fessor Arnold wished to say two or three words in the two minutes left, they would be glad to hear him. In response, Professor Arnold said that in the two minutes placed at his disposal by the President, it was of course impossible to attempt to reply to the numerous points raised during the discussion, some of which were worthy of careful consideration, and all of which would be fully dealt with in his answer to be published in the Journal of the Institute. In the meantime he would ask members to bear in mind that, although the gentlemen who had spoken in support of the theories attacked seemed to have proved to their own satisfaction that nickel and manganese should distinctly harden iron, yet the practical fact remained that the quenched bars of these alloys had bent double; and although the advocates of the β iron and periodic law theories still held that theoretically phosphorus and sulphur should soften iron, the alloys of these elements had, nevertheless, snapped short under the bending test. He therefore left it to the judgment of the members of the Institute which line of argument they would adopt as a guide to the mechanical influence of elements on iron.

The two following papers were taken as read: "On the Relations betwen the Chemical Constitution and Ultimate Strength of Steel," by Mr. W. R. Webster; and "On the Application of Electricity as a Motive Power in the Iron and Steel Industries," by Mr. D. Selby-Bigge. The meeting then terminated with the usual votes of thanks.

KRUPP ORDNANCE.

(*Continued from page 568.*)

THE 15-CENTIMETRE (5.9-IN.) QUICK-FIRING GUN.

FOUR calibres of quick-firing guns were shown in the Krupp Pavilion at the Chicago Exhibition; the largest of these was 15 centimetres (5.9-in.) bore, and represented a type forming an important part of the armament of cruiser corvettes, as well as the smaller guns in the armament of ironclads. This gun was shown on a central pivoted ship-carriage, consisting of the upper carriage, in the sides of which the two brake cylinders were placed, a lower frame, and a base-plate, these two last being separated from each other by a live ring of steel balls. Rollers are placed in the upper carriage to carry the weight during the recoil, and unless checked the gun runs back again into firing position automatically; a running-in apparatus is of course provided. Vertical and lateral training of the gun is effected by means of hand gearing. The following are some general particulars of this gun:

Calibre	5.9 in.
Length of barrel	19 ft. 6.64 in.
,, gun in calibres ...	40
,, bore	18 ft. 2.35 in.
Number of grooves	44
Weight of barrel and breech mechanism	4.44 tons

Four kinds of ammunition are fired with this gun, and each kind is made in three different weights—76.05 lb., 88.184 lb., and 100.3 lb.; the lengths of these projectiles vary from 2.6 to 3.7 calibres.

The following are the bursting charges for the heaviest class of projectile (100.3 lb.):

Cast-iron shells	3.196 lb.
Armour-piercing shells	1.499 ,,
Steel shrapnel	1.003 ,,
Number of balls in shrapnel ...	550
Weight of each ball	.057 lb.

In addition to the foregoing, case shot of two weights (88.18 lb. and 100 lb.) are employed.

The class of powder used for firing these projectiles is the smokeless cube, 1889 pattern. The projectiles are, of course, placed in brass cartridge-cases, in which the charge is contained. The charge is fired by means of a fuze screw placed in the base of the cartridge case. The bursting charge of the shrapnel is fired by a 30-second time fuze; the other shells are exploded by percussion fuzes.

Some of the ballistic data obtained by experiment with this gun are given:

Weight of projectile	88.18 lb.
Weight of powder charge ...	16.09 ,,
Initial velocity	2379 ft.
Total energy	3456 foot-tons
Energy per kilogramme of weight of gun	.767 foot-ton
Maximum range with an elevation of 30 deg	1750 yards

Penetrating power of armour-piercing shell with 2379 ft. initial velocity:

At the muzzle, wrought-iron plate	17.72 in.
At the muzzle, steel plate ...	12.32 ,,
At 1094 yards, iron plate ...	13.90 ,,
,, steel plate ...	9.80 ,,
At 2187 yards, iron plate ...	10.71 ,,
,, ,, steel plate ...	7.75 ,,

The following is an extract from the official statement of experimental firing with the gun exhibited, which was constructed in 1891, and had up to the time of exhibition fired 269 shots with full charges: "With respect to the speed of firing attained with the 15-centimetre (5.9 in.) quick-firing gun, 40 calibres in length, it should be noted that in shooting trials at the practice ground of the cast steel factory at Meppen, 55 shots, quick fire, were delivered in series of three, four, five, and 10 shots, with good aiming, in 396 seconds; this corresponds to a speed of firing of over eight shots per minute. A still more favourable result was obtained with a series of 18 shots, of which at first eight shots were fired in 46 seconds at a target at 2000 metres, and immediately afterwards eight shots in 40 seconds at 3000 metres out into the open, and then again two shots at the aforesaid target, making in all 18 shots in 126 seconds.

"Thus with aimed fire and two changes of the range and the target, 18 shots were delivered in succession at a speed of firing of over eight shots per minute. Without taking into consideration the alteration of range, the speed of firing was six seconds for one shot, that is to say, 10 shots per minute.

"Another series of 14 shots, of which the first eight shots were fired in 48 seconds at a target 2000 metres distant, then five shots in 22 seconds out into the open at 3000 metres, and, finally, one shot at the aforesaid target, took 93 seconds. This corresponds to a speed of firing of nine shots per minute.

"In this case, also, the speed of firing was six seconds for one shot, that is to say, 10 shots per minute, without taking the change of direction into consideration.

"The hitting capability shown in these trials was very good, because of the 18 quick-fire shots that were delivered consecutively with a double change of target and range, all the 10 shots fired at the target at 2000 metres were hits."

The breech and firing mechanism of the 15-centimetre quick-firing gun is illustrated by Figs. 4 to 7, page 642; the principal parts are the breech-block A, the closing plate B, the locking screw and its lever C and D, the ejector E, and the firing device F, G, H. The form of the block is shown in Fig. 6. It is not rounded, as in the larger calibres, but is formed with projections that slide in recesses cut in the body of the gun; in the centre it is pierced to receive the firing-pin F, and on the forward face it carries a hard steel plate L which bears against the base of the cartridge, and which is bored with a conical hole to allow the point of the firing-pin to pass. The covering plate B, which is large enough to close the opening cut in the gun to receive the block, is secured to the latter by four screws *g*. The inside of this covering plate is cut away in the manner shown to receive several parts of the mechanism: the locking screw and its lever C D, the striking bar J and its spring K. Upon a projection upon the outer side is a stud H which limits the range of movement of the lever D; this is fastened to the boss of the locking screw by means of a key, and carries a sliding stud M, by means of which the gun is fired automatically. The ejector is shown at E, and consists of a lever secured to the gun at *o*, and having a projection *p* falling into a narrow recess cut in the breech-block; the end of the longer arm is formed so as to embrace the cartridge, which is withdrawn from the bore by the sudden withdrawal of the breech-block when the end of the groove *c* comes into violent contact with the short arm *p* with the ejector lever; when the block is withdrawn to the extreme range of its travel, the cartridge can be finally removed from the gun through the enlarged opening at the back of the breech-block. The firing mechanism consists of the striking pin F, the actuating spring G, the firing lever H; these are all placed in passages cut in the sliding block; of the trigger J, and main spring K attached to the covering plate B, and to the automatic firing-pin *m* in the lever that actuates the locking screw. The firing lever H turns upon the pin p^1; at the inner end of this lever there is a projection X^1, that enters a slot cut in the side of the firing-pin. In Fig. 7 the mechanism is shown in firing position, that is to say, the pin F is drawn back by means of the block X^1 on the lever H, and the spiral spring G is compressed; as will be seen, one end of this spring, which is placed inside the hollow firing-pin, abuts against the latter, while the other end bears against the stud *a*, screwed into the back of the breech-block. Left to itself, the firing lever H is free to turn around the axis of p^1, so that, unless otherwise controlled, it would remain with the upper face near the top of the groove made in the breech-block to receive it, being raised by the extension of the spring G of the firing-pin. But at the other end of the lever H there is a groove *y* of such a form that the projection y^1 on the lever J can give it the requisite movement for withdrawing the firing-pin, and when the parts are in the position shown in Fig. 7, the gun is set at full cock. This lever J has two arms, the one shown in Fig. 7, the other projecting through the covering plate B, and bent to such a form that when the lever of the locking screw is turned the stud *m* comes in contact with it and draws the arm J of the lever back, so that the projection y^1 is free of the groove *y*, and the firing spring G is free to project the pin F against the base of the cartridge. The stud *m* can be withdrawn into its recess and locked by the nut *n* so that automatic or premature firing is avoided; in this case the gun can be fired by a lanyard attached to the bent arm of the lever J. The manipulation of the mechanism is as follows: The locking lever D is turned through half a revolution, when it comes into contact with a stop fixed in the face of the cover-plate: this half-turn removes the threads of the locking screw from the grooves cut in the breech of the gun, and by the same movement the firing lever H, through the agency of the lever J and the stud *m*, is brought back into the position Fig. 7, thereby compressing the spring in readiness for firing the next round. The block is then withdrawn by pulling on the lever D for the full extent of the travel, which is limited by the end of the groove *c*, which strikes against the arm *p* of the extracting lever and withdraws the cartridge case. A new cartridge is then introduced, the block pushed home again and secured to the gun by giving the lever D a half-turn in the opposite direction. The gun is then ready for firing, which can be effected either automatically by the stud *m* striking the bent arm of the lever J, or if this is withheld by the screw *n*, by means of a lanyard attached to the end of the lever *j*.

THE 7.5-CENTIMETRE (2.95-IN.) QUICK-FIRING GUN.

Following the 12-centimetre came the 8.7-centimetre quick-firing gun, also mounted on a central pivoting naval carriage (Fig. 8, page 650). This gun is intended chiefly for repelling torpedo-boat attacks, and, excepting in size, resembles very closely the 12-centimetre calibre, the latter being sufficiently powerful to form an important part in the armament of cruisers and large despatch-boats. The 7.5-centimetre quick-firing gun (Fig. 9, page 650) represented quite a different type; it was mounted on a land carriage, and was a special design for fortress defence, particularly as a flank gun for commanding the lines of ditches and trenches. It is very short, being only 25 calibres in length, and while firing a light projectile at a low velocity, the high speed of firing attainable should render it a very efficient and formidable weapon. The breech mechanism closely resembles that of the 15-centimetre gun already described. The method of manipulation of serving the gun is similar to that described for the 15-centimetre.

