their power to the axles by flexible connections. Each of the six motors takes 225 kilowatts, and runs at a normal speed of 70 revolutions. The motors are carried by the truck frame, so that the armatures are protected from "hammering." The wheel axles pass through the armature axles, which are hollow and of a much larger internal diameter than the external diameter of the wheel axles. These latter are driven by four arms attached to the armature axle, and engaging with four pairs of lugs on the wheels.

One of these locomotive motors is shown in Fig. 7, in which the general construction and the hollow armature shaft are well shown. The weight of the locomotive is 180,000 lb., and it exerts a drawing pull at starting of 60,000 lb. The length is 50 ft., with a width of 9 ft. 6 in., and a height of 14 ft. 3 in. The wheel base of each truck is 6 ft. 10 in., and the total wheel base is 38 ft. 9½ in. The driving wheels, of which there are 12, are each 5 ft. 2 in. in diameter.

Each truck has over it a sheet-iron cab, that in the centre being higher than the others, and from which an unobstructed view can be obtained, and from it, also, the engineer in charge can observe the working of all three motors.

The locomotive is designed to do the heaviest work that the largest steam locomotives do, and it has a possible speed of 50 miles an hour. The current is taken from three overhead wires shown in Fig. 6 by three trolleys corresponding to and connected with the three motors respectively, and the three trucks can be disconnected and used separately for shunting or other lighter purposes.

Electric freight cars have been constructed by the General Electric Company for the Rockland, Thomaston, and Camden Street Railway, which runs through and between the towns of Rockport and Camden through a distance of 9½ miles, and is being extended to the town of Thomaston, involving a further extension of three miles. The Knox and Lincoln Street Railway runs as far as Rockland only, for the very hilly character of the country beyond offers considerable difficulty for a steam-driven railway to the seaport towns of Rockport and Camden. An electric road was, therefore, adopted, and it has been attended with very successful results, so much so that the company has applied the system to the carriage of freight.

The freight car employed is similar in construction to those in use on steam railways, and is provided with sliding doors in the centre of each side, and with smaller doors at the ends, giving access to the end platforms. It is 25 ft. long, 7 ft. wide, and 7 ft. high, and has at each end a platform 30 in. wide, covered by the overhanging roof of the car, and having in front a dashboard similar to those in use on the ordinary street tramcar, and to this platform are attached the brakes, controlling and reversing switches, and starting gongs. The interior is illuminated by three lamps in series with the platform lamps.

The body of the car is mounted on two Bennis bogie trucks, with eight wheels of the standard gauge, and on each axle is a General Electric Company's motor, so that there are four motors in all, and the current is taken from overhead conductors by an ordinary trolley. The car weighs a little over 15 tons, and has a carrying capacity of 20,000 lb. It is intended to employ this car as a locomotive to draw an ordinary freight car as a trailer, which will add about 9000 lb. to the weight to be driven by the electric motors. The company guarantee to carry a minimum load of 20,000 lb. up an incline of 8 per cent. at a maximum speed of five miles an hour, and on the level at 10 or 12 miles an hour. It is an important fact connected with this line that it has secured the contract to carry the United States mails between the towns through which it runs, which opens up an entirely new condition under which street tramways must stand to the public.

We ought to add that the dynamos and motors referred to above were designed by Mr. H. F. Parshall, the consulting engineer to the General Electric Company.

THE GUNS AND THEIR MOUNTINGS OF SPANISH BELTED CRUISERS.

WE this week commence the illustration of the 28-centimetre Hontoria guns and their mountings fitted in the three belted cruisers built by the Sociedad Anonima de los Astilleros del Nervion, who also constructed the guns, while the mountings were made by Sir Joseph Whitworth and Co., Limited, Openshaw, Manchester. The guns and the breech mechanism are illustrated on page 266, while of the mounting we give, on our two-page plate, a longitudinal section showing the arrangement from the keel of the vessel to the top of the turret. We intend to give later a transverse section and plan on the same scale, and further details. The principle of the mounting is that known as the central loading system, in which the charge is always delivered to the breech of the gun ready for ramming without changing the direction of aim of the gun after firing, and thereby enabling it to be loaded in any position of training. The operations of loading, elevating and training, and running the gun in and out are all controlled by suitable mechanisms carried on the gun platform, the motive power being hydraulic. The ammunition is protected in its passage from the magazine to the gun by armour arranged around the central revolving ammunition tube, and the mounting itself is protected by a circular wall or barbette of armour, built on the upper deck, and protecting the roller path and turntable. The turntable carries a dome-shaped shield, which completely incloses the gun and machinery on the platform, except, of course, that portion of the gun protruding through the gun port. The dome-shaped shield is particularly adapted by its form to deflect any projectiles which may strike it, and is, therefore, not so thick as the armour usually carried on a turret.

