). Experiments recently carried on at Fort Monroe show that firing at a parapet with shells from the 3".2 gun does not injure the parapet. These examples show that for breaching, shell of large interior capacity will be required.

Abroad nearly every service has guns of 12 cm. (4.8 in.). 15 cm. (5.9 in.) or 6 in. and short guns 18 cm. (7.1 in.), Austria; 21 or 22 cm. (8.3 in.–8.7 in.), Austria, France and Spain. We have as yet no guns corresponding to the greatest caliber. Our 7-in. howitzer, with proper shell, will probably prove to be very efficient of its type. We have no gun representing the 15-cm. class, either short or long. The 12-cm. class is represented in our service by the 5-inch siege gun. This gun is very long, 30 calibers, it has a high initial velocity (1829 f. s.) and weighs 3660 ℔s. It is the successor to the 4.5-inch siege gun of cast-iron, having a length of bore 26.5 calibers, initial velocity 1280 f. s., weight 3570 ℔s. The 4.5-inch gun was the successor to the 24-pounder smooth-bore. The use for which the latter was constructed is shown in General Roberts's Hand-book of Artillery:

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* Professional Papers of the Corps of Engineers, No. 14.

"*Q.* In what manner should the fire of siege guns be conducted in order to form a breach?

"*A.* 1st. Make a horizontal section the length of the desired breach along the scarp, at one-third its height from the bottom of the ditch, and to a depth equal to the thickness of the wall.

"2nd. Make vertical cuts through the wall, not further than ten yards apart, and not exceeding one to each piece of ordnance, beginning at the horizontal section and ascending gradually to the top of the wall.

"3rd. Fire at the most prominent parts of the masonry left standing, beginning always at the bottom and gradually approaching the top.

"4th. Fire into the broken mass with howitzers until the breach is practicable."

Passing down the line of legitimate descent to the 5-inch siege gun we find that it is eminently fitted to perform the duties above described. But inasmuch as no walls are being built to-day for the purpose of being breached by direct fire, this gun will have to find some other sphere of usefulness in our next war. Its want of shell capacity would restrict it to the destruction of earthworks of light profile, while its lack of mobility would interfere with its successful use against these works. Perhaps the method sometimes adopted with the unserviceable personnel of the U. S. Artillery might be followed, viz.: transfer it to the foot artillery, then it could be mounted in a sea-coast fort as a rapid-fire gun for the defense of mine fields, &c.

It would seem advisable to reduce the length, weight and initial velocity of this type and thereby so increase its mobility as to make it a useful gun to an army in the field.

As an example of a gun approximating to the required conditions, we have the 12-cm. short Canet gun; weight, 1874 ℔s.; weight of shell, 39.7 ℔s.; initial velocity, 1312 f. s.

Against tactical fortifications.—It is prescribed in the Infantry Drill Regulations, that infantry on the defensive will always fortify, and even the offensive tacticians of the German school have recognized the value of entrenchments more or less hastily constructed. We may take it for granted then that on the battle fields of the future many entrenchments will be found. This would be especially the case with Canada, whose rôle would be to seek a sufficient delay to enable help to arrive from the other parts of the British Empire. These fortifications would then call for siege operations more or less extended, for their destruction.

We must then have with an army in the field guns such that no field works but those of a very strong profile can stand before them. General Tidball says: "It has been found from actual experience that the 4.5-inch siege gun is capable of accompanying an army in the field with almost the same facility as the 12-pounder. Its great range, power and accuracy endow it with many advantages when used as a heavy field piece, and it should form a portion of the artillery of every army organized for campaign purposes." This piece, carriage, limber and implements, together, weighed 7400 lbs.; which is about the weight of the 7-inch howitzer and carriage. As the country is well supplied with heavy draft horses, there should be no trouble in taking this piece into the field; where its large caliber and consequently great shell effect would make it very formidable. It seems doubtful whether there would be any advantage in constructing guns of 6-inch caliber, if we are to have the 5-inch and 7-inch, even though most European services have this caliber.

DIRECT OR CURVED FIRE GUNS FOR USE AGAINST THE PERSONNEL.

Abroad it is proposed to use shrapnel from the siege guns of smaller caliber and from field guns, against the personnel. It has also been proposed to use rapid-fire guns for this purpose. A 6-pounder 40–45 calibers long, with an initial velocity exceeding 2000 f. s., caliber 2.24 inches, shrapnel fragments 100, would be quite effective. On account of its great accuracy, quick aiming qualities and controllable recoil, it would compel the enemy to hug their cover very closely and would seriously interfere with the accuracy of the enemy's fire. It has still another advantage, the velocity of the projectile is greater than that of sound, so that the burst would come without warning.

HIGH ANGLE FIRE GUNS.

These guns are somewhat inappropriately styled mortars in this country. They are used both against materiél and personnel consequently they are supplied with shells and shrapnel.

The latest additions to the European armaments have been made in this direction, all of the countries adopting under the lead of Russia and Switzerland, for service in the field, mortars mounted on field carriages. The calibers adopted are 9 cm. (3″.54), 12 cm. (4″.7), 15 cm. (5″.9), 6″, 8,″, 21 cm. (8″.27), up to 27 cm. (10″.3). Of this series we have now only the 3″.6 mortar, which is intended to take the place of the Coehorn mortar. Like its prototype, this mortar bears the same relation to siege operations that a mountain gun does to field operations. Unfortunately it has been decided to follow the example of the Coehorn in the style of mounting. General Abbott says in his report: "Contrary to the usual theory it was found necessary to use a platform with the Coehorn mortar whenever any accuracy was desired." The smaller mortars used abroad are mounted wholly or partially like a field gun, thus saving the time that would otherwise be expended in building platforms. One great advantage of a mortar is its superior mobility for a given caliber. Lieutenant General von Sauer says: "Shells and shrapnel fired from guns, too, are effective by their burst and splinters, but this effect is different from the effect of burst of shells in vertical fire." "In vertical fire it is otherwise. Here the velocities are small and the shot themselves—and, therefore their internal contents, and bursting charges—larger."* In the old days when the principal siege operation was sapping, small mobile mortars were of great value. At the present time their value seems to be not definitely known. Our field mortar should have the caliber of the light position gun, 5 inches. We should have, to complete the series, a class of 8.5-inch and a class of 10.5-inch.

PROJECTILES.

A very capacious shell even six calibers long has been or is about to be adopted abroad by all of the great powers. The bursting charge is a high explosive. The cast-iron common shell is, except as a range-finder, a thing of the past. This shell

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* "Tactics and Vertical Fire," Journal Royal United Service Institution, January, 1891.

is as a rule to be used against earthworks, &c., but occasionally against animate objects, as the bursting charge gives a high velocity to the fragments. Against animate objects shrapnel is used. The destructive effect of the torpedo shell is so great that it seems to be generally considered abroad that sapping will no longer be necessary.

SIGHTS AND SIGHTING.

This is a most important matter to the artillerist and that we are now in our present deplorable condition is simply owing to the unfortunate quality of our people of refusing or neglecting to learn by experience. In this respect General Abbot's remarks, true in 1866, are worthy of careful attention to-day: "For a sharpshooter's rifle which is not expected to fire more than five or six hundred yards, we supply accurate globe sights and a really fine telescope. For a rifled gun, which is to fire three thousand or four thousand yards, we give sights far coarser than those of any old smooth-bore musket. * * * It may be objected that these sights would be expensive and too delicate for the field. The reply is that they should be as strongly made as possible, and that care corresponding to their value must be used in handling them. They are absolutely essential to accurate firing at long or even ordinary rifle ranges. We place telescopes on surveying instruments and on the rifles of sharpshooters; why not on the rifled siege gun, the ammunition of which is too expensive, too heavy, and of too much importance in the campaign to be wasted? Rifled artillery of the larger calibers can never accomplish what it ought until this matter receives attention."

As siege operations must necessarily be conducted at night an electric lighting plant has been generally supplied to the siege train abroad. The question is now entirely beyond the experimental stage and as one electric light can be fought only by another, their adoption into our service is now necessary.

Some theories have been advanced as to the materiél which will be necessary for the proper conduct of sapping. Of course the sap roller of wood is a thing of the past. The general idea seems to be that works can be made untenable and parapets breached without resorting to the operation of sapping. On account of the accuracy of the curved fire employed and the great angle of fall it is possible to continue the fire at the besieged until the assaulting party are about to enter the breaches.

We see that our next war will involve siege warfare at the outset. We know that the materiél of siege warfare is complicated in its construction and management; that in firing it is necessary to measure or find the range; to calculate the charge for a given angle of fall; to have a system for observing the fire and transmitting the results; to have a system of aiming at an unseen object such that corrections can be made; to have such a knowledge of the atmospheric effects and of the probable error of the gun under service conditions, as to enable the effect to be properly judged; and finally to have that intimate knowledge of the trajectory of the gun which can only be gained by practical experience. We know that the command must be able to construct entrenchments and shelters, must understand the care of horses and of materiél. All these requisites can only be obtained by the equipment and mounting of some of our present foot batteries as siege batteries, and their proper training in time of peace. One to a regiment would not be too many.

As to our materiél, neglecting that which is obsolete, we see that certain parts of it are excellently planned. As to the siege gun the general statement is justified that, in our country, there is no good reason for making a siege gun longer than 18 calibers.

As a proposed system of siege guns we should have (the numbers are approximate):

Cal.	Kind.	Wt. of gun. lbs.	Wt. of shell. lbs.	I. V.
2".24	R. F.	800	6	2000
5"	Short	1900	45	1300
7"	"	3710	105	1085
8".5	"	9000	200	1200

The 8.5-inch gun is quite heavy but it has an enormous shell effect which would make itself felt in a siege.

MORTARS.

3″.6	250	20	650
5″	1400	45	850
8″.5	6500	200	850
10″.5	12500	375	850

The light mortars of 3.6 inch caliber are for mountain service and light siege work.

Without discussing the subject of organization, these guns would be distributed as follows:

5″ mortars.—These would be with and form a part of the field artillery.

5″ guns.—These would be the light position guns. Some of them would be near the heads of columns to clear away obstacles.

7″ guns and 8″.5 mortars.—These would form the heavy position guns, or the first échelon of the siege train. They would march immediately in rear of the field army. They would participate in the great battles as well as siege operations of the army.

8″.5 guns and 10″.5 mortars.—These form the second échelon of the siege train and are directed as nearly as may be by rail on the besieged place. The rapid-fire guns form parts of the batteries of the two échelons of the siege train.

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A FEW THOUGHTS ON PRACTICAL ARTILLERY.

By First Lieutenant G. N. WHISTLER, Fifth Artillery, U. S. A.

The question which should most interest the officers of artillery is how to obtain the most efficient service from a given gun.

Remember this question does not rely for its solution upon any particular class or grade of guns, but refers as well to the antiquated smooth-bore as to the modern high power rifle.

It is of course natural that we should desire a modern armament, and a more perfect weapon than the old Rodman smooth-bore. The lack of such an armament, and the apparent indifference of our legislators for years past, may explain but cannot excuse the lack of interest shown by many officers of artillery in this all important question.

The true soldier is one who always tries to obtain the best results possible with the means at hand. It is true that our guns are antiquated, our powder old and deteriorated, our projectiles poor, our sighting devices crude and inaccurate; nevertheless there must be a maximum of efficiency obtainable from a given gun, even under these adverse conditions. What reason have we to assume that an officer who can obtain but 60 per cent. of this maximum efficiency, from our present armament, will be able to reach a higher percentage with the modern armament. It is true that 60 per cent. of the maximum efficiency of the modern high power 8″ B. L. rifle may far exceed in practical value 100 per cent. of the efficiency of the present 8″ M. L. rifle. And, therefore, the practical efficiency of the entire service will be increased by a mere improvement in the weapon; but is this enough, will this satisfy our Corps? Are we contented to rest our reputation for accurate artillery work upon the mere improvement in our armament? I think not—and therefore maintain that the question: *How to obtain the most efficient service from a given gun,* is the most important artillery question of to-day. I further maintain that the officer who is unable to obtain over 50 per cent. of efficiency from the old 10-inch Rodman with mammoth powder, will not be likely to obtain more than 50 per cent. of efficiency from any modern high power B. L. rifle with brown prismatic or smokeless powder. Inefficient service, and by this I mean a low percentage of the maximum obtainable from any given gun, is due in the first place to *inattention to details*, secondly to crude instruments and careless and inaccurate use of them; and thirdly, to a lack of knowledge of the fundamental principles of ballistics.

There is undoubtedly another influence tending to induce careless work—Captain Ingalls and other experts have elaborated careful scientific theories, and calculated valuable ballistic tables. And by means of these principles, enthusiastic young officers debarred from practical work, have calculated important practical range tables. Practical artillerists relying upon the ability and accuracy of these experts, with perfect confidence in their calculated tables; go to the firing point all cocked and primed with elevations, allowances, etc., load, aim and fire, and do not strike within 300 yards of the target.

Then they abuse the gun, the powder, the Ordnance Department, and "all others in authority," and are loud in their protestations, at the outrage of expecting an officer to do good work with a weapon that will not work to within 300 yards of what it should do in theory.

Let us note the difference between the theoretical and practical artillerist.

The former, using a theoretical gun, giving a theoretical muzzle velocity, firing a theoretical projectile, into a theoretical atmosphere, with theoretical hygrometric, barometric and thermometric conditions, finds no difficulty in obtaining a theoretical range and hitting a theoretical target.

The latter, using a gun in which the sight seat may be out of place, platform sunk, jump unknown, with pintle loose, top carriage guides not fitting; using a powder the initial velocity of which he does not know; using projectiles no two of which weigh the same; is required to fire into an atmosphere, which never is at the standard, and rarely constant for the entire range, often without barometer, thermometer and hygrometer (and if he has them is unable to apply them); and is disheartened because he does not obtain theoretical results; or more properly (as he does not know what the theoretical should be), because he does not obtain in the actual conditions the result which he should obtain under theoretical conditions.

Do my brother officers consider this far-fetched or offensive? Certainly no offense is intended; let me bring it home to you, by a few questions.

Take the 8″ converted rifle—with ordnance sight.

1. How many of you have adjusted the position of sight seats before beginning practice?
2. How many of you have tested to ascertain whether the line of sight was parallel to the axis of the bore before firing?
3. How many know how to make this latter test?
4. How many have tested level, to see whether either trunnion has sunk before firing?
5. How many have tested the spirit level on breech-sight, and adjusted it before firing?
6. How many know how to make this adjustment?
7. How many have adjusted spirit level on quadrant before firing?
8. How many can tell me exactly how much the particular quadrant used was out in its readings?
9. How many are certain that the same quadrant was used at the same gun, on two successive days?
10. How many have examined pintle key and top carriage guides, to insure as far as practicable the same jump for the same elevation?
11. How many are absolutely sure that the density of loading was the same for each shot?
12. How many have measured length of cartridges to insure that the powder was compressed about the same, each shot?

I could go on and give you question after question, all upon small minor details, but all important; in fact absolutely essential if the maximum efficiency is to be obtained from a given gun.

Circumstances having given me the opportunity to study and experiment with the 8″ converted rifle more than most of my brother officers, I have often thought of preparing a paper setting forth the results of such experience. In this paper I shall use the 8″ M. L. rifle as a model, but my remarks will apply equally well to any other gun, and I shall endeavor to show the principal details which must always be carefully noted, in order to obtain the "*maximum efficiency from any given gun.*"

In order that accurate work may be done, officers will often find it necessary to contrive apparatus which should be, but are not furnished by the Ordnance Department. In this respect the Ordnance Department is not to blame, it cannot be expected to furnish apparatus for the artillery until they know what is needed, and this can only be determined by experiment, *and these experiments must be made by the artillery.*

All the apparatus mentioned in this paper will be such as can readily be constructed at any post. I assume that there will be found at every permanent work, a screw cutting lathe, run by foot or water power, upright blacksmith drill, large breast-drill and an ordinary set of machinist's hand tools. I also assume that each post is now furnished with the articles lately issued for artillery work.

INSPECTION OF GUN AND CARRIAGE.

One of the requirements of existing orders, is the careful inspection of and report upon the condition of gun and carriage, before and after firing, and as the Inspector of Artillery at least in the Department of the East is very particular that such reports shall be rendered, I presume that the inspections are always made. The question is, how intelligently are these inspections made? What is inspected? And what points are important to notice? Presumably the usual inspection is simply to ascertain whether everything is all right. Now there is nothing more essential to accurate work, than these inspections. One of the main difficulties that we have to contend with is the *jump of the gun.* And while it is not known exactly what causes the jump, it is certain that it is a function of the form, construction and general condition of the carriage. While we cannot prevent jump, we should do all in our power to keep it constant. The first point to note is the pintle. The chassis invariably rises and lifts on the pintle, but does not always return to the same position and often the washer or transom jams so that the amount of lift will vary each shot. This should be carefully noted, and if necessary, the transom or washer should be freed by a blow with a handspike; always before the gun is run in battery, as it cannot be done afterwards.

The amount of oil in the cylinder is a matter of great importance; more or less oil is continually leaking out. In practice I invariably directed that the cylinder should be emptied, and the oil measured and be refilled before beginning practice. Of course with the few rounds usually fired in our target practice, once is sufficient, but never rely upon what was done by the battery which preceded you in practice. While the cylinder is empty you have a good opportunity to run the piece in and out of battery and note whether the piston works freely. It often happens that the nut on the head of the piston is jammed too tight, which prevents the piston rod from playing in the transom, and consequently puts a bending stress upon the rod, during recoil;* this should be carefully noted.

Note carefully the front guides on the top carriage, they should not be tight, but must be equally distant from the rail. If one be looser or farther from the rail than the other, the gun is liable to tip toward the tighter guide and thus derange the fire. In a rifled gun there is always a tendency to tip to the left. Examine carefully the left trunnion bed. With an 8″ M. L. rifle always drive the key in the sleeve well home, when any tendency to loosen is observed.

Examine carefully the elevating gear, it is almost impossible to put the arc on to the gun so that it will work absolutely true. The result is that the teeth become worn in certain places, the gear jams and will undoubtedly affect the "jump of the gun."

Assembling bolts of transom and guides often work loose, they should always be tightened before beginning practice.

These are some of the points which I have noted in practice. I am confident that there are others which have escaped my attention; but a careful and systematic inspection and examina-

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* [The piston rod of a 15″ S. B. gun was broken at Fort Monroe, Va., last summer apparently due to this cause.—ED. JOURNAL.]

tion carried on from year to year, will develop all these points, and not only teach us where to look for trouble, but also enable us to improve the construction of our carriages.

ADJUSTING SIGHTS, SIGHT-SEATS, ETC.

All our sight-seats are fitted by templates and it is mechanically impossible to fit them absolutely accurate; they are often taken off and put on by an ordnance sergeant with but little care to get them in true adjustment. Our sights readily get out of adjustment, and the more perfect the instrument, the easier it is to disarrange and the more important it is to insure accurate adjustment in order to obtain accurate work.

I wish primarily to place myself on record as maintaining the "*sine qua non*" of accurate artillery practice, to be that *each sight should belong to, be adjusted for a particular gun, and never be used on any other.*

No two guns have exactly the same inclination of the trunnion; no two platforms are exactly at the same level or out of level; no two sight-seats are in exactly the same position; and therefore no sight can be adjusted for use on more than one gun.

Each sight should be adjusted for a particular gun, be marked as belonging to that gun and be used on no other.

The first desideratum is a good *leveling bench,* upon which all levels may be adjusted.

The Ordnance Department should furnish one for each permanent work. It should consist of a solid casting, having sockets and seats attached for all service sights, fitted with ordinary leveling screws and sensitive levels, like transits. This should be permanently attached to the solid masonry of the work and be used for adjusting sights, levels, quadrants, etc.

In the absence of such instruments, a good plane table may be used, if it is provided with leveling device. A rough one can be constructed as follows:

Upon some part of the masonry fit a strong wooden frame; into this frame insert sockets and round headed screws, three in number, so arranged that they may easily be raised or lowered. These can be made on any screw-cutting lathe. Upon these screws place a slab of slate or stone. By means of a good level which can always be obtained at the post, this slab may be adjusted to the true level at any time, of course using ordinary precaution of reversing the level to insure accuracy. On such a slab, most, although not all of the levels, used in artillery work can be adjusted. The remainder must be adjusted on the gun itself using a pre-adjusted level, to level the gun.

TO LEVEL THE GUN.

This may at first appear to be a simple operation, but it is one of great difficulty to perform accurately.

The bore of a rifled gun cannot be used with accuracy, and the face of the muzzle is inaccurate, as in order to insure success, the level placed against it must be absolutely vertical.

Every gun should be, but is not, fitted with a flat surface, parallel to the axis of the bore, for this purpose.

The best device I know of is constructed as follows:

Have two disks turned a little larger than the caliber of the gun. Through the center points drill a hole in each disk about 1¼ inches in diameter. Shrink the disks over a central shaft, which will extend six inches beyond one of the disks, distance between disks about two feet. Place the whole device in the lathe, and turn the disks to the exact diameter of the bore, and turn the shaft absolutely concentric with the disks. Take off the levels from two old fashioned quadrants, and fit them to this device (they can readily be replaced upon the quadrants). One of these levels which we will call the *shaft level* is fitted on the shaft, on the end which projects beyond the disk. This can be accurately done in the lathe. The other level is fitted on the disk nearest to the end of the shaft which projects and at exact right angles to the *shaft level*, this also can be accurately done in the lathe. The instrument is now complete.

Take this instrument to the levelling bed and adjust both levels. Insert it in the muzzle of the gun, the end having the two levels to the front.

Turn the instrument until the cross-level has the bubble in the center, and then level the gun by the shaft level. It may then be found that the cross-level is out, if so turn the instrument until it is "true" and level again. Remember the gun is not

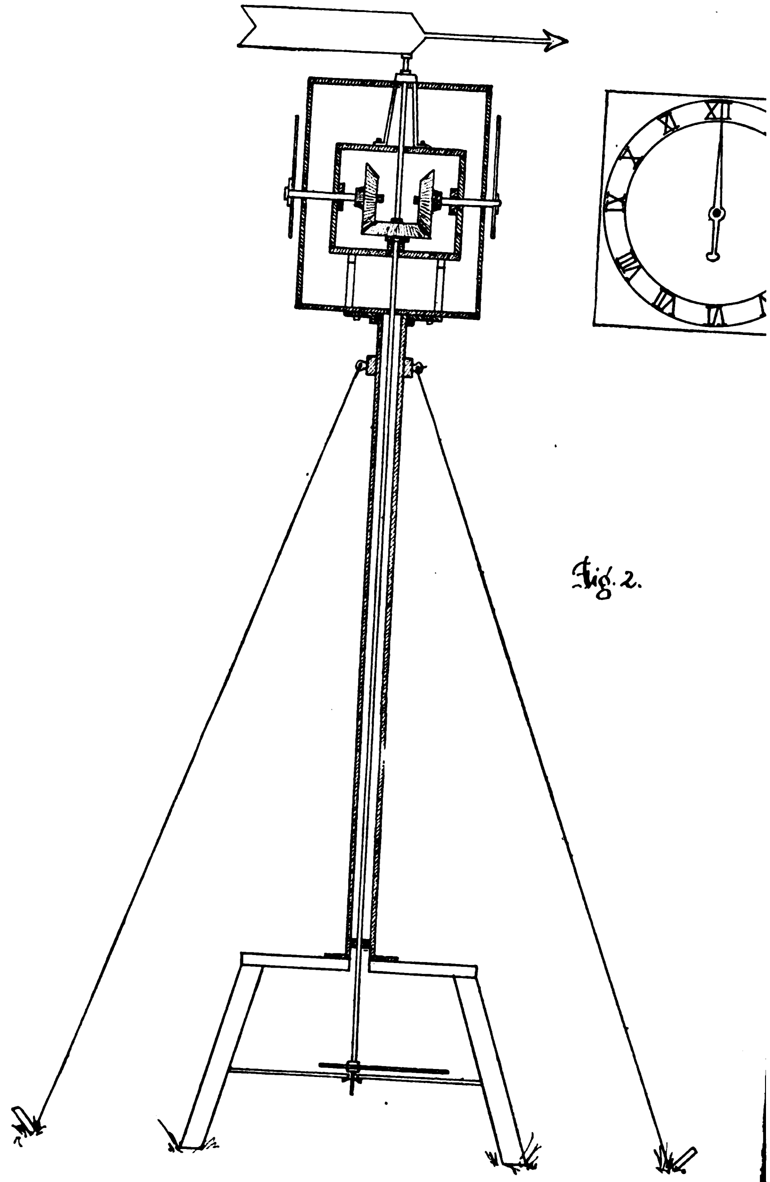

Fig. 2.

level until both levels are "true"; if this condition cannot be obtained, it is evident that your instrument is not in adjustment, take it back to the bench and adjust it. As all sight adjustments depend upon exact leveling of the gun, one cannot be too particular about this adjustment.

TO ADJUST THE ORDNANCE SIGHT.

The only adjustment for the sight proper is the level. Were properly constructed level-benches furnished, it would merely be necessary to insert the sight in the proper socket, level the bench and then adjust the sight level.

In absence of any such instrument the following method is suggested. Set up a light gin in front of the gun, and from it suspend a shot by a strong wire as a plumb-bob. Set your sight in its socket running the sight piece up to the top of the sight; level the gun and aim on the wire of the plumb-bob; be sure the gun is level; and also the sight; now drop the sight piece to the bottom, being careful to maintain the sight level; note whether in this position the gun is still sighted on the wire; if it is not, the sight piece has not dropped vertically, therefore your sight is not vertical and your level needs adjustment. If the aim has passed to the left of the wire, the left side of the level needs raising and *vice versa*. Adjust your level until the sight piece may be moved up and down the sight, without the aim passing off the wire. In other words so adjust your level that the center line of the rear sight shall lie wholly in the vertical plane, passing through the front sight and plumb-bob.

To adjust the line of sight.—Establish a line of metal, after having carefully leveled the gun. Using this line of metal, aim on some distant point, preferably one at a distance three times the range of the gun, now look through the sight and tap the front sight with a mallet to the right or left until the line of sight is on the same point.

It is manifest that at the maximum range of the gun, the line of sight will be out only ⅓ of the distance from the sight-seat to the axis of the bore, which is but a few inches. This is sufficiently accurate for all practical purpose. In practice I have found sights put on by the ordnance templates to be out sufficiently to make a difference of 15 or 20 yards for every 1000 yards of range.

To determine the error due to the axis of the trunnions not being in a horizontal plane:

Level the gun and sight on a distant object; elevate the gun 2°, raise the sight piece and note how many points it is necessary to move the sight to the right or left, in order to bring the line of sight upon the object. Perform the same operation for 5°, 7°, 9°, etc. Having several points, a curve can readily be constructed which will give the error of the gun for any elevation. This information is of *no value* when the rear sight is used, but it is *absolutely essential* when firing is done at squares. For practice at squares or any other system when the gun is pointed by the azimuth angle, this error must always be allowed for.

TO ADJUST THE ZALINSKI SIGHT AND SEAT.

Clean the left trunnion face as clean as possible, using acids to remove all paint, etc. Bore the holes as true as possible by templates; screw on the seat; leveling as accurately as you can. Level the gun, aim on some distant object by the ordnance sight; now place the Zalinski sight in position and looking through the search tube ascertain whether the cross hairs are also on the distant object. If not adjust the seat by inserting pieces of tin foil, between the seat and the trunnion, until the correct alignment is obtained. After removing the sight, pour strong acid between the seat and the face of the trunnion, to clean the surface, and then fill in with soft solder; repaint the face of the trunnion immediately, to prevent rust. Adjust the longitudinal level of the Zalinski sight at the leveling bench. Place the sight on the seat, level the gun and, if necessary, file the seat until the bubble of the longitudinal level is in the center. The seat is now in adjustment.

To bring the axis of the telescope parallel with the axis of the seat.

Place the sight in position, level the gun and also the instrument, traverse the gun until the cross hairs of the search tube are on some distant object, or preferably the long plumb-bob, now note whether the cross hairs of the telescope are on the same object; if not adjust until they are. This of course is only approximate, unless the cross level of the instrument is in adjustment, and must be repeated after the latter is adjusted.

To adjust the cross level.—Level the gun and the sight, aim upon distant object by the ordnance sight, be sure that gun and Zalinski sight are level. Note whether the cross hairs of the sight are upon the same object, if not take points to the left or right until they are; note this reading as it is a constant correction which must always be used with this gun. Now elevate the gun 7°; then by the ordnance sight bring the gun back upon the distant object. Note whether the cross hairs of the sight are on the object, if not adjust cross level, and re-level until they are. Repeat the operation until with a given constant lateral deviation the cross hairs of the telescope will be on the distant object; when the gun is pointed thereon, whatever may be the elevation of the piece.

This constant lateral deviation is the measure of the inclination of the sight-seat and trunnions, and as it will always be a constant which must be allowed for, should be marked on the gun. It is manifestly better to allow for this error, rather than to attempt to correct it, as your means of correction will always be crude as compared with the facility with which it may be allowed for on the sight.

We thus have two important corrections: 1st. The correction for inclination of the trunnions or sight-seats. This correction must always be made when the sight is used; but is not required to be considered when firing at squares. 2nd. The correction for axis of trunnions not being horizontal. This correction need not be made when the sight is used but must always be made when firing at squares. The gun should be tested frequently and the curve of allowance for this error accurately determined.

AMMUNITION.

The next important question is the preparation of ammunition. Every officer should be familiar with the proper grade of powder to be used in each gun. I have prepared a table which is appended to this paper; which, together with the remarks attached, gives the necessary information for the 8″ M. L. rifle.

Let us now consider the subject as applicable to this particular gun. I fear that the majority of our officers, while they know that a hexagonal or sphero-hexagonal powder is used in the gun, are not informed as to what particular grades of these powders are suited to the gun.

The ordnance sergeant reports that he has several grades of hexagonal and sphero-hexagonal on hand, and wishes to know which to use.

An examination shows the following grades in the magazine:

K.H.C.	Hexagonal,	Granulation	123.	Sp. Grav.	1.775
E.V.N.	“	“	72.	“	1.750
E.V.F.	“	“	72.	“	1.750
O.B.	“	“	123.	“	1.725
O.C.	“	“	123.	“	1.750
F.P.B.	“	“	67.	“	1.750
M.W.	“	“	123.	“	1.725
I.T.	“	“	30.	“	1.728
O.V.	Sphero-Hex.	“	100.	“	1.750
O.X.	“	“	100.	“	1.795

With a charge of 35 lbs. and 90 per cent. density of loading, the following results would be obtained with these different powders, all being new:

K.H.C.	M. Velocity	1367	ft. sec.	Pressure	30666	lbs.	per sq. in.
E.V.N.	“	1366	“	“	30480	“	“
E.V.F.	“	1367	“	“	30600	“	“
O.B.	“	1380	“	“	33000	“	“
O.C.	“	1325	“	“	25700	“	“
F.P.B.	“	1130	“	“	18000	“	“
I.T.	“	1000	“	“	17000	“	“
O.V.	“	1383	“	“	33500	“	“
O.X.	“	1330	“	“	27000	“	“
M.W.	“	1391	“	“	35800	“	“

The proper conditions for the gun are muzzle velocity from 1370 to 1400 ft. sec., pressure not to exceed 34000 lbs. per sq. inch.

The following grades are suitable in the order here given:—
O.V.—O.B.—K.H.C.—E.V.F.—E.V.N.

It would be useless to use F.P.W. or I.T. as the shot would not take the grooves.

O.C. and O.X. might be used but the velocity would be low. The proper charge for these powders is about 39 ℔s.

M.W. gives entirely too high pressure for the gun.

For the 8″ M. L. rifle the granulation should lie between 72 and 123. With sp. gravities from 1.750 to 1.775.

A granulation of 72 should go with a sp. gravity of 1.750 and 123 with 1.775.

Thus M.W. has a granulation of 72, but as the sp. gravity is 1.725, it is too quick for the gun, but may be used with lower density of loading.

F.P.W. has a granulation 67 to the pound and is therefore too slow, although the sp. gravity is 1.750.

O.X. has a granulation of 100, but its sp. gravity of 1.795 makes it too slow for the gun.

A granulation of 100 to the pound and a sp. gravity of 1.750 will give the best results.

There is however another difficulty to be met with which tends to discourage officers, and that is the deterioration of gun powder, which is often so great that the results obtained are simply ridiculous.

I will give an example from my own experience. We had at Fort Wadsworth some E.V.N. powder manufactured in 1881 which we were to use in the 8″ M. L. rifle.

Considering myself quite an artillery sharp, I determined to show my brother officers how to do it, scientifically. So I carefully searched the Ordnance Reports until I found the test of this powder in 1881, it was then 1888. I found they had obtained a velocity of 1367 ft. sec. with a pressure of 30500 ℔s. per square inch—I carefully worked out a range table by Ingalls's method, allowed for barometer, thermometer, etc., and at my first shot at 2000 yd. range I gave the elevation for a velocity of 1367 ft. sec., making all scientific allowances. You can imagine my sensation when the shot fell 325 yds. short. *Scientific artillery practice was below par.*

Some of this powder was sent to Sandy Hook and tested, and they obtained a velocity of 1221 ft. sec. and a pressure of but 19000 lbs. per sq. in.

The deterioration in seven years had been so great, that the velocity had been reduced from 1367 to 1221 ft. sec. and the pressure from 30500 to 19000 lbs. per sq. inch.

Nevertheless since that time I have made magnificent shooting with that same powder. Battery "K," 2nd Artillery, with this same powder struck the target five times out of the six shots allowed.

An analysis of the above results gives the following:

In 1881—the characteristics were as follows:

Pressure characteristic	1.5175
Velocity characteristic	0.7676
Force	1.0089
Time of burning	1.3144

In 1888 they were as follows:

Pressure characteristic	1.1994
Velocity characteristic	0.4795
Force	0.9691
Time of burning	2.0210

The principal change is the time of burning, due probably to absorption of moisture.

The variation in force was not necessarily due to any chemical change in the powder; the amount of fixed gas was probably the same in both cases, but the amount of heat developed by the deteriorated powder was probably much less than when the powder was new.

The chief difficulty to contend with is the lack of uniformity in old powder, we have no certainty that any two barrels will give the same results or even approximately the same.

I would therefore suggest the following plan. At all of our permanent works, there should be a large leather mixing barrel mounted on a wooden axle. This barrel should be large enough to hold eight or ten barrels of powder. Once every year all the powder of any particular grade should be emptied into this mixer and be thoroughly mixed and repacked in the original barrels. After which a test should be made, of at least two charges from each lot; and the barrels should be marked with the gun for which it was intended; muzzle velocity obtained therein with regulation charge; and its characteristic. The object of marking characteristic on the barrel is, that in case the powder is to be used in a gun of different caliber from the one in which it was tried, the probable pressure and velocity which it will give will readily be ascertained.

I would use a single characteristic. Thus for all hexagonal and sphero-hexagonal black powders, we may consider the force as equal to unity, and the coefficients depending upon form of grain are 3 and 1. Therefore Sarrau's formula for this grade of powder becomes:

$$\beta = \frac{a^2}{3}$$

We may therefore substitute this value for β in all the formulæ and consequently (a) will be our *sole characteristic*. This will materially simplify all the practical formulæ of interior ballistics. Thus for the 8″ M. L. rifle with regulation charge powder 35 lbs. and shot 183 lbs., reduces to the following:

Max. pressure $= Q a^2$ In which $\log Q = 4.12264$
Muzzle velocity $= Ma - Na^3$ In which $\log M = 3.08419$
and $\log N = 2.13372$

In both cases the density of loading is taken at 0.90, which corresponds to seating the base of the shot 22¼ inches from the bottom of the bore.

When the shot is seated 24 inches from the bottom of the bore, the density of loading is is 0.853.

When $\log Q = 4.09906$
$\log M = 3.07526$
$\log N = 2.12073$

For any other weight of shot Q varies directly as the ¾ power of the weight of the projectile, and M as the ¼ power of the weight of the projectile. The value of N is not affected by weight of shot.

Appended will be found a table which gives first the approximate muzzle velocity and maximum pressure, that will be obtained in an 8″ M. L. rifle with the regulation charge, for powders varying from one in which log $a = 0.22000$ to one in which log $a = 0.07500$. This is given for a shot seated $22\frac{1}{4}$ inches from the bottom of the bore, and for a shot seated 24 inches from the bottom of the bore. In the last column is given the charge of powder necessary to produce the standard muzzle velocity of 1370 ft. sec. See remarks following table.

EXAMPLE.

All the powder for the 8″ M. L. rifle is used up—there is in the magazine however a haxagonal powder for which log $a = 0.14549$. What initial velocity will be obtained in the 8″ M. L. rifle if we use a charge of 35 ℔s. of this powder and 90 per cent. density of loading, and what is the proper charge in order to obtain the standard velocity? From the table we find that log $a = 0.14500$ will give a pressure of 25861 ℔s. per sq. in. and 1326 ft. sec. muzzle velocity. The dif. for pressure is 602 and for velocity 6. $602 \times \frac{49}{500} = 60$

$25861 + 60 = 25921$ ℔s. per sq. inch. $6 \times \frac{49}{500} = 0.6$

$1326 + 0.6 = 1326.6$ ft. sec.

This powder will therefore give a velocity of 1327 ft. sec. and a maximum pressure of 25921 ℔s. per sq. inch. The proper charge to use in order to obtain 1370 ft. sec. velocity would be 38 ℔s. 5 oz.

The E.V.N. powder which had deteriorated so much, had for a characteristic log $a = 0.07895$, the proper charge therefore would have been about 47 ℔s.

DENSITY OF LOADING.

The density of loading plays a very important part in obtaining accurate results from our guns, particularly from muzzle-loading guns. An examination of Sarrau's formulæ will show that the velocity is an increasing function both of the density of loading and of the travel of the shot. Now in a muzzle-loading gun, any variation in the position of the shot alters both the density of loading and the travel of the shot, and materially varies the muzzle velocity. An examination of the table will show that a variation of less than two inches in the position of the shot makes a difference of 40 ft. per second in the velocity. At a range of 3000 yds. this means a difference in range of 100 yds. or thereabouts.

As our cartridges when loaded are about 24 inches long, the most convenient condition of loading is with the base of the shot 24 inches from the bottom of the bore. A slight alteration in the width of the cartridge bag would admit of seating the shot 22¼ inches from the bottom of the bore, which would be a considerable advantage. The table shows, that with 22¼-inch loading a velocity of 1385 ft. sec. is obtainable with a pressure of 34091 lbs. per sq. inch; with 24-inch loading the same, or nearly the same pressure gives only 1368 ft. sec. velocity.'

It is true that the shot with our present cartridges can be forced back to 22¼ inches, but it will not stay there. The spring of the bag will send it forward and uniform results cannot be obtained; in addition to this the pressure on the bag will vary the ignition.

Great lack of uniformity was found to result from the following conditions: the cartridge bags are all cut to the same size, but in sewing them up, the seam is sometimes a quarter and sometimes a half inch from the edge, the result is a cartridge is sometimes over 24 inches long, which prevents obtaining uniform density of loading.

It was also found that in our muzzle loading rifles, the position of the shot would be changed by elevating the piece. In order therefore to insure uniformity, the shot was seated at about 30 inches; the piece was then elevated and aimed, and then the shot sent carefully home. A very simple device can be constructed for insuring a uniform density of loading. It consists merely of a rammer-rest of wrought-iron, constructed somewhat like a strap hinge. One part is attached to the side of the gun near the muzzle by screws, the other part, which is a long bar, swings in front of and across the muzzle and is held in position by a latch attached to the side of the gun, on the side opposite to the hinge. This bar is swung in front of the muzzle while ramming the shot; is swung back out of the way, when inserting cartridges or shot. and is swung entirely back against the side of the piece when firing, where it is held by a catch. In the center of the rest, there is cut away a semicircular notch to receive the rammer, the center of notch being in the center of the bore. Through the rammer staff is a pin, which permits the rammer to go only so far in, when the rest is in position.

The notch insures the centering of the rammer and the pin insures uniform density of loading. When ramming the cartridge the rest is swung out of the way, so as to allow the rammer to go well home.

This is a far better device than the one furnished by the Ordnance Department, of a long pin through the rammer staff, which strikes against the face of the muzzle. In the first place this does not insure a uniform density of loading unless the rammer is always maintained in the center of the bore, and secondly these long pins always become bent. This muzzle rest is about the same thing as the muzzle rest for the star guage.

In conclusion I will give a few examples of the uniformity in range obtained when these details are carefully observed:

8″ M. L. RIFLE.

Angle of Elevation 5° 00′.

1st	shot:	Range,	2860	yds.
2nd	"	"	2882	"
3rd	"	"	2864	"
4th	"	"	2861	"
5th	"	"	2862	"
6th	"	"	2850	"
	Mean Range:		2862	"

Fired at Fort Wadsworth, N. Y. H.

IMPORTANCE OF ATMOSPHERIC VARIATIONS.

In order to insure accurate work it is exceedingly important to note carefully the atmospheric conditions.

I can best show this by a simple case.

We are firing at 3000 yd. range in the morning, barometer 29″, thermometer 80°; it cools off to 70° thermometer, and the barometer rises to 30″ while at dinner and before the afternoon firing. Now this is an ordinary change and which would simply be perceptible to the senses. Nevertheless this change in atmospheric condition would vary the range 35 yds. A head wind of

10 miles per hour, which is a very light breeze will shorten the range 20 yds. Therefore if with the above atmospheric conditions we had a rear wind in the morning and a head wind in the afternoon, of only ten miles per hour, the entire variation in range due to these conditions would be 75 yds.

Thus a battery stops firing at recall having just *hit the target*, returning in the afternoon find but slight apparent change in condition except that the light breeze is now blowing from the tront instead of from in rear. The same elevation is taken and the shot falls 75 yds. shot. "*Of course it is all the fault of the powder*," or the gun is not worth a "continental."

In this connection I would call attention to my Graphic Method, of Tables of Fire, by which all these allowances may readily be made, and which has lately been published by the War Department.

My purpose in this paper is to bring these practical ideas to the attention of my brother officers, recognizing them to be incomplete; but hoping that a discussion of the subject may lead to a more careful system of observation and study, looking to the improvement of Practical Artillery.

TABLE.

Approximate muzzle velocity and maximum powder pressures that will be obtained in the 8″ M. L. Rifle with regulation charge. *Powder 35 lbs. Shot 183 lbs.*; for various grades of powder. Also maximum charge of powder which can be used with safety in the gun, in order to obtain 1370 ft. sec. velocity. Maximum safe pressure, 34000 lbs. per sq. inch.

REMARKS ON TABLE.

The values of log *a* for American powders suitable for use in this gun lie between 0.22000 and 0.14000, when the powders are new. The muzzle velocities will therefore lie between 1400 and 1300 ft. sec. The average result with good powder is about 1370 ft. sec. The best about 1404 ft. sec.

Tidball's Manual gives a muzzle velocity of 1430 ft. sec. with a maximum pressure of 33000 lbs. per sq. inch. I can find no American powders which theoretically should give any such results, nor can I find any records in Ordnance Reports which justify any such expectations.

In the experiments with 8″ rifle No. 1, the best results obtained were 1407 ft. sec. with a pressure of 34081 lbs, per sq. inch, and the mean of all their tests gave a velocity of 1370 ft. sec. There were but two shots which in any way approximated to the statement in the Manual. I therefore consider that 1404 ft. sec. velocity and 34000 lbs. per sq. in. may be considered the maximum, and 1370 ft. sec. as the ordinary standard velocity for this gun.

Characteristic of powder, log *a*.	Base of shot 22¼ inches from bottom of bore. Density of Loading .90.				Base of shot 24 inches from bottom of bore. Density of Loading .853.				Maximum Charge.	
	Pressure lbs. per sq. in.	Diff.	Velocity ft. sec.	Diff.	Pressure lbs. per sq. in.	Diff.	Velocity ft. sec.	Diff.	lbs.	ozs.
0.22000	Pressure	too	high.		34599		1370		35	0
0.21500	“	“	“		33811	788	1368	2	35	0
0.21000	“	“	“		33042	769	1365	3	35	1
0.20500	34091		1385		32290	752	1362	3	35	2
0.20000	33315	776	1382	3	31555	735	1359	3	35	3
0.19500	32557	758	1379	3	30836	719	1355	4	35	4
0.10000	31816	741	1375	4	30134	702	1351	4	35	8
0.18500	31092	724	1370	5	29448	686	1347	4	35	12
0.18000	30384	718	1365	5	28778	670	1342	5	36	0
0.17500	29692	692	1360	5	28123	655	1337	5	36	4
0.17000	29016	676	1355	5	27483	640	1332	5	30	8
0.16500	28356	660	1350	5	26875	608	1326	6	36	12
0.16000	27710	646	1344	6	26246	629	1320	6	37	0
0.15500	27080	630	1338	6	25649	597	1314	6	37	5
0.15000	26463	617	1332	6	25065	584	1308	6	37	13
0.14500	25861	602	1326	6	24484	581	1301	7	38	5
0.14000	25272	589	1320	6	23937	547	1294	7	38	13
0.13500	24696	576	1313	7	23392	545	1287	7	39	5
0.13000	24135	561	1306	7	22859	533	1280	7	39	13
0.12500	23585	550	1298	8	22339	520	1273	7	40	6
0.12000	23049	536	1290	8	21831	508	1265	8	41	0
0.11500	22524	525	1282	8	21334	497	1257	8	41	11
0.11000	22011	513	1274	8	20848	486	1249	8	42	6
0.10500	21510	501	1266	8	20373	475	1241	8	43	1
0.10000	21021	489	1258	8	19910	463	1233	8	43	14
0.09500	20542	479	1250	8	19457	453	1225	8	44	9
0.09000	20074	468	1242	8	19014	443	1217	8	45	8
0.08500	19618	456	1234	8	18581	433	1209	8	46	5
0.08000	19171	447	1225	9	18158	423	1200	9	47	3
0.07500	18735	436	1216	9	17745	413	1191	9	48	2

I have taken 34000 lbs. per sq. inch as the maximum pressure which should be used in this gun, and have given values for log *a* down to 0.07500, which allows for great deterioration; powder below this should not be used, at least not with the service charge, as it is useless to fire this gun with less than 1200 ft. sec. muzzle velocity.

It is manifest that for powders the characteristic of which exceeds 0.18000, 22-inch density of loading should not be used, as the pressure would be too high.

It is preferable to set the shot home only to 24 inches from the bottom of the bore, this gives a density of 85.3 per cent., and is readily attainable, with uniformity; if the shot is set further home the cartridge is compressed and uniformity is difficult to obtain.

The following list of powders may be serviceable:

Best Grades.

Du Pont's	E.V.N.	Hex.	Gran.	72	log a =	0.18113
"	E.V.F.	"	"	72	"	0.19530
"	O.B.	"	"	123	"	0.19747
"	P.G.	Sphero. Hex.	"	100	"	0.19038
"	P.T.	" "	"	100	"	0.17962

Inferior Grades.

Du Pont's	O.C.	Hex.	Gran.	123	log a =	0.14412
"	O.X.	Sphero. Hex.	"	100	"	0.14820

Powders which give extreme pressures:

Du Pont's	O.V.	Sphero. Hex.	Gran.	100	log a =	0.20172
"	O.V$_1$	" "	"	100	"	0.20958
"	O.V$_2$	" "	"	100	"	0.21579

While it might not be wise to use the O.V. powders in target practice, they may safely be used in action, as the gun is well able to stand the pressure.

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TARGET PRACTICE.

By First Lieutenant HENRY C. DAVIS, Third Artillery, U. S. A.

"If we do not attain more than 75 per cent. efficiency with the old material, we shall not attain so great a degree with the new."*

This seems a rather startling announcement when made with reference to the handling of our war material, but sober thought will make the truth of this apparent. Any avoidable variation in loading and laying a gun, due to carelessness, oversight or ignorance, which gives a shot an absolute deviation at a given range, of say one yard, is evidently of far less importance when the probable error of the gun is fifteen yards, than when such error is but two yards. In the first case, the error, due to carelessness, &c., is but seven per cent., while in the latter it is fifty per cent. of the probable error. The former is the case of the old and the latter that of the new material. In short, the new guns, having inherently a greater accuracy than the old, respond all the more readily to any change in the conditions of firing, whether made intentionally or through inadvertance and lack of skill. By trusting to luck, instead of to painstaking and intelligent care, that the conditions for successive shots remain the same, the resulting errors, possibly relatively small for the old, become very important for the new guns, with the result that the efficiency attained in handling our tools decreases in proportion as the inherent efficiency of the tools increases. When viewed in this light the truth of the above proposition is evident.

How many officers have heard the statement: "Why fritter away time on the old material, which is worthless; why not wait till we get the new?" This is human, and, at first, seems excusable. The artillerist knows, that with all care possible in handling

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* Lieutenant Whistler's lecture at Fort Monroe, Va.

the old 8″ converted rifle, he cannot approach the accuracy which will be attained in firing the corresponding new one, even though he handle it with relative carelessness. He will think rather of the gain in accuracy than of the actual loss of efficiency in handling; he will think rather of his getting nearer the target, than of the fact that he is, relatively, shooting worse. On the other hand, if there is an accurate knowledge of the maximum efficiency of the guns now in use, and of the degree of proficiency attainable in handling them, the artillerist will readily perceive when he tries the new, whether he is really getting better or worse results than he did with the old—whether he has advanced with the improvement in the material or whether he has really gone backward. Some of this necessary information is attainable from theoretical considerations, but a great deal must be gotten at the gun. And here let us note that, in studying the gun, the great desideratum is not *how many shots may be fired in an afternoon, but how much intelligence may be exercised in the few that are fired.*

"This makes target practice too tiresome," some one says, The writer knows from experience that there are many more pleasant occupations than that of spending an afternoon at the end of a base-line; but if any officer finds his necessary professional duty too irksome there is a sure remedy. It is generally known that a *soldier* never grumbles at hard work or privations when he feels that something is being gained thereby; otherewise he yields his time and labor grudgingly and hence less efficiently.

When the writer first entered the service, the artillery was in the depths; it was practically red-legged infantry and his first experience of army life was gained in attendance from morning till night on the small arms target range. Although somewhat out of the line of artillery work, this was an experience; and every experience should teach a lesson. Look at the infantry of to-day and compare it with that of a dozen years ago. Compare its efficiency in handling its weapon to-day with that it attained to in the days when the old guard fired its volley into the clay bank. Ask the infantry officer, or the older artillery officer for that matter, how many times he has spent the whole day on the small arms range or in the gallery; ask him if he considered this work thrown away so far as the general results are concerned.

Now for our own arm. Are we striving as patiently and as persistently for improvement as did our friends the infantry? Are we utilizing to the *best advantage* all the opportunities afforded under the newer conditions? Are we advancing as rapidly as we should, and, finally, are we ready for the new guns for which we are clamoring?

At present the artillery is more concentrated than it has been for many years, but already there are rumors of a scattering anew. The larger the garrisons, the denser is the professional atmosphere, and the greater is the tendency to absorb knowledge even for those not naturally addicted to work and study. To-day is our school time for practical work, the time to get started on new lines, the time for laying together of heads to learn how to shoot and hit, not for theoretical work alone, which is of great importance, but for practically learning that which we should know. Now is the time to learn how to apply our theory and how to correct it in the light of practical experience. We have all heard, doubtless to satiety of Prince Kraft's three rules, but for all that they are gospel truths.

To attain the desired proficiency, it is necessary that we engage in gun practice, and this should be divided into three distinct parts;—*ballistic firing*, *target firing*, and *tactical firing*.

Ballistic firing.—The object of this is to give the artillerist an opportunity to thoroughly study his gun, to learn *how* to study it, to know what to expect of it under similar conditions and also to know the nature and extent of the corrections necessary when different conditions are imposed. In the firing it is *better to miss the target and learn why, than to hit it accidentally.* Who of us has not, on the small arms range, stood over a man who skilfully alternated his bull's-eyes with zeros, or twos, and feeling the hopelessness of the case, turned with relief to observe and encourage his companion who rarely made a bull's-eye and just as seldom made less than centers? Was there any doubt as to which was the better marksman? So with gun practice; that artillerist, who, knowing the error of his gun, keeps within it, is far ahead of him who does not know his gun, but occasionally destroys a target. Every artillery officer has Captain Ingalls's hand-book and feels that he has the results of the latest study on ballistics, also that he is prepared to solve any ordinary problem in gunnery, provided he has the necessary data. Lieutenant Whistler has made, from his own and Captain Ingalls's formulas, a chart for the 8″ converted rifle which makes the solution of problems for that gun very simple, provided the necessary data is given. The principal quantities which enter these problems are range, elevation, initial velocity, and jump. The first is given by range-finding, however executed; the second is obtained by calculations involving the remaining two; the third and fourth are obtained—where? The Ordnance Department completes its work when the guns and powder are turned over to the artillery. A certain grade of powder is furnished, amply marked on the barrel with kind, date of manufacture, &c., &c., for use, say, with the 8″ rifle. The charge to be used and the initial velocity obtained under trial are also given. We have curves of jump for this gun from both Captain Ingalls and Lieutenant Whistler. Apparently then nothing remains but the calculate reliable range tables for this rifle.

Have we such tables? There is one in Tidball's Manual, based on an initial velocity of 1430 f. s. This table, probably correct as far as it goes, does not seem to have satisfied those handling the guns; for we find, at Fort Monroe, a later table, computed by a student officer, based on an initial velocity of 1252 f.s. and giving jump as 29′. The introduction of jump was a step in the right direction, but the table did not fill the requirements, inasmuch as it assumed a certain initial velocity, and, so long as this initial was not obtained, the table did not apply.

The next advance toward practical tables of fire were made by Major Rodgers. They apply to the 8″ converted rifle and the 15″ S. B. These tables give ranges and elevations corresponding to standard initial velocities, weights, &c., &c., accompanied by coefficients of reduction in case of variation from these standards. These tables also give the allowance for jump at three elevations. These allowances for the 8″ C. R. correspond to those given by Captain Ingalls's jump curve. The most complete and most easily applied range table that has yet appeared is Lieutenant Whistler's graphic table of fire for the 8″ converted rifle. It differs from Major Rodgers's table in that it gives a graphical presentation of the problems to be solved, and hence insures rapidity of solution and continuity of results; it also gives a jump curve deduced from actual firing records.*

Complete as this table is, there is still a gap. Knowing beforehand the initial velocity, we may enter the table with fair prospects of getting the correct elevation. But can we know this beforehand? Lieutenant Whistler's method of reduced velocities depends on the assumption that all errors arise from variations in initial velocity. In the absence of a thorough knowledge of the causes of variations in range under supposed similar conditions, this assumption is probably as practical a solution as any; still it assumes that we may confidently expect to reproduce in a second shot the same velocity as in the first. Is this the case? Records of firing will show that it is not. In the ordinary target practice it often occurs that a shot strikes so close to the target that the officer in charge determines to fire the next with the same elevation and with a resulting hit at a distance of anywhere from 10 to 100 yards from the preceding one. Is it uncommon to hear that "I gave two minutes more elevation and the range was seventy-five yards less."

While this state of affairs exists, any range table, however correct and complete, will be of little value. Being dumb, neither the gun nor the range table can retaliate by declaring that failure is due as much, if not more, to the ignorance of the operator as to their own inaccuracies. Evidently then, the first thing the artillerist must learn is to be able to reproduce all the conditions over which he has control, and to recognize and appreciate any changes in those beyond his control. When this is accomplished, and not till then, he may expect good results from the use of good range tables.

The only place to acquire this information is at the gun and hence the necessity for what is here termed Ballistic Firing.

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* This firing was done in season and out, in hot weather and cold, and under many discouraging conditions. Sometimes *but one shot was fired during the day*. (Learned from officers who assisted in the work). This is the kind of work the writer pleads for, and the inside history of this firing, as well as that cited later, shows that when undertaken, it need not fail from lack of assistance from a sufficient number of officers, willing to work *out of hours*.

A FEW POINTS.

It was proposed, in June, 1892, to fire, from the 8″ converted rifles at Fort Monroe, a few shots to test the applicability of Lieutenant Whistler s graphic table, particularly with reference to the practicability of his reduced velocity method. Recognizing the difficulty of reproducing conditions and the necessity for this in applying the reduced velocity method, the writer requested an extension of the programme. It was extended and the scope is set forth in a report of Captain Mills, 5th Artillery, instructor of practical exercises. The following extracts are from this report:

"The objects of these experiments were to determine the initial velocities of the different powders that we were to use this summer with the different sea-coast guns—viz: the 8″ C. R., 15″ S. B. and the 10″ S. B., that we might have more reliable data to guide us in the usual target practice; also to verify the accuracy of Whistler's Graphic Tables for the 8″ rifles, and further to obtain some experience in ballistic firing with *heavy guns which the student-officers do not receive.*

"All the student-officers voluntarily gave me their services, but only a few could be advantageously used all the time. I desire to call attention to the intelligent zeal, interest and unceasing hours of labor enthusiastically given by those whose services were utilized.

"The general objects of these experiments were:—

"*First.*—To find the initial velocities of all shots fired, then to determine if the powder and gun would give uniform velocities.

"*Second.*—To fire five (or more) shots at each of the several ranges, under as nearly identical conditions as possible and, after correcting for variations in atmospheric conditions, &c., to find the center of impact of each group of shots. From this, by applying Captain Ingalls's tables, as given in Lieutenant Whistler's diagrams, to find the necessary corrections (jump &c.) to be applied to the tabulated elevations for any given range; thus completing and adapting Whistler's diagram to these particular guns.

"*Third.*—To note carefully lateral deviations for data as to wind and drift corrections.

"*Fourth.*—To vary the controllable conditions as to amount of moisture and absolute density of the powder, and density of loading; and to find from these results data for future estimates.

"This was carried out generally as follows:—

"*First.*—A sufficient quantity of powder for all experiments with the 8″ C. R. was thoroughly mixed.

"*Second.*—Carefully weighed cartridges (weighed on the standard scales in the Densimeter Room) were made up each day as needed, and tied in a uniform manner.

"*Third.*—Projectiles of the same weight, for each group of shots, were carefully selected and weighed.

"*Fourth.*—For each shot there was observed and recorded the following:—

"(*a*). Absolute density and moisture of powder,
"(*b*). Weight of charge and shot and density of loading,
"(*c*). Thermometer, barometer and hygrometer,
"(*d*). Velocity and direction of the wind,
"(*e*). Angle of elevation,
"(*f*). Range, deviation and time of flight,
"(*g*). Initial velocity."

Captain Mills then gives the organization of, and instructions to the personnel for this work. This is omitted here as the object of this article is to *arouse* interest in this kind of work rather than to suggest how the work should be done.

Before giving further extracts, attention is called to the fact that the shortness of time available, in this case, both for preparation for and execution of this programme, prevented the obtaining of all the useful information desired, but the experience gained as to the methods to be adopted and the arrangement of details for obtaining the desired end, was very valuable.

Owing to absence of favorable conditions (which could be obtained in future) no accurate data as to deviations was obtained. The ranges were obtained by using a single base-line. Several anomalous and unaccountable variations in observed ranges led, in subsequent firing, to the establishing of a third observation station: The necessity for these additional observations was clearly indicated by the results.

This check, as well as all others possible, should be used in ballistic firing, for, on the accuracy of the observations depends the value of the data obtained.

Owing to the absence of sufficient connecting lines, the wire for which could not be obtained in time, but one velocimeter, Bréger's Chronograph, was used. The same cause prevented the adoption of any more accurate method of getting times of flight than that by the stop watch.

Lack of time also prevented the determination of the effect of—

(*a*). Variations in moisture of the powder,
(*b*). Sunning the cartridges while on the range,
(*c*). Fouling of the bore,
(*d*). Heating of the piece,
(*e*). Compressing the cartridge by ramming the shot, and of several other causes which readily suggest themselves to the artillerist.

The following extracts are from a report on the preparation of cartridges for the 8″ C. R.:*

"Previous experience had shown us that the ordinary scales, furnished for weighing, were not accurate or sensitive enough for nice work, especially when the determination of important experimental data was involved." Hence the balance connected with the Mallet Densimeter was used.

"In all cases the weight was this amount (35 ℔s.) to within the weight of a single grain of powder. It was not deemed practicable to split grains to obtain greater refinement.

"The bags were carefully examined and compared before using. So far as the eye could detect, there was no difference in their size. After filling, it was ascertained by measurement that the cartridge was much less than 8″ in diameter, hence longer than it should have been. Some of the cartridges were used on the day of filling and others were used from day to day, being handled many times in taking them from the magazine to the guns and back again.

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* Report of Lieutenant Ruckman, who had this matter in charge.

"All the cartridges were shaken down, tied, and the 'chokes' cut short just before insertion into the gun. It was soon observed that, the more they had been handled, the shorter and thicker they became. This had the effect of admitting the projectile further into the bore.

"It was also noticed that, on filling, the cartridges appeared to differ in size. This fact was verified by measurement.

"In the process of shaking the cartridges down, just before tying, it was discovered that some went down to a fixed length without much trouble, while others could only be so reduced by much shaking and gentle pounding by raising and dropping them on a platform. It is quite probable that this difference in churning motion produced, in the charge, different amounts of dust and fine particles, with corresponding effects on inflammation and combustion.

"It is only by considerable stretching of the bag, that the cartridge can be shortened much below its first length. When the cartridges were reduced in length to about 21 inches, they accurately filled the cylindrical case used for carrying them from the service magazine to the gun. In shaking and jamming them down to this length, about one-third burst. It became apparent, in the case of others tried, that they also would have burst before reaching this limit. It is safe to say that, had all been pushed to this limit, one-half, at least, would have been ruptured.

"The shape of the bases of those which did stand this reduction was materially changed. As these shapes differed in different cartridges, the latter could not be made to occupy the same space in the gun without different amounts of ramming, and hence uniform conditions of loading became impossible.

"When the length of the cartridge varied from 20.5 to 21 inches the cross-section of the cartridges fitted the bore. Under these conditions the initial velocity varied from 1400 to 1425 f. s., with an average of 1415.* Hence the fair inference is that this gun will, contrary to the accepted opinion, give this velocity when loaded as above specified.

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* See following report on velocities obtained.

"The shape of the forward end of the cartridge is such that it may cause variations in the conditions of loading. This end is more or less convex outward as is also the base of the Butler projectile. In loading, these two surfaces come together and the position of the choke, upward, downward, to the right or left, may affect the position of the shot and density of loading accordingly."

The report suggests:

"*First.*—The weighing, under the supervision of an officer, of all powder charges, on the most accurate scales available, before putting them into bags.

"*Second.*—The obtaining, for the service, of suitable weighing apparatus for this purpose.

"*Third.*—The securing of better apparatus for seating the charge and projectile.

"*Fourth.*—The correction of the defects in the cartridge bags as noted above. This may be done:—(*a*) By making them larger in diameter, so that, when filled, but little shaking will be required to bring them to the correct length. (*b*) By using some inextensible material for the bags, thus securing the proper shape for the base. (*c*) By closing the front end of the cartridge with a disk corresponding in shape to the shape of the base of the projectile, thus causing a uniform bearing surface between the two."

For this practice it was considered necessary to obtain a greater degree of accuracy, in determining the direction of the wind, than could be obtained by holding up a handkerchief, or a wet finger near the gun. The direction of the wind near the ground is often materially changed from that higher up by surrounding objects, hence the necessity for raising the vane above all eddies.

The following extracts are from the report of the officer having this matter in charge: *

"A simple wind vane was constructed for temporary use. It consisted of a wind vane mounted on the top of a piece† of wrought-iron pipe, so as to be free to move with the wind. Rigidly connected with the vertical spindle of the same, was a

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* Lieutenant Parkhurst, 4th Artillery.

† Twenty feet, and placed on top of the parapet.

long, light, iron rod, extending downward through the tube. The lower end of the tube was mounted on a skeleton framework, and the interior rod from the vane projects downward and carries a light index which moved over a dial placed horizontally below it. The index and the vane being parallel, the former indicated on the dial the direction of the wind. The dial was movable and could be set so that the zero line was parallel to the line of fire of the group of guns in action."

"Fig. 2 shows a sketch of a proposed permanent 'wind clock.'* It consists of a wind vane rigidly attached to a vertical axis, carrying a mitre wheel which gears with four other mitre wheels. The axes of these are horizontal, at right angles to each other, and perpendicular to the faces of a large box. On these faces are clock dials over which, when the vane is turned, sweep indices connected with the shafts of the four mitre wheels.

"This gives a wind clock which, showing the direction of the wind on each of four faces, can be read from any direction.

"This box, or clock, is to be mounted on a long piece of 3 or 4-inch wrought-iron tubing; the axis of the vane may be continued downward with a horizontal dial at the base, as in the vane first described.

"This clock has the objection that it is not readily adjustable for the varying directions of fire of different groups of guns, but may be adjusted to agree with the greater number of groups, while the movable horizontal dial can be adjusted for any particular group, for fine observations.†

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* [The wind clock here described is essentially the vane of the Anemometer which was constructed at Fort Wadsworth by Lieutenant Whistler and which has been in use there several years.—ED. JOURNAL.]

† This objection is easily overcome by mounting permanently at each group of guns a "converter." This converter consists of a stationary horizontal dial plate whose zero line is parallel with the line of direction of the vane on the clock when its indices points to XII, or zero. Concentric with this circle and turning about its vertical axis, is a second smaller circular disk, graduated like the first, and provided with a movable pointer of length greater than the radius of this disk.

Operation: Read the indications of wind clock and turn the pointer of the converter to the corresponding graduation on the outer circle, hold or fasten it at this point. Now turn the small circle till its zero line corresponds to that of the fire. The indications of the pointer *on this* circle gives the direction of wind for this group of guns. This will allow the central clock to be adjusted once for all.

A great gain, in both time and accuracy, will be made if we take directly from the dials the *components* of wind velocity expressed *decimally*, instead of using the method now in vogue. H. C. D.

"There is nothing difficult or complicated about the construction of the clock shown in Fig. 2. It should be well within the resources of the School's shops, the only special material being the brass mitre gears."

The following extracts are from the report of the officer in charge of the gun:*

"Figure 1 gives a curve showing the relation between the variation in initial velocity and density of loading. In this connection attention is called to the fact that the variation in density of loading, there shown, viz: 0.33 ft. (nearly 4 inches), was not forced but occurred under service conditions. The shot was pressed home against the cartridge, as per drill regulations, and the variations shown arose from varying lengths of cartridge.†

"For this variation in density of loading the curve shows a variation in initial velocity of 90 f.s., which, at an elevation of 7° 30′, corresponds to a variation of 300 yards in range."

Two consecutive shots fired under the same conditions, except as to density of loading, may then fall at a distance apart of 300 yards, plus the instrumental error of the gun. If there are also variations in other conditions, and if all of them should tend to increase the variation in range, we may easily account for some of the results recorded in the target records.

"It was found that the projectiles were not of uniform length, or perhaps there was a variation in the distance to which the nose of the shot entered the open rammer head. This difference, when measurement was made from the base of the projectile to a fixed point on the rammer staff, corresponded to a variation in velocity, taken from the curve in Fig. 1, of 10 f.s. Hence making a *mark on the staff and always inserting to that point* is not so accurate as has been supposed."

The shot may always be placed at the same point as follows:—Attach a scale to the rammer staff, and make a measuring rod, equal in length to the required distance to the base of the shot from the muzzle of the piece. Place the rammer head against the point of the shot, as when in the bore, and one end of the rod at the base of the shot and note on the scale to what point

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* Lieutenant H. C. Davis.

† See extracts previously quoted.

the other end of the rod reaches: when the shot is in the bore force it down till the point noted on the scale is at the muzzle. A collar with projecting ends clamped around the staff at the proper point will greatly facilitate the placing of the shot.

"It must be remembered that the curve in Fig. 1 applies to the particular gun used. The variations in velocity corresponding to the variations in the density of loading may be relatively true for all of this type of gun, while it is very doubtful if the absolute values taken from the curve will apply to other pieces.

"The firing was also used to note the instrumental error of the gun," but the number of shots fired at each range was too small for conclusive results.

"By using Whistler's chart and assuming it correct for this purpose, the ranges of the several groups of shot were reduced to standard conditions, and the center of impact of each group was taken. This reduction was made possible by having the initial velocity of each shot. The following table contains the results of this reduction and, in addition, shows a comparison of the *deduced* jump with that given by Lieutenant Whistler:

Angle of elevation used.	Range of Center of Impact.	Angles called for by Whistler's chart.	Difference or jump.	Jump from Whistler's Curve.
2° 30′	1492	2° 37′	7′	11′ 00″
3° 15′	1897	3° 28′	13′	12′ 30″
4° 15′	2362	4° 30′	15′	15′ 30″
5° 20′	2885	5° 47′	27′	19′ 00″
6° 00′	3113	6° 22′	22′	21′ 30″

"The last two columns are plotted in Fig. 3, together with the curves given by Lieutenant Whistler and Captain Ingalls." The latter's curve stops at 5° elevation, while the other two go beyond that point and agree in showing a cusp. Whether a greater number of shots will confirm this result remains to be seen.

The foregoing extracts are given in the hope that they may excite interest in that kind of target practice. The curve of density of loading and velocities, it will be seen, gives merely the average of results, and, while the general law is clearly shown, the variations are sufficient to indicate that there are probably other causes not accounted for.

With the breech-loading rifles, there will not be this same difficulty, but we may rest assured that there will be just as many, and any investigation of the old difficulties will better fit us for grappling with the new; it will certainly be better than doing nothing.

It is true that all the material for ballistic firing is not to be found at all our posts: Fort Monroe is pretty thoroughly equipped if everything within reach is *made* available; the New York posts are believed to be in condition to do much, while all the others can do something more than fire shot into the sea.

There may, at first, seem little that can be done, or that it is desirable to do, but, as the work goes on, the horizon will widen and one thing will lead to another. Points which, at first, seem of too slight importance, will, when those of relatively greater significance have been thoroughly investigated and are understood, present themselves as being of prime importance.

Target firing.—It was seen that in ballistic firing the prime object was not to hit a target but to learn to obtain uniform conditions. The best target for this is some well defined stationary object, beyond any possible range: for target firing, however, there may be a target within reach, as well as some means of determining and communicating ranges.

This firing should be at known and unknown distances. In the first case the shot should be plotted for range with reference to that *range for which the elevation was taken* and *regardless of the position of the target at the time of firing;* this will indicate ability to hit at *given* ranges. In the second case ranges should be sent in at intervals, and the artillerist must make allowance for probable change in position: now the shot will be plotted with reference to the *target's position at the time of firing*, and this is a test for hitting under service conditions.

In both cases the demolition of the target is the object of the firing; but, for all that, hap-hazard changes in elevation should be avoided. An accurate knowledge of what the gun will do is supposed to have been previously attained, and there should be sufficient confidence in the accuracy of this, to prevent the artillerist from changing his data after he is satisfied that the center of impact is properly placed.

During this firing the artillerist in charge of the guns must be kept as fully informed as possible, as to all obtainable data that is of importance to him: moreover, he must have confidence in the reliability of what is furnished him. This confidence, unfortunately, does not exist to any alarming extent. We have all noted the unanimous verdict, of those around the gun, given as to when a shot struck to hear the plotters reverse it. No attempt will be made to show where the trouble lies, but the case is cited merely to call attention to the injurious effect this state of affairs has on target practice. The uneducated eye is easily deceived and operators may make mistakes; it matters not which has been responsible for the variance in the past, let us make sure of the future by perfecting the system of observation, by using checks,* and then educate the eye.

It is just as much a part of target practice to learn to place a hit, by eye, with reference to the target, as is the firing of the piece; for, in service conditions, the placing of the center of impact will depend largely on the accuracy of the eye. Almost no attention is at present paid to this and no headway can be made till confidence is established in the accuracy of range determination.

The record of firing should be accurate and full, but giving only such data as is of use. In this connection let us note that deviation right or left should only be taken from the transit observations; better trust the eye for this than the base line observations, for, on account of the length of the splash and other causes, these latter may displace the shot 5 or 10 yards, which is not much in range but very material in deviation. This is specially true when the shot is plotted to the right when it was observed by eye to the left: The eye is quite accurate so far as this determination is concerned and if the plotters give a verdict against it, there will be a case of "convinced against the will," with a resulting loss of confidence and consequently a blow to a vital principle involved in learning how to shoot.

The details of this and all firing must be worked out. They should not be subjected to cast-iron rules, but must be changed,

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* Three stations and the transit in rear.

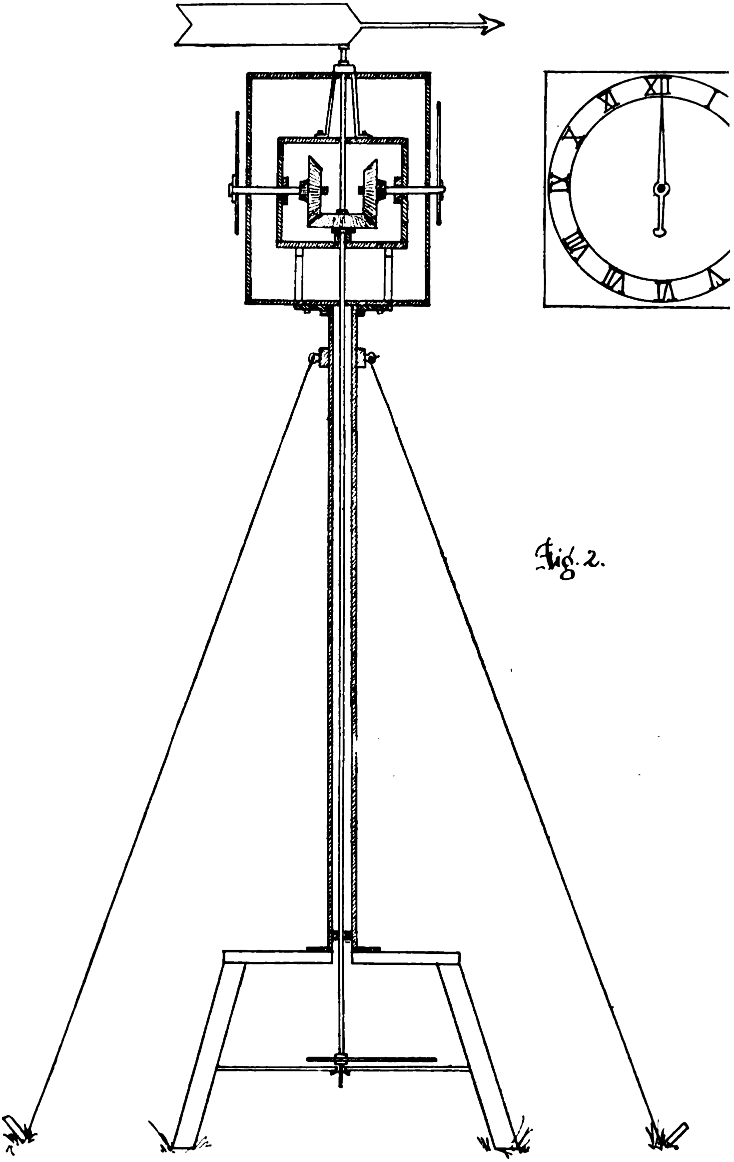

Fig. 2.

as often as necessary, to get the best results. The general good should not be sacrificed by special constructions of competition rules. It seems an absolute wrong to the service, to allow a gunner, through an error, noticed by the officer in charge, to fire a shot under conditions other than those supposed by him to exist and *recorded as existing*, merely to satisfy some rule of competition.

Tactical firing.—This corresponds to infantry fall manœuvres. It will test all arrangements made for the defense of the place, and will consist in assigning certain work to each battery and having it perform it in conjunction with all the others.

A given problem may be taken, as the demolition of a target, fixed, drifted or towed, by the united efforts of all the batteries. This gives an opportunity for simultaneous and concerted action by the battery officers, while field officers will have work commensurate with their rank.

The length of this article precludes going further into this division of target practice, and the desired object is attained if thought is directed to it.

Conclusion.—The first objection to the system, herein indicated, will probably be that it calls for more ammunition than is at present allowed; that would probably be true if it was contemplated that each individual officer, or battery, should go through the whole course. This is not at all necessary, for those concerned may be divided into groups, each to be assigned a certain part of the investigation. A thoroughly digested plan is presupposed; this plan should be the result of full and exhaustive discussion of all suggestions made, such suggestions being invited and fully received.

If this arrangement does not provide sufficient ammunition, continue the programme from year to year: in fact more than a year may be given to the first division with the result, it is hoped, of subsequently taking up the work where it was left off instead of beginning anew each year as at present.

Whether the writer has struck the key-note for changes in the method of target practice, remains to be seen, but it will scarcely be controverted that some change is necessary. Anyone doubting this should betake himself to the large posts at the opening of target practice; he will see a lack of continuity in the work and how little use is or can be made of the records of preceding years. That is, we begin anew each year.

To remove present defects, and elicit the best results, will require time and patience, but if our arm is to be of any use, it must be able to hit and that without any loss of time.

The other arms must be able to march, manœuvre, and place themselves where they can use their weapons. As heavy artillery is fixed in position it has nothing to do with these things and must depend alone on its fire for success. Target practice under such conditions becomes of prime importance; for when the enemy comes within its range, the artillery *must* be able to fire quickly and accurately, or fail to accomplish the single object of its existence.

A NEW PERCUSSION FUZE.

By HENRY P. MERRIAM.

The fuze to be described in this article was the outcome of a series of experiments made at the Sandy Hook Proving Grounds during the years 1890-91. It was the purpose of these experiments to produce a base percussion fuze which would be suitable for shells of the larger calibers and more especially for rifled mortar shells. The chief requirements to be fulfilled were: 1st. Safety; in handling and transportation; 2nd. Certainty of action upon concussion on a target; this to mean that a burst should occur whether the shell strikes point foremost or sidewise; 3rd. Delay after concussion, to allow time for the shell to penetrate before exploding.

The first fuzes to be fired were made with a spherical hammer mounted loosely in a recess in the fuze case, the percussion caps, of which there were three, were circularly disposed in front of the spherical hammer. This arrangement of hammer and caps is similar to that shown in Fig. 1. The action of this is such that a direct axial retardation of the shell causes the ball to strike all three caps simultaneously, while a side blow causes the ball to be displaced laterally and to move forward in the cavity, thus coming in contact with one or more of the primers. In this fuze the safety device consisted of a small weight and a spring which positively held the ball away from the caps until the shell was fired, then the small weight, in taking up the velocity of the shell, was forced over the spring and the spring and weight retreated together into the ball. Several of these fuzes were fired from an 8-inch M. L. rifle with satisfactory results. On further trial of this type in a 12-inch B. L. mortar, two out of the first three fired failed to explode. These two were recovered and it was found that the safety device had not been released. To investigate this point further, experiments were made with a 3.6-

inch B. L. field mortar, using small charges; the shells, not being loaded, were recovered and the fuzes examined. The results thus obtained served to confirm previously calculated results as to the relation between the total force applied to the base of the shell and that applied to the small releasing weight or plunger. This relation may be stated thus:—

$$\frac{\text{Total force acting on base of shell}}{\text{Force acting on plunger}} = \frac{\text{Total weight of shell}}{\text{Weight of plunger}}$$

This is strictly correct, only when the shell and the plunger are regarded as freely moving bodies; the total force imparting velocity to the shell is less than the total force applied by an amount necessary to overcome friction, to set up the rotation of the shell, etc. If the force applied to the starting of the plunger is calculated by the above equation, using the pressure per square inch as given by a crusher gauge, the result obtained represents the greatest possible force to which the plunger can be subjected in starting—frictional and other losses being neglected. The actual force applied is always less than this theoretical amount: some experiments showed a loss of upwards of 50 per cent.; this, however, may have been largely due to irregular friction of the plunger: To illustrate by an example:—Suppose a shell for a 12-inch B. L. mortar weighs 650 lbs.; that the maximum pressure applied in its discharge is 6000 lbs. per square inch—this being perhaps the extreme lowest pressure that would be used: the plunger may be assumed to weigh two ounces: The total force applied to the base of the shell equals $6000 \times 113 = 678{,}000$ lbs.

$$\frac{678{,}000}{X} = \frac{650}{\frac{1}{8}} \text{ from which } X = 130$$

This is the maximum limit of the force applied to the starting of the plunger. As is usually the case the plunger is pierced by a pin or spring which is forced through the plunger at the instant of discharge, this action serving to arm the fuze. For safety against premature explosion considerable force is required to overcome the friction of the pin or spring. If with such a plunger as this it is assumed that a force of 130 lbs. is necessary to start the pin, then, theoretically, the fuze would just be capable of arming by the shock of discharge.