The following are some particulars of this 7.5-centimetre gun:

Calibre	2.95 in.
Length in calibres	25
,, of barrel	6 ft. 1.82 in.
,, of bore	5 ft. 6.14 ,,
Number of grooves	28
Weight of barrel	.315 ton

The following ammunition is fired from this gun:

Cast-iron shells, bursting charge	.331 lb.
,, ring shells, weight of bursting charge	.309 ,,
Shrapnel, bursting charge ...	.132 ,,
Number of balls in shrapnel ...	180
Weight of each ball	.024 lb.
Case shot, number of balls ...	73
Weight of each ball	.132 lb.
Powder charge (smokeless) ...	1.323 ,,
Weight of loaded projectile ...	13 23 ,,
Initial velocity	1640 ft.

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KRUPP QUICK-FIRING GUNS.

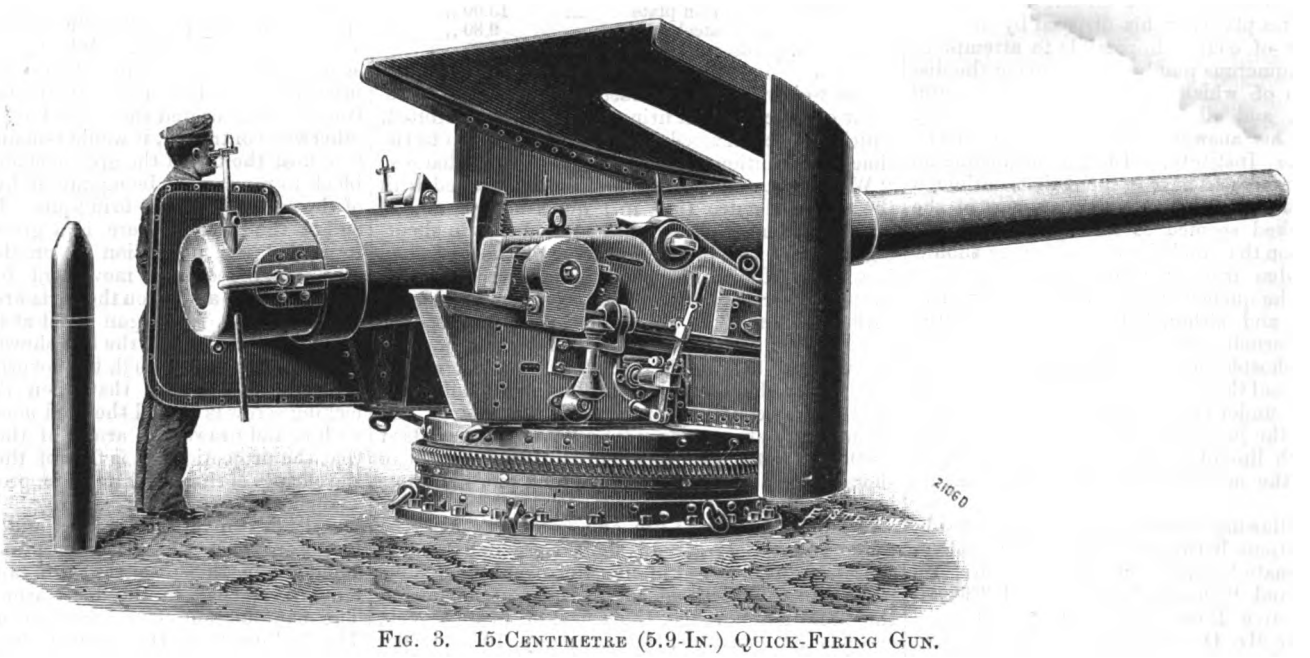
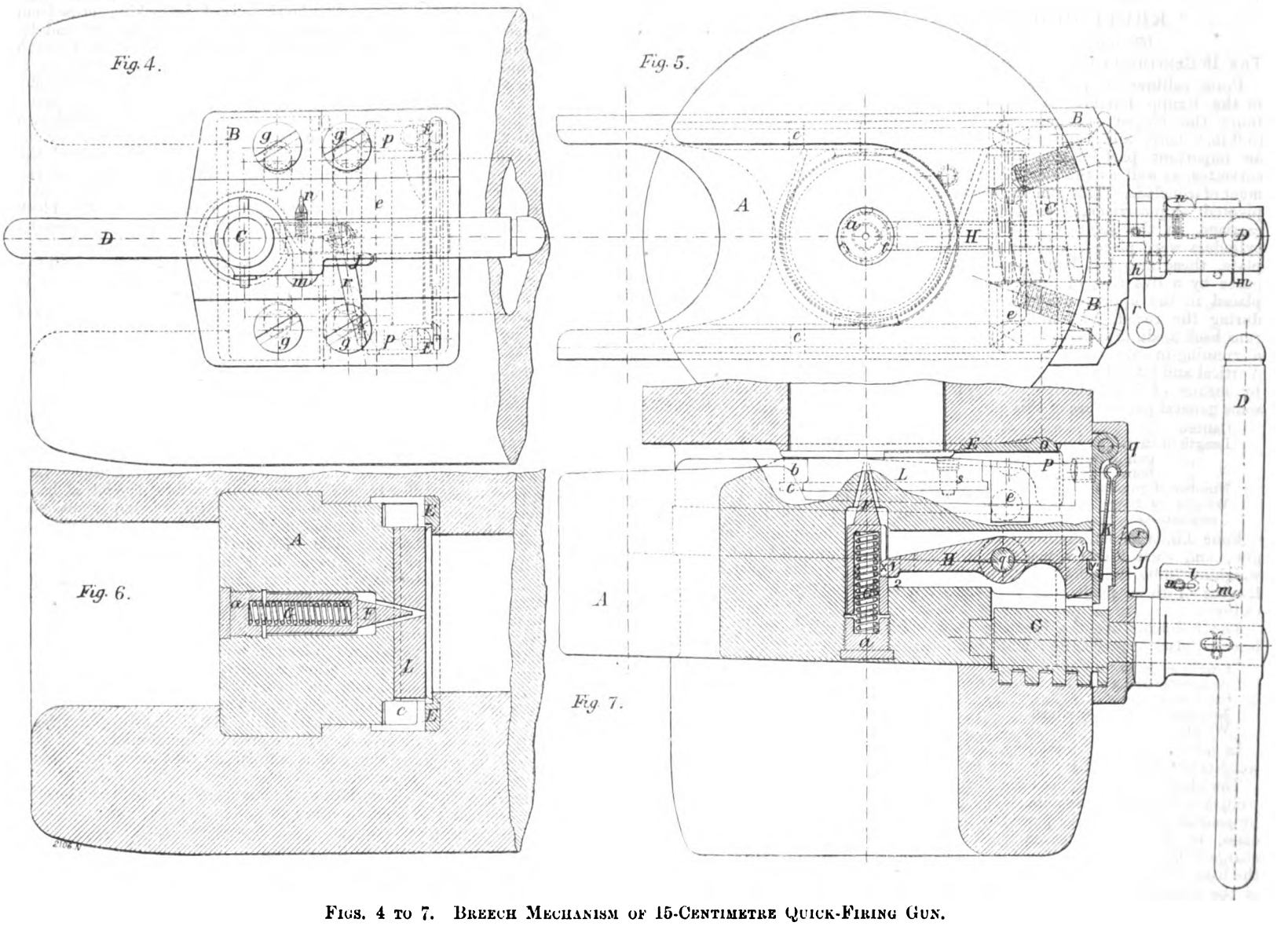


Fig. 3. 15-Centimetre (5.9-In.) Quick-Firing Gun.



Figs. 4 to 7. Breech Mechanism of 15-Centimetre Quick-Firing Gun.

Total striking energy	247 foot-tons
Greatest range with elevation of 8 deg.	4156 yards
Weight of upper mounting and frame	.506 ton
Weight of under-frame and pivot	.725 ,,
,, shield	.105 ,,
Total weight of carriage and accessories	1.644 ,,
Recoil	7.87 in.

The 12-Centimetre (4.72-In.) Quick-Firing Gun.

This gun, which is shown mounted on a central pivoting naval carriage, has the following dimensions (Fig. 9, page 650) :

Calibre	4.72 in.
Length in calibres	40
,, of barrel	15 ft. 8.98 in.
,, of bore	14 ,, 8.42 ,,
Number of grooves	36
Weight of gun	2.078 tons

The projectiles fired from this gun are of three kinds, each made of the three following weights : 39.683 lb., 44.092 lb., and 52.35 lb.; the lengths of these projectiles vary from 2.6 to 3.7 times the diameter. There is also a fourth class of projectile made in two sizes—case shot weighing 52 35 lb.

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KRUPP QUICK-FIRING GUNS AND MORTARS.

(*For Description, see Page* 641.)

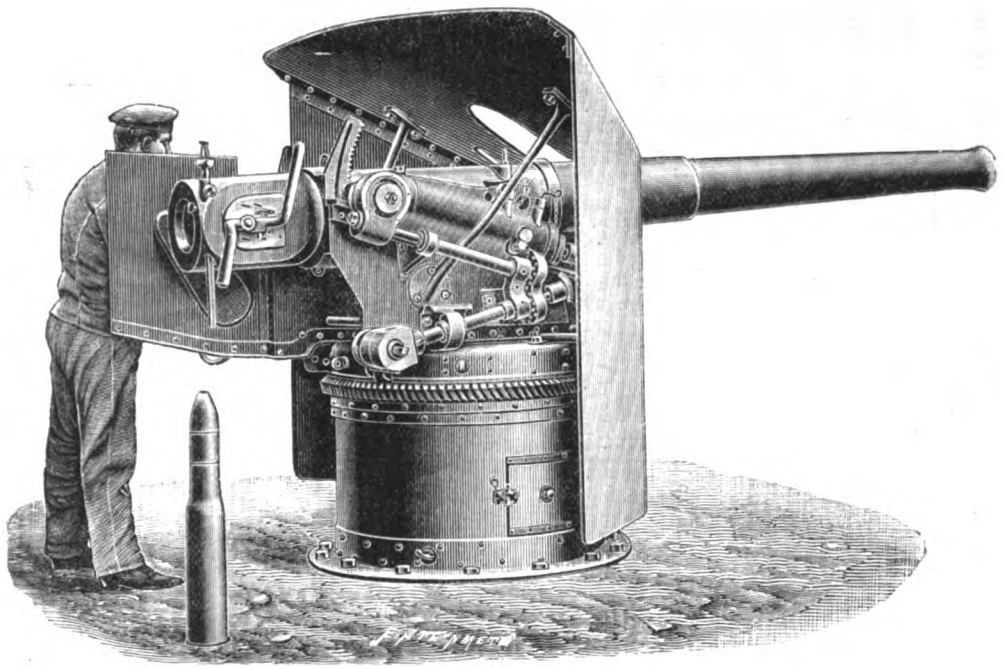

FIG. 8. 8.7-CENTIMETRE (3.43-IN. QUICK-FIRING GUN.