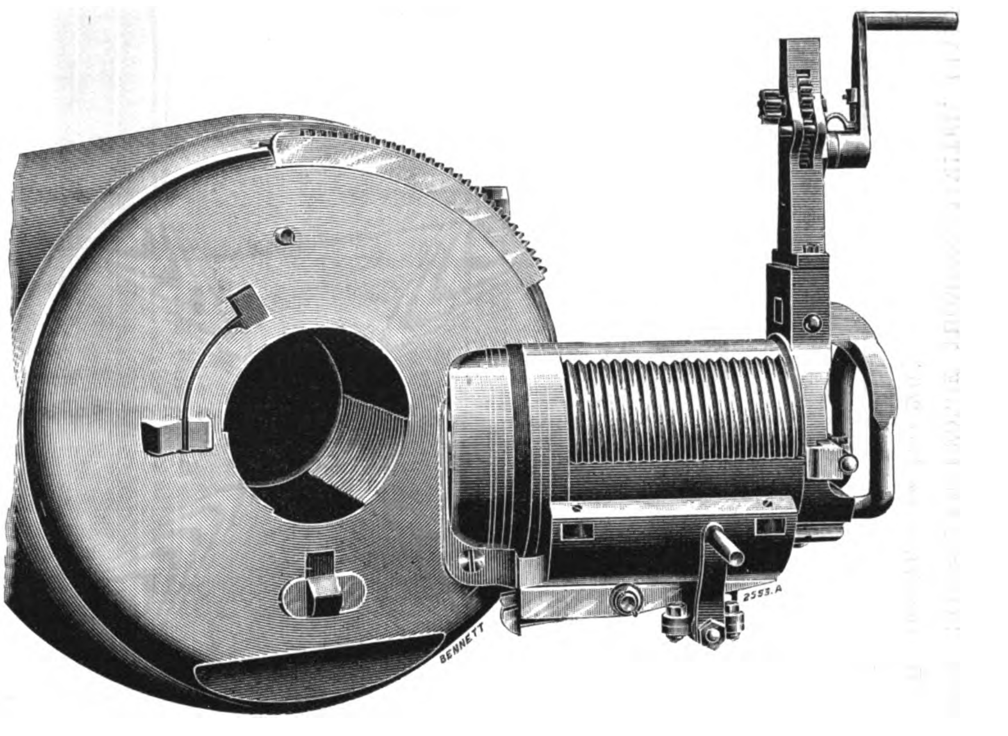


FIG. 7. BREECH MECHANISM OF 28-CENTIMETRE HONTORIA GUN FOR THE "VIZCAYA."

The loading angle of the guns is about 3 deg. as against the maximum angle of elevation of about 13 deg. in barbette ships in the British Navy, where a fixed loading station is preferred, except in ships of the Centurion* class. It follows, therefore, that while the gun is loaded above the level of the barbette wall, the whole of the breech mechanism and gear is protected by a fairly substantial shield. In the case of guns in most British warships some portion of the breech, at the moment of firing, rises above the armour wall, and is exposed to the fire of small arms and quick-fire guns.

Dealing now in detail with the installation we have thus briefly described generally, first consideration is naturally given to the gun itself, and in this connection it may not be inappropriate, before indicating the distinctive features of the Hontoria system, to cursorily review its evolution. In 1879 certain 16-centimetre cast-iron steel hoop guns had been devised by Hontoria, with results eminently satisfactory to the Spanish Government. About that time he directed his attention to the construction of artillery entirely of steel, the use of which, prior to this date, was only prevented by the absence of a native supply of reliable metal, the use of cast iron having thus been continued. Hontoria was sent by the Ministry of Marine to the principal countries, where he visited the most important works, and consulted with many eminent artillerymen, with the result that in 1883 he proposed a 16-centimetre steel gun, having an initial velocity of 630 metres = 2067 ft., with a projectile weighing 132 lb., the weight of the gun not exceeding 6 tons. The pressure in the chamber was 2400 kilogrammes per square centimetre, equal to 34,128 lb., or 15.2 tons, per square inch. The design of this gun was looked upon with some distrust by many artillery experts; but the designer was not disheartened, and having every confidence in his calculations, he entered into arrangements for the manufacture of this gun by the Forges et Chantiers Company at Havre. The gun, when tested, was highly spoken of by the French press, all the inventor's anticipations being realised, and even exceeded.