To see to what extent such a fuze can be roughly handled:—Suppose that the pin can be forced $\frac{3}{16}$ of an inch through the plunger and that the frictional resistance of 130 lbs. is constant for this travel. The energy necessary to arm the fuze is $130 \times \frac{3}{16} \times \frac{1}{12} = 2.03$ ft. lbs. and the height from which two ounces, the weight of the plunger, must be dropped to give this amount of energy is, $\frac{2.03}{\frac{1}{8}} = 16.2$ ft. If such a fuze be dropped 16 ft. and its velocity be suddenly checked by striking squarely on its base the fuze will be effectually armed; but to be reasonably sure that this will take place when fired under the conditions stated the fuze should be capable of arming with a drop of about half this distance. This then reduces the fall to eight feet which is much too small, and moreover a succession of shocks or falls from a less height will have the same effect as the single drop of eight feet. It is apparent that there is not margin enough between safety on one hand and certainty of action on the other, and for this reason there is required some means for releasing the plunger that in its action shall be more positive than the inertia of a weight; for to change merely the proportions of the weight and resistance will not solve the difficulty.

The gas pressure at the base of the shell presented a satisfactory means for operating the releasing device, and accordingly, experiments were made with a type embodying this principle. To avoid unnecessary expense, a 3''.6 field mortar and a 3''.6 field gun were used. Fuzes were fired under pressures varying from 3000 to 38000 lbs. per square inch and as no failures occurred, it was concluded that their certainty of action was fully established; as a final proof, however, a number of shells were fired successfully from a 12-inch B. L. mortar. During these experiments some difficulty was encountered in shells bursting in the gun, but this was not attributed to the action of the fuze; for, as was afterwards shown, bursts occurred with equal frequency in the firing of shells from the same lot, loaded with powder but with the opening in the base closed by a base plug instead of a fuze.

The delay was next taken up. To discuss this part more clearly take the case of a loaded projectile without a fuze—sometimes known as a "blind shell"—fired against armor. It is a well known fact that when the armor exceeds a certain thickness—this thickness varying with the size and character of the projectile—the heat developed at the instant of concussion is sufficient to ignite the contained bursting charge and cause explosion after the shell has passed through. With a still more resisting target the heat would be more intense and more quickly developed and the burst would then occur before penetration, in which case comparatively little damage would result unless the explosion be so violent as to shatter the plate. Attempts have been made to overcome this difficulty of premature bursting by enclosing the charge in non-conducting bags, but no advantage has been thus secured. For this reason it is considered advisable by some authorities to dispense with bursting charges in projectiles for use against armor and to trust to the destructive action resulting from the penetration of such a missle into the body of a ship.

In cases, however, where the resistance encountered is insufficient to develop the required amount of heat a fuze is a very necessary part of the shell and greatly increases the destructive effect. The greater proportion of war vessls are not provided with such effective protection as would require explosive projectiles to be dispensed with, and against these vessels armor piercing shells, loaded and fuzed, would do most effective work. If examination is made of the action of a shell at the instant of concussion it is seen that there is required a certain brief interval of time—about .005 second—in which to set up the action of the fuze and develop the force of the bursting charge. This causes a certain delay, but a delay in addition to this is necessary at times to insure complete penetration. To secure so short an interval of time by a train of powder is impossible; by restraining the plunger in its movement towards the caps, a limited delay may be obtained, but this renders the fuze less sensitive, and moreover would cause a shorter delay with a thicker target, which is the reverse of what is wanted. What is required is that the delay be proportional to the resistance overcome by the projectile in penetrating the target: i. e., if thin plating is encountered the shell should explode with no delay beyond the time required to ignite the charge; while if thicker plating is encountered the time before exploding should be proportionally greater; this discrimination should be made automatically.

It was with a hope of realizing, in a measure at least, this action that experiments were made on delay. At first the arrangements tried were complicated and the results showed that they were too slow in action, the shells bursting about seventy-five feet behind the target which was of 3-inch plank; finally the arrangement shown in the accompanying diagram was tried and this showed a marked improvement. With this device shells were fired from a 3″.6 field gun through a 3-inch plank target, through a 4-ft. butt of sand, and a plank target of varying thicknesses: shells fired through the three inches of plank burst about five feet beyond, and with a thickness of 52 inches of plank the burst occurred at practically the same distance in the rear. About thirty shells were fired in these experiments and the results were highly satisfactory. The final proof that the delay is proportional to the resistance would be a trial with armor-piercing shells fired against armor plates, so far this has not been attempted.

The fuze as now constructed will be readily understood from the following description and diagram.

Figure 1 shows a longitudinal section of the Fuze, showing parts as they exist previous to firing.

Figures 2 and 3 are end elevations.

Figures 4 and 5 are sections along x-x and y-y respectively, looking in the direction of the arrows.

Figure 6 shows in separate view, the valve upon which the delay action depends.

Referring to Figure 1. In the fuze case which screws into the base of the shell, the plunger or hammer A for exploding the caps is in the form of a sphere. This is held securely in the position shown by the clips B, B, which abut at one end against a circular recess in the ball, and at the other end against a shoulder in the fuze case. When, in the discharge of the shell, pressure is applied to the trips C, the clips B, B, are forced off from the shoulder in the fuze case and thus free the hammer A. A flat spring D serves to keep the ball to the rear of the cavity during the flight of the shell.

When the velocity of the shell is suddenly checked upon striking a target, the ball by its momentum, strikes one or more of the small balls E—see also Fig. 4—placed above the fulminate caps F and explodes the latter. The resulting flame escapes through the channels G—see also Fig. 5—into the chamber H. It is also evident from the arrangement of the ball A and its surrounding cavity that should the shell strike squarely on its side, the ball in being thrown to one side of the cavity is forced to move forward and thus explode at least one of the caps. In the chamber H is placed the delay mechanism which consists of a disc I of closely pressed powder carried on the front of the valve J. This valve is capable of a slight movement in an axial direction. This disc of powder when compressed between two surfaces and ignited at the edge burns in successive concentric rings, and it requires an appreciable time for the flame to reach the center; when the disc is not thus compressed, the igniting flame reaches the center immediately.

At the instant of impact the sudden stopping of the shell causes both the hammer A and the valve J to move forward, but the valve J, on account of its shorter travel, reaches its seat an instant before the hammer strikes the caps. When the flame from the fulminate caps enters the chamber H, the valve J, is pressed firmly against the front surface and the flame ignites the edge of the disc of powder through the windows K—see Fig. 6. As long as the shell is undergoing retardation, the disc I remains forced against the forward face and the flame advances slowly as before stated: when the shell has passed through or has stopped in the target, this force, due to the momentum of the valve, ceases and the gas pressure between the two surfaces forces the valve away from the forward face, thus allowing the flame to at once reach the center. A wisp of dry gun-cotton closing the channels O serves to conduct the flame to the powder contained in the radial chambers L, and from thence it passes to the bursting charge in the shell; these chambers L contain supplemental flashing charges to further ensure the ignition of the bursting charge.

A screw M, when screwed down serves positively to hold back the valve J, should it be desired to have the explosion as nearly instantaneous as possible at all times.

The pistons on the trips C are rendered gas tight by means of copper caps—arranged after the usual manner of crusher guages—and tallow or wax fills the space above these.

When screwed into the shell, leakage of the powder gas by way of the threads is prevented by a washer at the shoulder f, f.

The small balls E are secured in place by being set in the recesses somewhat deeper than half a diameter, a burr at the edge of the recess then holds them.

The safety of this fuze in handling has been abundantly tested by dropping and throwing about. As for certainty of releasing upon discharge, this is fully secured by the size of the pistons and the fact that there are two; either one releasing being sufficient. Certainty of exploding upon striking is secured by employing three percussion primers instead of one; that three defective caps should happen to be in the same fuze is well nigh impossible. Finally, the delay mechanism for mortar shells would seem to be all that could be desired. It may be said by way of anticipating a criticism, that the apparent complication is due to a duplication of parts which secures greater certainty of action—over sixty of these fuzes have been fired and not one has failed to act.

FIELD-ARTILLERY DRAFT.

By First Lieutenant A. D. SCHENCK, Second Artillery, U. S. A.

In every well organized and equipped army a system of field-artillery comprises mountain, horse, light and heavy guns, the necessary carriages and ammunition trains, and also the siege guns proper and their material which accompany the movements of an active army in the field during war. The subject of this paper is confined to field-guns proper. In the days of the old smooth bore guns, each kind of battery of the field artillery was armed with the particular gun best suited to its expected conditions of service. For horse batteries, mobility was, and is to-day to a far greater extent than ever before, the controlling factor, to secure which the power of fire of the gun is necessarily limited, as is the weight of the projectile which insures this power, in order to enable the battery to carry the number of rounds necessary to meet the demands of war conditions. At the other extreme is found the heavy field-gun, not infrequently supplemented in a favorable field of operations by siege guns used as field-artillery, as provided in our *Heavy Artillery Manual* for the 4½-inch siege gun. For this gun the weight of projectile is the greatest permissible; the power of fire of modern guns of this class being equal to that of our old siege gun, yet at the same time without exceeding the proper measure of mobility for field artillery. Aside from the natural desire to have such powerful guns, the necessity for their presence with an army is enforced by the number and strength of modern field-works and the character of their defense, so astonishingly developed during our late war. These defenses are such that, despite the great power of present field guns, the same use for the powerful modern siege gun as field artillery will exist as is indicated in the *Manual* for the old 4½-inch gun. As the heavy field batteries are generally confined exclusively to the corps artillery, or at least should be when the power of the gun is worked up to the full measure of mobility permissible for such batteries, and are also restricted in their use to reasonably favorable fields of operations, the measure of mobility called for is at the minimum. There still remains the necessity for a gun suited to the service of the light batteries forming the divisional artillery, and which constitutes the "backbone" of the artillery of an army. This gun must not only possess the maximum possible power of fire, only to be insured by the greatest weight of projectile which can be carried in sufficient number, but it must also be capable of a mobility which will permit of efficient service with the infantry in every phase of its marching, manœuvring or fighting, and over any ordinarily practicable ground. Strenuous efforts, in the interest of simplicity, have long been made to successfully use a single gun for both horse and light batteries; never, however, with satisfactory results.

With the advent of really rapid marching for cavalry, increased from twenty to twenty-five miles a day, and over much greater distances, and of present arms and methods of warfare, not only has horse artillery become of far greater importance than ever before; not only to insure the offensive and staying powers of the cavalry, but for quick work with the infantry on the battle-field; but also has the degree of mobility demanded of it become very much greater, consequently maintaining a careful proportioning of the loads behind the trains to what these new conditions demand. If the light field gun of sufficient power to insure its efficiency with a medium number of rounds per gun, be adhered to for horse artillery service also, simply discarding the weight of the cannoneers carried with the light battery, it will not give proper loads for a horse battery especially for the gun carriages, and a reduction of the permanent loads to the proper limit for the latter service becomes inevitable. This at once maintains a reduction in the amount of ammunition carried, and as a consequence the horse battery finds itself without a sufficient number of rounds per gun to meet war requirements, especially when serving with the cavalry, when a re-supply of ammunition is always small, frequently precarious, and sometimes not at hand at all. As a result the tendency is much stronger than ever to return to the old practice, and design guns of course with the greatest possible power, but with mobility suited to the varied requirements of war service with respect to the various arms, their tactical subdivisions and uses, the trains, roads, &c. Hence mountain, horse, light and heavy field, and even siege guns of different calibers, suited to each particular battery, and with degrees of mobility carefully proportioned to the character of the service required under the conditions of modern warfare.

As the power of fire depends directly upon the *weight of the shrapnel shell and its sectional density*, the tendency is to increase this weight to the maximum with a minimum of caliber, but as the demand is also for greatly improved mobility, this latter demand is met by decreasing the number of rounds per gun, a noted example being the new English 12-pounder gun, with which this number has been reduced to 108 rounds even for horse batteries, due to the fact that in modern battles the average number of rounds fired is small as compared with the old smooth bore guns.

As the efficiency of field artillery depends primarily upon the powers of horses, it is of the utmost importance that a thorough understanding should be had as to such powers, as limited by the conditions of artillery service in war, *i. e.* bad roads or none at all, bad or insufficient forage, rapid movements and forced marches, and unusual and often excessive marches in daylight and in darkness, in sunshine and in storm. For short distances over level roads in good condition, wagoners with small teams often make them draw more than 2000 pounds per horse, but the gait is always a walk with every condition favorable for the horse, while nothing of the kind would obtain for him in war.

Given the ordinary powers of a horse under ordinary circumstances, in order to determine what his powers will be when applied to the service of drawing artillery carriages, it is first necessary to determine the distance and time of marching in an army in the field. It is generally held by modern authorities that the marching capability of cavalry should be, and in fact is, 20 to 25 miles a day. But the weight carried by our cavalry during the late war was considerably less than is used in Europe, and it has since been reduced to an average of 234 pounds, a less weight than is carried by cavalry horses in any service. It has been asserted by General Merritt, based upon a careful study of the results of that war, verified by a wide personal experience, that "our cavalry can march 25 miles a day for six days in every week during a campaign." General Wilson's cavalry corps, in 1865, marched 253 miles in ten consecutive days, and our horse artillery must be prepared to make such marches, *maintaining their horses in as good condition as those of the cavalry*, which was very far from being the case in this instance.

WEIGHTS CARRIED BY CAVALRY HORSES:

		Pounds.
United States;	Average man, clothing, &c.,	146.
	Equipments, &c.,	88.
	Total	234.
England;	Man and clothing,	150.
	Equipments,	130.
	Total	280.
France;	Light Cavalry,	232.
	Dragoons,	241.
	Cuirassiers,	263.
Germany;	Hussars,	257.
	Cuirassiers,	322.
Austria;	Hussars,	293.
	Uhlans,	297.

Russia; from 253 to 289 pounds.

The powers of our cavalry horses as indicated by General Merritt appear quite reasonable, even when marching in large bodies. General Wilson's cavalry corps above referred to, in thirty-one days, twenty-five only being on the march, covered 537 miles, or 21½ miles a day for this large command, much of it over a very unfavorable country, and terrible roads. During the time indicated this command captured five fortified cities, twenty-three colors, 288 guns and 6820 prisoners. The rate of cavalry marching, including halts, is about three miles an hour.

The distance and rate of marching for a separate division of infantry is usually given as fifteen miles a day at about two miles an hour, and twelve miles a day at a somewhat less rate for an army corps or larger body of troops.

From the *Aide-Mémoire*, R. E., it appears that a heavy London dray horse can exert a *tractive* force of 360 pounds for a short time. In regular work, day by day for eight hours, 250 pounds, but that for the "average" horse this latter is only about 150 pounds, and that a good horse at three miles an hour can exert a force of 125 pounds for eight or ten hours. A powerful horse can carry 350 pounds, and a good cavalry horse can carry from 260 to 280 pounds twenty-five miles a day in seven or eight hours.

Now an artillery horse is by no means a heavy London dray horse. On the other hand reasonably well selected artillery horses are certainly much better than the "average" horse. Therefore his tractive force will fall somewhere between the 250 pounds for the dray, and the 150 for the average horse, and it would appear reasonable to place the measure of the tractive force of good artillery horses of heavy weight, such as would naturally constitute the teams for the heavy field batteries, at about 200 pounds. These batteries will generally be assigned to the corps artillery and march over the best roads.

As to the light batteries from the divisional artillery, their mobility must conform to the marching capabilities of the infantry division, whose distance and rate of marching have been given, and from which the tractive force of the light battery horse can be deduced, as compared with that for the other battery. It thus appears that good horses, under ordinarily favorable circumstances as to condition, roads, &c., can exert a tractive force as follows:

At	3	miles	per	hour	for	8	hours,	125	pounds	25	miles	a day.
"	2	"	"	"	"	7½	"	178	"	15	"	"
"	1.8	"	"	"	"	6¾	"	200	"	12	"	"

which may be considered as a very correct basis for theoretically determining the loads which artillery horses can draw for horse, light and heavy field batteries, as the distances, times, and rates accord very closely with what obtains with troops marching in armies in war service. If the rate be increased, the load decreases for the same time.

It is quite evident that this measure of tractive force is a high one by which to measure the amount of work a horse will be able to do under the adverse conditions of war service, and makes but little if any allowance for the general character of artillery draft horses, their probable condition from insufficient or bad forage, bad roads, forced marches, &c. It is true that when these conditions obtain for the artillery horses, it may be expected that they will also apply in kind equally to those of the cavalry, or impose other equally unfavorable conditions upon the infantry soldier. Unquestionably in the organization of the artillery for a completely equipped army, the horses would be classed and the heaviest assigned to the heavy, while the lighter and most active would be given to the horse batteries; thus to the greatest extent favoring the horse's condition for draft purposes. But after all, when the tractive force is taken at its full limit in the shortest time—eight hours—for a good horse in excellent condition, with good care and forage, and over fair roads, as the measure for horse artillery; at twenty-eight pounds above this force for the "average" horse as that for light, and at fifty pounds above for heavy field batteries, it may be confidently asserted that these limits are as high as can safely be assumed, no matter how good may be the class of horses we can obtain for our artillery service. This fact will presently be demonstrated. It may be of interest to call attention to the fact that the measure of tractive force which has been indicated is almost exactly what was assumed by the officers who determined the loads for our old smooth-bore material.

When double teams with mounted drivers finally succeeded the old tandem style in artillery, in every country in Europe hundreds of routes for postilion coaches had existed for generations, conducted by good horsemen and shrewd business men—to make money.

The powers of horses under such conditions were known to a pound from actual experience, and all of this vast experience and knowledge thus acquired was ready to the hands of artillery officers, to be but slightly modified to meet the conditions of his service, as the general run of the post roads of the time were but little better than the open country. One can to-day take a map of Europe and, judging by the topography and history, put his finger in succession upon those countries wherein the postilion coaches made the best time or carried the greatest weights; then turn to the loads behind the respective artillery teams of the present and find them to correspond, even only slightly modified for the more mobile artillery by the new conditions, because, as a rule, of the poor condition of the road, the artillery team going across country being about as well off as the coach on the road. And here be it particularly noted that, as the roads improved and coaches driven from the box appeared, the teams were hitched to double trees, while those driven by mounted drivers continued to the end to be hitched to a rigid splinterbar, additional teams being hitched-in upon the same principle as are our artillery teams. Then as now, these different methods were applied for the purpose of equalizing, so far as possible, the work done by the horses of a team, the rigid splinterbar being the only practicable means of equalizing this work when one horse in each team has to carry a rider, a "rule of thumb" determined by practical horsemen. The extra work done by the horse carrying the driver, at a walk, is a small factor compared with what he has to do when traveling at a rapid gait, which latter was the normal one for the postilion coach, while for the artillery teams the loads are always based upon the trot, and of course with a riding driver on each team. The slow gait, with only one mounted driver for the team, accounts for the fact that the teamster finds his riding animal to stand the extra work so well, coupled also with the fact that he generally selects the most powerful animal in the team for the saddle, the gait not counting as it often does in artillery, as it is always a walk.

In the artillery service all horses are trained to work anywhere in a team, to meet cases of emergency. But for regular service, each horse is assigned to the place he is best fitted for. He is a creature of habit to a wonderful extent and soon becomes accustomed to and knows his place, and in it will work quietly along till he drops in harness if need be, an example of devotion to duty not to be excelled. Change him, however, as might be advocated to relieve him of an undue share of work, and he at once begins to fret, and continues to do so until put back into his accustomed place, his fretting wearing out his strength quite as much if not more than his work. Hence the practical horseman in artillery—most certainly not anywhere else—never changes his horses about in order to "equalize" their work, notwithstanding that he well knows that one horse in each team has to do very much more work than the other. With the rigid splinter-bar the driver can make his off-horse do his full share, with the double-tree this becomes beyond his control and is impossible. Men born since the advent of the steam engine have not a tithe of the experiences with horses performing this kind of work, that was acquired by those engaged in it before this period, and they certainly do not know any more about the practical working powers of a horse. We now have plenty of accurate formulas with which to determine with great exactness what a horse can reasonably be expected to do under any given circumstance. But these formulas are all empirical, based upon a vast and varied experience, and verified for use in artillery service, not alone by the practical experiences of generations of capable artillery officers, but by the most complete and careful experimental determination with dynamometers, &c., of the powers of artillery horses, under every probable condition of ground, roads, &c., likely to be met with in actual service, and, what is no doubt quite as much to the point, these so-called theoretical results accord wonderfully with the conditions imposed by the "rule of thumb" deduced by the practical horsemen who doubtless never heard of "tractive force" or of an "angle of traction." It is not necessary for us now to subscribe to the contention that there really "were giants in those days," in order to accept the fact that our predecessors determined wisely and correctly as to the proper loads for our artillery teams in *this* country under the then existing conditions of service. Whether these conditions have since changed in the direction of lighter or heavier loads, will presently appear. Attention has already been called to the fact that the measure of tractive force assumed is probably almost exactly the same as that used by our predecessors, but it has thus far been impossible to learn just how they arrived at their loads. It was most likely by the formula that the total tractive force of the team P, divided by the load W, should be equal to the tangent of the angle of the traces B, which was taken at 7°, equal to the assumed "obstacle" for our wheel and over our roads. $\left(\frac{P}{W} = \tan 7°\right)$.

According to Gibbon's *Manual*, no doubt largely based upon the experiments made by the French artillery at Metz in 1825, a horse carrying a rider loses his force in proportion to the gait; this loss, which is about one-half at a walk, becomes two-thirds at a trot. This is the reason why "practical and experienced" horsemen adhered to the rigid splinter-bar for postilion coaches, and why in almost every service, save for our new and utterly untried carriages, the splinter-bar is adhered to for field artillery carriages. Single-trees and spring tug-links have been introduced, the latter of unquestioned value, rendering the former unnecessary. The single-tree is advocated for the purpose of compensating for the "forward and backward" movement of the "shoulders" of the horse, causing sores at the point of the shoulder when the rigid bar is used, of which more presently. To hitch an artillery team with a mounted driver to double-trees is not only a useless cruelty to the horses, but is also a piece of folly so evident as to scarcely require pointing out—save to the not uncommon exception of the man who, though having had a wide "practical experience," is yet incapable of clearly understanding or demonstrating the true meaning of the lesson such experience teaches—and one which the wisest and most experienced artillery officers in every service have combatted or carefully avoided time out of mind.

In proportion as the number of horses is increased, the relative force of each couple diminishes, in consequence of the difficulty of making them act together, and the results obtained are respectively about as 9:8:7:6, according as the teams are composed of two, four, six or eight horses. For field-artillery purposes it is generally conceded that six horses is the greatest number that can be worked or manœuvred to advantage. Applying these carefully determined conditions to the measured tractive force a horse can exert, at a trot—which gait every kind of field-battery must be capable of maintaining for long distances, very long ones Prince von Hohenlohe assures us—the tractive force for artillery horses as heretofore assumed becomes:

TRACTIVE POWER OF FIELD-ARTILLERY HORSES.

	One Horse.			Totals for 6-horse team.	
	Without rider.	Team of 6 horses with riders.			
	Walk.	Walk.	Trot.	Walk.	Trot.
Horse Artillery, lbs.	125	74	65.0	444	390
Light Field Arty. . "	176	104	92.3	623	554
Heavy " " "	200	117	103.7	702	622

It has been demonstrated that the tangent of the inclination of the traces should equal the ratio of the tractive force to the load. In 1825, at Metz, Migaut and Bergery found that this ratio over fine turf was $\frac{1}{22}$, and over recently ploughed and hoed ground $\frac{1}{10}$. It was found in general, that the most favorable angle for the traces of an unloaded horse was from 10° to 12°; and for a horse that carried his driver, from 6° to 7°.

Under the conditions of artillery service in our country, for a 57-inch wheel (58 being the limit), the "obstacle" to be surmounted was equal to a slope of 7°, and as the tractive force should be applied parallel to the plane of motion, the angle of the traces was also 7°, the limit for the horse carrying the driver. In the English service with a 60-inch wheel, these angles are 6° 30′.

The best formula at hand for determining the load is, for equirotal carriages, that of Colonel Kemmis, R. A.—Proceedings of the *R. A. Institution*, Vol. 9, 1875-6, Nos. 3 and 8—viz:

$$W = \frac{R(P - W' \sin E)}{ru \cos E + R \sin E}\text{, in which;}$$

W = weight of carriage-body in pounds.

W' = weight of wheels in pounds (here taken as 640—720—800, for the different batteries, i. e.: 160—180—200-pound wheels).

P = tractive force in pounds in direction of traces (7°).

R = radius of wheel in inches = 28.5.

r = mean radius of axle-arm in inches = 1.225.

u = coefficient of friction between wheel and axle = 0.01.

E = angle of slope due to height of obstacle = 7°.

By substitution, and, as compared with the loads as deduced from the ratio already mentioned, and those from our old material—cannoneers mounted—we have:

MAXIMUM LOADS FOR ARTILLERY TEAMS OF SIX HORSES:

		Kemmis.	Ratio.	Old U. S.
Load for horse battery, 6 horses,	lbs.	3191	3176	3183
Load for light field battery, 6 horses,	lbs.	4533	4511	4432
Load for heavy field battery, 6 horses,	lbs.	4955	5065	5031

These are the maximum loads which our artillery teams can draw under the conditions and limitations imposed. It will be noted that, with either formula the weight of wheel has a great influence upon the *load of ammunition carried*. In the horse battery for instance, whether the wheel weighs 160 or 200 pounds, the formulas will give practically the same load, but with the 200-pound wheel there will be 160 pounds less ammunition carried than there would be with the lighter wheel. So the size of the wheel, should not exceed fifty-eight inches in diameter. Although the 60-inch English wheel gives a better angle, &c., thereby enabling the same team to pull 216 pounds more than it can with a 57-inch wheel, it must be remembered that the English wheel weighs 234 pounds, which makes the apparent gain of 216 pounds due to the large diameter, an actual loss of eighty pounds in the weight of ammunition carried, as against the 160-pound wheel. If the wheel weighs 180 pounds, this difference in the weight of wheels exactly compensates for the greater load of 216 pounds which the larger wheel enables the team to pull. It is thus apparent that it is nothing to the point to compare our loads directly, with foreign ones. To infer, for instance, that because the new English gun gives a load of 4032 pounds, we can impose the same weight upon our teams. As has just been pointed out, 4032 pounds under the English condition of draft means 3816 under our condition other things being equal, and this too without their being able to carry any more ammunition than we can with a lighter wheel. This takes no account of the class of horses, nature of the country and conditions of artillery service generally. What is more to the point is the fact that the 60-inch English wheel, with 3-inch tread to insure proper traction for the heavier load, leaves but 3096 pounds for the gun, ammunition, &c.; while we can, for our smaller wheel with a less tread suited to our lighter load, make it weigh 180 pounds with ample strength, when we should have 3816—720=3096, or the same weight at our disposal with 216 pounds less load. The ponderous weight of the English wheel is not alone due to its diameter and tread, but to the absurd idea that the value, especially of a field gun, is measured by a high velocity and tremendous energy secured *at the muzzle* with a light projectile of very poor sectional density thereby insuring excessive strains on the carriage, wheels, &c., without any corresponding advantages at battle ranges. The French, and more particularly the German artillerists, have always recognized the fallacy of this idea. and the latter fire an 18-pound shrapnel with more than fifty per cent. greater killing power at *battle* ranges than for this English gun, with forty-two pounds less weight of wheel, 168 for the carriage. But the reaction has set in against these fallacious ideas, and the plane teachings of ballistic science are beginning to be heeded. This, as a subject of ballistics, might appear a digression from that of draft, but it is most intimately related thereto. For, by adhering to a heavy projectile of good sectional density, we can secure at battle ranges, far better results in every respect than is possible with reverse conditions, and can then reduce the weight of gun, carriage and wheels, and still carry the necessary number of the heavy projectiles without exceeding the proper loads behind our teams. The size, tread, and weight of wheel are the most important factors which enter into the proper determination of the construction and mobility of field artillery material, as respects the weight of ammunition carried, and instead of constructing a gun developing a tremendous muzzle energy with a projectile of poor sectional density, requiring a ponderous wheel to stand the recoil, the part of wisdom is first to construct a good wheel of proper weight, and then by the use of good sectional density, favor the gun with a proper muzzle energy, but obtaining as good if not much better results at battle ranges. With the designing of the wheel naturally goes the proportioning of the tread or width of tire, to the load imposed. Over good roads this load should not exceed from 373 pounds per inch of tire for small wheels of narrow treads, to 560 for large wheels of broad tread. Over poor roads or the open country these loads should be considerably reduced for field artillery.

It will be observed that the theoretical loads given by both formulas are practically the same as those for our old smooth-bore material, and that our predecessors rigidly adhered to theory for the horse, and light field *gun-carriages*, and for all of the carriages of the heavy battery, while the caisson for the horse battery exceeded the limit by 310 pounds, and for the light battery caisson by 483 pounds. The reasons for these conditions no doubt are that, in the case of the heavy battery the full limit of the power of the team had been reached and the power of the gun was developed up to this limit, giving a gun-carriage considerably heavier than the caisson when the cannoneers were dismounted, but with the latter mounted making the loads practically the same—it being noted that for the old material but three men were carried on the gun limbers, while six were carried on the caissons. For the other batteries where greater mobility as well as much more manœuvring was required, the limbers being kept constantly filled, the expenditure of ammunition consequently fell to the relief of the caisson teams, while for the light battery at least, when on the march the permanent loads for the two carriages were about the same. As it has generally been held that artillery ammunition should always be transported in caissons formed into trains properly horsed, manned and equipped—for it is quite as necessary to supply a battery after a battle with men and horses to replace those killed or wounded, as it is the ammunition expended—it is possible that the caissons in question were given the additional weight to meet the conditions of the service of the caisson with the train, when it might be expected a greater load could be handled, the spare wheel being removed the load would not much exceed the proper one. In any future war our artillery ammunition trains would be properly organized to meet the conditions of supplying the waste of battle, whether of ammunition, men, horses, or equipments; the empty caissons of the train readily going back to the depot unloaded with fewer men and horses. The caisson, without spare wheel, when loaded and equipped for service with its six cannoneers *should not weigh any more than the gun-carriage with its five cannoneers.* The caisson with spare wheel would thus be heavier than the gun-carriage when moving at a rapid gait, by the weight of one wheel—160—180—200 pounds, respectively. If it be deemed practicable to carry greater weight on the caissons when with the train, this can readily be done by adding to the load ammunition in the original packages, placed on the foot-boards of the caisson-body or other convenient place. In this way, and for this purpose, the caisson load can be increased to any desirable extent without interfering with what it unquestionably should be when the caisson forms part of a battery, and where the maximum load should be substantially the same as that for the gun-carriage, both with cannoneers mounted. During our late war the 3-inch rifle, which was our proper horse artillery gun, taking the place of the old 6-pdr. smooth-bore, when used with horse batteries in the Western armies had one ammunition chest removed from the caisson-body, the load for the gun team being 3315, and for that of the caisson 3323 pounds.

There were two such batteries with General Wilson's cavalry corps when it made its famous march in 1865, both, however, experiencing a considerably greater loss of horses due to the long and hard marching than did the cavalry, tending to show that these loads were too great for horse artillery under such conditions of marching, as will presently more fully appear. Toward the close of the war the same method was resorted to to lighten this caisson in the Eastern armies also, it being found that its 4081 pounds with three chests was entirely too heavy when long and rapid marching was required, especially when the work of the team was compared with that of the gun weighing 766 pounds less. Even when this gun was used with the light batteries this great disparity caused most artillery officers to seriously complain of excessive weight of the caisson, the contrast being made much more prominent as the gun limber carried only three men while the caisson carried six.

The "permanent" load for the carriages in horse artillery is of course the total load of about 3200 pounds. Those for the other batteries; the total load less five cannoneers—800 pounds—

for the gun-carriage, and less six—960 pounds—for the caisson, the knapsacks being carried in a wagon. and we should have, adhering to our old and war-tried practice:

PERMANENT LOADS FOR FIELD ARTILLERY CARRIAGES.

	Gun Carriages.			Caissons.		
	Horse.	Light.	Heavy.	Horse.	Light.	Heavy.
Permanent loads lbs	3183	3532	4234	3343	3652	.274
With men, "	3183	4432	5034	3343	4612	5-34

While every other service has been seeking to reduce the loads behind artillery teams ever since the wars of 1870 and 1877, ours have been greatly increased, and as an excuse therefore, the example of a single battery out of nearly a thousand is cited as ample justification. The experience of Horse Battery "D," 2nd Artillery, in its march with Sheridan, 10th—26th of May (inclusive), 1864, is cited, a period of seventeen days during which it is stated that "the marching and fighting was continuous." Divested of the poetic license which attaches to a somewhat distant past, and coming down to the sober facts as recorded in the morning report book of this battery, the "continuous fighting" is reduced to two "engagements," in which the battery lost neither man nor horse killed or wounded. The "continuous marching" is reduced by five days spent in camp when not a mile was marched. During the remaining twelve days a distance of only 214 miles was covered, an average of less than eighteen miles a day, the longest continuous marching being 108 miles in six days. As is well known, General Sheridan started out for the express purpose of demonstrating the fact that he could go where he pleased despite the enemy. He was in no hurry and could not be hurried. The record proves that the march of this battery, which is made the excuse for the preposterous increase in our loads, and cat's-paw to rake them out of trouble, was an exceedingly commonplace affair, whether with respect to fighting or marching. As for the latter, it could have been done with the greatest ease by any 12-pdr. light battery in the army, and was absolutely no test whatever as to the proper measure of mobility for horse artillery.

Horse Battery "I," 4th Artillery, also a 12-pdr. battery, made a march during this war that might have been cited as evidence of some real value, as being something which no light battery could accomplish, to discredit a horse battery record. It left camp at Chickasaw Landing on the Tennessee river March 21, 1865, and reached Macon, Ga., April 21st following, spending April 3rd, 4th, 5th, 6th, 8th and 9th in camp and twenty-five days on the march, thus covering by the morning report book, 537 miles in twenty-five days, as measured by the engineer officer; an average of 21½ miles per marching day, 3½ per day short of what it is claimed our cavalry can readily accomplish when occasion requires "six days in every week during a campaign." Eleven of these marches were of twenty-four miles a day or over, six of thirty miles a day or over, and 253 miles were made in ten consecutive days. During this campaign of General Wilson's cavalry corps it captured five fortified cities, twenty-three stand of colors, 288 guns, and 6820 prisoners, so that the battery probably had something to do in the way of fighting, besides marching and keeping up with the command. This is certainly tremendous marching for a battery of this kind, and so far as a single exceptional case can be relied on as data upon which to base general conditions, is probably as good an example as can be found in the records of the war. But instead of six it had *eight* horses to every carriage and even with this number, in a month's time over twenty per cent. of the horses were knocked-up or disabled from marching, and the battery commander asserts without qualification that with six horses to a team the march never could have been made at all, quite conclusive evidence that the loads were entirely unsuited for horse artillery in this country, a fact already well-known to all of our artillery officers of rank and experience. Had Horse Battery "D," continued its march after reaching Haxall's Landing, to Appomattox and Lynchburg, Va., Greensboro and Charlotte, N. C., Columbia, S. C., to near Augusta, Ga., its march would have about equalled that made by Horse Battery "I," and had such a march been made with six horses to a team we would know much more about the ability of this team to pull the loads under such conditions.

But had it been possible to make these marches with six horses to a team "one swallow (or even two) does not make a summer." They would by no means be, as isolated and exceptional marches, accepted as conclusive evidence as to what the loads for horse artillery should be under the general conditions of the service, save that the latter march would conclusively prove that the loads for the 12-pdr. carriage were greatly in excess of what should obtain. Then it must be remembered that the first march cited was actually performed in a very limited field of operations—and that conditions which were found to be entirely satisfactory in such limited fields, were found by wide and varied experience to be entirely unsatisfactory under other conditions. There is nothing in our war experience when fully stated and correctly weighed, to indicate that our old artillery loads were lighter than the general conditions of artillery service demanded; nothing in the conditions of either the past or of the present to indicate any change necessary save by a *reduction* of the loads.

As to present conditions, Prince von Hohenlohe in his *Letters on Artillery* says: * * * "At the time of smooth-bore guns and muskets it was possible to stand safely at a distance of one mile from the enemy's guns. At this distance the lines of artillery could quietly deploy, and when they received orders to move into action, an advance of 1500 paces was quite sufficient, in order to fire on the enemy's position at the most favorable range of 1000 paces. Very little was thus demanded from the mobility of the artillery. Field artillery required to trot only a few hundred paces. Horse artillery was indeed called to move very fast, but when it had rapidly passed over a total space of 1500 paces, galloping over the last 500, in order to reach its position, it was then considered to have done its utmost, indeed all that was necessary or possible. * * * The introduction of the rifle guns and the experience which was obtained in 1866, considerably altered the demands which must be made on the mobility of the artillery. The necessity of employing the great artillery masses early at the beginning of the fight demands quickness of movement not over distances of 200 or at most 500 paces, but over distances measured by miles and days' marches In order to come into action * * * I had to trot fourteen miles in a hilly country. And even this, as far as one can see, will not be enough in the future. General von Dresky, on the 6th of August (1870), after a march of thirteen miles up and down hill, went into camp, but received orders to proceed to Saarbruck. The country was terribly hilly, but his brigade made fifteen miles in three hours and went into the battle. * * * The war of 1870-71 is rich in such events. * * * (1) *Artillery must seek to crown its efficiency in learning to shoot well,* with all that belongs to it. (2) Artillery must *in its exercises direct the whole of its attention principally to render itself capable of being in position in masses at the proper moment;* that is to say, *it must be able to get over long, very long distances, even many miles, at a fast trot either in column of route or as a battery in line.* * * * It must be in condition *to come into position at the right moment,* and, with this object, it must practice itself in getting over distances of many miles, and even forced marches of a day or so, at a rapid pace. * * * In war, many miles must often be passed over at a trot in column of route. * * * We also ought to practice forced marches of at least thirty miles a day, so that all may learn how this is to be done without injuring the horses. We shall then be able in war to get over sixty miles, when we are ordered to do so at whatever cost."

This tremendous rate of marching now required to get the artillery into its position promptly, is not confined to horse artillery as might be supposed, but applies to field artillery in general. It is needless to say that the conditions and maxims laid down by this accomplished and experienced artillery officer are everywhere recognized as correct, and are to be found embodied in modern artillery drill manuals and tactics the world over.

If the distance required to be passed over at a rapid gait has changed from a few hundred paces to many miles, as our horses are no better than were those of our predecessors, it at once becomes very evident that the loads behind our teams is a matter of grave moment. If the loads for our old smooth-bore guns were correctly determined and applied according to the conditions of artillery service in our country, it is also very evident that under the new conditions of warfare, imposing such greatly increased powers of mobility—that there cannot possibly be any increase above the old loads if efficiency is to be secured, but on the other hand if any change is to be made it must be a reduction from the old loads. The German artillery has already applied these maxims as to practice marches, with the result that already in their horse artillery the loads have been reduced 420 and 460 pounds behind the gun and caisson teams, respectively: for the light batteries the reduction is about the same, and for the heavy batteries it is some 250 pounds behind the teams. This reduction in the loads has been secured by substituting hollow axles for the old solid steel ones, and in other ways by lightening the carriages, and by improvements and reduction in the equipments of the carriages.

[TO BE CONTINUED.]

SOME APPLICATIONS OF GLENNON'S VELOCITY AND PRESSURE FORMULAS.

By Captain JAMES M. INGALLS, First Artillery, U. S. A.

In the third number of this journal Mr. Benét gives an interesting and instructive account of an application of D'Arcy's method for determining the law of velocity and pressure in the chase of a Hotchkiss 57-mm. gun loaded with a service charge of smokeless powder. This method consists in cutting off successive lengths from the chase of the gun and measuring in the usual manner the new muzzle velocity at each shortening. In this way, and by lengthening a similar gun to fifty calibers travel of shot, Mr. Benét obtained velocities for eight different travels of projectile, these latter ranging from 8.8 dm. to 28.45 dm. From these observed velocities Mr. Benét deduces an empirical velocity formula similar in form to that adopted by Hélie for gunpowder, determining the constants by the method of least squares so as best to represent the observations. He also gives several other formulas for the velocity in terms of the distance travelled by the projectile, among them Sarrau's monomial and binomial formulas, the latter of which has a probable error of 20.53 m. s.!

The object of this article is to invite attention to Glennon's velocity and pressure formulas, in connection with Mr. Benét's experiments. These formulas, which do not seem to have received the consideration they deserve, were first published in the Proceedings of the United States Naval Institute in 1889;* and, as slightly modified by the author of this article, are the following:—

$$v^2 = M_1 \frac{\tilde{\omega}}{d} \left(\frac{z_0}{w} \right)^{\frac{1}{2}} X_0 \left\{ 1 - N_1 \frac{(wz_0)^{\frac{1}{2}}}{d} X_1 \right\} \qquad (1)$$

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* See, also, Ingalls' Interior Ballistics, Artillery School press, 1890, where may be found many applications of these remarkable formulas.

and

$$p = M_2 \frac{\tilde{\omega}}{d^3}\left(\frac{w}{z_0}\right)^{\frac{1}{2}} X_3 \left\{ 1 - N_1 \frac{(wz_0)^{\frac{1}{2}}}{d} X_2 \right\} \qquad (2)$$

in which

v is the velocity of the projectile at any point within the bore.

p is the corresponding pressure per unit of area on the base of the projectile.

$\tilde{\omega}$ is the weight of the powder charge.

d is the diameter of the bore.

w is the weight of the projectile.

z_0 is the reduced length of the initial air-space.

M_1 and N_1 are constants for the same kind of gun and powder, and are determined either by two firings from similar guns but with different conditions of loading—or from two firings with the same gun under the conditions of the Benét experiments.

$$M_2 = \frac{2M_1}{\pi g}$$

X_0, X_1, X_2 and X_3 are functions of the number of expansions of the powder gases. Thus if u is the distance travelled by the projectile from its seat, and if we make $x = u/z_0$, we have

$$X_1 = \int_0^x \frac{x}{(1+x)^{\frac{1}{2}}\sqrt{(1+x)^{\frac{2}{5}} - 1}} \qquad (3)$$

$$X_0 = X_1 \left\{ 1 - \frac{1}{(1+x)^{0 \cdot 4}} \right\} \qquad (4)$$

$$X_2 = \left\{ X_0 \frac{dX_1}{dx} + X_1 \frac{dX_0}{dx} \right\} \div \frac{dX_0}{dx} \qquad (5)$$

$$X_3 = \frac{dX_0}{dx} \qquad (6)$$

The values of these functions have been computed and tabulated, with x as the argument.* This makes it as easy to use Glennon's formulas as Sarrau's.

In applying these formulas to the data of Benét's experiments we take the observed velocity for the longest and shortest travel of the projectile, respectively, which are (see Benét's paper), for a travel of 28.45 dm., $V = 682.1$ m. s.; and for a travel of 8.80 dm., $V = 543.1$ m. s. From these velocities and travels, in connection with the given values of $\bar{\omega}$, d, w, and z_0 (this latter depending upon the density of loading and density of the powder), we deduce the following expressions for the velocity and pressure at *any point within the bore:*

$$v^2 = 189737X_0 \left\{ 1 - 0.065637X_1 \right\} \qquad (7)$$

and

$$p = 4431.7X_3 \left\{ 1 - 0.065637X_2 \right\} \qquad (8)$$

In these formulas the units have been so chosen in computing the constants that v will be given in metre-seconds and p in kilograms per square centimetre. The tabular quantities X_0, X_1, X_2 and X_3 being functions of the number of expansions of the powder-gas, are independent of the units employed.

Since the constants M_1 and N_1 were determined by means of the two extreme observed velocities, equation (7) will of course reproduce these velocities; but whether it will also give the six intermediate observed velocities depends entirely upon the correctness of the theory by which X_0 and X_1 were obtained; and we are thus afforded a good test of the practical value of Glennon's velocity formula. The pressure formula is deduced from the velocity formula by differentiation and simply expresses the force necessary to produce the acceleration of velocity of translation of the projectile. The following table gives the observed and computed velocities, with the corresponding number of expansions and the distances travelled by the projectile:

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* See Table II, Ingalls' Interior Ballistics.

CHARGE 0.46 KILOS. OF SMOKELESS (BN_1) POWDER.

Travel of Projectile.	Number of Expansions.	Velocities.		Diff.
		Observed.	Computed.	
Decimetres.	x	Metres.	Metres.	Metres.
28.45	12.2237	682.1	682.1	0.0
20.20	8.6786	648.3	651.5	—3.2
17.92	7.6981	636.5	638.5	—2.0
15.64	6.7187	622.3	622.3	0.0
13.93	5.9841	612.6	608.0	+4.6
12.22	5.2495	595.0	590.6	+4.4
10.51	4.5149	574.4	569.4	+5.0
8.80	3.7803	543.1	543.1	0.0

The differences between the observed and computed velocities average less than one-half of one per cent. of the former. If we take Mr. Benét's computed values of the velocities—which are their most probable values—and deduce a new velocity formula which satisfies the extreme velocities, namely, 679.9 m.s. and 545.5 m. s., we shall have

$$v^2 = 194295X_0 \left\{ 1 - 0.067657X_1 \right\} \tag{9}$$

The following table shows the agreement between the velocities computed by Mr. Benét and those furnished by equation (9). The travel of projectile and number of expansions are the same as those already given: The differences between the two sets of velocities are less than one-seventh of one per cent. of the velocities themselves, and are practically *nil.*

CHARGE 0.46 KILOS. OF SMOKELESS (BN_1) POWDER.

Velocities Computed by		Differences.
Benét.	Ingalls.	
Metres.	Metres.	Metres.
679.9	679.9	0.0
651.0	651.4	—0.4
639.0	638.9	+0.1
623.9	623.3	+0.6
610.0	609.3	+0.7
593.1	592.3	+0.8
572.1	571.4	+0.7
545.5	545.5	0.0

These tables show that for this gun and charge, Glennon's formula gives the velocity of the projectile with all desirable accuracy through nearly 70 per cent. of its entire travel in the bore; and, therefore, the corresponding pressures are correctly furnished by equation (8).

Mr. Benét also computes the velocity of the service projectile in the chase of the 57-mm. gun for a charge of 0.92 kilos. of brown cocoa powder (double the charge of smokeless powder) for the same travels of projectile as before, using Hélie's formula, which he has shown to be perfectly trustworthy. Glennon's formulas in this case, deduced as before, are the following:

$$v^2 = 87533 X_0 \left\{ 1 - 0.027648 X_1 \right\} \qquad (10)$$

and

$$p = 3399.5 X_3 \left\{ 1 - 0.027648 X_2 \right\} \qquad (11)$$

The table below gives the velocities computed by the two formulas, with their differences. These latter average less than one-third of one per cent. of the velocities.

CHARGE 0.92 KILOS. OF BROWN COCOA (C_2) POWDER.

Travel of Projectile.	Number of Expansions.	Velocities Computed by		Differences.
		Benét.	Ingalls.	
Decimetres.	x	Metre-seconds.	Metre-seconds.	Metre-seconds.
28.45	20.321	645.6	642.6	+3.0
20.20	14.428	600.0	600.0	0.0
17.92	12.890	583.8	584.6	—0.8
15.64	11.171	565.3	566.9	—1.6
13.93	9.950	549.6	551.4	—1.8
12.22	8.728	532.0	533.8	—1.8
10.51	7.507	511.9	513.2	—1.3
8.80	6.286	488.7	488.7	0.0

Having now shown that Glennon's formula can be relied upon to give the correct velocity of a projectile in the chase of the 57-

mm. gun, we will subject it to a much more severe test by extending our calculations of the velocities and pressures back to the origin, or seat of the projectile, where the velocity and pressure are both zero. We will first employ equations (7) and (8) which pertain to a charge of 0.46 kg. of smokeless (BN_1) powder, bearing in mind that the constants entering into the first of these equations were deduced from two velocities in the chase of the gun at a distance of 19.65 dm. apart, while the form of the curve depends upon the functions X_0 and X_1; and that the pressure formula is derived from the velocity formula by differentiation. The function X_1 is deduced in accordance with Sarrau's hypothesis that the velocity of combustion of the grains of powder which make up the charge is proportional to the square root of the pressure to which they are subjected. This hypothesis furnishes the following expression for the weight of powder burned for any given travel of the projectile:*

$$y = a\omega K X_1 \left(1 - \lambda K X_1 + \mu K^2 X_1^2 \right) \qquad (12)$$

in which y is the weight of the powder burned in the gun, a, λ and μ are numbers depending only on the form of the grain, and

$$K = \frac{N_1}{\lambda} \sqrt{\frac{w z_0}{d}} \qquad (13)$$

For the smokeless powders employed by Mr. Benét in his experiments $a = 2$, $\lambda = \frac{1}{2}$ and $\mu = 0$. We therefore have in this case, in kilograms,

$$y = 0.120774 X_1 \left(1 - 0.065637 X_1 \right) \qquad (14)$$

The following table computed by equations (7), (8) and (14) gives in the first column the values of $x = u/z_0$, taken as the argument of the table, and in the following columns the travel of the projectile, the pressure upon unit area of its base, its velocity and the weight of powder burned:

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* Ingalls' Interior Ballistics, page 68.

SMOKELESS (BN_1) POWDER.

$a = 57$ mm. $\bar{\omega} = 0.46$ kg. $w = 2.72$ kg. $z_0 = 2.32783$ dm.

$x = \frac{u}{z_0}$	u decimetres.	u calibres.	p kg. per cm².	v Metre-seconds.	y kilograms	$\frac{y}{\bar{\omega}}$
0.0	0.0	0.0	0	0	0	0
0.1	0.233	0.408	2132	81.0	0.112	0.243
.2	0.466	0.817	2574	129.6	.152	.330
.3	0.698	1.225	2741	168.9	.180	.392
.4	0.931	1.634	2787	200.2	.202	.440
.5	1.164	2.042	2770	228.0	.221	.481
.6	1.397	2.450	2720	252.5	.237	.515
.7	1.629	2.859	2651	274.3	.251	.545
.8	1.862	3.267	2573	294.0	.263	.571
.9	2.095	3.676	2491	311.9	.274	.595
1.0	2.328	4.084	2408	328.3	.283	.616
1.1	2.561	4.492	2325	343.4	.292	.635
1.2	2.793	4.901	2244	357.3	.300	.653
1.3	3.026	5.309	2166	370.3	.308	.670
1.4	3.259	5.717	2090	382.4	.315	.685
1.5	3.492	6.126	2018	393.7	.322	.699
2	4.656	8.168	1702	441.3	.349	.758
3	6.983	12.252	1254	507.2	.385	.836
4	9.311	16.336	962	551.6	.408	.887
5	11 639	20.420	759	583.8	.424	.922
6	13.967	24.503	612	608.3	.436	.947
7	16.295	28.587	500	627.5	.444	.965
8	18.623	32.671	413	642.8	.450	.978
9	20.950	36.755	343	655.3	.454	.987
10	23.278	40.839	286	665.4	.457	.993
11	25.606	44.923	239	673.8	.459	.997
12	27.934	49.007	199	680.7	.460	.999
12.244	28.450	50.000	191	682.1	.460	1.000

The results of this table—that is, the pressures, velocities and powder burned—are shown graphically in the accompanying plate by the continuous curves. The first two of these curves are at once recognized as the typical pressure and velocity curves as deduced by Noble and Abel from their experiments. The maximum pressure occurs when the projectile has moved 1.634 calibres and when 0.44 of the charge has been converted into gas. The theoretical maximum pressure on the base of the projectile is 2787 kilos. per square centimetre, while the pressure given by the crusher guage was 2550 kilos. This difference is easily explained: Glennon's formulas were deduced for *gunpowder* for which, according to the experiments of Noble and Abel, the volume of the solid products (including the unburned powder) at any period of the combustion is always equal to the original volume of the powder charge, exclusive of interstices; and therefore the volume occupied by the gas is constantly proportional to z_0+u. In the case of the new powders, which are supposed to be entirely converted into gas, the volume occupied by the gas is proportional to $u+z_0+\frac{\nu}{\omega}\left(u_0-z_0\right)$, u_0 being the reduced length of the powder chamber. At the point of maximum pressure in the case under consideration we have, since $u_0=3.4760$ dm.,

$$z_0+u=2.3278+0.9312=3.2590 \text{ dm.};$$

and if we add to this

$$\frac{\nu}{\omega}\left(u_0-z_0\right)=0.44\left(3.4760-2.3278\right)=0.5052 \text{ dm.},$$

we shall have 3.7642, which represents the volume actually occupied by the gas. We therefore have, for a rather rough approximation to the actual maximum pressure on the base of the projectile,

$$p_m=\frac{3.2590}{3.7642}\times 2787=2413 \text{ kgs. per cm}^2;$$

and this is probably very near its true value. Equation (2) when applied to powders which are entirely converted into gas, probably makes the pressures somewhat greater than they actually are for the entire breech; but the difference between the actual and computed pressures, is most marked near the point of maximum pressure, and practically disappears near the muzzle. This equation may however be used as a guide in determining the longitudinal profile of a gun designed for firing the new powders, since its errors (which are by no means great) are on the side of safety. There is a point of inflection on the pressure curve at, or near, where $x=0.9$ and $u=2.09$ dm.

BROWN COCOA (C_2) POWDER.

$d = 0.57$ mm. $\bar{\omega} = 0.92$ kg. $w = 2.72$ kg. $z_0 = 1.400$ dm.

$x = \frac{u}{z_0}$	u decimetres.	u calibres.	p kg. per cm².	v metre-seconds.	y kilograms	$\frac{y}{\omega}$.
0.0	0.0	0.0	0	0.0	0.0	0.0
.1	0.14	0.246	1726	56.1	.075	.081
.2	0.28	0.491	2135	90.5	.103	.112
.3	0.42	0.737	2317	118.1	.124	.135
.4	0.56	0.982	2395	141.6	.141	.153
.5	0.70	1.228	2417	162.0	.155	.169
.6	0.84	1.474	2407	180.2	.168	.182
.7	0.98	1.719	2378	196.5	.179	.194
.8	1.12	1.965	2337	211.4	.189	.205
.9	1.26	2.211	2289	225.1	.198	.215
1.0	1.40	2.456	2238	237.7	.207	.225
1.1	1.54	2.702	2185	249.3	.215	.233
1.2	1.68	2.947	2132	260.2	.222	.241
1.3	1.82	3.193	2079	270.5	.229	.249
1.4	1.96	3.439	2027	280.1	.235	.256
1.5	2.10	3.684	1976	289.1	.241	.262
2	2.80	4.912	1747	327.9	.268	.291
3	4.20	7.369	1404	384.4	.308	.334
4	5.60	9.825	1168	425.1	.337	.367
5	7.00	12.281	998	456.6	.361	.393
6	8.40	14.737	871	482.2	.381	.414
7	9.80	17.1 3	772	503.6	.398	.433
8	11.20	19.650	692	522.0	.413	.449
9	12.60	22.106	627	537.9	.426	.463
10	14.00	24.562	573	552.1	.438	.476
11	15.40	27.018	527	564.7	.449	.488
12	16.80	29.474	488	576.2	.459	.498
13	18.20	31.930	454	586.6	.468	.508
14	19.60	34.386	424	596.1	.476	.517
15	21.00	36.842	397	605.0	.484	.526
20.321	28.45	50.000	297	642.6	.518	.563

The following table gives the same calculations for the brown cocoa (C_2) powder as have been given above for the BN_1 powder; and the velocity, pressure and powder curves are also delineated on the plate. These calculations agree with experiments at all points where these have been made, and we may therefore accept equations (10) and (11) as the practically correct equations of the velocity and pressure curves, respectively, for the given conditions of loading.

The deductions that may be legitimately drawn from thes velocity and pressure curves are substantially those made b Mr. Benét, and need not be here repeated. We will only ad that the theoretical time of burning of a single grain of eac of the two powders, in free air, is for the BN_1 powder $0''.169$ and for the C_2 powder $0''.487$.

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ELECTRICITY AND THE ART OF WAR.

[BY FIRST LIEUTENANT C. D. PARKHURST, FIFTH ARTILLERY, U. S. A.]

Discussion *Continued*.

Lieutenant *W. S. Hughes*, U. S. Navy.—Lieutenant Parkhurst's article, "Electricity and the Art of War," printed in the October JOURNAL OF THE UNITED STATES ARTILLERY, contains so much that is excellent, and shows withal such familiarity with the history of the military uses of electricity, that little can be said concerning it except in commendation.

The subject which forms the title of the article is no new one to military or naval men, or to the public at large. It has been frequently treated, both in a popular way, in various current periodicals, and from technical points of view, in military, naval and other scientific journals. But it is, nevertheless, a subject of which the repeated and continued discussion is amply justified by the rapid development of electrical science and by the constant advances that are taking place in the methods and requirements of modern warfare. The historical portion of the article gives a number of examples illustrating the value of military telegraph lines that are interesting and indisputable; but there are a few points in Lieutenant Parkhurst's statements and recommendations to which some exception might be taken when considered in connection with the present state of electrical science.

The article advocates the immediate installation of electrical power and lighting plants in our sea-coast forts. Let us consider for a moment whether this should now be done: Our present land fortifications and their armaments are practically worthless as a means of defense. Modern forts and guns require years for their construction and manufacture. Until these shall have been built and manufactured, it would seem that the providing of search-lights and electric-power plants on land may well be deferred. Such appliances, however essential they may be, are only adjuncts to forts and guns; and an eminent military authority has said, in substance, that in providing for national defense those preparations should first receive attention which will require the greatest length of time for their accomplishment, and for which there will be the most urgent need in case of war. It may not be practicable to assign to each detail of preparation its proper place in the scale of importance, according to the rule of the authority mentioned, but it will hardly be questioned that forts, guns, gun-carriages and ammunition—all requiring relatively long periods of time for their production—stand among the first upon the list. All these are imperative requirements of war for which the pursuits of peace furnish no demand: while, on the other hand, the ordinary commercial interests of the country are causing electrical science to receive the constant study of an army of experts and inventors. Again, great as have been the advances of the past, in the development of electricity, that science, in all human probability, is now only in its early infancy. Judging wholly by the achievements of recent years, who at the present day will venture to assign limits to its future field of application? With a successful alternating current motor, with alternating "multiphase" current systems in practical operation, with the wonderful results so recently obtained from alternating currents of high frequency, with probably successful storage batteries, and with encouraging prospects of the practical generation of electricity directly from heat, may we not look for changes and improvements in the future at least as great and rapid as those of the past? Why, then, should the present military developments of this infant, but gigantic and rapidly growing, science be applied to our antiquated fortifications; only, in all likelihood, to be again and again discarded for better apparatus long before modern land defenses shall have been constructed for the protection of our sea-ports? The definite adoption of such accessories, it is believed, should *follow*, not precede, the building of forts and the manufacture of cannon.

Everyone will agree with Lieutenant Parkhurst that the applications of electricity are destined to play an important part in wars of the future. One of these applications, the military telegraph, has indeed already become, as he asserts, "an absolute necessity in the handling of troops, in mobilization, and in concentration of food, stores and munitions of war;" but the suggestion that trainmen, telegraph operators, and other employes of all our railroads and telegraph lines, should be "regularly enrolled in the event of war, as a part of the army's working force," would be hardly practicable and rarely necessary. No emergency of war is likely to arise in which more than a limited section of the vast railroad and telegraph systems of this country would be demanded for military operations; and the history of such cases, where they have arisen, goes to show that the efficiency of railroad and telegraph companies can be usually depended upon. Any symptom of disaffection or inefficiency on the part of such companies, in the exigencies of war, justifies the immediate seizure and control of their lines by military authorities. The general plan suggested, if carried out, would require, as well, the enlistment of the employes of inland water-routes, and, possibly, in some localities, those of coast-line steamers.

That the land torpedo-service "should belong to the artillery" is but the natural and pardonable belief of an officer of artillery, and is a point which the present writer hardly feels called upon to criticise or discuss. Such minor questions of personnel, in the event of war, will always be subordinated to the great object of attaining the highest possible efficiency in the common defense of our country. But, whatever arm of the service may be charged with the management of torpedoes operated from the land, no one will deny that officers and men of that arm should be given an opportunity to acquire a practical knowledge of "loading, connecting, testing and firing" these weapons of defense. Fields of fixed-mines, however, which are alone considered by Lieutenant Parkhurst, will require of their operators much less time and practice in order to become efficient in their use than will controllable, moving torpedoes; and to have included these latter in his argument would have added greatly to its force. But our sea-ports cannot be defended by any number, or class, of torpedoes alone, and until we shall have forts and guns, it would seem that a few experimental, or practice, stations, for acquiring and disseminating information, would be all that are required.

Beyond all doubt, incandescent lamps are in every way superior to any other known system of lighting "gun-platforms, casemates, galleries, magazines, shell-rooms, and all approaches thereto," and will assuredly be supplied to our future coast-defenses. The question of economy, in such a matter, is of infinitesimal importance; yet, as Lieutenant Parkhurst has cited authorities to indicate that an incandescent plant is cheaper than gas, or kerosense, the writer ventures to assert his belief that this is only the case, at the present day, under exceptional circumstances and conditions. That electricity surpasses in efficiency and desirability every other motive power for the handling and service of modern heavy ordnance, is now so well established as to render almost superfluous any comparison with other systems.

Lieutenant Parkhurst rightly regards the search-light as an indispensable equipment of modern fortifications, and of armies in the field, and quotes authorities to illustrate its incalculable value in a clear, or nearly clear atmosphere; but his paper might give an exaggerated idea of its *general* utility, for he fails to state that on thick, foggy, or rainy nights, when aggressive operations of an enemy are most likely to be attempted, it has been found in practice that the search light is nearly useless.

Upon the whole, it is but justice to Lieutenant Parkhurst, to say that his article is a valuable contribution to the military literature of electricity. It does not deal in generalties, but makes specific suggestions and recommendations, which—while they may not all meet with unqualified approval—cannot fail to be of substantial benefit to the service at large, by directing attention to, and causing discussion of, a most important subject.

Lieutenant *Hamilton Hutchins*, U. S. Navy.—I have been interested in this subject for several years, chiefly of course, from the naval standpoint. I think Lieutenant Parkhurst's article very complete, and he can rest assured that bringing the subject before the authorities and others interested is bound to tell. As we in the navy, who have to handle the appliances on board ship, are the only ones who are familiar with the conditions on shipboard and must decide what form of energy is most suitable, the system of supply and, in fact, all the details of the installation—so the artillerist alone can know what is best suited to fulfill the conditions to be met in our sea-coast defenses, Surelya great variety of electrical apparatus will be required to meet the modern necessities—search lights, incandescent lights and electric motors will be the principal consumers of energy, to say nothing of the telephones, telegraphs, fire-alarms, range-finders, range-telegraphs and indicators, torpedo and gun-firing circuits, &c. Though unfamiliar with the details of design and construction in our forts, I will ask you to "excuse the bluntness of a sailor" if I make a few general suggestions for your consideration.

Taking the propositions in turn:

First: The Search Light.—This would pay for itself even were its use confined to occasions of emergency in time of peace. A lookout suddenly discovers a vessel that has come to grief, for instance. He at once signals to the dynamo room, almost immediately a search light is turned on and may be the means of saving life. This has been strikingly illustrated in the last few years, as in the case of the floods on the Mississippi, on the occasion of the sinking of a large passenger steamer in Gibraltar bay, and many others.

An electric light apparatus portable enough to follow an army in the field, can be used for a variety of purposes. They should be kept in store ready for an emergency. Most of those so far manufactured have been found to be too heavy and noisy; but we need them. Foreign nations will continue to experiment until one is obtained that meets the conditions, and in this, as in all other war material, we should be independent of foreign manufacture. But the chief province of the search light is with the defense. Recent manœuvres abroad have demonstrated that for the defense of a port, the simplest and most effective adjunct is the search light in sufficient number to illuminate the entire approach. It is safe to say that you will require large and powerful lights electrically controlled from a distance. These are now being manufactured for the navy by at least one American firm. In the 30 ′ projector a current of 100 amperes is used. Some of the German projectors for coast-defense are enormous, currents of 200 to 250 amperes being used. Not only is the search light difficult to hit, but it can be worked from under cover if desired.

Second.—Inside illumination for night work, as well as general illumination for every day affairs. I take it that the necessity for the incandescent lamp is apparent and needs no argument. It is a mistake, however, to suppose that the naked lamp without extra protection is not dangerous, for if the lamp is suspended in an atmosphere of explosive gas, on puncturing the globe the gas is exploded by contact with the filament. I do not agree with the writer that the incandescent light is cheaper than gas. Besides it is a better quality of light than gas and we should expect to pay a higher price in proportion. Again, it is healthier than gas. But its chief value for naval (and I take it also for military) purposes, is in the fact that it can be utilized effectively to light important spaces that by gas or oil could not be lighted at all, or if at all, only indifferently. In running the circuits for the incandescent system those lamps that are required on board ship in time of battle are on independent mains from all others, so as to materially reduce the chances of important

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stations being suddenly plunged in darkness at perhaps a
take it that some such arrangement would be desirable as

Third.—The generation and transmission of power.

This subject, particularly the application of the electric
and working of the guns, has been most ably handled by Li
and will surely receive consideration by those who will b
reconstruction of our sea-coast defenses. Dr. Louis Bell, i
has stated in a nutshell the special advantages of the e
tributing power to the guns of a fort, and these feature
important both ashore and afloat. In addition, I should s
the electric power would be required at numerous points
shipboard, thus adding economy to the other advantage
mitting the required energy by electricity.

Signaling Installations.—The necessity for these is obvi
I am of the opinion that if a proper electric plant were i
our important forts, that the government would be rep
never used for other than purposes of instruction for office

In conclusion I trust the good work of the writer will b
mite that I have said will assist therein, I shall be content.

2nd Lieutenant *George O. Squier*, 3rd Artillery.—I hav
deal of interest Lieutenant Parkhurst's excellent article
the Art of War." What most interests us, as members o
What will be the application of electricity to our new sea
and what should be done now towards the solution of these
speaking of this, however, a word in regard to the use
field service in time of war. Some recent experiments
Charollois,* on the use of a field telephone outfit for milit
cate that it has great possibilities as a means of communi
Captain Charollois uses a bi-metallic wire with steel core su
Thus it is not easily oxidized, and has great strength for a
This wire is unwound naked upon the surface of the grou
being completed through the operator himself, or his
mounted. The small magnetic receivers can be used a
paid out on the ground, and this constant communicati
starting point as the line progresses. By the use of such s
material for a line of one mile weighs less than five and a
reel carries 10,000 feet of wire, and is conveniently and
to the soldier as a part of his equipment. On accoun
minute currents required in telephony, the only limit to
wire, and its consequent weight for a given length, is th
while it is being laid. Cavalrymen, or infantry on bicycle
line with great rapidity. In some recent experiments in
line was completed in five hours and taken up in one hou

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* *Annales Industrielles.*

of a division of cavalry over the wire did not interrupt the communication of a dispatch that was being sent at the same moment. No batteries are required; no poles of any kind; no heavy cumbersome wire to be strung, and anyone can operate.

In view of the above, and that we are now talking between New York and Milwaukee, there is but little doubt that the telephone is the instrument both for the field and for permanent lines.

The writing telegraph, when perfected, will undoubtedly have its important *rôle*, as by its use maps, plans of battle and fortifications, and drawings of all kinds can be reproduced with accuracy at any distance.

Passing to the use of railroads in the mobilization and supply of armies, those familiar with recent street-railway progress believe that the steam locomotive must give way to the electric motor for passenger service and also that with this change a speed of one hundred miles an hour will be the rule and not the exception. An electric line is now under construction between Chicago and St. Louis, which is to make the trip in three hours.

The suggestions of Lieutenant Parkhurst as to the applications of electricity to the modern sea-coast fortification are excellent, and instead of being, as some may think, the predictions of an enthusiast, they are not as progressive as the present state of electrical science warrants.

In regard to the security of the main power-plant against the long range fire of the enemy's guns, it is remarked that there seems to be no limit as yet to the distance which electrical power can be economically transmitted. We have recently before us the Lauffen-Frankfort line in Europe, where 300 horse power was transmitted 112 miles at a tension from 16,000 to 30,000 volts, at an efficiency of 74 per cent. As soon as we obtain a perfectly satisfactory alternating current motor, I see no reason why electrical power cannot be transmitted and converted into useful work at distances much greater than the above.

Electricity threatens to revolutionize our whole heavy artillery orgaization. With an enormous engine of war, weighing many tons, costing thousands of dollars, which can, however, by the application of results *already accomplished* in the industrial world, be lowered, raised, aimed, and fired by the movement of simple levers in the hands of a gunner—does not this point to *fewer* men and *more skilled* men in our organization?

The dozen men in a detachment required for the doomed "heave and embar" system, must be replaced by not more than half that number of carefully trained cannoneers. Each round fired from our new 12-inch rifles will cost $217.00, the gun itself costs $52,365.00, and these amounts in conjuntion with the cost of the carriage, and the limited life of the weapon, compels us to adopt that means of control which insures the most rapid, accurate, and reliable service.

Granting that the modern fortification will be equipped with an elaborate electrical plant, ought we to rely upon civilian electrical engineers to design, install, and care for the same? This brings up a subject of policy of which

I have been firmly convinced for the last five years, and [illegible] more and more as time goes on. Electrical science has reached [illegible] stage—that, given the set of conditions which the mount [illegible] in sea-coast matters the artillerist alone fully understands [illegible] machine [illegible] in this particular work can be made [illegible] under variation of load, field windings for perfect [illegible] every minute part can be calculated in the office, and when assembled in the work-shop it will do the work required near perfection.

We have only to look at our new navy for a practical illustration of [illegible] things are drifting in this regard. Every modern cruiser now has [illegible] in charge of all electrical matters on ship-board, and the generators and motors already in use are specially designed for conditions afloat. [illegible] manner each group of guns ashore, with its electric lighting system, [illegible] light system, range finding system, generators and motors, will [illegible] be under the supervision of an electrical engineer directly responsible to the senior artillery officer in command. If present conditions point to anything, they seem to me to point to the necessity of the following:

The War Department should speedily educate a [illegible] *electrical engineers at our best institutions of learning.* The word "[illegible]" is used because one cannot become an electrical engineer in six months, nor yet in one year, and he certainly cannot be created at pleasure by a general order from the War Department.

I am aware that objection would be made by some to such details, the applicant is supposed to desire to shirk his legitimate battery duties, and what not; but such reasons seem to me on too low a plane to merit serious consideration. The weeding process of requiring periodical reports of the work accomplished, and the efficiency reports already in vogue, would insure the details being given to those who would make the most of them for the Department.

Thanks to the foresight of the General Commanding the Army, officers of artillery have recently been sent to our principal arsenals to co-operate with the Ordnance in the manufacture and testing of our modern guns. With half a dozen expert electrical engineers at Sandy Hook, and the sea-coast gun carriage factory at the Watertown arsenal, co-operating and in perfect harmony with the ordnance experts already at these places, to design, test, and work out step by step the details of the plan, I doubt not that rapid progress would be made towards the selection of type carriages for our new guns and mortars, and we no longer would be threatened with the condition of possessing finished weapons with no carriages on which to mount them.

Mr. *Irving Hale*, General Electric Co. (Late 1st Lieutenant [illegible] Corps of Engineers).—The paper [illegible] a broad and suggestive [illegible] of the applications of [illegible] thoroughly as possible [illegible] in their technical details [illegible] question, a few points suggest themselves in regard to the benefits to be derived from electric light and power and the general methods that would give the best results.

The suggestion that army posts ought to keep abreast of the times in the adoption of the electric light seems a most natural one to those who are familiar with its general use in small towns, factories, hospitals, prisons, schools and other institutions where the electric plant is considered almost as much of a necessity as plumbing, heating and ventilating appliances. The only wonder is that it has not long since been adopted at all large and permanent posts, especially when it is considered that there are few situations where the advantages of electric light are more striking or where it can be produced so cheaply. It is especially desirable in hospital and barracks on account of its safety, cleanliness, healthfulness, non-pollution of the air, cheerfulness, saving of labor, and general convenience. Moreover the lights could all be under the control of the first sergeant, who could turn them off at taps and on at reveille, and could instantaneously light up any room or the whole barracks at any time in the night in case of fire, disturbance, inspection, or the long roll, thus avoiding confusion and facilitating the movements of the men. In short, it would contribute to health, safety, comfort, morals and military discipline. Electric light can be produced at unusually low cost at a post on account of the small expenditure for superintendence and labor and the avoidance of certain items of general expense. There would be no salaries of Manager, Superintendent and Book-keeper, as their duties would be performed by the ever-willing Quartermaster and his assistants. Enlisted men on extra-duty pay at fifty cents per day would replace firemen and engineers at two to four dollars per day. Ground for the power house costs nothing, taxes would be nil, and while private enterprise demands a profit of at least ten per cent. on the investment and must pay five to eight per cent. on its bonds if issued, "Uncle Sam" can borrow money at three or four per cent. and should be satisfied with a correspondingly small return on the invested capital.

A ten company post would probably require a plant having a capacity of about 1000 16 c. p. incandescent lights with perhaps 1400 lights wired, including, if desired, a few arc lamps on the incandescent circuit. Such a plant including building, steam-plant, dynamos and appliances, linework, street lights and inside wiring of buildings would cost in the vicinity of $20,000. Assuming that 600 lights are burned regularly from 6 P. M. to 10 P. M-, and an average of 100 lights from 5 P. M. to 6 P. M. and 10 P. M. to 7 A. M. (a liberal estimate), the annual operating expenses, with coal at $4.00 per ton would be about as follows, the estimate being based on experience of plants in actual operation.

Two men at 50 cents per day each	$ 365.
490 tons coal at $4.00	1960.
Oil and waste	180.
	$2505.

Transfer	$2505.
Lamp renewals	600.
Incidentals	120.
Depreciation and repairs, 5 per cent on $20,000	1000.
Total operating expenses	$4225.
Interest at at 4 per cent on $20,000	800.
Total including interest	$5025.

As the estimate covers 1,241,000 lamp-hours per annum, the cost is about $\frac{4}{10}$ cent per lamp-hour. While electricity does not pose as a rival of coal-oil on the basis of cheapness, except under conditions especially favorable to the electric fluid (cheap coal and dear oil), still when the items of chimneys, wicks and broken lamps are considered, to say nothing of labor of cleaning and filling lamps, lighting and extinguishing the outside lamps, damages from smoke and spilled oil, and damages from fire, it is probable that electricity, under the favorable conditions for economical production at a post, would compare very favorably in economy with the dangerous, dirty, ill-smelling, smoke-producing, oxygen-absorbing, semi-barbarous fluid now used in enlightening the army. This statement is of course based on the assumption that *the same amount of light* is produced by the two methods. The amount of illumination provided for in the preceding estimate on the electric plant undoubtedly exceeds greatly the amount usually produced by oil at a post of that size, and if the latter were considered sufficient, the size cost and operating expenses of the electric plant could be considerably reduced. It is usually the case, however, that when electricity is substituted for oil two or three times as much light is demanded and used, and it is probable that army posts would be no exception to the rule. While the subject hardly comes under the head of "Electricity in Warfare," still as the army will probably have twenty years of peace for every year of war, improvements which increase the comfort and welfare of the troops in time of peace are of about as much importance as those which increase their efficiency in time of war.

The designing of an electric plant for a fortification would be a more complicated problem, as it must supply arc and incandescent light and power, and should be so planned as to make failure of current for any of these purposes practically impossible, while preserving the greatest possible simplicity. The following general principles suggest themselves as being of fundamental importance:

First.—The voltage should, if practicable, be so low as to make fatal or even painfully severe shocks impossible. While the high-tension current has established itself, in the face of all opposition, as a valuable and necessary servant, without which the proverbial "infancy" of electricity would be likely to be a permanent condition, it is generally admitted that the low-tension current is preferable where it can accomplish the desired results without too great expenditure for copper. The dimensions of a fortification would in most cases be well within the limits of a 250-volt current. A safe voltage is especially important in a fortification, for in the smoke, confusion and excitement of action men would almost certainly come in contact with abraded or broken wires or parts of apparatus carrying the current. Low-voltage dynamos and motors usually give less trouble than high-voltage machines from burn-outs, grounds and breakdowns and are more easily managed—points of considerable importance where reliability and simplicity are so essential. The low-tension direct current dynamo is the only machine that can satisfactorily supply incandescent lights, arc lights and motors from the same circuit,—a consideration of some weight in connection with the sixth condition given below. Moreover the low-tension current can be more easily handled with underground wires.

Second.—The circuits should, as far as practicable, be underground, to reduce to a minimum the danger of cutting wires in action. With the direct low-tension current, this method of distribution presents no difficulties and is successfully accomplished in many of the large cities.

Third.—The circuits should, as suggested, be so arranged as to prevent failure of current at any point by the cutting of one or even of several sets of wires. This could usually be easily accomplished by multiple feeders supplying the mains at different points, duplicate or triplicate mains with the lights in each locality divided among them so that the disabling of all these mains would be necessary to leave the place in darkness, and by a proper system of switches and cut-outs. The detailed arrangements would be a matter of special study in each particular case.

Fourth.—The incandescent light is preferable to the arc light for most uses about a fort, as it has no mechanism to get out of order or carbons to change, requires less attention, is safer around explosives, and enables the light to be subdivided into small units distributed where they will do the most good, which is what is required in casemates, magazines, posterns, galleries, around the guns, and in fact in most portions of the works. In some places where large open areas are lighted the arc light could be advantageously employed. Of the two types of arc light, the one for operation on incandescent (constant potential) circuit would seem to be the most suitable. The distances would not be so great as to bring out the principal objection to these lamps,—the large amount of copper required to supply them at long distances,—and their advantages would be important. Their use would avoid the employment of a dangerous voltage, they are connected in independent pairs, instead of in a single dependent series, arcs and incandescents can be used interchangeably on the same wires, and their relative proportions varied, and the same type of dynamo can supply them both, thus securing greater simplicity of plant.

Fifth.—Although all the lights and motors of such a plant would seldom and probably never be in use at once, the dynamo capacity should certainly be sufficient to supply them all simultaneously, not only because such a contingency might arise, but also because where absolute reliability is of such vital importance, there should be a considerable reserve capacity.