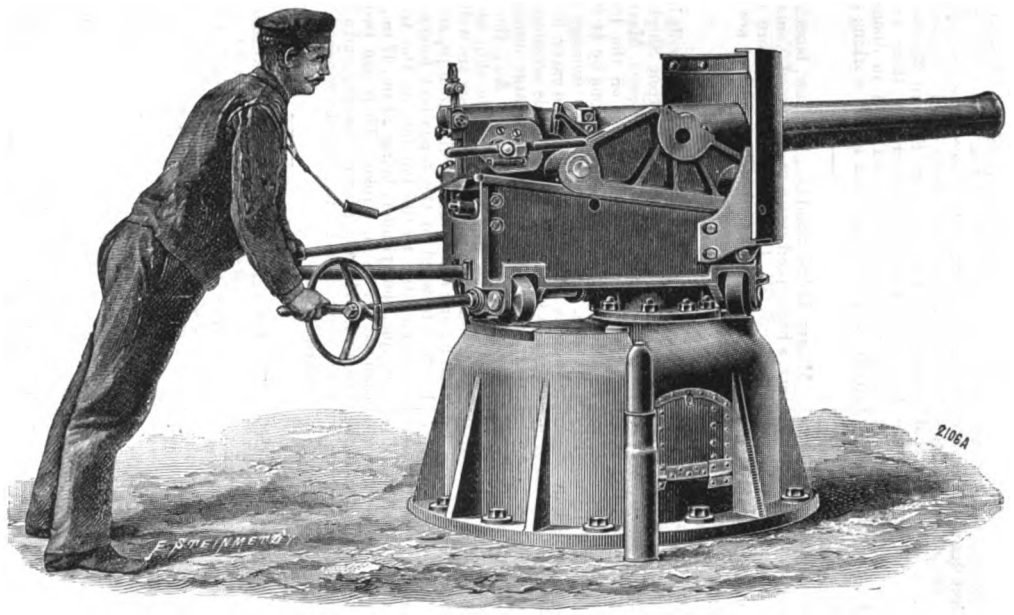

FIG. 9. 7.5-CENTIMETRE (2.95-IN.) QUICK-FIRING GUN.

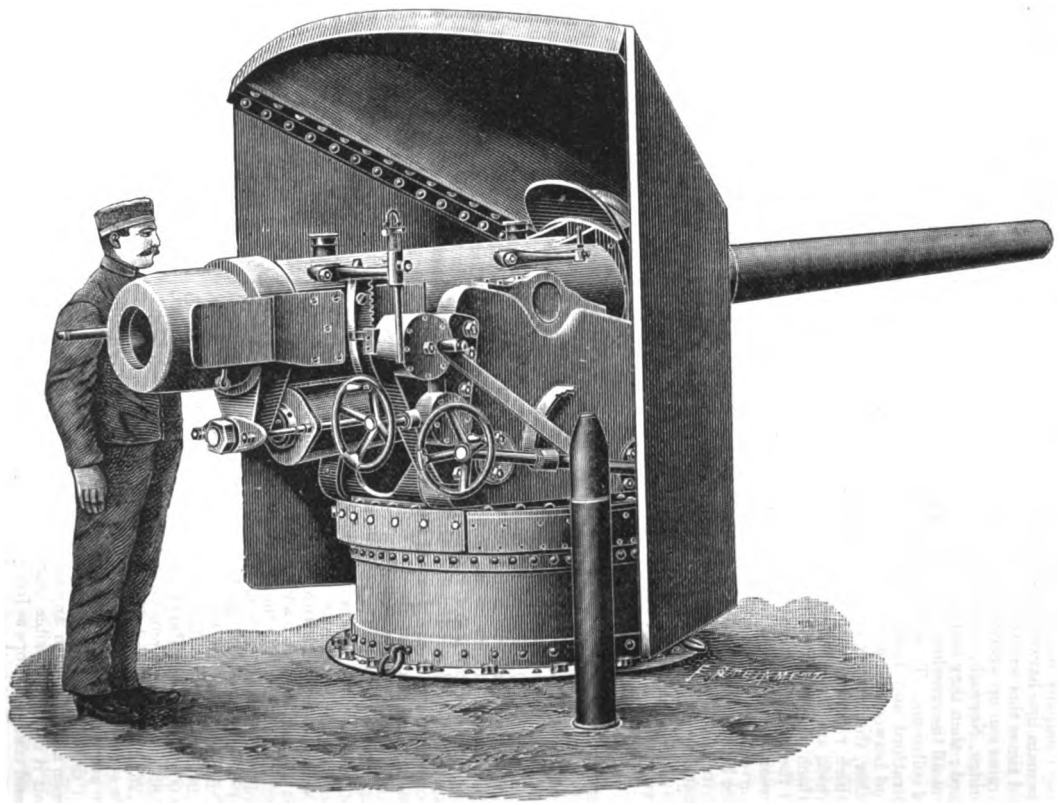

FIG. 10. 12-CENTIMETRE (4.72-IN.) QUICK-FIRING GUN.

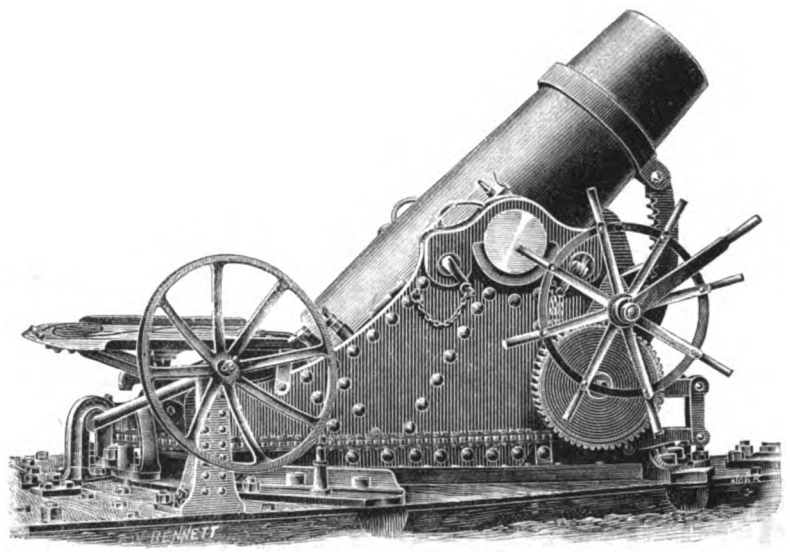

FIG. 11. 24-CENTIMETRE (9.45-IN.) MORTAR.

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KRUPP FIELD AND SIEGE GUNS.

(*For Description, see Page* 673.)

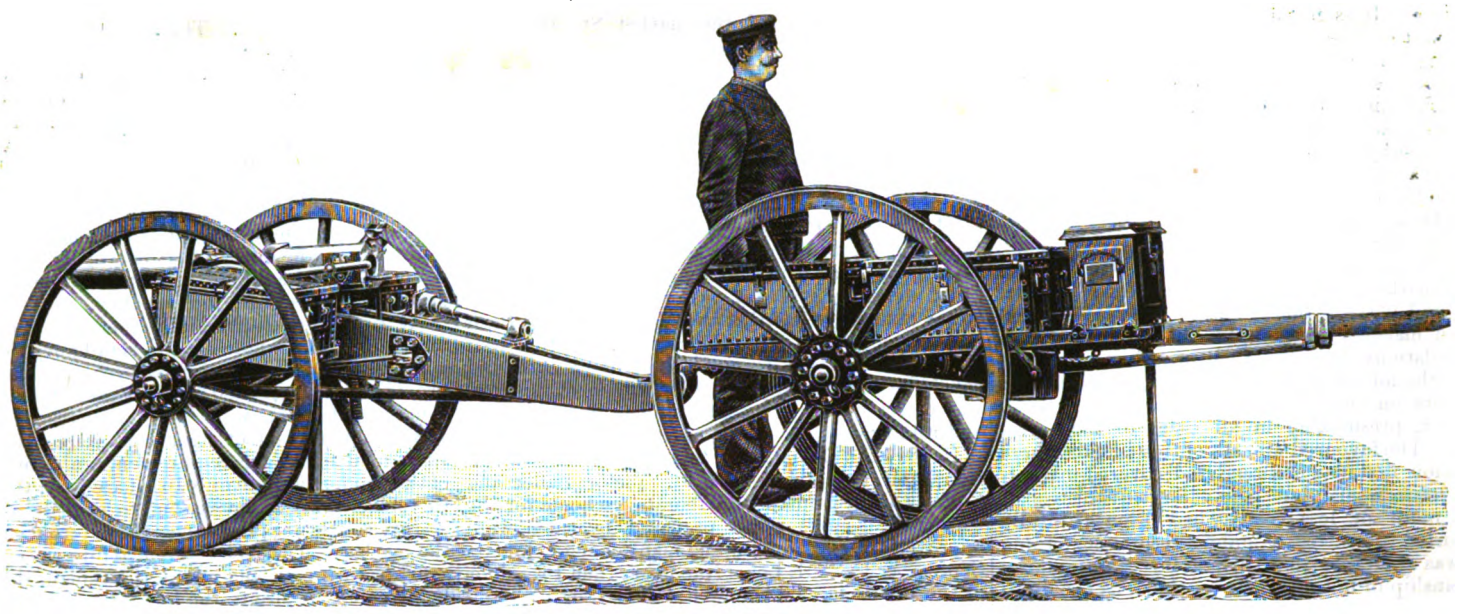

Fig. 12. 7.5-Centimetre (2.95-In.) Field Gun.