As a result of the tests, guns of 12, 14, 18, 20, 24, 28, and 32 centimetres were projected, completing a system which was adopted in the Spanish Navy. About 1884 a contract was made for the cruiser Pelayo with the French company named, and two 32-centimetre and two 28-centimetre Hontoria guns formed her principal armament. These guns were constructed in the Trubia Arsenal, General Hontoria being nominated Inspector-General for the construction of artillery for the Spanish Navy. These guns have been illustrated and described, and the remarkable results attained published in ENGINEERING (see vol. l., page 715), when we gave details of the cruiser and her equipment, so that they need not be further dealt with here. Suffice it to say that the results earned for their inventor promotion from the rank of brigadier to general, an honour which he only enjoyed for a year or two, a sad death carrying him off in 1889 at an early age. Though 11 years have passed since the 28-centimetre gun was designed, it may be said that it still holds its own with guns of similar calibre because of its high muzzle energy.

The inner barrel of the 28-centimetre gun in the new Spanish cruiser (Fig. 1, page 266), like that of the whole of the Hontoria guns, is formed of one forging, strengthened at its rear in after part by a long jacket, which incloses the gun chamber, besides which there are 10 hoops, six of which form a second course, the remainder forming a third course of strengthening. These hoops are of steel, forged, tempered in oil and annealed, and after being finished internally and on the ends (except the inner barrel itself, which was only finished externally), they are shrunk on hot, giving a radial extension of 1 per 1000.

The chamber (Fig. 1) is one of the features of the Hontoria system. It is very long, 77 in. = 6.9

* See ENGINEERING, vol. lvii., pages 358 and 415.

vessels in a preceding volume, and on page 7 *ante*, were manufactured at the ordnance works in the Astilleros del Nervion, where Lieut.-Colonel Albarran is chief director, while Major Navarrete supervised the work on behalf of the Government. The gun, as shown by Fig. 1, page 266, is trunnionless, but is provided with collars which fit into corresponding recesses in the cradle of the carriage, and is secured therein by four keys. The dimensions of the gun are given in Table I.

Table I.—*Dimensions of 28-Centimetre Hontoria Gun.*

Total length	10.310 metres = 33 ft. 9.91 in.
Sight line	2.370 metres = 7 ft. 9.31 in.
Length of rifled portion ...	309.1 in.
Powder chamber	77.1 in.
Bore over all in calibres ...	35
Number of rifled grooves ...	70
Depth and width	1.5 mm. and 4 mm. = .06 in. and .16 in.
Total weight	33 metrical tons.
Segment shell weight ...	
Common shell	617 lb. (bracketed)
Armour-piercing shell... ...	704 ,,
Firing charge for armour-piercing shell...	352.7 lb.
Reduced charge for other projectiles...	319 ,,

The muzzle velocity attained on the trials of the Spanish cruiser Pelayo, already referred to, reached 2034 ft., the total muzzle energy being 2403 foot-tons. The powder used was a brown cocoa powder made at the Spanish factory of Santa Barbara. The results indicate great power for a gun of this weight. Indeed, in Brassey's "Naval Annual" for two or three years there has been a foot-note to the effect that "the muzzle velocity and energy are probably estimated, and the power of the guns so great as to be out of the question; compare with British, French, or German guns, and the mistake is apparent." This statement is made notwithstanding that long ago the official results were published, verifying the figures questioned.* Indeed, the muzzle velocity reached 2038 ft. in some of the tests. It is true very few of these guns have been manufactured, and probably the firing from them has been a relatively limited number of rounds—some of them on board the Pelayo, however, fired 28 rounds before acceptance. It remains, therefore, to be seen what the effect of continued firing, such as takes place with British guns at quarterly practice, may have on the life of the gun.

As to the material used, the greatest care is taken. Messrs. T. Firth and Sons, Limited, Sheffield, supplied the steel, which was subjected to a tensile strain of 30 to 34 tons per square inch, before tempering, with from 25 to 30 per cent. elongation, and of 42 tons to 44 tons after tempering, with an elongation of 15 to 20 per cent. The elastic limit before tempering was 14 tons, after tempering 21 tons. We may take at random the detailed results (given in Tables II. and III.) of the tests of one of the tubes tested:

TABLE II.—*Tensile and Shock Tests on Tubes for 28-Centimetre Hontoria Guns.*

(Before Tempering. Specimens 13.8 millimetres =.542 in. in diameter).

	Elastic Limit. Tons Per Square Inch.	Breaking Strain. Tons Per Square Inch.	Elongation. Per Cent.
Breech ...	14.98	33.21	27
,, ...	13.90	31.24	27
Muzzle ...	14.92	32.63	26
,, ...	14.86	31.81	26

After Tempering. (Specimen 13.8 millimetres = .542 in. in diameter).