Sixth.—The use of only one kind of dynamo for incandescent light, arc light, and power, will greatly enhance the simplicity, flexibility and effectiveness of the plant. If a different kind of dynamo be used for each of these three purposes, not only will the operation of the plant be more complicated, but it will be necessary to have a reserve dynamo of each kind, making the capacity of the plant twice that actually required, whereas if all the dynamos are of the same type, a reserve of one dynamo, or one pair of dynamos (if on the three wire system) would be sufficient. Moreover, with three kinds of dynamos, it would be quite possible for all the dynamos of one kind to be disabled, thus entirely crippling that branch of the work, which might be the one most needed, while by the other plan, as long as a single dynamo remained fit for service, all kinds of apparatus could be operated, although the total amount of current would have to be kept within the capacity of that machine. It is not intended to recommend the habitual operation of motors and lights from the same dynamos, as the variation in voltage caused by the starting and stopping of the motors effects the steadiness of the lights; but the plant should be so arranged that this can be done when necessary.

In view of the above considerations it would seem that the best plant to fill the conditions imposed, would consist of direct current 110-volt dynamos, connected in pairs on the three wire system, giving 220 volts between the outside wires; one pair being used regularly to supply incandescent lights and arc lights of the constant potential type, the latter being connected in pairs across either side of the system, another pair supplying 220-volt motors on a separate circuit, and a third pair in reserve; switches being so arranged that any pair of dynamos can be thrown on any circuit, or all the circuits and all the dynamos thrown in together.

The relative merits of steam, compressed air, shafting, cables, water, and electricity for the distribution and application of power, are thoroughly and impartially presented. The superiority of electricity, under ordinary conditions, is now generally admitted. Concerning the successful operation of the guns and machinery of a fortification by electric motors, there can be little doubt. The street-railway and mining-machinery problems have presented more serious difficulties than are likely to be met with in fortifications, and these have been solved. Let the government say what it wants, and the electric companies will be ready to furnish and guarantee it. In this connection, however, one point should be emphasized. The working up of the details of any new application of electric power requires much time and study and most of the electric factories are so over-crowded with work equiping lighting, power, and railway plants, that is difficult for them to find time to design special applications of electric power. This work properly belongs to the officers of the army. They know what they want to do better than anyone else, and can work out the details of the gun-carriage, gearing, etc., ready for the motor. And in doing this, it would be well to visit the electric roads and factories and familiarize themselves with what is being done and the types and dimensions of motors in actual use, and then design their appliances as far as practicable to fit these motors. Motors which have done good service under a car or in a mine, will probably be equally satisfactory on a gun-carriage or shot-hoist or tram, and the utilization of such existing and tested types of motors will avoid not only the bugbear of special design but the danger of unforseen defects in new and untried types.

Professor *D. M. Greene*, C. E., Consulting Engineer, Troy, N. Y.—I have read, with great interest, the paper entitled "Electricity and the Art of War," published in U. S. ARTILLERY JOURNAL of October, last.

In this paper the writer has covered the entire ground so completely, and so thoroughly, that there seems to be nothing left for one to do but to congratulate him upon the thorough grasp of the subject, and the able and comprehensive treatment of it, which must be manifest, even to the casual or non-professional reader.

While endorsing, fully, his general conclusions, a single suggestion may be permitted, as follows: Would not the necessary plant be greatly simplified by the adoption of either hydraulic or pneumatic power for the operation of *ammunition hoists?* It seems to me that the necessary piping for these could be so far removed from possible danger from hostile projectiles, that they would be as secure and reliable as would be any part of the more exposed electrical installation.

Lieutenant *T. C. McLean*, U. S. Navy.—I regret very much that I have not been able to contribute properly to the discussion of Lieutenant Parkhurst's paper on "Electricity and the Art of War," in compliance with invitation to do so. I wish to say, however, that, in my opinion, there are no great electrical difficulties involved in carrying out the propositions made by Lieutenant Parkhurst, and also that there does not appear to be any good argument opposed to the adoption of the propositions in regard to the management, control and use of all of the electrical apparatus and the material operated by it.

The artillery officers are competent to perform the duties. The Artillery School affords facilities for any special instruction that may be needed.

The intelligent enlisted man could perform properly such work as would not require the constant attention of a commissioned officer; and, in addition, they would be trained artillerymen, available for service at the guns, or in any other duties of artillerymen.

Needless permanent assignments of certain duties to special classes of men, unnecessary departures from a uniform scheme of organization and performance of duties in concert, and interruptions in the natural sequence of authority for direction and control, are worse than useless in military establishments.

The search light is necessary to the proper defense of any fortified position, whether it is or is not subject to a naval attack. Under certain conditions it is capable of great service in operations in the field. In which case the search light outfit most naturally would go with, and be a part of, the field artillery. If the dynamos for field service were arranged to be worked by horse power, as has been proposed by foreign officers, the dependence on uncertain supplies of fuel and water would be avoided; and also the many derangements to which steam boilers and engines are liable when subjected to the rough usage unavoidable in field work.

In regard to who is to perform the duties of design and construction of the electrical apparatus and other material for army use, that is not a matter for me to discuss.

1st Lieutenant *C. D. Parkhurst*, 4th Artillery.—The very flattering manner in which this article has been received cannot but be both gratifying and encouraging to the writer. Thanks are due to all the commentators and critics for their great assistance in bringing this matter prominently into notice.

It is particularly gratifying to learn that the main ideas and suggestions contained in the article had already received thought and attention by those whose duty it is to provide us with the best system of sea-coast defense. We can therefore look forward to the time, which should not now be so very far distant, when we may see a modern gun mounted in a modern fort, and upon a modern carriage, provided with modern power for its manipulation.

If I may be allowed a moment for a side remark, I would say that it is very much to be regretted that some means of inter-communication of ideas does not officially exist. Until I saw General Abbot's statement in the October JOURNAL, I had no idea that any such consideration of electric power had been entertained; and, furthermore, knew of no one who did have any such knowledge: although I searched for information, certainly none was found on the subject. Any reports that may have been made were beyond my knowledge and reach, and I therefore wrote in utter ignorance of what was contemplated.

Now, would it not be a good idea if some means of imparting information from one department to another was officially adopted? Would it not conduce to harmony and unity of action if all those interested and who are writing were kept informed as to the desires and intentions of each separate branch of service in regard to the problem of our sea-coast defense?

We of the artillery are particularly interested in this matter. Upon us will fall the main brunt of sea-coast battle when necessity requires; we, and our sea-coast defense must stand or fall as we successfully or unsuccessfully man, handle, and defend the works and "tools of our trade" with which we have been provided by the labor and thought of the Corps of Engineers or the Department of Ordnance. We have no desire to usurp or acquire any of the duties pertaining to either service. The Department of Ordnance is making our guns, and making them well, as rapidly as the limitations of congressional appriations will permit, and we have, or should have, no desire to interfere with such manufacture. The Engineers are building our forts, and providing foundations for our gun-platforms and carriages, and certainly that is not the practical artilleryman's duty or proper function. Yet *we have got to fight with that with which we are provided*, and hence it would seem that we should be kept informed as to what that is to be, in the first place to enable us to look ahead and study up the requirements of successful service in regard to new apparatus with which we are to be provided; in the second to enable the service which has to put the "tools" to practical use, to study and investigate, and perhaps to suggest some ideas as to what we want, and how we want it.

It would seem to me that engineer, ordnance and artillery branches of the service are inseparable in this matter; we all must work for the common good, each in our proper sphere; life is too short, and time too precious for any of us to waste any of it in "plowing old ground," or in working without harmony and accord in every way.

With such an interchange would not the present tendency to exclusiveness and jealousy of ideas be removed? Would we not *all* be benefited by being brought closer and closer together and getting better acquainted? Would we not in the end be thereby compacted into one harmonious whole, each striving as best he might for the common good, independently of corps, department, or arm of service? When differences of opinion arise, as arise they must and will, should we not each be willing to "give a little, and take a little," and thus arrive at the inevitable "compromise" that attends *all* adjustments of human affairs, where the "greatest good to the greatest number" is sought? We should stop growling and grumbling and captious fault-finding. We should find out what we want (do we always know?) and then approach the matter in a rational, reasonable and reasoning spirit, ready to give credit where credit is due, ready to acknowledge difficulties and ready to try to overcome them, and ready to accept any valuable idea, no matter whence it comes.

To resume the question under discussion, if General Abbot will allow me, I would now explain my position upon the torpedo service.

Far be it from me, far be it from the artillery service at large, to try and create any heart-burnings, jealousy, or bitterness of spirit upon any question pertaining to our common service. Honest differences of opinion, honestly expressed should not do so, but rather lead to knowledge as to what is best for all. Though "silence may be golden" at times, an honest expression of views and opinions relieves one's mind, gives others new trains of thought, and perhaps leads to changes of opinion, or the correction of faults. When the best has been found, then all should work in hearty accord to further it in every way.

In the matter of torpedo service it would appear to me to be mainly a question of unity of service, of numbers ready to perform that service, to be prepared at all times with perfected *materiél* and instructed *personnel* in such numbers as the service may require. When needed, it will be needed in a hurry, judging from the suddenness of all modern wars; to quickly plant and to successfully watch, guard and manipulate the vast fields of mines that we must have would require a large force of well trained officers and men, to prevent that "failure" which "would be certain if officers and men without experience should suddenly be called upon to defend the coasts with mines." *

It is then, as said above, a question of numbers and previous instruction, rather than branch of service. It is a question of

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* Board on Fortifications—Report Committee No. 2.

unity of service rather than of comparative ability to perform the service. Granted that the calls that may be made upon us may be varied and multifarious in the modern system of coast-defense, are they any more so than those that will be made upon and must be met by the Corps and Battalion of Engineers? Our sphere is compartively limited, while that of the engineers must embrace the whole field. We will have harbors to defend and will be or should be separate and distinct from any field army and its campaigns, unless of course the field of operations embraces the districts that contain sea-coast works. The Engineers on the contrary belong to the *whole* army, and must be with it everywhere to aid and direct in the location and establishment of such field or siege works as may be required.

The questions then become, can Willets Point educate enough *engineer* officers whose services can be spared for torpedo service in time of war? Is the Battalion of Engineers large enough to provide all the men that will be needed for the multifarious duties *it* will be called upon to perform, *in addition to torpedo service?* If educated officers and men are needed as sappers, miners, and pontoniers for *general* operations, will there be "enough to go around" and provide other educated officers and men for the special torpedo service? Will not the demands be such that the torpedo service may "be left" in this distribution of talent, or, if provided for, only at the expense of some other equally important service?*

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* The Corps of Engineers embraces 117 commissioned officers and 500 enlisted men. These officers are in rank as follows:

1 Chief of Engineers—with rank as Brigadier General, 6 Colonels, 12 Lieutenant Colonels, 24 Majors, 30 Captains, 1 Battalion Adjutant, 1 Battalion Quartermaster, 26 1st Lieutenants, 10 2nd Lieutenants, 8 Additional 2nd Lieutenants.

The enlisted men comprise:—1 Sergeant Major, 1 Quartermaster Sergeant, 34 Sergeants, 34 Corporals, 8 Musicians, 210 1st class and 212 2nd class Privates. (See Army Register, Organization of Army.)

The Battalion of Engineers consists of 1 Major, 1 Adjutant, 1 Quartermaster, 5 Captains, 5 1st Lieutenants, 5 2nd Lieutenants. The enlisted men enumerated above comprise this Battalion. (See Army Register.)

The legal strength of the Battalion of Engineers is 5 companies of 150 men each. Its present strength is 18 officers and 437 enlisted men. The authorized strength of Cos. A, B, C, stationed at Willets Point, is 133 men each; of Co. E, stationed at West Point, 100 men.

The battalion has been employed during the past year at engineer, pontoon and torpedo drills, infantry drill, rifle practice, and photography. Co. E, at West Point, has assisted in

From the course that is being pursued it would look as though the fear existed that some of the above questions must be answered in the negative. Officers of cavalry, infantry and artillery, as well as engineers, are justly entitled to Willets Point for a course of instruction in torpedo warfare. As a matter of general education, or to fit them for special service with their own arms of service, this is to be commended. But, when war comes, are these cavalrymen, infantrymen and artillerymen to be detailed for torpedo service upon our sea-coast to make good any deficiency that may be found to exist in the numbers of the

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the instruction of cadets in military engineering and pontoon drill (see Report of Chief of Engineers, 1892. Page 19). Co. D, Battalion of Engineers, appears to be a shadow.

The post of Willets Point comprises 24 commissioned officers, and 353 enlisted men. At the U. S. Engineer School, "during the year 6 engineer officers, 2 cavalry, 1 artillery, and 5 infantry officers completed the course, and 7 infantry officers who have completed the laboratory work are still engaged in the practical work of planting and operating torpedoes, which it is expected will be completed October 1st, 1892." (Report of Chief of Engineers, 1892. Page 19.)

The commissioned officers of engineers were distributed as follows during the year 1892:

Commanding Corps of Engineers and Engineering Department	1.
Office of Chief of Engineers	3.
Board of Engineers, fortifications, river and harbor works and Division Engineer	1.
Board of Engineers, Board of Ordnance and Fortification, and Division Engineer	1.
Fortification, river and harbor works and Division Engineer	2.
Board of Engineers, Mississippi River Commission, Division Engineer and Board of Visitors	1.
Board of Engineers, fortifications, river and harbor works and Board of Visitors	2.
Washington Aqueduct, and light house board	1.
River and harbor works	33.
Fortifications and river and harbor works	30.
Mississippi River Commission and Missouri River Commission	1.
Fortifications, Post of Willets Point, U. S. Engineer School, and Battalion of Engineers.	1.
River and harbor works, and Missouri River Commission	1.
Public buildings and grounds, Mississippi River Commission, Missouri River Commission and Light-house Board	1.
Battalion of Engineers and U. S. Engineer School	14.
Mississippi River Commission	1.
Fortifications	1.
Missouri River Commission	1.
Leave of absence	1.
Detached service	20.
Total	117.

(See Report Chief of Engineers, 1892. Page 3.)

The artillery comprises:—5 Colonels, 5 Lieutenant Colonels, 15 Majors, 60 Captains, 5 Adjutants, 5 Quartermasters, 120 1st and 65 2nd Lieutenants, 5 Sergeant Majors, 5 Quartermaster Sergeants, 5 Chief Musicians, 10 Principal Musicians, 60 1st Sergeants, 260 Sergeants, 240 Corporals, 120 Musicians, 120 Artificers, 60 Wagoners, 2790 Privates, or total of 280 commissioned officers and 3675 total enlisted. (See Army Register.)

The stations and duties of the artillery cannot be given for want of data.

engineers? If so, who will supply the deficiency thus made in the cavalry and infantry? There will be no deficiency in the artillery, for torpedo service and artillery service can go on simultaneously. Will not the cavalryman and the infantryman be needed, and be fully occupied with their own arms of the service? Will not all their knowledge of torpedo service be valuable for field and land operations, in demolition and kindred work? If they are detailed for sea coast torpedo service will it not be at the expense of their proper arms of service, which must suffer from such loss? Will we be able to find cavalrymen and infantrymen who will willingly accept such work? And, if we do, will we not be "robbing Peter to pay Paul" in a most decided manner, to gain an end that can be accomplished much more easily and consistently?

I think it may be safely stated that every sea coast artillery garrison is equipped with boats, and has one or more boat's crews in regular training. If there are any that are not so equipped I do not know of them, while I do know of many that are.

So much of the training necessary is thus already established, and certainly men constantly on the ground at our sea-coast forts can be and are fully as familiar with all the details of channels, tides, shoals, &c., &c., as any other body of men who only know of them by the aid of charts.

Would it not be well then if, in addition to Willets Point, we had a school of application for torpedo service for the artillery alone? Would any harm be done if offcers and men of the artillery were to receive *practical as well as theoretical* instruction in mines, so that we would know the practice as well as the theory of "loading, connecting, watching, testing and firing?" Would money be wasted if we used a torpedo now and then, and thus learned by observation what "effects are to be expected?" Would we not, on the contrary, be fitting ourselves in advance for the performance of a legitimate and proper duty, a duty that circumstances may some day, in spite of all plans to the contrary, force upon us? This would add to our work, and to the demands to be made upon us; but if we are tried and not "found wanting" in the schools of Peace, we will be but more ready to respond to any and all of "the multifarious calls which will be made upon" us in time of War.

Now having expressed my views, and those of a large number of artillerymen at perhaps too great a length, let us in all harmony come to a conclusion as to what is best, and, when this has been ultimately decided, all accept it gracefully and labor honestly and faithfully for its accomplishment.

To touch upon another point, it was well known that experiments had been made for some years past at Willets Point with the electric search light. However much good these experiments may have done they have not as yet spread any great amount of information throughout the artillery service.

And in this arm, I respectfully submit, is where the knowledge and experience is needed for successful operations of sea-coast defense in time of war. The dynamo and general plant will have to be manned and supervised by artillery officers and men. Light for battery use must be under control of battery commanders, and, no matter how expert other specialists may be, we must have our own experts and specialists right at home and in our own service, and not be forced to depend upon others who doubtless would be able, and who would gladly give us their aid, but they "cannot serve two masters," or be in two places at the same time. Hence we need the outfit *right now* at some one, if not all of our artillery posts, to give the necessary instruction to train the specialists we need. When war comes we do not want to have many and multifarious duties suddenly thrust upon us. We wish to have time for preparation in order to be ready and able to respond to all demands.

In this connection let it be said that the defects of the search light as to fog piercing power are well known. The sun is often obscured by clouds and fog, yet we could hardly get along without him. Though the search light may not be able to penetrate through fog, it yet has a vast field of usefulness for sea-coast defense, and no fort should now be considered as properly equipped until it has one or many as the case may demand, the same as with our battle-ships and cruisers.

As to the size of the units of power, doubtless the modern tendency in the commercial world is to larger and larger engines and dynamos, capable of supplying large amounts of power, or maintaining a large number of lights, at an economy not dreamed of in the beginning. Yet it is within the knowledge of the writer that this has sometimes proved of very doubtful expediency. So long as everything runs smoothly, well and good; but when an engine breaks down (and they will sometimes), serious trouble results from the cessation of power or light over large districts, with no spare engines ready to put to work to supply the demand.

We must then be careful not to have all of our eggs in one basket; we should so install our plant as to be able, with spare engine or engines, and spare dynamos, to replace any disabled part at once, and thus insure certainty and constancy of action at all times during an engagement. Ships of war and merchant steamers now have twin and some triple screws each with engines complete, not only for the greater power, but also for greater safety. We too should provide against all contingencies, leaving the matter of mere economy as of secondary consideration.

As to waiting for something better than we now have before making a start: granted that what we now have is far from perfect, when will it be so perfect that further improvements will not be made? *When are we to begin*, now, or at some distant day? If we wait for any time short of the millennium, will we then have any guarantee but that we might have done better by *waiting just a little longer? I say we want to begin right now*, just as we have with guns both large and small, without further delay or further improvement. We have sat with folded hands long enough and we need to wake up and get to work with what we now have, and have a hand in developing improvements in our own special line, so as to be ready for the time when our guns, carriages, and forts are ready for their full use.

It is not so long since our navy had no ships worthy of the name. Such ships as they had were lighted in the old way. Yet they made a beginning, and to-day we have a "White Squadron"*

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* Report of Secretary of the Navy, 1892.

constantly growing in size, the vessels of which are now all lighted by electricity as a matter of course.* It cannot be claimed that constant improvement has not been made in ship building and in marine electric light plants. Yet the first ship and the first electric light plant are by no means obsolete. Even if they are they can well be relegated to the scrap-heap, having paid for themselves many times over from the practical demonstration of the possibilities that they have afforded. To-day in the electrical world we have dynamos, engines and the details of wiring and installation that possibly never would have existed except for the demands made upon inventors by the necessities of the marine electric light plant. The *Trenton's* plant showed the defects, the necessities as well as the possibilities, and we need a first plant as soon as we can get it to demonstrate defects, necessities and possibilities in a similar measure.

And are we as badly off for means of application as would at first appear? Have we no guns, carriages or forts that can be utilized? Let us turn to statistics and look for a moment and find what we have, and what we soon shall have.

GUNS ON HAND.

Rodman guns, smooth bore, two 20-inch, three hundred and eight 15-inch, nine hundred and ninety-eight 10-inch and about two hundred and ten 8-inch converted rifles,† to say nothing of the one hundred 200 and 300-pounder Parrotts.

These guns are not obsolete, for "some of these smooth bore and rifled guns will be used to defend the torpedo lines, and the remainder may be attributed to existing forts and batteries, as well as to ports not mentioned in the foregoing report."‡

To mount these guns we now have on hand 136 altered 10-inch carriages for service with 8-inch C. R.; sixty 15-inch carriages for 15-inch guns, using increased charges of powder.§ These carriages are being altered and strengthened yearly in limited numbers for use with the above guns for secondary battery. The

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* Electricity on Board Warships. Annual of the Office of Naval Intelligence, 1892.

† Report of Endicott Board 1886, page 20.

‡ Ibid.

§ Report of Chief of Ordnance 1892, page 17.

field of usefulness of these guns and carriages may have become restricted, but it is not yet extinct, and we may just as well recognize the fact and shape our course accordingly. There is much yet to learn that can be taught by the proper use of these guns. When we have learned all they can teach it will then be time for us to give exclusive attention to the 8, 10 and 12-inch high powered rifles of modern character.

Besides the above we now have or soon shall have fifteen 8-inch guns, eight 10-inch guns and three 12-inch guns, together with forty-four 12-inch cast-iron steel hooped mortars.* Thirty-seven of these mortars have already been delivered (October 21st, 1892) to the government.† For these mortars the Builder's Iron Foundry has delivered the first carriage under its contract, and "work on the remainder is so well advanced that the entire eight carriages should be completed by the end of 1892."‡

Now with all this material on hand shall we consent to wait? Shall we quietly sit by and "take another nap" while we are waiting for a perfect dynamo, motor, engine and installation to be developed? If we do consent to wait we may wake up and find something more surprising than ever greeted Rip Van Winkle after his sleep, as our slumbers are disturbed by a hostile fleet knocking at our doors with no timid touch. No! We have waited long enough! We have worn out enough trowsers sitting around, and we need to wake up, off with our coats and go to work; to insist upon having such tools of our trade as are available, and to put them all to use to learn their capabilities and defects, and with them to develop all the improvements possible in the application of power for their speedy use.

No fort is really needed in order to experiment with and develop our appliances. We can set up a gun anywhere and use it, and thus find out what the fort as well as the power must be. Our engineers are not idle. Work is going on at New York, Boston, San Francisco and Hampton Roads. Sites for forts are being enlarged and secured as rapidly as legal questions and

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* Report of Chief of Ordnance, 1892.

† See "Our Share in Coast Defense" Part I, Builders Iron Foundry.

‡ Report of Chief of Ordnance, 1892.

limited appropriations will permit.* Before we are fully awake we will have forts, gun carriages and guns, and these will be with or without electric power, depending to a great extent upon our desire and demands for *immediate* installation.

It is evident that some ideas exist looking to the utilization of alternating currents of high voltage from points of generation and distribution far remote from our works. Though the possibility is recognized and granted, the advisibility of such a project may well be questioned.

Our forts should be as self contained as possible. We should be independent of any outside aid or resource for our power and its application. We should be able to control its generation as well as its distribution, and not be liable to be cut off from it by any sudden dash of raiding parties, purposely sent out to cut wires and isolate us. We should use currents that are safe and harmless, as is most concisely stated by Mr. Hale, and not introduce any man-killing or demoralizing element, for we may have enough of that from the shells of our enemy. All of these reasons and many others, point to the use of direct currents for low voltage and large ampereage, such currents as are now to be had for the asking, without further investigation or development.

Lieutenant Hutchins strikes a key note when he says "that if a proper electric plant were installed in some of our important forts, that the government would be repaid even were they never used for other than purposes of instruction of officers and men." That is just what we want, what we must have, if we are to be ready to do our full duty in the event of war. It takes time to learn new duties. We cannot expect to succeed at many things we may be called upon to perform unless we are given a chance for study, practice and preparation. Duties that might be hard; in fact impossible, when suddenly thrust upon us, become easy and as a matter of course with such study and preparation as might be given to them by a little forethought. With such a plant the full possibilities and capabilities of both the light and power would become familiar to many ; we would be training our experts to be ready to serve us in time of need ; we soon would

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* Report of Chief of Engineers, 1892.

have confidence in ourselves in ways and methods now unknown, and would have nothing new and untried staring us in the face to add to our labors, to our need for knowledge, to make us afraid or to disconcert us at a time when we would if ever need the full use of all of our powers to enable us to perform our full duty.

In this connection the remarks of Lieutenant Squier as to the speedy training of experts is exceedingly to the point. We need them and we need them badly. It would be a wise policy on the part of the government if it would begin to recognize the fact that all of us may possibly become "jacks at" but not *masters* of "all trades." I doubt the ability now for the first proposition; certainly we are not all universal geniuses; yet each officer probably has one, perhaps two or three well recognized abilities and characteristics; these should be developed to their utmost capacity, when they are such as to be of any possible use use or benefit to the service. Then we soon should have our work done well in every department, by experts in that department, instead of being done sometimes very indifferently, as is now too often the case.

If the government would but allow it, there is no doubt that many of our officers would gladly avail themselves of all advantages as to special courses of study that might be offered, either at the schools of learning of the country or at our post graduate military schools. There are plenty of "willing horses" ready to make themselves as fully proficient and expert as education and practice can make them; some are doing so, as best they can by their own efforts; none within my knowledge are "shirks" seeking "soft snaps" to rid themselves of routine military duty. On the contrary they are eager for honest whole-souled *work*, work that would pay the government "an hundred fold" in the zeal and intelligence that these specialists could and would bring to bear upon any tasks that might be given them, for which they had become or were becoming specially fitted.

It is impossible, without going to too great a length to notice all the comments that have been made, or to try to reconcile all differences of opinion. It is impossible also to outline or define a full plan for the use of power of our guns. Many things that none of us have now thought of may be developed as experience and trial tests the general subject. It may be that in some cases a combination of electric, pneumatic or hydraulic power may be advisable. As a general proposition however it is the writer's opinion that the power should be uniform and simplified, in the generation and application in every conceivable way. Thus in these cases where hydraulic or pneumatic power is not called for imperatively by the nature of the mount and electric power can do all the work, there should be no combination. While pneumatic or hydraulic power is imperative, as may be the case with some types of disappearing mounts, then perhaps it can be applied for *all* purposes, for shot hoists, for training and elevating as well as for raising or lowering the gun, platform or carriage. We then would not have double power plant or double installations, but one plant for all work.

In closing this discussion I would now submit the following proposition:

It should be evident that the time has come for "deeds and not words." We have guns, gun-carriages and platforms in plenty of old model, still useful for secondary batteries, and we also have a few guns, mortars and carriages for the latter of more modern type.

We have an Artillery School that, no matter what its faults, has yet many merits. It is striving in the face of many adverse circumstances to be of benefit to us all. We should therefore try our best to give it a helping hand and to make it what it should be, the source from which we are to get the latest and the best of everything pertaining to our service.

To this school every two years a class is sent for special instruction. At this school should we not then put up a complete trial plant? Aside from its importance in a strategic sense, is it not one of, if not *the* most important of all of our forts?

Here guns and mortars are in time to be mounted as a part of our sea-coast defense. Here secondary batteries are to be erected for the protection of mine fields. Here mine fields are to be planted in the event of war. Work is already being done; but here it is contended is where—*first of all*—a *full* equipment of *all* guns should be allotted and installed. Here, *first of all*, should electric search lights, incandescent lamps and the application of electric power be attempted, and experiments and trials be made looking to its full use and development for any and all our forts.

With such a plant practical and theoretical instruction in the use of this power and these guns would be the soonest spread amongst the greatest number. As classes come and go, every two years would see a certain number of trained experts, ready to spread their knowledge wherever they went, ready to take hold and do expert work whenever and wherever needed, in the installation of similar plants elsewhere, or in the grim ordeal of battle that may come to test our works.

On the other hand if San Francisco, Boston or New York each receive its quota of guns and perhaps a power plant to work them, leaving Fort Monroe until one of the last, will there be the same possibility for a solid and thorough dissemination of knowledge? True enough *the local garrison at each fort* will be more or less instructed; but who else? Unless these forts are made special schools of instruction in addition to Fort Monroe, only that small part of the artillery stationed at these forts would ever receive instruction; the rest of the artillery stationed for years at small and perhaps obsolete works or garrisons, that will never receive a modern equipment, others at other works that will not be equipped for years, would be wholly uninstructed, the length of time necessary to "make the rounds" by regular changes of station precluding the idea that any general instruction could ever be given. The majority might therefore remain in entire ignorance of how a modern gun looks, to say nothing of how it should be handled. They might remain wholly uninstructed in anything pertaining to electricity in any of its applications to the art of war.

In the writer's opinion Fort Monroe and the Artillery School can be made the salvation of the artillery service. As I understand the question it is not necessary to wait for any legislation to accomplish this. The Board of Ordnance and Fortification has but to make an allotment of money for the purpose, and there is authority to say the word and it could be soon put in a condition such that all might look to it for the latest and best principles, instruction and practice relative to our service. Here then our experts could be trained; here should everything required for such training be centralized; here it should and could be possible for the experts and the specialists to pursue special courses of study, so as to fit themselves for the full use of Electricity in the Art of War.

THE ARTILLERY-FIRE GAME.

An introduction to the applicatory study of the firing regulations, and an aid to the acquirement of familiarity with the practical effects of fire. By H. ROHNE, Colonel, commanding the Schleswig Field Artillery Regiment No. 9.

TRANSLATED BY FIRST LIEUTENANT JOHN P. WISSER, FIRST ARTILLERY, U. S. A., 1892.

PREFACE.

The new firing regulations for the field artillery contain the important direction that each and every lieutenant must be instructed so as to be able, independently, to conduct the fire of a battery. A number of the lieutenants will go into the field at the head of batteries even at the outbreak of a war, on account of the reorganization that must necessarily take place and the consequent formation of new subdivisions; but, in consequence of the great and ever increasing losses, a much greater number will probably have to take command of batteries under the most unfavorable circumstances imaginable, in the hottest part of the conflict with an equal adversary. Woe to him then, who is not fully competent to fill the position which the fortune of war has assigned to him! On his knowledge of firing may depend not only his honor, but also the very existence of the battery, nay, even the result of the battle.

The increased importance of these requirements make it necessary, however, that the instruction of the officers in firing be not entirely confined to the artillery practice. The time devoted to this is too short; every day makes too great a demand on the individual officer as it is; so much so, indeed, that it may be said that only he who appears on the firing ground fully prepared beforehand, will be enabled to reap the proper benefit from the firing practice.

From his experience of many years as instructor at the Artillery Firing School, the author is of opinion that he can offer his comrades in the following proposed scheme a means whereby complete mastery of the application of the firing regulations—and this is next to correct observation the most important point—may be acquired. The method here proposed, when once it has become familiar, is remarkably simple, and in the course of the past winter was actually applied in all the subdivisions of the regiment under the command of the author, without any difficulty whatever being experienced, and everywhere with uniformly good results. A part of the evenings usually given up to professional meetings or to *Kriegsspiel* was devoted to these applicatory exercises—which can best be designated an "artillery-fire game."

This artillery-fire game can also be used with advantage at the war schools (*Kriegsschulen*) in the special instruction of artillerists, but more particularly at the Artillery School, and perhaps with certain changes at the battalion firing-schools of the heavy artillery.

A great advantage of this system of play lies in the fact that it is possible to gradually increase the difficulties or obstacles in the way, and thus introduce ever new and more interesting situations. The complete mastery of the firing regulations which may thus be acquired will permit of making the actual firing practice really useful, particularly by thus enabling the officers to perfect themselves in the difficult art of observation.

It may be remarked in passing, that in the French as well as in the Russian artillery similar exercises are prescribed. The French call them "Tir simulé," the Russians have the artillery game of Muratow. My proposed scheme originated quite independently of these systems, which, so far as I know, are limited to firing with shells and are not so carefully worked out in the details.

Rendsburg, December the 20th, 1890.

THE AUTHOR.

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* *Sprenggranaten*, shell charged with a quick-burning (brisant) explosive and furnished with time fuses. J. P. W.

INTRODUCTION.

The art of conducting properly the fire of a battery rests entirely on correct observation and the skillful application of the firing regulations. While the former can be learned only by continued practice on the firing ground, the proper application of the firing regulations—at least up to a certain point—can undoubtedly be learned without the use of ammunition. It is only necessary to imagine a target, at which the firing is directed, to assume the determination, by observation, of a fixed target distance and the corresponding range ordered,* and on these to base corrections in conformity to the firing regulations.

Such exercises in application are remarkably useful means of instruction, indeed they are quite indispensable; for without them it is quite impossible to obtain a clear mental picture of the subject, and without a clear mental picture it may be possible to comprehend the letter of the firing regulations but not their spirit. And yet is the latter quite necessary; for success does not belong to him who follows the firing regulations blindly, but to him who thoroughly grasps their significance.

As a rule such exercises are undertaken during the gun drill, at which the commanding officer, acting as instructor, imparts the results of the observation of the shots to the battery commander or other officer. But such exercises suffer in two ways. In the conditions imposed it is almost always assumed that the shot fired will strike the centre of impact. All possible dispersion of the shots is entirely neglected, and yet, even assuming *correct* observation, this may considerably interfere with striking the target. On the other hand the observations are also usually taken to be correct. By this method the officer does not learn how to tell in firing whether mistakes have occurred in the service of the piece or false observations been made, nor how such errors can be rendered without effect in the quickest and best way. Of course, as long as the object is simply to

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* Thus, if the distance to the target, as determined by observation is 2813 meters, the battery commander would probably order the range 2800 to be used.—J. P. W.

teach the officer the first principles of the firing regulations this is not a matter of any great importance.

In the following pages will be shown how, in a very simple manner—"in play" we might say—without any great effort both these factors (dispersion and uncertainty of observation) may be taken into consideration.

I. THEORETICAL FOUNDATION OF THE GAME.*

A. PERCUSSION SHELL.

When a shot is fired at a fixed elevation, it cannot be known just where in the horizontal diagram of hits that would be made by the continuation of the firing under exactly the same conditions, it would strike. Whether the shot fall short or over, whether it be little or far removed from the centre of impact, appears to us to be a matter of chance, and quite the same chance as that, out of an urn containing a hundred chances, numbered from one to one hundred respectively, the number drawn at any time will be under or over fifty. Indeed. the decision of this point, whether the shot will fall short or over, in the horizontal target may be left to chance. Evidently the chances for either a short or an over shot are even, and it would therefore be perfectly proper to take any chance number from one to fifty to represent a short shot, and any over fifty as an over shot. This would not, of course, determine how far a shot is removed from the centre of impact. But even that may be left to chance. If the number drawn is near fifty a slight deviation is assumed, if far from it a large one. Such assumptions be it remarked, are in accord with the probabilities in the case. The absolutely accurate determination of the deviation (longitudinal) of a shot is not at all necessary, it is more than sufficient if it be estimated to within five metres.

Let us take a horizontal target, laid out in zones five metres wide, by passing lines perpendicular to the projection of the line of fire, and symmetrically arranged with respect to the centre of impact (see Fig. 1). Now if we know the probable deviation of the shots, the probability of striking any one of these zones can be readily calculated.

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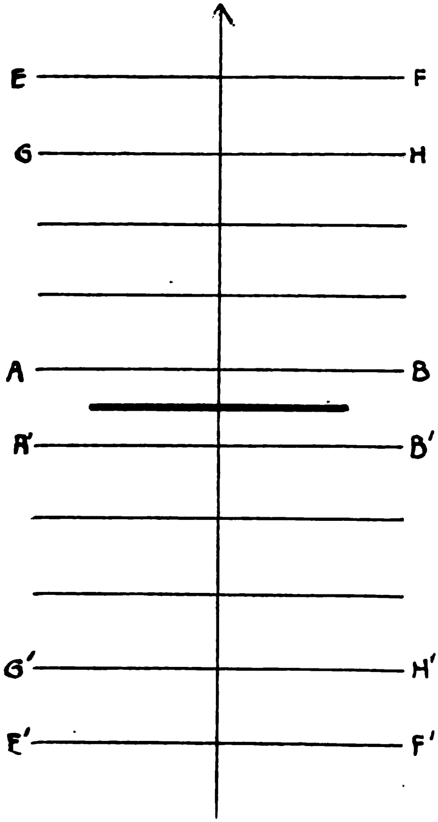
* The knowledge of the theoretical foundation is not absolutely necessary for the correct application of the game. It shows, however, that it is based on true principles.

Fig. 1.



The zone *A B A' B'* for example, five metres wide, lying on either side of the centre of impact, receives, if the probable longitudinal deviation amount to 2.5 metres, 50 per cent. of the hits. If the probable longitudinal deviation increase to 10 metres, the probability of hits falls to 13.5 per cent. ;* for the probability factor is $\frac{5}{2 \times 10} = \frac{5}{20} = 0.25$, corresponding to 13.5 per cent. hits.

To calculate the probability of striking the zone *E F G H*, we must first determine how many hits will fall in the space *G H G' H'*, then how many in the space *E F E' F'* ; half the difference of these two numbers will be the percentage of hits in the space *E F G H*.

Example. — Probable longitudinal deviation 15 metres. What is the probability that a shot will strike short at least 17.5, but not over 22.5 metres—20 metres in the mean then?

The probability of striking a target 45 metres (2 × 22.5) wide is first calculated. Probability facter, 45 : 15 × 2 = 45 : 30 = 1.5 ; probability of striking, therefore, 68.7 per cent. Then the probability of striking a target 35 metres (2 × 17.5) wide is calculated. Probability factor, 35 : 15 × 2 = 35 : 30 = 1.17 ; prob-

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* See Text-book of Gunnery, MacKinlay, page 120, and Handbook of Problems in Direct Fire, Ingalls, page 202, *et seq.* Probability factors, $\frac{5}{2 \times 2.5} = \frac{5}{5} = 1.$ corresponding to 50 per and $\frac{5}{2 \times 10} = \frac{5}{20} = 0.25$, or 13.5 per cent. J. P. W.

ability of striking therefore, 57 per cent. Half the difference is $\frac{1}{2}$ (68.7—57)=5.8 per cent. The probability that, in case of a probable longitudinal deviation of 15 metres, a shot will strike in round numbers 20 metres (not less than 17.5 and not more than 22.5) short is, therefore, nearly 6 per cent. Exactly the same degree of probability holds for a shot striking over by that same amount. The probability that a shot will strike 20 metres short (or over) is, therefore, exactly the same as that, in 100 chance numbers any *one* out of six pre-determined numbers, *e. g.* 17, 18, 19, 20, 21 or 22 (79, 80, 81, 82, 83 or 84) will be drawn.

It may, therefore, readily be calculated with what probability a shot will strike, in round numbers, 0, 5, 10, 15 metres etc., short of or beyond the centre of impact, when the probable longitudinal deviation is known.

From the firing table—accuracy of fire in case of percussion shells—it is seen that the probable longitudinal deviations increase with the range, but very slowly, so that for the actual battle ranges (1500 to 3500 metres) they may be taken as nearly equal to 10 metres. In firing in actual battle such small deviations cannot be counted on; and experience, moreover, teaches that even under ordinary circumstances in target practice they are in reality more than twice as great, on the average 25 metres. The reason for this is that the firing tables are calculated for the most favorable conditions—carefully prepared ammunition, fair weather, good service—but above all, on the supposition that the firing is all done by but a single piece. All these conditions are changed in the actual firing by troops in the field; the deviation of a battery of six pieces, the centres of impact of which never coincide, is naturally always greater than that of a single gun. As this is felt even in simple practice firing, it will be much more apparent in the field manœuvres, not to mention firing in actual battle at all.

We will not, therefore, make any great mistake if we take the probable longitudinal deviation of projectles provided with per-percussion fuses, under ordinary circumstances, as 25 metres: under particularly favorable circumstances it may possibly fall to 15 metres, under very unfavorable it may rise to 35 metres. On the basis of these assumptions the deviations of percussion shell, given in the columns *A*, *B* and *C* of Appendix 1, were computed.*

Every lottery number drawn corresponds then, to a particular deviation of a shot from the centre of impact, as indicated in columns *A*, *B* or *C*, in which it is assumed that the centre of impact lies at a distance from the battery equal to the range ordered by the commandant.

The distance of the target, say, is 1980 metres. If in a supposed practice firing, the range at which the firing is ordered to be conducted is 2000 metres and the lottery number 22 is drawn, this indicates that under ordinary circumstances—column *B* of the table—the shot will fall 30 metres short. It strikes consequently at 1970 metres, or 10 metres *in front of* the target. Had the lottery number 60 been drawn, it would have indicated that the shot went 10 metres too far, *i. e.* it struck at 2010 metres, consequently 30 metres *beyond* the target. On the supposition of specially favorable dispersion conditions on the one hand, or unfavorable on the other, the lottery number 22 would indicate that the shot went in the former case 20 and in the latter 40 metres too short, consequently it would strike in the former case just on the target and in the latter 20 metres in front of it; the number 60 on the other hand, would indicate that it went 5 metres too far in the first case, 15 in the second, consequently it would strike 25 metres *beyond* the target in the former case and 35 in the latter.

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* From the data of the firing of the 3.2-inch gun at Sandy Hook—Report of Chief of Ordnance, 1887, page 99 (8 shots). the probable deviation (in range) at 5280 feet is about 19.3 metres; from data of firing at Ganahl, Texas, Lieutenant E. Russel, 3rd Artillery—Journal Artillery, No. 2, page 112, at 4500 feet (12 shots) it is about 23.7 metres; from same report at 5280 feet (20 shots) it is about 17.6 metres; and at 6150 feet (19 shots) it is about 21.2 metres, or an average of 20.4 metres. Evidently, the data of the table (Appendix I) as regards percussion shell, may be used for our gun, the probable deviation under the most favorable circumstances being there taken as about 15, under average circumstances as 25, and under unfavorable circumstances as 35. The above number 20.4 is determined under *rather* favorable circumstance (a single gun being used in each case) but certainly not under the most favorable, so far as weather and other conditions are concerned. J. P. W.

B. SHRAPNEL.

The representation of the deviations of the points of explosion from the mean point of explosion in firing with time fuses is not quite so simple as the representation of the deviations in firing with percussion fuses. The reason is that in the former case the deviations must be reckoned in two directions, longitudinally and vertically, while with percussion fuses deviations in only *one* direction are considered. Were the deviations of the points of explosion in the two directions, longitudinal and vertical, independent of each other, as is the case, for instance, in a vertical target with the vertical and lateral deviations, the horizontal target on which the points of explosion are projected, since the deviations are known from the firing table, could readily be divided into one hundred rectangles, each of which would receive one per cent. of the points of explosion.* But this method is not applicable, because, as is readily seen, a shot, the fuse of which burns 30 metres too short, the distance of the point of explosion of which from the target will therefore be 30 metres greater than the average, will in all probability have also a greater height of explosion than one, the fuse of which burns correctly or indeed even too long. For this reason the data of the firing table relating to the dispersion of the points of explosion, cannot be adopted without some modification.

A further difficulty exists in this, that the law according to which the grouping of the points of explosion over the horizontal target takes place is not known. To arrive at a result, which shall be practical at least in a degree we must make certain assumptions, which cannot of course claim perfect accuracy, yet are very near the truth.

Undoubtedly the dispersion of the points of explosion is a consequence of the varying behavior of the fuses, and the differences in position of the trajectories of different shots. The *longitudinal deviations* (in range) are influenced by the varying behavior of the fuses in different shots as well as by the different velocities of the projectiles; while the differences in

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* Compare Rohne: "Das Schiessen der Feld-Artillerie," page 33.

elevation are of but slight effect in this particular. On the other hand variations in the *vertical deviations* (heights of the points of explosion) are caused of course by variations in the longitudinal deviations, but in addition to this cause and quite independently thereof, they are due to the different positions of the separate trajectories.

When, for instance, at a range of 2000 metres—angle of fall $6\frac{4}{16}°$—a fuse burns 30 metres too short or too long, as the case may be, the point of explosion will, in the normal trajectory lie $30 \times \text{tang } 6\frac{4}{16}° = 3.4$ metres higher in the former case, lower in the latter, than the normal point of explosion. Now if the trajectory also varies from the normal, the point of explosion will naturally also rise or fall corresponding to the higher or lower position of the trajectory.

Hence it will be possible to represent the grouping of the points of explosion on the target in a manner approaching reality in case the following are known:

1. The probable longitudinal deviation of the points of explosion from the mean point of explosion.
2. The probable vertical deviation.
3. The angle of fall.

For a range of 2000 metres, for instance, the probable longitudinal deviation of the points of explosion is 17 metres, the probable vertical deviation 0.95, or in round numbers 1 metre, the angle of fall $6\frac{4}{16}°$.

We can calculate now—exactly as we did in case of firing with percussion fuses above—what per cent of all the points of explosion will have a longitudinal deviation of 0, of + or — 5, 10, 15, &c., metres from the mean point of explosion.

For the range 2000 metres (probable longitudinal deviation 17 metres) this calculation gives:

8 per cent. of the points of explosion will have a deviation of 0 metres.*
8 per cent. of the points of explosion will have a deviation of + and — 5 metres.†

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* Calculations are made to within 5 metres only, so that this means up to 2.5 metres, and the zone will be 5 m. wide. $\frac{5}{2 \times 17} = \frac{5}{34} = 0.15$ as probability factor, giving 8 per cent. J. P. W.

† 7.5 metres deviation, zone 2 times 7.5=15 m. wide. $\frac{15}{2 \times 17} = \frac{15}{34} = 0.45$, as probability factor, giving 24 per cent. 24—8 16 . $\frac{16}{2}$=8 per cent. in the zone +2.5 to +7.5 and 8 per cent. in the zone —2.5 to —7.5 m. For assistance in regard to every point in this paper relating to probabilities, I am much indebted to 1st Lieutenant F. S. Harlow, 1st Artillery. J. P. W.

7 per cent. of the points of explosion will have a deviation of + and —10 metres.
7 per cent. of the points of explosion will have a deviation of + and —15 "
5 per cent. of the points of explosion will have a deviation of + and —20 "
5 per cent. of the points of explosion will have a deviation of + and —25 "
4 per cent. of the points of explosion will have a deviation of + and —30 "
3 per cent. of the points of explosion will have a deviation of + and —35 "
2 per cent. of the points of explosion will have a deviation of + and —40 "
2 per cent. of the points of explosion will have a deviation of + and —45 "
1 per cent. of the points of explosion will have a deviation of + and —55 "
1 per cent. of the points of explosion will have a deviation of + and —65 "
or over.

Since the angle of fall is $6\frac{4}{16}^\circ$, all points of explosion which lie short of the mean point of explosion (the deviation of which points therefore, will be negative) would have, were there no variatians in the trajectories, a greater height of explosion, all points of explosion which lie beyond the mean point of explosion a less height of explosion than the mean. If A represent the deviation, ε the angle of fall, the difference in the height of explosion would be $A \tan \varepsilon$. If we place the height of explosion for the mean point $= 0$, the height of those shots which have a longitudinal deviation of ± 15 metres will be, as an average, $\mp 15 \times \text{tang } 6\frac{4}{16}^\circ = \mp 1.7$.

In consequence of the vertical dispersion of the trajectories, however, one-half the points of explosion will lie higher than that corresponding to the normal trajectory, one-half lower. By the assistance of the method already employed on several occasions, it is possible to calculate what per cent of all the trajectories coincide with the normal trajectory, *i. e.* lie not more than 0.5 metre vertically away; also how many are ± 1, 2, 3 metres away. In case of a probable vertical deviation of one metre, the calculation shows that:

26½ per cent. of all trajectories coincide (practically) with the normal.

21 per cent. of all trajectories deviate ± 1 metre vertically.

11 per cent. of all trajectories deviate ± 2 metres vertically.

4 per cent. of all trajectories deviate ± 3 metres vertically

1 per cent. of all trajectories deviate more than 3½ metres vertically.

If, as we saw, out of 100 points of explosion some seven have too great a distance for the point of explosion from the target by about 15 metres, hence in the mean, a height of explosion of +1.7 metres referred to the mean point of explosion, then 26½ per cent. of these, in all, therefore 7×0.265=1.85 will have a height of explosion of nearly +1.7 metres.

21 per cent. or 7×0.21=1.47 a height of explosion between +2.2 and 3.2.
11 per cent. or 7×0.11=0.77 a height of explosion between +3.2 and 4.2.
4 per cent. or 7×0.04=0.28 a height of explosion between +4.2 and 5.2.
1 per cent. or 7×0.01=0.07 a height of explosion over 5.2 m.
21 per cent. or 7×0.21=1.47 a height of explosion between +1.2 and 0.2.
11 per cent. or 7×0.11=0.77 a height of explosion between +0.2 and—0.8.
4 per cent. or 7×0.04=0.28 a height of explosion between —0.8 and—1.8.
1 per cent. or 7×0.01=0.07 a height of explosion below —1.8.

As it is a question only of probabilities and not of exactness, and as the heights of explosion can only be recorded in entire metres, it may be assumed that of the seven shots, the explosion distance of which from the target is greater than the mean by 15 metres in round numbers.*

1 will have a height of explosion differing from the mean by + 4 metres.
1 will have a height of explosion differing from the mean by + 3 "
2 will have a height of explosion differing from the mean by + 2 "
2 will have a height of explosion differing from the mean by + 1 "
1 will have a height of explosion differing from the mean by — 1 "

In this number the data under *E* in the appended table (see Appendix I) are obtained. A similar method is applied to compute the data under *D* and *F*, in which the figures of the firing

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* For the range 2000 metres for our own gun (3.2-inch), the angle of fall as given in the table computed by Major John I. Rodgers (Artillery Memorandum No. 2, 1892, pages 14 and 15) is 5° 10′ 08″ (I. V. 1608, φ 3° 48′ 28″); as determined from the firing practice at Ganahl, Texas, August 1891 (Journal Artillery, April 1892). it is 4° 49′ (I. V. 1595, φ 3° 20′) or as an average about 5°, somewhat less than the German.

Assuming this as correct, the above table becomes by calculation of the probabilities.

1 will have a vertical deviation of + 3 metres.
2 will have a vertical deviation of + 2 metres.
2 will have a vertical deviation of + 1 metre.
1 will have a vertical deviation of + 0 metres.
1 will have a vertical deviation of — 1 metre.

So that the probabilities are very little changed, if we remember that the "3 metres" above is really 3.3 and the "4 metres" in the text is really 3.7 being rounded off to entire metres. In the absence of reliable practical data giving the dispersion of the points of explosion of time shell or shrapnel, it appears that these tables (Appendix I) may also be used for our field gun. J. P. W.

table for the ranges between 1000 and 3000 metres served as a basis for computation.

Appendix II gives two horizontal projections of 100 points of explosion at 2000 and 3000 metres range respectively, the examination of which will, it is hoped, assist the comprehension of the method just developed.

Whereas, for firing with percussion fuses, the three columns given in the table, though good for all distances, apply to different degrees of dispersion, in case of shrapnel the three columns are intended for different ranges. The data under *D* can be used approximately for ranges from 300 to 1450 metres; those under *E* from 1500 to 2500 metres; those under *F* from 2550 to 3000 metres. Naturally the data apply with greater accuracy the more nearly the range coincides with that on which the calculation was based.*

The data of the table have reference, as stated, to the deviation of the separate points of explosion from the *mean* point of explosion. It is therefore necessary to determine the position of this point with reference to the target. Evidently it is dependent on the actual range as well as on the range given or ordered, and finally also on the behavior of the fuse. In case of *normal* behavior of the fuse the mean point of explosion lies 50 metres in front of the target, when the range given or ordered and the actual target distance are one and the same. Any difference between the two naturally enlarges or reduces the distance of the mean point of explosion from the target. The height of explosion is taken from the firing table, but only in entire metres..

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* Whoever carefully tests the data under *D*, *E* and *F* will find that the dispersion of the points of explosion, in comparison with the heights, exceeds the data of the firing table by a not inconsiderable amount. This is true for instance for the ranges 2000 and 3000 metres. The probable deviation of the points of explosion in height, calculated according to the data of the table at 2000 metres is about 2.15 metres, for 3000 metres as much as 4.9 metres, whereas the firing table gives for the probable deviations in height 1.55 and 2.7 metres respectively. I consider the latter as too favorable; the probable deviation in height of the points of explosion must, according to my view, be *at least* equal to the product of the probable longitudinal deviation by the tangent of the angle of fall, *i. e.* for shrapnel at 3000 metres, 20 times tangent 12° 8′ = 4.3 metres. The proof of the correctness of my view would lead me too far into detail.

EXAMPLES.

Target distance 2000 m., range ordered 2000 m., point of explosion $\frac{-50}{6}$.

Target distance 2020 m., range ordered 2000 m., point of explosion $\frac{-70}{6}$.

Target distance 2020 m., range ordered 2050 m., point of explosion $\frac{-20}{6}$.

Target distance 2020 m., range ordered 2100 m., point of explosion $\frac{+30}{6}$.

The deviations given in the separate columns and corresponding to the different lottery numbers, are referred to this position of the mean point of explosion. By adding algebraically the numbers expressing the deviations to those designating the position of the mean point of explosion, we obtain the position of every particular point of explosion,

Suppose for example that the range ordered is 2000 metres, that the mean point of explosion is given as $\frac{-70}{6}$, and that the lottery number 25 is drawn, then adding the deviation under *E*, $\frac{-15}{4}$, to the figures for the mean point of explosion gives $\frac{-85}{10}$. With lottery number 85—deviation $\frac{\pm 25}{4}$—the point of explosion would have been at $\frac{-45}{2}$.

In case the fuses do not burn normally, but too short or too long a time, the position of the mean point of explosion is naturally changed too, and in such wise that the distance of the point of explosion in front of the target becomes as much shorter or longer as the fuses burn too long or too short a time (estimated in distance of course). In the same way the mean height of explosion becomes less or greater, so that since the normal height of explosion corresponds to a distance of the point of explosion in front of the target equal to 50 metres, it will, for every 5 metres that the fuse burns too long or too short, be $\frac{1}{10}$ the normal height less or greater.

If we assume for the actual target distance 2020 and for the range ordered 2000 metres, and then suppose that the fuses burn 30 metres too long, the distance of the mean point of explosion in front of the target is not —70 but —40; the mean height of explosion will be $0.6 \times 6 = 3.6$[*] metres less than the normal which was 6 metres, therefore 2.4; the mean point of explosion lies therefore at $\frac{-40}{2.4}$, or in whole numbers, $\frac{-40}{2}$. Had the fuse burned 80 metres too long, the point of explosion would have been at $\frac{-70+80}{6-6\times 0.6} = \frac{+10}{-3.6}$, or in whole numbers at $\frac{+10}{-4}$. On the other hand, had the fuse burned 30 or 80 metres too short, the mean point of explosion would have been at $\frac{-110}{+10}$ and $\frac{-150}{16}$, respectively.[†]

In firing with fuses that burn too long innumerable ground hits (with or without subsequent explosion) are naturally obtained; these are recognized by a negative value for the height of explosion. Suppose for instance, that with the position of the mean point of explosion at $\frac{-10}{1}$[‡] (the fuses burning 40 metres too long with a range of 2000 metres), the lottery number 81 (deviation $\frac{+20}{-4}$ is drawn, then we have for the point of explosion $\frac{+10}{-3}$. The shot strikes short before explosion, not at —10 metres but somewhat farther in front of the target. To determine the position of the point of striking on the ground is seldom necessary in the firing game, yet it may be, as

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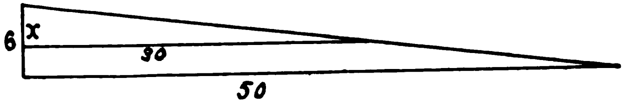
[*] From the figure it is evident that the tangent of the angle of fall is $\frac{6}{50}$, consequently, if the fuse burn 30 metres (horizontally) too long, the point of explosion will be 3.6 m. lower:

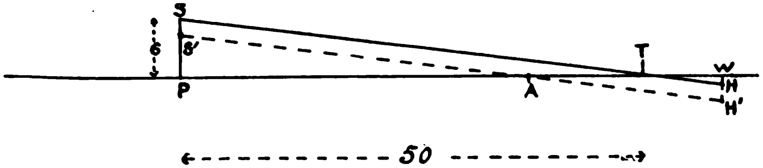
$x = \frac{6}{50} \times 30 = 3.6$m. J. P. W.



[†] The normal height of explosion, which, according to the firing table amounts to from 5.5 to 6 metres is here assumed; exact computation gives the point of explosion as situated at $\frac{-150}{14.3}$. The difference of 1.7 metres in the height of the point of explosion is without effect in practice.

[‡] $\frac{6}{50} \times 40 = 4.8$; $6 - 4.8 = 1.2$, or in entire numbers 1 metre; $-50 + 40 = -10$; therefor $\frac{-10}{1}$. J. P. W.

for instance in case of shots, the points of explosion of which, with a negative height of explosion, lie *behind* the target, while the actual striking point on the ground may still lie in front of the target. The point of striking may be found as follows:



In the preceding figure let S be the normal point of explosion (50 metres in front of the target), SP the normal explosion height (6 metres for a range of 2000 metres), T the target and STH the normal trajectory; now let TW be the distance of the point of explosion of any shot from the target and WH' its known (negative) height of explosion (both given by the table), A being the point where it strikes the ground, $S'AH'$ (parallel to STH) will be its trajectory. The following relation then, results directly from the figure:

$$\frac{AT + TW}{WH'} = \frac{50}{SP}, \text{ from which we find:}$$

$$AT = \frac{50 \times WH'}{SP} - TW.$$

In the example above in which $TW = 10$, $WH' = 3$, $SP = 6$ (or more exactly 5.5) metres, AT becomes $\frac{50 \times 3}{6}$ --10 or 15 metres; that is, the point where the shot, the point of explosion of which was found to be $^{+10}_{-3}$, strikes the ground lies 15 metres in front of the target.

Finally let us see what effect the use of a plate* will have on

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* Sight plates (*Aufsatz-platten*)—Small plates of steel placed on the socket of the tangent-scale fitting around the latter to diminish the reading on the scale; for example, if the scale be set at 2100 metres and a "plate" be placed in position, it will then (read from the upper surface of the plate) mark about 2050 metres, now, if the scale be run up until it again reads 2100 metres, it is evident that that individual gun, though normally laid at 2100 metres, is really laid at 2150 metres. Similarly by taking away a plate, a gun may be made to fire with an elevation less than used by another, though setting its tangent scale at the same range. This expedient is intended to make it possible to work guns, which differ in their shooting by one command; and it is customary to use with common shell one plate at the commencement of the ranging, in order to have a margin in both directions. The plates are also used to give a slight increase or decrease of elevation throughout the battery, and to make sure that such variation is regular. (Taken from the note-book of 1st Lieutenant A. B. Dyer, 4th Artillery)

the position of the mean point of explosion. By the insertion or removal of a plate the trajectory will be turned $\frac{3}{16}$° upward or downward; the explosion distance (from the target) remains therefore nearly the same; and only the height of explosion becomes greater or less. By the aid of the firing table for shells (Column 6) the amount of this can be accurately determined, and it is of course recorded in entire metres only. But in order not to multiply slight errors, it is best first to compute the position of the mean point of explosion to one decimal place, and then pass to whole numbers. For instance, if for 2000 metres the mean height of explosion is $+5.5$ metres, it would become by the use of a plate $+12.1$, by the removal of a plate -1.1 metres. Had we worked with whole numbers to begin with, the mean height of explosion would have been taken as 6, the effect due to the plate as 7 ($2000 \times \tan \frac{3}{16}° = 2000 \times 0.0033 = 6.6$). and we would have obtained for the height of explosion 13 (or, in case of removal of the plate -1) metres. However, even if we work with entire metres from the beginning, no *grave* errors can be made.

C. OBSERVATION.

However much the deviation of a shot may influence the accuracy of fire, a false observation of it much oftener leads to complete failure to strike the object, or at least interferes more with successful firing. Only by constant practice can the number of false observations made be gradually reduced, and perfection in the art of observation be acquired. The important point is however, under any circumstances to be able from the results of the firing, to recognize the fact that a false observation has been made, to see where it has been made and to know how to remedy the mistake. For this reason, after it has been determined where a given shot actually struck, it is still necessary to consider whether its striking was correctly or incorrectly observed.

As the result of experience it is found that about $\frac{2}{3}$ (67 per cent.) of the shots are correctly observed, $\frac{1}{4}$ (25 per cent.) not at all (*i. e. doubtfully*), the rest (8 per cent.) falsely. The probability therefore that a shot will be correctly, doubtfully or falsely observed is, consequently, the same exactly as that out of 100 lottery numbers, *one* out of 67, 25 or 8 (respectively) numbers *previously* designated will be drawn. We may therefore assume that an observation is correct in case the number drawn is between 1 and 67, that it is doubtful in case the number is between 67 and 92 and that it is false when the number is between 93 and 100. As a matter of fact the conditions in every firing practice are different from those of any other. It is therefore best to decide before beginning the game, and for every particular target, what shall be the relation of correct, doubtful and false observations to one another. It should be noted however, that the relation of the number of false to the number of correct observations is the most important point,—the number of doubtful observations has less influence. A slight change in the number of false observations may raise or lower the *ratio* to the correct ones considerably.

The observation of shrapnel and torpedo-shell with time fuses is far more uncertain than that of shell with percussion fuses. This is partly due to the small volume of the explosion cloud of the two former and its rapid dissipation, but much more to the position of this cloud in the air, often far above the target. It may be taken for granted that all shrapnel, which have a height of explosion of over 3 metres, will, under *ordinary* circumstances be observed doubtfully, because the position of the cloud of explosion with reference to the target in such a case cannot be determined, and also because it will not be possible, except under specially favorable circumstances, to so determine the position of the point of explosion, from the observation of the pieces of the projectile which strike near the target and the little clouds of dust thrown up by them, as to the permit of putting another shot in the same point. If, in case of points of explosion 3 metres or less in height, we consider the same observation relations to hold for shrapnel as we did for percussion shell, the results will certainly not be too unfavorable for the former. Since the explosion cloud of torpedo-shell is larger and the innumerable fragments strike nearly vertically downward, the points of explosion in their case may be regarded as observable up to and including four metres in height.

As long as old powder was used in firing, the conditions of observation for shrapnel, and more especially for torpedo-shell were not unfavorable. It could be assumed that every explosion which covered the target with smoke and stood out *distinctly* from it lay in front of it. But this aid to observation no longer holds, and for that reason the observation of high points of explosion has become more difficult.

TABLE SHOWING FOR EACH LOTTERY NUMBER THE AMOUNT OF DEVIATION OF THE SHOTS FROM THE CENTRE OF IMPACT.

Lottery numbers.	SHELL. DEVIATION FROM THE CENTRE OF IMPACT IN CASE OF			Lottery numbers.	SHELL. DEVIATION FROM THE CENTRE OF IMPACT IN CASE OF		
	small	medium	large		small	medium	large
	DISPERSIONS.				DISPERSIONS.		
	A.	B.	C.		A.	B.	C.
1	—60	—100	—140	26	—15	—25	—35
2	—50	—85	—120	27	—15	—25	—30
3	—45	—75	—105	28	—15	—20	—30
4	—40	—70	—100	29	—15	—20	—30
5	—40	—65	—90	30	—10	—20	—25
6	—35	—60	—85	31	—10	—20	—25
7	—35	—55	—80	32	—10	—20	—25
8	—30	—55	—75	33	—10	—15	—25
9	—30	—50	—70	34	—10	—15	—20
10	—30	—50	—70	35	—10	—15	—20
11	—30	—45	—65	36	—10	—15	—20
12	—25	—45	—65	37	—10	—15	—20
13	—25	—45	—60	38	— 5	—10	—15
14	—25	—40	—60	39	— 5	—10	—15
15	—25	—40	—55	40	— 5	—10	—15
16	—25	—40	—55	41	— 5	—10	—15
17	—20	—35	—50	42	— 5	—10	—10
18	—20	—35	—50	43	— 5	— 5	—10
19	—20	—35	—45	44	— 5	— 5	—10
20	—20	—30	—45	45	— 5	— 5	— 5
21	—20	—30	—40	46	— 5	— 5	— 5
22	—20	—30	—40	47	± 0	— 5	— 5
23	—15	—30	—40	48	± 0	± 0	— 5
24	—15	—25	—35	49	± 0	± 0	± 0
25	—15	—25	—35	50	± 0	± 0	± 0

TABLE SHOWING DEVIATIONS

Lottery Numbers.	SHRAPNEL or TORPEDO SHELL. Deviation from the mean point of explosion as regards short RANGES D.	DISTANCE OF EXPLOSION / HEIGHT OF EXPLOSION medium RANGES E.	from target in case of long RANGES F.	Lottery Numbers.	SHRAPNEL or TORPEDO SHELL. Deviation from the mean point of explosion as regards short RANGES D.	DISTANCE OF EXPLOSION / HEIGHT OF EXPLOSION medium RANGES E.	from target in case of long RANGES F.
1	− 45 / + 2	− 65 / + 7	− 75 / + 16	26	− 10 / + 1	− 15 / + 3	− 20 / + 3
2	− 40 / + 2	− 55 / + 7	− 65 / + 13	27	− 10 / + 1	− 15 / + 2	− 20 / + 1
3	− 40 / + 1	− 50 / + 6	− 60 / + 15	28	− 10 / + 1	− 15 / + 2	− 15 / + 7
4	− 35 / + 2	− 45 / + 6	− 55 / + 11	29	− 10 / + 1	− 15 / + 1	− 15 / + 5
5	− 35 / + 1	− 45 / + 5	− 50 / + 10	30	− 10 / + 1	− 15 / + 1	− 15 / + 4
6	− 30 / + 1	− 40 / + 5	− 45 / + 10	31	− 10 / ± 0	− 15 / − 1	− 15 / + 3
7	− 30 / ± 0	− 40 / + 3	− 45 / + 7	32	− 10 / ± 0	− 10 / + 4	− 15 / + 2
8	− 25 / + 3	− 35 / + 6	− 40 / + 12	33	− 10 / ± 0	− 10 / + 2	− 15 / ± 0
9	− 25 / + 2	− 35 / + 4	− 40 / + 8	34	− 10 / − 1	− 10 / + 2	− 10 / + 5
10	− 25 / + 1	− 35 / + 2	− 40 / + 3	35	− 5 / + 1	− 10 / + 1	− 10 / + 4
11	− 25 / ± 0	− 30 / + 5	− 35 / + 12	36	− 5 / + 1	− 10 / + 1	− 10 / + 3
12	− 20 / + 3	− 30 / + 4	− 35 / + 7	37	− 5 / + 1	− 10 / ± 0	− 10 / + 2
13	− 20 / + 2	− 30 / + 4	− 35 / + 5	38	− 5 / ± 0	− 10 / − 1	− 10 / + 1
14	− 20 / + 1	− 30 / + 1	− 35 / + 3	39	− 5 / ± 0	− 5 / + 3	− 10 / − 1
15	− 20 / + 1	− 25 / + 5	− 30 / + 9	40	− 5 / ± 0	− 5 / + 1	− 5 / + 4
16	− 20 / + 1	− 25 / + 4	− 30 / + 7	41	− 5 / ± 0	− 5 / + 1	− 5 / + 3
17	− 20 / ± 0	− 25 / + 3	− 30 / + 6	42	− 5 / ± 0	+ 5 / + 1	− 5 / + 2
18	− 15 / + 2	− 25 / + 2	− 30 / + 3	43	− 5 / − 1	− 5 / ± 0	− 5 / + 1
19	− 15 / + 1	− 25 / ± 0	− 25 / + 8	44	± 0 / + 1	− 5 / ± 0	− 5 / ± 0
20	− 15 / + 1	− 20 / + 4	− 25 / + 6	45	± 0 / + 1	− 5 / ± 0	− 5 / − 1
21	− 15 / + 1	− 20 / + 3	− 25 / + 3	46	± 0 / + 1	− 5 / − 1	− 5 / −
22	− 15 / ± 0	− 20 / + 2	− 25 / + 1	47	± 0 / + 1	± 0 / + 2	± 0 / +
23	− 15 / ± 0	− 20 / + 2	− 20 / + 9	48	± 0 / 0	± 0 / + 1	± 0 / +
24	− 15 / − 1	− 20 / + 1	− 20 / + 7	49	± 0 / 0	± 0 / ± 0	± 0 / +
25	− 10 / + 2	− 15 / + 4	− 20 / + 4	50	± 0 / 0	± 0 / ± 0	± 0 / ±

FROM MEAN POINT OF EXPLOSION.

Lottery Numbers.	SHRAPNEL or TORPEDO SHELL.			Lottery Numbers.	SHRAPNEL or TORPEDO SHELL.		
	Deviation from the mean point of explosion as regards DISTANCE OF EXPLOSION / HEIGHT OF EXPLOSION from target in case of				Deviation from the mean point of explosion as regards DISTANCE OF EXPLOSION / HEIGHT OF EXPLOSION from target in case of		
	short	medium	long		short	medium	long
	RANGES				RANGES.		
	D.	E.	F.		D.	E.	F.
51	±0 / ±0	±0 / ±0	±0 / ±0	76	+10 / −2	+15 / −4	+20 / −4
52	±0 / ±0	±0 / ±0	±0 / −1	77	+15 / +1	+20 / −1	+20 / −7
53	±0 / ±0	±0 / −1	±0 / −2	78	+15 / ±0	+20 / −2	+20 / −9
54	±0 / −1	±0 / −2	±0 / −3	79	+15 / ±0	+20 / −2	+25 / −1
55	±0 / −1	+5 / +1	+5 / +3	80	+15 / −1	+20 / −3	+25 / −3
56	±0 / −1	+5 / ±0	+5 / +1	81	+15 / −1	+20 / −4	+25 / −5
57	±0 / −1	+5 / ±0	+5 / ±0	82	+15 / −1	+25 / ±0	+25 / −8
58	+5 / +1	+5 / ±0	+5 / −1	83	+15 / −2	+25 / −2	+30 / −3
59	+5 / ±0	+5 / −1	+5 / −2	84	+20 / ±0	+25 / −3	+30 / −6
60	+5 / ±0	+5 / −1	+5 / −3	85	+20 / −1	+25 / −4	+30 / −7
61	+5 / ±0	+5 / −1	+5 / −4	86	+20 / −1	+25 / −5	+30 / −9
62	+5 / ±0	+5 / −3	+10 / +1	87	+20 / −1	+30 / −1	+35 / −3
63	+5 / ±0	+10 / +1	+10 / −1	88	+20 / −2	+30 / −4	+35 / −5
64	+5 / −1	+10 / ±0	+10 / −2	89	+20 / −3	+30 / −4	+35 / −7
65	+5 / −1	+10 / −1	+10 / −3	90	+25 / ±0	+30 / −5	+35 / −12
66	+5 / −1	+10 / −1	+10 / −4	91	+25 / −1	+35 / −2	+40 / −3
67	+10 / +1	+10 / −2	+10 / −5	92	+25 / −2	+35 / −4	+40 / −8
68	+10 / ±0	+10 / −2	+15 / +0	93	+25 / −3	+35 / −6	+40 / −12
69	+10 / ±0	+10 / −4	+15 / −2	94	+30 / 0	+40 / −3	+45 / −7
70	+10 / ±0	+15 / +1	+15 / −3	95	+30 / −1	+40 / −5	+45 / −10
71	+10 / −1	+15 / −1	+15 / −4	96	+35 / −1	+45 / −5	+50 / −10
72	+10 / −1	+15 / −1	+15 / −5	97	+35 / −2	+45 / −6	+55 / −11
73	+10 / −1	+15 / −2	+15 / −7	98	+40 / −1	+50 / −6	+60 / −15
74	+10 / −1	+15 / −2	+20 / −1	99	+40 / −2	+55 / −7	+65 / −13
75	+10 / −1	+15 / −3	+20 / −3	100	+45 / −2	+65 / −7	+75 / −16

TABLE SHOWING FOR EACH LOTTERY NUMBER THE AMOUNT OF DEVIA
OF THE SHOTS FROM THE CENTRE OF IMPACT.

Lottery numbers.	SHELL. DEVIATION FROM THE CENTRE OF IMPACT IN CASE OF			Lottery numbers.	SHELL. DEVIATION FROM THE CENTR IMPACT IN CASE OF		
	small	medium	large		small	medium	la
	DISPERSIONS.				DISPERSIONS.		
	A.	B.	C.		A.	B.	C
51	± 0	± 0	± 0	76	+15	+25	+
52	± 0	± 0	± 0	77	+15	+25	+
53	± 0	± 0	+ 5	78	+15	+30	+
54	± 0	+ 5	+ 5	79	+20	+30	+
55	+ 5	+ 5	+ 5	80	+20	+30	+
56	+ 5	+ 5	+ 5				
57	+ 5	+ 5	+10	81	+20	+30	+
58	+ 5	+ 5	+10	82	+20	+35	+
59	+ 5	+10	+10	83	+20	+35	+
60	+ 5	+10	+15	84	+20	+35	+
				85	+25	+40	+
61	+ 5	+10	+15	86	+25	+40	+
62	+ 5	+10	+15	87	+25	+40	+
63	+ 5	+10	+15	88	+25	+45	+
64	+10	+15	+20	89	+25	+45	+
65	+10	+15	+20	90	+30	+45	+
66	+10	+15	+20				
67	+10	+15	+20	91	+30	+50	+
68	+10	+15	+25	92	+30	+50	+
69	+10	+20	+25	93	+30	+55	+
70	+10	+20	+25	94	+35	+55	+
				95	+35	+60	+
71	+10	+20	+25	96	+40	+65	+
72	+15	+20	+30	97	+40	+70	+
73	+15	+20	+30	98	+45	+75	+
74	+15	+25	+30	99	+50	+85	+
75	+15	+25	+35	100	+60	+100	+

The numbered squares are to be cut out as separate lottery numbers.—Those without numbers are extra and can be used in place of any that may be lost.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50

51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

COMMENT AND CRITICISM.

General Willcox's History of the Mexican War.

I am truly sorry that the criticisms in my review of General Wilcox's History of the Mexican War should have excited discussion. The opinions I advanced were modestly enough conceived, but probably the language carried too much presumption in questioning the wisdom with which success was gained. One of Major Lane's positions is unquestionable; and as honest confession is a good thing to start with I will say that I was "clear off" in saying General Taylor fell back from Buena Vista the day after the battle. My error was due to forgetfulness more than to ignorance. I had naturally forgotten that before falling back on Monterey any forward movement had been made, since it was not a pursuit and was resultless.

I also erred in criticising the book's orthography of Santa Anna's name. I have since seen some of his autograph letters in which he spells his name with two n's, *á l'antique*. Wilcox is correct. The President preserved the ancient spelling; *now* there is no double n in Spanish, and the Mexicans pronounce his name in three syllables, San-táh-nah, and as one word.

And now let us pass to the Major's criticisms. General Taylor *would* appear to have misjudged his enemy at Point Isabel. It is hard to believe that he hurried forward to fortify in front of Matamoros with any fear of his communications being cut off. They were threatened and he posted back to fortify his supply base with all his force except a few light guns in Fort Brown, and certainly without a knowledge of the enemy's available artillery.

Certainly the battle of Resaca *had to be* fought in order to save Fort Brown. I simply mentioned what Wilcox said, that many of his officers advised against it, in order to show to what a strait Taylor had been reduced by his ignorance of his enemy. Success under such circumstances was due to the indomitable individualism of the American Soldier, rather than to the skilled foresight of the leader.

Nobody ever questioned Taylor's pluck or dogged perseverance. Was it a part of General Taylor's plan, "knowing his enemy," to leave his base of supplies in the air, for the mere purpose of planting a few light guns against Matamoros and risk them there, besieged, with a minimum of service, while he should go back to Point Isabel with all available troops to fortify and then to return to crush the possible Mexican Army that might intercept him? He did it all, but was it generalship? Wasn't it done at a big sacrifice of bone muscle and blood, avoidable in a great measure? Wasn't it in the opinion of many of his officers, after their taste of the enemy at Palo Alto—at the risk of a complete defeat?

The Major objects to my holding Buena Vista to have been a drawn battle. I cannot well define a "drawn battle." It may well be claimed that if the party taking the initiative is repulsed—he is defeated; certainly he is defeated in his plans. But if he be not followed and disorganized the defense cannot well claim a victory. Lundy's Lane, Buena Vista and Antietam may be called drawn battles, though the plans of British, Mexicans and Confederates were defeated. Yes, I think, whether General Taylor "knew it" or not, that at Wool's speaking we were whipped. It may have been the magnetism of Taylor's coming presence, it may have been the arrival with him of comparatively fresh troops (a large percentage of a total of "4800" about 700 of whom were *hors du combat*, and a larger proportion still of probably but 3500 effectives), or it may have been both that saved disastrous defeat.

I quote from page 55, *Congressional Reports on Mexican War*, 1847. Letter dated Buena Vista, February 24th, 1847, General Taylor says "An obstinate and sanguinary conflict was maintained with short intervals during the day, the result being that the enemy was completely repulsed from our lines. An attack of cavalry upon the rancho of Buena Vista, and a demonstration upon the city of Saltilio itself were likewise handsomely repelled. Early in the night the enemy withdrew from his camp [unmolested—J. H.] "and fell back upon Agua Nueva a distance of eleven miles." No word of any advantage taken of the enemy's defeat.

On March 1st Taylor reports, page 57, from Agua Nueva that he had arrived there on the 27th, three days after the battle and that on said 27th the last of the Mexicans left there in the morning, and added that he was to despatch a command that day, March 1st, four days after, to harass the enemy's rear and to secure whatever military supplies should be found, up to Encarnacion.

General Taylor here continues "I have no doubt that the defeat of the *main army* [italics mine—J. H.] at Buena Vista will secure our line of communications [what line of communications?—J. H.] from further interruption, but I still propose in a few days to change my headquarters to Monterey with a view to make such further arrangements as may be necessary in that quarter. The dispositions made to harass our rear *vindicate the policy and necessity* of defending a position in front of Saltillo, where a defeat has thrown the enemy far back into the interior. No result so decisive could have been obtained by holding Monterey, and our communications would have been constantly in jeopardy."

It will be seen that the General is very modest in claiming a *victory*. He says "the enemy were handsomely repulsed from our lines." Why did he *pursue* the enemy on the *fourth day* after their falling back on Agua Nueva? Did he go there before retracing his steps to Monterey, in order to pick up the trash abandoned by the last remnant of a Mexican Army on the way to Encarnacion and "harass" them four days after they left?

General Taylor's last quoted sentence will strike the reader,—knowing that the government and General Scott expected him to stay at Monterey—as giving an *excuse* for his original forward movement, viz: to secure his "line of communication from furthur interruption." That is, he had extended his line to make it need protection, had passed on without preparing the necessary defense, and without knowing that Santa Anna was gathering an army to overwhelm him if possible.

Four strategic plans may be divined of General Taylor's movements. 1. A brilliant, bold, attempt to reach the City of Mexico from the north before Scott, depending on the country for his supplies. If this was his plan. Buena Vista was a defeat. 2. Simply to carry out "*l'audace toujours l'audace* " to go as far as he could without any defined objective. 3. To make a diversion in favor of Scott's campaign; or 4. To extend a line of communication in order to defend it.

Can it possibly be assumed that he pushed forward from Monterey to Agua Nueva to find a main army to conquer in order to defend his line of communication behind Monterey?

Let us pass on to the San Pascual affair. I have not time to hunt up General Kearny's report, and I doubt its bearing on the case even. It has none without he claims a victory, absolute. If he does it would make old Californians smile.