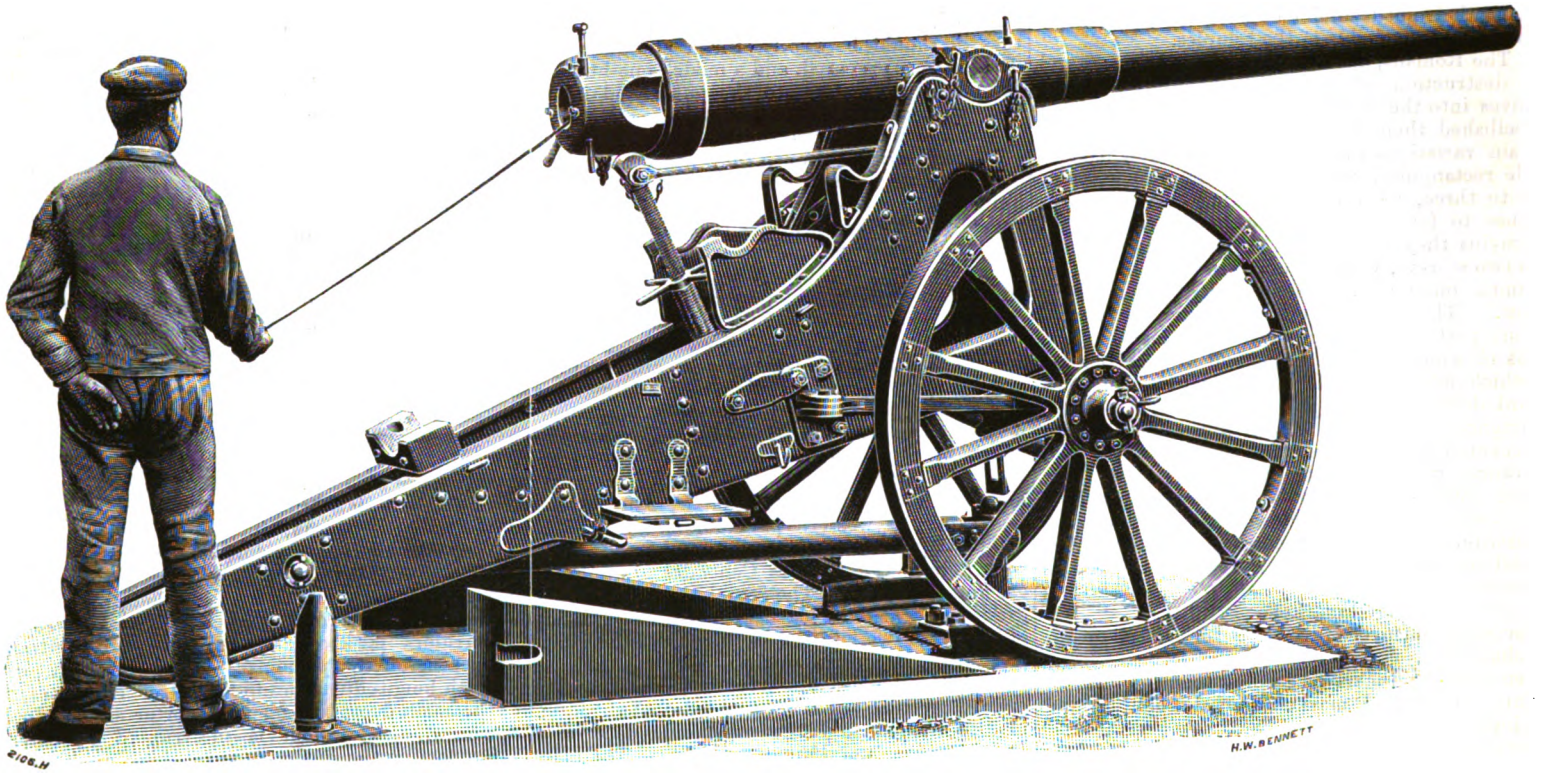

Fig. 13. 10.5-Centimetre (4.13-In.) Siege Gun.

recent ones are distinguished by their monumental proportions, and he places Farringdon Market at the head of his list. It was first erected in 1737 near the Fleet Ditch, but no signs of the old market are to be found in the handsome building now existing between Shoe-lane and Farringdon-street. It is rectangular in plan, and covers 41,900 square feet; then come Covent Garden, treated far too kindly by the author; Columbia Market, a handsome Gothic structure covering 67,800 square feet, which London owes to the liberality of the Baroness Burdett Coutts; and Billingsgate, erected for a fish market in 1846, and enlarged in 1872; it now covers 38,700 square feet, about double the area of the original building. The largest wholesale market of London is Smithfield, between Long-lane and Charterhouse-street, occupying about 400,000 square feet, including the annexed market between Snow-hill and King-street, used for the sale of flowers, and another, and larger one, to the north of Charterhouse-street. It will be noticed that this area is smaller than that of the Halles Centrales in Paris, designed for a much smaller population. In 1867 the foundation-stone of the London Central Meat Market was laid; this market contains 162 stalls, a large proportion of which average an area of over 500 square feet. The London Central Poultry and Provision Market occupies 64,500 square feet, and the London Central Fruit and Vegetable Market, opened in 1880, covers 43,000 square feet for wholesale business, the retail sales being carried on in two rows of stalls round the building; the total space covered by the market is more than 60,000 square feet.

Two Bavarian markets may be referred to: first, that of Augusta, which was built in 1872, and is well arranged and easily accessible. It covers an area of 62,400 square feet; second, that of Monaco, which is of considerable size and importance, on account of the large amount of business done. This market was constructed in 1851. Its covered area is approximately as follows:

			Sq. Ft.
Central building	...	76 ft. by 100 ft. =	7,600
Two wings, each	...	57 ft. by 90 ft. =	10,260
Supplementary sheds and	... ...	879 ft. by 85 ft. =	74,715
Total	... ...		92,575

Towards the end of 1881, when the completion of the Metropolitan Railway system gave great facilities for easy transport of provisions inside the city, the Municipality of Berlin took into consideration the construction of covered markets. They acquired a site for a large central market near the Kœnigsbrücke, an area of ground of 130,000 square feet, at a cost of about 12s. 5d. per square foot. At the same time it was decided to build smaller markets for retail purposes in different parts of the city. There are actually in Berlin eight covered markets. One, adjoining the Alexander Platz, near the Metropolitan Railway, is a large covered building that serves partly for wholesale business, and for which purpose it has direct connection with the Metropolitan Railway, and partly it is used for retail trade, replacing the two uncovered markets that previously existed on the Alexander Platz; they were resorted to by about 1018 stall-keepers. The building is rectangular in plan, 383 ft. by 324 ft., or about 124,000 square feet, of which 102,000 square feet belong to the municipality, and 22,000 square feet to the administration of the Metropolitan Railway. Cellars extend under the whole market, and the connections with the Metropolitan Railway are on a sufficiently large scale for handling at least 51,000 tons annually, this being the

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KRUPP FIELD AND SIEGE GUNS.

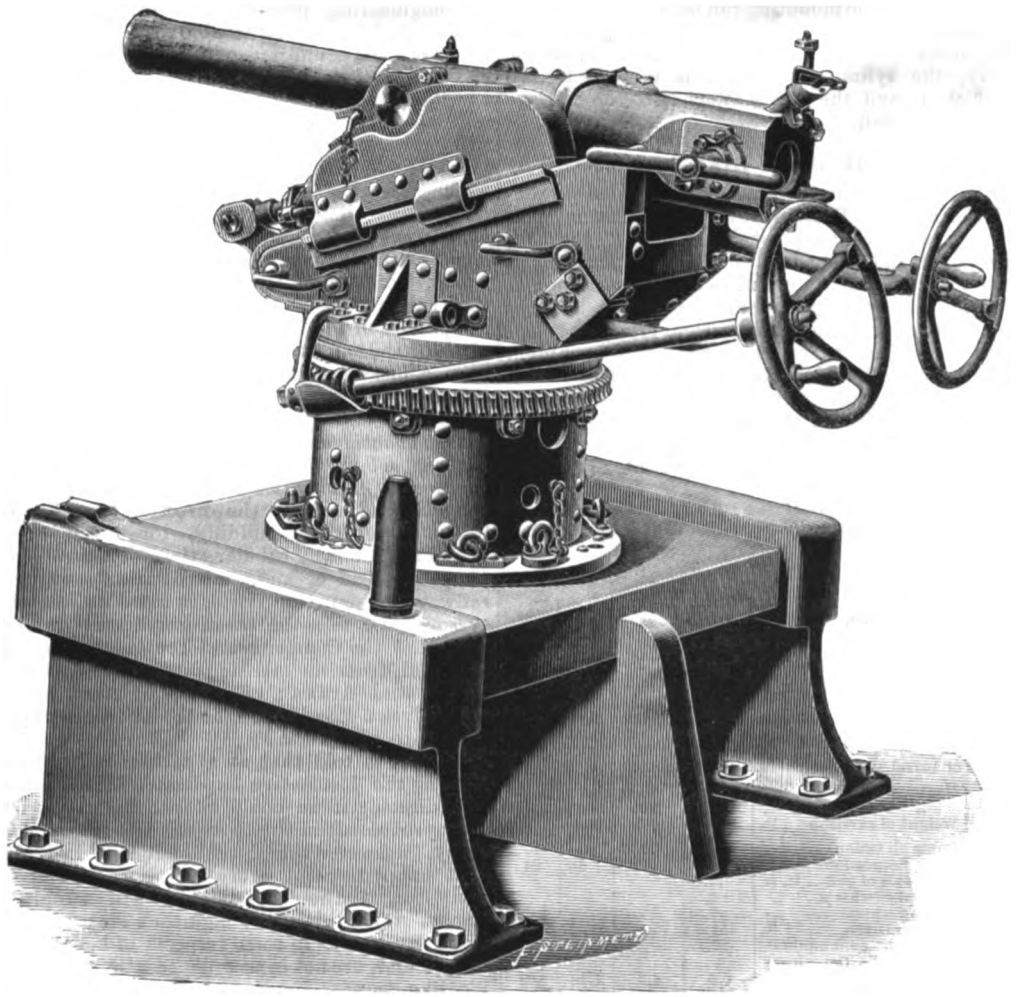

FIG. 14. 6-CENTIMETRE (2.4-IN.) BOAT AND LANDING GUN.

estimated capacity of the market. The areas directly utilised for commerce in the market are as follows :

	Sq. Ft.
790 stalls for meat and fish, varying in size from 38.5 to 76.5 square feet ...	40,300
Store-rooms	8,820
Offices	3,810
Restaurants	1,100
Offices, &c., in the galleries	9,570
Open stalls for wholesale trade ...	18,400
Total	82,000

There are besides nearly 50,000 square feet of cellars. The market can be lighted by electricity ; is well provided with water for cleaning purposes; and the drainage is very good. Ventilation is assured by mechanical means as well as by the open doors, and by the persiennes in the upper windows, while the movement of air is controlled by fans.