Breech ...	21.46	40.89	20
,, ...	21.21	41.33	18
,, ...	21.59	41.46	24.5
Muzzle ...	21.59	43.17	17
,, ...	21.65	43.94	18
,, ...	22.03	44.06	19

In all cases the aspect was fibrous. In the case of the shock test, of which the results in the case of the same tube are also appended, the weight of the tup was 18 kilos = 39.68 lb., and the height of fall being 1.10 metres = 43.3 in., the calculated force of the blow being 143 foot-pounds. The deflection at each fifth blow is given in the Table III.

During the construction of the gun, and before any hoops were placed on the barrel, the tubes, as is the usual practice with Hontoria guns, were submitted to an exceptionally severe test—two projectiles were placed in the bore, with a charge of powder between them. This charge was adjusted to give when firing a pressure in the bore of 11 to 12¾ tons to the square inch, so that, when considering the relative strength of other guns which have not a naked chase, this test should be borne in mind.

* See ENGINEERING, vol. l., page 718.

TABLE V.—*Gun Mountings of Spanish Belted Cruisers. Key to Lettering on Two-Page Plate.*

- A The revolving turntable.
- A^1 Upper floor of turntable.
- A^2 Turntable clips.
- A^3 Sighting platform.
- B Central revolving ammunition tube.
- B^2 Central pivot box for hydraulic pressure.
- B^3 Loading bracket.
- B^4 Upper shelf for projectile.
- B^5, B^6 Lower shelves for powder.
- C Armour protecting ammunition tube.
- D Barbette armour protecting turntable.
- D^1 Locking bolt.
- E Charge carrier.
- E^1 Hydraulic presses for raising and lowering charge carrier.
- E^2 Receptacle in charge carrier for projectile.
- E^3, B^4 Receptacle in charge carrier for powder.
- F Circular overhead rail.
- G Hydraulic rammer.
- G^1 Standard supporting rammer.
- G^2 Rammer valve.
- G^3 ,, head.
- H Pedal for working catch pawl.
- J Hoist valve handle.
- K Gun cradle.
- K^1 Piston-rod crosshead.
- K^3, K^4 Sliding faces on gun cradle.
- K^5 Slide clips.
- L Brake piston rod.
- M Slide beams.
- M^1 Non-return valve on slide beams.
- M^2 Discharge pipe of ditto.
- M^5 Buffer stops on ditto.
- M^6 Securing stays.
- N Trunnion bracket.
- N^1, N^2 Pipes to brake cylinder.
- N^3, N^4 Swivel joint for cylinder.
- O Brake cylinder.
- P, P^1 Elevating rams.
- Q, Q^1 ,, cylinders.
- R Stops on gun slide
- R^1 Supporting pawls.
- R^2 Shaft for pawls.
- R^3 Working lever for pawls.
- S Elevating valve.
- T Handwheel for controlling elevating rams.
- T^1 Arc on gun slide.
- U Training valve.
- V Handwheel for controlling training rams.
- V^1 Shaft for operating training rams.
- W Toothed ring on central tube.
- X, X^1 Training presses.
- X^2, X^3 Rams of training presses
- Y Shield armour.
- Y^1 Rear extension of shield
- Y^3 Sighting tower.
- Z Shield structure.
- Z^1 Skin plating of structure.
- Z^2 Fore sight.
- Z^3 Rear sight.
- Z^4 Weighted lever attached to wire rope.
- Z^5 Wire rope for safety bolt.
- Z^6 Safety bolt in shield.
- a Upper roller path.
- a^1 Rollers.
- b Lower roller path.
- b^1 Fixed vertical pivot ring.
- b^2 Packing ring below roller path.
- c Revolving vertical pivot ring.
- c^1 Vertical rollers.
- c^2 Vertical roller ring.
- d Guides in central tube.
- d^1 Socket for locking bolt.
- e Rollers in charge carrier.
- e^1 Ditto.
- f Wire ropes.
- f^1 Leading pulleys.
- f^2 Ditto.
- g Stop catch.
- g^1 Ditto
- g^2 Ditto
- h, h^1 Securing keys.
- i Discharge pipe of wash-out tank.
- k^1, k^2 Grooves on gun cradle.
- m Wash-out tank.
- n Trunnion pivots.
- o Clips for trunnion bracket.
- r Pinion gearing with arc on gun slide.
- r^1 Shafting for ditto.
- r^2 Bevel gear for ditto.
- t Pitched wheel on elevating handwheel shaft.
- t^1 Pitched wheel on sleeve.
- t^2 Pitch chain.
- u, u^1 Swivel joint for training pipes.
- v Rack for training valve automatic control.
- v^1 Pinion gearing with automatic control rack.
- v^3 Vertical shaft for automatic control.
- x Pitch chain for training presses.
- x^1 Auxiliary tension press.
- y^2 Horizontal shaft for training valve.
- y^3 Valve operating lever for ditto.
- M^* Water tank.