I give the following extract from Fayette Robinson's *History of the Army of the United States*, page 142, as complementary to Wilcox's account.

"It was now evident that Pico intended to harass the American troops by making an attack in every pass that afforded him an advantage. He was enabled by his superior horses to occupy them [the passes] before General Kearny; and as his wounded men were suffering severely and required rest, and this position [on San Bernardo] was a strong one, Kearny determined to hold it until he should receive a reinforcement from Commodore Stockton, to whom an express had been sent by a trusty indian. He remained there four days and was closely surrounded by the enemy, who had received an addition to their forces and now numbered over two hundred men, so that he could procure no more provisions [nor water], and had to subsist entirely on mule flesh. Seventy-five marines and a hundred seamen under command of Captain Zeilin of the Marine Corps, came from the ships *Congress* and *Portsmouth* to his assistance; and with this efficient force he marched into San Diego without molestation. The distance was thirty miles and was marched in two days without difficulty * * * arrived in San Diego on the 12th of December."

As Robinson was an old Dragoon officer, it is not probable that he would derogate anything from his old arm. The whole tone shows tenderness to our troops. The brackets in the quotation are mine. I shall call attention to four points here. 1. "*Had been sent*, *i. e.* the trusty indian had been sent for the navy support before Kearny determined to hold the strong point which he could not leave. 2. *A trusty indian* was the express sent to Stockton; what would have happened if the indian had not proved trusty or had been intercepted? 3. The addition to the enemy's force were the neighboring rancheros; there were no organized Californian troops to call on. 4. With seventy-five marines and one hundred seamen and Kearny's victorious command (as Major Lane would have us consider it), he marches without molestation into San Diego, despite the formidable force of two hundred mounted rancheros—men with scarcely anything but the lance!

To revert to the first charge of our dragoons, the scattered nature of it was so unlike what American soldiers can do, that it lends much proximate credibility to Juan Largo's (Warner's) charge that Davidson had taken his horses to replace their broken down ones. It can't be called a successful charge of trained troops that will leave their leader to be lanced, and only saved from death by Lieutenant Emory's (not of the ranks) pistol. If the horses are broken down the more it behooves the commander to recollect that the movement of the mass is governed by the slowest horse. If none are fit, don't charge. Davidson's howitzer mules ran away. His men must have been weakened by the march and couldn't hold the mules, or was it because they were playing artillery and hadn't got the run of their mules yet? Davidson should have taken oxen. It looks, Major, as if Kearny didn't know when he was whip't, no?

Poor old Don Juan, I shouldn't wonder if he did try to reimburse himself from Lawrence Graham's command for what he charged Davidson with stealing from him? It was his only chance in those days, of making things square. Then, the strong arm was law.

Lastly, I am sorry my criticisms have impressed the Major with a want of patriotism in me. There were plenty of bad moves in the Mexican War. The charges on Molino del Rey were bad, very bad. I think the Major will admit that there were some mistakes made in the rebellion. Should he point them out I would not think him unpatriotic. Again, little glory attaches to our successes if we belittle our enemy. The poltroonery of the fellah adds nothing to the glory of Wolseley. So far as my review went I tried to show that we had not a despicable foe to encounter, and that for Texas, California, etc., good American blood had been paid.

If the Major desires to learn what a good fight the Mexicans made under their circumstances and handicapping, I suggest that Colonel Balbotin's "La Invasion Americana" be read. With all allowances our conquest was glorious enough for our arms personelle and morale.

I am sure I intended nothing that would show that I did not admire the tone and temper of Wilcox's work as history. If I hinted at a peculiarity it was not to brand it as a blemish. The book heightened the general in my estimation, and I had known him since '43. Altogether he is eminently moderate and fair; if anything, he leans to the avoidance of all blame, but a military review is useless without it seeks for the lesson that history conveys.

JOHN HAMILTON,
Colonel, U. S. A.

Our Field Gun.

Captain Moch of the French Artillery, in his "Notes on the Field Gun of the Future," recently published in the *Revue d'Artillerie*, gives some very interesting and suggestive data in regard to foreign field guns. An inspection of his tables shows that our own field gun does not bear comparison well, in some important respects, with one or two foreign guns of recent type.

The standard fire to which field guns are held up for comparison is shrapnel fire; it is *par excellence* the fire that will be used on the next battle fields; no other fire can approach it in man-killing power at long ranges. Below will be found a few statistical facts, some taken from Captain Moch's tables, and others computed by the writer, which serve to compare along this line the Spanish 7.85 cm. (3.09-inch) gun of the Sotomayor system with our own 3.2-inch field gun.

	Sotomayor.	U. S. Field Gun.
Calibre	3.09 in.	3.20 in.
Weight of gun	770 lbs.	829 lbs.
Weight of projectile	14.33 lbs.	13.5 lbs.
Number of bullets in shrapnel . . .	231	170
Muzzle velocity	1509 f. s.	1700 f. s.
Muzzle energy	226 f. tn's	271 f. tn's
Range at which final velocity will be 600 f. s.	6430 yds.	5930 yds.
Number of rounds in limber chest . .	36	42
Weight behind horses with piece limbered up	3608 lbs.	3789 lbs.

It is to be noted that the smaller caliber and lighter Sotomayor gun give decidedly better shrapnel effects than our larger caliber and heavier gun. The Spanish gun fires a shrapnel which contains more than 30 per cent. more bullets than the American gun and this projectile carries these bullets with a man-killing velocity, up to a range 500 yards greater than that at which our gun gives the same remaining velocity to its projectile. This is done with a less strain upon the carriage by 55 ft. tons, than that caused by the recoil of the United States' gun, and with less weight behind the horses by about two hundred pounds. Our gun carries six more projectiles in the limber than the Sotomayor gun, but adding this number to the load of the Spanish limber, the weights behind the horses would still be 90 lbs. less in the Sotomayor system.

Lieutenant Schenck's proposition in the October number of the JOURNAL to increase the weight of our projectile to 18 lbs., using a muzzle velocity of about 1400 f. s., would, without doubt, restore the ballistic supremacy of our gun, even though it would place additional weight behind the horses; it would give us 278 bullets in each shrapnel, and would increase the range at which there would be sufficient remaining velocity to give man-killing power to the shrapnel bullets, to a limit beyond which there is no need of going, and it would reduce the strain on the carriage due to recoil by 26 ft. tons.

It is believed that this is a question well worthy the serious consideration of the Ordnance Department.

E. M. WEAVER,
1st Lieutenant and R. Q. M., 2nd Artillery.

BOOK NOTICES.

Felddienst-Ordnung. Ernst Siegfried Mittler und Sohn. Berlin, 1890. Official. Pp. 218, with Appendices.

This little volume is supplemental to the "Drill Regulations" in the German army. Its aim is to lay down the rules and principles applicable to every variety of field service both in war and during the Autumn Manœuvres. Essentially intended as a book of reference, it is arranged with this end in view and is quite characteristic of German methods. The first one hundred and fifty-five pages are devoted to questions of field service in war, while the remaining pages are devoted more particularly to the Autumn Manœuvres.

Even the casual reader will be struck by the clearness and conciseness with which rules and principles are enunciated, a feature often wanting in German text-books. The book is entirely free from confusing details and does not attempt to lay down rules of conduct for individual cases that may arise in the field, but rather seeks to state clearly the objects to be accomplished by the different field duties and the general means of their attainment, leaving to officers of all ranks, the selection of the details. The governing idea seems to be to secure to all officers within their own spheres of action the opportunity of initiative and thus to teach them self reliance, independence, and freedom from fear of responsibility. The complexity of modern military operations forbids rigid and fixed methods and this fact seems clearly recognized in the volume under consideration. As pertinent to this fact, a paragraph of the Emperor's order, promulgating the "Instructions" may be of interest. It reads as follows: "The liberty permitted herein in the practice of field service, is intentional and should be to the advantage of leaders of all ranks in independent determination." The contents of the volume are conveniently divided into subjects and the separate items numbered consecutively, thus securing a systematic arrangement.

To indicate more clearly the manner in which a subject is treated, the following translation of "Protection on the March," is given:

INTRODUCTION.

68. Marching troops, for the most part confined to the roads in great depth of formation, require a certain time to get into battle formation. It is the problem of the troops appointed for protection to assure this time and to brush aside slight disturbances so that the march of the whole may not be hindered.

69. A good orientation is the first step in security. To complete the same, immediate protective measures are not to be neglected.

70. The main body of an advance has for its protection an advanced guard in front, and the main body on a retreat has behind it a rear guard. The security of the flanks is effected through flank guards.

ADVANCED GUARD.

71. Cavalry divisions, or parts of the same in front of an army, are not generally in a condition to assure the protection of the following masses, by virtue of their other duties. Therefore the latter, even when there are advanced cavalry divisions, must always push out an advanced guard. It is a problem of the advanced guard to take up and maintain connection with the advanced cavalry divisions.

72. The consideration that an effective orientation forms an essential means of security, leads to sending out beyond the advanced guard, the attached cavalry troops. They may for this purpose as well be under the immediate orders of the commander-in-chief (independent cavalry) as assigned to the advanced guard (advanced guard cavalry).

In this way the cavalry procures more rest and steadier advance for the whole, than if it be advanced only in cases of necessity.

Its movements are so appointed, that, while fulfilling all the requirements of orientation, connection with the following infantry is never lost, and that it is always at hand in the deployment for battle.

Circumstances may also make it desirable to send the greater part of the cavalry in some other direction or to hold it back at times.

So soon as close contact is established with the enemy, the tactical conduct of the cavalry comes to the front; but even then orientation must not cease.

73. The distance between the advanced guard and the main body depends on one's object, strength, considerations with respect to the enemy, and nature of the ground. The lead of the advanced guard on the one hand, must be great enough to prevent delay or interruption to the march of the main body and, on the other hand, not so far as to debar the timely attack of the main body.

In an advance to attack the distance may be lessened in order to hasten the development to the front.

74. The strength and organization of the advanced guard varies according to the ground and strength of the whole; in larger groups according to the strength of the foremost masses. It comprises from $\frac{1}{6}$ to $\frac{1}{3}$ the infantry.

If the mass of the cavalry is not assigned to the advanced guard, at least a detachment sufficient for the purpose must be attached.

Artillery and pioneers, as much as possible by tactical groups, are assigned according to necessity.

The presence of a bridge train and part of a sanitary detachment may be necessary.

75. The advanced guard consists of the main body, advanced body and, finally, the advanced-guard cavalry (compare 72).

76. The main body comprises the mass of the infantry and, as a rule, the artillery.

77. The advanced body consists, preserving units as much as possible, of ¼ to ⅓ the infantry and the necessary cavalry and pioneers.

The advanced body marches at such a distance before the main body as to secure for it the time necessary for deployment, on coming in contact with the enemy, usually ½ to 1 kilometre; small advanced guards, so far that the main body cannot be surprised by an effective rifle fire.

A strong advanced body may, if it promises a better security, send forward a detachment (company, platoon) 300 to 400 metres.

78. At about the same distance in advance of the advanced body is the infantry point, beyond this the cavalry point, or the cavalry of the advanced body with its point.

The infantry point consists of one officer and at least a section, so that it may have a certain degree of resistance and may be able to search a broader front without having to take the advanced body into consideration. The point generally marches in dispersed order, two men as a rule serving as connecting files, half way back to the advanced body.

The cavalry point consists of one officer and four to six troopers. As one or two troopers are left on the road in the rear, the point utilizes the neighboring heights for observation.

79. Infantry marching alone divides its advanced guard in a similar manner.

80. A cavalry division and other independent cavalry choose a division of the advanced guard, and means of orientation and security commensurate with the problems presented.

81. All measures of an advanced guard must have for their object to *prevent the steady and uniform march of the whole from being unnecessarily interrupted.* It is of essential importance to protect the troops from a serious surprise. Smaller hostile detachments are themselves compromised by the fact that the leader of the advanced guard is justified in assuming a bold attitude from the knowledge that he is followed by the main body.

With regard to advancing, the smaller divisions are always dependent on the larger. It devolves on these to maintain the connection to the front.

The foregoing translation is a fair sample of the manner in which different subjects are treated, and, as will be observed, nothing but general principles are touched upon. A subject so presented will always lead to a more comprehensive understanding than one burdened with a mass of unimportant details which often serve to bury from view the main principles.

In a nine page introduction some general observations are made on discipline and military training. The latter, it is stated, can be acquired by practice in a comparatively short time; but the former is a thing of gradual growth and can be acquired only after a sufficient period. Athletics are put down as a valuable factor in military training, both for officers and men, as increasing their bodily strength and dexterity. The various elements that make up an officer's training are gone over briefly and the observations concluded with the significant remark that "delay and neglect of accomplishing results are far more serious than a failure to grasp the proper methods."

Following the introduction, Army Organization and Command are touched upon. Next comes the Preparation and Transmission of Orders, Reports, and Military Sketches. The rules and principles present nothing unusual except, perhaps, the organization of mounted relays and their conduct, in cases where the field telegraph or signaling is not available.

Orientation by the advanced cavalry troops follows next in order. Some of the more important observations read as follows:

" For purposes of orientation all suitable means are to be set in motion.

"For observation, single soldiers and small parties are most suitable.

"An officer should possess in a marked degree the powers of drawing correct conclusions from short moments of observation. Well mounted, provided with reliable field glasses and maps, skilled in judging ground and map-reading, sufficiently well acquainted with the object of the movement and the enemy's circumstances, he is the most important organ of orientation.

" All independent cavalry leaders down to the chiefs of squadrons and of officer's patrols are responsible that contact with the enemy once established should not be lost."

The different duties for security of the troops, on the march, at a halt, or in siege operations are then taken up and concisely treated.

Under the subject of marching some points of interest are to be noted. The greatest enemy to marching troops is stated to be the heat. To quench the thirst of the men, mounted officers ride ahead and have the inhabitants of towns and villages place vessels of water along the line of march so that the soldiers may drink and fill their canteens without delaying the march unnecessarily.

The order of march in sets of fours is put down as requiring the following extent of road:

A battalion with small baggage	400 metres.
A battalion with large baggage	500 metres.

A foot battery requires 500 metres, a squadron 150 metres, and a division bridge train 310 metres.

To allow for the elongation of the units the following distances are to be maintained between the various divisions:

After a company	8 metres.
After a battalion, squadron, battery	16 metres.
After a regiment	30 metres.
After a brigade	60 metres.
After a division	250 metres.

Commanders are authorized to permit loosening of clothing and any other reliefs deemed advisable.

Night marches are to be avoided as much as possible as being harassing and fatiguing to the men.

After marching, the subject of cantonments with the interior regulations for the same is taken up, followed by bivouacking. The order of bivouac for the units of the different arms of the service is graphically presented.

Fifteen pages are devoted to the subject of baggage, ammunition columns and trains.

The small baggage outfit of a battalion is:

7 spare horses.
1 2-horse medicine wagon.
4 2-horse cartridge wagons.

The large baggage outfit adds:

1 2-horse staff pack wagon.
4 2-horse company wagons.
4 2-horse supply wagons.

Single companies have as a small baggage allowance:

1 spare horse.
1 2-horse cartridge wagon.

The additional for the large baggage outfit is:

1 2-horse company pack wagon.
1 2-horse supply wagon.

The baggage allowance of units of the other arms of the service is also given.

Under the subject of the supply of troops, the principles governing contributions and requisitions are laid down. The iron ration is to be used only in case of absolute necessity and by order of the commanding officer, and is to be replaced as soon as possible.

The medical service is also briefly touched upon. A sanitary detachment goes with each division and consists of 7 surgeons, 1 field apothecary, 8 hospital assistants, 8 military nurses, 176 ambulance bearers.

The supply of ammunition to troops on the firing line is secured by causing the cartridge wagons to take up a covered position 800 m. from the line and in pressing cases, near the line, regardless of loss. The supply to the foremost firing line is regulated by the battalion commander. For this purpose, some men of the reserve companies are to be utilized and no men on the firing line sent back. The cartridge wagons are to supply ammunition on demand, regardless of source, whether their own organization or not. All fresh troops sent to the firing line are to carry a supply to those already engaged. The cartridges of the dead and wounded are to be removed whereever possible. It is not a question of keeping up the prescribed supply of cartridges in a fight, but wherever ammunition is to be had, it is to be divided up and carried in the breadsack, trousers or coat pockets, &c. In defensive positions a previous supply of ammunition must be laid down in the firing line. The replacing of empty cartridge wagons devolves on the battalion commander.

The construction, preservation and destruction of telegraph lines and railroads is touched upon in a few pointed observations.

The remaining 64 pages of the volume are devoted to the regulations governing the autumn manœuvres and prescribing the method and time for the exercise of the various divisions of the troops, individually and collectively, beginning with brigade drills and manœuvres and leading up to the final grand manœuvres.

The appendix contains descriptions and well executed plates of the different headquarter flags of the German service.

A time programme of the autumn manœuvres and the formation for the parade of an army corps conclude the subject matter of the book.

. The typography is above criticism but the binding is far from what it should be for a book that would be referred to as much as the one under consideration.

The little volume is a veritable mine of information on all matters pertaining to field service and the only regret is that a lack of knowledge of German should debar the great body of our officers from perusing it.

Joseph E. Kuhn,
1st Lieutenant Corps of Engineers.

Interior Ballistics. Part I, Theoretical. Part II, Experimental. By Colonel Pashkievitsch, Professor in the Michael Artillery Academy, St. Petersburg. Translated from the Russian by Lieutenant Tasker H. Bliss, First Artillery, Aide-de-Camp. Adjutant General's Office, 1892.

This is the second of the series of monographs on subjects relating to the science of artillery which have been issued from the Adjutant General's office during the present year. The first of the series, also by Colonel Pashkievitsch and translated by Lieutenant Bliss, treats of the resistance of guns to tangential rupture, and forms with the work under notice, a connected and rather complete treatise on the variable pressures produced in the bore of a gun by the expansion of the powder gas, and the best means of controlling these pressures by a properly built up gun. These monographs contain the substance of lectures delivered by Colonel Pashkievitsch during the years 1888 and 1889, to the senior classes at the Russian Artillery school.

After a few paragraphs on the well known phenomena of ignition, inflammation and combustion of single grains and charges of gunpowder, the author gives a condensed account of the experiments made by Nobel and Abel in 1875 (so well known to our artillery officers through the republication of their memoirs, unabridged, by the Artillery School press), with a description of the apparatus employed—illustrated with plates—and a resumé of the most important of the deductions made by these experimenters from their labors. Though these experiments relate to the phenomena accompanying the explosion of gunpowder in a *closed vessel*, they have an important bearing upon the subject of interior ballistics, since they help to determine the temperature of combustion of fired gunpowder, the mean specific heat of the products of combustion, the ratio of solid to gaseous products, and what is technically called the "force of the powder"—all of which are factors in computing the work done by the expansion of the gases.

The author next takes up the important subject of the motion of a projectile in the bore of a gun; and within the compass of twenty-seven pages gives the substance of M. Sarrau's classic "*Recherches sur les effets de la poudre dans les armes*" and "*Formules pratiques des vitesses et des pressions dans les armes*," memoirs originally published in the *Mémorial de l'Artillerie de la Marine* during the years 1874 to 1878.* Colonel Pashkievitsch, like all recent writers on interior ballistics, has followed Sarrau's methods very closely from the elegant deduction of the fundamental equations of thermodynamics —equations which "contain all the thermodynamic laws of gases"—through their application to the establishment of the differential equation of motion of a projectile in the gun, and the approximate solution of this somewhat intractable equation so as to take into account the gradual combustion of the powder grains under the variable pressure to which they are subjected. The practical results of this analysis are Sarrau's well known binomial and monomial formulas for muzzle velocity and his formulas for the maximum pressure upon the base of the projectile and the breech of the gun. The binomial formula for muzzle velocity is illustrated by a single example with data taken from the results of firing brown prismatic powder, at the Ochta factory, in 1885, in 28 cm. and 22.9 cm. guns. The constants thus obtained are made use of in an elegant discussion of the characteristics of a powder suitable for these guns, which is a model for such investigations.

Colonel Pashkievitsch—following Sarrau—assumes that the relation between the maximum pressure on the breech and the maximum pressure on the base of the projectile is expressed by the equation

$$P^1_{\max} = P_{\max}\left(1 + \tfrac{3}{2}\frac{\tilde{\omega}}{w}\right)$$

in which P^1 and P refer, respectively, to the breech and base of the projectile, $\tilde{\omega}$ is the weight of the powder charge, and w the weight of the projectile. It is believed that, for the relatively large charges employed in the latest types of guns, the following expresses more nearly the ratio between these maximum pressures:—

$$P^1_{\max} = P_{\max}\left(1 + \tfrac{1}{4}\frac{\tilde{\omega}}{w}\right)$$

The next section is on "Formulæ for the designing of guns," and is a short, but fairly complete, resumé of Sarrau's memoir entitled "*Recherches théoriques sur le chargement des bouches à feu*," published in the *Mémorial des Poudres et Salpêtres*. Vol. 1, page 35.†

The fourth, and last, section of Part I consists of an original and extremely interesting discussion of that part of the work of expansion of the powder gases which was not introduced into the differential equation of motion. In deducing this equation it was assumed that the entire work done by the gases at any instant was expressed in the corresponding velocity of translation of

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* These memoirs have been translated into English by Lieutenants Meigs and Ingersoll, and are published in Vol. X of the Proceedings U. S. Naval Institute, 1884.

† This memoir may be found in "Notes on the Construction of Ordnance." No. 42. Translated by Lieutenant D. A. Howard, Ordnance Department, U. S. Army.

the projectile, thus neglecting the heat communicated to the walls of the gun—the work expressed in the rotation of the projectile—in forcing the base ring into the grooves and in overcoming the subsequent friction—in communicating motion to the gun and carriage and to the powder charge—in overcoming the resistance of the air to the acceleration of the projectile—and, finally, the loss of gas through the vent and by windage. The author remarks: "The united influence of the above causes of loss of the store of work of the powder gases was partly taken into account in the preceding discussion by the fact that the coefficients in the expressions for the initial velocity of the projectile and for the pressure on the breech were so determined that these data should have the values actually observed in the experiments. But, in order to judge of the influence which each of these causes separately has on the initial velocity and on the pressure, it is necessary to consider them separately."

The author takes up these various losses of energy *seriatim*, and arrives at the following conclusions:

The loss of heat communicated to the gun, as determined by experiment varies from one-fourth part in a rifled musket barrel to one-tenth part in a 12-pounder gun, and rapidly diminishes as the calibre increases.

The rifling, rotation and recoil exercise but a small influence either on the initial velocity of the projectile or of the pressures in the bore.

In the communication of motion to the products of combustion there is employed approximately not more than ten per cent. of the living force communicated to the projectile.

The object of the second or experimental part of the work, as stated by the author, is "The discussion of the various methods of determining the pressure of the products of decomposition, developed on firing, in the different sections of the bore of a gun; the velocities of the projectile at these different sections; and the times required for its passage through different lengths of the bore." Under the head of "The Statical Measurement of Pressure" the author gives a very complete discussion of Rodman's knife and of Noble's crusher guages, with methods of constructing tables for their use. The dynamical determination of pressure is quite fully discussed, and among the apparatus described are the accelerometer and accelerograph of Marcel-Deprez, the Noble chronoscope, the Schultz chronograph and the Sebert velocimeter.

The work appears to be well translated and but few typographical errors have been noticed. "Initial velocity" is used throughout for muzzle velocity. In interior ballistics the initial velocity is zero. Some changes of Sarrau's notation are noticed, without apparent reason.

JAMES M. INGALLS,
Captain 1st U. S. Artillery.

Alloys of Iron and Chromium. By R. A. Hadfield. Including a Report by F. Osmond, on the Chromium Steels of Mr. R. A. Hadfield: Reprinted from the Proceedings of the *Iron and Steel Institute*. Received through courtesy of Captain E. L. Zalinski, 5th U. S. Artillery.

This is a most interesting presentation of the subject of chromium steel. Beginning with an historical account of the discovery of chromium by Vanquelin, the author proceeds to treat the subject with considerable detail up to include the latest application of chromium steel in the manufacture of armor piercing projectiles by his own firm. He refers to the labors and contributions of Berthier, Frémy, Bouissangault, Brustlein, Baur, and others.

Of Baur, he writes: "After considerable investigation the writer is led to the conclusion that it is to Mr. Julius Baur, of New York, to whom credit must be given of first introducing on a practical scale the manufacture of chromium steel." M. Brustlein, the metallurgist of the Holtzer Company of Unieux, France, has frankly admitted that he was, in 1875, led to make his own experiments from seeing an account of Baur's work in America.

Here, then, is one more American invention of greatest importance to military science, which was permitted to go to Europe for development because of neglect or oversight at home. The principle of initial tension, the slotted screw breech fermeture, the Broadwell gas check, the perforated powder grain, breech-loading arms, metallic ammunition, magazine small-arms were, respectively, placed before us very early in their histories, but they were all in succession pushed aside, and only accepted after they had received the stamp of European approval. It would be a very interesting contribution to our professional literature if the history of these acts of mistaken judgment could be written.

Mr. Hadfield discusses his subject under the following headings: Early History, Description of the Metal, Early Experiments, Production of Ferro-Chromium by Crucible and Blast Furnace, Magnetic Properties of Ferro-Chromium, Use of Ferro-Chromium in Cast-iron, Manufacture of Chromium Steel, General Application of Chromium to Steel Manufacture.

Mr. Osmond's report on the Hadfield chromium steels is exhaustive. From his experiments he finds that chromium may exist in steel in three states, at least, either separately or simultaneously: 1. In the state of *dissolved* chromium, 2. In the state of a *compound* of chromium, iron and carbon in the form of *isolated globules*, 3. Same as "2," in the form of a *solidified solution*. The data connected with the physical and chemical characteristics of the specimens and with the various tests and experiments made, are fully set forth in tables, and, graphically, by charts.

It will be interesting to give some of Mr. Hadfield's conclusions:

"It is noteworthy that whilst chromium, so far as we imperfectly know its properties, is a hard metal, yet its addition, in the absence of carbon, does not produce any greater hardness, at any rate up to three or four per cent., than steels of similar silicon and aluminum percentages. Chromium, therefore, in its effects upon iron *as regards hardness*, may appropriately be classed along wiih most of the other non-hardening elements alloyed with that metal. Probably carbon must still be considered to be the only true hardener of iron." Page 36.

"We may imagine that hardened steel (that is, water or oil hardened) is a material in which the molecules are in a state of intense strain, often relieved, in the case of hardened steel projectiles, by the material spontaneously rupturing itself. It appears, therefore, that any material to be used, where subjected to sudden and intense strains [stresses] should not be in the condition of having a high elastic limit. If heavy guns were made of a grade of steel having medium tensility, but with a disregard to high elastic limit, it is probable that less failures would occur. In other words, it might be found better to have a harder grade of steel with a lower and natural elastic limit than a milder steel in which a higher elastic limit is obtained by means of sudden cooling, and which is probably a 'strained' elastic limit." Page 41.

"It hardly seems probable that this steel [chromium] will, at any rate for some time, come into general use or displace ordinary carbon steel except in special work." Page 45.

At present the use of chromium steel is confined to armor piercing projectiles, certain special classes of armor, and tools.

Mr. Hadfield's firm has supplied armor piercing projectiles to the English Government since 1882. He gives a short resumé of some of the latest tests of his projectiles supported by excellent reproductions of the plates and projectiles employed. The results of these tests are given in condensed form in the following table:

PROJECTILE.		PLATE.		Striking Velocity.	Penetration	REMARKS.
Cal.	Wt.	Kind.	Thickness.			
in.	lbs.		in.	f. s.	in.	
13.5	1120	Compound	18	1950	Complete.	Also penetrated a 6-in. wrought-iron plate, 20 feet of oak backing, a second 10½-in. wrought-iron plate, a third 2-in. wrought-iron plate; total penetration of armor 36½ inches. Projectile broken after passing through last plate.
6	100	"	9	1825	"	Reception test. Projectile whole. Only slightly altered in shape. Face of plate 1.25 per cent. carbon.
"	"	"	"	"	"	Same as last.
"	"	"	"	"	"	Projectile whole, very slightly altered; was fired a second time through another 9-inch plate, was still entire and was fired a third time at a special plate which broke it up.
"	"	"	6	"	"	A "bursting" shell with thin walls and double the capacity of core of a. p. shell. Found entire 2000 yards beyond target.
"	"	"	10½	1830	26½	Four projectiles. All entire and uninjured.

The percentage of chromium used in armor pirercing projectiles varies from 1.25 per cent. to 2 per cent., and the percentage of carbon varies according to the special requirements in each case.

M. Brustlein observed that the effect of chromium is to increase the tensile strength of steel and also its elastic limit without diminishing the elongation. Mr. Hadfield considers that the hardening effect of chromium is confined to the higher carbon steels, the effect increasing, in a measure, directly with the per cent. of carbon present. The great hardness of high carbon chromium steels is due, according to M. Osmond, to the formation of an iron-chromium carbide, which is itself very hard, and which, at high temperatures (1200° C. and higher), is dissolved and held in solution in molten steel, the cooled mass yielding a solidified solution of the carbide in carbon steel, and producing chromium steel.

The entire paper is very interesting and instructive. It is to be hoped we may soon have an equally thorough treatment of the iron-nickel-carbon steel which has so recently appeared on the scene to the undoing of chromium-steel projectiles. E. M. W.

The Annual of the Office of Naval Intelligence. General Information Series No. XI, July, 1892.

Again it becomes our pleasant duty to notice the Annual of Naval Intelligence in the *Journal.* The product of 1892 is similar in appearance, arrangement, and value, to those of previous years and as usual furnishes the reader with a vast amount of naval and military information which cannot be found elsewhere except in disconnected fragments scattered here and there throughout the world. The general subjects treated are arranged in chapters and, as several of these contain valuable information for the artillerist's profession, it may be well to consider each with sufficient detail to give him an idea of each chapter and the contents of the book as a whole.

I. NOTES ON SHIPS AND TORPEDO BOATS.—Begins with facts relating to the U. S. Navy, such as appropriations, vessels proposed or laid down, launched or dropped during the year. An object of interest under the head of torpedo boats is a brief description of the Baker submarine boat. Following in the same order, similar information is furnished with respect to England, France, Italy, Russia, Germany, Spain and less important countries of Europe and South America.

Considerable interest attaches to submarine boat experiments in France and Italy, which, taken in connection with those of our own navy, indicate an approaching solution of this problem. Therefore' the next naval war, it is probable, will see this unknown but important element introduced amongst many others yet untried. Russia is introducing electrical launches as picket boats.

II. NOTES ON MACHINERY.—This part relates principally to ship machinery. Although not dealing directly with artillery matters, it is believed that officers of this arm will find much information which will aid them in their preparation for the new artillery problems and conditions. Several discussions of scientific interest are presented, the more important of which are, extracts from the report of the Chief of the Bureau of Steam Engineering for 1891 on "Steel Castings," "Deterioration of condenser tubes in the U. S. S. Baltimore" and "Vibration of Vessels." The last subject is set forth to considerable extent in the words of Mr. A. F. Yarrow, a most careful investigator. He points out causes of vibration and suggests means of removing them. He has proved by experiment that they are independent of the screw. The subject is illustrated by photographs.

III. NOTES ON ORDNANCE.

High Power Guns.—In the notes relating to high power guns abundant evidence appears, showing a rapid tendency towards the abandonment of all calibers larger than 13''.5 and this size is becoming rare. During the year no new 110-ton guns have been ordered in England, the manufacture being restricted to 67-ton 13''.5 guns. Italy is confining her orders to 68-ton, and Germany to 28-cm. 35-caliber guns. The record of the English 110-ton gun is by no means encouraging. Out of a contract for twelve, ten have been delivered. Five of these are now mounted on ships and are *assumed* to be in serviceable condition, one is to be repaired, one failed on trial and is now reserved for experimental purposes, one was strengthened to replace another, a fourth was condemned and the remaining one has just been accepted. Those now mounted are not considered safe with full charges and in some cases are said to be defective. The 13''.5 67-ton guns have a record little better, and the same may be said of most of the other guns in the English service.

In France there is a reaction towards smaller calibers and higher initial velocities. The largest gun of the future is to be the 30-cm. 50-caliber gun, projectile 625 pounds, initial velocity 2625 f. s. This type is to replace that of the 42-cm., whose record is little better than that of the 110-ton guns. Two Krupp 119-ton 40-cm. guns have been mounted in a Gruson Cupola and the system was found to work well, but it does not appear as having been thoroughly tested.

It would appear from the facts here given that very large guns in Europe have had their day. Expensive but valuable lessons have been learned by England, France and probably Germany, in regard to these "obsolete masses of iron," and these and other foreign nations are showing a strong disposition "to have done with them." Their experience now comes to the rest of the world free of charge, and to us very opportunely. In view of this and much other experimental information obtained in foreign countries, we are especially fortunate in being somewhat backward in our new armament, since we may now profit by all their experience and avoid all their recognized mistakes.

The first three 24-cm. Canet guns for the *Capitan Prat* have passed their trial successfully. The guaranteed velocity of 2400 f. s. was obtained with smokeless powder. The last two of the Canet 32-cm. guns for the Japanese navy passed their trials. One gave a veloctty of 2386 f. s. with a pressure of 16.15 tons. All the mounts and mechanism worked satisfactorily.

Rapid Fire Guns.—The principal systems which have been prominent during the year are the Armstrong, Canet, Krupp, Schneider, Hotchkiss and Driggs-Schroeder. The use of cordite in the Armstrong guns gave 2660 f. s. The great length and resulting high velocities of Canet guns, the bursting of a Hotchkiss gun at the battle of Vina del Mar, Chili, 1891, and interesting mechanical details in the various breech mechanisms are the special features relative to this class of ordnance during the year. France has been adopting rapid fire guns in her armament and is now converting her 10, 14, and 16 cm. guns into rapid fire guns. Future conditions will exact rapid fire guns of large caliber and this step seems merely to anticipate the future armament which, in all probability, will consist almost if not entirely of rapid fire guns. The Dashiell mechanism for quick firing guns of large caliber, have been adopted in the U. S. navy. A description is given. It is not unlike that of Canet.

Machine Guns.—The Maxim automatic, and Koda 8-mm. machine guns are considered and described.

Gun Mounts.—The Vavasseur housing apparatus has for its object the withdrawal of the gun inboard from the firing position when desirable. The Schneider and Krupp mounts and hoists are fully described and illustrated. The Fletcher mount adopted for 4″ rapid firing guns in the U. S. navy deserves study.

Small Arms.—The small arms of all nations are carefully discussed and tables and data relative to the latest models, interesting experiments with smokeless powders, and statistics in regard to the re-arming of Europe given.

Torpedoes.—Sims-Edison dirigible torpedo underwent experiments which showed methods of launching and clearing the ship and, with one or two exceptions, controllability. The Whitehead, notwithstanding its great number of failures during the year, and previous years, still holds its own, and is being manufactured after larger models and is being more generally adopted. The motive actuating European nations seems to be that it is absolutely necessary to possess this torpedo regardless of its record, until a better one can be secured. Successful experiments with the Howell torpedo led to an order for a number for use in our own navy. The Ericsson submarine gun and *Destroyer* are explained and experiments made by the U. S. navy given. The tabulated results indicate a range of 500 ft. A comparison of these with the results which will soon be obtained from trial of the guns of the *Vesuvius* will be interesting. Torpedo booms, net cutting attachments and discharging apparatus come in for notice.

High Explosives.—The Justin and Snyder high explosive shells are shown, with results of experiments during the year. Very little interest however is attached to either of these make-shifts.

In France experiments were made (1) *Firing against protective decks.* The target represented as nearly as possible a ship's deck and side. A splinter screen was placed behind the protective deck. 32-cm. common fuzed cast-iron shells, containing 55 pounds of melinite, were fired with velocities of about 1635 f. s. The trial showed that a 0''.315 sheet iron splinter screen caused the shells to explode before striking the deck. The effect on the deck depended on the distance of explosion therefrom. The details are too numerous to be given here, but merit careful study.

(2) *Firing against light armored upper works.* The target was made up to represent the light upper works of the *Brennus*, and was attacked with projectiles in a manner similar to that described above, and also with 16-cm. projectiles containing 8.8 pounds of melinite and black powder. Again the details are too numerous to present here, but the conclusion was that armor is worsted when attacked with powder charged shells which perforate before explosion, or with large melinite charged cast-iron shells, striking normally with velocities from 1968-2132 f. s. In April, 1892, 10 melinite shells fired from a mortar destroyed a target at a range of 1970 yards.

Armor face hardening.—Patent specifications of the Harvey and Tresidder processes given showing means and methods used in hardening plates.

The remainder of the chapter is devoted to cellulose, coffer-dam tests, etc., ordnance instruments, particularly Fiske's position-finder, illuminated sights and projectiles.

IV. NOTES ON NAVAL ADMINISTRATION AND PERSONNEL.—Here we find a continuation of the subject touched upon in earlier numbers. These notes are based mainly on foreign official publications and relate principally to England, France, Italy and Germany. They constitute a valuable contribution to naval studies, but possess only general interest for the artillery.

V. ELECTRICITY ON BOARD NAVAL VESSELS.—The electrical paper this year differs materially from those of previous years. The development and introduction of arts and sciences are generally accompanied by a great variety of kinds and forms of apparatus, without any necessary relation to one another. They are usually the products of different minds working along different and independent lines toward the same end, but with wholly different kinds of devices and units. The transition from this condition of affairs to one of simplicity and uniformity marks an epoch in such development. The application of electricity to naval warfare has been no exception to this rule, and we find the navy now passing through this change. It appears from the paper now before us that the efforts of the navy during the year in regard to its electrical problems have been in the direction of standardizing all apparatus and of producing such correlation of parts in future equipments as will secure well devised and uniform systems, fulfilling certain conditions evolved from experience. Such efforts always mark an advanced stage in adoption of machinery and shows how early and well our naval friends have perceived the value of electricity for modern conditions of war. The standardizing movement is proof of the hold which this agent has upon naval problems.

The subject is treated carefully and progressively, and the principles—

based upon experience—which all standard apparatus should fulfill are given· Following this method the writer considers generating sets, number and size of dynamos and location of rooms, accumulators, batteries, switch-boards, wiring lamps, etc., with respect to unformity of equipment and operation.

The question of search lights on shipboard is discussed in a thorough manner and the different methods of arranging and controlling them are presented. The development of a German lamp with horizontal carbons and results obtained from it are of special interest. The introduction of electric motors is given considerable space and their superiority in many cases, over all other forms of motors is recognized, not only in regard to weight, convenience, cleanliness, and efficiency, but also in cases where no other motor will accomplish the desired result. The contrast in favor of power transmission through means of wires as against pipes and similar devices, is well brought out. The conclusions here laid down are interesting when compared to those of an English officer recently discussing the same subject, in which it is concluded that pipes should be much simpler and safer than wires. The means and importance of internal communication are dwelt upon.

While none of the electrical problems on shipboard can ever be quite the same as those in a fort, still the majority of them must be essentially the same, and abundance of information may be obtained from ship problems already solved. In reading this chapter and reflecting on its contents, the question naturally arises in the mind as to how long it will be after we have begun to solve our "electrical problems" before the "standardizing" period is reached. With all this experience similar to what our own must be, we should be able to commence practically where the navy stands to-day. Here again the army can find much experience and resulting information free of cost and trouble and should profit by it.

VI. THE NAVAL MANŒUVRES OF 1891.— The naval exercises embraced in this subject relate to England, France, Germany, Austria and Russia. The manœuvres are principally valuable in showing the plans of operations in each case, the rules laid down for governing umpires, and the mass of details with reference to attack and defense by torpedo boats. Owing to the imperfect or double nature of the evidence the decisions of the umpires were not always conclusive. The failure of torpedoes in the English fleets were pronounced and torpedo boats showed up in very poor light. Fewer casualties resulted than in former years.

VII. ARMOR IN 1892.—After giving a brief statement as to the necessity for equal conditions in comparing armor plates, the writer divides the subject into I. French trials at Gâvres. II. English trials. III. Indian Head trials. IV. Conclusions deduced from the year. He then proceeds to discuss the results in each particular series. In each case ballistic and firing details are given, with illustrations of the results. These form a collection of great value. In part IV the writer concludes that the U. S. Bethlehem plate tested at Indian Head November 14, 1891, stands higher in order of merit than either English or French plates tried during the year. The appearance of this

Harveyized high-carbon nickel-steel plate after trial is clearly reproduced. Additional tests at Indian Head have demonstrated beyond question the value of nickel-steel, which used in connection with the Harvey process has developed armor to an efficiency never realized before. The most remarkable results in the history of armor were obtained with the 10″½ Harveyized nickel-steel plate of the Bethlehem Company tested at Indian Head July 23, 1892, and with a similar plate tested at the grounds of the Bethlehem Company July 30, 1892. In each case the navy 8″, 250-pound projectile, 1700 f. s. was used and five shots were fired. Each blow being delivered with 5008 foot-tons, or a total of 25040 foot-tons was spent on the plate. Neither plate was essentially injured and, to all appearances, were nearly as strong as before.

VIII. SOME STANDARD BOOKS ON PROFESSIONAL SUBJECTS.

In closing these remarks it may be well to emphasize some of the characteristics of the work under consideration.

1. It is a professional book the compilation of which is performed by officers of the navy who are especially detailed for this purpose.

2. It is an *annual* and therefore represents systematic organized effort with well defined objects in view.

The Bureau of Information is established and run according to business principles. Officers of the navy alternate between ship and shore duty. While on shore they are assigned to various duties as, collecting information, work in shops, at proving grounds, etc., where they are enabled to study theoretically the results of such practical experience as they may have obtained at sea, or to construct and test any theoretical apparatus which they may have devised during the same period. The results of this rotation in duty by which theory can be reduced to practice and experimental data brought within the mellowing influence of scientific light, need no comment. Some construct guns and carriages, while others use them. Then comes a time when the constructors go out and operate the machines which they have made and soon learn whether or not their designs are ideally perfect. In the same manner some collect information and others, while using it, come directly in contact with subjects and problems in regard to which information is deficient and are sent in their turn to make up the deficiency.

The collection of such a book may seem a small matter, and in itself it is, but when considered in connection with the work of preparation, organization, and above all the acumen of its founders to perceive the ultimate benefits which the bureau of information would return, it must be regarded as a great undertaking. Keeping in mind the live and liberal policy which originated and continues *this necessary department in a progressive profession*, we need not wonder that emergency finds them ready. J. W. R.

BOOKS RECEIVED.

Report of Adjutant General of Pennsylvania, 1891.

Report of Adjutant General of Massachusetts, 1891.

List of Foreign Correspondents of the Smithsonian Institution, by GEORGE H. BŒMER.

A Catalogue of Scientific and Technical Periodicals (1665 to 1882), by HENRY CARRINGTON BOLTON.

Alloys of Iron and Chromium, by R. A. HADFIELD, including a report by F. OSMOND.

Smithsonian Report, 1889.

Smithsonian Report, U. S. National Museum, 1889.

Annual of the Office of Naval Intelligence, 1892.

Annual Report Bureau of Ethnology, 1885-86.

Descriptive Map of Army Posts, by *Lieutenant* H. C. HALE, U. S. A.

SERVICE PERIODICALS.

Revue d'Artillerie.

SEPTEMBER.—75-mm. field materiél, Schneider system, constructed for Brazil. Artillery in the United States in 1892. Metallurgical industries in the United States. Rules of fire for the German foot artillery. The materiél of the Russian field mortar.

OCTOBER.—Notes on the Austrian artillery.

Subdivisions of the year of instruction into periods.

First Period.–(*a*) Instruction of recruits. 1st October, 1st July.
(*b*) " " veterans. All battery exercises

Second Period.–1st July to August 9 includes manœuvres of groups, regiment and fire.

Third Period.–August 10—31, manœuvres with other arms.

Fourth Period.–Manœuvres with division of infantry and cavalry; general manœuvres.

Fifth Period.–General rest, preparation of personnel for instruction of recruits and transfers to reserve.

Notes on Italian fortress artillery [continued].

NOVEMBER.—Artillery of the future and the new powders [continued]. Fire manœuvres of masses of artillery and their teachings.

Under this title the author [Cohadon, Lieutenant Colonel 2nd Regiment of Artillery,] discusses the operations of the artillery collected at Camp Chalons, 1st—14th August, 1892, and gives suggestions and conclusions which are the results of his observation.

DECEMBER.—Notes on the Austrian artillery. Methods and formulas of experimental ballistics.

First Part: Exterior Ballistics. Chapter I. Law accepted for the resistance of the air. Chapter II. (1) Rectilinear movement. Table of Ballistic functions. (2) Fire with elevation under 5°.

Fuses and detonators of the German artillery. J. W. R.

Revue Militaire de l'Etranger.

SEPTEMBER.—Military organization of railroad service in Austria-Hungary.

History of the subject. Organization of the service in peace. Organization of the service in war.

The military forces of Denmark (continued in October). The Danish army. II. General organization of the army upon a peace footing. Military news.

OCTOBER.—Field magazines in the German army. Military utilization of the navigable rivers in Italy (continued in November and December).

NOVEMBER.—Officers of the Reserve and "Landwehr" in Germany.

DECEMBER.—The new regulations of manœuvre for the German field artillery. The Italian budget for the exercises of 1893-94 and projects of reform of the Minister of War.

J. W. R.

Revue du Génie Militaire.

MAY-JUNE.—Notes upon the organization of the Corps of Engineers in the 18th Century. Note upon the trace and measure of the carapace in Béton cement.

An analytical discussion of the subject with several examples.

The Italian fortifications; from a course at the Turin school of application for the artillery and engineers. J. W. R,

Revue Maritime et Coloniale.

OCTOBER.—New Caldonia and its inhabitants. Balloons and exploration of Africa. The origin of French India. Four contributions to the geometry of naval tactics. Shipwreck statistics. Study upon the mechanical theory of heat.

J. W. R.

Revue du Cercle Militaire.

SEPTEMBER 11.—The Russian naval manœuvres of 1892. The technical corps (troops) of Austro-Hungary.

SEPTEMBER 18.—The Military Club of Vienna (continued). The new regulations of instruction and internal service for the Italian infantry (continued). The first combats of the Army of the Rhine (continued).

SEPTEMBER 25.—The Chinese army of the green flag (continued).

OCTOBER 16.—The reserve divisions in the manœuvres of 1892 (continued).

NOVEMBER 6.—Impressions of manœuvres. The Italian mobilization. The new war formations.

NOVEMBER 13.—Letters of an English officer on our grand manœuvres (continued).

NOVEMBER 27.— Medical statistics of the French army in 1890 (continued).

DECEMBER 4.—The Souchier prism Telemeter (continued). Pacification tactics in Tonquin.

DECEMBER 11.—Electrical transmission through space without any intermediate conductor.

DECEMBER 18.—The new Chalais-Meudon dirigible balloon.

J. W. R.

La Marine Française.

NOVEMBER 27.—The Coloniale army. The Russian naval manœuvres.

DECEMBER 4.—Mathematical pointing. Preface to the discussion of the Washington conference upon moderate speed.

DECEMBER 11.—The Franco-Russian and English fleets compared.

DECEMBER 18.—Auxiliary dispatch boat cruisers. The marine budget.

J. W. R.

Journal de la Marine, Le Yacht.

No. 765.—The national marine.

No. 766.—The cruiser *Olympia,* U. S. Navy. The navies of the world (from Broad Arrow).

No. 767.—The marine budget. The navies of the world.

No. 768.—The use of heavy oils for fuel in the Navy. Electrical launches.

No. 769.—The national marine work in the marine arsenals.

No. 770.—The English navy. Ideas on the electric propulsion of boats. The navies of the world. English torpedo vessels.

No. 771.—English cruisers.

No. 772.—The new constructions in the Arsenals at the end of 1892.

No. 773.—Trials of the *Capitan Prat* (artillery and speed).

J. W. R.

Revue d'Infanterie.

December.—Treatise on the exercises and manœuvres of infantry. History of infantry in France. The Russian army. Chapter VII (artillery). Our cavalry. J. W. R.

Revue Militaire Universelle.

Tactics applied to the terrain. Explosives. Information upon small arm cartridges. The Dahomeyan Expedition of 1890. The Chaplain of St. Cyr. In Algiers. J. W. R.

Mémoires de la Société des Ingénieurs Civils.

Revue Militaire Suisse.

June.—A reform in the instruction of our cavalry. Supplement—Report for 1891 on the administration of the federal military department.

August.—Fortification of the passage of Luzienstieg. The French manœuvres.

October.—General organization of the army corps.

December.—Military budget for 1893. J. W. R.

Memorial de Artilleria.

September.—Applications of electricity to artillery, by D. Severo Gómez Nuñez, Captain of Artillery (continuation).

The author in this article treats principally of the collection of electrical apparatus exhibited at the Moscow exposition by Messrs. Sautter Harlé and Co. He mentions a continuous current lamp for light-house work which embodies steadiness of light and freedom from oscillations inherent in alternating currents.

Motors and dynamos were divided into three groups.

1. Those of highest potential coupled direct to a fifteen H. P. engine used for illuminating warships.

2. Those in which the dynamo is coupled direct to a compound vertical engine, and intended for use in torpedo boats.

3. Those of smaller size for smaller class of torpedo boats. All these different models light lamps within and projectors from 30 to 40 cm. without and are also used for signaling.

The writer further considers the present necessity for electric light in the proper equipment of a fortified place, not only for the purposes of war but for the thorough drill and preparation for the same. His argument is to the effect that the electric current is essential for signaling, illumination and searching by night, and for pointing the guns and working the range-finders by day. He maintains that it is not judicious on account of expense, to curtail these auxiliaries, that the pieces must be pointed and handled so as to elicit the greatest possible return, that he who has to direct the guns, receive the hostile fire and repel it, must avail himself of all possible auxiliaries, and that he who does not have light in his magazines and over the field of fire at night will not be equal to the emergency.

Coast artillery. Warships (continuation).

A review and comparison of English, French and United States vessels, and their relation to coast artillery.

Modern small arms and their ammunition (continued). Our arm in the East Indies (continuation). Note on the energy absorbed by friction in the bore of a gun.

Translation of Captain Noble's paper.

OCTOBER.—Scheme for the assimilation of classes of guns for the service of modern siege and fortress artillery.

In the paper the author brings forth a plan for simplification in the nomenclature and a general correlation of the corresponding parts in different classes of artillery. He holds that in all cases where the corresponding parts can be made alike and of the same material they should be made so.

NOVEMBER.—The most suitable period for practical instruction and exercises. Study upon a single fuze for our artillery. A target with an electric bell. A few thoughts relative to the probable perturbating causes in the determination of initial velocities with the Bréger chronograph. J. W. R.

Revista Cientifico Militar [Barcelona].

NOVEMBER 15.—The Spanish American Military Congress. The health of the soldier. The manœuvres of 1892 (continued).

DECEMBER 1.—The 6-mm. gun. The initiative in tactics Metallic bridges. Abridged ballistics (continued).

DECEMBER 15.—The manœuvres of 1892. J. W. R.

Boletin del Centro Naval. Vol. IX.

MARCH AND APRIL.—*Nautilus*, of the Spanish Royal navy. Plan for a swift cruiser.

An analytical discussion of the problem to construct a vessel that will have a speed of 22 knots with forced draught and 18 knots with natural draught (continued in June).

JUNE.—The national dynamite factory. Trials of a 75-mm. gun manufactured by shops of Creusot. Cruiser *Patagonia*. H. M. S. *Resolution*. Torpedo despatch-boats (continued in July).

July.—Material of the 15-cm. R. F. gun, 45 calibers, Schneider system.

August and September.—Comparative study of the material of 15-cm. rapid fire guns.

Consists in a comparative description of the four systems of rapid fire guns, Canet, Armstrong, Krupp and Schneider, translated from *Le Génie Civil*, also appeared in *Engineering*.

Squadron Evolutions, 1892.

Treats of the orders given for the instruction of the squadron, consisting of manœuvre and use of torpedoes.

Reports of chiefs of squadron and torpedo divisions. Tactics of torpedo vessels. J. W. R.

Circulo Naval, Revista de Marina [Valparaiso].

November 30.—Our last squadron of manœuvre and questions pertaining to it (second part). European navies. General instruction for officers in charge of the electrical and torpedo branches. Organization of the naval personnel of the principal maritime powers of the globe. A vocabulary of powders and explosives. The great war of 1892, a prophecy (by Lord Salisbury).

Revista Militar [Lisbon].

Revista Maritima Brazileira.

November.—The warship and naval war. Powders and explosives. The construction of forts.

Archiv fuer die Artillerie-und Ingenieur-Offiziere des Deutschen Reichsheeres.

September.—Laws regarding twist; an illustration as to how to obtain the kind of twist, including an essay in regard to the use of variable twist, by Lieutenant Colonel Von Scheve, Inspector of the 2nd Artillery Inspection Depot.

In relation to the velocity of rotation of oblong projectiles and the determination of the most advantageous length of twist, from an essay by N. Zaboudski, Professor at Michael Artillery Academy, St. Petersburg, and Captain of the Russian Artillery Guard. H. C. S.

Mittheilungen ueber Gegenstaende des Artillerie-und Genie-Wesens. 9th and 10th Number.

The behavior of steel and iron when subjected to low temperatures, with special reference to the construction of steel "laffetten." An essay on the Electrical Exhibition at Frankfort A. M., 1891.

A full description is given, among many others, as to the methods employed in transmitting electric power from Laufen to Frankfort, a distance of 108.74 miles.

Experiments carried on with different kinds of armor plates, at Annapolis. Horse shoes made out of aluminum, in Russia. A full description of the Souchier range-finder (with plates).

H. C. S.

Jahrbuecher fuer die deutsche Armee und Marine.

October.—A composition giving the details of the siege of Thionville in November, 1870, from the diary of one of the German officers present. Work to be done by torpedoes when attacking and when defending bodies of water. The Russian Empire on the Pontus and the oriental question, by Otto Wachs. The theory in regard to military riding instructions.

H. C. S.

Internationale Revue ueber die Gesammten Armeen und Flotten.

Allgemeine Schweizerische Militaerzeitung.

September 3.—Austrian regulations in regard to target practice. About the practicability of using the absolutely best form for projectiles and the results to be attained thereby.

The writer demonstrates the practicability and points out the importance of having the projectiles ogival "based" as well as ogival "headed."

September 10.—Extracts from Dragomirow's report of his inspection of the field exercises in July and August, 1891.

September 17.—A study of army corps, chiefly as regards their composition (continued). Cavalry swimming across rivers.

A translation from the "Revue de Cavalerie," February number, 1892 (continued).

September 24.—Use of cavalry in future wars. H. C. S.

Marine Rundschau.

Mittheilungen aus dem Gebiete des Seewesens.

Militaer Wochenblatt.

Militort Tidsskrift.

The Journal of the Royal United Service Institution.

SEPTEMBER. Magazine rifles, their latest developments and effects. Saddles. Color blindness. Torpedo-net defenses. The military situation in upper Egypt. Cavalry swimming. Comparison of the most important regulations of the four continental powers, as regards the attack and defense.

OCTOBER. Annual reports upon the changes and progress in military matters during 1891. The French Naval Manœuvres (1892). The field-gun of the future.

NOVEMBER. German Divisional Cavalry. General Jarras. The Russian Navy. A long distance ride. Regulations for mobilization for home defense regular force.

DECEMBER. The strategic positions in the Mediterranean. The magazine rifle question. A field firing exercise with all arms, in the XIV German Army Corps. Recent works by Captain Holnig. A short account of the French Marine Infantry.

J. W. R.

Journal of the United Service Institution of India.

Aldershot Military Society.

Proceedings of the Royal Artillery Institution.

SEPTEMBER. Fire discipline, its necessity in a battery of horse or field artillery and the best means of securing it. Skill at arms. Mountain artillery progress. Achievements of field artillery.

OCTOBER. The United States Military Academy. "I" Troop Royal Horse Artillery at the Battle of Fuentes D'Onore. Fire discipline, its necessity in a horse or field battery and the best means of securing it. Achievements of field artillery.

NOVEMBER. Fire discipline, its necessity, etc. Mounting hydro-pneumatic disappearing guns. Achievements of field artillery.

December. The Sudan, past and present. Fire discipline and skill at arms. Achievements of field artillery.

Engineering.

September 23. Modern United States Artillery No. XXV (continued). The national gun factory (Figs. 504 to 511).

Under this head is given a brief description of the gun shops, and in detail the manufacture of an 8-inch breech-loading steel rifle under—1. Operations before shrinkage, (*a*) the tube; (*b*) boring; (*c*) assembltng of the tube and jacket; (*d*) assembling the hoops. 2. Operations after assembling. 3. Table XLIII, presented and actual shrinkage in assembling guns. (*a*) First shrinkage. (*b*) Second shrinkage.

H. M. Battle-ship *Ramillies* in course of construction.

October 21. Canet quick firing guns.

November 11. The cost of electric supply. Two new British battle-ships.

November 18. H. M. S. *Vulcan.* J. W. R.

The Engineer.

November 4. The Vickers-Harvey nickel plate at Portsmouth.

November 11. The Brown segmental wire-wound gun. Her Majesty's first class battle-ship *Howe.*

November 18. The Vickers-Harvey armor plate.

This article shows a half tone photograph of the effect of five 6'' Holtzer projectiles upon the plate. The plate apparently stood the test well. In the word of the text "it looks practically nearly as strong and stiff as before the attack."

The Argentina twin screw armor clad *Libertad.* H. M. S. *Revenge.*

November 25. Factory driving by electricity.

December 9. Breech-loading rifled mortars for the United States Government.

December 16. Notes on the recent Russian plate trials.

Data and description of experiments given. Illustrated by ten cuts showing the development and results of the trial.

J, W. R.

The United Service Gazette.

September 17. The late naval manœuvres (mining and countermining at Belfast).

SEPTEMBER 24. Artillery fire discipline. Our position in the Mediterranean and our navy.

OCTOBER 1. The next naval war.

OCTOBER 8. Continental methods of attack. The lessons of the Chilian War.

OCTOBER 15. The French Fleet in the Mediterranean. Naval supremacy.

OCTOBER 22. Professor Hebler on the best possible form of bullet. Continental methods of defense.

OCTOBER 29. The Russian Navy. The torpedo net.

NOVEMBER 5. Mobilization for home defense. Torpedoes and torpedo craft.

NOVEMBER 12. Our naval deficiencies.

NOVEMBER 26. The *Militär-Wochenblatt* on public opinion and the coming war I (continued).

DECEMBER 31. Progress in French shipbuilding.

J. W. R.

The Army and Navy Gazette.

SEPTEMBER 17. Field artillery practice. Torpedo boat catchers.

SEPTEMBER 24. The study of naval war.

OCTOBER 1. The French Naval Manoeuvres.

OCTOBER 15. Lord Roberts and the Royal Artillery.

OCTOBER 22. The Russian Naval Manoeuvres.

OCTOBER 29. The staff college. The next naval programme.

NOVEMBER 5. British and foreign ordnance.

A reply to the recent articles in *Engineering* which treated of the Schneider system of R. F. guns and comparisons with other systems. The article is devoted to consideration of statements made by Schneider & Co., and correction of erroneous statements made by them in reference to Armstrong guns.

NOVEMBER 12. The Harveyized armor plate.

NOVEMBER 19. Specialists in the Royal Artillery.

J. W. R.

Journal of the American Society of Naval Engineers.

NOVEMBER. An analysis of the results of the experiments made on the paddle-wheel Steamer *Ville de Douvres*. Speed trials.

Influence of shock on propeller efficiency. Tests of riveted joints at the Watertown Arsenal. Coal endurance and machinery of the new cruisers. Boilers and their determination. The marine engine. The elimination of sulphur from iron. Bending tests of steel. Notes.

Proceedings of U. S. Naval Institute.

No. 63. First aid to the injured and transportation of the wounded.

Journal of the U. S. Military Service Institution.

November. Guns and forts. Queries on the cavalry equipment. Artillery service in the rebellion. The field gun of the future. Abstract of lectures on explosives.

Journal of the U. S. Cavalry Association.

The Army and Navy Journal.

October 8. The evolution of the naval officer. The new army gun.

October 15. The detachable ram. Sail power for our new navy.

November 5. Whale-backs as monitors. Army ordnance work.

November 26. The Woodbridge wire wound guns. The Naval Bureau of Ordnance.

December 17. Small arm projectiles, past and present. Report of the Secretary of the Navy.

December 24. The state troops at Buffalo. Smokeless powder and magazine rifles.

The Army and Navy Register.

November 19. The lance for the cavalry.

November 26. Commodore Folger's report.

December 3. Testing an armor plate.

December 10. The lake naval question again. Bureau of steam engineering.

December 24. Proposed scheme for test of the pneumatic guns of the *Vesuvius*.

Cassier's Magazine.

JULY. Ship building in America.

A highly interesting and valuable article, with description and many illustrations of the ship-yard and machinery at Newport News, Virginia.

Direct connected engines (continued).

Fully illustrated article showing different types of engines connecting directly with dynamos.

Electrical equipment of modern war-ships II.

An article by Lieutenant Hamilton Hutchins, U. S. Navy, in which he shows the numerous advantages of electricity over other sources of power for many purposes on warships.

SEPTEMBER. Modern methods of quarrying.

This is an article devoted principally to modern methods of drilling with view of producing the least waste in the stone when blasted.

Hammersley's United Service.

OCTOBER. I Methods of marching.

In the author's mind (Captain H. R. Brinkerhoff, 15th Infantry) there are two methods of marching; the one in which officers and men know nothing of their destination or the object in view, the other in which all as far as possible possess such information. The former is bad the latter is good. While admitting the absolute necessity for forced marches with infantry under heavy burdens, he presents a strong sensible argument for making them no oftener than necessary, and for lightening the burden whenever possible.

III Europe in 1890-91 (continued). The coming revolution in tactics and strategy (from the *Contemporary Review*).

An argument tending to show that the adoption of smokeless powder marks an epoch in tactics and strategy, and that the first week's fighting in the next great European War will show that a new departure must be made. The weight of the argument inclines to the defensive, claiming that all recent changes in weapons and material will be to the advantage of the defense. It is further maintained that there is nothing in either the offensive or defensive which gives the one or the other a moral advantage, but that this consideration shifts from one to the other as experience establishes superiority in war.

NOVEMBER. I Wanted a defensive policy.

A paper giving an argument in favor of a large and efficient navy, and a more liberal policy in regard to the acquisition of coaling stations and possessions, especially in the West Indies and Sandwich Islands. The value to the United States of the South American and China trade are brought out in a clear and interesting manner.

December. I A plea for seamanship. II A cavalry raid.

The Iron Age.

OCTOBER 6.—Making great guns. Test of an Ellis-Tresidder compound armor plate. Torpedo boat No. 2 nearly completed.

OCTOBER 20.—Electric motors in a machine shop.

Treats of the introduction of electric motors into the new shops of De La Vergne Refrigerating Machine Co., at the foot of 138th Street, New York. This interesting article is fully illustrated and treated under the following heads:—Erection of the shop building; heating; fire protection; equipment; appliances; machines driven by electric motors; wiring; the motors; the power required; general advantages; tests.

Elimination of S. from iron.

NOVEMBER 24.—The Morgan mortar mounting.

DECEMBER 15.—The turrets of battle ships.

DECEMBER 29.—A French steamship mobilization trials.

Scientific American.

SEPTEMBER 17.—A submarine search light.

OCTOBER 1.—German military balloon apparatus.

OCTOBER 29.—Improved armor plates.

NOVEMBER 12.—A remarkable warship.

A description of the English battle-ship *Ramillies*, with armament, dimensions, and other important data.

Engines of a modern battle-ship. Data of battle-ships given in tabular form.

NOVEMBER 19.—Fast torpedo boats. The Gathman torpedo.

NOVEMBER 26.—A recent projectile trial. Large dynamo for direct driving.

DECEMBER 3.—Loss of a great ship of war (Howe).

DECEMBER 10.—Improved armor plate planing and slotting machine.

DECEMBER 17.—The astounding military force of Europe.

DECEMBER 24.—Progress of our navy.

DECEMBER 31.—Smokeless powder. The new army magazine rifle.

The Engineering Magazine.

OCTOBER.—How electricity is measured.

NOVEMBER.—Relative cost of electricity and gas.

The Railroad and Engineering Journal.

OCTOBER.—The dynamite cruiser *Vesuvius*. A new English battle-ship *Barfleur*.

NOVEMBER.—Electricity in welding and metal working. Cruiser *Olympia*.

DECEMBER.—The first light ships with electric light. The new breech-loading mortars.

The Engineer (N. Y.).

DECEMBER 10.—The position of naval engineers. Abstract of report of Bureau of Ordnance.

DECEMBER 24.—The Sims-Edison torpedo. Machinists in the navy.

Electrical Review.

NOVEMBER 12.—Electric torpedo boats.

The Western Electrician.

DECEMBER 10.—The Baker submarine boat.

DECEMBER 17.—Submarine operations by electric light.

BOOKS, EXCHANGES, ETC.

American Journal of Mathematics.
Annual Report Bureau of Ethnology.
Annual Report Smithsonian Institution.
Annual Report American Iron and Steel Institute.
Annual of the Office of Naval Intelligence.
Institution of Mechanical Engineers.
Journal of the American Chemical Society.
Journal of the Franklin Institute,
Popular Science Monthly.
Proceedings of the Royal Society N. S. Wales.
Transactions of American Institute of Electrical Engineers.
Transactions of American Institute of Mining Engineers.
Transactions of Canadian Society of Civil Engineers.
Transactions and Journal of the Photographic Society of Great Britain.

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THE INTERNATIONAL ELECTRICAL CONGRESS OF 1893, AND ITS ARTILLERY LESSONS.

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PART I.

The World's Electrical Congress assembled at Chicago on Monday, August 21st, 1893. Probably never before in the history of the world have so many men distinguished in the domain of electrical science—electrical engineers, investigators, and specialists, of international reputation,—been assembled at one time for mutual conference, and benefit; and I think it can be safely said that, in the importance of its deliberations and the immediate influence they will exert upon the industrial and commercial progress of the world during the next decade, no gathering of men among the many congresses at Chicago during the great Fair, will compare with the World's Congress of Electricians.

As early as August, 1889, the American Institute of Electrical Engineers, as the representative electrical society of the United States, conceived the idea of such a congress in connection with the World's Columbian Exposition, and appointed a committee of arrangements, but subsequently the official management of the congress passed into the hands of the World's Congress

Auxiliary Electrical Committee of which Dr. Elisha Gray was chairman. For two years Dr. Gray and his associates labored assiduously to make this congress the successful and worthy representation of the best electrical science and practice in all parts of the world. The American Institute of Electrical Engineers though deprived of the actual official management of the congress, heartily coöperated by all means in its power, and certainly contributed very materially to ultimate success.

His Excellency, Dr. H. von Helmholtz, official delegate from Germany,—distinguished alike in electricity, optics, acoustics, and general physics; a man whose name and fame is known and honored wherever science is taught,—was the natural honorary president, and father of the congress. His advanced age prevented him from taking a very active part, but whenever he appeared it was the signal for the wildest enthusiasm. On account of the large number of subjects to be considered, the general congress was divided into three sections as follows:—

(A). The section of pure theory, including electric waves, theories of electrolysis, electric conduction, magnetism, &c.

(B). The section of theory and practice, including studies of dynamos, motors, storage batteries, measuring instruments, materials for standards, &c.

(C). The section of pure practice, including telegraphy and telephony, electric signaling, electric traction, transmission of power, systems of illumination, &c.

The educator was promptly in evidence as will appear from the list of presiding officers of the sections.

Section (A). Professor H. A. Rowland, of Johns Hopkins University.

Section (B). Professor Charles R. Cross, of the Massachusetts Institute of Technology.

Section (C). Professor Edwin J. Houston, of Philadelphia.

THE CHAMBER OF DELEGATES.

In addition to the sections the Chicago Congress included a smaller body, the Chamber of Delegates, appointed by the respective governments at the request of the United States, a feature which gave it the stamp of an official affair like the congresses of 1881, and of 1884.

The official delegates were men of the highest attainments in their chosen field, and many of their names are household words to all students of electrical science.

The following gentlemen composed the official Chamber of Delegates.

England:—W. H. Preece, F. R. S.; Professor W. E. Ayrton, F. R. S.; Professor S. P. Thompson, D. Sc., F. R. S.; Alex. Siemens, Major General C. E. Webber.

France:—M. Mascart, M. Hospitalier, M. Violle, M. de la Touanne.

Germany:—Dr. H. von Helmholtz, Dr. Budde, Dr. Lummer, Professor Voit, Privy Councilor Schræder.

United States:—Professor H. A. Rowland, Professor T. C. Mendenhall, Dr. H. S. Carhart, Professor Elihu Thomson. Professor Edward L. Nichols.

Switzerland:—Dr. A. Palaz, M. Thury, Dr. Weber.

Italy:—Professor Galileo Farraris.

Mexico:—Señor Don A. M. Chavez.

President of the Chamber of Delegates, Professor H. A. Rowland of Johns Hopkins University.—Secretary, Professor E. L. Nichols of Cornell University.

The subjects considered by the Chamber of Delegates were those requiring united action by the various governments represented, such as the following:—

"Adoption of definitions and values of fundamental units of resistance, current and electromotive force.

"Adoption of definitions and values of magnetic units.

"Adoption of definition and value of the unit of self-induction.

"Definitions and values of light, energy, and other units.

"The standardization of electric lights.

"The consideration of an international system of notation and conventional symbols, and of a more uniform and accurate use of terms and phrases in electrical literature.

"A commercial standard of copper resistance."

Their meetings were private and were held in parlors of the Grand Pacific Hotel.

The experience of previous congresses had shown that little is accomplished in the four or five working days of a congress unless a thorough outline and discussion of the subjects to be considered are had prior to the actual assembling of the congress. To this end the American Institute of Electrical Engineers appointed a sub-committee on provisional program whose report was published in their *Transactions*, and an epitome of the discussion and criticism was available before the Chamber met.

PAPERS AND DISCUSSIONS.

Of the large number of valuable papers which were presented before the different Sections of the Congress it is impossible to to speak here. One paper which attracted perhaps the most attention, both on account of the eminence of its author and the boldness of its project, was that upon *Ocean Telephony* by Professor Silvanus P. Thompson, F. R. S. of England. His method in brief is to remedy the retarding effects due to the electrostatic capacity of submarine cables, by introducing self or mutual induction devices distributively along the cable. This he accomplishes very ingeniously and economically by a specially constructed three-wire cable.

Professor Thompson considers the transmission of telephonic speech across the Atlantic as entirely practicable, and an accomplishment of the near future.

Undoubtedly the most important and valuable discussion of the entire congress, was that upon multiphase motors and the transmission of power.

Professor Houston and Dr. Duncan had arranged for this in Section C, and so successful did it prove that both other sections adjourned and the entire time for two days was consumed upon this subject.

The participants included the most noted experts in this field throughout the world, and the amount of benefit all received from this interchange of ideas along the line, which will mark the greatest development during the next ten years, can scarcely be estimated. Briefly it can be stated that the foreign engineers rather favored the single-phase alternating system on account of its simplicity, while the American engineers who had had practical experience advocated the polyphase system with rotary transformers.

Professor George Forbes of England, Chief Engineer of the Cataract Co., which is to transmit power from Niagara Falls to Buffalo and neighboring cities, stated that the two-phase independent circuit system had been adopted with transformers to reduce the voltage to safe limits. In the mills and other works synchronizing alternating current motors or two-phase motors would be used.

The great advantage of this system is that it at once supplies power for all possible cases that may arise at the consumers' end of the line—*e. g.* alternating single-phase or two-phase currents of any pressure are available, as well as continuous currents suited to any machinery by the use of rotary transformers. This with the great economy due to high-pressure transmission.

In view of what is being done in this field it seems probable that our western waterfalls will soon play an important part in the development of mining and manufacturing interests throughout that great region.

GENERAL RESULTS.

With the important work accomplished by the Chamber of Delegates,* universal satisfaction is expressed, but it seems to be generally regretted that names were not adopted for the magnetic units, and that some decision was not reached in defining a practical unit of illumination.

We now have an international ohm, ampère, and volt, not equivalent to concrete standards which are kept buried in governmental archives like the standards of length, weight, &c., but units capable of being reproduced in any laboratory.

Although the practical unit of illumination was not authoritatively settled, yet the work of securing such a standard has been taken up by the American Institute of Electrical Engineers in this country, and by Mr. W. H. Preece in England.

This is an age of periodical literature, and especially is this

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* See Appendix.

true in electrical domains where discoveries and investigations are given to the world at once without the delay incident upon elaborate treatment in text-books and treatises. For this reason the large number of papers presented to the general congress were characterized by a freshness and timely importance which will cause the bound proceedings to become immediately a book of reference.

But not the least of the benefits of such a congress is the opportunity it affords of meeting on a common ground for a common purpose, the giants of the profession—the men who have long been admired and emulated through their works,—and I am sure that all, especially the younger struggling element of the congress, found this feature the privilege of a life-time, and an inspiration to higher and more sustained efforts in the future.

PART II.

Although not pertaining directly to the subject of the congress, yet in an *Artillery Journal* it cannot be wholly illogical to state some of the writer's impressions upon the future development of artillery in an electrical way, in the light of the present state of the science as revealed at the Electrical Congress, and in the electrical exhibits at the great Fair. They are submitted with caution and reserve, bearing in mind that the inexperienced are frequently accused of being theorists or enthusiasts, but if such be the case the conservatism and sound practical experience and judgment of our seniors, will contribute solidity and balance to the whole, and prevent the pendulum from swinging too far in either direction.

What we want is theory applied to practice—the two are inseperable, and must proceed *pari passu*, and this is nowhere more plainly exemplified than in electrical science and practice to-day the world over. The essential oil from the abstruse memoir of to-day, lubricates the commercial machine of to-morrow.

ELECTRICITY IN COAST DEFENSE ABROAD.

In the first place, however preëminent the United States may stand in leading the World in invention and execution in the industrial world, yet from the very nature of our position and military policy, we must look to Europe to study the problems of coast defense. For this reason I may be indulged a few extracts from the latest catalogue of Messrs. Sautter, Harlé & Co., of Paris, who have made a specialty of the adaptation of electrical power to military and naval purposes in France.

"A great number of electric motors have been constructed for the propulsion of ships and for submarine navigation."

"On board ironclads and in fortresses the ammunition hoists are electrically driven."

"More recently electricity has been applied in the most thorough manner to the working of heavy ordnance, replacing hydraulic mechanism by electric motors."

"On shipboard the command of the helm and also of the search lights is obtained electrically."

"The types of search lights, originally few in number, have multiplied in proportion as their applications have extended; at the present moment 40 may be counted and this number is not likely to remain stationary."

"*Mangin Search Light*, 60-*inch*, *electrically controlled for Coast Defense.*—This Mangin search light is constructed for coast defense. It is worked by electricity, the electromotors are placed in the pedestal. The search light is provided with screens for flashing also worked by an electric motor: thus the light may be instantaneously stopped without extinguishing the lamp; this quite recent improvement is very much appreciated. The mechanism is connected to a manipulator by a cable with several conductors.

"This electric control gives extreme precision in the pointing as regards direction and elevation."

"*Search Light*, 30-*inch* (*suspended*), *with electric control.*—This apparatus was constructed for use on board the Russian ironclad *Navarin.* It is suspended by a Cardan on a movable carriage guided along the ship's side. The beam may thus be brought almost to the water's level, and be rapidly drawn up by the ship's winch. When it has reached its highest position, the search light and its carriage come into a truck, which is drawn into the ship. The movements of the beam are electrically controlled at a distance."

"*Outside Gun Port Search Light.*—This model of a Mangin search light, 60 centimeters in diameter, is intended to direct a beam level with the surface of the sea. Put out a port-hole, it may when desired be made to project from the ship's side or be brought back again into the interior of the hull."

"*Search Lights*, 24-*inch*, *electrically controlled.*—Generally placed in protected tops, and are electrically controlled from a distance. These apparatus have become an indispensable engine of modern war ships."

"Same mounted upon a two-wheeled carriage to accompany a detachment in the field."

"*Apparatus for electrically working an armored turret.*—Ironclad *The Tonnant* of the French Navy. The electric apparatus for working the turret of the ironclad *Tonnant solves in the most complete manner the problem of the electrical transmission of power for working artillery. The turret and the gun weighing* 130 *tons, have all their movements, either slow or rapid, electrically controlled by the means of four levers. The gun is brought into its loading position, charged and placed ready for firing by electricity. The ammunition hoists and the rammer are worked by electric motors.*"

"*Safety Ammunition Hoists for Fortresses.*—This hoist with safety break was constructed for moving projectiles in a modern fort. Electrical control is applied which allows a variable speed and instantaneous stoppage."

"*Portable Military Observatory for electric lighting.*—The 90-centimeter Mangin search light with its accessories, is placed on a carriage the platform of which may serve as a base for distant observation. The apparatus is of great service in flat countries where there are no hills, giving a view of the surrounding country."

The above words from such a prominent firm as that of Messrs. Sautter, Harlé & Co., speak far more eloquently than anything that can be added here.

It thus appears that nearly every suggestion as to the use of electrical power for manipulating heavy ordnance made by Lieutenant Parkhurst in his excellent article on *Electricity and the Art of War* published in the *Journal* a year ago, has been realized already and is an *accomplished fact* to-day.

Indeed electrical progress is so great at the present time, that while we are discussing the practicability of certain adaptations of electrical power, they are being done before our very eyes.

GUNS AND CARRIAGES.

The accuracy of our new type-guns is something truly wonderful. When we are told* that with our 8-inch gun in a target of five shots at a range of one mile, four out of five shots struck within an area 20 by 21 inches, and in a target of eight shots at a range of 3000 yards (about 1¾ miles) six shots struck within an area 1½ by 4 feet, to those familiar with the abnormal results with our present obsolete weapons, it reads like a fairy-tale.

The country at large is certainly indebted to the Ordnance Department for the thorough and successful manner in which they have worked out such results. But is the carriage less important than the gun? It appears to the writer that if either is to be imperfect let it be the gun.

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* Report of the Chief of Ordnance, 1892.

Let us earnestly hope then, that our present backward condition in regard to sea-coast carriages shall prove our salvation, and that we will be given an electrically controlled barbette carriage up to the advanced line of engineering practice in Europe to-day, as only by the agency of electricity can the cardinal conditions of *quickness*, *accuracy*, and *reliability* be obtained..

The Engineer Department is building our forts as fast as the appropriations will permit, the Ordnance Department is overwhelmed with work on our guns and carriages, but is the artillery doing its part toward the advancement of the whole? We have guns on hand which are to be used as secondary batteries in the proposed system, and modern guns on modern carriages are now being mounted at Fort Monroe.

Give us then *at once* a suitable electrical plant at the Artillery School,* that we may get to work upon the numerous details of installation which the artillery alone can work out by actual practice and experience under service conditions.

At the Artillery School, which should be the fountain head of artillery information, instruction and experimentation, is the proper and economical place *to begin* this important work. Here the knowledge obtained is most easily spread throughout the service and here should be trained the specialists which the new conditions will impose. From every point of view this move should be made *at once*, there is every reason for it and absolutely none against it.

The Board on Fortifications and other Defenses places Hampton Roads fifth in order of urgency among our ports which need protection, and the defense is to include turrets, armored casemates, barbette batteries, mortar batteries, submarine mines and torpedo boats, therefore any immediate steps towards securing the accessories for this system will not have to be retraced.