The market on the Magdeburg Platz was opened in 1888 ; it covers an area of 19,400 square feet, and is surrounded by wide streets ; there is one entrance on each side of the building, which consists of a basement or cellars and a ground floor ; it contains 60 stalls for meat, 16 for game, 16 for fresh-water fish, 73 for vegetables, and 23 for dairy produce, making 188 in all ; these stalls cover together 9250 square feet ; there are besides 42 independent stalls arranged in groups.

It is interesting to note that until 1865 Vienna had no covered markets ; during that year the municipality built one called the Central Markt Halle ; it cost nearly 60,000*l*., but it was not successful, and in 1868 it was converted into a dépôt for wholesale business, to which purpose it seemed well adapted ; ultimately it was used as a wholesale fish market. In 1871 the first successful retail market was opened, that of the Parade Platz ; this is the most complete and finest market in Vienna.

The covered fish market at Trieste is situated close to the sea, and is used entirely for the sale of fish, except in the outer stores, which are given up to general merchandise. It was built in 1879, and is rectangular in plan, measuring about 125 ft. by 95 ft., the greater part of which is under roof. The floor is paved with limestone from Carso, and the stalls for the display of fish are made of the same stone polished. The market is provided with a sea and a fresh water supply, the former being pumped into two large and high tanks at one end of the building, while at the other end are similar tanks for the fresh water. There is thus provided a means for constant cleansing, the sea water being first used, and followed by the fresh. The drainage arrangements are good, and a large stock of ice is provided for the preservation of perishable merchandise.

In Holland, Breda, Delft, and Rotterdam all possess notable markets. Aia has a fish market, which is a beautiful building, with a liberal water supply that permits of the most scrupulous cleanliness.

Nishni Novgorod has, since 1890, possessed a magnificent market, which serves as the great annual mart for the whole of Russia. The details of its plan and erection are somewhat interesting. The design was submitted for competition, three prizes, amounting together to 5000 roubles, being offered for the three best designs. The examining committee decided that although the three selected plans possessed great merit, all were faulty, and a fourth plan was prepared, combined from the three prize designs. The building was commenced on June 22, 1889, and actively carried on. It is a large structure, 557 ft. long and from 138 ft. to 167 ft. wide, the height varying from 42 ft. to 105 ft. It contains a number of official rooms, and cost 500,000 roubles.

Italian markets—that is to say, those of recent design—closely resemble each other, and on that account only a few need occupy our attention. Among them is the market in the Piazza Bodino, at Turin, facing on the piazza, and bounded by streets on the three other sides. It was built in 1864-65 from the designs of the architects Pecco and Valesco. All general articles of food are sold there. Its area is 20,700 square feet. In the centre there is a dome-covered octagonal hall, from which radiate four galleries, the average width of which is about 33 ft. The galleries are lighted by large windows on each side ; they contain 208 fixed stalls in three rows, one in the centre and two at the sides ; the fittings are of wood. The central rotunda contains 24 stalls, in which the counters are of wood, covered by white Carrara marble ; they are provided with very complete fittings, and cupboards that can be locked. There are no stores excepting four rooms in the corners between the four galleries. During the day the superintendence of the market remains in the hands of the stall-keepers, but at night the responsibility of guardianship rests with the lessee or managing official.

Pavia owes her market to the generosity of the Count Annaboldi Gazzaniga ; it is intended for the sale of agricultural produce on a large scale, and is one of the modern architectural ornaments of the town. It constitutes, as it were, an agricultural "Bourse," and is surrounded on every side by booths for miscellaneous merchandise. The market was designed by Ercole Balossi, and was opened on April 10, 1882. It is composed of galleries, a main portico, and an octagonal hall. The total area is 8500 square feet. The sides of the octagon are symmetrical, and it is roofed in by an iron and glass dome ; a gallery runs round the base of this dome, and an iron staircase leads to it from the ground floor and thence to the roof. The weight of iron in the cupola is 15.56 lb. per square foot, amounting in all to about 50 tons. The outer galleries occupy 1360 square feet, and the portico 2360 square feet. The height of the building towards the street Victor Emanuelo is 62 ft., divided as follows : 19 ft. for the ground floor, 13 ft. for the second, and 29 ft. for the top floor. In one part there are four storeys, the top floor being divided into two, one about 17 ft. and the other 12 ft. The height to the top of the cupola is 106 ft. For internal decoration, stone from Viggiu and Breno is used, and artificial stone enters largely into the construction.

There are four separate buildings forming one large market at Bologna. Of these, three are connected, and the fourth is at a distance from the others ; they are situated in the centre of the town, close to the Piazza Victor Emanuelo II., and take their names from the streets on which they face : (*a*) Clavature, (*b*) Orefici, (*c*) Drapperie, and (*d*) Ranocchi. These markets were constructed in 1877-78 ; the ground covered is divided as follows :

Markets.	Not Used.	Occupied by			Totals.
		Passages.	Stalls.	Shops.	
	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.
(*a*) Orefici	..	1830	2370	..	4200
(*b*) Ranocchi ..	..	1260	1180	..	2440
(*c*) Clavature ..	516	162	882	1230	2790
(*d*) Drapperie ..	..	689	678	..	1367
Total ..	516	3941	5110	1230	10,797

The markets called Orefici and Drapperie are protected with sheds ; Rannochi has 1390 square feet covered by a roof, and 1044 square feet by sheds ; Clavature has 2500 square feet of sheds, and the rest is covered by a closed roof. The market Orefici contains 119 stalls, of which 65 are placed against the walls and 54 are intermediate ; Ranocchi market has 69 stalls, 20 against the walls and 49 in the passages ; Clavature has 14 shops and 44 stalls between the thoroughfares ; Drapperie market has 36 places, of which two are shops, 12 are side stalls, and 22 are in the middle. There is no space for wholesale business, nor any arrangement for municipal surveillance. The walls are built of brick, and the passages, which are paved with stone from Bevola, are washed twice a day ; the stalls are chiefly of cement. The principal advantage of the market is its central position. The cost of the four structures was 8500*l*.

(*To be continued.*)

KRUPP ORDNANCE.

(*Concluded from page* 644.)

FIELD GUNS.

Two types of field gun (Fig. 12, page 672), both 2.95-in. calibre, the one heavy and the other light, were exhibited. They were adapted for firing brass cartridges, and presented all the specialities of the Krupp system, as regards breech mechanism, firing device, and steel carriage with hydraulic brake. The following Table contains general particulars of both these guns :

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Particulars of 2.95-In. Heavy and Light Krupp Field Guns.

	Heavy.	Light.
Calibre...	2.95 in.	2.95 in.
Length of barrel ...	6 ft. 10.68 in.	5 ft. 10.87 in.
,, bore ...	6 ,, 2.8 ,,	5 ,, 5.55 ,,
Number of grooves ...	28	24
Weight of barrel and breech mechanism	683.42 lb.	518 lb.
Maximum elevation	20 deg.	20 deg.
,, depression	5 ,,	8 ,,
Weight of carriage	1058 lb.	573.20 lb.
,, empty limber	1124 ,,	716.50 ,,
Weight of equipment	101.4 ,,	66.14 ,,
,, ammunition carried... ...	515 ,,	293.22 ,,
Number of projectiles carried	36	26
Weight of projectile	12 89 lb.	9.48 lb.
Bursting charge of ring shells	.308 ,,	.22 ,,
Bursting charge of shrapnel	.198 ,,	.11 ,,
Number of balls in shrapnel	180	130
Weight of each ball...	.024 lb.	.024 lb.
Number of balls in case shot	72	55
Weight of each ball...	.132 lb.	.13 lb.
Weight of powder charge (smokeless)	1.124 ,,	.639 smokeless 1.769 coarse grained
Weight of brass cartridge...	1.104 ,,	
Initial velocity ...	1640 ft.	1394 ft. 1509 ,,
Total energy	240.56 ft.-tons	132.4 ft.-tons 150.15 ,,
Energy per 2.2 lb. weight of barrel ...	1756 ft.-lb.	564 ft.-lb. 639 ,,
Greatest range with 20 deg. elevation ..	6890 yards	5470 yards 5900 ,,

The heavy gun exhibited had fired 322 rounds.

SIEGE GUN, 4.13-IN. CALIBRE.

One siege gun (Fig. 13, page 672) was exhibited, of 4.13-in. calibre. It is 35 calibres in length, and is fired with a powder charge of 4.96 lb. The following are some of the leading particulars of this gun, which is provided with the ordinary Krupp type of breech mechanism, and a ring gas check. Five classes of ammunition are employed—cast-iron shell, steel shell, steel armour-piercing shell, shrapnel, and case shot. The weight of these projectiles is about 36 lb. The powder and bursting charges are:

Cast-iron shell	.88 lb.
Steel shell	2.64 ,,
Shrapnel	.353 ,,
Number of balls in shrapnel ...	185 and 300
Weight of balls	.057 lb. and .035 lb.
Prismatic powder (black) ...	8.8 lb.
,, ,, (brown) ...	10.36 ,,
Smoke ,, 1889 type ...	4.96 ,,

Ballistic Data.