TABLE VI.—*Gun Mountings of Spanish Belted Cruisers. Key to Numbering of Pipes on Two-page Plate.*

1. Main pressure pipe.
2. Main exhaust pipe and discharge from brake.
3. Pressure pipe from distributing box to rammer slide valve.
4. ,, ,, ,, ,, hoist slide valve.
5. ,, ,, ,, ,, run in and out slide valve.
6. Pressure pipe from distributing box to elevating press slide valve.
7. Pressure pipe from distributing box to training press slide valve.
8. Pressure pipe from distributing box to gun wash-out valve.
9. Exhaust pipe between collecting box for exhaust water and rammer slide valve.
10. Exhaust pipe between collecting box for exhaust water and hoist slide valve.
11. Exhaust pipe between collecting box for exhaust water and run in and out slide valve.
12. Exhaust pipe between collecting box for exhaust water and elevating press slide valve.
13. Exhaust pipe between collecting box for exhaust water and training press slide valve.
14. Pipe between rammer slide valve and rear of rammer.
15. ,, ,, ,, front ,,
16. ,, hoist ,, rear of piston.
17. ,, ,, ,, front ,,
18. ,, run in and out slide valve and front of brake.
19. ,, ,, ,, rear ,,
20. ,, elevating press ,, ,, of presses.
21. ,, ,, ,, front ,,
22. ,, training press ,, right-hand press
23. ,, ,, ,, left-hand ,,
24. ,, foot valve and hose connection for wash-out.
25. Discharge of wash-out from gun.

TABLE III.—*Shock Tests of Tube for 28-Centimetre Hontoria Gun.*

(Specimen, side, .79 in.)

Deflection at		5th Blow. in.	10th Blow. in.	15th Blow. in.	20th Blow. in.	Broken at
Breech	...	.63	1.06	1.38	1.61	38th blow.
,,	...	.63	.98	1.34	1.54	54th ,,
,,	...	.63	1.02	1.38	1.58	81st ,,
Muzzle	..	.63	1.02	1.38	1.61	44th ,,
,,	...	.59	.98	1.34	—	20th ,,
,,	...	.59	1.02	1.34	—	16th ,,
,,	...	.63	1.02	1.26	1.54	63rd ,,

TABLE IV.—*Firing Proof of Spanish 28-Centimetre Tubes.*

—	Centre. Recorded Pressure in Tons per Sq. In.	Breech. Recorded Pressure in Tons per Sq. In.	Muzzle. Recorded Pressure in Tons per Sq. In.
First tube ..	11.42	12.88	6.59
	12.12	13 64	6.80
Second tube ..	12.74	14.06	8.36
	14.76	14.20	8.02
Third tube ..	12.0	11.9	7.5
	11.8	13.4	7.4
Fourth tube ..	12.7	13.0	8.1
	12.4	13.6	6.8
Fifth tube ..	12.6	13.6	8.2
	12.2	13.7	6.9
Sixth tube ..	12.7	13.5	8.3
	12.5	13.6	7.0

The proofs were conducted in this country, the tubes being smooth-bored to within 8 millimetres of the finished size, and carefully measured at various points of the length, both before and after firing. The internal and external diameters in each case showed no alteration.

On the two-page plate showing the mounting and equipment of the gun, we have adopted a system of lettering the principal items in the complete installation, and of numbering all the pipes. The key to this lettering and numbering is given in Tables V. and VI. annexed. In a subsequent issue we shall give further drawings of the mountings, and may therefore defer our description of them.

(*To be continued.*)

THE INTERNATIONAL LINER "KENSINGTON."

(*Concluded from page 200.*)

ON pages 258 and 259 are given illustrations of the International Liner Kensington, including a profile and deck plans. As indicated in our previous article, when we illustrated and described the machinery, the vessel was built to carry a large cargo, as well as 120 cabin passengers and a large number of emigrants, attaining a moderate speed on a low consumption of fuel. The dimensions are:

Length between perpendiculars ...	480 ft.
Breadth moulded	57 ,,
Depth ,, ...	40 ,,
Gross tonnage	8670 tons