There are lighting questions to settle, ammunition supply service to develop, central or group control to work out, proper range and position service to devise and coördinate,—and these

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* We learn through the daily press, that the Board of Ordnance and Fortifications has recently allotted $5,900.00 for a 150-centimeter search-light plant for coast defense to be installed and tested at Sandy Hook.

in the particular manner suited to our organization and the new conditions which will obtain in practice.

These conditions, it is claimed, can be most correctly furnished after intelligent and exhaustive experiment by those who are expected to effectively use the weapons in the event of war.

SYSTEMS OF POWER TRANSMISSION.

In regard to the particular electrical system to adopt there is the choice between the direct current system of distribution and the alternating current system, and between isolated plants or a connected whole, and one would be pretentious to claim arbitrarily that any one system is *the best* system as in actual practice a combination will probably be used depending upon the particular site to be defended. In the case of large ports, where in the opinion of the writer the turrets, armored casemates, barbette batteries, secondary batteries and mortar groups should be under central control and from any point of the line, the polyphase alternating current high-potential system of distribution from a central power-station is the system advocated by the advanced thinkers both in this country and abroad. This system would place the main power-plant at any safe distance from the enemy's guns and do away with all generating machinery at the various batteries, thus removing from harm what would certainly be one of the enemy's most important targets.

The chain of defenses, involving perhaps several miles, would be energized as a whole from cables bearing alternating currents of say 10,000 volts buried in conduits or sub-ways. At the various batteries, and within the sub-way itself the currents would be transformed to say 50 volts or any voltage desired which is perfectly safe, and led to polyphase motors for gun training, or properly utilized for search lights, incandescent lights, or in fact any service that may be required. If direct currents are wanted two-phase motors are simply shifted to run as rotary transformers delivering direct current.

On the other hand with the direct-current system of transmission, the potential would be say 1000 volts, involving the extra cost of copper incident upon low-tension transmission, while the potential at the armatures of the training motors would be approximately 1000 volts, which is very apt to cause trouble.

In regard to introducing man-killing devices in the form of "deadly alternating currents," it may be remarked that some misunderstanding is current on this subject. Roughly speaking the destroying power of any system is proportional to its energy rather than to one factor of energy alone. The voltage alone is not the criterion but voltage in connection with current. A million volts is taken from a Holtz machine with impunity simply because the currents are so minute that the energy product is kept sufficiently low to be harmless. By the use of step-down transformers inside the sub-ways as mentioned above, the alternating system is perfectly safe. The alternating system is the natural system, it is the wave system,—the system which gives us light from the sun in the form of electro-magnetic waves differing only in magnitude from the waves emitted through the ether of space by ordinary alternating current apparatus. From this view the direct current which has until recently been the *only commercial current*, becomes the particular case instead of *vice versa*, and the rapid strides made in the theoretical and practical applications of the alternating system during the last two years, demonstrate its complete elasticity in meeting the various demands for energy transformed into useful work.

ELECTRO-TECHNICAL EDUCATION.

The subject of the technical education of officers is in itself an inviting one, and too long for more than mention here; however, one or two things appear evident.—

(a). Judging from present tendencies our future sea-coast defenses should be manipulated by electrical power.

(b). These huge electrical plants like any other electrical plant, must be under the superintendence of competent electrical engineers.

(c). We do not at present possess these specialists in our service, and should therefore take immediate steps to train them.

Of course, with proper facilities, the ideal place to train artillery specialists is at the Artillery School, by retaining a certain number from each class who have shown a special aptitude in any course, for post-graduate investigation of permanent value, but as an *immediate step* a limited number should be sent to our principal electrical schools for at least a year's study, and to such work-shops abroad as those of Sautter, Harlé & Co., to furnish us with the latest details of electrical artillery progress in Europe.

The service such a corps of specialists would render now if we had them, in instructing others, developing the details of minor artillery installations, and assisting our over-burdened Ordnance Department in its labors, cannot better be inferred than from the words of the Chief of Ordnance in his annual report for 1893, in which he says:—

> "Before entering into an account of the operations of my Department during the past year, I desire, in this part of the report, where it may attract attention, to advise you of the insufficient number of officers in my Department for the performance of the necessary duties imposed upon it. The increase of technical knowledge and of highly educated and technically trained men demanded in the industrial pursuits of civil life, and the advantages resulting from supplying this demand, are well known and practiced. The advantage and imperative necessity for having specially educated and technically trained officers for the numerous duties imposed upon this Department is, generally speaking, greater than for the industrial pursuits mentioned. I think this statement will be borne out by examination and consideration of the report, further on, of the operations of the Department during the past year. For most of the duties required of the officers, not only special and technical education is required, but also much subsequent study and experience is necessary to make the officer's services of value. At the present time, in my judgment, at nearly every important ordnance station, additional trained ordnance officers would give to the government benefits far exceeding in value the cost of their maintenance. It might be admitted that ten years ago there were enough officers for the performance of the duties, but the large number of officers required on inspection work in connection with gun construction alone has totally changed the condition of affairs. Further, the increase of technical and scientific work of all kinds connected with modern armaments and equipments, and the advantages which have been referred to of having more technically trained officers employed on such work, has further increased the demand. Further, in my judgment, it is not probable that at any future time this demand will be diminished."

The artillery contains plenty of competent and willing hands, ready and anxious to undertake their part in the development of a system of coast defenses in keeping with the engineering practice of this electrical age, and commensurate with the vast interests now so totally unprotected. Will the opportunity be given them now?

APPENDIX.

OFFICIAL REPORT OF THE CHAMBER OF DELEGATES.

Resolved, That the several governments represented by the delegates of this International Congress of Electricians be, and they are hereby recommended to formally adopt as legal units of electrical measure the following:

As a Unit of Resistance, the International Ohm, which is based upon the ohm equal to 10^9 units of resistance of the C. G. S. system of electromagnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grammes in mass of a constant cross-sectional area, and of the length of 106.3 centimetres.

As a Unit of Current, the International Ampère, which is one-tenth of the unit of current of the C. G. S. system of electromagnetic units, and which is represented sufficiently well for practical use by the unvarying current which when passed through a solution of nitrate of silver in water, and in accordance with the accompanying specification deposits silver at the rate of 0.001118 grammes per second.

As a Unit of E. M. F., the International Volt, which is the E. M. F. that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampère, and which is represented sufficiently well for practical use by $\frac{1000}{1434}$ of the E. M. F. between the poles of electrodes of the voltaic cell known as Clark's cell, at a temperature of 15° C., and prepared in the manner described in the accompanying specification.

As the Unit of Quantity, the International Coulomb, which is the quantity of electricity transferred by a current of one international ampère in one second.

As the Unit of Capacity, the International Farad, which is the capacity of a conductor charged to a potential of one international volt by one international coulomb of electricity.

As the Unit of Work, the Joule, which is 10^7 units of work in the C. G. S. system and which is represented sufficiently well for practical use by the energy expended in one second by an international ampère in an international ohm.

As the Unit of Power, the International Watt, which is equal to 10^7 units of power in the C. G. S. system, and which is represented sufficiently well for practical use by the work done at the rate of one Joule per second.

As the Unit of Induction, the Henry, which is the induction in the circuit when the E. M. F. induced in this circuit is one international volt, while the inducing current varies at the rate of one international ampère per second.

ARTILLERY, STATE OF NEW YORK.

By Captain H. C. ASPINWALL, Late National Guard, New York.

To those who have ever given the subject a moment's thought, it will hardly seem possible that the State of New York. with its population, its wealth, and its extended line of seaboard, should not include in its national guard a single organization, trained as heavy artillery; such however, is the fact, and since the war this most important branch of the service has been almost totally neglected.

How much more strange will it seem when we consider that the city of New York with its suburbs, comprising within a radius of thirty miles, the wealthiest community on the American continent should be, and have been allowed to remain for years, as unprotected as it is at the present time.

That the universal apathy of our people, in the imagined security of obsolete fortifications and armament, leaving harbors and cities defenceless, has affected the government of seaboard states is hardly to be wondered at, when the federal government until quite recently has been quite as apathetic, not to say negligent.

The national guard of New York is, as a whole, a fine body of men well instructed and disciplined, and (having seen the troops of most of the states) I may add the best in the country.

The infantry is armed with the 50-caliber Remington rifle, but will probably soon be re-armed with the more modern magazine rifle lately adopted for the army. It is well uniformed and equipped, except as to camp equipage.

Besides the infantry the national guard comprises one troop of cavalry, two signal corps (companies), and five light batteries of artillery.

The aggregate of the force in 1892 was 12,886 officers and men, of which the artillery number 387, three per cent. of the whole, or one artilleryman to each 15,000 of the population.

THE FIRST BATTERY. NEW YORK CITY.

Armed with four 3-in. M. L. field guns; the caissons are old pattern but in fair condition, harness old and poorly fitted. The battery is well uniformed and equipped, is well instructed; drill and discipline good.

THE SECOND BATTERY. NEW YORK CITY.

Armed with four steel 3.2-in. B. L. R. field guns, caissons and harness new, having been lately received from the government. Harness is fairly well fitted.

The battery is well uniformed and equipped, it is particularly fortunate in its officers who are intelligent and painstaking, well posted in their duties and alive to all that tends towards the improvement and welfare of the command; as a consequence the men are well instructed and drilled, discipline is very good, and the organization ranks first in the state.

This battery will shortly be in possession of a new armory, now nearly completed, where with handsome quarters, and a drill floor nearly 200 feet square an opportunity will be afforded for indoor drills that have heretofore been impossible.

THE THIRD BATTERY. BROOKLYN.

Armed with four Gatling guns, it is well uniformed and equipped, well instructed, drill and discipline good; it is mounted and drills as a light battery.

The Fourth (Syracuse) and the Fifth (Binghampton) Batteries are armed with the 3-in. M. L. R. field guns, they are well uniformed and equipped. Drill and discipline, I believe, are good, but not having seen them I am unable to give fuller details.

These batteries are all light batteries, but the greater part of the instruction and drill is dismounted, executed indoors in the armories where space is usually so limited that only the simplest maneuvers can be performed. It is only on rare occasions that they have mounted drill.

Being dependent for horses upon such as can be hired or borrowed when required for mounted drills or parades, they suffer in being poorly horsed; the horses are green and untrained to the work, and consequently with so few mounted drills, the drivers also, are not well drilled.

This is a difficulty almost impossible to avoid in national guard organizations; but if the state were to maintain permanently, four or five teams at some readily accessible point, much valuable and practical instruction could be imparted to drivers, also to the batteries, and that at very small expense; by having all the gun squads drill with these teams as often as might be necessary. It would also afford to the men an agreeable break in the routine of drill.

The First and Second Batteries were in camp at Peekskill, N. Y., with Captain Dillenback's Battery "K," 1st U. S. Artillery, during the early part of August. They left New York on Saturday, July 29th, and the three batteries marched the entire distance to Peekskill (42 miles by rail) arriving there the following Monday in good condition; the horses of the two national guard batteries having stood their unaccustomed work remarkably well.

The work accomplished during the week was astonishing, and particularly so when the fact that the horses were green, and the drivers comparatively untrained, is taken into consideration. The drills were remarkably clean and well executed, distances very fairly maintained throughout. It was evident that both officers and men had studied their duties well; the result of the week's work showed great improvement, and has undoubtedly proved of great benefit to both the national guard batteries.

Following a review on Thursday, was a battalion drill of the three batteries under command of Captain Dillenback, which was excellent in every way and proved a surprise to a number of regular and other officers who witnessed it.

The batteries left camp on Saturday, August 5th, marching back to New York, and reached home in first rate condition.

The association of the regular and the national guard troops has in this instance been a great success, and I hope there may be more of it in the future, as it will undoubtedly prove of great advantage to both services.

A battery of instruction, consisting of two 10-in. M. L. S. B. guns and two mortars, was placed in position on the State camp grounds at Peekskill about four years ago, but I much doubt if the pieces have ever been moved since they were turned over to the State by the federal authorities.

Some of the national guard regiments still wear the artillery color (a tradition of their original organization), they have never of late years been drilled as such though the 7th has a volunteer "artillery squad," which drills as such, in addition to the regular infantry duty. These regiments are infantry and are so designated in all orders and official documents; they, themselves, claim no distinction as artillery.

During the year 1883 an effort was made to interest the national guard in heavy artillery and seacoast defense, and was so far successful that the 12th Infantry went into camp at Fort Wadsworth for a week during the early part of August in that year.

Much valuable instruction was imparted to officers and men by the regular officers stationed at the fort and those detailed from Fort Hamilton.

The artillery drill and instruction under supervision of the regular officers was in addition to the usual work as infantry.

The daily routine was about as follows: Company drill, one hour to an hour and a half before breakfast. Infantry battalion drill after guard mounting for about the same length of time; at the conclusion of drill one to two hours drill and instruction at the guns until dinner; shortly after which the work at the guns was resumed and continued until close on to supper time. Dress parade at sundown concluded the day's work. This routine with some few exceptions was continued during the entire week; Saturday, however, after infantry drill in the morning, being devoted to breaking camp and packing up. The regiment left early that afternoon and proceeded home by steamer.

The 100, 200, and 300-pdr. Parrot guns, the 8-in. converted rifle, and 15-in. S. B., were manned, detachments drilling at the various pieces; the last two days (Thursday and Friday) were devoted to target practice and fair results obtained.

One of the companies drilled with Gatling guns, another in mechanical maneuvers and succeeded in mounting an 8″

converted rifle on the parapet where it still remains, solitary and alone.

Detachments were instructed in plane table work, signaling, etc., and in the magazines.

The expense of the camp, including pay, subsistence, and transportation, was borne by the state of New York, the regiment taking this tour of duty instead of their regular tour at Peekskill.

So great was the interest created that the desirability of changing the 12th to a heavy artillery regiment was seriously considered, but the project fell through, mainly owing to the fact that it would have been nearly impossible to have accomplished efficient work as heavy artillery, in addition to the full duties and requirements of an infantry organization, which it was then understood would have been required by the state; and further the regiment was not unanimous in wishing the change.

During the two or three years following some attempts were made by individual company commandants to maintain and further the interest thus created; and some detachments went down (at their own expense) both to Forts Hamilton and Wadsworth, where every courtesy was extended to them by the regular officers, and every opportunity afforded for drill and instruction as well as for target practice, but the enthusiasm died out and little or nothing has since been done. At the present time but few of the members of the 12th who participated in that camp are still in service, and the information and instruction then gained may now be considered as lost. With the exception, possibly, of a few small detachments from other regiments, the above is the only attempt that has been made since the war to interest the people in the subject of coast defense through the instruction of the national guard at the forts. An attempt was made a few years ago to organize a heavy artillery company as a part of the national guard; but it failed.

I must say here that the regular service rendered every assistance and did all in its power, to further and promote the success of these attempts.

In view of the peculiar organization and requirements of the state national guard, liable at any time to be called upon to suppress disorders or riots in its own state, and the consequent necessity that it should be so armed and drilled to meet such requirements, besides which, the fact that in times of peace it is in nowise amenable to, or under the authority of the federal government, precludes the idea of its efficiency, as an auxiliary volunteer force, instructed in heavy artillery, and other work requisite to seacoast defense.

It is by no means my intention to disparage the national guard in any way as I know that it will do its work nobly and well when called upon, and, should it be required to man the forts in defense of the country, the work will be performed to the utmost extent of its ability.

But with high-power ordnance, modern carriages, and the machinery required to work them, torpedoes, high explosives, electricity, and all the multifarious requirements of modern defensive works, the *absolute* necessity of a body of men instructed at least in some degree in such matters must be manifest even to the citizen who has never given much thought to the subject.

I cannot understand why the people do not realize this; any more than they do the fact, that at the present time our seacoast is almost defenseless, and that any power can blockade and close our ports, prey upon our commerce, and inflict misery and suffering on our seaboard communities and through them affect the entire country: what is to prevent?

The defense of the seaboard is conceded to be the duty of the federal government, and not that of any individual state within whose jurisdiction the various ports and harbors may be, therefore the question of an artillery militia, volunteers, or national guard, whatever designation may be preferred, is one for the federal government to determine, and is in no way the duty of or in any way identified with that of the national guard of any state.

The necessity for an auxiliary force instructed as heavy artillery must be conceded and I only hope that the near future may see the organization of such a force under the authority and control of the federal government.

The five regiments composing the artillery force of the United States consist of 280 officers and 3675 men, of which ten batteries are drilled, instructed and equipped as light batteries, leaving but 240 officers and about 3,000 men for garrison duty; or taking the number of guns at present available and with the 1299 new guns recommended by the Fortification Board, an average of less than one man per gun. Even should congress authorize the organization of the two new regiments of artillery the average would still be less than 1½ men per gun.

In active service we may estimate the number of men required to man each gun at 40, so that an aggregate of from 90,000 to 120,000 *artillerymen* would be necessary in the event of war; how far the present force of 3,000 would leaven this mass is a question worthy of consideration, and may afford the basis of some interesting mathematical calculations.

I believe that a heavy artillery militia force under control of the federal government, supervised and to some extent commanded by officers of the regular service, could be readily organized at comparatively small expense, and which would become practically efficient and thoroughly effective. Such organizations in all the seaboard cities would undoubtedly prove attractive to young men; the duty required could be easily arranged so that it would occupy less time of the individual, and be less burdensome, than in the national guard of the states.

Of the details of such an organization I may have something to say at some future time.

Comparisons are odious, but I cannot refrain from calling attention to England, the only country whose military establishment is in any away akin to ours.

With a population of 38,000,000 (Great Britain and Ireland), little more than half of ours, there are in the auxiliary forces alone, of garrison artillery, some 33 militia battalions and 62 battalions of volunteers, exclusive of the Channel Islands, Malta, India, and the colonies.

I regret I have not before me the aggregate of the number of men in this force.

Compared with the above, the United States has not to my knowledge a single battalion of heavy artillery militia or national guard.

Is it not time that some interest was aroused in the subject? We have been fortunate in nearly thirty year's peace and prosperity, but, though some people affect to believe that there will be no more war, who can tell when some question may arise that can be determined in no other way.

Admitting for the sake of argument that war with a foreign power is improbable, should we not feel more secure, and especially now that the government is improving and re-arming the forts, in the knowledge that there was an auxiliary force drilled and trained in the use of the armament?

May the occasion never arise when the services of such a force shall be required for actual combat; the best way to prevent such a necessity is to be prepared.

SIEGE ARTILLERY.*

By First Lieutenant HENRY J. REILLY, Fifth Artillery, U. S. A.

Siege artillery is a general term which comprises all the artillery material and personnel necessary for the successful attack of permanent or temporary fortifications. To consider it as a whole would be impracticable in a paper of this kind, consequently I will limit myself to a statement of some of the more notable changes in the material and in its application, which have occurred since the commencement of our war, where rifled guns were first extensively used.

I also expect to be able to show that owing to the new conditions which have appeared on the battle field, due to the use of rifled arms, and consequent development of cover, either, that an intermediate branch of artillery should be formed of howitzers or mortars, which will furnish vertical fire on the battle field, or that our new siege howitzer ought to be given sufficient mobility to accompany the main body of an army in the field.

In a country like ours, where the officers were untrammeled by precedent, with a rank and file second to none in intelligence, ingenuity and resource, it was only natural that new methods, the result of experience, should have been successfully applied; consequently such authoritative histories and narratives of our war as are available are even at this date well worthy of careful study.

In 1862, when the Army of the Potomac was confronted by the enemy's works on the Yorktown Peninsula, the first siege train was organized; it was noticeable for the large calibers used.† Among the 71 pieces which it comprised were two 200-pdr, and five 100-pdr. Parrott rifles; and ten 13″ S. C. mortars; the 200-pdr. Parrott weighed 16,570 lbs., and the 13″ mortar 17,120 lbs.

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* Read before the Lyceum, Presidio, San Francisco, Cal., February, 1893.

† Campaign against Richmond.—Abbot.

For maneuvering and transporting these pieces and material there was furnished one gin complete, three mortar wagons, two large sling carts; one treble, two double, and one single block. With this equipment and such additional means as could be devised, all these pieces with material were embarked, disembarked, and mounted.

The guns and mortars were hauled from the landing to the works by the horses of the reserve artillery, no siege train horses having been supplied.

Sometimes the roads were in such good order that the wagons supplying ammunition* made two and even three trips a day; and sometimes so bad, that they were a day and one-half on the road; a variation of importance to be rembered by any artillery officer who has charge of the ammunition supply of a siege battery.

The maximum amount carried in one day was 62 wagon loads; 40 wagons carried 30 each, and 22 carried 31 each, a total of 1882, ten-inch mortar shell.

The personnel attached to the train was the 1st Connecticut Artillery, which by arduous labor continuing day and night succeeded in placing the 71 guns "in battery" in 23 days: an unexampled piece of work under such circumstances. After the evacuation of the works, the guns and the material were re-embarked by the same regiment assisted by the 5th New York Volunteers.

Two companies of the 1st Connecticut, "B" and "M," were afterwards equipped as field artillery, and given two 4-gun batteries of 4½" siege pieces, which accompanied the Army of the Potomac in its campaign of 1863. Captain Pratt in his report† states that "these batteries marched over 500 miles, kept well up in the column, took the lead in their turn, marched 30 miles in a day, at times passing through swamps and rivers, over mountains and as difficult roads as any campaign is likely to be conducted upon." "The batteries came into action at a trot at Kelly's Ford, about 2 p. m., after marching fourteen miles."

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* Ibid, page 147.

† Ibid, page 154.

What this means is understood when it is remembered what Virginia roads were, and that the weight of one of these guns is about 3500 lbs.; the carriage and limber complete without equipment added an additional 3743 lbs.; there were ten horses to each gun and eight to each caisson. Captain Pratt attributes the mobility of the pieces to the position of the gun on its traveling bed, which distributes the weight on all four wheels, while with the ordinary field piece the weight is all on the rear axle. These guns, which did such good service, were really guns of position.

After the old smooth-bore had been replaced by the rifled muskets, and later breech-loaders, the severity of fire became so great, that the men appreciated the utility of cover, and soon became so expert in providing it that whenever they took up a position, it only took them a few hours to produce intrenchments, behind which they were comparatively safe from the horizontal fire of both infantry and artillery; under these conditions front attacks became excessively costly in human life, they were rarely successful, and extension to a flank became a marked feature of the campaigns.

General Hunt appreciated the ineffectiveness of horizontal fire against intrenchments, and when he prepared for the campaign of '64, he provided eight coehorn mortars, which were used at Cold Harbor, where their vertical fire did good service. This is the first time, so far as I can learn, that vertical fire was used under such circumstances.

The second siege train was organized* for the campaign of '64 and it included many mortars. After the failure of the first assault upon the Confederate position at Petersburg it was called into action, and General Abbot tells us "then began for the first time in the experience of the armies operating in Virginia, a really heavy mortar fire; the result of their sudden and unexpected opening on the Petersburg lines was appaling. On one occasion which came under my personal observation, a confederate soldier was blown entirely over his parapet by the explosion of one of our shells, and his body lay, the clothing consuming by fire, beyond the reach of his friends who were deterred from

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* Ibid, page 17.

approaching by our sharpshooters." The personnel of this siege train was the 1st Connecticut.

While in the defenses of Washington General Abbot had given much attention to the proper training of the gunners, "and they were familiar with all the minor but essential details" upon which vertical fire depends; at Petersburg the precision of their fire was much admired.

Mortars were first introduced and multiplied upon the Petersburg front with a view to preparing the way for an assault, and for keeping the artillery of the enemy quiet when it was delivered. This purpose they accomplished most effectually.

While in the defenses of Washington and in command in front of Petersburg General Abbot brought vertical fire to great perfection and we are fortunate in having a record of the very useful results he gained. In October, 1863, he made experiments in firing spherical case from a mortar,* probably the first time it was done in this country, and afterwards proved the incontestible value of this fire in action. He had 27 of the balls of the 12-pdr. canister inserted through the fuze-hole of a 10" shell and a bursting charge of 2½ lbs. powder added on top of them; the shell weighed 90 lbs. and each ball 0.43 lb., making a total weight of 104 lbs.; a charge of 1 lb. 6 oz. powder gave a range of 800 yards, 13 seconds time of flight; when the shell burst the balls had ample force to kill, as they penetrated from three to seven inches in the turf.

This projectile was used at the Petersburg mine where General Hunt's orders for the artillery were to use every exertion to keep quiet the batteries of the enemy bearing upon the point of assault, "in consequence" a battery of ten 10" mortars directed its fire at a range of 800 yds. upon a salient battery of the enemy from which much trouble was anticipated: "After its range was obtained not a shot was fired from this battery, the confederate gunners found it impossible to remain by their guns and endure the shower of balls falling from shells bursting about once every thirty seconds over their battery."

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* Ibid, page 26.

In this siege the great value of the howitzer with its large canister capacity was also demonstrated, as the following instance will show:* "Captain Pride, with his company of the 1st Connecticut and a few dismounted cavalry supports, garrisoned the small incomplete advanced redoubt "Dutton" which was on our Bermuda front and armed with two 32-pdr. and one 24-pdr. brass howitzers. It was subjected to a determined assault by the 22d South Carolina regiment, Colonel Dentzler commanding. Only two of the howitzers could be brought to bear, but so rapid a canister fire was maintained as to repulse the column with severe loss. Tne colonel was killed and his command was so demoralized that a lieutenant and twenty-two enlisted men surrendered, rather than attempt to retreat under fire."

During the siege over 2400 tons of ammunition were used and the system of supply organized was so simple and excellent that it should be regarded as a standard for future similar operations.

The following description of a novel platform which was used in these operations is of considerable interest: An ordinary platform car was strengthened and a 13″ S. C. mortar mounted upon it; the car was placed on a curve of the railway track which afforded facilities for changing the plane of fire by simply moving the car backward or forward. "At the battle of the Mine, as reported by three observers stationed at different points, the explosion of one of its shells blew a confederate field gun and carriage above the parapet at a range of about 3600 yds."

The fire of this mortar was so effective that it was much dreaded by the confederates, and the ease with which its position could be changed made it impracticable to silence it.

The personnel of our siege trains, the foot artillery, usually consisted of such volunteer regiments as were available; the 1st Connecticut Artillery, that made such an enviable record, entered the service as an infantry regiment; the advantage of the training it had in the Washington defenses was amply demonstrated by the work it did. As there is a tendency to overlook the demands made upon foot artillery while with a siege train in war, a statement of some of the work done by the 1st Connecticut,

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* Ibid, page 48.

while in front of Petersburg, will be instructive:* "When not serving their guns, the greater part of the regiment would act as guards for the reserve artillery; it would be specially charged with the construction of magazines, gabions, fascines, &c., for battery use, and would always be ready to accompany assaulting columns, to do what is well related in the following instance: "In the assault of the Petersburg lines by the 9th Corps on April 2d, 1865, a detail of four officers and 400 men, 1st Connecticut Artillery, commanded by 1st Lieutenant W. H. Rogers, was made. It was divided into three platoons; the platoon into detachments of ten men and chief of piece; all the detachments were armed with their muskets and provided with lanyards, primers, fuzes, &c.; this detail joined the assaulting column and entered the enemy's works among the first. They instantly began to serve four captured light 12-pdr guns upon the retreating masses of the enemy. Two more 12-pdrs. were moved by them across the work under a heavy fire, and within half an hour, were also opened upon the enemy. These six guns were served most gallantly, all day and during the night; about 400 rounds captured with the pieces were expended, and a like amount in addition, which was carried by hand from our lines; the men not required at their pieces used their muskets effectively, expending all their own ammunition, and much more taken from the prisoners and from the dead and wounded. Much praise was given to Lieutenant Rogers, his officers, and men, for their gallant conduct which contributed to the success of the charge, and greatly to the repulse of the desperate assaults made by the enemy to retake the captured works."

These facts would seem to be sufficient to warrant the continuance of the present armament of rifled musket for foot artillery and to show the necessity for skill in its use.

At all the European siege artillery schools of practice the foot or fortress artillery have yearly practice in constructing field and siege works, and demolishing them with fire from the different siege pieces.

In the attack on Fort Wagner in Charleston Harbor, in 1863,

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* **Campaign against Richmond.—Abbot.**

rifled artillery was used, with great advantage.* Wagner was built to prevent the erection of breaching batteries against Sumter, and as it had to be attacked by regular approaches, which would take considerable time, it was determined to attempt the demolition of Sumter by firing at it over Wagner, from batteries in the trenches; this would have been impracticable for smooth-bores, as the ranges were respectively 3428, and 4290 yards, but was readily accomplished by the one 300-pdr., four 200-pdr., and nine 100-pdr. Parrotts used.

General Gilmore is fully as emphatic as General Abbot in his appreciation of vertical fire. He says† "that there was but one 8- and one 10-inch mortar in Fort Wagner, and yet these when earnestly served, caused the most serious delay in the progress of our work and on one occasion suspended it entirely," and he attributes the success achieved at Wagner to be due to the over-powering mortar fire from our batteries.

In the siege of Wagner, the calcium light‡ replaced the light balls used in the Crimea; and this has in turn been displaced by the electric search light; which has been so improved that from experiments made in Austria,§ it was concluded that a powerful light can be maintained, with three wagons which could accompany an army. From experiments made in Germany in 1891 it was concluded that troops could make better practice in firing, when aided by the light than they could without it.

In addition to those already mentioned there are the sieges of Vicksburg and Port Hudson. In neither case was there any siege train; consequently they were both prosecuted under serious disadvantages; although at Vicksburg the field artillery was assisted by the fire of the fleet,‖ and a battery of 32-pdr. guns landed from the flagship *Benton*. Both were also subjected to bombardment from 13" S. C. mortars fired from mortar boats.

At Vicksburg mortars were improvised¶ by taking logs of the

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* Owen's Modern Artillery, page 404.

† Artillery and Engineer Operations against Charleston, 1863.—Gilmore.

‡ Owen's Modern Artillery.

§ Journal of the Royal United Service Institution, No. 150.

‖ Grant's Memoirs, page 437.

¶ Ibid, page 540.

toughest wood, boring them out for 6- and 12-pdr. shells and binding them with iron bands; they then answered as coehorns and shells were successfully thrown from them into the trenches of the enemy. From the foregoing it will be seen that pieces of the largest caliber were used in our siege operations and it will also be noted that when vertical fire was used, successful front attacks could be made on works of strong profile defended by the best troops.

Our ironclad cars armed with artillery for the defense of railway bridges and the flat car platform, were probably the prototype of the famous ironclad train used by the English at Alexandria.

The excellent results both as to mobility and power obtained with the 4½″ siege gun batteries justified that piece being taken as a type for the gun of position, and its organization into batteries, with tables of supplies, appears in our Heavy Artillery Manual as a standard for future use; the organization of the personnel being the same as in this regiment, the model adopted for the reorganization of the other artillery regiments after the close of the war.

The advantages of vertical fire are also similarly recognized, and the Manual prescribes the organization of a battery of coehorn mortars, to accompany an army in the field, each caisson to carry one mortar, together with sixty rounds of ammunition; the mortars to be carried on the caisson in place of the front chest which is removed.

General Abbot also advocated the carrying of mortars with the reserve train of armies in campaign. One government wagon to carry a 24-pdr. with 100 rounds of ammunition; or an armament similar to that of the confederates, a 12-pdr. with 200 rounds in the wagon. The Manual says an army in the field should be abundantly supplied with these handy and useful weapons.

In the Franco-German war siege artillery was not used by the French, except in combination with the heavier calibers of fortress artillery in defense of permanent fortifications. None of the French fortresses were properly prepared for defense; the absence of trained gunners was particularly noticeable as an element of weakness, in the defense of Strasburg and of corresponding advantage to the Germans, who were able to build their trench batteries *en barbette*, in consequence.

The Germans did not bring up their siege train until it became evident that an investment and bombardment of Strasburg would be insufficient to compel its surrender; although in order that no time might be lost, immediate preparation for a formal siege was entered into, which actually commenced on August 28th. On September 9th the Germans had 96 rifled cannon in battery;* the largest calibers were, guns, 12-cm. (4″.77), 15-cm. (5″.96), and 38 mortars of 21 cm. (8″.34), 23 cm. (9″.14) and 28 cm. (11″.12).

Regular parallels and approaches were constructed and on September 28th a practicable breach, 25 paces wide, was opened; this was made by covered fire with 24-pdrs. which threw shells weighing 56 lbs. with bursting charges of 4 lbs. powder; the range was 1100 paces; the angle of projection 6¼°; the target was not visible from the batteries.

On the same day, and before an assault was made, one month after the siege was opened, the place surrendered, because, as stated by the Council of Defense,† "the artillery was placed *hors de combat*, the ramparts and roads at their foot were overwhelmed with projectiles, fired with an accuracy hitherto unexpected and therefore all troops assembled there for repelling the assault must have been killed before the commencement of the struggle. The assailants would have reached the ramparts without firing a shot."

This is certainly very strong testimony, by officers, to the efficacy of the fire of rifled guns and smooth-bore mortars.

At Toul, as at Strasburg, heights were crowned with batteries of rifled guns which were far beyond the ranges of the guns in vogue when the fortresses were built.

Belfort affords an excellent example of the effect of a fortified position in a line of connection, even when inadequately armed and garrisoned. It also shows the advantages to be derived from the possession of an organized siege train.

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* **Franco-German War.—Clarke's Translation.**

† **Franco-German War.—Clarke's Translation.**

When the command of Belfort devolved upon Colonel Denfert, he directed his efforts to fortifying the outlying ground so as to render the investment as difficult as possible; he also organized a garrison of about 17,000 men, which with the exception of between 3000 and 4000 troops of the line was composed of ineffective *gardes mobiles* and *gardes nationales*. Some were armed with Chassepots, part with Sniders, and part with Tabatières.

By the middle of November, 1870, the German siege material commenced to arrive,* and on January 21, 1871, their combatant force amounted to 17,602 infantry, 34 field guns, 1166 fortress pioneers, and 4699 fortress artillery; the day after the capitulation, when the garrison marched out with the honors of war, there were 235 pieces in the German siege park, 163 guns and 72 mortars, and a total of 145,887 rounds of ammunition had been supplied, of which 98,552 had been expended.

The neutralization of such a large force and quantity of siege material, with the inadequate means available, is an example of the results which can be obtained by an energetic and capable commander. The French used the electric search light.

Except in the attack on Düppel I find in this siege the first mention of rifled mortars. In the investment of Paris and the bombardment of the outlying forts the guns and mortars were all rifled except some 50-pdr. S. B. mortars; among the pieces in the siege train was a rifled 21-cm. (8¾") mortar which would throw a projectile weighing 180 lbs.

The Prussian siege guns had a bracket bolted to the carriage† which raised the trunnions at least six feet above the ground; in consequence men in the trenches were fully protected; the firing being at high angles, and the guns being breech-loaders, there was no difficulty in loading them.

We note in this war, as in our own, and for similar reasons, front attacks even when prepared by field artillery, were often unsuccessful and always very costly. At Gravelotte, for instance, it was the extension to their left flank, by the 12th Saxon Corps, by the Germans which compelled the falling back of the French.

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* **German Official Account.—Section 18.**

† **Artillery Retrospect.—Colonel T. B. Strange.**

In the Russo-Turkish war, which is rightfully called a war of positions, the Russians used no mortars. At Plevna there were only twenty siege guns, 24-pdr., throwing 60-lb. projectiles;* consequently nearly all the attacks on the Turkish field works, although thoroughly prepared by the fire of 250 pieces of field artillery, light and heavy, were executed with great losses and they were generally unsuccessful. In neither of these wars was the mortar, or vertical fire, used on the field of battle as it was used in our army.

From the short resumé already given it will be seen that in all the wars mentioned the successful siege of fortified places proved to be important factors in hurrying them to a successful issue. Vicksburg and Port Hudson gave us the Mississippi, Petersburg and Richmond closed the war; Strasburg, Montmidy, Toul and Belfort opened important lines of communication, and the capitulation of Paris closed the war of 1871. Plevna delayed all advance of the Russians until it was captured; Rustchuk neutralized the army observing it; and had the war continued there would have been an eventful siege of the lines of Buruk-Teckmedje before Constantinople could have been captured.

That in the future well organized and equipped siege artillery will be of even greater necessity and importance, no one, with any knowledge of the extent to which the fortification of European frontiers has been carried since 1871 and 1878 can doubt for one moment.

France, for instance, has now practically three fortified lines for the protection of her eastern frontiers and capital, which must be forced by an enemy. That after her experience in 1871 they will be fully equipped and garrisoned goes without saying.

In the first line† are the intrenched camps of Belfort, Epinal, Toul and Verdun. In the second there are the intrenched camps of Besançon behind Belfort, Langre behind Epinal and Toul, Dijon behind Besançon and Langre, Rheims behind Toul, and Laon behind Verdun.

The extent of one of these camps is indicated in the case of Belfort which now has a double line of detached works, which

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* Green's History Russo-Turkish War

† Journal of the Royal United Service Institution.

practically follows the line of heights occupied by the German line of investment in 1871. If it took 17,000 men and 235 pieces to reduce it then when it was insufficiently prepared for defense, it is an interesting question, what will be necessary under its present conditions either to mask or reduce it? Yet similar conditions exist on all the lines of connection, and they must be met.

On the German frontier, although requiring less artificial aid we find Metz turned into an intrenched camp with a perimeter of thirteen miles. Some of the forts on this line have Gruson turrets. Strasburg is also a vast intrenched camp. These works are fully connected by telegraph, underground cable, and railways, and every provision is made for their defense.

I think I can correctly say that the system of detached works, used as stated, was first put in practice during our war. In April, 1865, the defenses of Washington consisted of sixty-eight inclosed forts and batteries, having an aggregate perimeter of thirteen miles, and emplacements for 1120 guns.

As it is fully recognized that in any advance the army which is acting on the offensive, must necessarily come in contact with some of these permanent works, the organization of adequate siege trains has received every attention, and in the principal European countries, they are kept in a state of preparedness for immediate movement, on the mobilization of the field army.

We may take the French trains for example. They were re-organized in 1882, have not been materially changed since then, and those of the other countries are very similar, differing only in detail.

One train consists of 180 pieces of artillery; rifled guns and mortars, with an average of 1000 rounds per piece. Each train is divided into two half trains each of four parts, viz: 1. Main body; 2. supporting position; 3. transport park; 4. railway division. The main body consists of three sections; the first section is composed of 108 vehicles for the conveyance of all that is necessary for the establishment of the park, and the construction of the batteries. The second section has eighty of the

180 pieces and fifty wall pieces, defensive implements and ammunition. The third section carries ammunition alone.

The supporting portion is comprised equally of three sections, the numbers being consecutive; the fourth section carries the rest of the ammunition for the main body; the fifth contains the material for establishing workshops for the repair of material, and the sixth has the guns required for special purposes, *i. e.* four 8″.6 guns and four 10″.6 mortars, with their ammunition and appurtenances.

The transport park is composed of two columns each of forty-four wagons. The railway division conveys in two half trains material for the construction of thirteen miles of line.

Thirty-four trains are required for the conveyance of a half siege train by rail.

The personnel of the siege train consists of fortress artillery armed and equipped similarly to the infantry, and pioneer companies, attached for the purpose, although last June, 1892, Russia formed two battalions of siege artillery apparently intending to make it a separate and distinct organization.*

At the beginning of operations the artillery park is formed in five echelons placed along the line of railway leading to the army; the first echelon with the transport division must always be near the chief supply station and the army so as to be able to complete the ammunition and the material in the shortest possible time.

When the enormous quantities of material to be brought up in case of siege operations alone are considered the value of railway communication is apparent; if the line is broken its immediate repair is of such serious importance that material for mending it should be provided beforehand. France† now carries portable steel bridges sixty meters in length for use in such emergencies. European troops were never so well provided with intrenching tools as they are to-day, nor in their history has there ever been so large a proportion of these tools carried by the combatants; in consequence in future wars the tendency to the construction of cover may be expected to increase rather

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* *Revue d'Artillerie*, July, 1892.
† Journal of the Royal United Service Institution, No. 54.

than diminish, and to shake the morale of troops so protected requires an artillery development to meet the new conditions.

There is no more apt illustration of the inadequacy of horizontal fire, powerful as it is, of the present field artillery, even if it use shrapnel, than in the attacks on the Plevna works, when 250 guns silenced those of the Turks, and swept the parapets so the soldiers of the garrison dared not show themselves, yet when the fire was masked by the advance of the Russians to the assault, the Turks came forth from their shelter, and decimated the attacking columns with the fire of their Peabody rifle. Their success warrants the use of such cover by any troops on the defensive and it can only be destroyed by vertical fire.

The use of Schuman towers by troops on the defensive may also be anticipated; they were so used by the Germans* in their maneuvers in 1890. In that case they were taken to the position the night before the expected attack, and so placed in pits dug for them, that only their tops were visible above ground; they are armed with Q. F. guns of 37 and 53 mm. with ranges of 3400 and 5600 meters, respectively; these guns can fire from thirty-five to forty rounds per minute and require but two men and three horses for each tower; they have considerable mobility and are easily and quickly placed.

Intrenchments with two or more tiers of fire are also advocated for use in the future and will probably be thrown up when practicable. The successful assault of a position so strengthed will be impracticable unless some provision is made for a fire with heavier projectiles and greater angle of fall than is available with the present field artillery; if such provision is not made the delay caused by awaiting the arrival of the siege artillery, will permit the strength of the works to be carried to such a point, that a regular siege may become necessary.

This need has been appreciated, and since 1878 the problem, what is the best method of securing vertical fire, with sufficient mobility to accompany the main body of the army, has been in process of solution and seems now to be in a fair way of settlement.

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* Journal of the Royal United Service Institution.

In 1879 Krupp constructed his first 15-cm. (5″.9) mortar,[*] which gave such precision of fire at 3500 m. that Russia ordered four of them; and at the same time ordered four mortars of 42 lines (3″.6) each. Four experimental Boards convened to test these pieces, declared unanimously that the 3″.6 mortar was of insufficient capacity. They were divided as to the merits of the 15-cm. mortar, but after further experiments and modification it was adopted.

In 1889 Russia formed two regiments,[†] each consisting of four batteries, each battery of six pieces, eighteen ammunition wagons, six carts, spare wagon, &c.; caliber of mortar 5″.9, weight of shell 60 lbs., bursting charge 10 lbs.; full charge 3 lbs. 13 oz., divided into four parts, one-fourth, one-half, three-fourths and whole.

It was objected that such a battery would be deficient in mobility, but the ammunition wagons were so improved, that with much less weight sufficient strength was obtained, and when one of these batteries was horsed with teams taken from a field gun battery, and sent on a march over difficult ground in competition with a field battery, the mortar battery returned first and proved its mobility beyond question.

In 1890 a third regiment of similar batteries was formed,[‡] and proved its mobility in the maneuvers at Volkynia; at present I believe Russia has four of these regiments.

If the advantage of vertical fire was so great with the smoothbore material used in our war, an instance of the results obtained by the rifled field mortar of to-day in comparison with those of a heavy field gun which threw a 28-lb. projectile, against earth works, may be interesting.

Target:[§] shelter trenches occupied by standing and kneeling dummies; range, 2130 yards. Projectiles: field gun 24 common shell and 100 shrapnel; field mortar, 12 common shell and 50 shrapnel. Hits: field gun, 37 out of 96 dummies, or 39%, 176 hits; field mortar, 48 out of 88 dummies, or 52%, 199 hits. Time: field gun, 1 hour 15 minutes; field mortar, 1 hour 6 minutes.

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[*] *Revue d'Artillerie*, July, 1893.
[†] Journal of the Royal United Service Institution, No. 158, page 357.
[‡] Journal of the Royal United Service Institution, No. 165.
[§] Journal of the Royal United Service Institution, Nos. 171 and 172.

In firing at a range of 1100 yards the craters of the common shell, fired from the 5″.9 field mortar, had diameters of from 5.74 to 9.84 feet and a depth of from 2.95 to 4 feet.

Protection from such a vertical fire as this would necessitate a use of material not usually available for the use of a field army. It is a pertinent question as to what would have been the result had the four Russian field mortar regiments been available for use at Plevna?

The organization of the Russian field mortar battery is similar to that of the heavy field gun battery; it consists of 5 officers, 18 non-commissioned officers, 208 men and 167 horses. The weight behind the teams of the piece is 3840 lbs., of the caisson, 2840 lbs.

"The equipment carries 92 rounds per mortar,* which would enable the fire to be kept up at the rate of one round per minute for 552 minutes or, 9⅕ hours, without calling on the flying park for a new supply."

Switzerland has also adopted a complete equipment for her field mortar batteries of 4″.7 caliber. Austro-Hungary preferred the 5″.9 caliber, the mortar being of steel bronze.

The Swiss howitzer, when prepared for firing, rests on a bed which weighs 300 lbs., and is carried with the piece; it takes the shock from the wheels; the Russians, after trial, decided that too much time was lost in coming into action by the use of the bed, and substituted supports under the axles, with rubber spring bearings which relieve the wheels from the shock of discharge.

The average weight per horse in their field mortar batteries is between 600 and 700 lbs.

It is well understood that in the next war the German forces will be divided into armies of about 100,000 combatants, and it is expected that one or more brigade divisions of field howitzer batteries will be attached to each army,† and considered as a force at the hand of the commanding general alone.

In Russia, and in Austro-Hungary also, it seems probable that the field mortar batteries will not be attached to corps or divisions, but act under direction of the army commander.

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* Journal of the Royal United Service Institution, No. 171.
† Journal of the Royal United Service Institution, No. 165.

The terms mortar and howitzer are applied indiscriminately to these pieces; there is no practical difference in them as they have large shell power and can be trained from an angle of depression to 60° or more of elevation.

All the siege artillery material used in our war, 1861 to 1865, has become obsolete; the principles governing its use, however, are just as applicable now as then.

New material is being provided and there are now, I believe, eleven new B. L. 5″ siege rifles and carriages already completed. Eleven B. L. 7″ howitzers have also been finished and an experimental carriage for them is probably now ready for test; some 3″.6 rifled mortars have also been manufactured and with their carriages are probably nearly ready for issue.

None of these pieces have yet been issued for trial under service conditions; but from the construction and test reports it appears that all the ballistic properties desirable have been obtained, and in the case of the siege piece within weights approximately those of the old gun, which proved its mobility so well in campaign. The greater weight of the projectile and cartridge of the new gun, a total of about 1700 lbs. for 96 rounds, may possibly be compensated for in the greater lightness, without any sacrifice of strength, of the new steel caissons.

The new howitzer alone weighs 3750 lbs.,* against a total weight of 6600 for the old one, which included the carriage and equipments; deducting this weight there would be 3650 lbs. left for the weight of the new steel carriage, so that the weight of both may approximate that of the siege gun and carriage. It seems improbable, however, that this can be done when we consider the great strain of the full charge of 9½ lbs. and the high angles of elevation to be used.

In the ammunition supply, owing to the greater weight of the new projectile and charge, fully double that of the old ones, will be the greatest difficulty to be overcome—for in the 96 rounds to be carried there will be an excess in weight of over 6200 lbs., which would necessitate a third line of caissons for carrying a minimum supply of ammunition which makes it questionable if

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* Report Chief of Ordnance, 1890 and 1891.

ballistic power, with weight of projectile, have not been obtained at too great a sacrifice of mobility.

The new 3″.6 mortar uses the same projectile as the field gun, a very great advantage when ammunition supply in the field is considered: I cannot help thinking, however, that the projectile is too light to be efficacious in these days when overhead cover is so quickly built; the recoil, eight feet when the mortar is unrestrained and fired at an angle of 45°, seems to be excessive for a piece to be used in the trenches; its weight also, 504 lbs., to be moved after each discharge, would make its service very exhausting to the cannoneers. Besides, to get the best results, platforms would have to be carried or improvised. The Russian Experimental Boards were undoubtedly right in rejecting a similar piece.

Neither the siege gun, howitzer, or field mortar, have been tried by service conditions, and in order that ballistic power, mobility and strength of carriage may be properly proportioned, such field tests appear to be not only desirable, but necessary.

A field howitzer somewhat similar to that adopted by European nations, an intermediate between the field and siege pieces of an army, would seem to fulfill best the requirements of the modern battle field, and to be a necessity.

VERTICAL FIRE.

By Captain EDMUND L. ZALINSKI, Fifth Artillery, U. S. A.

General Abbot, in his interesting paper on *Vertical Fire*, presents us with much valuable data from which the subject may be studied and conclusions drawn. Without practical experience in the manipulation and actual firing of batteries of mortars, we can hardly draw definite conclusions. For the present, as well as for some years to come, we are forced to consider the subject in the abstract.

It will not be safe to coincide with General Abbot as to the probable course of action of naval officers in conducting an attack on a fortified seaport. The objective point of attack and injury is the city, as it likewise is the object of the defense to prevent this. They will not aim so much to silence the batteries of the defense as to run by them to positions where they can freely bombard the towns. The attack will therefore first bend all their energies and resources to countermining the channel and then run by the batteries at their greatest speed. The arrangement of the batteries and their mode of manipulation must be made to prevent this purpose.

With batteries and fire tactics suited to attacking a swiftly moving target, they will be able to cope with the easier conditions of the target being anchored or moving slowly. For firing at moving targets it would be well to use two groups of mortars of sixteen each, or in other words thirty-two mortars, as a tactical group. There should be at least ten of these double groups for each line of approach. Each group to be assigned to defend definite zones; as soon as it has fired at its outer zone of action it is at once trained on an interior zone, ten zones removed from its first zone.

From the data given by General Abbot, a zone 800 feet long and 300 feet wide would be considered effectively covered by the fire of a battery of sixteen mortars. Granting the correctness of this, we can safely assume a zone of 300 yards in length as being well covered by the double group of thirty-two mortars, and ten groups will cover at their first fire a length of 3000 yards of the channel. Assuming a speed of movement of the enemy's ships, of twenty knots, we would have about 4.4 minutes for re-pointing and loading, which should, with suitable loading appliances, suffice; particularly, as the mortars are to be brought to a pre-arranged elevation and azimuth.*

It would be a rather dilatory and expensive mode of ascertaining the wind allowances by firing a 12″ mortar previous to firing the group. It would weaken the fire of each group to this extent, if the fire is to be delivered immediately following the dropping of the first shot. It would appear to be better to have two or three groups of 8″ mortars, or even smaller caliber, which shall be fired continuously for this purpose. These mortars should have such weight of projectile and charge as to make their trajectories practically the same as of the heavier mortars. Their deflections and retardation, etc., will be in a fixed ratio to the larger calibers and the allowances for atmospheric conditions can be deduced therefrom and applied. The smaller "pilot" shell might contain a bursting charge and sensitive fuze, which would act on striking the water, so as to enable us to distinguish their splashes.

The smaller mortars might be fired at intervals of two minutes, each group firing at different ranges, for the information of the groups trained to fire on corresponding zones. It is easy to devise a slide rule computing disk which will readily transform the results obtained, for application to the different lines of fire or ranges.

It might even be found advisable to supply each double group of mortars with a small auxiliary battery of small mortars for ascertaining the allowances for atmospheric conditions.

The system above indicated implies the use of a very large number of pieces. In the present instance, 320 are required.

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* The present time for loading and firing the 12″ mortar is given as 11.5 minutes. With proper appliances this time should be reduced to within the limits mentioned.

But, as stated by General Abbot, the emplacements are relatively inexpensive, the mortars and carriages are likewise so, particularly when we compare them with the cost of 12″ direct firing guns mounted on disappearing carriages or gun lifts with the expensive machinery and cover for machinery demanded. They have the further advantage over the direct firing guns in having usually a much larger sector of fire and may be placed in almost any position. A much larger choice of position is possible and the expense of obtaining the same may be very much reduced.

Although the chances of hitting by vertical fire are given as only one-half that of the direct fire, yet it is not too much to assume that the chances of producing vital results with the shell from the 12″ rifled mortars are more than twice as great as those possible by the direct hitting gun, striking, as they may, the heavily armored sides.

The large development of vertical fire which is sure to take place, will naturally lead to greater protection against it, in ship construction. The improvements in steel armor, particularly the Harveyized process, will enable the ships to obtain the same protection now given with reduction of weight of side armor. They will be able, therefore, to devote more weight to deck armor. We may look for a dispensation of the present protective deck and a replacing of this by an over-all steel deck of not less than 5″ to 8″. Such a deck, of Harveyized steel, will be likely to defeat the present deck piercers, particularly if these shells contain a considerable bursting charge. It will therefore be desirable to increase the weight of the mortar projectiles to the utmost and a very sharp twist of rifling should be used in order to impart stability of flight to the longer projectiles. It would appear, from the fact that the projectiles now used do not have full stability of flight at the higher angles of fire, that the twist used is not sufficiently sharp even for the weights of shell now in use. An extreme weight of shell of 1000 lbs. is now used, but we may look for a weight of 1200 lbs.

From recent comparative firings at Sandy Hook with a type 12″ mortar having a uniform twist of rifling of 1 turn in 35 calibers, and a 12″.2 mortar having an increasing twist of 1 turn in 50 to 1 turn in 25, it has been concluded that the increasing twist should be adopted, as the latter gave the best results. May not the superiority of the latter have been due to the greater sharpness of final twist rather than the fact that it was increasing. The late experiments of Captain Noble show conclusively that the uniform is superior to the increasing twist. It would be well if a mortar having a uniform twist of rifling of 1 turn in 25 calibers be tried comparatively before finally adopting the increasing twist. It would be well also to try a twist of 1 turn in 20 calibers or even sharper. Should longer projectiles, either solid shot or torpedo shell, be used, as they probably will, the sharper twist will be required to maintain stability of flight.*

There are many practical details to be attended to in order to secure the greatest obtainable accuracy of fire. We may assume from the beginning that it is well nigh impossible to construct the mortar platforms so solidly and accurately as to ensure their absolute horizontality throughout and their retention of this after a considerable number of fires. Even granting that this has been accomplished, there are still possibilities of inaccuracies in the mortar carriage and its bed of live rollers.

The errors in direction due to the axis of the trunnions not being horizontal may be very great in vertical fire for slight angles of inclination. The deflection formula is $R \sin a \tan E$,
where $a =$ angle of inclination of trunnions,
$E =$ angle of elevation,
$R =$ Range.

Thus for a range of 10,000 yards (elevation of 45°) where the inclination of the trunnions is only 15 minutes, the deflection will be 436 yards. Should it happen that two mortars of a group have slight inclinations of only 15 minutes, but in opposite directions, a dispersion of 872 yards might ensue.

Fortunately this source of error may easily be eliminated if provisions are made, preferably on the mortar itself, of a ledge having a plane parallel to the axis of the trunnions on which the quadrant may be placed. Within the limits of the angles of inclination likely to be found, the arc and sine may be considered equal. This angle can therefore be applied directly

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* See page 16, Report of Chief Ordnance for 1892.

by adding or subtracting from the proposed azimuth of fire, using as a correction factor one of the following table, easily remembered or which may be engraved on the quadrant.

Natural tangent 30°=0.577=0.6
" " 35°=0.700=0.7
" " 40°=0.839=0.8
" " 45°=1.000=1.0
" " 50°=1.191=1.2
" " 55°=1.428=1.4
" " 60°=1.732=1.7
" " 65°=2.144=2.1
" " 70°=2.747=2.7
" " 75°=3.732=3.7

In view of the high angles of fire used and variable changes, the retention of the shell so it is surely held in its normal position, must be secured. This may be readily done by two or more spring clips near the base of the shell with soft metal buttons which will press into a slight cannelure cut into the rear part of the shot chamber. It is an open question whether the various charges to be used had best be put into serge or other soft bags. The disposition of the powder may vary considerably when in reduced charges owing to their flexible character. Uniformity of inflammation and burning are more vital in the short mortars than in longer guns. May it not be well to encase the powder in card board or metallic boxes either of uniform (chamber) *diameters* and of varying height, or of uniform *lengths* and varying diameters. To simplify the charging, if the latter method is adopted, only two sizes might be used besides the full charge, combination of the two smaller sizes giving various intermediate charges.

There are questions of detail sure to arise when we have practical experience with the mortars. These should demand our earnest attention, if we desire to obtain the maximum efficiency from the most important part of our sea-coast armament.

CORRIGENDUM:

Vol. II, page 320, first line below table 5, for "fifty" read "fifty-five."

ADDENDA:

Vol. II, page 322, after fourth paragraph, insert—

Assuming then that skillful practice at a ship of war lying at a distance of two miles will afford 20 per cent. of hits, it is easy to compute what this percentage should be at any other range, from the law above deduced (precision inversely as the square of the range) and from the condition that 100 per cent. must correspond to zero distance. The formula expressing these relations in mathematical language is the following, in which R represents the range in miles, and X the percentage of hits:

$$X = \frac{100}{R^2 + 1}$$

From this formula the following percentages of hits at different ranges result; but it should not be forgotten that at less than about a mile the projectiles lack energy sufficient to pierce an armored deck:

At 0	miles	100 per cent.	At 2.5	miles	14 per cent.
At 0.5	miles	80 per cent.	At 3	miles	10 per cent.
At 1	mile	50 per cent.	At 4	miles	6 per cent.
At 1.5	miles	31 per cent.	At 5	miles	4 per cent.
At 2	miles	20 per cent.	At 6	miles	3 per cent.

But to return to our typical battery: an inspection, &.

Vol. II, page 323, after the word "longitudinally" in the 14th line, insert "Formulæ (2) and (3) above given, based on the entire fifty-five rectangles now available, indicate 43 feet and 138 feet for these figures."

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FORMULAS FOR VELOCITY AND PRESSURE IN THE BORE OF A GUN.*

By Captain JAMES M. INGALLS, First Artillery, U. S. A.

Within the last few years M. *Emile Sarrau*, engineer-in-chief of the French powder factories, has published a series of most important memoirs upon the effects of fired gunpowder in the bore of a gun, in which he has deduced practical formulas by means of which we are able to calculate the muzzle velocity of a projectile and the maximum pressure in the gun with a considerable degree of approximation. In these investigations M. *Sarrau* has for the first time taken into account the *progressive combustion* of the charge under the influence of the *variable pressure* to which it is subjected in the gun, and has thus been able to introduce explicitly into his formulas the characteristic elements of each powder employed, that is, the form and size of grain, and the velocity of combustion in free air. Some of the most important applications of *Sarrau's* methods are those which regard the powder as the principal variable; and by so regarding it he has succeeded in deducing formulas for determining in advance the proper weight of charge, the kind of powder, and the best form and size of grain to bring about desired results.

In his investigations *Sarrau* assumes that the time required to ignite the charge is so short that it can be neglected in comparison with that required for its combustion, an assumption which is undoubtedly correct for the large and dense grains of modern powders. He also assumes that the permanent gases of the products of combustion neither receive heat from the non-gaseous products, nor give off heat to the walls of the gun, but expand adiabatically. This last assumption, which has been proven incorrect by *Noble* and *Abel*, is only adopted provisionally and as a convenient working hypothesis; and in his practical formulas

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* Chapter IV, *Interior Ballistics*.

the constants are so determined by experiment as to correct in great measure whatever error there may be in this hypothesis—in fact, to render these formulas independent of any hypothesis as to the gases receiving or giving off heat, and also as to whether all the powder is consumed before the projectile leaves the bore.

Differential Equation of Motion of a Projectile in the Bore of a Gun.—Let

y be the weight of powder burned in the gun in the time t, counting from the instant the charge is inflamed.

ε the weight of gas formed by the combustion of unit weight of powder; and, therefore,

εy the weight of gas in the bore of the gun at the time t.

T_1 the absolute temperature of combustion, or the absolute temperature of the mass of gas εy if formed in a close vessel, without performing work.

T the actual absolute temperature of the mass of gas εy at the end of the time t, and when the projectile has been moved by the expansion of the gas a distance u.

E the mechanical equivalent of heat.

c the mean specific heat of the gases under constant volume.

Then, since in an adiabatic expansion the external work done is proportional to the fall in temperature, we have, for a mass of gas εy falling from temperature T_1 to temperature T, the relation

$$W = \varepsilon y c E (T_1 - T) \qquad . \quad . \quad . \quad (1)$$

Equation (1) is true whether we consider the combustion of the powder as instantaneous or gradual, provided the initial and final temperatures are the same in both cases. In the one case we have a mass of gas εy instantly formed at a temperature T_1, expanding and thereby performing work, until its temperature is reduced to T. In the other case we have a progressive formation of gas at temperature T_1, from zero to mass εy, expanding as formed, and doing work until, as before, the temperature of the mass becomes T. Equation (1) can be transformed by introducing in place of the temperature of the gas, the volume and pressure, upon which its temperature directly depends. We have by

Mariotte's law for a weight of gas εy occupying a space v at the absolute temperature T, the relation

$$pv = \varepsilon y R T \quad . \quad . \quad . \quad (2)$$

where p is the pressure exerted by the gas upon unit of surface.

Substituting for T in Equation (1) its value from Equation (2) it becomes

$$W = \varepsilon y c E \left\{ T_1 - \frac{pv}{\varepsilon y R} \right\} \quad . \quad . \quad . \quad (3)$$

Making $f = \varepsilon R T_1$, where f is the *force of the powder*, and writing for $\frac{cE}{R}$ its value $\frac{1}{n-1}$, Equation (3) becomes

$$(n-1) W = fy - pv \quad . \quad . \quad . \quad (4)$$

To express the space occupied by the gas at any instant as a function of the distance traveled by the projectile, let

ω be the area of a right section of the bore.

u the distance traveled by the projectile from its seat, or initial position.

z_0 the reduced length of the initial air-space.

Then since, according to *Noble* and *Abel's* experiments, the volume of solid residue left after explosion is equal to the volume of the powder, we evidently have

$$v = \omega (z_0 + v)$$

and this substituted for v in Equation (4) gives

$$(n-1) W = fy - \omega p (z_0 + u) \quad . \quad . \quad . \quad (5)$$

an equation which expresses at each instant of the expansion the relation which exists between the weight of powder burned, the tension of the gas, the distance traveled by the projectile, and the external work performed.

If we assume that the work done by the expansion of the powder gas is measured by the energy of translation imparted to the projectile, we may put

$$W = \frac{w}{2g} v^2 = \frac{w}{2g} \left(\frac{du}{dt} \right)^2$$

in which w is the weight of the projectile.

Also, p being the pressure per unit of area, ωp is the entire pressure on the base of the projectile; and therefore $\frac{g\omega}{w}p$ is the expression for the acceleration. Therefore

$$\omega p = \frac{w}{g} \cdot \frac{d^2u}{dt^2} \quad . \quad . \quad . \quad (6)$$

Substituting these values of W and ωp in Equation (5), we have finally,

$$(z_0+u)\frac{d^2u}{dt^2}+\frac{n-1}{2}\left(\frac{du}{dt}\right)^2 = fg\frac{y}{w} \quad . \quad . \quad . \quad (7)$$

which is *Sarrau's* differential equation of the motion of a projectile in the bore of a gun.

In deducing Equation (7) there were neglected the following energies:

1st. The heat communicated by the gases to the walls of the gun; and also the heat received by the gases (if any) from the solid products.

2d. The work expended on the charge, the gun and carriage, and in giving rotation to the projectile.

3d. The work expended in overcoming passive resistances, such as forcing, friction along the grooves, the resistance of the air, etc.

It will be seen, however, from the form of Equation (7), that all of these neglected energies may be allowed for by giving to f a suitable value; and this without changing the form of the differential equation of motion. The "force of the powder" then, can only be considered as a coefficient in Equation (7) whose value must be determined by experiment.

If v is the velocity of the projectile in the bore of the gun at any instant we have

$$\frac{du}{dt}=v,$$

and

$$\frac{d^2u}{dt^2}=\frac{d(v^2)}{2du};$$

substituting these in Equation (7) it becomes

$$(z_0+u)\,\frac{d(v^2)}{du} + (n-1)v^2 = \frac{2fg}{w}y \quad . \quad . \quad . \quad (8)$$

There is great uncertainty as to the proper value to be given to n for the gases of fired gunpowder. As we have seen in Chapter II, the value of this ratio for perfect gases is nearly 1.4; and it has been assumed that at the high temperatures maintained by the powder gases in the bore of a gun they may be regarded as possessing all the properties of perfect gases; and therefore many of the earlier writers on interior ballistics assumed that $n = 1.4$. But recent investigations have shown that this value is too great, but they have not fixed its true value. The value of n derived from *Noble* and *Abel's* experiments is nearly $1\frac{1}{8}$ for the gases of fired gunpowder at or near the temperature of combustion; and this is the value which, for want of a better, will be adopted in what follows. Introducing this value of n into Equation (8) it becomes

$$3(z_0+u)\,\frac{d(v^2)}{du} + v^2 = \frac{6fg}{w}y \quad . \quad . \quad . \quad (9)$$

Equation (9) expresses the relation which must exist at any instant between the distance traveled by the projectile and the velocity it has acquired, when a weight of powder y has been burned; and its solution will give the velocity when y is known and f has been determined by experiment. In order to determine the velocity at any point within the bore it will be necessary to know the value of y at that point; and this involves a knowledge of the law of combustion of the grains of which the charge is composed, as a function of the distance traveled by the projectile, which will be considered further on.

If x is the ratio of u to z_0, we have

$$u = x z_0 \quad . \quad . \quad . \quad . \quad (10)$$

and this value of u substituted in Equation (9) gives

$$3(1+x)\,\frac{d(v^2)}{dx} + v^2 = \frac{6fg}{w}y \quad . \quad . \quad . \quad (11)$$

Since y is a function of the time it is also a function of u and of x, and may be written

$$y = \varphi(x);$$

and substituting this in Equation (11) it becomes

$$3(1+x)\frac{d(v^2)}{dx}+v^2=\frac{6fg}{w}\varphi(x) \quad . \quad . \quad . \quad (12)$$

It appears impossible at present either to determine the actual form of $\varphi(x)$, or to integrate Equation (12) in finite terms even when we give to $\varphi(x)$ the simplest approximate form which the nature of the problem admits of. If we regard y as constant Equation (11) can be solved as follows: Separating the variables we have

$$\frac{d(v)^2}{v^2-\frac{6fgy}{w}}+\frac{dx}{3(1+x)}=o;$$

from which we get by integration

$$\left\{v^2-\frac{6fgy}{w}\right\}(1+x)^{\frac{1}{3}}=C$$

Determining the value of C from the condition that when $x=o$, $v=o$, and solving for v^2, we have

$$v^2=\frac{6fgy}{w}\left\{1-\frac{1}{(1+x)^{\frac{1}{3}}}\right\} \quad . \quad . \quad . \quad (13)$$

which is the same in form as Equation (22), page 40, otherwise deduced. It follows, therefore, that making y constant in Equation (11) is equivalent to supposing that the combustion of the charge (or that part of it which is burned in the gun) is instantaneous, whereas we know it to be progressive. If all the charge were burned before the projectile left the bore the work of expansion would be the same by either hypothesis provided the final temperature, (that is, the temperature when the projectile is about to leave the muzzle) were the same in both cases. But it is well known that the muzzle tension (and therefore the temperature) of the gases of a slow burning powder is greater *caeteris paribus* than obtains with a quick burning powder, though we may assume that the temperature of combustion is practically the same for both powders. It follows that the work of expansion of a charge of slow burning powder in the bore of a gun is less than that of a quick burning powder of the same weight other things being equal. The hypothesis of an instantaneous combustion of the powder charge gives therefore, by means of Equation (13), too great a muzzle velocity.

It may be however that the *form* of Equation (13) may be employed both for the purpose of calculating muzzle velocities for different guns with different conditions of loading, and also for determining the velocity of the projectile at any point within the bore of the gun. For the first object it would be necessary to determine the value of the coefficient f by means of a measured muzzle velocity, using a typical gun with standard conditions of loading, and employing a charge all of which is burned in the gun. For the second object we should assume that the coefficient f determined as in the first case would give in Equation (13) the velocity of the projectile at any point within the bore, provided the weight of powder burned up to that point, were substituted for y. We know that this would give the correct velocity at two points, namely, at the origin of motion and at the muzzle; but whether this method gives correct velocities at intermediate points must be determined by experiment, which is the final test of nearly all physical formulas

If we make, for convenience,

$$X_4 = \left\{ 1 - \frac{1}{(1+x)^{\frac{1}{3}}} \right\}^{\frac{1}{2}},$$

Equation (13) may be written

$$v^2 = \frac{6fg}{w} y X_4^2 \quad . \quad . \quad , \qquad (13')$$

a monomial form which will be found of use in the sequel.

Muzzle Velocity for Quick Powders.—If we suppose the powder to be all consumed before the projectile leaves the bore, a supposition which is true only for the small grained powders used in small-arms, y will be equal to $\tilde{\omega}$ in Equation (13), and if we designate muzzle velocity by V and the muzzle value of x by x_1, we deduce from Equation (13)

$$V = \sqrt{6fg} \left(\frac{\tilde{\omega}}{w} \right)^{\frac{1}{2}} \left\{ 1 . - \frac{1}{(1+x_1)^{\frac{1}{3}}} \right\}^{\frac{1}{2}} \quad . \quad . \quad . \qquad (14)$$

With a proper mean value of f determined by experiment Equation (14) should give the muzzle velocity of a projectile with a considerable degree of accuracy when it is certain that all the powder is burned in the gun.

Expression for the Velocity for Slow Powder.—In deducing Equation (14) it was assumed that the charge was composed of quick powder all of which was converted into gas before the projectile had left the gun. With slow powder this assumption cannot be made, and it becomes necessary to take into account the progressive combustion of the charge under the variable pressure to which it is subjected in the bore; in other words to determine a suitable expression for y which shall represent the weight of powder burned in the time t, or when the projectile has traveled the distance u.

If we suppose the entire charge to be ignited at the same instant, an assumption that is nearly realized in the use of the large grained powder employed with heavy guns, the combustion of the charge will be expressed by the same function that expresses the combustion of a single grain. Therefore if $\psi(t)$ is the fraction of a grain burned in the time t, the total weight burned in the same time will be

$$y = \tilde{\omega}\,\psi(t) \quad . \quad . \quad . \quad (15)$$

$\tilde{\omega}$ being the weight of the charge.

Combustion of a Grain of Powder in Free Air.—The form of the function $\psi(t)$, when the combustion takes place in free air, and therefore under a constant pressure, can be expressed as follows for all the various forms of grain used in practice:

$$\psi(t) = \frac{a\,t}{\tau}\left(1 - \lambda\,\frac{t}{\tau} + \mu\,\frac{t^2}{\tau^2}\right) \quad . \quad . \quad . \quad (16)$$

in which τ is the time of combustion of the entire grain, and depends upon the nature of the powder, on the size of the grain, upon its density and, generally, upon all the characteristics which have an influence upon the *velocity of combustion;* while a, λ, and μ depend only upon the *form* of the grain, and are purely numerical, retaining the same values as long as the grain in burning remains similar to its original form. It only remains to determine the values of these coefficients for the various forms of grain used in practice. It will be assumed that the grains are homogeneous throughout and of the same density; also that the combustion takes place in successive layers and with uniform velocity.

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Values of the Constants a, λ and μ for different Service Powders.—For all irregular shaped grains, and for sphero-hexagonal, hexagonal, mammoth, cubical and cannon powders the law of burning is approximately that of a sphere; and for these we have $a=3$, $\lambda=1$ and $\mu=\frac{1}{3}$.

The pierced prismatic powders, such as the German cocoa and *Dupont's* brown powders, assimilate to the pierced cylinder. For these powders $x=\frac{1}{2}$; and, therefore, from Equation (25),

$$a=\tfrac{3}{2},\ \lambda=\tfrac{1}{3} \text{ and } \mu=0.$$

For the square prismatic powder used in our army $x=0.72$; and, therefore, for this powder, Equation (21) gives

$$a=2.44,\ \lambda=0.8,\ \mu=0.21.$$

Smokeless powders are frequently made into long thread-like grains or cylinders; and since for these forms x is a very small fraction, we have approximately, from Equation (23),

$$a=2,\ \lambda=\tfrac{1}{2} \text{ and } \mu=0.$$

It will be seen in all the preceding expressions for $\varphi(t)$ that when λ and μ are zero, the grains give off equal quantities of gas in equal times. Therefore the smaller these factors the more uniform is the generation of gas and the more equable the pressure in the bore of the gun. The best form of grain would make μ zero and λ a small fraction.

Combustion under a Variable Pressure.—The value of y when the combustion takes place in free air, and therefore under constant pressure, may, in accordance with the preceding discussion, take the form

$$y=\tilde{\omega}\varphi(t)=\tilde{\omega}\,\frac{at}{\tau}\left(1-\lambda\frac{t}{\tau}+\mu\frac{t^2}{\tau^2}\right) \quad . \quad . \quad (26)$$

for all geometrical forms. But when the combustion takes place in a gun this formula is not applicable in its present form; and it becomes necessary to take into account the law of variation of combustion due to the variable pressure developed in the bore. For this purpose it is better to introduce into the expression for

y, the length of grain burned in place of the time of burning. Let l_0 be one-half of the mean least dimension of the grains of which the charge is composed, and l the length of grain burned in the time t under a variable pressure p. Then it may be shown, as before, that, when l is burned, the weight of powder consumed is expressed by the equation

$$y = \tilde{\omega}\frac{al}{l_0}\left\{1 - \lambda\frac{l}{l_0} + \mu\frac{l^2}{l_0^2}\right\} \quad . \quad . \quad . \quad (27)$$

whatever may be the law of combustion.

Velocity of Combustion under Variable Pressure.*—The velocity of combustion under the constant atmospheric pressure p_0 is constant and equal to $\frac{l_0}{\tau}$, while under a variable pressure p, the velocity is $\frac{dl}{dt}$. Therefore, if we assume with *Sarrau* that the velocity of combustion under variable pressure is proportional to the square root of the pressure, we shall have

$$\frac{dl}{dt} = \frac{l_0}{\tau}\left(\frac{p}{p_0}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad (28)$$

To express l in terms of u, the distance traveled by the projectile, we have from Equation (6),

$$p = \frac{w}{g\omega}\frac{d^2u}{dt^2},$$

which by Equation (10) becomes

$$p = \frac{wz_0}{g\omega}\frac{d^2x}{dt^2};$$

and this substituted in Equation (28) gives

$$\frac{dl}{dt} = \frac{l_0}{\tau}\left(\frac{wz_0}{g\omega p_0}\right)^{\frac{1}{2}}\left(\frac{d^2x}{dt^2}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad (29)$$

an expression for the velocity of combustion at any instant when we may suppose a weight of powder y to have been burned.

We may replace dt by dx as follows:—We have

$$\frac{d^2x}{dt^2} = \frac{d^2u}{z_0dt^2} = \frac{d(v^2)}{2z_0du} = \frac{d(v^2)}{2z_0^2dx}.$$

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* See paper entitled "Velocities and Pressures in Guns" by Ensign *J. H. Glennan*, U. S. Navy, in Proceedings of the United States Naval Institute, vol. XIV, pp. 395-418.

$$\therefore \quad \frac{dl}{dt} = \frac{l_0}{\tau}\left(\frac{w}{2g\omega p_0 z_0}\right)^{\frac{1}{2}}\left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}}$$

We also have

$$\frac{dl}{dx} = \frac{dl}{dt} \div \frac{dx}{dt};$$

but

$$\frac{dx}{dt} = \frac{du}{z_0 dt} = \frac{v}{z_0}$$

$$\therefore \quad \frac{dl}{dx} = \frac{l_0}{\tau}\left(\frac{wz_0}{2g\omega p_0}\right)^{\frac{1}{2}}\left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}}\frac{1}{v} \quad . \quad . \quad . \quad (30)$$

Differentiating Equation (13) with reference to x, regarding y as momentarily constant, and reducing,

$$\left(\frac{d(v^2)}{dx}\right)^{\frac{1}{2}}\frac{1}{v} = \frac{1}{\sqrt{3}\sqrt{1+x}\sqrt{(1+x)^{\frac{1}{8}}-1}} = \frac{1}{\sqrt{3}}\,F(x), \text{ say:—}$$

an equation independent of y.

Substituting this last in Equation (30) and reducing, gives

$$dl = \frac{l_0}{\tau}\left(\frac{wz_0}{6gp_0\omega}\right)^{\frac{1}{2}} F(x)\,dx; \quad . \quad . \quad . \quad (31)$$

whence integrating between the limits o and x, we have

$$l = \frac{l_0}{\tau}\left(\frac{wz_0}{6gp_0\omega}\right)^{\frac{1}{2}}\int_o^x F(x)dx \quad . \quad . \quad . \quad (32)$$

Making the following substitutions:

$$\omega = \frac{\pi d^2}{4},$$

$$K = \frac{1}{\tau}\left(\frac{wz_0}{6gp_0\omega}\right)^{\frac{1}{2}} = \frac{2}{\tau d}\left(\frac{wz_0}{6\pi g p_0}\right)^{\frac{1}{2}},$$

and

$$\int_o^x F(x)\,dx = X_0,$$

Equation (32) becomes

$$\frac{l}{l_0} = KX_0;$$

and this substituted in Equation (27) gives

$$y = \bar{\omega}\, a K X_0 \left\{ 1 - \lambda K X_0 + \mu (K X_0)^2 \right\} \quad . \quad . \quad (33)$$

which gives the weight of powder burned as a function of the distance traveled by the projectile.

Expression for the Velocity.—Substituting the value of y from Equation (33) in Equation (13), and making

$$X_0\left\{1-\frac{1}{(1+x)^{\frac{1}{3}}}\right\}=X_1,$$

it becomes

$$v^2=6gfa\frac{\tilde{\omega}}{w}KX_1\left\{1-\lambda KX_0+\mu(KX_0)^2\right\} \quad . \qquad (34)$$

Restoring the value of K and making

$$M=2\sqrt{6}\left(\frac{g}{\pi p_0}\right)^{\frac{1}{2}},$$

and

$$N=\left(\frac{2}{3\pi g p_0}\right)^{\frac{1}{2}},$$

whence

$$M=6gN,$$

Equation (34) reduces to

$$v^2=M\frac{fa\tilde{\omega}}{\tau d}\left(\frac{z_0}{w}\right)^{\frac{1}{2}}X_1\left\{1-N\frac{\lambda}{\tau d}(wz_0)^{\frac{1}{2}}X_0+N^2\frac{\mu}{\tau^2 d^2}(wz_0)X_0^2\right\} \qquad (35)$$

which is the general expression for the velocity of a projectile in the bore of a gun in terms of the distance traveled and the weight of powder burned.