Weight of Projectile.	Charge.	Initial Velocity	Energy. Total.	Energy. Per 2.2lb Weight of Barrel	Maximum Range, 35 deg. Elevation.
lb.		ft.	ft.-tons.	ft.-lb.	yds.
35.27	P.P. C/68, 8.8 lb.	1591	..	..	..
35.27	P.P. C/82, 10.36 lb.	1886	868	1650	11,260
35.27	W. P. C/89, 4.96 lb.	2034	..	..	..

Penetrating Power of Steel Armour Shell (35.27 lb.), with Initial Velocity of 1886 ft.

Range.	Descending Angle of Trajectory.	Wrought Iron Plate.	Steel Plate.
		in.	in.
At muzzle ..	.. ..	9.84	7.09
,, 1093 yards	1 deg. 8 min.	7.09	5.12
,, 2187 ,,	3 ,, 3 ,,	5.12	3.94
,, 3200 ,,	5 ,, 52 ,,	..	..

The leading dimensions of the gun and the carriage are:

Calibre	4.13 in.
Length of barrel	12 ft. 0.88 in.
,, bore	11 ,, 1.86 ,,
Number of grooves	32
Weight of barrel and breech ...	1.156 tons
Maximum elevation	35 deg.
,, depression	5 ,,
Weight of carriage and wheels...	1.417 tons
Height of axis of gun from ground	6 ft.
Width apart of wheels	4 ft. 5.73 in.
Weight of limber	.374 ton

The carriage is built of steel, and is mounted on two wheels that are run in and out on a foundation track. This foundation is a heavy timber structure, and is arranged to permit of lateral training through an angle of 45 deg. on each side. Inclines are placed behind the wheels in such a way that, in firing, the gun and mounting run back up the inclines, and then automatically forward into firing position. The amount of recoil is regulated by an hydraulic brake, the cylinder of which is pivoted to the foundation, and the ram is attached to the carriage close to the trail.

SMALL GUNS FOR LAND SERVICE.

Four small guns completed the ordnance exhibit of Essen. These were a boat and landing gun 2.4 in., with centre-pivot boat mount (Fig. 14, page 673) and a steel-plate wheeled carriage; a 2.95 in. mountain gun and wheeled carriage; a 2.36 in. mountain gun, built in pieces, both as regards the barrel and the carriage, for mule transport. Four mules are required, the maximum weight for each being about 280 lb. The fourth gun was for bush service, 1.46-in. calibre, and carried on a pivoted standard, mounted on a pair of wheels. The leading particulars of these four guns are collected in the following Table:

Particulars of 2.4-In. Boat Gun; 2.95-In. Mountain Gun; 2.36-In. Mountain Gun; and 1.46-In. Bush Gun.

Particulars.		2.4-In. Boat Gun.	2.95-In. Mountain Gun.	2.36-In. Mountain Gun.	1.46-In. Bush Gun.
Calibre..	in.	2.4	2.95	2.36	1.46
Length of barrel	ft. in.	4 1.21	3 2.38	3.28	4 6
,, bore	,,	3 8.29	2 9.27	2.88	1 4.15
Number of grooves		24	24	12	12
Weight of barrel and breech	lb.	232	220.46	198.41	88.18
Boat mounting: Maximum elevation,	deg.	15	20		
,, depression	,,	3	10		
Weight of carriage	lb.	611.4			
Land Carriage: Maximum elevation ..	deg.	20	..	20	10
,, depression ..	,,	10	..	5	20
Height of axis of gun ..	ft. in.	2 11.43			
Width between wheels..	,,	3 6.52			
Diameter of wheels ..	,,	3 7.31			
Weight of carriage ..	lb.	454	344	277.7	101.41
Weight with ammunition	,,	750.4			
Ammunition; shells (length 3 2)	lb.	6.6	4.3	5.18	.99
,, ring shells (length 3.2)	lb.	6.6	4.3		
Ammunition; shrapnel (length 2.7)	lb.	6 6	4.3	5.18	1.1 case shot
Powder charge (coarse-grained)	,,	.882	.882 .296 smokeless	.441*	.154*
Initial velocity	ft.	1168	984	918	1329
Total energy	ft.-tons	62.58	61.03	30.33	12.11
Energy per 2.2 lb. weight of barrel	ft.-tons	.73	.614	ft.-lb. 752	.3
Maximum range with 20 deg. elevation	yards	4867	4265	3720	2784

* Fine grained.

LITERATURE.

British Locomotives; Their History, Construction, and Modern Development. By C. J. BOWEN COOKE. London: Whittaker and Co.

HAVING perused the preface to "British Locomotives," we must confess to a feeling of pleasurable anticipation as to the actual contents of the work. "The books which have hitherto been published on the locomotive appear to be either altogether technical and scientific in their character, or else to deal with the subject entirely from a non-professional point of view. The former can only be understood by experts, and the latter do not give much idea of the principles of working or of construction." Feeling that a book which should strike a happy mean between these extremes would be an acceptable addition to railway literature, Mr. Bowen Cooke has set himself to accomplish the task. The outcome is, in fact, a companion work to Pattinson's "British Railways." When reviewing the latter, we had reason to complain of the author's evident partiality for the London and North-Western; on the part of Mr. Bowen Cooke such a tendency is perfectly legitimate, seeing that he holds a responsible position as outdoor assistant on the "leading line;" and the reader must make up his mind to a somewhat frequent reference to North-Western practice.

There can be no doubt that—as Mr. Cooke truly remarks—"there are a great many people in the world who take an intelligent interest in railway working outside those directly connected with this particular branch of engineering." We have often wondered why this should be so; why so many people—not otherwise possessing engineering predilections—willingly give up much valuable time and trouble to the collection and study of facts connected with railways in general, and locomotives in particular. A glance at the excellent illustrations of locomotives past and present which are to be found in Mr. Cooke's work will perhaps furnish an answer to this question. Here we can trace, step by step, the several links which, together, make the chain of history complete. Take the old "Rocket," the sturdy pioneer of our modern engines, with her single pair of leading driving wheels, her cylinders working forwards, her funnel almost as long as the boiler; then each successive engine shown until we reach the picture of the Midland "single," which is one of the handsomest engines in the world, and we have a most fascinating study before us. We say "fascinating" advisedly, for surely the evolution of a beautiful and symmetrical design is, in its way, almost as interesting a study as the higher work of nature. Of all the numerous branches of modern engineering, locomotive design seems to be the only one which advances in the direction of artistic outline. Take bridge-building, for instance: the Menai and Conway tubular, the Forth Bridge, the Chepstow Bridge, and, indeed, nearly every big railway bridge in the world, is more or less of an eyesore. Or take the ocean greyhound: who will deny that the Campania and Teutonic are far less beautiful, from an artistic point of view, than the Ormuz and Arawa; or that the latter are not themselves a step lower than the Aberdeen clippers which preceded them?

A story is told that at a certain railway board meeting the locomotive superintendent was asked by a director if he could not see his way to effect an improvement in the looks of his engines: "Certainly," answered the superintendent, "I should be most happy to paint every engine we possess with gold leaf, if the shareholders will supply the money." We think this engineer's ideas of sombre simplicity, while in some respects of benefit to the shareholder, are not in accordance with public taste. We like to see our locomotives bright and well groomed; just as in the old days we appreciated a well-appointed team of coach horses. Standing beneath the roof of Paddington Station, where an important express is just about to start, say the night mail at nine o'clock, observe the glint of the electric light on polished brasswork and chocolate splashers, who can repress a word of admiration for the handsome appearance of that triumph of mechanical skill?

It is curious that no other country should have given so much attention to the design of their locomotives. American engines have long been proverbial for their clumsy appearance; and some of the Continental engines are more like a fitting shop turned inside out, with a factory chimney for funnel. But we are glad to note considerable improvement in this respect of late years. Both America and the Continent seem to be adopting to a certain extent English ideas. They are beginning to realise that there are more convenient places than the top of the boiler for such things as brake reservoirs and sand boxes. The four-cylinder compound locomotive which we recently examined on the Chemin de Fer du Nord might, at a distance, almost be mistaken for an English engine.

Mr. Cooke's book is divided into twenty chapters, of which the first and second are devoted to historical matters, and are illustrated by a number of engravings of notable locomotives. The mechanical details of a locomotive are next considered, six chapters being devoted to this branch of the subject, and the descriptions given being clear and concise. Then follows a chapter dealing with the putting together of a locomotive in the erecting shop — London and North-Western practice being specially described—and then one on valve setting. Chapters XI., XII., and XIII. deal respectively with the "Classification of Engines," "Tenders," and "Brakes," and we then come to two chapters in which the chief standard types of modern British locomotives are described and illustrated, compound locomotives, however, being treated separately in Chapter XVI. The important subjects of lubrication and packing are considered in Chapter XVII., which contains some useful notes, while the next deals with the principles of combustion and the consumption of fuel. Finally we have two chapters headed "Engine-

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KRUPP ORDNANCE.

THE ordnance exhibit of Essen at Chicago was certainly the most complete and splendid that has ever been seen in the United States of America; probably it was the most important ever made at an International Exposition by any single manufacturer of ordnance. It was contained in a pavilion erected near the east front of the Agricultural Building, and quite remote from the Transportation Exhibits Building, to which it belonged. This pavilion was about 200 ft. long, 42 ft. high, and 82 ft. wide. It was designed and constructed in Germany, and shipped to Chicago complete for erection. The contents comprised a large series of ordnance, from the great 120-ton gun to the smallest calibres for mountain service; a large display of projectiles; a series of armour-plates; and a great number of rolled and pressed objects in steel, prominent among which were the steel frames and trucks of rolling stock referred to elsewhere. The most conspicuous object in the ordnance collection was the 120-ton gun, which presented a monumental appearance in the centre of the hall.

THE 42-CENTIMETRE (16.54-IN.) GUN.