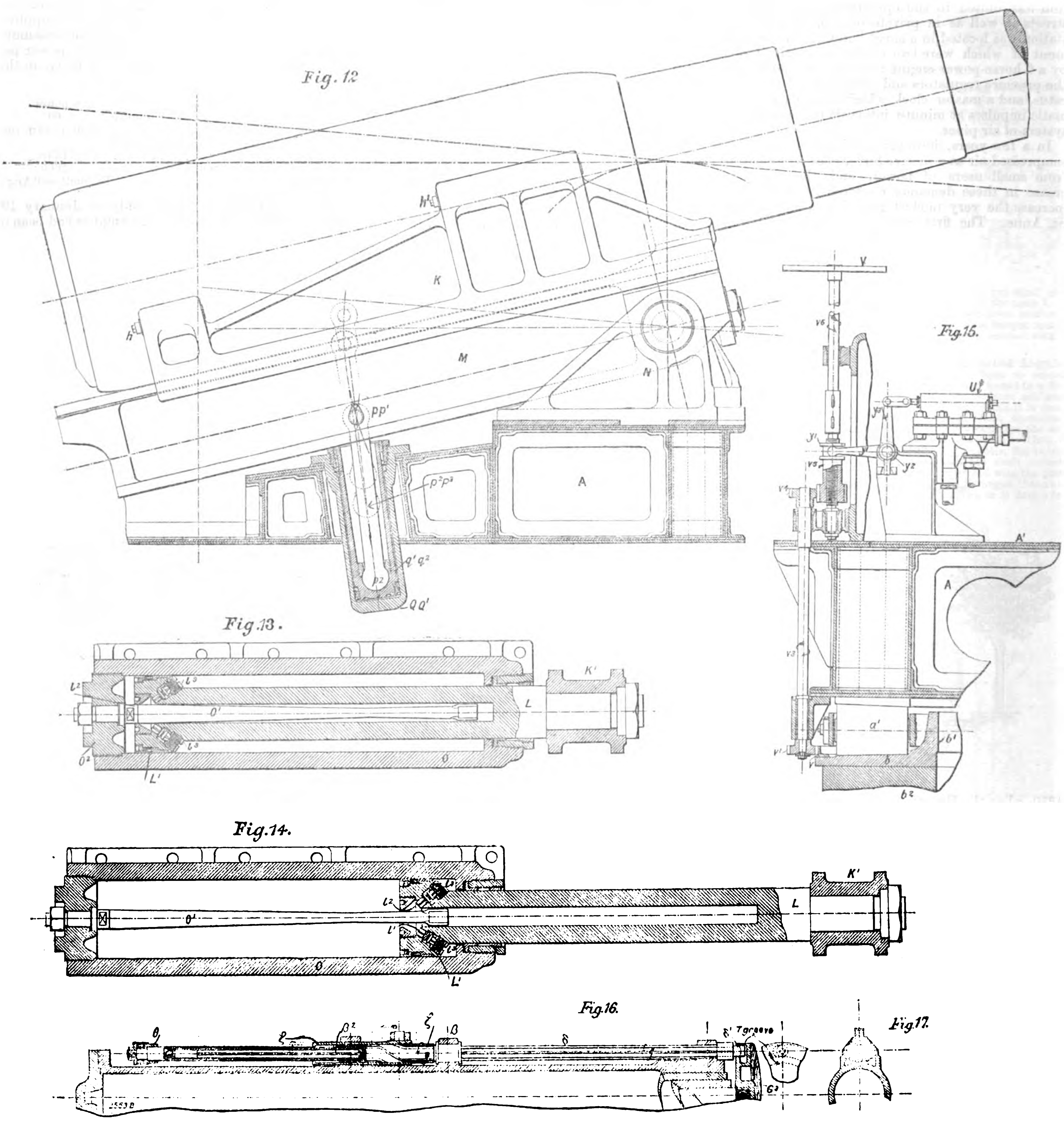
In a vessel such as this, which is intended to cross the North Atlantic at all seasons of the year, and with very large cargoes of varying density, the question of structural strength is of the first importance. The vessel is framed on the cellular double-bottom principle, the distance between the outer and inner skins being generally about 4 ft. The vertical keelplate is 48 in. in depth, with double angles on top and bottom edges. It extends continuously for the whole length of the ship, and is made water-tight for the midship portion of the ship, so that the midship compartments of the ballast tank can be used for correcting any heel which the ship may get. The edgeplates of the tank are, of course, continuous, and three intermediate intercostal girders are fitted between the centre keelplate and the edgeplate on either side. The floorplates, which are spaced 30 in. apart, and are ½ in. in thickness, extend in one plate from the vertical keel to the edgeplate, and are lightened by oval manholes 30 in. by 20 in. between the intercostal girders. These manholes were punched out in one operation by a hydraulic machine. The inner bottom plating is 1 in. in thickness under the engines, ⅞ in. under the boilers, and less than ½ in. at the ends of the ship. The butts and edges are overlapped, except under the engines, the butts being treble, and the landings double, riveted.