Expression for the Pressure on the Base of the Projectile.—To deduce an expression for the pressure per unit of surface, on the base of the projectile, we have

$$p=\frac{m}{\omega}\frac{d^2u}{dt^2}=\frac{w}{2g\omega}\frac{d(v^2)}{du}=\frac{2w}{\pi d^2 g z_0}\frac{d(v^2)}{dx};$$

whence, differentiating Equation (35), and reducing,

$$p=\frac{2w}{\pi d^2 g z_0}M\frac{fa\tilde{\omega}}{\tau d}\left(\frac{z_0}{w}\right)^{\frac{1}{2}}\frac{dX_1}{dx}\left\{1-N\frac{\lambda}{\tau}\frac{(wz_0)^{\frac{1}{2}}}{d}X_0+N^2\frac{\mu}{\tau^2}\frac{wz_0}{d^2}X_0^2\right\}$$

$$-\frac{2w}{\pi d^2 g z_0}M\frac{fa\tilde{\omega}}{\tau d}\left(\frac{z_0}{w}\right)^{\frac{1}{2}}X_1\left\{N\frac{\lambda}{\tau}\frac{(wz_0)^{\frac{1}{2}}}{d}\frac{dX_0}{dx}-2N^2\frac{\mu}{\tau^2}\frac{wz_0}{d^2}X_0\frac{dX_0}{dx}\right\} \qquad (36)$$

Equations (35) and (36) are the complete expressions for the velocity and pressure upon the base of the projectile, respectively, in terms of the distance traveled by the projectile. The factors M and N are constants independent of the elements of fire; the quantities $\frac{fa}{\tau}$, $\frac{\lambda}{\tau}$ and $\frac{\mu}{\tau^2}$ are constants for the same powder; while $\tilde{\omega}$, w, d and z_0 are constants for the some gun and charge. The only general variables in the second members are, therefore, X_0 and X_1 together with their first derivatives with reference to x. These equations may be simplified by making $\mu = o$, which is its value for pierced grains and for most service powders. We thus have, after reducing,

$$v^2 = M\frac{fa}{\tau}\frac{\tilde{\omega}}{d}\left(\frac{z_0}{w}\right)^{\frac{1}{2}} X_1 \left\{1 - N\frac{\lambda}{\tau}\frac{(wz_0)^{\frac{1}{2}}}{d}X_0\right\} \quad . \quad (37)$$

and

$$p = M'\frac{fa}{\tau}\frac{\tilde{\omega}}{d^3}\left(\frac{w}{z_0}\right)^{\frac{1}{2}} X_2 \left\{1 - N\frac{\lambda}{\tau}\frac{(wz_0)^{\frac{1}{2}}}{d}X_3\right\} \quad . \quad . \quad (38)$$

in which M and N are the same as before, while

$$M' = \frac{2M}{\pi g},\ X_2 = \frac{dX_1}{dx} \text{ and } X_3 = \left\{X_1\frac{dX_0}{dx} + X_0\frac{dX_1}{dx}\right\} \div \frac{dX_1}{dx}.$$

For the same powder and type of gun $\frac{fa}{\tau}$ and $\frac{\lambda}{\tau}$ are constants and may be incorporated with M, N and M', respectively. Making then

$$M_1 = M\frac{fa}{\tau},\ N_1 = N\frac{\lambda}{\tau} \text{ and } M_2 = M'\frac{fa}{\tau},$$

Equations (37) and (38) may be written

$$v^2 = M_1\frac{\tilde{\omega}}{d}\left(\frac{z_0}{w}\right)^{\frac{1}{2}} X_1 \left\{1 - N_1\frac{(wz_0)^{\frac{1}{2}}}{d}X_0\right\} \quad . \quad . \quad (39)$$

and

$$p = M_2\frac{\tilde{\omega}}{d^3}\left(\frac{w}{z_0}\right)^{\frac{1}{2}} X_2 \left\{1 - N_1\frac{(wz_0)^{\frac{1}{2}}}{d}X_3\right\} \quad . \quad . \quad (40)$$

in which, in the last equation,

$$M_2 = \frac{2}{\pi g}M_1.$$

In all the above equations the units are the pound and foot. Therefore, the velocity will be in foot-seconds and the pressure upon the base of the projectile in pounds per square foot. As this latter is usually required in pounds per square inch, we must divide the second member of Equation (40) by 144; or what is the same thing compute M_2 by the formula

$$M_2 = \frac{M_1}{72\pi g}.$$

Making $g = 32.16$, which is its mean value for the United States, we have

$$\log M_2 = \log M_1 - 3.86180.$$

We also have for the factors M and N, which are independent of all the elements of fire,

$$\log M = 9.5323975$$
$$\log N = 7.2469302.$$

The quantities X_0, X_1, X_2 and X_3 which enter into the expressions for the velocity and pressure, are all functions of x alone, and may be tabulated with x for the argument. We have,

$$X_0 = \int_0^x \frac{dx}{(1+x)^{\frac{1}{2}}\sqrt{(1+x)^{\frac{1}{3}} - 1}} \quad . \quad . \quad . \quad (41)$$

whence integrating,

$$X_0 = 3(1+x)^{\frac{1}{6}}\sqrt{(1+x)^{\frac{1}{3}} - 1} + 3\log_e \left\{ (1+x)^{\frac{1}{6}} + \sqrt{(1+x)^{\frac{1}{3}} - 1} \right\}$$

This expression for X_0 may be simplified by means of circular functions. Thus, if we make

$$\sec\varphi = (1+x)^{\frac{1}{6}},$$

and therefore,

$$\tan\varphi = \sqrt{(1+x)^{\frac{1}{3}} - 1}$$

Equation (41) reduces to

$$X_0 = 6\int_0^\varphi \frac{d\varphi}{\cos^3},$$

This last definite integral is a well known function of φ and has been extensively used in exterior ballistics, first by *Euler* and afterwards by *Otto*, *Didion* and others.* Symbolizing this function by (φ) we have

$$X_0 = 6\,(\varphi)$$

and

$$(\varphi) = \tfrac{1}{2}\tan\varphi\sec\varphi + \tfrac{1}{2}\log_e(\tan\varphi + \sec\varphi).$$

The other functions readily reduce to the following:—

$$\frac{dX_0}{dx} = \cot\varphi\cos^3\varphi$$

$$X_1 = X_0\sin^2\varphi$$

$$X_2 = \sin\varphi\cos^4\varphi\left(1 + \tfrac{1}{8}X_0\frac{dX_0}{dx}\right)$$

$$X_3 = X_0\left(1 + \frac{1}{1 + \frac{1}{3}X_0\frac{dX_0}{dx}}\right)$$

$$X_4 = \sin\varphi \text{ (See page 52)}$$

The values of these functions are given in Table II. In the first edition of this work it was assumed that the gases produced by the combustion of a charge of powder might be considered, on account of their high temperature, as perfect gases; and the value of n was therefore taken at 1.4. The table of the functions X_0, etc., computed upon this hypothesis is also here given as Table II′.

Practical Applications.—All the quantities which enter into the second members of Equations (39) and (40) are known or may be easily computed by means of formulas already established. It will readily be seen however that the velocities thus determined must be too great on account of the resistances which were omitted in establishing the differential equation of motion, Equation (7); and which are of such a nature that their evaluation seems to be beyond the power of analysis. This difficulty may be avoided, practically by supposing the force of the powder f to be so diminished that the acceleration produced upon the projectile, free to move, shall be equal to the real acceleration. The value of f will also be still further diminished if we suppose that any part of the heat of the gases is lost by conduction to the walls of

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* See *Otto's* Tables. Paris, 1845. *Didion's* Traité de Balistique. Paris, 1860. *Ingalls'* Handbook of Problems in Direct Fire. New York, 1890, p. 301 and Table IV.

the bore. It will be necessary then to determine the force of the powder, or, what amounts to the same thing, the factors M_1 and N_1 in Equation (39), by experiment. Two equations will be needed for this purpose, and these may be obtained by firing the same kind of powder with varying charges and weights of projectiles, in two similarly constructed guns of different calibres and conditions of loading, and measuring the respective muzzle velocities with a chronograph.

Determination of M_1 and N_1—Let, at the muzzle of the gun,

$$\frac{\tilde{\omega}}{d}\left(\frac{z_0}{w}\right)^{\frac{1}{2}} X_1 = \frac{1}{A}$$

and

$$\frac{(wz_0)^{\frac{1}{2}}}{d} X_0 = B;$$

then Equation (39) becomes, for one of the guns,

$$V_1^2 = \frac{M_1}{A_1}\left\{1 - B_1 N_1\right\}$$

and for the other

$$V_2^2 = \frac{M_1}{A_2}\left\{1 - B_2 N_1\right\};$$

whence

$$M_1 = \frac{A_1 B_2 V_1^2 - A_2 B_1 V_2^2}{B_2 - B_1},$$

and

$$N_1 = \frac{M_1 - A_1 V_1^2}{B_1 M_1} = \frac{M_1 - A_2 V_2^2}{B_2 M_1}.$$

It will readily be seen that the value of M_1 deduced from the above formula will be the more accurate as the divisor $B_2 - B_1$ is the larger; and therefore in selecting the guns and charges care should be taken to have as large a variation of the quantity $\frac{(wz_0)^{\frac{1}{2}}}{d} X_0$ as possible.

The values of M_1 and N_1 can also be determined with the *same* gun and a *single* charge by measuring the velocities of the projectile with a *Noble* chronoscope at two points in the chase. The data in this case will be, in addition to the elements of loading, the two measured velocities v_1 and v_2, and the corresponding distances traveled by the projectile u_1 and u_2.

Example 1.—As a first example of the applications of Equations (39) and (40) we will compute the velocities of a 300-pound projectile at different points in the bore of the English 10-inch (18-ton) gun, propelled by a charge of 70 pounds of pebble powder, and compare the results with the actual velocities measured by means of *Noble's* chronoscope, which are mentioned in Chapter III. The data for the calculations are as follows:

$w = 300$ pounds
$\bar{\omega} = 70$ "
$u_1 = 2.26$ feet
$u_2 = 8.26$ "
$d = \frac{5}{6}$ "
$v_1 = 1027$ f. s.
$v_2 = 1464.19$ f. s.
$\delta = 1.8$ (assumed)
$\Delta = 1$

From these data we find by employing the proper formulas, already given, as follows:—

SHORT TRAVEL.	LONG TRAVEL.
$z_0 = 0.9137$ feet	$z_0 = 0.9137$ feet
$x = 2.4734$	$x = 9.0398$
$\log X_0 = 0.6672832$	$\log X_0 = 0.87774895$
$\log X_1 = 0.1983650$	$\log X_1 = 0.6070231$
$\log A_1 = 9.1355059$	$\log A_2 = 8.7268478$
$B_1 = 92.3497$	$B_2 = 149.8449$

From these numbers we find

$$\log M_1 = 5.28319$$
$$\log N_1 = 7.43133 - 10$$
$$\log M_2 = 1.42139;$$

and these substituted in Equations (39) and (40) reduce them to the following:

$$v^2 = [5.94932] X_1 \left\{ 1 - [8.72948 - 10]\, X_0 \right\} \quad . \qquad . \ (42)$$

and

$$p = [4.76218]\, X_2 \left\{ 1 -]8.72948 - 10]\, X_8 \right\} \quad . \qquad . \ (43)$$

in which the numerical coefficients are replaced by their logarithms (in brackets) for convenience of computation. These formulas give the velocities in foot-seconds and the pressures upon the base of the projectile in pounds per square inch. They are extremely simple in comparison with any other formulas that have been suggested; and with the help of Table II the velocity of the projectile at any point within the bore and the corresponding pressure upon its base can be easily computed. It remains now to determine the degree of confidence that can be placed in the velocities and pressures computed by these formulas. For this purpose the following table has been prepared showing the agreement between the theoretical velocities and those deduced by *Noble* and *Abel* from the *time measurements* made by means of the *Noble* chronoscope. The first and second columns are the arguments of the table and need no further explanations. The third and sixth columns are interpolated from *Noble* and *Abel's* Table X*; and they give the velocities and pressures, respectively, corresponding to the distances traveled by the projectile, recorded in the second column. The fourth and seventh columns give the velocities and pressures computed by Equations (42) and (43). The fifth column shows at a glance the differences between the velocities furnished by Equation (42) and those deduced by *Noble* and *Abel* from the experiments with the *Noble* chronoscope. These differences are practicall *nil* except during the first six inches of the projectile's travel; and for this short distance the data given by the experiments are hardly sufficient to determine positively which set of velocities is the more accurate. The curve of velocity, (Equation (42)), is concave throughout toward the axis of x, differing in this respect from the curve of velocity deduced by *Noble* and *Abel*, which for a distance of two or three inches from the origin, is convex to the axis of abscissae; but for nineteen-twentieths of the entire distance traveled by the projectile in the bore the two curves of velocity practically coincide.

The curve of pressure (Equation (43)) begins by being concave toward the axis of x, has a maximum ordinate when $x = 0.5$ (nearly) and changes curvature, becoming convex to the axis of abscissae when $x = 1.0$ (nearly). These correspond very closely with *Noble* and *Abel's* deductions.

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* Researches, page 79.

Table of velocities and pressures in the bore of an English 10-inch, 18-ton gun. Charge 70 pounds of pebble powder of density 1.8. Weight of projectile 300 pounds.

$\frac{u}{z_0} = x$	Distance traveled by projectile in feet. (u)	VELOCITY IN FOOT-SECONDS, ACCORDING TO—			PRESSURE IN POUNDS PER SQUARE INCH, ACCORDING TO—	
		Noble & Abel.	Equation (42).	Diff.	Noble & Abel.	Equation (43).
0.001	0.0009	. .	5.768	. .	. .	3136
.004	.0037	. .	16.002	. .	. .	6204
.007	.0064	. .	24.273	. .	. .	8133
0.01	0.0091	. .	31.633	. .	. .	9644
.1	.09	109	169	+60	20320	25811
.2	.18	224	270	+46	31170	31485
0.3	0.27	317	352	+35	36336	32821
.4	.37	405	420	+15	39215	34656
.5	.46	474	479	+ 5	40224	34703
0.6	0.55	534	532	— 2	39988	34308
.7	.64	569	579	+10	38277	33661
.8	.73	614	622	+ 8	35883	32872
0.9	0.82	657	661	+ 4	33781	32005
1.0	.91	695	696	+ 1	31837	31104
1.1	1.01	732	729	— 3	30027	30193
1.2	1.10	763	760	— 3	28878	29291
1.3	.19	791	789	— 2	27935	28406
1.4	.28	818	816	— 2	27115	27545
1.5	1.37	843	841	— 2	26237	26713
1.6	.46	866	865	— 1	25381	25911
1.7	.55	888	887	— 1	24553	25140
1.8	1.65	911	908	— 3	23764	24400
1.9	.74	930	928	— 2	23072	23689
2.0	.83	949	948	— 1	22355	23009
2.47	2.26	1027	1027	0	19501	19302
3	2.74	1097	1098	+ 1	16981	17580
4	3.65	1173	1203	+30	13819	13917
5	4.57	1258	1281	+ 23	11601	11322
6	5.48	1323	1342	+19	9943	9390
7	6.40	1378	1390	+12	8640	7903
8	7.31	1424	1430	+ 6	7638	6724
9	8.22	1459	1463	+ 4	6857	5769
9.04	8.26	1464	1464	0	. .	4980
10	9.14	. .	1491	. .	. .	. .
11.081	10.125	1527	1516	—11	. .	. .
X	U	V				

Weight of Powder Burned.—We have from the definitions of K and N_1,

$$K = \frac{N}{\tau} \frac{\sqrt{wz_0}}{d} = \frac{N_1}{\lambda} \frac{\sqrt{wz_0}}{d} \quad . \quad . \quad . \quad . \quad (44)$$

TABLE II.

x.	log X_0.	log X_1.	log X_2.	log X_3.	log X_4.
0.001	9.03899	5.56162	8.73764	9.16405	8.26132
0.010	9.53911	7.05911	9.23296	9.66437	8.76000
0.1	0.03494	8.53009	9.68493	0.16295	9.24757
0.2	0.18111	8.95170	9.78653	0.31194	9.38529
0.3	0.26509	9.18802	.82962	.39851	.46147
0.4	0.32372	9.34942	.85051	.45956	.51285
0.5	0.36855	9.47036	9.86028	0.50663	9.55091
0.6	.40469	9.56610	.86371	.54488	.58070
0.7	.43489	9.64471	.86325	.57705	.60491
0.8	0.46075	9.71100	9.86027	0.60479	9.62512
0.9	.48334	9.76802	.85562	.62913	.64234
1	.50334	9.81784	.84984	.65081	.65725
1.1	0.52128	9.86193	9.84329	0.67034	9.67032
1.2	.53752	.90136	.83623	.68809	.68192
1.3	.55234	.93693	.82882	.70436	.69229
1.4	0.56597	9.96926	9.82119	0.71936	9.70165
1.5	.57856	.99884	.81343	.73328	.71014
1.6	.59026	0.02605	.80561	.74625	.71789
1.7	0.60119	0.05122	9.79777	0.75840	9.72501
1.8	.61143	.07459	.78996	.76981	.73158
1.9	.62106	.09638	.78219	.78057	.73766
2	0.63015	0.11678	9.77449	0.79075	9.74331
3	.70032	0.26858	.70304	.87009	.78412
4	.74836	0.36662	.64225	.92527	.80913
5	0.78469	0.43759	9.59029	0.96700	9.82645
6	.81379	.49253	.54521	1.00074	.83937
7	.83801	.53698	.50549	1.02890	.84948
8	0.85873	0.57411	9.47004	1.05304	9.85769
9	.87682	.60585	.43809	1.07413	.86452
10	.89284	.63349	.40901	1.09283	.87032
11	0.90723	0.65790	9.38233	1.10963	9.87534
12	.92027	.67972	.35770	1.12485	.87972
13	.93219	.69941	.33484	1.13877	.88361
14	0.94317	0.71734	9.31350	1.15159	9.88708
15	.95334	.73377	.29351	1.16346	.89021

by means of which K can be computed for the powder employed, and substituting in Equation (33) we find the value of y for any travel of the projectile, X_0 being taken from Table II for the given value of x or u/z_0.

For the pebble powder of Example 1 we have $a = 3$, $\lambda = 1$, $\mu = \frac{1}{3}$ and $K = 0.05364$. Substituting these values and the value of $\bar{\omega}$, in Equation (33) we have, in pounds,

$$y = 11.264\,X_0 \left\{ 1 - 0.0536\,X_0 + 0.000959\,X_0^2 \right\}$$

At the point of maximum pressure we have, approximately, $\log X_0 = 0.36855$; and at the muzzle $\log X_0 = 0.90833$. Substituting these in the expression for y we find when the projectile is at the point of maximum pressure $y = 23.16$ lbs.; and when at the muzzle $y = 57.3$ pounds. From this it follows that but 82 per cent of the weight of the charge was burned in the gun; and that one-third of the charge was consumed when the projectile had traveled but about six inches.

Time of Burning of a Grain in Free Air.—From the definition of N_1 we have

$$\tau = \lambda \frac{N}{N_1} \quad . \quad . \quad . \qquad (45)$$

Applying this formula to the pebble powder of Example 1, we find $\tau = 0''.654$.

Value of the Factor f.—From the definition of M_1, and the value of τ given by Equation (45), we find

$$f = \frac{N}{M} \cdot \frac{M_1}{N_1} \cdot \frac{\lambda}{a} = [7.71453 - 10] \frac{\lambda}{a} \frac{M_1}{N_1} \quad . \quad . \quad . \qquad (46)$$

For the pebble powder and gun of Example 1, Equation (46) gives $f = 122820$.

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ARTILLERY TARGET PRACTICE.

By First Lieutenant G. N. WHISTLER, Fifth Artillery, U. S. A.

The article on target practice by Lieutenant H. C. Davis, 3rd Artillery, in the *Journal of the United States Artillery* for January, 1893, deserves the most careful attention.

His division of artillery practice into three parts, "Ballistic Firing," "Target Firing," and "Tactical Firing," strikes the key-note of the only efficient system of artillery instruction. These three terms will live and become a part of the nomenclature of our service.

In order to become proficient in any art, it is absolutely necessary that we should understand and become familiar with the use of the tools which pertain thereto. In any art which involves the use of instruments of precision, in order to become proficient, we must learn to adjust them to the varying conditions of the environment, and to surmount the many difficulties which are continually presenting themselves.

This is true in all the arts and sciences; but particularly so of artillery, where we are required to use an instrument, the accuracy of which is measured at the far end of a long range.

Unless a man is familiar with the many causes of error, which continually multiply as he proceeds in his work, unless he has learned how to allow for them, and how to correct for the varying conditions of his environment, his work will be utterly valueless.

Theoretical instruction will not counterbalance his lack of experience; but simply gives to the student an amount of information which enables him to gather *his experience* in a more rapid and systematic manner.

A scientific education does not make a practical scientist, but merely establishes a foundation; maps out the line of work, and the method of work, which, if followed, will produce in due time the practical scientist.

The most thorough course in one of our universities, in mathematics, electricity or chemistry, may give to a student a fine education, but will never make him a practical engineer, electrician or chemist.

Mere laboratory experiment, with chemically pure materials, or perfect apparatus, where every joint is sound, no leakage, nothing out of order, no unaccountable conditions, is not sufficient to make a skilled chemist or electrician. The practical scientist must, by actual experience, learn to purify his ingredients, find his leaks, solder his joints, and account for his peculiar conditions.

The same is true of artillery. Demonstrating ballistic principles, deducing ballistic formulæ, solving ballistic problems under hypothetical conditions, and calculating range tables, by Bashforth's, Niven's, or Siacci's methods, will not produce a practical artillerist, although it may, and undoubtedly will, give a thorough artillery education.

An officer may be able to calculate with great accuracy the precise elevation required to cut the truck from the flag-staff on Gibraltar from a vessel in the offing, and yet be unable to put even one shot through the twenty-foot plane with the 8-inch M. L. rifle at 3000 yards range.

Another fallacy which seems to be very common, is the idea that it is merely necessary to learn how a thing should be done, or an instrument used; and in fact by many a working model is deemed ample for all purposes of instruction. This may be sufficient as a mere method of education for a class in college or West Point; but it is not sufficient when it is required to produce practical scientists and artillerists.

In my own time at the Artillery School we were all permitted to see the chronograph and electro-ballistic pendulum at work, but were not given any experience in using them.

The chief objection to mere model work or section room use of instruments, however, is the fact, that we have no errors or difficulties to contend with, and everything is plain sailing. When we begin to use the instruments practically we find stumbling blocks, corrections and variations at every step of which we have never heard or thought.

Our present system of artillery practice expects a battery commander to produce a high grade of efficient gunners from his command, when no opportunity has ever been given him to become an efficient gunner himself.

The first desideratum is "*Ballistic Firing.*" We must learn something about our guns before we can teach others. We must understand our ammunition before we can use it, with effect; and we must know something about the effect of atmospheric conditions, before we can allow for them.

I will guarantee, that if you ask Lieutenant Davis, that he will tell you that he learned more about practical ballistics in computing the table on page 54 of his article, than he could by performing all the examples in Ingalls's Handbook.

I will guarantee that the officers who took such an active part in the "*ballistic firing*" at Fort Monroe, learned more of practical artillery in that work than in anything they have ever done since they have been in the service.

Do not misunderstand me to under-rate theory. I value theoretical instruction as high as any one. All I maintain is, that to make theoretical instruction of any practical value, *it must be accompanied by practical and experimental work.*

It is not at all necessary that every officer in the service should be a *scientific artillery expert;* but it is necessary that all should be *practical artillerists.*

The ordinary theory is, that an education should ground the student well in the fundamental principles, and give him a general idea of how the work should be done; thus establishing a foundation upon which he can build in after life. Therefore, in our colleges and universities, great attention is given to theory; and students are required to apply the theory to innumerable examples presumed to cover the general ground. The practical work is confined to a few laboratory examples, merely to show the student how the work ought to be done in a general way. And this method is undoubtedly sound for the fundamental education, intended more for mental development than for any other purpose; where, however, the object is to produce *practical artillerists,* the very opposite plan should be adopted.

A general knowledge of the theory, sufficient to give the student a thorough grasp of the subject, should be required; and a sufficient familiarity with the formulæ, so as to be able to use them, is, of course, necessary. The great work should, however, be the practical application of theory to actual practice and experiment; what Lieutenant Davis calls "*Ballistic Firing.*"

First.—*Theory*, until the student is familiar with the principles involved.

Second.—*Ballistic Firing*, until he is thoroughly familiar with every piece in the service.

Third.—*Target Firing*, until he can make a satisfactory record.

Fourth.—*Tactical Firing*, until he has a practical knowledge of artillery defense.

It should be manifest to any one that the only way to learn to *hit, hit, hit*, is to *fire, fire, fire;* and that, with intelligent regard to the surrounding conditions.

I am fully aware of the fact that the chief reason for the present condition of practical work is the idea that it is useless to do anything with our present armament.

I have endeavored elsewhere to show that this is an error, and the ballistic firing at the Artillery School last summer has demonstrated that our old fashioned guns will shoot, and shoot well, if properly handled.

The question to which I would call your attention is as follows: What can be done at our artillery posts to establish a course of "ballistic firing," so that those who have completed their course at the Artillery School may learn something of this all-important work?

My idea is that a certain number of shot should, by order, be reserved each year for ballistic firing at every artillery post.

The ballistic firing should be carried on by a board of officers selected by the commanding officer.

This board should be required to prepare a scheme, which should be read and discussed in the lyceum, and after final approval by the post commander, should be carried out with great care.

The result of the ballistic firing should be prepared and tabulated by the board, and again be read and discussed in the lyceum. The proceedings of the board, with the complete record of the firing, and a digest of the discussion and views of the post commander, should become part of the artillery record of the post. A copy of this should be forwarded to army headquarters, and it should be the duty of the Inspector of Artillery to cause to be prepared a digest of the work, which should be published as artillery memoranda, for the use of the corps.

The annual publication of the ballistic firing at all the posts would become of immense value to the service.

In suggesting a model for such ballistic firing I would simply point to the work done at Fort Monroe as set forth so ably by Lieutenant Davis in his article.

The work was admirably conceived and carried out, and the gentlemen concerned deserve great credit.

I know the difficulties that lie in the way of accurate work, and I know of my own blunders when I first began ballistic firing, and I can appreciate the character and accuracy of the work done.

I have carefully studied the work, and have but two criticisms to make:

First.—They forgot to take the height of the tide at each fire,* at least it is not down in the report. Fortunately the tide table admits of calculating the height of trunnions above the water level sufficiently accurate for all practical purposes.

Second.—Lieutenant Davis placed *entirely too much confidence in Whistler's Graphic Tables of Fire.* These tables are accurate enough for target firing, and can be used with great accuracy to reduce range to plane of trunnions and to standard atmospheric conditions; but it is impossible to interpolate with sufficient accuracy in Table No. 1 to *determine jump.*

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* The state of the tide was taken each day. The firing as a rule lasted about two hours and a half. As the maximum variation in tide at this post is, under normal conditions, only two and a half feet, the change during the practice each day was really inappreciable. The greatest effect would result when the angle of fall was smallest. Assuming this angle o fall to be 4°, we have $\frac{2.5}{\tan 4^\circ}$ = variation in range = 10 yards. But even in this case the change could, in three hours, be only a fraction of this value.

For greater angles of fall the variation or error would diminish as the angle of fall increased. Therefore in no case could the error due to this cause have affected the result in any appreciable degree.—Editor *Journal.*

I have calculated the jump from the firing record by Ingalls's formulæ. It will be noted that the curve differs somewhat from that given by Lieutenant Davis. In these tables when the muzzle velocity of several shots differed by less than five ft. sec. and the ranges seemed to accord therewith, I have combined them, taking the mean of the series, otherwise I give the jump for each shot. Column No. 1 gives the number of shots in each series.

No. of shot in series.	Elevation by Quadrant.		Muzzle Velocity, ft. sec.	Actual Range, yds	Reduced Range, yds.	Ingalls *A*.	Angle of Departure.			Jump.	
	°	′					°	′	″	′	″
1	2	30	1319	1515	1403	0.0312	2	33	06	3	06
2	2	30	1335	1570	1462	0.0321	2	36	00	8	00
1	2	30	1345	1590	1481	0.0321	2	38	00	8	00
2	2	30	1416	1716	1617	0.0321	2	38	00	8	00
1	3	15	1372	1987	1905	0.0414	3	21	55	8	55
3	3	15	1400	2072	1990	0.0419	3	26	19	11	19
1	3	15	1423	2118	2036	0.0419	3	26	19	11	19
3	4	15	1327	2380	2293	0.0550	4	31	27	16	27
1	4	15	1344	2463	2375	0.0562	4	37	25	22	25
1	4	15	1377	2508	2420	0.0550	4	31	27	16	27
1	5	20	1327	2850	2794	0.0700	5	46	23	26	23
1	5	20	1336	2965	2868	0.0713	5	52	55	32	55
1	5	20	1340	2940	2863	0.0707	5	49	50	29	50
1	5	20	1343	2862	2806	0.0687	5	39	53	19	53
1	6	00	1324	3175	3101	0.0792	6	32	40	32	40
2	6	00	1336	3187	3119	0.0792	6	32	40	32	40
1	6	00	1345	3185	3111	0.0782	6	27	36	27	36

NOTE. Range reduced to $\frac{\delta_1}{\delta} = 1$, to plane of trunnions; to zero wind; and to 183-℔. shot.

Throwing out the first and fourteenth record as manifestly abnormal, we have:

Mean jump for 2° 30′ = 8′ 00″
" " " 3° 15′ = 11′ 00″
" " " 4° 15′ = 17′ 20″
" " " 5° 20′ = 29′ 30″
" " " 6° 00′ = 31′ 24″

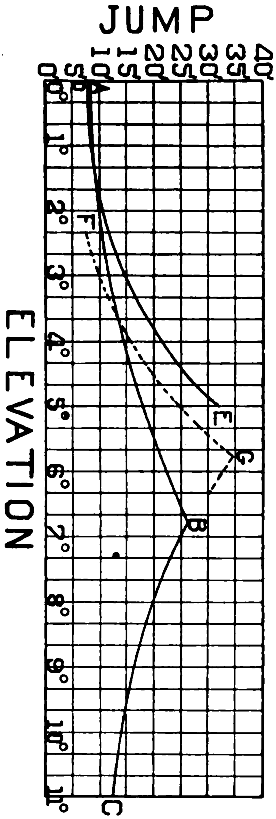
The character of the curve is shown in the plate. The first point which attracts our attention is the fact that the trend of the curve is similar to that of Captain Ingalls; as both were determined from guns at Fort Monroe, it would be interesting to know what gun and carriage was used by Captain Ingalls in his experiment.*

The curve *A B C* was determined for gun No. 26, twist of rifling one turn in sixty calibers. Mounted on a No. 3 carriage. Temporary wooden plattorm. The two peculiarities of this carriage, which could possibly affect the jump, are the following:

First.—The gun recoils up an inclined plane on the chassis; thus the axis of the bore is changed during recoil.

Second.—The chassis is provided with rollers resting on the pintle plate instead of truck wheels.

The ballistic firing at Fort Monroe was done with gun No. 69, rifling one turn in forty-five calibers.



It will be noted that in the curve deduced from this firing, that the cusp occurs somewhere between 5° and 6° elevation. An examination of the trend of Captain Ingalls's curve already shows that it is also approaching a maximum, otherwise the jump would become infinite at about 15° elevation. Judging by the eye I should say the cusp in Captain Ingalls's curve would occur somewhere between 5° and 6° elevation also.

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* The gun used by Captain Ingalls in his experiments is No. 44, carriage and platform similar to those used in the ballistic firing at Fort Monroe in 1892. The platforms are made of wood and are now in a state of decay. That used by Captain Ingalls appears to be in better condition than the other, and when the experiments were made it was comparatively new. In the ballistic firing at Fort Monroe the platform was considerably damaged and is now almost unserviceable.—Editor *Journal.*

What do we Learn from the above Record?

First.—For the 8-inch M. L. rifle, for the same angle of elevation, the jump is constant for all ordinary muzzle velocities. This idea of jump being to a certain extent independent of muzzle velocity, is not at all new. Under the idea that jump was a constant for all elevations for a particular carriage, experiments have been made to ascertain the jump for certain guns and carriages; usually by firing at a screen, as in Captain Ingalls's experiment; except that only one elevation was used. In many cases the jump has been found to be constant for very considerable differences in muzzle velocity. In *Journal of the Military Service Institution*, March, 1893, page 350, Lieutenant Ludlow gives the jump for various naval guns. In this list it is manifest that the jump is looked upon as a constant for all elevations. For the 10-inch B. L. rifle the jump is given at 6′ 42″ for 1700 f. s. and 2000 f. s., for the 12-inch it is 7′ 18″ for similar velocities. In fact, for guns mounted on ordinary chassis carriages the jump appears to be independent of muzzle velocity.

Second.—The jump appears to be fairly uniform for the lower elevations, and becomes more and more variable as we approach the elevation corresponding to maximum jump.

In my experiments at Fort Wadsworth I found similar conditions for both branches of the jump curve. The nearer I approached in my firing to the elevation corresponding to the maximum jump, the more uncertain was the result obtained. More uniform results were obtained from both lower and higher angles of elevation.

Important consideration. Orders prescribe 3000 yards as the target range for the 8-inch M. L. rifle. The elevation for 3000 yards will lie between 5° and 7° for all conditions of atmosphere, and for ordinary height of gun above level of target. The ordinary conditions of practice will, therefore, coincide with the conditions of *maximum jump*, and also of *maximum variation of jump.*

We may, therefore, say that the prescribed range for target practice is probably the most inaccurate range for the gun.

Now this inaccuracy, this variation in jump, is undoubtedly due entirely to mechanical causes, and is within our control. So much the more credit then to the officer who succeeds in doing efficient work.

I would suggest, until we know something more about it, that *twenty-five minutes* be used as the jump for a range of 3000 yards with the 8-inch M. L. rifle. That the greatest care be taken in all matters of detail as to carriage and gun, so as to insure uniform conditions of firing, for each shot.

Principle of Reduced Velocities.

It is important to determine how much reliance can be placed upon the practical value of this principle. In the ballistic firing at Fort Monroe the density of loading was purposely varied; as the principle of reduced velocity only applies when the conditions are maintained constant, we can only compare shots which had approximately the same muzzle velocity.

The first shot fired had an elevation of 2° 30′, muzzle velocity of 1346 ft. sec., actual range 1590 yards. Ignoring all allowances we enter Graphic Table No. 1 with elevation $=$ 2° 30′ and range 1590 yards. We ascertain that the reduced velocity for the day would be 1440 ft. sec. As the atmospheric conditions did not vary much during the entire firing, in fact no more than would ordinarily occur during any summer day, I will consider that the entire firing was done on the same day, *in action*, and that everything was ignored except reduced velocity for the day. This is a very trying condition, as the weight of shot varied from 181 lbs. to 183 lbs. Wind from $+10$ miles per hour to -15 miles per hour. Thermometer from 79° to 88°. Barometer from $30''.09$ to $30''.228$, however, the variation is not more than might occur during battle.

With $V = 1440$ ft. sec., we find from Table No. 1:

$$\left.\begin{array}{l}\text{For } 3^\circ\ 15' \text{ range} = 1980 \text{ yds.}\\ \text{For } 4^\circ\ 15' \text{ range} = 2450 \text{ yds.}\\ \text{For } 5^\circ\ 20' \text{ range} = 2950 \text{ yds.}\\ \text{For } 6^\circ\ 00' \text{ range} = 3200 \text{ yds.}\end{array}\right\}\text{Theoretical ranges.}$$

For 3° 15′ we find but one shot fired with anywhere near 1346 ft. sec. muzzle velocity. The actual range obtained was 1987 yds. Difference 7 yds.

For 4° 15′ we find one shot with about the same muzzle velocity, gave 2463 yds. range—Dif. 13 yds.

For 5° 20′ we find two shots giving 2965 yds. and 2940 yds. range — Dif. 15 yds.

For 6° 00′ we find three shots giving 3175, 3187 and 3185 yds. range — Dif. from 13 to 25 yds.

These results are simply remarkable and demonstrate, beyond question, the great practical value of the principle of *reduced velocity of the day.*

In conclusion I desire to say that the entire object of this paper is to present the following idea.

The fundamental view that seems to pervade all artillery work, is that there exists *an artillery science,* which can and must be learned theoretically. Now I maintain that the science of artillery is now passing through a period of transition, and that *new artillery science* is yet to be developed; and that the great desideratum is the application of artillery science to practical work. The Artillery School, under its present management, has reached a very high state of efficiciency as an *educational institution;* but this is not sufficient, the School must become the center of artillery work. The School must not be satisfied with simply teaching artillery science—the School must *make artillery science.*

Again I maintain that we are wasting time in trying to educate gunners for our old guns. Admitting freely the high state of efficiency to which artillery instruction is being carried on throughout the service, I think the time could be better employed. Instead of teaching men to become gunners, I think our officers could be better employed in *learning gunnery.* In other words, with the class of material now in the service, a good gunner is a man who is familiar with our present guns—that is all that can be expected from the enlisted man. Therefore, when we obtain our new armament, these gunners will have to be taught all over again.

For the study of practical gunnery, however, the old gun is as good as the new. Whoever succeeds in conquering the difficulto be met with now, will have but little trouble with the new guns.

Therefore let us use the present time with the inexpensive and old ammunition in "ballistic firing" for the purpose of learning and in the application of modern scientific methods to practical artillery work, and thus become prepared, so that when we obtain our new armament, we can go intelligently to work to build up efficient service. Not, of course, neglecting in the meantime the instruction of gunners.

I simply desire to take advantage of the work, so well begun by the authorities of the Artillery School, to turn the attention of those in power, to a class of work which has so far been neglected in our service.

I have confined my suggestions to the establishment of a course of instruction in gunnery at the various permanent sea-coast fortifications, as a part of the regular system of instruction, at such stations. I am however of the opinion, that in addition to the splendid work now being done at the Artillery School, there should be added *a School of Gunnery*. Of course, I do not know whether there is time during the two years, for this work; if not, each officer after graduation, at the School, should be required to serve for at least one year at a school of practical gunnery. The opinion as expressed to me by Lieutenant Greble, after a year's service at the United States Proving Ground at Sandy Hook, together with my own experience at that station, has convinced me of the great value of such work and such experience. A large portion of the work done at Sandy Hook is artillery work, and should be done by the artillery, and in my opinion the Experimental Artillery Gunnery Station should be at or near the Artillery School, so that student officers could have the opportunity to witness the work.

Of course at Sandy Hook only so much artillery work is done, as is absolutely necessary to obtain the data required, for use by the Ordnance Department. A great amount of exceedingly important work, such as properly belongs to ballistic firing they have no time to engage in; and in this class of work has been entirely neglected in our service.

There is ample work for an Experimental Artillery Gunnery Station, without in any way interfering with the ordnance work, including preparation of practical range tables, determination of jump, wind effect, and the various data pertaining to ballistic firing; not to speak of the as yet unknown subject, so far as our own service is concerned, of *tactical firing* and the *defense of a seacoast work.*

FIELD ARTILLERY FIRE.

By First Lieutenant A. D. SCHENCK, Second Artillery, U. S. A.

In order to fully understand the conditions and requirements of field artillery fire it is first necessary to give some consideration to the history of its fire, especially with respect to the initial velocity of the rifle projectile. At the time of the advent of the rifle gun this factor was soon developed to the extent then practicable with wooden carriages, but the velocity was low even for a short and light projectile. It was found that the very imperfect time fuze of the epoch was of little value for the greatly increased ranges readily commanded, and it was regarded as of but little value at any range, and was almost entirely superseded by percussion fuzes; the result being that for man-killing purposes reliance was had upon improved forms of the common percussion shell, so constructed as to give the maximum number of effective fragments, and used against troops by being burst on graze. As the angle of rebound was considerably greater than that of incident or fall, the fragments of the shell were thrown up into the air at too great an angle and in a direction least conducive to effectiveness, and it was impossible to secure good results with any but a flat trajectory; consequently, the range with this kind of fire was quite limited as compared with the ranges readily attainable with the gun.

As the power of musketry fire increased so did the demand for an increased range for the man-killing projectile of the artillery, and every effort was made to increase the velocity, flatten the trajectory, and thereby increase the range of the shell burst on graze without impairing its effectiveness, and improved wheels and steel carriages of extraordinary strength were produced to insure the desired end. But it was found that for even moderate ranges the tendency of the fragments of the shell to fly up into the air at too great an angle; the inequalities and nature of the ground, and many other difficulties, demonstrated that to insure efficiency required extraordinary velocity, flatness of trajectory and accuracy of shooting.

As there was a rigid limit to the weight of the gun, carriage, and projectile, to attain the necessary velocity and flatness of trajectory for the required ranges, ranges readily attainable with the gun, was found to be entirely impracticable, and attention was again turned to the development of shrapnel, and especially of the time fuze necessary to render it effective. The results have been so satisfactory that the shrapnel has entirely superseded the shell burst on graze for man-killing purposes. To such wonderful precision has practice with the time fuze attained that it is claimed as practicable to burst a shell by means of it over a line of troops sheltered behind a parapet, with such accuracy that the shell can be filled with a high explosive whose force overcomes that of the velocity of the shell and scatters fragments in all directions, thus searching out the men behind the cover. But from this very violence of the explosive these fragments are small and their range and effectiveness proportionally so. So far as respects the fuze it is claimed to be all that is necessary, but whether the ranges can be determined with the accuracy necessary for such practice, or the smokeless explosive properly observed, are quite different matters. The time fuze is already more accurate than the gunner, and is all that can reasonably be desired by the artilleryman. But when it is sought to apply shrapnel fire with the high velocity gun with the flat trajectory which had been developed for firing shell burst on graze, practical experience proved that the value of these once desired factors was small when applied to shrapnel fire, and that the conditions necessary for the efficiency of the latter were essentially and altogether different.—*Journal of the Military Service Institution*, March, 1892, pp. 321—330.

With good time fuzes shrapnel was inevitable as the man-killing projectile and the shell burst on graze practically obsolete. But when shrapnel was found not to give the expected results when fired with the high velocities which had been developed and which now had numerous advocates, rather than give up their pet velocity hobby they cried aloud for a special "howitzer" for shrapnel fire. But the howitzer was consigned to museums and scrap-heaps a generation since, and cannot be revived to take again the place of a properly designed field gun, which must be a gun-howitzer, as was the Napoleon gun of smooth-bore days.

Before passing to the particular consideration of the present requirements of, and efficiency of shrapnel fire, it may be well first to consider it with relation to the so-called machine "gun" fire. With regard to this it is only necessary to say that a "gun" in the artillery sense for field artillery purposes must be capable of firing a projectile with a time fuze, and artillerymen do not recognize anything else as "artillery." At the shorter ranges the field gun can quickly determine the range with great accuracy, and can fire two rounds per minute, including proper aiming. The light field gun with a well designed shrapnel of proper weight will thus fire 524 bullets per minute, and the heavy field gun 840, and effectively up to ranges more than three times as great as those attainable with machine guns. It is true that the Hotchkiss pattern can attain a considerable range, but when the range becomes at all extended it is wholly impossible to observe the fall of the homeopathic projectiles and the fire becomes worthless. Such guns can fire effectively about 400 bullets or missiles per minute if no hitch occurs, but have no projectiles that are effective against inanimate objects, and the difficulties of determining the range and of correcting the aim restricts their uses to very short ranges when their fire is at all rapid. The field artillery has found no use for machine guns, and with their modern magazine rifles of great range the infantry appear to be of the same opinion, except for special defensive purposes.

At the present time shrapnel fire alone is considered as necessary for man-killing purposes, the common shell being used for range-finding and for firing at inanimate objects, while the so-called torpedo shell containing a high explosive is considered of doubtful utility. In relation to shrapnel fire Major G. C. Clarke, C. M. G., R. E., in the *Proceedings of the Royal Artillery Institution,* August, 1891, pp. 387—402, states that " * * * into time shrapnel practice then other factors enter—*design* of shell, fuze. and handling—any one of which is of infinitely greater importance than initial velocity or a small superiority in accuracy," and he concludes; "1. High muzzle velocity, even if open to no practical objection, confers no advantage upon field guns. 2. The design of the shell, &c., are of infinitely more importance than small differences in the accuracy of guns."

A properly designed shrapnel shell unquestionably calls for the greatest practicable number of effective bullets which it is possible to make the shell contain, irregular pieces of metal to fill up the shell being from their shape and want of range and penetration in no-wise equal to the bullet; the smallest bursting charge whose smoke it is possible to observe at battle ranges—reliance being had to the rotation of the shell for a proper cone of dispersion, and the axiomatic condition which has always obtained for field artillery that the weight of the projectile must be the greatest possible which will admit of being carried with the battery in sufficient number.

What this latter may be is, therefore, the first matter for determination in connection with a properly designed shrapnel shell. In designing the shell its sectional density must be good, otherwise it is utterly impossible to obtain good results at *battle* ranges, and as the gun must be of value in battle it is needless to say that these ranges are the only ones to be considered. In its day our old 3-inch M. L. rifle was the best and most powerful gun of its kind to be found in any army, and this was due entirely to the excellent sectional density of its projectile. The Absterdam and Eureka shrapnel commonly used weighing 11.5 pounds, the former being much preferred as it contained 58, to 42 bullets contained by the latter, while the device for insuring rotation was equally good. A shrapnel for our present B. L. 3".20 gun of relatively as good sectional density as these for the old gun in use thirty years ago would weigh 14.87 instead of the present 13.5 pounds, while a similar projectile for the 3".60 gun will weigh 25, instead of 20 pounds as at present. Evidently our old officers made a very much better practical application of the requirements of ballistic science than we do, despite the wonderful advances in this direction which have been made since their day. We have retrograded instead of advancing with the advances in the application of ballistic science as all other services have done. One of the many curious facts connected with this gun is that the shrapnel originally designed for it actually weighed 15 pounds, and was, therefore, a slight improvement upon that for the old gun. But for some unknown reason this improvement was discarded and the weight dropped to 13 pounds, and has since been increased to only 13.5, a far poorer projectile than was in use nearly a generation ago, and this in face of the fact that the tendency everywhere and during all of this time has been to increase the length of all projectiles whether great or small, thereby increasing the sectional density, and consequently the ballistic power of the projectile; the result being of course that we have very inferior guns.

The text-book at West Point, *Metcalfe's Ordnance and Gunnery*, chap. 16, p. 7, states that the *spherical* density of the first oblong projectile used in cannon in 1859, was about 2.0; but that recent improvements in guns, powder and projectiles have increased it from about 3.0 in 1880, to about 4.5 in 1887, the muzzle velocity not being correspondingly reduced (this density for our 13.5-pound projectile being 2.62 and for the 3.60—20-pound projectile —3.43). So that as far back as 1887 the proper weight for the projectile for our 3.20 gun was 18.43, and for the 3.60, 26.25 pounds, respectively, *without reduction in velocity* below that obtained in 1880. Since 1887 the spherical density has been increased still further, but we pay no attention to the requirements of ballistic science as taught at the Military Academy, or as applied in every other service; the natural result being, of course, that under existing conditions we have astonishingly poor guns as compared with what they ought to be, or with what they might readily be if we but applied this science as it is taught that we should apply it if good results are to be obtained.

Possibly some change may be made when our conditions of firing have been left so far behind as to become matters for contempt rather than for ridicule.

The French and German shrapnel for light field guns weigh 18.04, and 17.97 pounds, respectively, and as they are the heaviest in use for such guns, a weight of 18 pounds will be satisfactory for our service, moreover, as will presently appear this is about the greatest weight of projectile we can carry with a battery in a satisfactory manner.

The heaviest projectiles for heavy field guns are 26.4 pounds for the Krupp, and 27.5 for the Russian guns. The latter being about the maximum weight of projectile which we can carry in proper numbers, adhering of course in both cases to the proper loads for artillery teams for service in our country. With smokeless powder the weight of charge, &c., will not exceed two, and three pounds, respectively. For our service the maximum permissible loads for artillery teams is for light, 4511, and for heavy field batteries, 5065 pounds, respectively.—*Journal of the United States Artillery*, January, 1893.

Turning now to our present material, we should have:

	Calibers, inches.	
	3.20	3.60
Guns, lbs.	829	1281
Carriage and equipments, lbs. . .	1166	1166
Limber " " " . .	1031	1031
Ammunition, lbs.	685	793
	3711	4271
5 cannoneers, lbs.	800	800
Total load, lbs.	4511	5071
Caisson and equipments (2 chests), lbs.	2369	2369
Ammunition, lbs..	1370	1586
	3739	3955
6 cannoneers, lbs.	960	960
Total load, lbs.	4699	4915
Rounds with battery (9 caissons), no.	816	624
Projectile, lbs.	18	27.5
Bullets in shrapnel, no.	262	420
Initial velocity, f. s.	1400	1350

The weight of the light field caisson is 188 pounds in excess of the allowance, but it is at the same time 216 pounds less in weight than the caisson for the old 12-pdr. light, while the caisson without spare wheel will be twelve pounds within the proper limit. The heavy field gun is six pounds over, while its caisson is 150 within the limit even with a spare wheel.

The number of rounds carried in the limber chest (34) for the light field gun is the same as for the German gun, and is two greater than was carried with our old 12-pdr. light during our late war, and this too despite the fact that the projectile is fifty per cent. heavier than was the old one. If a 180-pound wheel be substituted for the present 200-pound one, which can readily be done, four additional rounds can be carried in each chest, increasing the number of rounds per gun from 136 to 152. But as matters now stand we can carry 816 rounds with the battery, as against 768 for the old 12-pdr. light, 808 with the German horse, and light batteries, and 648 for the new English 12-pdr. horse, and light batteries.

The heavy field gun would carry 26 rounds in the limber as against 32 for the old 12-pdr. heavy; but these 26 projectiles weigh 715, as against 384 pounds for the old gun. If the English artillery are satisfied with 648 projectiles weighing 12.5 pounds each—total 8100 pounds— for their horse, and light field batteries, we can be satisfied with 624 projectiles weighing 27.5 pounds—total 17,160 pounds for a heavy field battery.

It thus appears that with modern projectiles we can carry an ample supply with the batteries to meet modern battle conditions.

In their late war the German artillery was used to a greater extent than has ever before obtained. The highest average number of rounds fired per gun in any battle was 94, at Mars-la-Tour; while this average for nine of their greatest battles was only 45, the maximum average fired per gun in these battles being 137.3. A single battery at Mars-la-Tour fired 320 rounds per gun. As it only carried 154, it had no trouble in obtaining ammunition from other batteries whose opportunities for firing were not so great.

Our present 3.20—13.5—1668 f. s. gun is claimed to be a "high" velocity gun with a flat trajectory. As compared with the Canet 2.95—13.67—1804 f. s., with 20° elevation our gun ranges 6400 yards, the Canet 10,433, while the latter guns insure as flat a trajectory at 5000, as ours does at 3000 yards; the effective range for the Canet gun being about sixty per cent. greater than for our gun, so that there is no favorable comparison with a genuine "high" velocity gun with a flat trajectory for fire with shell burst on graze.

On the other hand the German 3.42—17.97—1407 f. s., gun gives about sixty per cent. more chances for hitting with shrapnel fire, counting bullets alone, while the more favorable conditions of firing with shrapnel will still further increase the efficiency of the German gun.

Pit a battery of our guns against the Canet with shell fire, or against the German with shrapnel, and the chances against us would be more than three to two, and in either case we should be wiped out of existence in short order.

If we are to have a "high" velocity, flat trajectory gun with a 13.5 pound projectile, the caliber must be reduced to less than three inches and the velocity increased to over 1800 f. s. On the other hand if we are to have an effective shrapnel fire gun, the weight of projectile must be increased to about 18 pounds, and the velocity reduced to about 1400 f. s. As matters now stand our gun, for either purpose, bears no reasonable comparison with these modern guns and their conditions of firing.

The ballistic improvement here called for is precisely like the one heretofore demanded and conceded to the infantry in our service. It is well remembered how, a few years since, the Springfield rifle was so mercilessly criticised for its want of ballistic power, and its trajectory compared with that of the Martini-Henry and other rifles to prove that this criticism was just. So persistent was the demand for a better gun that the authorities were forced to take action. The result was that the gun was not changed at all, but the weight of the bullet was changed from 405 to 500 grains, the result being of course a wonderful improvement in the ballistic power of the gun.

A similar change in the weight of our 3.20—13.5-pound projectile to that made years ago for the musket bullet, would increase the weight of our projectile to 16.66 pounds, and improve our gun quite as much as the Springfield rifle was improved. But since that time we have come down to a rifle of cal. 0.30, with relatively a much longer and heavier projectile of greatly improved sectional density, and a far more powerful gun, and the infantryman has increased his volume of fire by increasing his *rate* of fire. We can only increase the volume of our fire by increasing the weight of our projectile and consequently the number of bullets it contains, as the rate of our fire is controlled entirely by the ability to aim correctly, which can be done just as quickly with a heavy, as with a light projectile, this increased weight improving the ballistics of our gun also, though in this case the caliber remains the same.

The German 3.42—17.97-pound shrapnel contains 262 bullets, 34 to the pound; 18 and 27.5-pound shrapnel of equally good designs will contain 262 and 420 bullets of the same size, respectively. The initial velocity for the German gun is 1407 f. s., and 1400 f. s. for the 3.20 gun with an 18-pound projectile of much better sectional density will insure very much better ballistic results, the recoil being about the same in quantity as at present, though the violence of the recoil will be greatly diminished. With 1350 f. s. for the 3.60 gun with a 27.5-pound projectile similar results will obtain. Any one who deems such velocities to be "low" ones can readily disabuse his mind of such an idea by calculating the remaining velocities and energies at battle ranges for the present conditions and compare them with those which will obtain with the above conditions of firing, or by plotting the respective trajectories, when it will be found that the new conditions will insure vastly improved results in every respect, insuring us guns whose mobility and power of fire are not equaled in any service.

The effects of artillery fire before the use of rifle shrapnel to any great extent may be illustrated as follows:

1864, Danes lost	84	per cent. by	musketry fire.
	4	"	saber and bayonet.
	10	"	artillery fire.
	2	"	unknown.
1866, Austrians lost	90	per cent. by	musketry fire.
	4	"	saber and bayonet.
	3	"	artillery fire.
	3	"	unknown.

1870, French lost	70 per cent. by	musketry fire.
	5 "	saber and bayonet.
	25 "	artillery fire.

In all such “statistics” it must be remembered that nearly all small wounds are classed as “gun-shot” wounds, no matter whether made by rifle-balls or by shrapnel or case (cannister) bullets or by small fragments of shell. A man generally has to be split wide open to be put down as killed by artillery fire, and while artillery fire is directed chiefly against artillery with few men to hit, the horses hit are not counted at all, though of quite as much importance to artillery efficiency as are the men. Prince von Hohenlohe has very clearly pointed out that, despite the poor results obtainable with the old shell fire, the astonishing increase in the effectiveness of artillery fire was almost entirely due to the boldness of the tactical principles for the employment of the German artillery, as well as to better training in shooting. Since then the steel shrapnel with an admirable and wonderfully accurate time fuze has come upon the scene as the man-killing projectile, and whose destructive effects as compared with the old forms of shell burst on graze are incomparably greater.

Colonel Brackenbury, R. A. (*Field Works*, pp. 14-17), in relation to the effective uses of artillery fire, and this before the perfection of the shrapnel shell and time fuze, says: “ * * * There has been so much controversy on the comparative effects of infantry and artillery fire, and the statements on either side have generally been so difficult to reconcile, that the results of a trial in France, carried out with the intention of arriving at definite results, can hardly fail to gratify all who seek for truth rather than the support of preconceived opinions. The facts were published in 1880, and are detailed in General Brailmont's *Formations de Combat*, &c., which was published in that year.

“To represent infantry fire there were 100 men of the 95th regiment occupying 110 yards front; for the artillery a battery of six 90-mm. guns (the 3.54 light field gun) occupying an equal front. The duration of fire was the same in every case for each arm, ten to fifteen minutes. In some cases the distance was unknown. In others it was first determined by the artillery and given to the infantry before the firing began. Both sides then fired together. The targets were exactly alike, in each case two rows 157.5 feet long and 4.8 feet high, one row being 164 yards behind the other to represent a shooting line and its supports of infantry. The conditions were rather against the artillery, because no allowance was made for the fact that it sometimes knocked down portions of the target by its shells, and therefore had a smaller target upon which to count hits. The infantry fired sometimes independently, sometimes by volleys from half-sections. The artillery fired projectiles—shell and shrapnel—usually giving 150 fragments per projectile, and on one occasion a form of shrapnel which gave only 100 fragments. The ranges were 800, 1050, 1100, 1200, 1300, 1350, 1600, and 1800 meters.

"Taking as examples the firing at 800, 1300, and 1800 meters, we have:

Arm.	Range, yds.	No. of rounds.	No. of bullets.	No. of hits.
Infantry, ...	875	4500	4500	410
Artillery, ...	875	50	7500	820
Infantry, ...	1421	10417	10417	163
Artillery, ...	1421	68	10200	795
Infantry.	1968	3650	3650	149
Artillery, ...	1968	84	12600	1000

It is at once to be noted that the shrapnel here used was a very poor one as compared with the present steel shrapnel, while the shell could only be used by bursting on graze and when this was done the effect was confined to a single one of the two targets; whereas with present shrapnel practice a shell properly burst will score about as many hits on one as on the other of two targets such as above indicated. Both the shrapnel and shell have since been abandoned, and with the French, artillery shrapnel fire is now a very different matter from what it was in 1880, both as to accuracy of fire, perfection of fuze and number of bullets, contained in the shrapnel shell. While for the infantry, above a range of 800 yards, when any effort is made to maintain aimed fire, little has been gained over the old Chassepot rifle here used, except to increase the number of rounds carried by the soldier.

The German 3.42—17.97-pound shrapnel contains 262 bullets, 34 to the pound, or 45 per cent. of the total weight in bullets.

For 18 and 27.5-pound shrapnel of equally good design there would be 262 and 426 bullets of the same size, respectively. The 18.04-pound shrapnel for the French 3.54 light field gun used in this trial gave 150 fragments and bullets, the shell only 100, but to be on the safe side suppose all to give 150. The modern shrapnel as indicated will give 61, and 180 per cent. more effective missiles than for the French projectiles. The accuracy of the French infantry rifle is not much exceeded by any modern rifle, though the trajectory has been much flattened, and the number of rounds that can be fired at short ranges has been doubled; this, however, does not apply to ranges beyond or even up to 875 yards. Not only has the number of missiles for the artillery been doubled, but this has been done for the same rate of aimed and accurate fire; the direction of the bullets with respect to the target has been changed from the most unfavorable to the most favorable direction; while the accuracy of the time fuze has been perfected to an astonishing degree. So that on the whole, the improvement in the volume of fire at any except the very shortest ranges, where the artillery will not be called upon to compete except from positions on the flanks, is decidedly in favor of the artillery. Furthermore, the accuracy in practice for the latter when firing at even extreme ranges shows very little falling off as compared with infantry fire, and continues to be effective up to 5000 or more yards. But suppose that the present shrapnel fire and fuze are no more accurate than for the old shrapnel and shell burst on graze, and improved only by the increased chances for hitting due to the greater number of missiles contained by the modern steel shell, we should now have:

3".20 LIGHT FIELD GUN, 18 POUNDS—1400 F. S.

Arm.	Range, yds.	No. of rounds.	No. of bullets.	No. of hits.
Infantry, ...	875	4500	4500	410
Artillery, ...	875	50	13600	1487
Infantry, ...	1421	10417	10417	163
Artillery, ...	1421	68	18496	1442
Infantry, ...	1968	3650	3650	149
Artillery, ...	1968	84	22848	1813

3.60 HEAVY FIELD GUN, 27. POUNDS—1350 F. S.

Arm.	Range, yds.	No. of rounds.	No. of bullets.	No. of hits.
Infantry, ...	875	4500	4500	410
Artillery, ...	875	50	21000	2300
Infantry, ...	1421	10417	10417	163
Artillery, ...	1421	68	28560	2226
Infantry, ...	1968	3650	3650	149
Artillery, ...	1968	84	35280	2800

Thus in equal times the results of the fire of the light field battery will be at 875 yards 2.6 times, at 1421 yards 7.8, and at 1968 yards 8.6 times as great as those for the infantry fire, and for the heavy field gun 5.6, 13.6 and 18.8 times as great, respectively, as the results of infantry fire, while the practicable range within which the effects of shrapnel fire does not materially fall off is more than thrice as great as that for infantry without regard to its want of accuracy.

The artillery cannot get closer than about 800 yards until the infantry take a hand in the game, and then it advances with the latter to make good what it secures, or to cover its retirement if it cannot score its point. On the purely defensive the power of the magazine rifle may much more nearly equal that of the artillery. But armies that choose to fight defensive battles will generally lose them.

Taking into consideration the whole of the results of the French trials, the following are the conclusions: 1. Starting from 875 yards and up to the extreme practicable range for infantry, the killing effect of the light battery would be equal to that of from 260 to 860 infantry rifles, and for the heavy field battery equal to from 560 to 1880 rifles, while the effect of artillery fire continues with little dimunition up to more than twice this range. 2. It appears from the experiments at Bourges that infantry cannot deliver a very rapid fire for more than five minutes, either because the men may become fatigued, or because of the heating of the gun-barrels.

In the above trials the slowest rate of fire by the artillery was one shot in 1.2 minutes, the most rapid one shot in 44 seconds. Aimed fire under such conditions can readily be maintained at the rate of one shot in 30 seconds from each gun.

To a division of infantry numbering 9600 muskets with 150 rounds carried on the person of the soldier, there would be 1,340,000 rounds, or 2,680,000 for an army corps of two divisions. To this corps there would be attached normally (not counting horse artillery) four light field batteries to each division and eight heavy field batteries as the corps artillery; the former carrying 816, and the latter 624 rounds per battery. Ninety per cent. of the former and eighty per cent. of the latter being shrapnel, would give 3,275,000 shrapnel missiles carried with the batteries. But the comparative results of the practice heretofore given show that on an average the effect of one light field shrapnel is equal to 575 rifle bullets, and the heavy field 900. If ten minutes be allowed as each firing period each infantry soldier fired six rounds per minute, which is certainly pretty rapid firing for ranges of from 875 to 1968 yards, while the artillery gun fired a round once in a little less than a minute, which is not remarkable.

It thus appears that, if the total time be considered which would be required for the infantry and artillery to fire this supply of ammunition, viz: twenty-five minutes for the infantry, two hours for the light and one and one-half hours for the heavy battery—supposing continuous firing possible—a light field battery would in two hours equal the killing power of 3024 infantry rifles in twenty-five minutes; the heavy battery in one and one-half hours 3216 infantry rifles in twenty-five minutes. Reduced to the same time, supposing that the infantry soldier can fire 150 aimed shots in twenty-five minutes at known distances and that the gunner can fire one aimed round per minute for the same time, the fire of the light battery will equal that of 605 rifles, and that of the heavy battery 893, and this takes no account of the 80 common shell carried by each light, and 124 carried by each heavy field battery of an army corps. Furthermore, while with a range of 2000 yards the infantry rifle will cover a semicircle whose area is 6281 sq. yds., the artilleryman's shrapnel with a range of 5500 yards will cover an area 7.5 times as great.

While the infantry may claim to be the "backbone" of an army, the above illustrates very clearly why modern artillery has become the backbone of the line of battle in action. When the infantry has fired for twenty-five minutes the last round has been expended and if no more be immediately forthcoming, it becomes useless for further fighting purposes. Not so for the artilleryman, however, for although he has during the same time with a light battery been the equal of 605 infantry, he has at the end of this time expended only one-fifth of his shrapnel, and for the heavy battery equal to 893 infantry a little over one-fourth. The former is capable of repeating such a storm of fire four, and the latter three times, or each can begin and keep up the battle at three times the range attainable by the infantry, and still have an ample supply of ammunition when the enemy comes to close quarters. The gunner cannot shoulder his gun and run away with it at pleasure, it has no nerves nor is it held in the hands of the man who fires it, nor is it fired in a hurry. Consequently, though deductions from target practice be never so wide of the mark as applied to battle conditions, these conditions are all such that these deductions as applied to artillery practice will be very much nearer the truth than will those of the infantry. That the increased powers of artillery fire are not the mere deductions of the theorist or the target crank, is evinced by the records of recent wars, and by comparison of the projectiles of the present and of the past, as well as by the records of the target ground. The Germans have not increased the normal strength of the field artillery with an army corps of 24000 muskets from fourteen batteries in 1864, to twenty batteries in 1893, or 4.6 guns per 1000 muskets and sabers, without urgent reasons, the infantry strength remaining the same.* Such an increase has involved a tremendous cost but is worth the money.

If we are ever to receive properly designed shrapnel for our guns, and in sufficient number to admit of reasonable training for our gunners, when the infantry get their new magazine rifles we can invite them to participate in just such a shooting match as the one here discussed, and without fear that the results obtained will fall below those above deduced for a properly designed modern shrapnel. If, however, we are to be confined to

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* The number of field guns per thousand of infantry muskets is a fraction over five. For poorly trained troops, as our volunteers, this proportion should be considerably greater.

the present homeopathic projectiles of ridiculously poor sectional density and ballistic powers and containing few bullets, it will be best for the artillery to defer such a match indefinitely.

Foreign artillerists have been practicing with very good modern shrapnel and time fuzes for ten years or more, while our artillerymen have not yet even seen, much less fired one.

FIRE-MANOEUVRES OF ARTILLERY MASSES, AND THE INSTRUCTION TO BE DRAWN THEREFROM.

Revue d'Artillerie for November, 1892. By Lieutenant-Colonel COHADON Second Regiment of French Artillery. (Officially designated to attend the artillery mass manœuvres at Chalons, in August, 1892.)

Translated by First Lieutenant CHARLES W. FOSTER, Third Artillery, U. S. A.

[CONCLUDED.]

Regulation of, and Mode of Conducting, the Firing.—The former was left entirely to the discretion of the battery commander. There was, properly speaking, no group fire. The group commander ought no longer to meddle with the regulation of the fire; his rôle, so far as relates to the fire, is limited to the designation of the objectives, to the indication of the initial range, and to orders upon the opening and conduct of the firing. In consequence, the *batterie-guide** was never made use of.

The regulation of the fire when several batteries fire simultaneously is impossible if each has not a distinct objective. This is one of the reasons for assigning to each battery a particular portion of the enemy's line; but the principal reason for the establishment of the rule to this effect is the necessity of leaving no hostile battery exempt from fire, and, in consequence, free to act without being itself disturbed.

When the batteries fired with C_1 powder, the regulation of the fire of those to leeward was a very long process; and batteries so situated were seen still endeavoring to find their brackets up to the time when the firing should have ceased. The intervention

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* The battery occupying the most favorable position for the observation of shots.—Tr.

of the group commander would perhaps have been beneficial in such a case.

With smokeless powder, however, this inconvenience is not presented.

On account of the difficulties attending the regulation of the fire, as prescribed in the Manual in force, and on account of its slowness, it has been recommended that the progressive fire be resorted to,—a method much more easy, and one that gives desired results much more rapidly. It is true, however, that it involves a much greater expenditure of ammunition than the regular fire.

At the beginning of the action, the fire was generally directed against the hostile guns, and exceptions to this rule were very rare.

The group commander having, as we have seen, the conduct of the fire among his functions, should not, in the orders which he gives on this subject, lose sight of the following considerations:

With a regular fire or a suitable progressive fire, a battery is entirely sufficient to cover a portion of the hostile line equal to its own front. But it is well to provide for the case where the enemy is met in superior force. It seems advisable, under such circumstances, for a portion of the batteries to fire upon the entire hostile front, and for the others to concentrate their fire upon the various parts of that front successively, in a manner to produce prompt destruction. These concentrations of fire, these squalls as they have been figuratively called, necessarily involve an enormous expenditure of ammunition, and the attention of the major should be especially directed to the measures to be taken to insure the constant re-supply of his batteries.

The major is, in fact, charged with the duty of keeping up the supply of ammunition in his group; and this further justifies the proposal previously made, to substitute for the three battery combat-trains, one train for the group, to be entirely in the hands of the major.

The changes in the objectives are likewise ordered by the major, save in exceptional and urgent cases. These changes were often very tardily made, partly on account of the time necessary for re-laying the guns. I did not see put in practice the method of laying by the gunners alone, a method indicated in the Instructions upon the training of gunners, and which is susceptible of good results.

Again, it is the major who orders a cessation of the firing; and here I make an observation which may perhaps be of importance. At the moment when the order to cease firing is given, there are always at least two pieces loaded with time shell, and if the firing is stopped in order to move to a position where the range will be shorter, which is the general case, the pieces should remain loaded, and will thus be of use in the new position in determination of the range. But in case the change in the battery's position is accompanied by an increased range, all the pieces should be fired before the movement begins.

Abandonment of the First Combat Position.—The major prescribes changes of position in accordance with the orders of the commander of the divisional or corps artillery.

These movements should be executed with the greatest discretion and coolness.

Here is the advice I think it useful to give on this subject:

In order that the adversary may not suspect the intended change in the battery's position, the movement of limbering to the front should almost always be avoided. If a marked superiority over the enemy has not been gained, if the ground lends itself thereto, and if there is no urgency for the battery to move instantly to the front, the best plan is to limber to the rear, retire down the slope on which the guns are situated, following the folds of the ground, and gain the new position without exposing the movement to the enemy. The battery will execute the movement in column of sections or of platoons.

If, on the contrary, this movement is not possible out of view of the enemy, or if for any reason it is found advisable to get into the new position at once, the crest must be crossed, and then limbering to the front becomes a necessity; but the inconveniences attending it should, as much as possible, be avoided, and to this end the pieces should be run by hand to the rear or be allowed to recoil freely, so that the movements of the limbers may be completely concealed. The battery then being in line with open intervals, moves forward at as rapid a gait as the terrain will permit, continuing thus until sheltered ground is reached or the new position gained.

The combat train having observed the manœuvre of the group or been apprised of it in advance, conforms to its movement, following the group in similar formations and at like gaits.

Marches Forward or in Retreat on the Battle-field.—The marches of batteries on the field of battle, in order to gain another position either to the front or rear, should, as much as possible, be concealed from the adversary's view, and be executed at a rapid pace, with exception, however, of the march in retreat, which should be begun at a walk, so that order may be maintained and that the moral effect of the movement upon the neigboring troops may not be too great. In this case, the trot will be taken by the batteries only after the infantry lines engaged in their immediate vicinity have been passed.

The formations to employ in these marches depend essentially on the form and nature of the ground to be traversed and on how much is to be feared from the enemy's fire.

It is advisable to avoid deep and compact formations when it is a question of moving over ground swept by the adversary, and especially to avoid long columns under such circumstances, if a flank is to be exposed during the march. If the ground is not cut up, or if it is muddy, marches in line with open or closed intervals, are recommended. If, on the contrary, it contains many obstacles, the column of sections or platoons for the battery, and for the group, the line of columns with open or closed intervals and the mass formation, are preferable.

It is indispensable to explore the ground for some yards in advance of the heads of column, in order to discover obstacles betimes and to indcate the manner of turning or crossing them. For this, I propose the utilization of the chiefs of platoon at the head of the column, who instead of holding themselves abreast of the lead drivers of the pieces, should march five or six yards in advance, This, in most cases, will suffice to avoid accidents which might lead to serious consequences.

The combat trains conform to the movements of the group, while retaining their distances and remaining united. It should not be forgotten that they are to move in front of the batteries or upon a flank, in case of marches in retreat.

The direction of the march is given by the *agent de liaison* accompanying the commander of the divisional or corps artillery, who has reconnoitered the new positions to be occupied and the road to be followed in reaching them.

Upon arriving near these positions, it is well to calm the troops, restore order, and see to it that they approach the new ground with regularity and coolness. The officers and non-commissioned officers all put forth efforts to this end. In no other way can the rapid opening of fire be so well assured. This recommendation is so much the more imperative as the bound to the front has been the greater, the pace the more rapid, and the ground marched over the more difficult.

During the movements we are considering, a double manœuvre was executed in which the batteries of one part had to cross the Suippe, a small stream ten or twelve yards wide. A bridge-equipage detachment sent in advance had thrown across two double-bay trestle bridges. This manœuvre suggested to several officers the idea of providing artillery groups with *matériel* which would permit this operation on the battle-field. One wagon would be sufficient for the transport of this *matériel*, which, when the proper occasion arose, would be of great service. But where place it? Evidently in the combat trains, which alone are near enough to the batteries to enable this *matériel* to arrive in time.

Reconnaissance of the Second Combat Positions.—It is necessary to understand by second combat positions all the positions occupied after the first, up to that where the artillery duel is finally decided. Accordingly, a battery may take up two or three second combat positions. The reason for the definition given is that what may be said of one of these positions is applicable to all.

As a rule, the batteries do not take up a position of waiting before occupying the second combat position; and from this it follows that reconnaissances should be made during the march of the batteries. The major leaves his group, and repairs to the place where the commander of the artillery awaits him. This he does at the full speed of his horse, as soon as the batteries have begun their march. The most interesting points to be studied by him are the position and nature of the principal objectives; their distances, with all possible exactness (for here one cannot count upon a methodic regulation of the fire, and, moreover, the fire ought to be, so to speak, immediately efficacious); the extent of front to be occupied by the batteries of the group; and the dangerous dead angles in front and upon the flanks, in order that the necessary protection may be asked for from the neighboring troops as soon as possible. The essential characteristic of this reconnaissance is rapidity.

The battery commanders themselves precede their batteries whenever possible, gain the designated position, receive from the group commander the necessary directions for coming into battery and opening fire, and make such dispositions as they judge most favorable for bringing their guns into place with absolute accuracy. It cannot be too strongly insisted on that an attitude of calmness and coolness in a battery, beyond the moral ascendency thereby given, is a guarantee of the rapidity and efficacy of its fire.

All these reconnaissances are then terminated before the arrival of the batteries, and should not be permitted to retard their entrance into action.

Occupation of the Second Positions.—The selection of the second combat positions will be especially controlled by the events of the action, which dominate topographical considerations. It will not always be possible to take full advantage of cover and the form of the *terrain*. Restricted by this observation, the general directions given on the subject of the occupation of the first positions will serve as rules in the present case.

It should be well borne in mind that, at least in general, the advantage of surprise can no longer be counted on. The adversary will be sufficiently acquainted with the *terrain* to know very nearly, according to the turn of the combat, the point the batteries will occupy to re-open fire. Ruses are here out of the question. Vigor and audacity are the requisites. Above all, then, it is necessary to be so placed as to see well, and to be able to strike the adversary with energy.

The batteries arrive in good order on the new position. Here the captain will have taken care to place a mounted man to mark its center.

I consider it advisable, also, that the lieutenants precede their platoons, and, if the *morale* of the troops and other circumstances permit, that the chiefs of section likewise move forward in advance at a trot to mark the line, and assure accuracy in coming into battery.

The Fire and Manner of Conducting It.—What has already been said on the subject of fire is applicable here. However, I do not believe that a methodic regulation of the fire can be counted on. One must be content with improving upon the first-used range by the result of shots observed by chance. If the captain has not sufficient confidence in the original range given him, and if he is not able to judge satisfactorily of his shooting, he should adopt the progressive fire.

This is the second combat position, and it is understood that this expression signifies the last position taken up by a battery in order to terminate the artillery duel, and that the assault is to be prepared by the fire of concentration. The latter subject, it is proper to develop somewhat.

Fire of Concentration.—The fire of concentration by artillery should always prepare for the decisive act of the conflict,—the assault by the infantry for the seizure of the point of attack.

This concentration of fire cannot then be an unexpected event. The commander-in-chief has foreseen in his plan of attack or has determined during the first stages of the combat, the point of the defensive line against which his efforts must be directed. Here, in my opinion, is the way this fire should be prepared, directed, and executed.

The general commanding, having fixed upon the point of attack, at once indicates it to the chief of artillery. The latter informs his subordinates in order that while continuing the combat, they may make all dispositions with a view to changing as suddenly as possible from the ordinary fire to the fire of concentration and to giving the latter its maximum effect.

The fire of concentration can be undertaken only at the end of the artillery duel, when the batteries of the defense have been so weakened that the attacking artillery may neglect them.

The artillery of the attack generally receives upon its second positions the orders relative to the fire of concentration, and it is from these positions that this fire is to be executed.

The distance to the objective will be so limited (about 1500 metres), and the combat fronts so reduced, as to render any change in the positions of the batteries not only useless but dangerous.

In order that the fire of concentration may have its full value, it is essential that it be sudden and that its effects be overpowering, so as to deny the enemy time to modify the disposition of his troops, increase the energy of his defense, and prepare a counter-offensive stroke. With this result in view, it is advisable to avoid all changes of position among the batteries, and to have delivered, as soon as possible, the necessary orders to the battery groups that are to take part in the fire of concentration.

Let us examine the case of an army corps employing the artillery of its two divisions and the corps artillery.

Whether this corps acts alone or engages in conjunction with other forces either on an intermediate portion of the line of battle or upon a flank, if it is to assault a *point d'appui* of the hostile line, its commander will at the outset fix upon the minimum amount of artillery necessary for the protection of his flanks, and the general surveillance of the battle-field, and will designate the groups to be employed on this service. All the other groups will be employed in the preparation of the attack. If the direction taken by the corps has been favorable, as regards the point of attack, if the front has not been unduly developed, and if the battery sites of the second position have been judiciously selected, nearly all the batteries will be able to participate, without too much difficulty, in the fire of concentration. Now this concentration of fire being the decisive act in the rôle of the artillery in battle, it is indispensable to have it in mind from the outset of the action, and the principal duty of the commander of the artillery will be to constantly direct his batteries so as to assure their participation in the fire of concentration, while at the same time seeing that they are able at each step in the conflict to produce effects commensurate with their strength.

If the artillery of the corps is judged insufficient for the preparation of the attack, the corps commander requests additional batteries of the commanding general. The latter accords them, and they are designated as circumstances dictate. With this in view, it would perhaps be advantageous to place in the hands of the army commander a special artillery reserve. But no matter whence the batteries may come, they should be warned betimes, so as to arrive in position and begin the fire of concentration simultaneously with those of the corps. Their movement should be concealed from the view of the enemy, and places ought to be reserved for them on the artillery line, the corps batteries, perhaps, with this in view, reducing the intervals between their pieces. The reinforcing batteries may also be installed upon a line in rear, if the character of the ground is such as to permit a double tier of fire. In no case, however, should they bring their pieces into battery between those of the batteries already in position.

The consequences of the fire of concentration are important enough to draw to its beginning and development the entire attention of the commanding general. It will be directed by the chief of corps artillery, who should previously take all precautions to assure a sudden and powerful opening of fire and the means of sustaining its intensity.

The chief of corps artillery will hold himself near that group from the vicinity of which he will be able the most readily to give the signal to commence firing, watch the effects of the shots, and break off the firing. All the group commanders having been already notified, and moreover foreseeing the approach of the decisive moment, from the turn taken by the conflict, hold themselves in readiness to respond instantly to the proper signal.

Whatever may be this signal, which will be decided upon in advance by the general commanding the artillery, the groups charged with the fire of concentration, will execute this fire by battery salvos. There are two advantages in this: First, the effect of a salvo is generally apparent, and observation of this effect will give means for correcting the elevation, should such be necessary; secondly, salvos against material obstacles to be overthrown, will be more destructively effective than a succession of single shots.

The fire of concentration should be begun with percussion shell, not for its regulation but its rectification. The first three salvos of each group will, in general, suffice to insure proper effectiveness in the fire. If the point of attack is not covered by obstacles such as walls, houses, or parapets, the batteries will pass to the time shell after the second salvo. If, on the contrary, there are on this point, obstacles or shelter to be broken up, it will be necessary to continue the use of the percussion shell. The fire will be kept up thus until the complete attainment of the result sought. This is the precise moment for the infantry to be launched forward to the assault; and after this movement has begun, all the batteries taking part in the fire of concentration should cease firing, or give increased elevation to their pieces, so as to reach the hostile troops which may come up to attempt a counter-offensive.

To sum up, the fire of concentration should be prepared for as soon as the point of attack is decided on. All the artillery commanders down to captains of batteries should be notified in the matter as soon as possible, in order that they may make all suitable dispositions. It will take place on the second combat position, after the termination of the artillery duel, and be shared in by all the batteries of the corps that have not been specially assigned to other duties. It will be directed by the general commanding the artillery. It will be executed by battery salvos. Percussion shell will at first be used, so as to permit corrections in elevation by observation of firing results; afterwards, time or percussion shell will be employed according to the nature of the objective. The fire will cease, or be continued with sights at a higher elevation, as soon as the infantry moves out to the assault.