The 42-centimetre gun was built for coast defence service, but it is more likely to remain as a monument to the wonderful producing power of Essen, than to come into active use as a weapon of offence. A few particulars of this magnificent piece of ordnance may be added. The breech mechanism is of the standard type, with rounded sliding wedge block, and the charge is fired by a friction fuze. The following are some of the chief dimensions:

Calibre	16.54 in.
Length of barrel	45.93 ft.
,, bore	41.66 ,,
Number of grooves	120
Weight of barrel with breech ...	120.46 tons
Weight of projectile	2204 lb.
Powder charge	903.8 ,,
Initial velocity (feet per second)	1981
Total striking energy	60,002 foot-tons
Energy per kilogramme (2.2 lb.) of barrel	1099.42 foot-pounds
Maximum range with 10.5 deg. elevation...	9680 yards

Perforating power of steel shell on wrought-iron plate:

At muzzle	3.53 ft.
,, 3281 ft.	3.26 ,,
,, 6562 ,, ...	3.01 ,,

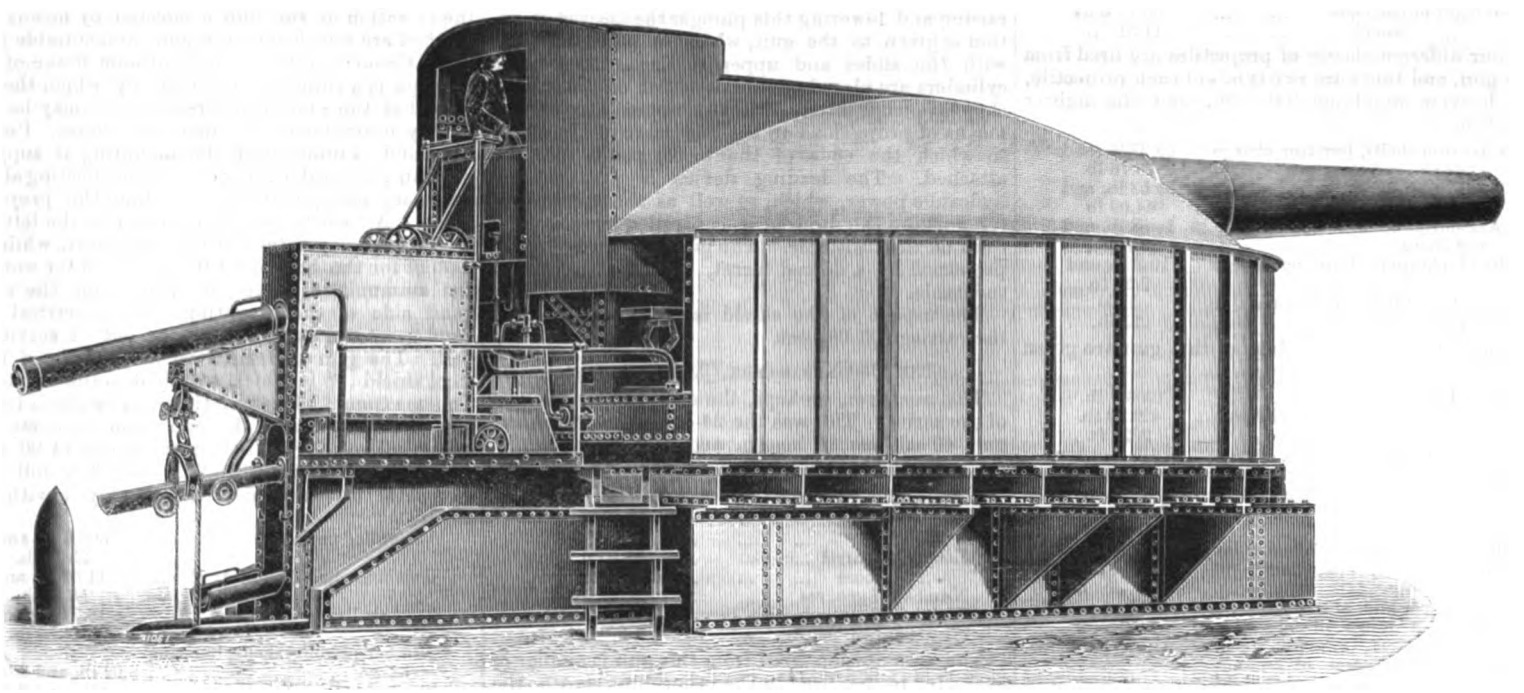

FIG. 1. KRUPP 30.5-CENT. NAVAL GUN AND CARRIAGE.

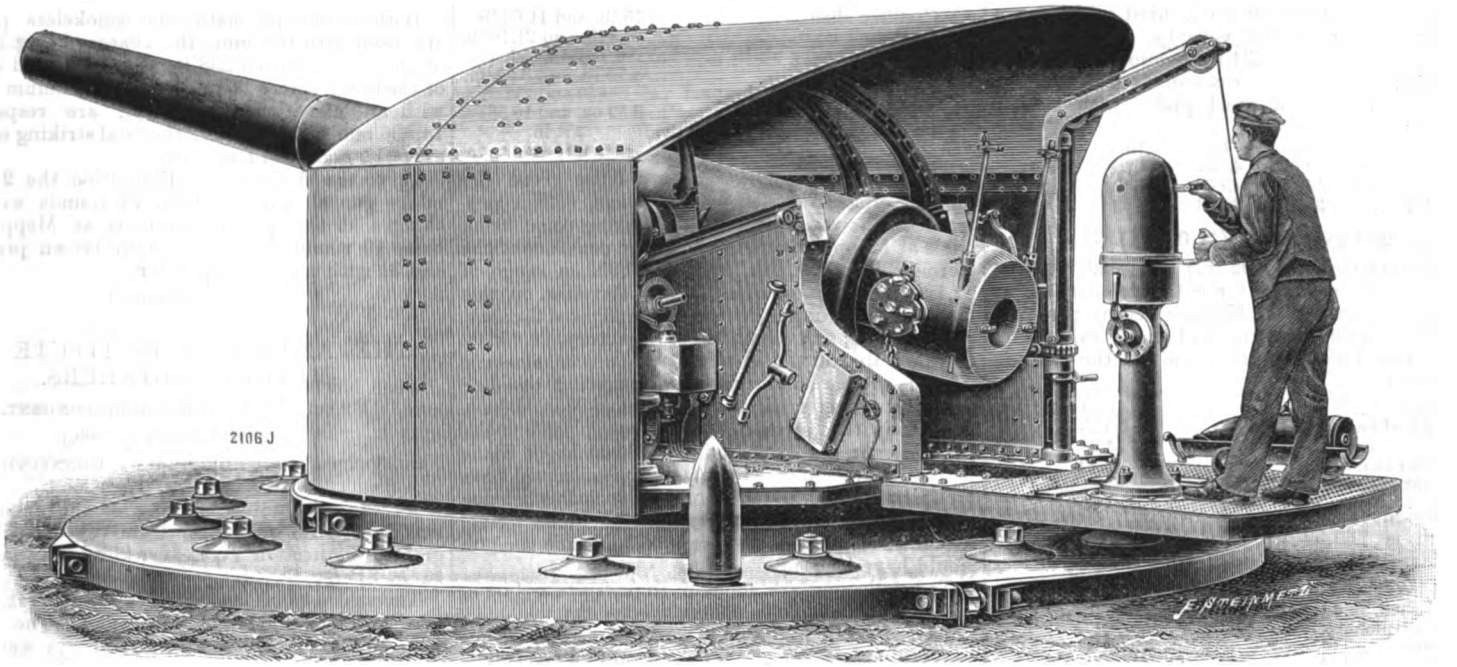

FIG. 2. KRUPP 21-CENT. NAVAL GUN AND CARRIAGE.

Four classes of ammunition were made to be fired from this gun: cast-iron shells, steel shells, armour-piercing projectiles, and steel shrapnel; the weights of these varied from 2204 lb. to 2513 lb. The weights of the bursting charges of the various projectiles were as follows:

Cast-iron shell	72.75 lb. and 88.18 lb.
Steel shell	119.04 lb. and 143.29 lb.
Armour-piercing shell	22.04 lb. and 27.55 lb.
Shrapnel	22.04 lb. and 25.13 lb.
Number of balls in shrapnel ...	3000 and 4000
Weight of each ball	3.52 oz.

As stated above, there have been sixteen rounds fired from this gun, and the following results were obtained from the experiments made:

At the Exposition the gun was mounted on a front pivoting carriage, the rear part of the mounting being supported on four rollers traversing on a curved roller path; this formed the lower part of the mount. The gun itself was supported on an upper carriage which could be moved to and fro on the inclined slides of the pivoted mount. A toothed quadrant is attached to the side of the gun, and it is raised and lowered by a train of hand-worked gearing engaging in this quadrant. Horizontal training is effected by a pitched chain and gearing operating on the back of the underframe. The recoil is taken up by hydraulic brakes, the piston-rods of which are attached to a cross frame on the upper carriage, the brake cylinders themselves being on the lower carriage. The gun and upper carriage are run out by means of a chain and windlass. As already stated, the gun is interesting as a specimen

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of magnificent workmanship, rather than as an example of efficient ordnance or of the modern practice at Essen.

THE 30-CENTIMETRE (12.01-IN.) GUN.

The following are some of the particulars of this gun (see illustration, Fig. 1, page 567):

Calibre	12.01 in.
Length of barrel	35 ft. 1.2 in.
,, bore	32 ,, 0.6 ,,
Number of grooves in rifling	68
Weight of barrel and breech mechanism	61.46 tons
Maximum elevation	13 deg.
,, depression	5 ,,
Weight of carriage	53.15 tons
,, shield	11.81 ,,

Four different classes of projectiles are fired from this gun, and there are two types of each projectile, the heavier weighing 1003 lb., and the lighter 725.3 lb.

Cast-iron shells, bursting charge	35.27 lb. and 29.76 lb.
Steel ,, ,,	59 53 lb. and 44.09 lb.
Armour-piercing shells, bursting charge	10.58 lb. and 9.70 lb.
Steel shrapnel, bursting charge	10.3 lb. and 7.25 lb.
Number of balls in shrapnel	1360
Weight of each ball	.22 lb.