Under the engines the double bottom is somewhat increased in depth, additional longitudinal girders are fitted, and the thickness of the floorplates is increased to nearly ⅞ in. The bedplates of the engines are bolted directly to the inner bottom, thus giving a thoroughly rigid foundation for the machinery. Outside the limits of the inner bottom the framing is almost entirely of channel bars, which have to a very great

DETAILS OF GUN MOUNTING OF SPANISH CRUISER "VIZCAYA."

CONSTRUCTED BY SIR JOSEPH WHITWORTH AND CO., MANCHESTER.

(*For Description, see Page* 317.)



Figs. 12, 13, and 14. Elevating Cylinder, with Brake Cylinder at Run-In and Run-Out Positions; Fig. 15. Automatic Cut-Off for Training Gear; Figs. 16 and 17. Automatic Return Gear for Rammer when Ramming Powder to Prevent Crushing.

made to test the efficiency of the engines and compressors, and the results tabulated on the preceding page were, it is stated, arrived at.

It would appear from these trials that the mean total efficiency is 80.8 per cent. It is claimed that the actual cost of 100 cubic metres (3530 cubic feet) of air compressed to 113 lb. per square inch is .4536 fr., or less than 5d. This figure was arrived at after a trial of 24 hours in the station of the Quai de la Gare, and it was confirmed by the results obtained from three months' subsequent working.

The applications of compressed air in Paris are very numerous and varied, but according to the latest information the following classification may be made:

1. Distribution of power in quantities ranging from the minute time impulses, to motors of 150 horse-power. It is worth noticing that in many workshops old steam engines are now worked with compressed air, the boilers serving as reservoirs in which the air is heated before admission to the cylinders.

2. Ventilation and other sanitary purposes.

3. Refrigerators, especially cold stores for the preservation of meat, &c.

At the Bourse du Commerce the installation for this purpose is large, comprising 16 cold air stores, when working under a heavy load, the rim of the wormwheel springs off to one side a little, under the drag of the worm, and then jumps back.

In another design the spokes of the wormwheel ought to have stiff ribs added to the rather thin section shown in Fig. 8, to prevent sidewise distortion.

In order to retain torsional strength with this small diameter, at the crank end of the worm the screw thread starts in from the 4-in. cylinder without any notch (see Figs. 5 and 6). Ball bearings were also introduced (see Fig. 6). They were 1 in. in diameter, and cost 2.50 dols. per dozen. In Figs. 7 and 8 are shown the forms of the involute rack teeth and the pinions used. The holes D are to allow the water to escape. In Figs. 8, 9, and 10

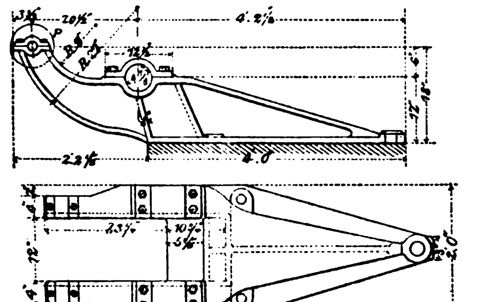


Fig. 9.

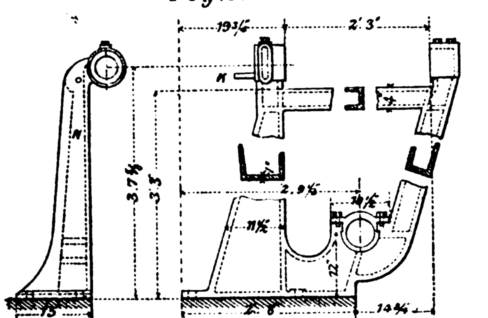


Fig. 10.

are the details of the precautions taken to hold the bearings rigidly in line.

The writer, after describing these details at length, concluded with the following:

"The ratios of the train of gearing are such that one revolution of the pinion raises the gate 30 in., and this calls for 126 revolutions of the crank, or one revolution of the crank lifts the gate very nearly $\frac{1}{4}$ in. From 30 to 50 revolutions per minute can readily be made on a crank of this sort, and at 40 revolutions per minute the gate would be raised 10 in. per minute."