The fire of concentration was several times executed at the camp at Chalons on principles very similar to these. Following is the order given for this fire at the mass manœuvres in question:

"The commanders of divisional and corps artillery are informed in advance of the designation of the groups of batteries which are to take part in the fire of concentration upon the decisive objective of attack.

"They receive precise information respecting the point upon which the attack is to be made, and are advised betimes of the probable hour of its execution. This hour coincides, moreover, with the arrival of the infantry upon the position from which it opens the violent fire that precedes the assault.

"They fix the limits of the front to be fired at, and, if necessary, divide it among the groups under their orders. They immediately communicate to the commanders of these groups all information they deem necessary for the guidance of these officers.

"The group commanders estimate the distance to be used as the initial range by the different batteries (the result of observations made during the course of the combat with respect to the salient features of the ground, position of infantry lines, etc.), and, in case of need, determine the elevation to employ by the use of a few percussion shells, being sure that it is not too low. They fix, from the indications thus obtained and from the nature of the hostile position, the depth of the zone upon which the progressive fire is to be executed.

"They determine the possibility of directing the fire upon the new objective from the sites occupied by the batteries, and, if need be, cause slight modifications in the position of the latter.

"The battery commanders inform their chiefs of platoon in advance as to the precise point on which they are to fire (a single point for the entire battery), and the latter instruct their gunners accordingly.

"At the hour fixed, upon the order of the officer commanding the forces, the commander of the artillery group the most immediately supporting the movements of the infantry charged with the attack, causes to be fired successively but rapidly, upon the point designated, three battery salvos with the percussion shell, which serve as a signal for the commencement of the fire of concentration. The group will continue the fire with the same kind of projectile."

The firing executed in conformity with this order gave, in general, good results. However, some confusion was observed from the fact that the salvo firing of other batteries was confounded with the three salvos indicated in the order, and was taken for the signal to open the fire of concentration.

Batteries Accompanying the Infantry.—The Instructions of May 1, 1887 (Articles 36 and 37), indicate that divisional batteries and even corps batteries will accompany the infantry, marching either between the regiments of the attacking brigade or on the outer flank of this brigade. The commander of the forces himself fixes the moment when these batteries are to commence their movement, and directs the commander of the artillery to make the necessary dispositions in this regard.

It was not possible, in the camp at Chalons, to simulate this operation; but I am of the opinion that only very rarely will circumstances permit its being carried out, and that it will never produce the results expected of it.

The musketry fire at short range over the ground where artillery must move in accompanying the supports of the infantry is so destructive in its effects that the batteries run great risk of being overwhelmed before they are able to fire a single shot. Nevertheless, if this sacrifice is necessary to success, the artillery will not hesitate, and it will know how to do its duty.

But at the Chalons camp there was prescribed and executed a manœuvre (aimed at, moreover, in the next to the last paragraph of Article 36) which is capable of producing great results. A group of horse batteries placed on one of the flanks was sent forward at all speed to the position conquered by the infantry, its movement being so timed as to insure its arrival upon the position simultaneously with the latter. This manœuvre is fully justified, because the artillery reaches the zone most exposed to infantry fire only after this fire has lost much of its intensity, and because, thanks to their speed, the horse batteries arrive in season to strengthen the hold of the infantry on the position, and to oppose themselves to any counter-offensive strokes that may be attempted.

Replenishment of Ammunition.—Very interesting practice was had in re-supplying the combat trains by the ammunition sections.

The batteries occupying a combat position, the ammunition sections took post in accordance with the Instructions of May 1, 1887, and were put into connection with the groups of batteries whose ammunition was to be replenished, by means of an *agent de liaison.*

As soon as three caissons of the combat train of a mounted battery group were emptied, and in case of a group of horse batteries, two caissons, the *agent de liaison* went to the ammunition section for the same number of full caissons, and had them conducted to the trains, each of them being placed beside an empty caisson. The ammunition was transferred, and the empty caissons sent to the ammunition section.

Two or three minutes sufficed to transfer the ammunition of a mounted battery caisson when the cartridges and shells were left in their cases; but about ten minutes were required when it was necessary to remove the shells from the cases. There is hence an advantage in leaving the shells in the cases; and that this may be done, it is essential that the batteries specify clearly to the commander of the section, the model of the caissons to be sent them.

During the transfer of ammunition, the small package of friction-primers should not be forgotten; and to avoid mischance in this particular, I propose that in each cartridge-case a small pocket be constructed to hold a package of primers. This modification, insignificant in itself, will be the sure means of avoiding forgetfulness, the effects of which may prove incalculably injurious.

THE IMPORTANCE OF SMOKELESS POWDER IN WAR.*

By General BAUMGARTEN, Russian Artillery.

Traduit du russe et résumé par le capitaine d'artillerie A. OLLIVIER.

Translated from the *Revue d'Artillerie* by First Lieutenant HENRY C. DAVIS, Third Artillery, U. S. A.

The question of smokeless powder is the order of the day. It is certainly interesting to investigate its influence on the art of war. Experience fails to determine it; it can be evaluated only by the law of probabilities.

Already the new powder has evoked a special literature, and opinions, the most diverse, have been put forward. Some declare that it will have no influence on tactics, others, that it will reduce tactics to a single principle: *to see and not to be seen.* According to the latter, the center of gravity of the struggle is removed from the side of the defense; that cavalry has sung the song of the swan and will disappear from the ranks of armies.

It is our opinion that smokeless powder modifies the conditions of application of tactical principles, without modifying the principles themselves. Some of these principles increase in importance, as that of seeing without being seen, but, in fact, tactics cannot change since it is composed of two principal factors: man and chance.

Tactics imposes principles and application adapts these principles to the circumstances. If we consider artillery for example, its ideal tactics has always demanded the employment of masses. The adoption of rifle cannon has allowed a partial realization of, and the use of smokeless powder, by suppressing smoke, the

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* This translation presents that portion of the original article that bears specially on artillery questions and which was omitted in a translation recently published.—Tr.

principal hindrance to massing, permits a still closer approach to the ideal.

We shall assume in this discussion the absence of smoke and noise (?) and pass by the changes in ballistic qualities, noting that, beyond a certain point, these changes are ot no importance, as effective fire is limited in range by our powers of sight and observation..

(The author states that the dimunition in noise is not so great as is sometimes supposed; that the clearing of the atmosphere increases the efficacy of the fire; that smoke will no longer afford a target for the enemy or a screen for secret movements; that the course of the battle will no longer be clearly defined; that special cartridges will not be necessary for outposts in giving an alarm; that patrols will be held off at a greater distance, rendering their work more difficult and less trustworthy.)

6. MORAL EFFECT PRODUCED BY SMOKELESS POWDER.

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Where lies the truth? War will decide. Doubtless the truth lies between these extreme opinions. Smoke is rarely so thick that it conceals from view scenes of carnage: still men fight bravely.

The oppression of uncertainty bears less heavily on a lower order of intellect than on a higher which alone possesses a sufficient power of analysis to appreciate the situation. The latter is more capable of facing a danger visible and threatening, than an uncertain one against which he finds no *point d'appui.* The former, on the contrary, is impressed by a plainly seen danger, which alone can shake his nerve centers; uncertainty has little effect on him.

C. Smokeless Powder on the Battlefield.

We shall examine the probable effect of the new powder on the mode of action of the three arms separately,* then on the superior tactical direction of troops and finally, we will give our conclusions from the standpoint of the attack and of the defense.

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* Part I Infantry, II Cavalry: see Journal of the Military Service Institution.

III. ARTILLERY.

It is on artillery that smokeless powder will have the greatest influence and that influence will be generally favorable. Smoke interferes with pointing and observation; it sometimes renders them impossible. There always results from it a great diminution in the efficacy of the fire. The evil became more sensible with the increased use of masses of artillery.

By the suppression of smoke it is indeed allowed to artillery to transfer from theory to practice its ideal tactics: fire by masses. The absence of smoke allows the uniting on the same position of large batteries; it is possible to close up the intervals and to employ polygonal lines. Evidently the concentration of artillery, in too restricted a position, ought not to be the normal rule, but the possibility of so doing at a given moment and of obtaining thus a fire of enormous intensity, has great tactical value.

As concerns fire, the only means of action for artillery, the introduction of smokeless powder presents, on the whole, more advantages than disadvantages.

Black powder formed, in front of the battery firing it, a thick curtain which interfered with aiming and observation. If, with the new powder, that curtain has not disappeared it is, at least, transparent however so rapid the fire may be or unfavorable the conditions of the atmosphere.

All artillerists, the commandant of the artillery, the commandant who directs the fire, the captain who attends to the ranging, the chief of section who regulates the direction, even the gunners, see disappear a part of the difficulties which the smoke from black powder created. The view of the battlefield, always clear, allows the commandant of the artillery to see all the phases of the combat and permits him to rest the tactical direction of the fire on his personal observation, which extends not only to his subordinates but also to his neighbors.

The commandants are not forced to place themselves on the flanks of their batteries, They go where they like. They still have their batteries under their eyes and see all that passes. The personnel perceives itself observed and the morale of the battery gains thereby. The chiefs of section observe well the direction and correct for deviation. The gunners point more quickly and with less chance of error Thus from a technical and a moral point of view artillery gains by the employment of the new powder.

At the same time all those disadvantages, caused by the use of black powder, such as the necessity of considering the wind in selecting positions, of taking sufficiently great intervals between the pieces, of slackening the fire and of conducting the fire in a certain order from one flank to the other, disappear. The firing gains much in simplicity; more freedom is allowed in placing the pieces according to the terrain, either in view of a probable change of front, of closing in or of increasing the rate of fire according to the phases of the battle.

The smoke from the old powder revealed the position of the artillery at the first shot no matter how skilfully the terrain had been used for concealing it. Now the artillery can keep the enemy a long time in ignorance, not only of the extent of its front, but even of the place it occupies.

If one side succeeds in gaining this advantage for itself, it will be able after a short time to leave the opposing artillery in order to fire on the infantry. Often the terrain will allow both sides to occupy sheltered positions, then the struggle will be long and will demand a great expenditure of ammunition.

When artillery is covered, not necessarily by a crest but by any obstacle slightly raised, as the vegetation on a field, it will be impossible to fix the extent of the position or the number of the batteries taking part in the struggle. The article *Das Rauchfreie Pulver* states the uncertainty in this respect experienced during the last great German manœuvres (1890).

The noise of the projectile and its furrow in the ground will indicate the point whence the shot comes, but this information is subject to error principally as regards the noise. To determine its position by the furrows, one must await the opening of fire by the hostile battery, even though a previously observed movement has shown that it is already in position. The furrows indicate the direction in which telescopes must be turned in seeking the enemy's position, but are made only by ordinary percussion shell.

These mutual advantages and disadvantages will often be neutralized by the necessity of showing the muzzles of the pieces above the cover which shelters them, in order to fire down on the moving target, or to strike the ground immediately in front. A careful reconnaissance will assist in showing up the enemy's position. The movements of the cannoneers will be visible, at least with field glasses, and perhaps also those of the limbers and caissons which are still not easily hidden. The light from the discharge will also give an indication.

But if the position is discovered neither its extent or the number of pieces is determined, and it will be necessary to resort to a reasonable dispersion of shot in order to reach the entire position.

The conclusion is then reached that well sheltered positions alone must be occupied and it seems that indirect pointing will be the result. Aside from the fact that indirect pointing is not sufficiently practical to be followed *de rigeur*, its essential inconvenience lies in the fact that it renders difficult the concentration and shifting of fire, and accordingly lessens its tactical value.

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Smoke from firing formerly gave a mask which artillery might use to conceal from the enemy certain movements, such as, by hand to the front or rear, with the idea of escaping from a dangerous zone, and to disturb the enemy's adjustment (*réglage*).

The first of these advantages is very doubtful. As to the other, it is certain that it will cause the enemy to make errors of judgment and hence cause great dispersion in range. With the new powder the remedy will be in multiplying masks, natural or artificial.

The new powder will render adjustment (*réglage*) more easy, once the position of the target is discovered.

From all this it appears that smokeless powder is generally favorable to the action of artillery, but its use gives rise to some difficulties in details. In order to avoid these, there must be more ability than was formerly required.

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The action of the artillery from the opening of the combat to the decisive assault by the infantry presents the following phases:

First.—For the preparatory struggle, the artillery will occupy a position within the limits of effective shrapnel fire and from which the enemy can be seen. This distance will generally be greater than 2500 meters.

Second.—For the decisive artillery combat, the masses of artillery will approach the enemy to distance less than 2500 meters, according to the conveniences for observing the results, while covering itself as much as possible by natural or artificial shelter.

Third.—At the close of the artillery duel, that arm will proceed to prepare for the assault, either from the position just occupied or from a new one: the requisite, in either case, is the ability to strike effectively the point chosen for the attack. The change in position will be covered by the terrain or artificial shelter. This move will be begun by those batteries which have best retained their mobility. Care should have been taken to preserve this mobility and to shelter the limbers and replace the horses; but, in order to spare them, it is not necessary to keep out of the artillery duel those batteries which are to prepare the assault.

Let us see how, under the new conditions, the artillery will lend its support to the infantry at the moment of assault. Heretofore the assault was supported by masses of artillery directing their fire on the point of attack, and by means of batteries, which accompanied the infantry up to 800 or even 600 meters, with the double object of sustaining the morale of the infantry and of being better able to distinguish friends from foes so as to cease firing at the proper time. These last batteries were intended to crown the captured position or to protect the retreat of the repulsed infantry.

All these reasons have conserved their value, except that the sight of the ravages produced in the neighboring batteries by the fire of the enemy will counterbalance the moral support that they would otherwise offer. The absence of smoke allows a clear discernment as to the time to cease firing. As to the immediate crowning of the captured position, that is an illusion: the batteries which have accompanied the infantry will not have a single horse left. It is equally doubtful if they could protect the infantry in retreat; the flood of repulsed infantry will sweep over them, and when that living wave has passed there will remain scarcely any one to fire. The protection of the retreat will generally be assured by the batteries which prepared the assault and which have not been removed.

In case of retreat, it will be difficult, in abandoning a defensive position to make the batteries occupy certain *points d'appui* in rear of the line. Batteries, previously placed in these positions, will produce a great effect by opening fire against the enemy's artillery unmasked in crowning the captured position or in executing the pursuit. Artificial cover can render great service in retreat. In pursuit, smokeless powder greatly simplifies the task of the artillery, but artificial cover will allow troops to reform and prevent a disorderly flight.

Let us now pass to a more detailed examination of the influences of smokeless powder on the problems in the tactical employment of artillery.

I. Artillery Reconnaissance.

Smokeless powder complicates artillery reconnaissance. Its ballistic effect on small arms renders the adversary's fire more effective, while his range of vision is extended by its use. It seems clear, as stated by Captain Moch, that for the artillery to show to the enemy its movements, its operations and intentions, is truly suicidal. To be under cover is an actual necessity for the artillery as well during the time preparatory to the combat as during the development of the combat itself. The only means of putting this principle into practice is by the skillful employment of the terrain. With this end in view, the reconnaissance should be intelligently and skillfully made.

Moreover the artillery should have, immediately on its arrival on the line, full information as to the position of the enemy's guns. We understand by that, not only the general information afforded the commander of the troops by the cavalry reconnaissance, but such precise details of the enemy's position as will guide in the selection of our own. The information, afforded by the cavalry, will be useful but it should be completed. From this arises the grave necessity for the organization of artillery reconnaissance. Attention has been called to this point, but not sufficiently so when the importance of the matter is considered.

These reconnaissances are usually made by non-commissioned officers or trumpeters, who report as to the possibility of routes in unknown country, but, as to the enemy, they give nothing. With smokeless powder it is absolutely necessary to feel the enemy from the beginning and the whole extent of horizon, even far distant from the battery, must be closely scrutinized.

Artillery reconnaissance requires skillful horsemanship, a good eye capable of seeing and appreciating, and lastly the art of reporting what is seen. For this work there must be picked officers and well mounted men.

Until now, the artillery has paid little regard to this work, but henceforth smokeless powder will demand it: to be successful it must not make a single move towards the enemy without knowing his strength and position.

Finally, smokeless powder has rendered very difficult this preliminary reconnaissance and the artillery has done little towards surmounting the difficulties. This must be done by preparing, for the scouting service, skillful officers and non-commissioned officers capable of filling out the general information given by the commander of the troops. Following these new conditions, the mechanism for the technical direction of fire will undergo important modifications.

The peace manœuvres should be so directed as completely to fulfill the conditions of actual battle. The commander will lead forward his units only after receiving the reports of these officers and scouts, while the latter will report only such things as the reconnaissance has shown them. This exercise is of most importance because, the new *matériel* has not been subjected to actual war service, and these exercises afford the only means of gaining experience for future use.

II. Choice of the Artillery Position.

The general conditions imposed are always the same. In the first place, the peculiarities of the position itself; in the second place, the means of sheltering the pieces, limbers and caissons, of remaining concealed while taking up the position and while leaving it. With smokeless powder more skill is required than formerly, in utilizing a position fulfilling these conditions.

It is admitted that a position compelling our artillery to use indirect fire over a covering crest, diminishes the effectiveness of the fire and such positions should be chosen only when there are no others or when it is necessary to occupy it in order to attain some special result. Many think that indirect fire over a crest should be the new principle of artillery: *it is a gross mistake.* Efficacy of fire cannot be thus attained.

The shelter which artillery can and ought to make use of is not confined exclusively to mounds for stopping fragments of shell and bullets, but is afforded by any screen, which, without unduly contracting the horizon, renders it difficult, if not impossible for the enemy to lay his guns or observe his shots.

These masks, artificial or natural, should not be too near the pieces: those which are deep and multiplied are the best. If the terrain offers little or no screen, it must be created or what little there is should be improved.

Artillery should employ the shovel in attack as in defense, but care must be taken that the position is not revealed by the freshly thrown up intrenchments: steps to that end must be taken. Intrenchments, concealed from view by masks, render valuable service.

III. Conducting the Batteries to the Combat Line.

The steps are always the same, viz: lead the batteries to a preparatory position, stop there, pass from the preparatory to the combat position and occupy it. These movements, with the new powder, must be made under cover, and the ability of the commander so to conduct them depends on the skill with which the reconnaissance has been made.

IV. Opening the Fire.

Although the first shot does not reveal one's position, still it is necessary to follow the old rules and not to fire the first shot till such thorough preparation has been made that the adjustment (*réglage*) will speedily follow.*

V. Shelter in rear of the Battery.

It is very important to cover the rear of the battery from both the view and projectiles of the enemy. As a change of position will be necessary for the closer artillery duel and for the preparation for attack, it is necessary, in order to retain mobility, to assure protection for the teams. Major Lariz recommends the non-employment, in the artillery duel, of those batteries which are to prepare the assault. This does not seem admissible. In chosing between two evils, we prefer to complete the teams of those batteries changing position, at the expense of those which remain in place, rather than weaken the artillery in the close and decisive duel.

VI. Discipline, Tactical and Technical Direction of Fire.

The ability to aim and observe shots unhindered by smoke and to continue a rapid fire without interruption, has the effect of improving the fire discipline, and facilitates both the tactical and technical direction of fire. The course of battle is better seen in absence of smoke, and the commander can determine precisely the moment at which he should modify the direction, nature or rapidity of fire. The visibility of their neighbors will draw more closely the bonds between the artillery units themselves and also between them and the other arms.

To show the advantage gained in the technical direction of fire, we shall consider some of its elements:

a. Laying the pieces.—The difficulty of seeing an object hidden with the greatest care, and the clearness with which neighboring objects may be seen, will surely lead to the designation of landmarks for the gunners (*pointeurs*), which will increase the accuracy of laying. Direct laying was formerly much interfered with by smoke, as was also the indirect method from the necessity of taking the land marks in rear of the pieces.

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* This indicates the necessity for some range-finder capable of rapid use giving fairly approximate results, and also the advantage that may accrue from previous training in the use of the quickest of all range-finders—the eye.—TR.

b. Observation of results.—The fall of the adjusting shots will be more easily seen but, on account of the care taken to use shelter, the effect will not be easily determined. Observers must be stationed where they can have a good view of the enemy's position. In firing at a target, invisible or very indistinctly seen, the selection of means of observing will be of prime importance as in this case the regularity of adjustment for range can be assured only by a careful adjustment for direction: it is necessary first to obtain the latter and then pass to the former. This fire is possible only when the observer is elevated, as in a tree, tower or captive balloon.. In the general case, there will be but one elevated point giving a view of the enemy's position. In most cases the battery will occupy a height, and when it does the point of observation will be a flank, giving the well known inconvenience of parallax.

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If the enemy's position is on a height, the firing is first adjusted to the crest; then follows the shrapnel fire in salvos of batteries or half batteries, the sights adjusted to two elevations. One of these salvos must strike the target or its prolongation, which fact is immediately communicated by the observer to the commander.of the battery or group who gives corrections for elevation and direction. The observer should take for the unit, in noting errors, the front of the battery or interval between pieces. For targets little elevated, the methods are the same but more time will be required.

IV. Superior Direction of Troops.

(The author makes the following points: The use of smokeless powder has not changed any general principles of tactics, but has necessitated greater thoroughness in preparation of a plan of battle and greater skill in applying the principles of tactics thereto.)

(The general can no longer follow the phases of the battle over the whole field, for smoke no longer pictures the course of events. There were many cases in 1870 where commanders took their positions after having seen the field and without reconnaissance. This may no longer be done and Napoleon's maxim, "*On s'engage et puis on voit,*" no longer applies. The relative smallness of armies and the smoke of battle allowed of the application of this principle, but now the general is more dependent on the reports of reconnaissances. As, at best, these reports cannot supply the place of seeing the battle, the system for collecting the data for, and for the making up of these reports, must be as thoroughly perfected as possible.)

(With infantry in dispersed order, the artillery becomes the regulator of the combat. There must be the closest relation between the direction of artillery fire and the general plan of battle. Hence again the necessity for such a perfected system for making reports and transmitting orders as to secure to the artillery the greatest "receptivity" possible.)

(The general must often yield the initiative to his subordinates because of the rapid march of events and because the enemy's movements cleared from the smoke mask often give to them an insight into his plans.)

(The absence of smoke, while beneficial to troops, is a disadvantage to the commander-in-chief.)

V. Attack and Defense.

(Neither side has gained by the new order of things. The more arms are perfected, the greater is the difficulty experienced in conducting troops while at the same time it becomes more important to conduct them properly. It is the skillful employment of arms and not their perfection that counts, while the more perfect the arms the greater the necessity for their skilful use.)

Attack.

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The success of a frontal attack on a place previously prepared is more doubtful than ever. In every case the way must be prepared by artillery masses before the assault is made. These masses will first endeavor to crush the opposing artillery. If shelter within effective range has not been obtained, the attacking artillery will find itself in a very unfavorable position: it will present, when passing to the near combat, a target plainly visible to the defense, which, on the other hand, occupies a position difficult of discovery. The attack will under these conditions often experience the difficulty of combining efficiency of fire and shelter.

The artillery at long range cannot give decisive results, it must draw closer the better to see the target and, if it has found no shelter, it may be annihilated.

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Defense.

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The defense should not open artillery fire too soon, as it thus reveals unnecessarily its position. It need not reply to a too long range fire by the enemy. If the artillery approaches can be reached, ammunition should not be spared in endeavoring to hinder deployment by the enemy and, indeed to prevent any movement whatever. If this is successful, fire from artillery masses may be brought to bear on the near batteries, for, at each step of the attack, the defense sees less chance of holding its position and of passing to the attack.

If the attacking artillery has had the best of the duel, the defense may expect to lose in its artillery one of the most powerful means of retaining its position.

Certainly good positions may be lost without the destruction of its guns and inversely; the guns may be placed *hors du combat* without the loss of the position, but with smokeless powder, the advantage is more than ever to him whose artillery is victorious. The defense should then defend, to the last, points giving favorable conditions for close combat.

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Résumé.

With smokeless powder, the reconnaissance of the enemy's position before the combat will be very difficult to execute and will demand the employment of masses of cavalry. It will become more dangerous than ever to base operations on conjecture, supplementing ignorance by fanciful imaginations. To operate successfully in the future the commander must have *exact* information.

Since smokeless powder is not noiseless, the conditions of outpost duty will remain unchanged.

Infantry will be forced to use dispersed order, undoubtedly in parallel lines of chains of skirmishers. The fire of infantry masses gains in efficiency, its discipline is increased and it is more easily regulated. The simultaneity of fire by infantry and artillery will allow the former to make use of the ranges determined by the latter, and the intensity of fire is increased.

Cavalry, which in the information service, finds complex problems confronting it, loses nothing of its value in the combat. It remains, as before, during the combat, an arm of circumstance and occasion.

It watches attentively the enemy's flanks, and, in following the tide of battle, there will not fail occasions for showing what a powerful factor it can be, provided it knows how to make use of conditions favorable to it and unfavorable to the enemy.

It is artillery that gains most from the use of smokeless powder in the extension thus allowed to its tactical principles. The best artillery, however, will be of little use if badly employed. If it is too scattered or if the fire is distributed among the targets successively, it will not have force or time to obtain good results.

Smokeless powder draws a distinct line between the two phases of the artillery combat; the long range artillery combat of reconnaissance and the short range artillery duel. The latter has for its object the crushing of the enemy's artillery and the preparing of the assault within the limits of effective range (1100 to 2500 meters).

The general will hereafter base the tactical movements almost exclusively on the reports he receives. Accordingly the information service ought to receive a practical organization and means, well adapted to the end in view, both as regards quantity and quality. All economizing in this direction is an error. Troops badly directed cannot conquer.

Attack and defense remain in the same relative state of equilibrium as before. With arms equal on both sides, skill alone can displace the center of gravity of the struggle. If the assailant, forced to deploy under the fire of the defense, can, under these adverse conditions, skillfully combine a flank with the front attack, he has the chances of restoring the equilibrium.

PROFESSIONAL NOTES.

Adjuncts of Defense. By Major Sir G. S. Clarke, K. C. M. G., R. E.

The term "adjunct," however cacophonous, appears indispensable. Any secondary weapon, any scientific invention which, while in no sense necessary, may be distinctly beneficial, can only be thus labeled. Of such adjuncts there is an increasing number, varying in value. Each year brings forward new claimants for admission to the national armory. Each such claimant is duly heralded by the Press, as needing only sufficient scope in order to "revolutionize" warfare. Yet warfare has never been revolutionized even by radical changes in primary weapons, such as the small-arm and the field gun. The adjunct cannot possibly alter the conditions of war by sea or land; but, in proportion to the increase of efficiency, simplicity, economy, or merely convenience practically attained, it will prove an aid in deciding military issues. By this test each new invention must be judged, and the examination should be conducted somewhat on the following lines:—

1. What can it actually accomplish; not in peace experiments, but under service conditions?
2. Does it lend itself to the requirements of the British Empire?
3. If so, under what local or other conditions?
4. Does the advantage justify the cost?

The first question is one for the inventor to answer by practical demonstration on lines laid down for him. As regards the third, it would be proper for the inventor to offer suggestions; but the second and fourth should be determined by those in authority, who would be more likely to form a right judgment uninfluenced by the inventor.

In a previous paper* it was sought to show how a useful adjunct of defense —the submarine mine—tended, by a process of unchecked scientific enthusiasm, to usurp a position extravagantly expensive in peace and probably dangerous in war. At the same time, it was endeavored to arrive at certain principles which should guide the employment of mines in British waters.

Two other adjuncts of defense—the position-finder and the Brennan torpedo —may be similarly discussed, without revealing any of their secrets; but merely with a view to arrive at some limiting principles. The statement that every coast defense gun does not require a position-finder, nor any channel a Brennan installation, will be accepted without question. It follows that there must be limitations to the tactical employment of either adjunct, and, in the interests of efficiency and economy, it must apparently be worth while to seek to arrive at these limitations.

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* *Proceedings of the Royal Artillery Institution*, Nos. 11 and 12, Vol. XVII.

THE POSITION-FINDER.

Accurate fire from permanently mounted guns at a stationary target depends on the exactitude and accuracy with which at least four separate conditions, independent of the gun itself, are [fulfilled] viz.:—

(*a.*) A line observed by the eye.
(*b.*) An ascertained range.
(*c.*) Correction for drift.
(*d.*) Correction for wind.

(To the above may have to be added in some cases a correction for variability in powder.)

Of these conditions, the first (*a*) can be met by (1) sighting pure and simple; (2) sighting for direction only; (3) a telescope with cross-hairs attached to the gun; (4) a telescope separate and at a distance from the gun. The second (*b*) can be fulfilled by suitable instruments, or (with loss of time and ammunition) by trial shots alone. The third (*c*) is a mere clerical matter; the fourth (*d*) is largely a question of unaided judgment, *i. e.*, of practical experience.

The relative importance of the fulfillment of these conditions in regard to accuracy of fire varies somewhat according to circumstances. Thus, in firing at a square target of small dimensions, the non-fulfillment of any single condition will ensure failure; (*a*), (*b*), and (*c*) may be exact, but a wrong estimate of wind correction will cause the shot to be thrown away. In this case, therefore, assuming equal care to be taken in performing each operation, the relative importance will depend upon the probability of the limit of permissible error being exceeded. In each operation, error up to a certain point will not vitiate the result. In which operation is that limit of error most likely to be exceeded—in the purely visual operation (*a*); in the determination of range (*b*); in the wind correction (*d*)?

Assume that the length of target is great in proportion to its height, as in the case of a ship's broadside, then errors in direction become of less importance than those in elevation. In other words (*a*),* (*c*), and (*d*) become of relatively less account, and success turns merely on the fulfillment of (*b*).

If the target is moving, the question becomes complicated by the need of a further correction which affects ranges if the motion takes place along a line passing through the gun, and range and direction in varying degrees according to the obliquity of the path. Thus this correction usually involves two variables, and is practically a prediction of the position of the target at the moment when the projectile will reach it, such prediction being based on observations previously made.

What now are the special functions of the position-finding system, and how far does it tend to reduce the elements of error above pointed out? (1.) It reduces (*a*) to the comparatively simple operation of laying the cross-hairs of an easily manipulated telescope on a mark. By this one operation the range and the line of bearing are automatically transmitted to the emplacement,

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* Except possibly when ordinary sights are used and visual errors in elevation therefore become possible.

there to be translated from dials to pointers connected with the mounting. Thus conditions (*a*) and (*b*) are both fulfilled, while corrections (*c*) and (*d*) remain to be applied, either by the operator or in the emplacement. (2.) Since the instrument enables the course of a vessel to be followed and plotted, the prediction involved in the supplementary correction can be made without difficulty unless the course of the target is specially erratic. (3.) The position of the observer being independent of that of the gun, the latter is able to carry on aimed fire over water not visible from its site. (4.) The operator is removed from danger, and is comparatively little liable to have his field of view obscured by smoke.

The instrument, when in adjustment, is theoretically perfect, and from its nature the probability of observation error is reduced to a minimum.* Assuming adjustment and electrical communication to be maintained, it is also practically perfect. Thus, once the principles are fully grasped, first thoughts naturally lead one to assume that an absolute solution of a difficult problem has been reached, and that a new method so accurate and simple as to demand general application has been provided.

Further consideration serves to modify thi[illegible] materially. Assume, for example, that condition (*b*) can be otherwise fulfi[illegible]t accurate ranges can be otherwise obtained. Then clearly a portion of the advantages of the system disappear. To lay *for line* by sight is an easy operation, and two possible sources of error—the mis-reading of a dial, and the incorrect adjustment of a pointer to an arc—are actually eliminated. The possible sources of error in elevation remain practically unaffected. Although prediction, in the sense above adopted, may not be equally inconvenient, the difference will not be marked. The instrument does not remove the more important sources of error, which still depend upon fallible private judgment. Thus, on purely theoretical grounds, it might be expected that when good range-finding can be carried out, no increased accuracy of practice can be attained by position-finding. Practical experience appears to bear out theory in this respect, and now that a good system of drill exists there is reason to believe that superiority both in speed and accuracy of fire can be claimed for the range-finder.

Abandoning theory and coming down to matters of infinitely greater importance in war—tactics and human nature—certain inevitable disadvantages attach to the new system. Under it the responsibility for accurate practice centers upon the observer in his cell. The gifted individuals to whom the grave responsibility of directing the fire of a heavy gun or group of guns may safely be entrusted, become the real commanders of the battery in regard to its war functions. They must be trained officers, possessed of iron nerve and wide experience. But, if this is admitted, a necessary limitation at once presents itself. Material, apart from *personnel*, is expensive in peace and useless in war. How many trained and experienced officers can be spared for the multitudinous position-finding cells which would be required? Even if it

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* This applies to a vertical base instrument only. In the case of a horizontal base apparatus other sources of error arise.

could be admitted that competent non-commissioned officers will be forthcoming, a powerful objection deeply rooted In unchanging human nature remains. The position of the fort or battery commander is deprived of its first right. The work exists only for its fire effect. Failing that effect it is a mere futile excrescence marring a coast line. A commander deprived of all responsibility in regard to the one war function of his command is surely placed in a pitiable position, which only the most cogent reasons can justify. If, on the other hand, he is taken out of his command and placed in a position of some security on the top of an adjacent hill—the position selected in action by Osman Digna—the moral result will be deplorable. The position of the commander of a tactical unit, in action, is with his men, whose energies he must stimulate, whose dangers he must share.

Turning to the question of simplicity, the verdict depends upon tactical considerations. Some of the writing to which position-finding has given birth seems to show that simplicity in the actual working of coast defense has gone by the board. New titles have been freely mounted; involved systems of communication have been demanded entailing a maze of telephone and telegraph wires, and presenting the fighting of a coast battery in a light calculated to appal the imagination. All this lends itself readily to diagrammatic illustration. Has it the smallest value in war? It is remarkable that, at a period when the idea of interfering with tactical units, once engaged, is losing ground, the coast battery should be threatened with the loss of all independence. The chain of responsibility—general officer commanding, section C. R. A , battery commander—is essential in peace where the object is preparation and the all-important element of time does not enter. It may be ruinous in war. The battery commander should know his work, his guns, his field of fire, as no one else can. His duty is clearly defined. Interference with his functions can only mean loss of time, with possible misunderstandings and confusion. His superior may be able to warn him to be on the alert, may reinforce him if his casualties are severe; but cannot hope to do more. Once engaged, he is, or ought to be the best judge of the distribution of his fire. Unless this view, which has at least the sanction of experience, is correct, the complications threatened by position-finding must be regarded with grave distrust. Circumstances may justify them. In the rule, they are fraught with danger.

Of the many possible difficulties involved in the enormous electrical communications which any extended application of the system involves it is, perhaps, premature to speak. Those difficulties will not be adequately realized till such an application has been made and actually tried under service conditions.

The above considerations seem to lead to the following as the limiting condition to the use of this valuable adjunct. *Position-finding should never be employed where sights can be used, and when accurate range-finding within effective fighting distances is possible.* Ample scope remains for the system. In the case of a battery intended for high-angle fire, or which is required for fire on water not visible from its site, the drawbacks disappear in face of the unique solution of a great difficulty. Similarly, casemates liable to be quickly obscured by smoke may be transferred into effective gun positions. Thus limited, the system will rest on a solid foundation, defy all criticism, and secure itself against the violent reaction which its exaggerated employment would inevitably provoke.

THE BRENNAN TORPEDO.

Judged as a mechanical success, the Brennan torpedo stands unrivalled among all competitors. Other controlled torpedoes have certain commendable features. None have so far proved mechanically perfect. Local conditions may offer special difficulties in launching, but such difficulties can undoubtedly be overcome, and once overcome the actual working of a Brennan installation properly supervised may be relied upon. The percentage of faulty runs is infinitesimal. The steering is excellent, the immersion exact. The weapon, as a machine, is effective and complete. What functions can it, therefore, fairly claim?

(1.) A certain area of water, extending to a range of at least a mile but laterally limited, is open to the action of a dirigible torpedo under full control, and carrying a charge which would probably be fatal to any ship.

(2.) The torpedo itself has a speed even at the end of its run equaling or exceeding that of most battle-ships.

(3.) It is completely submerged and indestructible by fire.

(4.) Torpedo netting would not arrest its action.

(5.) The installation can, under favorable circumstances, be rendered secure from fire except at close quarters, and countermining operations, even if practicable, do not affect it.

(6.) The observer can be at a distance from the installation and can change his position.

(7.) Finally, with suitable arrangements, torpedoes can be successively launched from a single installation, at intervals not exceeding the mere duration of the run.

Certain conditions modifying the above statement may be alleged.

(1.) The manœuvring of the torpedo towards the conclusion of its run is slightly impeded, except when an elevated observing station is available, by the difficulty of ascertaining whether the torpedo has ranged up to or beyond the target. This difficulty would, however, be experienced only when dealing with a rapidly-manœuvring ship, and fuller experience may prove it to be less than might be anticipated.

(2.) Smoke intermittently obscuring the mast would render doubtful the accuracy of the practice at a moving target except at a moderate distances.

(3.) Night practice against a manœuvring ship would probably be ineffective. At moderate range, however, employing the electric light, a ship running a straight course across the front of the installation should be hit with certainty, provided that no smoke intervened to perplex the observer.

(4.) The cost of an installation is necessarily great, equaling that of a completely equipped battery of four or five 6-inch B. L. guns. The cost of maintenance will prove high and the *personnel* must be specialist and expensive.

Even when due reservations have been made, the torpedo must evidently be regarded as an extremely formidable weapon within the limits of its action. The question of its application is of a different kind. It is clearly unnecessary as a provision against unarmored ships, with which the gun can effectually deal even at greater than Brennan ranges. It provides no defense against torpedo-boats—the principal danger to shipping in ports situated near an enemy's base. Its range is less than that at which a ship's fire is effective—far less, for example, than the range at which good practice was made by the *Inflexible* and *Téméraire* at Alexandria. For the defense of a sea front, it is quite unsuited. In many positions it would not range up to the water which an unarmored ship would attempt to navigate.

These considerations appear to limit the justifiable employment of the Brennan torpedo to the defense of deep channels not exceeding about 1500 yards in breadth.

But a further limitation arises. Whither does the channel lead and what is the nature of the inner waters? If the channel open rapidly into broad and deep water which it is necessary to deny, if, in fact, it is a passage which can be rushed,[*] a Brennan installation is a suitable protection. In such a channel as that of the *Thames*, it would be obviously superfluous. To superimpose the Brennan upon an effective existing mine defense would clearly be unjustifiable. If a mine-field is real, that is to say intended for physical as well as moral effect, it will suffice; if not, it is a useless expense.

The Brennan torpedo, therefore, enters into competition with observation mines, over which in some cases it possesses undoubted advantages. In a deep channel with a strong current, for example, the mine is impossible. When the conditions are equally favorable to both weapons, the decision must turn upon relative economy which appear to be worth more careful consideration than has at present been forthcoming. At the same time, for the defense of a narrow deep channel opening into broad waters, and at a sufficient distance from a dockyard to render effective bombardment impossible,[†] the torpedo would probably be a more formidable defense than the gun. If, in such a case, the installation is rendered self-defensible, and supplemented by a few quick-firing guns as a protection against boat attack, there seems to be no reason why it should not stand alone. It will not, however, obviate the necessity for providing some fire over interior waters, nor will it enable precautions against torpedo-boat attack to be dispensed with.

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[*] Such cases are few in the British Empire. The Heads at Sydney and the Syemun Pass at Hong Kong may possibly be included in the category. The idea of a heavy ship "rushing" into such a harbor as Malta is obviously preposterous.

[†] By effective bombardment is meant fire capable of causing serious injury to national resources required for war. Such bombardments can under no circumstances be so undertaken unless certain immunity from naval intervention exists.

Even in the peculiar case of Foochow, the effect of bombardment proved to be strictly limited.

Broadly speaking, therefore, the torpedo must be regarded as a means of denying certain limited waters to armored ships. The first question to be considered in any specific case is whether an enemy has anything to gain by placing armored ships in such waters, or attempting to pass them at speed. This question is essentially naval, and lies wholly outside of the legitimate sphere of the technical expert. When it has been answered in the affirmative, a *primâ facie* case for a Brennan installation arises.

Fixed installations on shore have so far been dealt with. Such installations have the apparent disadvantage that their positions are certain to be accurately known in advance by an enemy. Where, however, the installation is properly sited and arranged, this disadvantage is of small account, since the torpedo can be freely used outside the zone of its vulnerability. By establishing it close behind a conspicuous building, which would be partially destroyed by a single projectile from the bow armament of an advancing vessel, all possibility of usefulness in war would be abandoned.

Assuming that a floating installation can be rendered as satisfactory as one on shore, the general conditions laid down remain practically unchanged. If the Brennan vessel is to be used at anchor, the advantage of the unexpected may be attained and the scope of action of the torpedo may be somewhat extended. If it is to be manœuvred against an enemy, it becomes a vessel of war with which we of the army have nothing whatever to do.

The two adjuncts above discussed are both capable of rendering valuable aid to the defense when employed with due regard to their limitations and to the outstanding requirements of British ports. Such aid is, however, in both cases, available only against purely naval attack, *i. e.*, attack by ships apart from operations on shore. This form of attack found little favor in the past wherever moderate coast defenses, manned by trained gunners, existed. It is even less likely to be attempted in future now that ships are fewer, far more valuable, and, for the most part, relatively more vulnerable. Against an Algiers, an Acre, an Alexandria, it may unquestionably continue to play a part in war. Against the existing defenses of British ports it is the least probable policy for an intelligent enemy to adopt. Such risks as they may run lie in other directions, and of such risks torpedo-boat attack at the outset of war is the greatest, although it applies to certain ports only. Here neither the position-finder nor the Brennan torpedo promises any assistance to the Empire.

Many of the principles which the writer ventured to urge as regards the employment of submarine mines have subsequently received official sanction. *Absit omen.—Proceedings of the Royal Artillery Institution*, September, 1893.

Modern Field Artillery.

The paper read by Captain C. C. Townsend, R. A., at the United Service Institute, Simla, on the 30th August, opened some questions of general interest, though its subject, "Modern Gun Carriages," seemed at first somewhat too technical for the ordinary reader. The main lesson brought away from this lecture was the great quantity of highly technical knowledge required by the Royal artilleryman of the present day. Even the field artillery have a weapon which is, as far as its breech mechanism and the hydraulic arrangements in the carriage to lessen recoil are concerned, far more complicated than anything taken into the field but a very few years, and more complicated than anything to be found even in a fortress fifty years ago. Much as this complication is to be deprecated, we do not see how it is to be avoided if the present desire for high velocities is to be satisfied. Even with existing velocities we find the carriages so complicated that field and horse artillery officers can hardly find time to give them that attention which is absolutely essential to their perfect working. If the craze for "high velocity" continues, we tremble to think where it will land us. Those who advocate "high muzzle velocity" are following a most dangerous trail. High muzzle velocity—for that is all that modern "high velocity" means—does not imply "high remaining velocity" (indeed its concomitants are against "remaining velocity," as a rule) but merely that the shot leaves the gun at a high rate of speed. Except when case shot is used, the object of artillery is never to kill an enemy at or near the muzzle, consequently the behavior of the shot at the muzzle ought to be a very secondary consideration. What is wanted is a gun that will throw a shell giving a good killing "remaining velocity" at, say, 2500 yards.

Apart from other considerations, an extreme velocity, even at this range, is unnecessary, as within the limits of shell-speed a low velocity "kills" at least as well as a high one. The velocity of a gun for horse and field artillery must always be taken with reference to the effects of its shrapnel-shell; for it is on shrapnel that its value as a man-killing machine depends. But shrapnel is a peculiar thing to deal with. The outer envelope or shell should burst so as to scatter the contained bullets over as effective an area as possible, having regard, on account of the present methods of infantry attack, to breadth rather than depth in the space of ground swept by the shrapnel fire. Now, an excessively high remaining velocity does not tend to efficiency in the shrapnel-shell as a man-killing machine for two or three reasons. In the first place, velocity makes for depth rather than breadth, as the forward velocity imparted to the bullets by the velocity of the shell completely overpowers the scattering effect of the bursting charge, so that, from this cause alone, the bullets would move forward in the form of a very narrow fan. But to keep the long shell of modern warfare steady at very high velocities it is necessary to give a very sharp twist to the rifling of the gun, so that the spin may overcome the inherent tendency of a long shell to "wabble." This sharp spin when the shell bursts communicates itself to the bullets, and tends to keep them together, so that the "dangerous area" contracts from the "narrow fan" due to high velocity pure and simple to a "cylinder," on account of the way in which the spin causes the bullets to revolve round each other when liberated.

But if high velocity is bad from a ballistic point of view, it is disastrous when we come to the carriage necessary to carry the gun. High velocity implies violent recoil, and violent recoil means one of two things. We must either let the gun and carriage recoil more or less as it will, thereby causing the gunners undue and excessive fatigue in running up—a fatigue which men of "Mercer's troop" thoroughly realized and suffered from—or we must make the carriage cumbrous and complicated to a degree which renders it totally unfit either for manœuvring or traveling behind a six-horse team. It is all very well to ask, as has been done, for a carriage without any recoil buffer whatever, which shall have a recoil of not more than three feet; but until we have an explosive that is much gentler in the recoil it gives than even cordite, it is hopeless to ask for a rigid carriage that will do anything of the kind. In the present 12-pdr. breech-loading field-gun we reach what we ourselves consider an unnecessarily high velocity, and in order to reduce the recoil of this gun to anything reasonable, it is found necessary to provide a (for field-guns) complicated arrangement of slides, hydraulic buffers and springs, and to make the carriage so heavy that practical gunners cry out and complain of the weight behind their teams. The endurance of the horse has not increased with the advance of modern artillery—a truth that seems almost forgotten in the present craze for scientific weapons. These two chief reasons, viz., the bad "killing zone" of the shrapnel, and the necessary weight and complication of the carriage, ought to be sufficient to refute the supporters of "higher velocities," who, if not closely watched, may stand a good chance of seeing their disastrous policy accepted. There is something taking at first in the words "high velocity" that is apt to entrap those who do not look steadily at the consequences. They sound so progressive, so scientific, so truly modern, that they are liable to carry us away till we realize that a gun which is too heavy to drag about, and has an infinitesimal killing zone, is not of much use as a field gun, though its velocity be equal to that of lightning. As a matter of fact, the tendency of the field artillery of all nations towards the close of long campaigns is towards the introduction of howitzers into their field batteries, a tendency that goes to prove more than anything, that what field batteries really want to make their killing powers as effective as possible is a gun of low velocity that can throw a large shell, *i. e.*, a shell containing a large number of shrapnel bullets. Let the tendency of our garrison, and even our siege artillery, be towards high velocities if they will, for from them we need the power of throwing common shell, *i. e.*, a shell filled only with a large bursting charge, whose work ends when the shell bursts as far as possible with the highest possible penetrating power, whether against armor, concrete, or earth; and with them weight and complication are less objectionable. But let us avoid high velocities for our horse and field batteries.

Another point touched on by Captain Townsend was the proposed introduction of quick-firing guns for horse artillery. Perhaps it is logically correct to say that horse artillery should have a quick-firing gun, but how about the ammunition? This point was incidentally raised by the Inspector-General of Artillery in the short discussion which followed the lecture, but though the lecturer admitted the difficulty, we should like to see it made more of. Already we only carry (approximately) about two-thirds as much as foreign nations do, *i. e.*, we carry 108 rounds per gun, where we should carry at least 150 rounds. If, as has been authoritatively stated, it will take the ammunition columns four hours on a good road before they can join the batteries in action—taking the case of an ordinary army corps on the march—what is to become of the batteries if they are in action most of that time? In four hours they can fire 190 rounds; and, though it is very improbable that any gun would approach that number, yet we must admit that 108 rounds is far too small a supply. We leave the means to the specialists, but some means must be found to increase the amount of ammunition carried with our present field guns—and if with them, how much more with any quick-firing gun?—*The Englishman* (*Calcutta*).—Taken from *The Broad Arrow*.

Trial of Schneider's Nickel Steel Armor for Russia.

An excellent statement of the conditions of a recent trial of nickel steel armor, at Creusot, for the new Russian battleship, *Tria Sviatitelia*—Three Saints—appeared in the *Times* of September 9th last. The plate measured 8 ft. by 8 ft. by 15.9 in. It, therefore, probably weighed nearly 18¼ tons. The conditions of acceptance were that it should receive four blows from Holtzer projectiles of chrome steel, weighing 317 lbs. each, fired from a 9.4-in. gun, with a striking velocity of 1945 foot-seconds, without any portion of the plate being broken off, while in no case should the "*base* of the projectile" enter 7.8 in., measured from the face. The exact words used are "penetrate the target to a depth of as much as 7.8 in." The four rounds were delivered at the corners of an imaginary square of 4-ft. sides.

Round 1: Had a velocity of 2001 foot-seconds; the shot's point entered 14.1 in., and the projectile rebounded "with the point smashed, and the shoulder somewhat set up." "The target showed three very fine cracks running from the wound."

Round 2: Striking velocity, 1948 foot-seconds; penetration of point, 10.9 in. The projectile rebounded, broken into numerous fragments. Three fine cracks, as before, were developed in the plate.

Round 3: Striking velocity, 1923 foot-seconds; penetration of point, 14 in. The projectile rebounded with the head smashed, and the cylindrical part somewhat set up. A single fine crack was developed.

Round 4: Striking velocity, 1962 foot-seconds; penetration of point, 9.9 in. The projectile rebounded, broken into numerous fragments. There were no fresh cracks, and the old ones were not increased.

At the back the bulges behind the points of impact varied from 1 in. to 1.7 in. high. Behind 1 and 2 were some fine cracks.

We presume that this plate passed the test. To Messrs. Schneider is the credit due of having first applied nickel to the manufacture of armor, and having been long the sole manufacturers of through steel armor, which is now universally approved. Rare indeed is it for Messrs. Schneider to make a bad plate, and this plate is a very good one indeed. Messrs. Holtzer's projectiles have long been taken as the standard of highest excellence. These facts being so, it is interesting to compare the above trial with recent American and English results. In a trial which took place at Indian Head on July 11th last, a Bethlehem all steel nickel plate, 17 in. thick, was attacked by a 12-in. gun, firing forged-steel Carpenter projectiles with varying velocities. The second round most nearly corresponded to the results now before us. The velocity was much lower, namely, 1495 foot-seconds, but the theoretical penetration and the shock per ton were not so much less as to prevent comparison. On the English system the theoretical conditions are as follows:—Schneider plate, 3rd round, theoretical perforation through iron 17.36 in., the plate being 15.9 in. thick. Bethlehem plate, 2nd round, theoretical perforation 19.18 in., the plate being 17 in. thick. The energies per ton of plate were respectively 483 and 425 foot-tons. The Schneider plate was therefore more severely tried as to fracture, and it may be noted that it exhibited a slight hair crack. The shot entered much more deeply in the Bethlehem, which, we think, was decidedly softer than Schneider's; undoubtedly both plates were excellent. To come to the projectiles, it can hardly escape observation that Holtzer's larger projectiles do not behave as well as those for his 6-in. gun. It may well be expecting a good deal to ask that 9.4-in. projectiles should rebound intact after impact at over 1900 ft. velocity on steel, although the 6-in. projectiles will often do this. The Carpenter 12-in. projectiles rebounded at 1838 ft. velocity apparently uninjured from the Bethlehem plate after striking. It may be urged that the Bethlehem plate was rather softer, and at this velocity it was overmatched. Still, making all allowance, the fact remains that, putting fracture aside, the Holtzer 8-in. projectiles at Indian Head, America, have been regularly and symmetrically setting up, and here, on this occasion, the 9.4-in. projectiles in two cases set up as well as breaking up. A projectile ought not to set up under any circumstances. Consequently, we think that Holtzer's larger projectiles can not at present claim at all the high character that the 6-in. ones have maintained. —*The Engineer.*

Field Artillery on the Smokeless Battlefield.

Time was when field artillery was justified in massing guns on bare plateaux, secure in the conviction that grape, canister and such-like would hold at bay the most determined infantry—for a while. We now have to face the fact that infantry have passed within the range of shrapnel which but a while ago kept the frontal attackers at arm's length *pro tem.*, while the light which beats down upon the artillery, as a target, is fiercer than ever before. The smoke-screen, therefore, which can no longer be depended upon must find a substitute in other means. At from 1,500 to 1,800 yards of the fire of *formed* infantry, artillery, we assume, must be covered in some way or other, and at longer ranges it is almost unnecessary to add, cover is desirable where large artillery units are concerned. Now as it is obviously undesirable to lay down hard-and-fast rules that the position of the guns is to be always subservient to the fire to be employed, we are compelled to find a method which shall allow the fire on all occasions to conform to the exigencies of ground; it cannot always be that what are called artillery positions can be found to suit the requirements of the guns, which are tactically assisting the advance of the infantry. We have, therefore, to insist on a system of artillery drill and manœuvre adapted to teach all ranks the uses of indirect fire. It is not, however, enough to study the subject as one of siege-practice or even of dealing with the question as one of an attack upon an entrenched position, where the mere retirement of the guns to a remoter distance enables the gunner to make the trajectory adapt itself to the terrain in rear of his enemy's crest-line. The scientific methods of securing effective indirect fire must become rules-of-thumb to artillery commanders of minor units. We have, be it remembered, on service to deal with moving targets, whose successive advances on guns exposed are proportionately more dangerous (to the artillery) as the range decreases. Successive retirements of echelons of guns and alternative sightings cannot from the nature of the case meet all requirements; indirect fire from well prolonged flanks under cover must be insisted on as a matter of drill if artillery are to be compensated for the serious handicapping of modern infantry. We shall be apt to be misled in future manœuvres by the conspicuous positions which guns must take up to mark the part they are taking on smokeless battlefields; but the most unmilitary of spectators, who have watched artillery in position, when the "cease fire" sounds, must be aware of the deadly target offered by the guns and gun detachments.

The case has to be met of want of artillery positions and cover and the impossibility of an immediate advance of our guns owing to the shot-swept and well-measured zones which lie before them. We find a target now in the massed or otherwise formed infantry of the enemy's local and general reserves and other troops at rest and in movement, unseen, indeed, by the gunners, but commanded by the mechanical methods employed by the battery staff or range-finders. Now though for very obvious reasons it is not expedient here to describe in detail the systems well known to artillerists and others, who deal with the ballistic capabilities of ordnance of all kinds, we may at least hint at the possibility of reducing to common practice what perhaps is too much regarded as an academic function. The prolongation of the front of a battery forming the base and the observer on higher ground to the flank, with a very simple mechanical arrangement for correction of the lateral error, briefly describes the well known continental system for conducting practice against an unseen foe. But the point at issue is not, how to find the range of an unseen and perhaps moving object, but how to reduce the system to so simple an art as to render it merely a matter of drill for the gun detachments spread over a mile or two of front to play upon targets marked out cruelly into deadly zones of fire, though unseen by those who are working the instruments of destruction.

Of all arms artillery is the one in which it is most desirable that all secrets of the art should be understood by all ranks. The superiority of our artillery in these days of well-nigh perfected armaments can hardly depend entirely on superior mechanisms; a dead level of efficiency in this respect is well-nigh the rule among civilized States. What we have to do is to demonstrate our greater mobility and fertility of resource by resorting to every "trick of the trade" with which the academic knowledge of our best artillerists can prime us, and by making drill-exercises of these theories. The question of expense should never stand in the way of artillery improvements. "A penny wise and pound foolish" policy in dealing with this arm must eventually prove a dear method of buying experience, convinced as we are that the rôle of artillery if more difficult than of yore will be proportionately more decisive in the battles of the future, when that side whose leaders can place guns under cover with least loss, and are conversant with the greatest number of problems in the shape of fire on unseen targets, must inevitably reap successes not to be measured by the relative numbers of guns or troops placed in the field by either side. Having arrived well-nigh at a standstill in the improvement of our weapons, we look to our officers to provide us with an equivalent advance in the mental development and training of the "men at arms" for whom they are responsible, while of every artillerist in all ranks it may be said that he of all men is required to give his country of his very best, both mental and bodily service, his arm being in the truest sense of the term a "*corps d'élite*."—*The Army and Navy Gazette.*

German Artillery Drill.

The Intelligence Department of the Horse Guards has just reproduced the drill regulations of the German field artillery. The work has been translated by Captain W. A. Macbean, R. A.

In the introduction we are told:—"1. The object of drill is the training and preparation of leaders and men for their duties in war. All exercises therefore must be based upon the conditions of war. The most important demands which war makes are: the strictest discipline and order, coupled with extreme tension of every faculty. So to foster these qualities among troops, that they may become second nature, is one of the chief aims of all drills. In war, simplicity alone gives promise of success. It is requisite therefore to learn and apply a few simple forms only, but these must be rigidly inculcated and thoroughly mastered. All petty over-refinements are prohibited.

"2. Every officer in command of troops, from the battery commander upwards, is responsible for the training, according to regulation, of the troops placed under his command, and he is to be given the utmost latitude in choosing his means for that end. *It is the duty* of immediate superiors to interfere as soon as they notice misapprehensions and shortcomings.

"3. Training without and with guns is completed within the battery. In the brigade division, the co-operation, according to regulation, of several batteries for a common tactical purpose is to be practiced. Large artillery units are directed by transmitted orders only.

"4. Long-continued repetition of one and the same matter is fatiguing to mind and body. Variety must therefore be introduced into drills and exercises. Their nature and duration must, moreover, be proportioned to the powers of man and horse; otherwise the inevitable slackening of mental concentration imperils discipline. Training in easy ground must be supplemented as frequently as possible by varied exercises in difficult ground. Every opportunity, every time of year, must be utilized for this end. Junior officers must also be given the opportunity of learning to command a battery, for this task will fall upon them in war. Of especial value to field artillery are exercises executed by units *upon war strength*, for by this means alone can the difficulties be appreciated and mastered, which are attendant upon the employment of such units.

"5. The mission of field artillery is to prepare the road to victory. *The paramount consideration for field artillery is therefore good shooting, at the right time and from the right place.* This requires complete mastery of the arm, with its many-sided peculiarities, and great mobility.

"6. Commands are divided into cautions and executive words of command. A slack word of command leads to slack performance. Words of command, therefore, in every situation, in every place, and in every kind of duty, must be given with the same smartness. The words of command given in the regulations are alone to be used. If words of command, calls, and signals do not suffice, these are replaced by transmitted orders.

"7. *Commanders of all ranks* are responsible that the drill regulations are thoroughly practiced, and that the spirit of their requirements is fully satisfied."

In Part III, "Training with Guns, Mounted," it is said that "the training of the *battery* commences with instruction in driving. As soon as the requisite proficiency is attained in driving, drill is commenced. This is at first to be carried out upon level ground with no other object than the inculcation of the prescribed formations and movements. Here it is of no consequence which gun is on a flank, but sections are not to be broken up; to form front rapidly in any direction is the paramount consideration. During training special importance is to be attached to the following points:—To a long steady trot in column of route over all kinds of ground. To rapid formation of line. To quickly fixing upon various points to march upon when in line at open interval. To smartness in unlimbering and limbering up. Strict service of the guns according to regulation; coupled with the employment of targets such as will be met with in war, is always to be kept carefully in view. According as progress is made in drill, exercises are combined with a tactical purpose and transferred to difficult ground. In brigade division training *drill under tactical conditions* is to be made the chief consideration."

In Part IV, "Battle," we find the following "Introduction":—"The service element of peace exercises lies in the *correct selection of forms* for the specific object of the action, combined at the same time with utilization of ground. This selection must be such as is imperative in order to attain the greatest effect upon our side, and as is permissible in order to diminish the effect produced by the enemy. Exercises must be graduated from the easy to the difficult; hence they are to be carried out upon the basis of a simple tactical situation, first in the battery, then in the brigade-division and in larger units, at first in open and easy ground, then in difficult ground. By degrees, harassing circumstances of every kind are to be introduced and taken as a basis, and especially the carrying on of the action under the assumption of great losses."

And under head of "Orders" it is laid down:—"Until the action commences the place of the artillery commander is with the commander of the troop unit to which he is attached. First, he must receive from this commander the orders necessary for the conduct of the action. He then takes charge of his command or, after the grouping of the troops, of the united greater portion of it, but keeps up constant communication with the commander of the troops. If during the action batteries or portions of batteries come into position within a strange brigade-division or battery, they come under the orders of the commander of this brigade-division or battery. The re-establishment of units must be striven for when position is changed. Upon the same principle, batteries of, a cavalry division, when employed in conjunction with another force of artillery, come under the orders of the higher artillery commander in command at that spot. The battery is always, the brigade-division only so far as is feasible, directed by commands, trumpet sounds, and signals. In larger units than these, instructions and transmitted orders are substituted for the above. The employment of trumpet calls is to be restricted as far as possible. It is the especial duty of every officer and non-commissioned officer to see that the order to halt or front is *at once* executed within the sphere of his command, and that the order is passed on. Officers, or, if not available, orderlies, are to be as far as possible employed to carry the more important verbal orders. The latter must be so trained for this duty that they understand the sense of the orders they receive."

The general principles are thus summed up:—"The fire-action will, as a rule, be commenced by artillery. Here it is important in most cases to be able to develop a *superior number of guns* from the very outset, and to produce a *mass effect* at an early period. Since the *selection of the first artillery position* frequently has a decisive effect upon the general deployment, but is always dependent upon the tactical plans of the commander of the force, the artillery commander must receive orders upon this point, as also as to what force of artillery is at first to be developed. The *fire effect of artillery* should principally be utilized at ranges *beyond the zone of effective infantry fire*, but it must be laid down as a principle that our own infantry must never lack artillery support; therefore *at decisive moments artillery must never shrink from the very heaviest infantry fire.* Artillery is, as a matter of principle, protected by advanced infantry from the fire of hostile infantry. As a rule, artillery has [illegible] need of special protection. Every body of troops in the vicinity of im-[illegible] sound, to render assistance. A battery which has exhausted [illegible] must not retire, but must await the arrival of ammunition in [illegible] position. Batteries in action are not relieved, but are supported [illegible] ing. Even heavy losses are no reason for the evacuation of [illegible] ments are, as a matter of principle, commenced at the walk. *Earthwork, for purposes of protection, especially of the men, against the enemy's fire* [illegible] even in an offensive action, when there is time for [illegible] In prepared defensive positions they are to be employed [illegible] scale. Cover for limbers and ammunition wagons will only [illegible] in long prepared positions or in siege warfare. In order to di-[illegible] to order the personnel of the battery to kneel down [illegible] Artillery must gain protection against surprise by its own [illegible] in addition to the protection afforded by the other arms. When [illegible] position is occupied, attention should especially be directed to an [illegible] flank, and every flank battery is, without any special instructions, [illegible] to the flank. Should hostile cavalry get into the battery, the struggle is continued with revolver, and is by no means hopeless. Officers and men get between the wheels; the carriages of the lines of wagons close together. Horse batteries are especially adapted for speedily reinforcing a threatened point or utilizing favorable moments in the action. *Direct fire is to be preferred to indirect fire;* but the latter will have to be used when the ground or the state of the action do not permit of direct fire. In some cases isolated batteries, hidden from view, and difficult of discovery by the enemy, may, by the effect they produce in a specified direction, afford the means of gaining the superiority of fire."—*The Army and Navy Gazette.*

The German Cavalry and Artillery.

The military correspondent of the *Times*, in his fifth letter on the recent manœuvres in Germany, writes as follows on the subject of the cavalry and artillery:

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ARTILLERY.

I was not surprised to find the German artillery slower than our own. So far as my experience goes, the foreigner everywhere lacks the dash and smartness which characterizes our own Royal Regiment. I do not intend to imply that rapidity in coming into action is a sign of efficiency. The deliberation of the Germans is far preferable to undue haste; but in getting out of action, in limbering up and withdrawing out of range or changing position, in a word, in all movements, they by no means reach the English standard. On several occasions, when speed was of importance, I timed brigade-divisions limbering up, and the operation was very seldom concluded under two and a half minutes. I once saw three batteries, in action against artillery at a range of [illegible] yards, suddenly ordered to retire. Three minutes elapsed before the guns got under way, and during that time the opposing batteries put in from 50 to 60 shells. The non-commissioned officers in charge of the limbers were certainly soundly rated for their slowness; but it was not an exceptional case, and the ground was eminently favorable. It is to be remembered, however, that the German horses are by no means so powerful as our own, the drivers less experienced, and pole draught possibly less handy than shaft.

Putting mobility aside, the German artillery merits the highest praise. It was always admirably handled by its own leaders. Save on one occasion it always worked in close combination with the other arms, and the failure then was due to the officer commanding the whole force. With this one exception the batteries were always at the right place at the right time. The infantry were never left unaided. Guns advanced under the hottest fire to take their part in the decisive attack, dashing to close range if necessary, and the umpires permitted such audacity without demur. Like its sister arms the German artillery has no hesitation in facing heavy losses. The splendid results of such tactics in 1870, the vast preponderance of physical and moral superiority which they secured in so many battles, influence the gunners of to-day; and in any future war--if peace practice goes for anything—the most gallant achievements of the past will most certainly be repeated. Inoculated with such fearlessness, the artillery officers show no bigoted prejudice in favor of cover. Their chief aim is to do as much damage to the enemy as possible, and therefore the first thing they look for in a position is a clear field of fire. Immunity from loss is a secondary consideration, and it can to a certain degree be secured by bringing a large number of batteries into action simultaneously. The guns, then, approach their first position as much as possible under cover; and after the battery commanders have ascertained the section of the line they are to occupy and made certain of the target, the whole move forward and commence firing. If a clear field of fire is not to be secured, there is no hesitation in placing guns, limbers, and teams in the open; but at the manœuvres the undulating ridges favored positions on the reverse slope, just in rear of the crest, and of this advantage was always taken. The bright clear atmosphere and the absence of heather, hedges, and dark woods made observation far easier than in England, with its landscapes of more varied coloring and its misty horizons. Still I saw favorable backgrounds utilized; and the positions of particular batteries were often for a long time difficult to ascertain. As regards points of detail, I noticed that distribution of fire, when the number of batteries on either side was equal, was generally ordered. No portion of the enemy's line of guns was left unmolested. But concentration was always aimed at. Where one side was numerically superior, this was easily effected. Where no inequality existed, the fire of several batteries was "switched" from time to time on to a fraction of the enemy. I never heard instructions issued for the use of the high-explosive shells, 150 of which are carried in action by each battery, but I cannot say that this was not done.

There seems to be no objection in the German service to distributing batteries in groups, often at wide intervals; and on several occasions I noticed how such tactics exposed the enemy to oblique and even enfilading, as well as direct fire. Limbers and teams were, as a rule, kept close to the line of guns, often in columns just in rear of the flank of the battery, and sometimes beyond the flank altogether. As the choice of their position is left, I think, entirely to the battery commanders, there is much variety; but the power of changing position rapidly seems the main idea.—*Army and Navy Gazette.*

The Latest Studies on the Detonation of Explosives—The Explosive Wave. Excerpted by El Sñr. Teniente J. S. Sanchez, of the Chilian Service, from Berthelot.* Translated by Colonel John Hamilton, U. S. Army.

The explosives such as the dynamites, nitroglycerin, dry gun-cotton, and the picrates detonate with extreme violence when a relatively small quantity of fulminate of mercury or chlorate of potash is detonated in close contact with them. These small primers are generally of 0.4 gramme to each 50 gr. of charge. In practice 1.5 gr. of fulminate will explode any ordinary charge.

Dry gun-cotton will not explode by the use of iodid or chlorid of nitrogen: fulminate of silver as violent as that of mercury fails also unless a large quantity is used; whilst chlorate of potash and sulphuret of antimony accomplish it easily.

Wet gun-cotton does not explode even under the excitement of the fulminates of mercury or silver, nor by the dynamites; a primer of dry gun-cotton, itself excited by a fulminate is necessary. The weight of the primer-cartridge must be at least the $\frac{1}{200}$ of the wet powder charge.

The common charcoal powders have four times the effect when exploded by a nitroglycerin primer, that they have under ordinary means.

These high explosives, with the exception of the wet cotton, explode at a distance under the influence of the detonation of a certain mass of the same substance. This distance varies with the nature of the explosive, and with the weight used. Wet gun-cotton and explosive gelatin are insensible to the detonation of identical bodies placed quite near.

It was Abel who discovered these properties of these explosives, the basis of their adoption for war purposes, and in explaining these phenomena he says: "All explosion is accompanied with vibrations. If there be isochronism between the vibrations of the bodies to be exploded and those of the detonating bodies, these requiring to be in a state of high chemical tension, there results from this correlation that the vibrations of the detonator produce, an effect which is the cause of bringing about explosion in the other mass; or, if you wish, these vibrations facilitate the perturbing, sudden action of the mechanical forces."

This explanation is called the theory of *isochronal vibrations.* Abel, a learned chemist, accepts the sole mechanical propagation, and does not take into account the heat which undoubtedly exists. According to Abel's theory the determining cause of the detonation of an explosive is the isochronism of the

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* *Sur la force des matières explosives d'Apres la Thermochimie.*

vibrations that primer and charge produce in each other, as a string at a distance will sound when in unison with another that may be sounding.

Berthelot in his notable work "Study of the force of explosives according to thermodynamics" [*sic.* thermochemics?], gives another theory, saying: "The study of the manner in which the chemical decomposition of the different explosives is affected and especially that of detonation compared with combustion as also of explosions by *influence*, has induced me to admit the existence of an undulatory movement, peculiar and characteristic, of explosive phenomena: It is The Explosive Wave. Let us define it in a more precise manner, and more completely by showing how it is propagated in gaseous systems, substances whose physical constitution give to these researches a theoretic extension, and an interest entirely peculiar. This study was conducted in varying the conditions; the pressures of the gases, their nature and relative proportion, their form, and the class of vessels in which the experiments were made.

"In this manner we have succeeded in confirming the existence of a new kind of undulatory movement of a mixed order; that is, produced in virtue of a certain accord between the physical and chemical impulses within the body being transformed. What characterizes this order of phenomena is the production of an explosive wave, of regular surface on which the transformation is effected, and which realizes the same state of combination, of temperature, pressure, etc."

PROPAGATION AND CHARACTERISTICS OF THE EXPLOSIVE WAVE.

"This surface once produced is propagated from stratum to stratum [ridge to ridge.] These experiments were made in tubes.] through the whole mass, by means of successive shocks of the gaseous molecules which have attained a highly intense vibratory state through the heat set free by combustion, *in situ* [or to speak more exactly with a trifling displacement of the particles]. Analagous phenomena take place in both solid and liquid explosives.

"These effects are comparable to those of a sonorous wave; but with the difference that this wave is transmitted with a comparably inconsiderable velocity and slight pressure, and the velocity is determined by the physical constitution of the vibrating medium and is equal for all species of vibrations. On the contrary, the change of chemical constitution by which the explosive wave is propagated communicates to the system in movement an enormous living force, and a considerable pressure. The velocity of the explosive wave differs greatly from that of the sonorous wave transmitted in the same medium." For example, Berthelot has observed that in an atmosphere of carbonic oxid the velocity of the explosive wave reaches 1,089 meters per second while that of the sonorous wave is but 328 m. In the oxyhydric [mixture] the velocities were 2,841 meters and 514 m.

It is also to be observed that in the explosive phenomenon the wave is not of regular periodicity but of a unique and characteristic manner, whilst the sonorous waves are engendered in succession, similar to one another.

The propagation of the explosive wave is a phenomenon very distinct from that of ordinary combustion. The first takes place only when the inflamed stratum (or ridge, or slice) exercises its maximum pressure upon its proximate stratum; that is when the molecules of ignited gas are animated by a velocity, and consequently by a force of translation, at their maximum, and this is but the mechanical translation of the fact that the molecules preserve nearly all the heat liberated by the chemical reaction, which again is that which constitutes the *regimen* of detonation. This is that which is proven by the close agreement of the calculations founded on the theoretic valuation of the living force of translation with the experimental numbers found for the velocity of the explosive wave. This shows also the correlative growth of the pressures and velocities in the neighborhood of the point of inflammation."

"The characteristic or regimen of ordinary combustion obeys a system in which heat is lost in great part by radiation, conduction, contact with neighboring bodies [and inert gases], etc., with the exception of the small quantity indispensable to carry the temperature of combustion to the adjoining parts. The excess of heat tends to reduce itself to zero, as also consequently the excess of velocity of translation of the molecules; that is, the remainder of the pressure of the flame stratum against that which follows it."

Let us examine the question of the explosive wave under all its conditions.

"In the gaseous state is where the study is easiest and most rigorous and where the results are of the most theoretic importance."

This wave is propagated uniformly with a velocity that corresponds essentially to the nature of the explosive compound and which is independent of the diameter of the inclosing tubes, unless they be capillary.

Also it is independent of the pressure and of the fundamental property which determines the general laws of the phenomenon.

Finally, the living force of translation of the molecules of the gaseous system preserves all the heat set free by the reaction which produces it, and is proportional to the living force of the same gaseous system which contains only the heat that it retains at the final temperature of the experiment. This is the essential relation that experiment confirms and which enables us to calculate the velocity of the explosive wave in any explosive compound whatever.

It would appear that in the act of explosion a certain number of gas molecules of those that form the gas stratum are shot forth with all the velocity corresponding to the temperature developed by the chemical combination. Their shock determines the propagation between this and the adjoining stratum and the motion is propagated from stratum to stratum with incomparable velocity.

EXPLANATION OF EXPLOSION BY INFLUENCE, THROUGH MEANS OF THE EXPLOSIVE WAVE.

The preceding considerations enable us to account for explosions by influence, singular phenomena which have engaged the attention of engineers and artillerists to a high degree. For instance, it is well known that a dynamite or gun-cotton cartridge, detonated by a fulminate primer, is able on its part again to detonate other cartridges that may be in its vicinity, even at considerable distances and without any direct propagation by flame.

Submerged torpedoes charged with gun-cotton can be detonated by the influence of large cartridges of the same agent being discharged near by.

These phenomena are explained by the setting free of the explosive wave and its action on the medium of immersion and through the violence of the sudden shock against this medium and which is by it transmitted to the neighboring cartridges. This transmission obtains in a higher degree in solids than in liquids and better in these than in gases. The propagation is proportionately more energetic through a series of cartridges as the inclosing case of the exciting one may be more resistant, since the gas must reach a great tension before bursting it.

The explosive waves have no relation with the particles of matter which burst. The propagation of the movement in the chemically inactive medium which envelops the cartridge takes place under the form of a wave whose characteristics are essentially different from those of the explosions which have preceded this wave and are of a chemical and physical order.

In the ingenious theory of isochronal vibrations, the cause which determines the detonation of an explosive body resides in the isochronism of the vibrations of the provocative body with those that would be produced in the influenced body. Berthelot has demonstrated that this theory does not explain the observed facts and he has established by direct experiment the chemical stability of matter in sonorous vibrations. These experiments have been made on unstable gases such as ozone arseniuret of hydrogen, sulphuric acid, etc. [in presence of ethylene, oxygenated water, and persulphuric acid].

There is still the capital objection to the Abel theory that reciprocal action does not obtain. That is, a substance as gun-cotton which through *influence* explodes nitroglycerin, while itself is not exploded by the latter. Nevertheless there are some remarks to be added on this point. It is certain that Abel in the conditions adopted by him did not obtain reciprocity, still nitroglycerin can beyond doubt serve as a detonator for gun-cotton: the explosive wave propagated by nitroglycerin is at the rate of 1000 meters a second, whilst that of gun-cotton is from 4000 to 5000 m. This difference explains the superiority of nitroglycerin as a detonator [*sic*].

Under no circumstances properly speaking are sonorous waves the agents which propagate chemical decomposition nor explosions through *influence*: their living force and pressure soon fall off too much to provoke such effects. But, the propagation is due to the physical explosive wave, a very different phenomenon, in which the pressure and living force are incomparably greater and which are regenerated constantly in the passage of the wave, through its chemical transformation.

So, then, according to this new theory explosive matter detonates through *influence*; not because it transmits the vibratory initial movement but that it preserves and appropriates to itself the living force.

There are two conditions under which explosions take place through influence:

1. The constitution of the first explosive should be such as to produce through a sharp violent deflagration an explosive wave and consequently a very uniform series of shocks, step by step regenerating the living force in the trajectory of the wave within the body of the detonating material, whence results a great quantity of energy which is propagated in physical waves through the inert medium which separates the two explosives.

2. The two bodies, in order to detonate by influence, must possess such a chemical structure as to rapidly transform the living force of the molecules which strike against each other into heat-work which is that which suddenly raises the temperature of the matter to a point that produces decomposition.

Of these two conditions one may be more emphasized than the other depending on the structure of the explosive. We may not expect to realize both conditions; one generally will be sufficient. Thus for some bodies as iodid of nitrogen the second condition is sufficient, because the body detonates from being highly sensitive to friction in general and particularly to the rubbing produced by the vibration of the medium in which it may find itself.

However, the two conditions are different and no harmonic relation binds them together.—*Revista de Marina*, September, 1893.

BOOK NOTICES.

The Naval Annual, 1893. Edited by T. A. Brassey, B. A., F. R. G. S.

This work by Lord Brassey, K. C. B. and Admiral of the Fleet, leaves little untouched in the progress of navy matters during the past year. He reviews the marine construction and armament of the nations and gives as his opinion that naval representations of the different navies last year at Genoa did not give confidence to the seaman in the efficacy of his heavy armament. The heavy guns were likely to be rendered nugatory by the fire of the small quick-fire guns through unmanning the heavy pieces.

In setting forth the differences of opinion of the navy officers as to the best mode of attack, considering the present formidableness of the quick-firing gun, we are reminded of the infantry discussions as to the best plan of attacking a line with the new rapid-fire musketry. Some advocate a species of exhaustion at long taw, and then a close engagement: others would depend on a rush from the first and an immediate attack with all the arms. These, it is to be supposed, assume that their losses in the rush will not be disabling.

In armor plates the admiral gives the superiority to the Harvey process. He says that the carburization was invented by the American, Harvey, and adds as an *ergo* we suppose, "It is derived from very old methods of treating steel." Was Cammel's or the other plate makers' processes new ways of treating old metals? Probably they were, being the Briton, Cammel's, you know. Columbus and his egg will keep a-turning up forever. In general the noble admiral and his coadjutors are eminently fair and even complimentary to the United States.

The tendency of modern construction is to armor more decks. Has our own mortar system had any influence on this determination? Three decks are now armored in some ships.

Greater protection for men and guns is demanded.

France prefers closed turrets and is adopting England's arrangement of gun-*pairs* in the turret, while in England some are arguing against the pairs already adopted. Pairs reduce the weight of turret per gun.

Outjutting protecting shields are introduced in cruisers; while originality in means of protection is confessedly about exhausted.

The admiral declares in favor of the screw breech-closure as against the wedge; we Yankees think this a bit late, forgetting how hard it is for the "old nations" to give way to each other. Let us keep our youth as long as we may and grasp the best thing at once, regardless of national prejudices or local interests.

The various quick-fire guns are approximating to the same value.

The predilection for the dirigible torpedo is falling off and little is reported in its development.

The author considers submarine navigation an accomplished fact, but needing further development, we should judge, from the few skeleton cases reported.

Vertical have superseded horizontal engines.