Some of the ballistic data of this gun are given below:

1.	Weight of projectile	1003.9 lb.
	Powder charge, brown prismatic	429.89 lb.
	Initial velocity	2021 ft.
	Total energy	28,415 foot-tons
	Energy per kilo. of weight of gun	1019.13 foot-pounds
	Maximum range, with elevation of 13 deg.	10,827 yards.
2.	Weight of projectile	1003 lb.
	Powder charge, smokeless cube	227.07 lb.
	Initial velocity	2234 ft.
	Total energy	34,728 foot-tons
	Energy per kilo. of gun	1245.52 foot-pounds
	Maximum range of elevation 13 deg	11,975 yards
	Penetrating power of armour-piercing shell striking at right angles an iron plate at muzzle	39.09 in.

The first two columns of figures below refer to the steel armour-piercing shell, fired with brown prismatic powder (initial velocity, 2021 ft.) and the smokeless powder (2234 ft.) against a wrought-iron plate; the last two rows of figures refer to shell fired against a steel plate with similar vel cities:

	In.	In.	In.	In.
At the muzzle	39 09	45.66	25.75	29.69
At 1094 yards	35.71	45 58	23 62	27.29
At 2187 ,,	32.48	38.03	21.62	25.08

THE 28-CENTIMETRE (11.02-IN.) GUN.

The 28-centimetre (11.02-in.) gun that was exhibited is also intended for coast defence, and is an admirable example of Krupp's recent practice. It is of the 1889 pattern, and is 40 calibres in length. The following are some of the leading particulars:

Calibre	11.02 in.
Length of barrel	36.75 ft.
,, bore	33.99 ,,
Number of grooves	84
Weight of barrel and breech	42.62 tons

The weight of the loaded projectile fired from this gun is 760.59 lb., and the following are particulars of the four kinds of shell employed:

Cast-iron shell, bursting charge	25.35 lb.
Steel shell, bursting charge	44.09 ,,
Armour-piercing shell, bursting charge	7.94 ,,
Steel shrapnel, bursting charge	7.61 ,,
Number of balls in shrapnel	1030
Weight of each ball	.22 lb.

Firing experiments made with this gun gave results which may be summarised as follows:

Weight of projectile	760.59 lb.
,, charge (prismatic powder)	352.74 ,,
Initial velocity	2067 ft.
Total energy at muzzle	22,536 foot-tons
,, ,, 1094 yards	19,633 ,,
,, ,, 2187 ,,	16,145 ,,
Energy per kilogramme weight of barrel	.52 foot-tons
Maximum elevation	45 deg.
Range at maximum elevation	22,200 yards

Under the above conditions, the penetrating power of the armour-piercing shell in a wrought-iron plate is as follows:

At the muzzle	34 in.
,, 1094 yards	30.74 in.
,, 2187 ,,	27.8 ,,

This gun, which was finished only in 1892, is provided with a vertically rising breech-block. Although specially designed for coast defence service, it can, with a modified arrangement of the ammunition hoist, be employed for naval service. The mounting is peculiar in affording a very great range of elevation—from plus 45 deg. to minus 5 deg. The mounting is carried on a turntable placed on a live ring of steel balls, and the under carriage is secured to this table; upon this are placed the slides, which in their turn support the upper carriage. The slide is carried at its forward end on journals, and in the centre by a cross frame, to which is connected the plunger of a hydraulic cylinder; by raising and lowering this plunger the desired elevation is given to the gun, which is lifted together with the slides and upper carriage. The brake cylinders are placed one on each side of the slides; they are connected with the upper carriage by means of projections on the underside of the latter to which the ends of the brake piston-rods are attached. The loading device is operated by hydraulic power, which, as well as the mechanism for working the breech, is controlled from a platform on the turntable. The gun and mounting are protected by a domed turret, also carried by the turntable.

The weight of the shield is 23.62 tons, and of the carriage 59.05 tons.

THE 24-CENTIMETRE (9.45-IN.) GUN.

The next was, perhaps, the most interesting gun of the series. This was the 24-centimetre (9.45 in.) gun, 40 calibres in length, and built on the 1886 pattern; the breech mechanism is of the standard Krupp type. The following are some of the leading particulars of this gun:

Calibre	9.45 in.
Length of barrel	31 ft. 6.13 in.
,, bore	29 ft. 1.75 in.
Number of grooves	56
Weight of barrel with breech mechanism	30.51 tons

The ammunition fired from this gun is similar in character to that used in the other guns shown, the weights being 353 lb. and 474 lb. The bursting charges of the different shells are as follows:

Cast-iron shell	15 lb. and 11.68 lb.
Steel shell	26.4 lb. and 21.16 lb.
Armour-piercing shells	No bursting charge
Steel shrapnel	4.75 lb. and 3.53 lb.
Number of balls in shrapnel	650 and 217
Weight of each ball	3.52 oz. and 10 58 oz.
Powder charge—prismatic	254 lb.
,, ,, smokeless	92.7 lb.

This gun is remarkable as having given the longest range recorded by any trials, with a projectile of the weight specified. During some firing trials at Meppen, carried out in the presence of the German Emperor, on April 28, 1892, a range of 22,120 yards was obtained. The elevation on this occasion was 44 deg.; the duration of flight of the shot, 70.2 seconds; and the height of trajectory, 21,456 ft. On the walls of the Krupp Pavilion was shown a diagram of this famous round, illustrating the line of trajectory referred to the height of Mont Blanc, and shows that if the gun had been placed at Pré St. Didier in the Alps, and directed at Mont Blanc with an elevation of 44 deg., the shot would have fallen in the vicinity of Chamounix, after having passed 5675 ft. over the summit of Mont Blanc, which is 15,781 ft. above the level at which the gun would have been fired.

The following are some of the results obtained with firing trials of the 24-centimetre gun:

1.	Weight of projectile	352.7 lb.
	Nature of powder	Brown prismatic
	Weight of charge	253.53 lb.
	Initial velocity	2510 ft.
	Nature of powder	Smokeless cube
	Weight of charge	2623 lb.
2.	Weight of projectile	473.97 lb.
	Nature of powder	Brown prismatic
	Weight of charge	253.53 lb.
	Initial velocity	2100 ft.
	Total energy	14,482 foot-tons
	Energy per kilogramme of gun	.467 ,,
	Maximum range, elevation 25 deg.	15,092 yards
	Maximum range, elevation 44 deg.	21,872 ,,
3.	Nature of powder	Smokeless cube
	Weight of charge	92.59 lb.
	Initial velocity	2300 ft.
	Total energy	17.328 foot-tons
	Energy per kilogramme of gun	.559 ,,

THE 21-CENTIMETRE (8.26-IN.) GUN.

The 21-centimetre (8 26-in.) gun, as shown in Fig. 2, page 567, was exhibited mounted on a centre-pivoting naval carriage. The length of the gun is 35 calibres, and it is specially intended for large gunboats or the smaller class of ironclads. The mounting possesses some features of special interest; it consists, as usual, of the upper carriage, the underframe, and the turntable. The gun is mounted by its trunnions in the upper carriage, in the sides of which the hydraulic brake cylinders are formed, the piston-rods of these cylinders being attached to the forward end of the lower mounting. The turntable to which this latter is attached revolves on a central pivot, and is supported on a live ring of steel balls. The gun can be revolved horizontally with gearing worked by hand; the elevation of the gun is effected by means of a toothed arc attached to the gun, and suitable gearing. Connected with the hydraulic brake of the carriage is a running-out brake by which the gun is held at the end of the recoil, or it may be held in any desired position upon the slides. Besides the hand training gear the mounting is supplied with an electrical driving device for effecting all the necessary manipulations, including the projectile crane. An electric motor mounted on the left side of the frame operates the elevating gear, while the motors for the horizontal training, and for working the ammunition crane, are placed on the right-hand side of the mounting. The electrical and hand gears can be thrown in or out of service at will. The gun and carriage are protected by a steel shield .98 in. thick attached to the turntable. The maximum elevation that can be given to this gun is 25 deg., and the maximum depression is 5 deg. The weight of the mounting is 14.90 tons, and that of the shield is 6.98 tons. The following data refer to the ammunition employed with this gun:

Weight of projectiles	308.6 lb. and 238.1 lb.
Cast-iron shells, bursting charge	11.02 lb. and 8.82 lb.
Steel shells ,, ,,	18.74 lb. and 14.33 lb.
Armour-piercing shells, bursting charge	3.09 lb. and 3.09 lb.
Steel shrapnel, bursting charge	3.09 lb. and 2 43 lb.
Number of balls in shrapnel	975
Weight of each ball	.11 lb.

Both brown prismatic and smokeless powders are used with this gun, the charges being 51.8 lb. of the former with a 238-lb. projectile, and 50.7 lb. of the latter with a 308.6-lb.; the maximum ranges, with an elevation of 25 deg., are respectively 14,436 and 15,037 yards; the total striking energies are 9012 and 9616 foot-tons.

Up to the date of the Exhibition the 21-centimetre gun shown had fired 74 rounds with full charges at the practice grounds at Meppen; of these 40 rounds were fired with brown prismatic, and 34 with smokeless powder.

(To be continued.)

THE AMERICAN INSTITUTE OF MINING ENGINEERS.

(BY OUR NEW YORK CORRESPONDENT.)

(*Concluded from page* 509.)

SURVEY OF AN UNDERGROUND CONNECTION AT LEAVENWORTH, KANSAS.

AT the concluding meeting of the Society the first paper read was on the "Survey of an Underground Connection at Leavenworth, Kansas," by E. A. Sperry.

The shafts to be connected were 5020 ft. apart, and work was started at both ends. The map in Fig. 10 shows the line. The surveys were commenced on December 1, 1891, and on December 31, 1892, the headings met with an error of less than 3 ft. in lateral measurement, and about 2 in. in length.

The men employed were new at this business, and such as could be obtained at a coal mine. The author had to drop his base lines 720 ft. down each of the two shafts, but 10 ft. in width. The line of the tunnel ran down the middle of the Missouri River, and the only surface checks possible were by running down the river bank along the bluff. His plan was:

"1. To tie the two shafts by carefully checked lines, three in number, down the Missouri Pacific Railway track, using only parts of any one line for either of the others, and thus checking the traverse on the various points.

"2. To drop the base down the two shafts.

"3. To run the underground lines to the point of starting in each mine. I had a fair opportunity to

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