Forced draft he declares as condemned. He lays to its charge the leakage of pipes and their failure at the ends. Farther on in the book where the water pipes are recommended and where they are reported as being adopted the question of forced draft is not discussed. Ferruling is discussed and admitted as a temporary but costly protection to the fire-pipe. It of course reduces the draft immensely.

The admiral reports on the use of petroleum as fuel. In high speeds its flame exposes the course of the torpedo-boat.

One of the most startling statements made is that the finest navies no longer fulfil the requirements for fighting at sea. Presumably he means that the most modern ship leaves the mass so far behind that *as* a navy these are not fit to cope with the best models. But we imagine that the weakness of one is the weakness of all and that relatively the situation is not much changed among the nations trying to keep abreast with the times.

In the line of improvement the tendency is to increase the power, speed, and fighting qualities of the cruiser class, while remaining satisfied with the eighteen knots of the battle-ship. Spain is even reducing this.

After a very detailed and complete description of the ships added to the French navy during the year, the author remarks that electricity is rapidly taking the place of hydraulic power in the working of heavy guns. It is now employed for turning the turrets, hoisting the ammunition, and laying the guns. The first introduction of this power was made in the Chilian iron-clad, the *Capitan Prat* [in other places spelt *Captain Prat*], and under the discussion of the Chilian navy he calls attention to the necessity for a special staff to keep this plant in order, otherwise they will be left with manual power alone. What alternate is hinted at is not set forth. Steam, hydraulics, or pneumatics, is about as liable to derangement, in action, as is electricity, and is far more cumbrous. The care of those first would probably require an extra engineer and his assistants

The only comment of importance made on the year's work on the German navy is the compliment on their torpedo-boats. For them the Germans claim twenty-six knots speed.

In Russia, after an account of work done, we learn that there is a policy of increasing the force in the Baltic. The power in the Black Sea fleet is far superior to that of the Ottoman fleet. In construction Russia is rivaling the German navy.

Austria observes with bitterness the increase of the navy of the neighboring powers.

In Bulgaria's heterodoxy in ordering gun-boats from an *Italian* firm the admiral says that the *United States* [our italics] may become a rival of England, France, and Germany in supplying war craft to countries which have no dockyards. Admiral, all we need is cheap labor!

In giving the progress of the United States the report of Secretary Tracy is quoted. *Katahdin* is misspelt. It is strange how independent of orthography compositors are in foreign words. A type-setter who would be ashamed to introduce a wrong gender in French is often entirely indifferent to correct Spanish or to German.

The admiral appears to incline to the opinion that the personnel of our navy might be improved by laws for promotion. It is difficult to say whether he approves or disapproves of the "fighting" element having the direction of all the military services which concern the navy. He conservatively says that the fact that it does so, should be noted.

In speaking of the *Benjamin Constant*, of Brazil, he quotes from *Engineer* that this vessel will carry the most powerful quick-fire armament of any in the world.

In the second chapter we find a summary of the ship building going on in the works of the leading naval powers.

Here, also, is pointed out the discount on speed that shallow water imposes when over fifteen knots is demanded. A warning to those making trial trips.

The French consider the high command given to the heavy guns by their system as being desirable: thirty feet above water in the *Charles Martel*, as against but twenty-three feet in the *Royal Sovereign* class. After a sufficient height is gained to make the gun available in fighting weather, a land artillerist cannot see the advantage of increasing the target for the enemy, or the moment of instability. The crankness of late constructions would not be corrected by higher command.

The new ships of the Italian navy discard the armor belt at the water-line and protect by two inner skins constituting a triple bottom, but (p. 49) the admiral prefers that the water-line armor belt shall be retained. Their heavy guns have a command of thirty-three feet. Criticizing the *Italia* and *Lepanto*, of 15,900 tons displacement, he says the same expenditure would have given four smaller iron-clads, carrying collectively an equal armament, and able with their four rams and their guns worked independently to engage with success a single ship of monstrous dimensions: these smaller vessels could have been distributed at four different ports if required, and could have broken through a blockading fleet with less risk: the draft of water would not have excluded such ships, as is the case with the *Italia* type, from all but the deepest harbors. No more colossal iron-clads are to be laid down for the Italian navy. The question as between a few large battle-ships and many small ones is discussed fully, and the author leans to the side of the latter. He says "It is not desirable to concentrate so much expenditure on a naval vessel which cannot claim to be invulnerable."

The admiral is complimentary to the United States in their new departure in gun and naval construction. "The powers of resistance exhibited by the Harveyized plates in the trials in Russia, in the United States, and aboard the *Nettle*, must secure the continued use of this armor. The new metal is steel with a hardened exterior surface, breaking up shot and shell on impact. As yet the Harvey plates have been found impenetrable."

Under the head of "Rams" he gives Captain Alan Thomas's bracing consolation to the sailorman combatant;—"being a strong believer in the ram I look to its being used more frequently as artillery becomes more destructive. High explosives and rapid-firing guns must sweep away unprotected or partially protected combatants very early in the fight, and the man who may live to direct the ship will sooner or later find the ram his only chance."

The admiral has an eye to the windward in remarking in regard to armored cruisers, that England is not a match for *France and Russia combined* [italics, ours]. He evidently considers as a probable danger, France and Russia uniting forces against England. This presumption is at the base of all his estimates.

For *harbor defense* he advocates the torpedo-vessels and torpedo boats, but in speaking of "building the *matériel* of naval defense" he is a bit obscure we think, in the phrase.

Some of the admiral's optimistic conclusions are pleasing to the lovers of Old England and we confess ourselves to be of the number. May never a plume of her glory be plucked from Britannia's noble brow except by ourselves, if mayhap, we unfortunately should collide. He says "France, Italy, and Germany have no reserve of power [a mercantile marine from which to draw] such as we are able to command. Our army is small * * * * but England hits the furthest reaching blows of any power in the world. She can send 15,000 men to Burmah with less fuss than France can send 10,000 men to Algiers. In other elements of power the British Empire is relatively stronger than at any former time. The amount contributed by each individual to national taxation is less, and the ability to pay is greater. The public credit stands higher than that of any other power. The supply of food is abundant and cheap. The relations between class and class are harmonious,—we are gradually effecting a national reconciliation, even in Ireland. Our colonies are thoroughly loyal, and they have freely and readily assumed the burden and responsibility of local defense. All their richest ports are now secure against a *coup-de-main*. In wealth and population they are making rapid strides. By the year 1900 the aggregate population of Canada, the Australias and the Cape will number not less than 15,000,000, and will be equal to the population of the United Kingdom at the battle of Waterloo." Who would be a Rooshan or a Prooshan when he might be an English-man? Yankees are not the only spread-eaglers. It pertains to human nature.

Under "Training under sail," the author dwells strongly on the practical as against too much theory in naval affairs. He wishes everything to be put to practical test at once: constant cruising, heavy seas, storms. Ships should come home to be re-commissioned, or to refit, or to recruit; the cruise is necessary to perfecting in seamanship. Naval maneuvers every year. He quotes Lieutenant Stanton, U. S. N., and our Soley very favorably as giving a good schedule of instruction for the naval officer, and for naval practice. He more than hints that bad seamanship was the cause of the accidents to the *Wasp*, *Naiad*, *Apollo*, *Torpedo-boat* 75, the steamboat from the *Nelson*, the *Warspite*, *Howe*, and *Victoria*. He strongly favors the Naval Reserve organization. We make fun of our own limited means of instruction, but listen to the admiral. "Time should not be wasted on drilling men at obsolete guns. On the drill-ship *Eagle* at Liverpool, 1238 officers and men; the *President* in London, 787 officers and men; at Battery Stornoway, 2000 officers and men; there is only one breech-loading gun to each, while the Wick battery, 1160 officers and men, had no B. L. gun." Our own coast-artillery schools are of the Wick battery type.

Though considering the French and German power of conscription the most effective way to man a marine, yet he shows that in the Crimean war the English command was in the Baltic a considerable time before that of the allies.

We believe that the naval reserve system of England, which the admiral is desirous to improve, would be inapplicable to our country;—we as a people are not of sufficient fixity of residence. Our own actual volunteer system, when well developed and popularized will be most likely to succeed in our state of labor interests and want of facility for legislation.

While among us many are talking of the want of advisability of retaining a marine corps, the admiral is very eulogistic of that service, and would have it increased and its functions extended. If this reviewer might be permitted to here state his policy, it would be to merge the marines in the army, and have the present functions of the marines discharged by details from the army. Arguments are plentiful for this scheme, but this is not the place to discuss the question.

The admiral regrets the abandonment of the old apprentice system and gives a scheme of years' elaborate training to prepare seamen for the navy, —and it certainly should make finished sailors,—which would be entirely impracticable we think under our socio-economic system. English captains are great theorists about high standards for their fighting force. Wellington wanted some nine years to prepare a soldier for war. Brassey wants a long time to prepare a sailor for war-cruising. Britain's best fights have been made by green crews just impressed; our own rebellion was over in four years' hard fighting. It is not to the point to say that a respectable army of nine-year soldiers would have settled it at once, the question is how long does it take to make a soldier or sailor? If a man cannot by active work be made into a soldier in eighteen months he never will be a soldier. Of course we speak of the pure manipulator. Fighting puts on the finishing touches.

As in the *Annual* for last year, the author urges the necessity of sails for instruction in seamanship. His arguments leave nothing important unsaid.

Although we may see how a steamship's company may be kept occupied, yet to a landsman it does not look like sailoring. Steam renders one so independent of wind and wave that the tendency is to neglect the observation of them and to underestimate them: if a ship be crank it will be observed quickly under sail and the chances of sticking tenaciously to a dangerous course will not be taken.

The tubulous steam-engines [water-tubes] are driving out the old fire-tube and water-pot boilers, thus getting over leaky joints and gaining speed.

The *Annual* quotes "the man who shall invent a system of steam-steering that should be as trustworthy, as say the propelling engines of a man-of-war will deserve well of his country. At present no such system exists." Here we have to remark that it would appear that steam could not be relied on as a substitute for electricity as discussed here before and as we there said, would involve a special corps for its management.

"An efficient means of communicating orders from deck to engine-rooms, gun batteries, magazines, and to the torpedo department is still a desideratum. The mechanical engine-room telegraph is constantly getting out of order. The telephone is out of the question and the electric contrivances have constantly broken down. Voice-tubes are limited in their *porte* and require practice and discretion to use them properly."

It is held that no sufficient trial is given to war-ships: That their coal-endurance is not over 70 per cent. of what they are credited with. Our American ships also fall within this charge, well sustained by the reports of our own officers. Mr. Maxim prophecies a great increase of speed by the adoption of an injector of his invention, which is to hasten the circulation of water in the boiler. The admiral demurely adds: "It should not be forgotten that Mr. Maxim believes in the possibility of a flying machine."

The subject of the triple screw is discussed; the author appears to regard this as the fifth wheel of the coach. We have adopted them for Nos. 12 and 13, commerce destroyers, in imitation of the French, but none of these have yet been tried at sea. The German *Kaiserin Augusta* is said to have made twenty-two knots with forced draught, but no authentic details are known. The *Campania* and *Lucania* have been driven by their double screws and two sets of five-cylinder triple-expansion engines at a rate of twenty-two knots.

Great praise is justly, we think, accorded to the engineer of the *Umbria* for repairing her broken shaft in mid-ocean.

The *Nueve de Julio*, Argentine Republic, is the fastest cruiser afloat.

In commenting on colonial relations under the head of "Colonial Defense," Captain Wilmot, R. N., argues over again our own old colonial troubles. History repeats itself. An officer of the Home Establishment views from his standpoint the colonies' policy with a paternal advisement that we suspect is not so convincing to the provincials. He condemns the systems the colonies have adopted for their own defense, independent of mother's employees' advice, and though we may agree with the captain in most of his criticisms, yet the reason for their independent action is very clear. It is founded in human nature. Though the colonies no doubt are loyal enough, they are just removed enough to engender a local pride, as they are held to a local responsibility. They no doubt feel that the remote incidental protection their commerce may receive from the mother's distant cruiser is small compared with the imperiled condition of their home interests. We have plenty of like feeling within our own sectional limits which mars all attempts at general seaboard defense, despite (or by reason of) our very popular representation. A remark worthy of observation occurs here, p. 121: "Misled by military experts, *who should have been the last persons called in when it is a question of attack by sea*, they [Australian colonies] wasted their substance in providing elaborate batteries, etc." Italics ours. What does General Casey say to this? Mr. Thursfield in the next article, p. 156, partly answers it—" * * * * it may be said with some confidence that in actual warfare, fleets will avoid forts and other fixed land defenses as much as possible."

In this chapter, IX, Captain Wilmot gives a most able, and quite detailed estimate for the defense of the harbors of the colonies.

In the succeeding chapter on "naval maneuvers" Mr. Thursfield does not favor English dependence to any extent on torpedo-boats. Deprecates lying at anchor, or depending upon temporary defenses. Attack, attack, attack!

Our Captain Mahan must feel it a great compliment to have a whole chapter of this noble book (*Naval Annual*) devoted to a review of his *Influence of sea-power on the French Revolution and Empire.* His book is a most far-reaching work of analysis tracing back results to their remotest causes in the most masterly manner; equally statesmanlike and professional.

In Part II of the *Annual* is given the usual accurate list of the naval vessels of the world accompanied by tables of most general information required for a full estimate of their power and condition. Seventy-six plates are given of the leading types of war-ships.

In the question of "armor and ordnance," Captain Orde Browne, R. A., quotes an officer on naval gunnery to settle the question of using heavy shell for piercing purposes:—"Supposing you are bringing the *Royal Sovereign* into close action with an enemy, with what projectiles will you load your guns? No ship afloat has armor capable of keeping out the armor-piercing shot of the 57-ton gun, if it strikes fairly directly (*sic*). Surely, then, you will attack the enemy's vital parts with these projectiles. On the other hand very few ships have armor that could be perforated by 6-inch projectiles. You will naturally then employ your quick-fire armament to riddle the upper structure and weaker parts with shell fire." From this Captain Browne deduces that "the chief uses for common shells for the heavy guns would be for engaging with ships at long ranges, when nothing can be attempted beyond *firing into the brown* [we don't know the term], or for the attack of unarmored coast-batteries."

Under rules for attack of armor about the only new point developed is that the hard-faced steel armor of Harvey and the Ellis-Tresidder compound must be *smashed* by constantly firing at the same spot, something, he adds, which is seldom feasible against ships. Russia proposes to point her hardened missiles with soft iron for use against these plates.

The 10-in. old gun and the 6-in. new gun aboard the *Nettle* have nearly equal perforation, while the former has double the energy or smashing power of the latter.

The diagrams showing perforations corresponding to foot-tons of energy, thickness of plates, and at varying distances are repeated from last year's *Annual*.

In the chapter on ordnance our Brown segmental gun is ignored, and yet it promises to be of great strength and endurance.

In the captain's remarks on cordite, he says "It should be clearly understood, then, that cordite possesses a great advantage over ordinary black and brown powder [powders?] in the fact that its products of combustion are wholly gaseous; whereas in powder there is with the gas a large proportion of solid and liquid matter. Consequently a gun firing powder discharges a projectile and some additional heavy matter, while one firing cordite discharges only a projectile so far as inertia is concerned and thus has a great advantage." Now, we think that in both and in all cases the weight of the matter producing dynamic effects has to be considered as a part of the *load*. It has itself as well as the projectile to throw out, and the throwing of itself out makes a demand on the elastic force of the gases. If P be the weight of the powder which is converted into gas, and p be the weight of the liquid and solid residue, and S the weight of the shot, then the *elastic force* of the powder-gas is called on to throw out $P+p+S$. In this regard the only advantage that cordite has is that its weight to produce the same potential is less than that required for charcoal powder, and thus it makes less draft on the *elastic force* of its gas. In the pneumatic gun (Zalinski) this law was clearly exhibited. Using different degrees of compression the firing results obtained did not follow the law of simple increase of elastic force, but the greater weight of the more greatly compressed air had to be taken into consideration as a part of the load.

Again, the captain infers that as a blank charge of cordite makes no noise, hence the noise made by charcoal powder is due to the inertia of the non-gaseous products of combustion. Well, yes, anything that serves as a *tamp* will add to the noise of an explosion: to obtain the "first-class order" of explosion from cordite we need both confinement and a high detonator, otherwise it burns slowly as will its moister forms, explosive gelatin, and dualin. Charcoal powder detonates under little confinement, but fluffs up when loose and free with little noise despite the non-gaseous products of combustion.

The question of light or heavy chases and advantageous lengths of bore as best serving the old and the new powders, would appear to require much further examination before positive conclusions are drawn. The captain gives about all that is known on the phenomena of the interior ballistics of the smokeless powders. He also quotes Benét's experiments from the *Journal of the United States Artillery*, July, 1892. These are unquestioned for the brands used. The captain makes a terrible mistake in debiting Mr. Benét, the engineer of the Hotchkiss gun, with employing in these experiments, "special *Canet* long 57-mm. guns." Won't Benét make wry faces? Such is fame! The experiments were made with and for the Hotchkiss.

The *U. S. Naval Intelligence Annual* is quoted in saying that Germany has restricted her guns afloat to thirty-five tons, 11.02'' cal., and thirty-five calibers of length.

Some attention is given to the Zalinski pneumatic dynamite gun. It is called the "black horse." [*Mirabile dictu!* has our Yankee campaigning phrase gained British acceptance? In another place we find a ship doing "her level best." There is still some hope of the acceptance of Yankee speech.] It would strike us that cordite is the complete solution of the practical difficulties attending the ærial torpedo.

In treating of quick-firing guns the writer refers to the want of *stopping power* in the small-caliber musket, and mentions the proposition to remedy this by bullets with heads made to "set out" or "mushroom" on impact (General Tweedie's). Not having knowledge of the general's experiments we do not know if the system is consonant with the necessary hardening of the ball necessary to resist the abrupt twist for the eight-penny nail projectile Our new army pistol proves nothing in favor of small calibers. The determination for its reduced bore must have been founded on the intention of fighting at long ranges instead of on close personal combat. For this latter, the old Remington 0.50'' cal. pistol is much safer. Then it is presumable that the horse could carry the additional ammunition load. It is such a poor consolation to know that you have fatally perforated an enemy, when he lives long enough to give you the same or a worse sauce.

In a list of the naval ordnance of the nations we may pride ourselves on the wisdom of our naval ordnance experts in their system of weight, bore, and length: a glance at the tables impresses one with the thoroughly practical character and simplicity of our scheme. The only apparent indeterminateness is in the varying twists of the rifling.

My lord gets into a valorous virtuous vein in reviewing our so-called commerce-destroyers. Far be it from the true Briton to build commerce-destroyers! the true Briton stands up and fights; he doesn't build ships to run away from an armed antagonist, and destroy an unarmed one, O, no!!! This brings up the old story of the Treaty of Paris. At a time when our naval force was low, England and France wanted to abolish privateering:—quite natural and "business-like" for the strongest naval powers of the world. Secretary Marcy could not take a like view of the matter for business-like reasons. Our carrying trade was great in 1856 and our naval force trifling. But (let us too play the virtuous for a moment), he declares to M. de Sartiges that our government will readily agree to an arrangement by which the private property of the subjects or citizens of a belligerent power shall be exempted from seizure by public armed vessels of the enemy except it be contraband of war, and that "with this we will consent to the placing of privateering under the ban of the law of nations." Although M. Vergé held this to be logical [and it can't be denied to be a christian advance on the Treaty of Paris] still for business-like reasons, England and France "couldn't see it" [*Introduction to the study of international law. Theod. Woolsey. West Point School Book.* § 128]. We don't remember anything unfavorable from the LORDS OF THE ADMIRALTY to the commerce-destroying of the Confederacy. They and the English rulers favored that scheme in every way under the self constituted fiction of Semmes & Co. being belligerents. For our own part we rather like the term commerce-destroyer. It evidently has a searching quality in it which makes the patient squirm. It reminds the great "carrying powers" that there are open joints in their armor which their vast navies cannot entirely cover. From our limited acquaintance with the individuals of our *cadre* of navy officers we have no fear of their shirking a stand up fight under any fair terms, and we hope they are not fools to be quiet in a 22-knot commerce-destroyer under the guns of an 18-knot first-class iron-clad and be sunk.

A table is given for the conversion of meter measures into English measures. Pity it is that we have no decimal system of measures, whatever might be the unit. Professor Meyer has offered us an excellent one with the present inch as a unit. As most civilized nations have adopted the French unit, why shouldn't we? Would it be harder for us than it was for Germany, or Spain, or Russia, to change their measures and weights? Is it necessary for us to wait for England to change? We dropped her complicated coinage for a sensible decimal system. Had the metric system then been in vogue we are quite sure Benjamin Rush and Thomas Jefferson would have blessed us with it. It would be but a gracious thank to France for the labor and expense expended on her measurements of the meridional degree. Any slight error (and no two measurements will ever agree) can in no way affect the accuracy of standard. No physical unit is unchangeable except perhaps the wave-length of light. Let us not be butt-headed like France in rejecting the Greenwich initial meridian, nor like Russia in running a calendar of her own in opposition to that of Gregory XIII.

As a whole this number of the *Naval Annual* appears to discuss and give well digested opinion on every moot question of the past year. The ships and armaments of the great naval powers are completely exhibited, and the navy estimates for 1893 are also given. However various the subjects, they all show the marks of a comprehensive and masterful grasp from the hand of the editor.

In Brassey England evidently has a man to ornament his position with brains, industry, and seamanship.

General Information Series No. XII. Information from Abroad. Navy Department. Washington, 1893. Pp. 238, index and plates.

The *Annual* for the current year, owing to the circumstances of its preparation, is not so complete as those of previous years. It was originally the intention of the Intelligence Bureau to publish no number at all, and the present one has been called into existence primarily to serve as a record of the International Columbian Naval Rendezvous and Review at Hampton Roads and New York.

The *Naval Annual*, however, cannot fail to be both useful and interesting. While, therefore, the number under notice is limited in scope as compared with its predecessors, it is nevertheless a valuable compilation. The volume opens with a description of the Columbian Naval Review It is not necessary to dwell on the character of this review. Unique in naval annals, it deserves the commemoration it receives here,—a commemoration important not only historically but professionally. A feature of this account is the publication in full of all orders and regulations governing the movements and evolutions of the review fleet.

The second division of the work is devoted to the principal naval maneuvers of 1892, taken up country by country. The English operations were strictly naval in character. With the French it was otherwise: "The naval maneuvers of 1892 were * * devoted to the study of problems connected with the attack and defense of the coasts and ports within defined geographical limits." These maneuvers obviously possess, then, for us, an altogether special interest, and all the more because "the general scheme * * was based on the supposition that the cruising force in home waters was temporarily absent through the exigencies of war, and that in its absence different parts of the coast were to be subjected to attack by hostile squadrons."

Operations were confined to the neighborhood of Toulon, Brest and Cherbourg. They included attacks both by day and by night on each of these ports. The defense was wholly under naval control. Several points call for notice. Ships engaged forts at ranges from 1000 to 3000 yards. In actual war these ranges may or may not be found practicable: we have a right to infer from these peace-operations, that they will at least be tried. Extensive use was made of search-lights. Those on shore were directed with excellent effect against ships, "not only causing them to present good targets, but also confusing the vision of those on board." This was at Toulon. In the attack of Brest, "the channel was lighted as if by day." At Cherbourg, "in some of the batteries in front of which there were crossing beams of light, it was found impossible to train the guns upon the ships with accuracy." It is noted that in this engagement (August 10), "the ships appeared to restrict the use of their search-lights as much as possible." It is a not altogether unfair deduction that the search-light is more valuable to the defense than to the attack.

Another feature of these French maneuvers consisted in the thorough preparations made for collecting and transmitting information to the defense. In addition to the usual means employed, as telephones, submarine microphones were used to make known the approach of vessels at night or in thick weather.

A detailed report of the operations of the defense would be of great value to the sea-coast artilleryman.

Passing over the maneuvers of other European countries, we come to "Notes on Naval Administration and Personnel," and then to "Notes on Ships and Torpedo-boats." These naturally are of chiefest interest to the naval officer.

The "Notes on Ordnance" show that the authorities are ranging themselves more and more on the side of smaller calibers for installation on board ship. Thus the heaviest guns to be mounted in new English battle-ships are 12-inch; Colonel De Bange is of opinion that the largest naval guns should not exceed 12.6-inch; the Austrians will have nothing greater than 9.45-inch, L/35-40; the limit of weight in Italy is fixed at 68 tons.

Wire-wound guns of large caliber are to be mounted in English ships, but the French refuse to adopt them, believing them to be weak in the breech. As regards length of guns, Krupp will not guarantee against drooping, lengths greater than 35-40 calibers. The French, however, as already noted in the *Journal*, have adopted a ruling length of 45 calibers, and are experimenting with 55 calibers.

The volume closes with "Notes on Small-arms," and the usual list of "Standard Books on Professional subjects,"

It has been said above that the *Annual* under notice is limited in scope as compared with previous publications of the same series. Apart from this, it reaches the standard that has made this series an authority on all naval professional subjects. C. De W. W.

Verschluesse der Schnellfeuer-Kanonen, by Georg Kaiser K. und K. Professor Am Hœheren Artillerie-Curse, 86 pages 8 plates, price 2 Fl. Verlag des K. und K. Techn. und Adminstr. Militær-Comites Wien, 1893.

In this little book of 86 pages, accompanied by eight large plates, the author carries out his promise made in the preface of his book on the "Construction of rifled cannon" in regard to the fermeture of rapid firing guns. The first six pages are devoted to a discussion of the causes which led to the necessity for the use of rapid firing guns; as torpedo boats are the principal cause, he enters into a short discussion of these, stating their speed, modes of attack, and length of time they are under fire before they can throw their torpedoes. Then he mentions nine requirements that must be fulfilled by rapid firing guns for use aboard ships and fully discusses these requirements.

The book is divided into parts "A" and "B:"

"A" treats of the wedge fermetures, or as we generally speak of them, Krupp fermetures. In this chapter he describes the following breech mechanisms,—Hotchkiss, Skoda, Gruson, Nordenfelt for small calibered guns, Driggs-Schrœder, Krupp, the fermeture bronze steel 7.5-cm. experimental cannon, Gericke, that used by the Finsponger cannon manufactory, and Maxim's automatic fermeture.

Under "B" he describes the interrupted (slotted) screw mechanisms and gives a complete description of the following:—Canet, Armstrong, Maxim-Nordenfelt, Schneider and that of the Société Nordenfelt (Paris) M. 1891.

Following "B" is a short description of the Krupp primer and the primer used in 7.5-cm. bronze steel rapid firing gun.

Like all of the author's lectures on gun construction, the information which this book imparts on the subjects dealt with is complete. The plates accompanying the book are of great aid to the student in reading the descriptions of the various mechanisms.

In concluding the author devotes a few pages in favor of the wedge fermeture, not so much to show that this is better than the interrupted screw mechanism, as simply to refute the arguments of those who claim that the wedge fermeture is not adapted for use in rapid firing guns. His claim that the wedge fermeture is as well adapted as the other for use in these guns is supported by sound argument and by statistics bearing on the subject.

H. C. S.

The widening uses of compressed air by Whitefield Price Pressinger, Clayton Air Compressor Works, 43 Dey Street, New York. Reprinted from *Engineering Magazine*, Nov. 1893.

The writer in a seven page article mentions a large number of the various applications of compressed air in art and engineering and shows how its sphere has constantly widened within the last few years. Its value in the construction of bridge caissons, tunnels, airbrakes, etc., are too well known to require any comment, but with the enlargement of its scope of usefulness it has found many applications in the military service ; one of the most notable being its use as a propelling agent in the dynamite gun. It has been extensively tried for training and elevating guns, for shot hoists, fans and ventilators, and will in all probability find still wider scope with further development. The very efficient mail service now carried on by means of pneumatic tubes suggests a similar application for transmitting information within a sea coast fortress and we believe is a subject ripe for investigation. These different questions have all been previously considered in the *Journal*.

J. W. R.

Aeronautics, published by the *American Engineer and Railroad Journal*. Monthly magazine, price $1, foreign countries $1.20.

"An International Conference on Aerial Navigation formed one of the series of "congresses" which have recently met in Chicago. The meetings of this Conference proved to be successful and interesting beyond expectation. The efforts of the committee in charge of them to secure the co-operation of scientific and capable men, and reports of experimental investigations, facts and positive knowledge rather than speculations or descriptions of projects, was abundantly rewarded. Some forty-five papers were contributed, covering many of the problems of æronautics and aviation, and presenting the observations and results of experiments of experts who are eminent as scientific men or experienced engineers or both. The subject was taken out of the hands of "cranks" and was discussed by those who by reason of their knowledge and training were competent to do so. These papers are of very great interest to all who have any concern in the fascinating subject of ærostation."

'At the conclusion of this conference the papers and proceedings were placed at the disposal of the editor of the *American Engineer and Railroad Journal* for publication in that paper, if it was thought judicious to make such use of them or any portion of them. After due consideration it was thought that as probably only a portion of the readers of that journal would be interested in the subject of æronautics, that it would hardly be fair or wise to devote as much of its space to that subject as would be required to give all of the proceedings at the conference, or that portion of them which has special value. At the same time it was felt that the interest in æronautics has grown, and is increasing so rapidly that it would be desirable to have all the proceedings at the Conference made accessible to those who are concerned in its subject. It was therefore concluded to print them in the form of a supplement to the *American Engineer*, which may be furnished to the subscribers of that paper at a small extra charge for subscription, and to whoever else might be sufficiently interested in the science and art of flight to be willing to subscribe to the supplement alone.'

'The proceedings of the International Conference on Aerial Navigation will therefore be issued in monthly parts, each having not less than eight pages the size of those of the *American Engineer*, and printed in the same type (brevier), and of the size and form employed in the paper already referred to.'

No. 1 of this interesting paper gives the classification of the general subject as it was considered by the congress of the World's Fair. In addition are numerous papers and discussions touching directly upon the questions of flight.

No. 4 contains a contribution to the discussion of ærial navigation held at the Chicago Conference last summer. The article is written by Professor S. P. Langley and deals principally with *The Internal Work of the Wind.* It would be impossible to give even a synopsis of the original researches and results of this earnest and profound investigator in this line. One of the prominent features of his paper is graphic representation of his measurements of wind velocity. He constructed his anemometer to register several times a minute and found that the wind's velocity varies during each minute through wide limits. The wind is thus found to be "variable and irregular in its movements far beyond anything which had been anticipated so that it seemed probable that the very smallest part observable could not be treated as approximately homogeneous, but that even here there was an internal motion to be considered distinct both from that of the whole body and from its immediate surroundings. It seemed to the writer to follow as a necessary consequence that there might be a potentiality of what may be called 'internal work' in the wind."

J. W. R.

Iron Alloys with Special Reference to Manganese Steel,* by Mr. R. A. Hadfield, Sheffield, England.

This is a pamphlet of forty-nine pages. It constitutes Mr. Hadfield's contribution to the International Engineering Congress which met in Chicago in August. Probably no metallurgist has a more profound knowledge of the properties of the alloys of iron than Mr. Hadfield; certainly no one has a wider practical experience in the manufacture of these alloys.

The exhaustive study of Mr. Hadfield on the "Alloys of Iron and Chromium" was recently noticed in this *Journal*.† The same careful treatment is found in the paper now before us. The author discusses his subject under four main heads, namely. I. Iron; II. Carbon-Iron Alloy; III. Manganese-Steel; IV. Uses of Manganese-Steel. Under the first heading he gives special consideration to the so-called Beta-iron theory. This Beta-iron is according to the theory, the very hard product formed in an iron alloy by water quenching at suitable temperature. This hard beta-iron is taken to be a distinct form of iron, differing from alpa-iron (ordinary soft iron) in the structure of the molecules. Mr. Hadfield asserts that his own experiments and his translation of other facts leads him to doubt the truth of the theory. He says: "Iron may undergo allotropic modifications, but, at any rate, this cannot be conscientiously accepted until more direct proof is forthcoming. Upon the suggestions put forward hitherto, it is difficult to believe that the profound molecular changes which occur upon quenching the comparatively soft metal steel are not directly dependent upon the carbon present, or that the latter only plays an indirect or secondary part, as the Beta-iron theory indicates." As expressed in his treatise on chromium-steel, he is firmly of the opinion that the only true explanation of the hardening of steel is, that it is due to the influence of carbon in combination with the iron; the presence of silicon, chromium, manganese, *etc.*, merely operates to modify the effect of carbon bv determining whether it takes the graphite or combined form.

Coming to manganese-steel the writer traces in a brief way the development of the present commercial product. The importance of the manganese alloy was first noted in 1840, but it was necessary first to have ferro-manganese manufactured on a commercial basis before further steps could be taken. The Terre Noire company is given the chief credit in this work, and it is to this company that "we owe the first production of a rich and cheap ferro-manganese."

Favorable comment is especially made of the samples of steel exhibited by the Terre Noire Company at the Paris Exposition of 1878. Samples were on exhibition containing as high as 2½ per cent. of manganese. "But at this point owing to the brittleness of the product, whether cast or forged, their experiments stopped. Naturally enough they imagined further additions would only produce still more harmful effects." Subsequently Mr. Hadfield

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* *Transactions of the American Institute of Mining Engineers.*

† Vol. II, No. 1, January, 1893, p. 154.

had occasion to carry the percentage of manganese higher in experiments conducted by him at the Hecla Works, Sheffield, and these experiments "resulted in the discovery of what is now known as manganese-steel."

Up to 1¼ per cent. of manganese there is little or no effect on a low carbon steel, but after passing 3 per cent. there is a marked change; especially between 3½ and 5 per cent., within which limits there is a decided falling off in strength and ductility, the product being exceedingly hard and brittle. This deficiency in strength holds up to about 6½ per cent. of manganese, but as soon as this point is passed a remarkable increase of all good qualities takes place; the strength, toughness, and ductility all increase in increasing ratio up to about 14 per cent., but on passing this they all fall rapidly again until at 18 to 20 per cent. of manganese we again have a weak brittle metal.

The remarkable strength and ductility of the 14 per cent. metal is only given when the sample is water-quenched.

Among other noteworthy facts connected with this alloy is, that the magnetic permeability of steel decreases as the percentage of manganese increases until at 14 per cent. it is practically non-magnetic. The conductivity of the metal for heat decreases also as the percentage of manganese increases. In illustration of the non-magnetic property of manganese-steel the author says that a magnet with a lifting power of nearly a ton will not attract a few grammes weight of 12 per cent. manganese-steel. In referring further to this matter he remarks: "No satisfactory explanation of the non-magnetic qualities of this steel has yet been brought forward, though the material has been examined by most of the leading scientists of the day. It is certainly remarkable that iron which, in the form of carbon-steel, makes the best permanent magnet becomes, when existing as an alloy or combination of manganese, practically non-magnetic."

This property is odd enough but it is pushed aside by a recent experiment of Mr. Hadfield. He found by heating a bar of the ordinary non-magnetic alloy in a cementation furnace imbedded in charcoal that while the per cent. of carbon in the bar changed but little, the bar had become susceptible to magnetic influence. "This was an interesting result," he goes on to say, "but the next portion of the experiment was still more so. The same bar, 1¼ inches square was heated at one end, forged down into a thinner section, ½ by ⅛-inch, raised to a yellow temperature (about 1000° C), water-quenched and bent double cold as is usual with manganese-steel under this treatment. This portion had again become non-magnetic. Thus in the same bar there resulted one portion unaffected by strong magnetic influence, while the other portion was susceptible to a considerable degree." The author cites the experiment against the Beta-iron theory.

Under the head of "Uses of Manganese-Steel" the author gives illustrations and describes the life features of the various articles now in general use made of this metal, referring especially to the product of his own works. This portion of the paper is replete with tabulated statistics of experimental tests, many of them being comparative between ordinary steel and manganese-steel. It would seem that this alloy ought to come to the front as an armor metal. A plate having a body of 13 per cent. manganese-steel with a hardened face ought to behave in much the same manner as a nickel-steel plate Harveyized. Mr. Henry M. Howe refers to this use of manganese-steel in a recent paper published in the *Journal of the Franklin Institute* (February and March, 1893). He states that manganese-steel armor plates 2 inches thick have been tested giving results 77 per cent. better than wrought-iron and 48 per cent. better than carbon-steel plates.

Those interested in the properties of this iron-alloy will find much to interest and instruct them in this paper of Mr. Hadfield, and also in the excellent paper of Mr. Howe referred to above. E. M. W.

The Art of Subsisting Armies in War. Compiled by Henry G. Sharpe, Captain and Commissary of Subsistence, U. S. Army. New York: John Wiley & Sons, 1893. Pp. xv., 222.

It is hard to see what class of readers will be benefited by this work. The student of the art of supplying an army in the field will learn nothing from it, while the general reader will be frequently in doubt whether he is reading a work on strategy and tactics, rather than one on supplying an army. There is room in our service for a business-like treatise on army supply. Such a book, for obvious reasons, should record past *American* experience, and provide for future *American* conditions. Captain Sharpe's does neither. It is only just however to say that he has not tried to do the former, on account of inability "to consult the official records of that [the civil] war." But this ought not to have prevented him from investigating the second subject. Such an investigation would be of real value, and would do more to show the "necessity for the establishment of a Staff School" [author's preface], than a library full of generalities on transport, magazines, requisitions and the like.

These objections apart, the chief criticism to be passed on Captain Sharpe's book is that it is a piece of patch-work. The data have been collected from a great number of sources, and then pieced together. There is a lack of continuous treatment: the material has not been digested. Whole paragraphs are, so to speak, in the air,—entirely disconnected from what precedes and from what follows. In many cases the statements made are so general in character, as to be of little practical utility.

Of the 222 pages, 64 are assigned to the "Rise and Development of the Art." In tracing this development, the author leads off with the ancient Egyptians, follows with the Persians, Greeks and Romans, and concludes with the Middle Ages. Without stopping to question the utility of going back to the Egyptians, &c., &c., the reader here again will ask himself if the author has not mistaken his object. By merely changing its title, the chapter on the "Rise &c.," would serve just as well for a very brief statistical account of some of the principal campaigns of by-gone days, with occasional remarks on organization and supply.

In spite of its radical defects, however, Captain Sharpe's little book will do a useful work, if it will help to fix the attention of the authorities upon the important subject of which it treats. C. De W. W.

The Service of Security and Information by Captain Arthur L. Wagner, U. S. A. Washington: J. J. Chapman, 1893. 265 pages.

"This book lays claim to no other credit than that of being an earnest attempt to meet the demand, often expressed, for an American text-book on the subjects discussed." Captain Wagner is Assistant Instructor in the Art of War at the U. S. Infantry and Cavalry School and has had, therefore, proper opportunities to measure the demand which he mentions: he may also feel sure that his brother officers, in all branches of the service, are grateful for the manner in which he has met it. The writer of this notice promptly recommended the adoption of the book as a text-book on the subjects which it discusses, in his course of Military Science at the Artillery School and the recommendation was approved.

The demand for American text-books is a good sign. We are beginning to understand that the details of our profession vary as greatly with "national characteristics" as do those of commerce or of jurisprudence. When, years ago, we were obliged to create and direct great armed forces, Europe sent us old muskets, second-hand officers and patronizing counsel: perhaps we were a little constrained and diffident and received her advice with something of inquietude and misgiving. Fortunately for us, we commanded the services of cool heads as well as of stout hearts; of men who saw that lack of traditions meant absence of trammel and was clearly to our advantage, and who entered, undismayed, on their unparalleled task. Our war was followed closely by the wars of '66 and '70; so closely that military criticism has since been busy with them all, during the long peace. The result,—we might say the verdict,—has been a vindication and is well known to all who will read this. The author of "Security and Information" was among the first to dissect foreign official accounts of recent campaigns in the light of the American War which preceded them. The same knife has been freely and pitilessly used,—be it said to their credit,—by foreign officers of authority and standing, notably German and English. For these reasons and for others which we cannot go into here, American military methods and ideas of to-day, as evinced in discussion, papers, essays and periodicals are aggressive and independent: we have finally cast off alien tutelage and it has left no trace,—save, perhaps, the "property" helmet which we still see fit to wear.

The headings of chapters,—Advance Guards, Rear Guards, Outposts, Reconnaissance, &c., &c., may be anticipated from the title: but there are, in addition, chapters on Spies, Newspapers, Orientation and Map reading, and Indian Scouting. At the last there is a complete list of convenient questions covering the entire text as with a summary or analytical index. The chapter on Indian Scouting,—to which most readers will turn at once,—is naturally narrative in style "as contributing to a demonstration of the fact that sound theories of war are simply the accumulations of experience." The demonstration is sound as it is new and timely. The chapter on newspapers we would abridge to one of its sentences: "No newspaper correspondent should be allowed to accompany the army, * * " and we do not agree with the author in his estimation of "the power of the press in the United States." The public is a little tired, perhaps, of the meddlesome and verbose reporter and does not grieve when he is ejected.

The book must soon be in the hands of every officer or he will have convenient access to it and there is so little to find fault with that anything beyond general mention would be out of place here. It is a drill book, in the best sense of the word, and the note of warning in italics on page 24 might well appear in generalized form on the title-page. There will be some difference of opinion as to the value of the formulated "drill" for advance guards. It should have a tendency to establish something of uniformity of method throughout the service, and this is desirable.

On page 15 it is made the duty of the commander of the vanguard to transmit to the commanding officer all information that he may gain about the enemy, *first testing its accuracy as far as possible.* The instructions in (our own) italics should be omitted and it should be provided that all information be transmitted literally as recived—with a statement of its source. "Great part of the information obtained in war is contradictory, a still greater part is false, and by far the greatest part is of a doubtful character. What is required of an officer is a certain power of discrimination, which only knowledge of men and things and good judgment can give. * * This is not a trifling difficulty * * but it is enormously increased when in the thick of war one report follows hard upon the heels of another; it is then fortunate if these reports in contradicting each other, show a certain balance of probability, and thus themselves call forth a scrutiny. It is much worse for the inexperienced when accident does not render him this service, but one report supports another, confirms it, magnifies it, finishes off the picture with fresh touches of color, until necessity in urgent haste forces from us a resolution which will soon be discovered to be folly, all those reports having been lies, exaggerations, errors, &c., &c. In a few words, most reports are false, and the timidity of men acts as a multiplier of lies and untruths. * * Firm in reliance on his own better convictions, the chief must stand like a rock against which the sea breaks its fury in vain. * * This difficulty of seeing things correctly, which is one of the greatest frictions in war makes things appear quite different to what was expected."

On Plate I the drawing indicates one platoon, reserve, in platoon front and on Plate III three companies, support, in column of companies: that this is intentional and not a mannerism of construction in the drawing is shown on Plate II where the reserve is drawn and lettered as in "column of fours." As the text is silent on the subject it would seem as though this formation were considered desirable but ideal. In our opinion it is neither desirable nor practicable.

The commander of the advance guard must maintain a proper distance from the main body. This distance will often vary on a single day's march according to terrain and weather. No book with which we are familiar, covers or even mentions this important duty.

The instructions for infantry and cavalry patrols are comprehensive and excellent throughout. American cavalry (as the author somewhere indicates) is especially fit for this duty in equipment, temperament and drill. In this connection it is interesting to note that recent German regulations restoring a regiment of cavalry to each infantry division (divisional cavalry) also decree that in future no body of troops down to, and including single battalions, are to be without a few cavalrymen for reconnoitering purposes, and it is expressly stated tnat the number of cavalrymen is to be measured by the necessities of each case, so that it will not be necessary to employ infantry patrols when on the march.

W. A. Kobbé,
Captain 3rd Artillery

Upon the Reduction of the Draft in Field Batteries, by Major Bertrang, Commanding the Horse Batteries of the 4th Regiment of Belgian Artillery.

It appears that at the Beverloo maneuvers in August, 1891, the 38th and 39th batteries, 4th regiment, equipped for war, were heavy and cumbrous. At the same time the author was struck with General Wille's statement that although at Vionville and Gravelotte some batteries fired more ammunition than was carried in their caissons the neighboring batteries made up the deficiency, no batteries being obliged to call upon the ammunition trains for supplies. This fact, with the large quantities of ammunition unused; the data furnished by the German method of re-supplying the trains when exhausted; and the enormous expense attached to such transportation, led the writer to undertake the present investigation. The object is therefore to seek a means by which the draft of the caissons may be lightened by a different distribution and a reduction of the amount not used. Space will not allow us to enter into any of the reasoning employed, but we may mention the scope covered by his investigation:

I.—AMMUNITION SERVICE. (A.) *Basis of calculation of ammunition.* (B.) *Calculation of ammunition,* containing several sub-heads giving cases of isolated battery, group, etc. (C.) *Cavalry batteries.*

II.—SERVICE OF SPARE STORES, PROVISIONS AND BAGGAGE. (A.) *Present carriages,* three sub-heads. (B.) *Proposed carriages,* two sub-heads.

Conclusions and appendixes. The appendixes are very numerous and give data relating to expenditure of ammunition for all wars during this century. In his conclusions he shows a great gain in horses, men and carriages.

J. W. R.

DEPARTMENT OF SCIENTIFIC AND MILITARY INFORMATION.

Under this head it is proposed to review and summarize the contents of current scientific and military publications as they are received in exchange for the *Journal*. This will enable the reader to see at a glance what questions are being discussed and investigated by leading scientific and military men throughout the world. Having the titles of all articles with synopses of the important ones, with correct references as to date and place, before him, it will be an easy matter for the student to select those in which he may be specially interested, and to obtain them when desired for any work in which he may be engaged. All who may be interested in this most important function of the *Journal* are requested to lend their aid to its development and are urged to correspond with the editor with view to profit by the opportunity. [Editor of the *Journal*.]

Revue d'Artillerie.

SEPTEMBER.—Elementary steps for the placing of shrapnel fire. *Discussion of results found.* Study upon the efficacy of shrapnel fire. Conclusion of the article in which we find the subject is exhaustively treated. Deviations of the projectiles, also variations of their fuze, and their effects upon the fire. The subject is illustrated by diagrams showing slope of earth, etc. *Calculation of war fire.*—Treated in a manner similar to above. *Efficacy of a regulated fire with a given approximation.*—Treated as to the zone of the object and forking the target; properties of the zone; case of the fork not verified; case of fork verified; case of the inferior bracket with eight deviations; probability of the object occupying any portion of the bracket, limits of the zone of the object; effect of a turn of the elevating screw; echelon fire; masked objects, observatory, etc.

General Eblé. Methods and formulas of experimental ballistics.

DECEMBER.—Notes upon the construction of a bridge over the Loire in the maneuvers of the 11th Army Corps in 1892. A comparison of material of field artillery. The initial direction of pieces in indirect fire. Methods and formulas of experimental ballistics.

Revue Militaire de l'Etranger.

SEPTEMBER.—The Servian Army in 1893. The railroads of the northwest of India.

OCTOBER.—The war budget in Italy for the exercises of 1893-94. The great maneuvers of *Krasnoé-Sélo* in 1893. The Danish

Infantry fire regulations. Reorganization of the Dutch Navy.

NOVEMBER.—The new regulation upon field fortifications in the German Army.

Part I.—General considerations. *II.*—Execution of the work of field fortification. *III.*—Works of attack constructed by the infantry and pioneers. The article is thoroughly illustrated, showing sections, elevations and plans of the different trenches and works.

The Servian Army in 1893.—Present military organization. The English Navy and the budget for 1893-94.

Revue du Gènie Militaire.

JULY–AUGUST.—The new cavalry quarters of Vincennes. 2nd note upon the trace and measure of the carapace in Béton cement. How the Versailles Army effected its entry into Paris in May 1871.

Revue Maritime et Coloniale.

SEPTEMBER.—Civil and military organization of China. Project for route signals in fog and at night.

OCTOBER.—Geometry of diagrams. Economic questions upon indicator curves. Geographical, topographical and statistical note upon Dahomey. An exploration of the magnetic field in the interior of armored conning towers. Description of a new hydrographic circle. Statistics of shipwrecks and other accidents at sea.

NOVEMBER.—Agde.—Its origin and history. Conclusions and recommendations of the engine and boiler commission. Description of a temporary rudder. Jean-Gaspard Vence. Vocabulary of powders and explosives. Statistics of shipwrecks.

DECEMBER.—Note upon a project of steaming-power-curves.

In this note the writer gives diagrams of steaming power of ships in terms of the speed. The diagrams cover ten cases varying by one-tenth from full to one-tenth supply of coal.

Vocabulary of powders and explosives.

Revue du Cercle Militaire.

SEPTEMBER 10.—The Swiss in 1892 (continued). Our naval maneuvers as judged by the English. New instruction upon fire for the Italian Artillery (continued).

SEPTEMBER 17.—The great maneuvers of 1893 (continued). The new German regulations upon field fortification (continued).

OCTOBER 1.—A French system of light bridges for infantry.

OCTOBER 15.—Three advance-post maneuvers of the 86th Infantry.

OCTOBER 22.—The "Okhotniki" Russians and night combats.

OCTOBER 29.—The problem of mounted infantry solved by the use of bicyles (continued). A letter with respect to the great maneuvers.

NOVEMBER 12.—Instruction maneuvers for the reserve officers of the land army.

DECEMBER 17.—Spain in Morocco,—the mobilization of the Spanish Army.

DECEMBER 24.—The Maxim machine gun and the Swiss Cavalry.

Journal de la Marine, Le Yacht.

SEPTEMBER 2.—Trial of plates for the Russion armored ship "*Trois-Saints*,"

SEPTEMBER 9.—The loss of the *Victoria*. The new English cruisers *Magnificent* and *Majestic*.

SEPTEMBER 16.—Submarine torpedo-boats,—their rôle in future naval war. The English cruisers *Powerful* and *Terrible*.

SEPTEMBER 23.—The leading of squadrons.

SEPTEMBER 30.—The visit of the Russian squadron.

OCTOBER 7.—The Italian marine budget.

OCTOBER 14.—The Russian squadron at Toulon.

OCTOBER 28.—The Franco-Russian *fêtes* and the launching of the "*Jauréguiberry*." The Spanish cruiser "*Infanta-Maria-Thérésa*."

NOVEMBER 4.—The departure of the Russian squadron. The English torpedo carrier *Vulcan*. Accident to the boiler of the *Dupuy-de-Lome*.

NOVEMBER 11.—The superstructure of war ships. American projects for submarine torpedoes.

NOVEMBER 25.—A campaign in England for an increase of the navy (continued), The fleet of the Brazilian government.

DECEMBER 2.—The double reflecting micrometer of Admiral Fleuriais.

DECEMBER 16.—The augmentation of the English fleet.

DECEMBER 23.—The French navy. The mobile defense of coasts.

La Marine de France.

SEPTEMBER 17.—The Italian naval maneuvers (continued). Last echo of the English maneuvers.

SEPTEMBER 24.—Reflections upon the war marine (continued).

OCTOBER 8.—The defense of Corsica.

OCTOBER 15.—A Colonial Ministry. The last days of the north squadron.

OCTOBER 22.—The canal of the two seas. Corsica and Contentin. Necessary experiments.

OCTOBER 29.—A greeting to the officers of the Russian squadron. The war material of the United States. Semaphores in time of war.

NOVEMBER 5.—The Paris sea-port question.

This article forms part of a discussion relating to the project of connecting Paris with the sea and forming a capacious harbor above the mouth of the *Seine*. The political, financial and economical questions of the scheme are considered.

Considerations upon naval technology.

NOVEMBER 12.—The canal of the two seas.

NOVEMBER 19.—The defense of the coasts. The crisis in the personnel. Paris,—coasting trade port.

DECEMBER 16.—Is the navy ready? Paris a sea-port. The royal naval college of Greenwich.

DECEMBER 23.—Torpedo boats. English ship yards and French ship yards.

Revue d'Infanterie.

SEPTEMBER.—History of Infantry in France (continued). The instruction of Infantry.—A single rule (continued). Infantry against Cavalry. Methodical exposition and summary of Infantry tactics in combination with Artillery in the offensive and defensive combat (continued). Infantry instruction and short term service. The Hygiene of European troops in the colonies and colonial expeditions (continued).

Revue Militaire Universelle.

OCTOBER.—The service of the Engineer troops in Armies.

The siege of Mézières (continued). The war of Secession. Night marches and operations. In Algeria.

NOVEMBER.—The war of Secession. Night operations and marches. The three years' service and the recruitment in the subordinate lists in the mounted batteries of field Artillery. The French Cavalry of 1800 to 1815.

Le Génie Civil.

SEPTEMBER 9.—Trials of an electric locomotive.

SEPTEMBER 16.—A new gas motor.

SEPTEMBER 23.—Petroleum motors. A new system of electrical traveling crane.

SEPTEMBER 30.—The transmission of force by electricity.

OCTOBER 7.—Ship elevator at San Francisco.

OCTOBER 14.—The artillery of the future.

OCTOBER 28.—The electrical projections of the *Place de l' Opéra* during the Franco-Russian *fêtes* and modern electrical projectors. Measure of efficacy of dynamos. New cryptography based upon the system of Commandant Bazeries.

NOVEMBER 4.—Aluminum barge for the Monteil Mission.

NOVEMBER 11.—Color photography,—its principle, history and results. Perspective applied to topography.

DECEMBER 23.—Trials recently made upon plates of the Harvey process.

Mémorial des Poudres et Salpêtres.

NOS. 1 and 2.—Dictionary of Explosives by Major J. P. Cundill, R. A. Note upon a few formulas of ballastics.

The note relates to the recent discussion which has been carried on relative to the "field gun of the future." The writer takes General Wille's data and considers them analytically and goes into the fundamental conditions of interior ballistics which must be fulfilled in order to produce the gun projected by Wille. The discussion is based upon Sarrau's investigations. The writer establishes the fact that in order to design a gun the caliber, weight of projectile, velocity, and allowable pressure must be stated, leaving the variables, the density of loading and modulus of the powder to be determined. The argument seeks to find under such circumstances the minimum length of gun. The substance of the discussion is as follows: *I.—Study of the Wille gun.* The results under this head are extremely instructive. Three cases are assumed,—the maximum pressures allowed being $\left.\begin{matrix}2500,\\3000,\\3500,\end{matrix}\right\}$ kg. per square centimeter. The values with Wille's data give lengths of gun 61.44, 51.69 and 45.34 calibers instead of 40 as laid down by Wille. The powder assumed by Wille is the strongest attainable. *II.—General study of a cannon with respect to minimum length.* This part relates to consideration of the modulus of the powder. The writer here gives formulas for computing the different functions of the modulus with tables covering the cases considered. The article closes with an example; the factor $\frac{fa}{\gamma} = 3$ and x(modulus) varies from 1. to .6 and the length of gun varies from 20 to 100 calibers. Maximum pressure = 2250. The velocities for these different values of the variables are tabulated and form a valuable study upon the subject.

Upon the elastic vibration of cannon.

An ivestigation with reference to the vibration which takes place in a gun when subjected to the strains of discharge. The author utilizes the experiments of Sarrau and Vielle made to ascertain whether powder gases really exercise a static or a dynamic effect upon the gun. The analysis is very deep and involves the differential equation of wave motion. Practical application and talks giving values of certain functions computed.

Note upon a process of drying gun cotton.

This process has for its object the elimination of the danger in drying gun cotton, on account of dust and other causes. It is proposed to dry the product by mixing with wet gun cotton a solution containing alcohol. The process and formulas, etc., for its application are described.

Explosion which occurred July 1, 1891, in the mill-stone shop, No. 3, of the Saint-Ponce powder factory.

Contains reports, etc., with respect to the accident embracing general circumstances, loss and responsibility.

Specifications for gun cotton manufactured for the navy department.

Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils.

No. 9.—Notes upon polyphase alternating currents. The society of civil engineers during the siege of Paris.

Revue Militaire Suisse.

November.—The military velocipede, its rôle and use. MacMahon, the Marshal of France. The association of sub-officers.

Revue de l'Armée belge.

JULY–AUGUST.—Offensive combat of the Army division (continued).

Preparation of the attack. Assaults.

Considerations upon the fundamental principles of different projects presented in Austria for the organization and employment of the troops and general-staff of the engineers. The occupation of defensive positions. Historical, political and military study of Constantinople and the Peninsula of the Balkans. Study upon applied interior ballistics.

The article is an application of formulas proposed in *Tratado de Balistica interior.* The writer enters into a theoretical discussion and deduces principles. He then states several practical problems and proceeds to solve them. The motion of the projectile in the bore and specific value of the force of the powder are considered.

SEPTEMBER–OCTOBER.—A study upon light infantry, the organization and use of the engineer troops in field and siege warfare, by General Brialmont. Study upon infantry engagements in combination with other arms. The occupation of defensive positions.

A critical review of the defensive positions assaulted during the Franco-Prussian war. The writer quotes largely from recent military authorities and clearly illustrates the difficulties to a frontal attack. The Turco-Russian war also furnishes illustrations of the same subject.

Modifications introduced into the Mauser gun since 1889. Tests made in the United States for the determination of a smokeless powder and a small caliber arm.

NOVEMBER–DECEMBER.—Krupp at the Chicago Exposition of 1893.

The entire number is taken up in a description of Krupp's exhibit.

La Belgique Militaire.

DECEMBER 31.—The forts of the Meuse.

An article showing the economy secured by building cupolas instead of rampart-forts on this line. The amount saved is estimated at ten million francs and would now be considerably greater.

Maneuvers of infantry.

Memorial de Artilleria.

AUGUST.—Shrapnel fire (impressions of the practical school). Mountain Artillery and economy. The equipment of a siege train. Note referring to the cylindrical shells used in the 17th century. Modern guns and their ammunition (continued). Points upon the military organization of Great Britain in 1893 (continued),

SEPTEMBER.—The fourth regiment of horse Artillery and the general order with respect to the schools of practical exercises of 1892 (continued).

OCTOBER.—Our corps in the East Indies.

NOVEMBER.—The equipment of the first section of the siege train. The fortress of Melilla.—Topographical and strategical situation.—Military history and geographical importance.—Events of October, 1893. A few words upon our practical schools.

Revista Cientifico Militar y Biblioteca Militar.

AUGUST 1.—The armament for our infantry (continued). The minimum caliber of guns (continued).

SEPTEMBER 1.—Servia. Military life in the 16th Century (continued).

SEPTEMBER 15.—The health of the soldier.

OCTOBER 1.—The question of Melilla.

OCTOBER 15.—The tactics of the future (continued).

NOVEMBER 14.—The health of the soldier (continued). The Mauser gun (7.65 mm.) (continued).

DECEMBER 1.—The Campaign of Melilla.

Revista General de Marina.

SEPTEMBER.—The voyage of the ship "*Santa Maria*" to Chicago (continued). Vocabulary of modern powders and explosives (continued). Contraband of war. Administration of hydrography at Washington and pilot charts. The raising of the "*Howe.*" Information acquired in the recent English maneuvers.

OCTOBER.—Our naval maneuvers (French). Notes upon the length of cannon. Short cannon. The Great Canary Island. The most important changes introduced into the Whitehead-Schwartzkopff torpedo. The perturbation of the needle on board produced by electric light. Armored cruisers.

NOVEMBER.—Guns and armor.

DECEMBER.—Development of the military and naval power in the United States.

Boletin del Centro Naval.

JULY.—Method of obtaining latitude by means of equal altitudes measured with the sextant. The reorganization the navy requires first of all, new methods.

AUGUST.—Modern construction. The new infantry armament.

Circulo Naval, Revista de Marina.

JULY.—Regulation of the loading line in the English merchant marine (continued). Memoir upon the correlation of electrical phenomena, static and dynamic, and the definition of electrical units (continued). Vocabulary of powders and explosives (continned).

AUGUST.—The loss of the *Victoria.* The Buonaccorsi automobile torpedo.

SEPTEMBER.—The Maxim machine gun.

This article gives a general description of the gun with its methods of operation and uses, and shows modifications to suit different circumstances of service. The description is lavishly furnished with plates which thoroughly illustrate the subject.

The hydrography of our coasts and the instruction of officers. Recent studies upon the detonation of explosives.—The explosive wave (theory of Berthelot).

OCTOBER.—Submarine mines,—defense made in Caldera Bay.

A description of the plans given with illustrations showing apparatus and operation.

Upon a cause of terrestrial magnetism and atmospheric electricity. Our military marine from the retirement of Lord Cochrane until the independence of Chile. History of submarine boats.

Revista Militar.

SEPTEMBER 15.—The new military territorial division in Spain. The army and the country. The codification of our own military legislation. Excerpts of studies upon military education and organization (continued).

SEPTEMBER 30.—General Miribel. Suspension of the sword to the saddle.

OCTOBER 15.—Our military maneuvers.

OCTOBER 31.—The imminent war. The regulation schools and the project of their reorganization.

DECEMBER 15.—Health tactics in wars of to-day. The great French maneuvers.

Revista de Exercito e da Armada.

SEPTEMBER.—Modern explosives and smokeless powders (continued). An experiment upon military velocipedes. A short study with respect to the ballistic effects of the modern small arm. Portuguese military architects and engineers in the service of Portugal. A few words with respect to lightening and diminishing the weight of the various articles of individual equipment and dress. Colonization.

OCTOBER.—A few thoughts upon the tactics of the combat of to-day. The War Course. The management of the artillery in the recent brigade exercises.

NOVEMBER.—A few thoughts upon present combat tactics,—war explosives. Study upon combat tactics. The 1st Battery of Artillery, 4th Regiment, in the expedition to Mozambique in 1891. The employment of Artillery in our recent brigade exercises.

Revista da Commissao Technica Militar Consultiva.

APRIL–MAY.—Artillery of large caliber. The question of new armament. Notes on artillery. Letters to our foreign readers upon country of the great river of the south.

Rivista di Artiglieria e Genio.

SEPTEMBER.—The oblique fire game—Artillery.

Article treated under the following heads:

Introduction. General rules. Material necessary to play the game. Method of proceeding with the game. Settlement of allowances (points). Conclusion. The article is elaborate, showing methods of obtaining components of motion and the distance of the ship. Diagrams clearly show methods of procedure.

Fortress war,—reciprocal conditions of the attack and defense.

The following influences upon this kind of war are considered. *Curved fire, torpedo shell.* The writer here proceeds to show the effect of this new engine of attack upon modern fortifications, quoting numerous authorities and experiments to show that fortifications will have to be rebuilt in order to give the necessary protection. *Smokeless powder.* The new powder is considered to favor the defense in that the latter can maneuver artillery under cover whilst the assailant may not be able to come within effective range. *Indirect fire.* This subject is treated in full and the advantages of this method of directing the fire is considered to favor the defense since in time of peace all arrangements may be made and the ground thoroughly studied. The assailant will be comparatively ignorant of these conditions.

Practical ideas upon the fire of fortress artillery. Some considerations upon the direction of siege artillery fire.

OCTOBER.—The re-equipment and the service of the field artillery. Mountain war, the Campaign upon the Alps. Practical questions, the field artillery and its employment in the maneuvers with the other arms.

NOVEMBER.—Mountain war,—Campaign upon the Alps, 1747. A few thoughts upon instruction with respect to choice and occupation of position by a battery of field artillery.

Organ der Militaer-Wissenschaftlichen Vereine.

No. 8.—The disposition of Artillery in an attack on fortifications. Mountain tactics.

Rundschau in den Militaerischen und Technischen Zeitschriften.

For the first half of 1893.

A valuable *resumé* of military periodical literature, which is classified under the general heads, Artillery, Engineering, Navy, General Army Matters, and Science. Each of these heads has several sub-divisions.

Mittheilungen ueber Gegenstaende des Artillerie- und Geniewesens.

Nos. 8 and 9.—Attack on fortifications. Danish national defense and the fortification of Copenhagen. A method of follow-a moving target with automatic elevation, by using the existing sights. Firing regulations of the German Light Artillery for the year 1893. Firing against balloons (Russian Artillery Journal, No 10, 1893).

No. 10.—Apparatus used on the practice-range of the central Naval laboratory in Sevran-Livry.

No. 11.—Essay on the general fortifications of the country. Armor tests. The organization of the Swiss national troops. Russian maneuvers against fortifications.

Archiv fuer die Artillerie- und Ingenieur-Offiziere des Deutschen Reichsheeres.

AUGUST.—Suggestions on military ballooning. Belgian Light Artillery.

SEPTEMBER.—Sketches on the history of the Engineer corps of the Austrian army. Contribution on the exterior ballistics of oblong projectiles.

Marine Rundschau.

SEPTEMBER.—Tests of armor plates. The training of cadets in the American navy, and the Naval Institute at Newport, R. I.

NOVEMBER.—Test of American armor-piercing projectiles. "Schnebelit," the new explosive.

Mittheilungen aus dem Gebiete des Seewesens.

Nos. 8 and 9.—The torpedo and the rapid-fire guns of large caliber. The new regulations for the improvement of the personnel of French naval gunners. Final tests of armor-plates in America. Nickel-steel armor-plates in Russia. Steel boats without seams. The breech-closing mechanism of rapid-fire guns. New ballistic theories.

No. 10.—Comprehensive statement of tests and improvements in ships' armor and armament.

No. 11.—The fortification of the Italian citadel Spezia. Trial of the armor-plate of the Russian ship "*Tri Svjatitelja.*" Artificial cooling of powder magazines. Optical sighting arrangement for firing at sea.

Internationale Revue ueber die Gesammten Armeen und Flotten.

AUGUST.—The war of 1806 and the present time.

Jahrbuecher fuer die deutsche Armee und Marine.

SEPTEMBER.—The comparative efficiency of Cavalry against Infantry and *vice versa*, from recently gained experience. The smallest rifle-caliber. What rôle will cruisers play in future naval battles?

OCTOBER.—The reformation of the Austro-Hungarian Engineer corps. The French Army since 1889. The new Russian firing regulations.

NOVEMBER.—The Italian army in the first half of 1893. Our intensive development, and the French view of their own military needs.

Schweizerische Militaerische Blaetter.

Nos. 9 and 10.—The equipment of the Light Artillerist. Ballistics in Italy. Compression of Artillery projectiles.

Allegemeine Schweizerische Militaerzeitung.

AUGUST 5.—The increase in the strength of the German army. The formation and tactics of the French army.

AUGUST 19.—A new steel shell.

SEPTEMBER 16.—Roumanian national fortifications.

OCTOBER 21.—Target practice.

Militaer-Wochenblatt.

AUGUST 30.—Hebler's heavy and light projectiles, with air-channel.

Journal of the Royal United Service Institution.

SEPTEMBER.—Handling of masses of Artillery with special reference to the preparation for the infantry attack, as illustrated by the French experiences at the camp of Chalons in 1892. The phonograph and its application to military purposes.

This paper dwells on the various uses to which a phonograph may be put and brings out its great value in sending messages on the battle field. The failure of the phonograph to record the noise of discharge of guns and other clamor on the battle field and the necessity for a phonograph in all respects identical with the one recording the message in order to read it renders this instrument especially useful in war. Having a message in the recognized voice of the sender is a positive guarantee of its authenticity. The instrument may also be used for taking evidence of witnesses in one part of a country for use in another distant part, thus saving great expense. These remarks simply indicate the scope of uses to which the instrument may be subjected in the military profession.

Recent progress in marine machinery. German field fortification for 1893.

OCTOBER.—Dress and equipment with practical illustrations. Coal consumption of ships-of-war. Mobilization for the home defense. The French naval maneuvers of 1893.

November.—Recent naval literature. Coast Artillery practice. This is an excellent discussion of the whole question of *Coast Artillery Practice*. The writer begins with a general classification of the subject and passes to the questions of a social and moral nature which make coast defense problems unattractive. The writer then gives his own experience in firing, on taking command of a fortress about ten years ago. At this time there was no organization of the Coast Artillery practice. One day's experience taught him that a thorough organization of the command, systematic efforts with rules evolved from future experience, were absolutely essential to success in maintaining a defense. The details of the writer's own scheme, based upon his own experience, follows. All possible questions relative to the subject are carefully and conscientiously treated. The organization of the different groups into distinct elements of the defense connected with the whole fort claims his attention. The duties in detail of group officers follows. The characteristics of the militia and volunteer troops are considered and the results obtained from them. Amongst the many considerations embraced in the article are those of position finding, diagrams of vessels, requirements of coast defense, targets—stationary and moving—record targets, use of explosives, ricochet, placing guns, and numerous other minor but important problems which must be developed in order to secure efficacious defense. The article will be especially valuable to our officers in dealing with target practice questions since nearly all the conditions, requirements and questions elucidated are very similar to our own.

December.—Discussion of the military prize essay 1893. Löbell's annual reports on the changes and progress in military matters during 1892. Some opinions of the Whitehead torpedo and its relation to modern armaments and tactics.

Journal of the United Service Institution of India.

June.—The law of warrantry and soundness of horses. A Geography of the Turkestan country. On the strategic rôle of Cavalry.

July.—Mountain warfare as applied to India (prize essay). The use of the bayonet. The double company system.

August.—Modern gun carriages.

Proceedings of the Royal Artillery Institution.

September.—Adjuncts of defense. Horses' snow shoes. A proposed method of firing at moving objects at moderate ranges. Memoirs, historical. Practical hints on the selection, treatment and training remount horses in India. Penetration and effect of projectiles on earth and masonry.

OCTOBER.—Journal of Major George Brooke, 1st brigade, Bengal Horse Artillery. Royal trophy guns at Windsor. Tactical problems. Self adjusting firing lanyard for field Artillery. Siege of Minorca. Tactical observations.

DECEMBER.—A visit to Aspern and Wagram, being an account of the passage of the Danube. Some notes on naval gun drill and practice. Clipping of troop horses. Army Schools. Horse Artillery guns at Waterloo.

The Broad Arrow and Naval and Military Gazette.

OCTOBER 21.—The ram in action. Private means and professional advancement in the army. Wanderings among the Cavalry on the Downs, 1893 (continued). The rôle of the Russian Cavalry in the commencement of the next war. Modern field Artillery. Army gymnastics, Sir Evelyn Wood's report on the maneuvers. Home district tactical and war game society.

OCTOBER 28,—The objects of Infantry field firing. Have we war ships enough?—III. Dr. Maguire on strategic geography. Are the Channel Islands safe? The dearth of subaltern officers. The Indian Army reorganization scheme.

The Army and Navy Gazette.

SEPTEMBER 9.—The right of appeal. The Royal Marines. The army maneuvers. The education of officers—English, French and German. Controlled mass fire,—volleys.

SEPTEMBER 16.—Seaside shooting· The army maneuvers. The German maneuvers.

SEPTEMBER 23.—The Aldershot command. Artillery by land and sea. Artillery organization. The army maneuvers. The German maneuvers. The Austrian maneuvers.

SEPTEMBER 30.—The employment of reserve men. Military education in parliament. Artillery organization. The generals at Armageddon. Provision of munitions of war. The bayonet fight. Lord Roberts on the Volunteer Artillery. Army promotion.

OCTOBER 7.—The British Army in 1892. The new first-class cruisers. The Admiralty Inspection. The home defense scheme. The Italian naval maneuvers. Admiral Vignes and the French naval maneuvers. Cavalry expenses.

October 14.—The new Army book. The Naval staff. Battle formations and the new drill book. The autumn maneuvers. The Aldershot command. The Cavalry command. Artillery organization.

October 21.—Seamen or landsmen? Cavalry expenses. India between two fires. The staff college in India. Army organization. Marshal MacMahon. The Royal Naval reserve. India as a field for soldiers.

October 28.—France and Russia. First appointments to the army. The pell-mell firing line. Report of the autumn maneuvers.

November 4.—Fighting tactics. The loss of the *Victoria*. Colonial feeling. Can Europe afford her armies? Artillery organization. German Artillery drill.

November 11.—The Government and the Navy. The care of the wounded. Army remounts. Royal Artillery in India.

November 11.—Coast Guard service. Note on Infantry tactics.

November 18.—The employment of the reserve men. Naval supremacy.

November 25.—The three factors of an all-powerful navy. The German Army bill. The Army book. Range finding and military topography.

December 9.—The Navy and the Government.

December 16.—The German army maneuvers. The Chamber of Commerce and naval defenses.

December 30.—The "Army Book" and imperial defense. The Egyptian Army of occupation. Fire discipline.

United Service Gazette.

September 9.—The Army autumn maneuvers (continued). The sovereignty of the seas. The navy and the spirit question. The defense of India. The *Victoria* fund.

September 16.—The Army estimates debate. The Admiralty and engine room artificers.

September 23.—Turkish irregular cavalry. The Admiralty inspections (continued).

September 30.—Lord Armstrong on the Navy. The command of the sea (continued). Recent Army maneuvers.

OCTOBER 7.—Field Artillery fire. The needs of the Volunteer force. The British Army in 1892. The Home defense scheme.

OCTOBER 14.—Russian Army maneuvers. Soldiers' rations in India. The Army maneuvers. Field firing at Aldershot. Development of the Navy.

OCTOBER 21.—Trafalgar. The ills from which the Volunteer force suffers.

OCTOBER 28.—Reorganization of the Indian Army. The Italian Navy. Imperial German maneuvers in Alsace and Lorraine (continued). Our greatest need. India and imperial federation.

NOVEMBER 4.—The fastest vessel in the navy. The loss of the *Victoria*. Care of our wounded in war.

NOVEMBER 11.—General Brialmont on *corps d'elite*-II. The education of German war dogs. Our naval weakness (continued). Army examinations.

NOVEMBER 18.—A French review of the Morocco question. Volunteer law and administration. Our present naval position. Field works in military operations.

NOVEMBER 25.—Our naval unpreparedness. Our naval weakness. Ammunition supply. Russia in the northern seas—important naval project. Our Army and military system.

DECEMBER 16.—Our naval weakness.

The Engineer.

SEPTEMBER 1.—Shipbuilding in America (continued). Lessons from the naval manœuvres—III. The new battleships *Majestic* and *Magnificent*. The naval estimates.

SEPTEMBER 15.—Trial of H. M. S. *Leda*. Instantaneous photographs of discharge of Krupp 12-inch gun.

SEPTEMBER 22.—The Russian battle ship *Twelve Apostles*. Trials of H. M. S. *Devastation*. Chicago Exposition. War ships of the 10th, 15th and 19th centuries.

SEPTEMBER 29.—The iron and steel institute. Ordnance exhibits at the Chicago exhibition. Krupp guns.

OCTOBER 6.—United States war ships and war material. French naval construction.

OCTOBER 20.—American nickel-steel armor plates. Proposed torpedo-ship. Photographing colors in the camera.

OCTOBER 27.—The first class battle ship *Royal Oak*. The Russian ship *Admiral Nachimoff*. War ships of the five great naval powers.

NOVEMBER 3.—Krupp's heavy guns and mountings at the Chicago exhibition. Naval manœuvres in 1892. Casualties on board ships of war.

NOVEMBER 10.—H. M. S. *Speedy*. The loss of H. M. S. *Victoria*. Trials of H. M. S. *Hebe*. Captain Neal's apparatus for signaling under water.

NOVEMBER 17.—Her Majesty's first class battle ship *Hood*.

NOVEMBER 24.—Adjuncts of defense. The Bethlehem 125-ton hammer. The Italian battle ship *Sardegna*.

DECEMBER 1.—Lord Charles Beresford's new naval program. Trials of H. M. S. *Royal Oak*.

Engineering.

SEPTEMBER 22.—Loss of Her Majesty's Ship *Victoria*. Electric forging.

OCTOBER 6.—The Iron and Steel Institute. A 90-inch gun lathe.

OCTOBER 13.—Engine and dynamo for search light.

NOVEMBER 3.—The loss of the *Victoria*. The United States Navy. On the modifications of carbon in iron.

NOVEMBER 10.—The sinking of the *Victoria*.

NOVEMBER 17.—Lists of the battle ships and fast armored cruisers of the English and of the French and Russian fleets, with approximate speed and armaments (over 3 in.). The torpedo gunboats.

DECEMBER 1.—The capsizing of a torpedo boat. The *Antelope's* trial.

DECEMBER 8.—The fastest cruiser in the world. Some practical examples of blasting.

DECEMBER 22.—The American Society of Naval Architects. Engines of the Italian cruiser *Aretusa*. The debate on the navy. Some practical examples of blasting (continued).

DECEMBER 29.—Electric signaling by telephotos. Warship building.

Arms and Explosives.

DECEMBER 1.—Cordite. Dynamite explosions in Spain. Gun proofs with nitric powders. A modern method of testing explosives. Vieille's registering crusher gauge. Notes on explosives. Use of high explosives in shells. Blasting with the aid of electricity. The origin of smokeless powder. Report of French explosives commission. Improved electric high tension fuze head for use in blasting. Improvements in and to the manufacture of smokeless powders.

Journal of the Military Service Institution.

NOVEMBER.—Army organization. Field works in military operations.

This article was thoroughly reviewed and commented on in the *Army and Navy Gazette.*

A proper artillery field armament. Proper equipment of officers. Organization of the armies of Europe. Reprints and translations. Military notes. Reviews.

The United Service.

OCTOBER.—Army or school. The loss of the *Victoria.* The lieutenant. The fight between the *Monitor* and the *Merrimac.*

NOVEMBER.—A true history of the Army of Fort Fisher. Reorganization of the Artillery.

DECEMBER.—Recent Army legislation. The transformation of Japan. Frontier service in the fifties.

The Army and Navy Journal.

SEPTEMBER 23.—Small arms for the navy. Ages of our army officers.

OCTOBER 14.—Firing at moving objects.

This relates to a sighting device by Colonel James M. Rice, G. I. R. P., Illinois, by means of which allowance can be made on the sight for the motion of the object. This is accomplished by setting the sight leaf to one side a number of points determined by the distance and object's speed. The improvement in shooting at moving objects by this method is remarkable. A sketch of a target for practice at a moving target is also given.

NOVEMBER 4.—Ordnance at Chicago—Bethlehem exhibit. Brazil's improvised navy. A new dynamite projectile.

NOVEMBER 11.—Improved type of machine gun.

NOVEMBER 18.—The rapid-fire gun trial.

NOVEMBER 25.—Current needs of our army. Battle formations. The Howell torpedo.

DECEMBER 30.—Artillery and infantry. Personnel of the navy.

The Army and Navy Register.

OCTOBER 14.—A new machine gun.

NOVEMBER 18.—Trial of 6-pounder rapid-fire guns.

NOVEMBER 25.—Torpedo nets.

DECEMBER 30.—The naval policy at Rio.

Scientific American.

SEPTEMBER 16.—The new 13-inch guns. The Brown wire gun.

SEPTEMBER 30.—Test of Holtzer shot.

OCTOBER 14.—Blowing up a wreck. Two wonderful warships.

OCTOBER 21.—Torpedo boats for men-of-war. Working Harveyized armor plate. Bullets as microbe carriers.

OCTOBER 28.—An English view of United States warships and war material. The new rifle for the navy.

NOVEMBER 4.—Coaling cruisers at sea. Disappearing gun carriage (Gordon's).

NOVEMBER 11.—Amateur naval operations.

NOVEMBER 18.—The year's progress in naval ordnance and armor. Torpedo net tests.

NOVEMBER 25.—The *Columbia.*

DECEMBER 2.—Terrible effects of dynamite. The new Brazilian Navy.

DECEMBER 16.—U. S. large caliber mortars.

DECEMBER 23.—The torpedo net testing. The sea trial of the *New York.* A machine for forming projectiles. The new American warship *Olympia.*

The Iron Age.

SEPTEMBER 23.—Test of Holtzer projectiles. The new Navy rifle.

NOVEMBER 2.—Launch of the Battleship *Oregon.*

NOVEMBER 9.—Modern fixed ammunition.

NOVEMBER 16.—Naval rapid-fire guns. Ideal bullets.

NOVEMBER 30.—The Mansfield disappearing gun-carriage.