A lively discussion followed, for there were present quite a number of sluice-men, dam-builders, and waterway "cranks" generally. Each one had his own ideas, even on the subject of anchor ice. One preferred to have the gate fitting flat on a flat sill rather than a mitre sill. He did not advocate carrying the sluice gates of a water-power canal on rollers, nor did he approve of hoisting by man power when there was water power available. He cited a case where he built a gate 14 ft. by 7 ft. with no water in the down stream fall, and it was raised by a man with one hand. What would have resulted if he had employed a two-handed man he did not state, and as one-handed men are not always available, this was certainly a case of special pleading. Another told of gates 4 ft. by 5 ft. made water-tight by brass sliding on brass. Gates 6 ft. by 10 ft. with sills 16 ft. below a dam, were made water-tight by inclined falls on the gate and the jambs.

An arrangement, consisting of a pipe 8 ft. in diameter, fitting vertically on to a bevelled edge of the opening, and raised and lowered by chains over a differential pulley, was the next speaker's theme. It worked under a head of 25 ft.

A variation of this, it was said, had been used on the Welland Canal. It had square holes and inverted pyramid-shaped valves built up of oak. As the day was very hot, the discussion drifted into anchor ice. A case was named where a rapidly flowing river was frozen over, and on cutting off piles below the water, they were found thickly coated with ice, which he attributed to the coldness of the piles. Anchor ice was defined by another, and one of authority, as consisting of the needles of crystallisation kept apart by the motion of the water by wind or current; these form slush ice, which flows under the surface ice, adhering to it and growing downwards, forming a suspended dam. The ice will also adhere to the bottom of the river to a depth of 2 ft., and if broken off will at once rise.

This closed the discussion, and it was high time, for when personal experiences, each one more startling than its predecessor, continue for any time, they are apt to degenerate into ideas instead of facts, and the possibilities of emulation become so great, that Ananias might be considered a novice. Mr. Freeman certainly can congratulate himself that his able paper was as thoroughly discussed as any presented at this meeting.

(*To be continued.*)

THE GUNS AND THEIR MOUNTINGS OF SPANISH BELTED CRUISERS.

(*Concluded from page 260.*)

WE conclude this week our illustrations of the guns and their mountings of the Spanish cruisers. On our two-page plate we give a cross-section and plan, while on page 314 we give other views showing details of the gear. In these various views we have adopted the same lettering and numbering of parts and pipes respectively as in the longitudinal section given in our issue of August 24. The same key (Tables V. and VI., on page 260 *ante*), therefore, applies.

The mounting of the gun and its apparatus for manœuvring are carried on a revolving turntable A, which is built of steel plates and angles. The upper surface of the turntable forms a platform A^1, which is circular in plan. The lower part does not extend round the complete circle, but is shaped as shown in Fig. 11, having a width of 11 ft. 6 in. At its front and rear portions it is provided with a conical-faced ring a which forms the upper roller path. The mean diameter of this path is 17 ft. The turntable is carried on a live ring of conical rollers a^1, which bear upon the upper roller path in the fore and aft section of the turntable, and run upon the cast-steel circular lower roller path b, which latter is carried on a suitable packing ring b^2 on the deck. This lower roller path also forms a pivot ring b^1 for keeping the turntable in true axial position. On the underside of the turntable and attached to the central revolving ammunition tube B is a faced ring c of smaller diameter within the pivot ring b^1 of the roller path. Between the latter and the faced ring c again there is interposed a series of vertical rollers c^1, Figs. 8 and 11, connected by a ring c^2 forming a live roller pivot.

The ammunition tube B is attached to the underside of the turntable, and revolves with it. At its point of attachment it has a diameter of 12 ft., and for a depth of 10 ft. it is conical. It extends parallel from this point downward, almost to the bottom of the ship, the diameter being 4 ft. 6 in. From the protective deck upward, the tube is encased in steel armour O, having a thickness of 8 in. (20 centimetres). Inside there is a 1-in. skin plating of double thicknesses of plate. The thickness of the armour D protecting the turntable is $10\frac{1}{2}$ in., and this is supported by a backing of 6 in. of timber, with similar skin plating in the interior.

The ammunition tube is fitted with guides d of a channel section, defining the course to be taken by the charge carrier E, Fig. 8, in its ascent from the loading position on the magazine deck to the breech of the gun. It also contains the hydraulic presses E^1 for raising the charge carrier, and at its bottom end it is fitted with a revolving centre pivot box B^2, which serves for the introduction of the water under pressure, for operating the various organs, and for carrying away the exhaust water from the apparatus. On the magazine deck, attached to the tube and revolving therewith, is a bracket B^3 with three shelves. On the upper shelf B^4 the projectile is placed, and on the lower shelves B^5, B^6 the half-charges. When the charge carrier descends to its bottom position, the projectile and charges can be pushed from the bracket into the corresponding receptacles E^2, E^3, E^4 in the charge carrier. The deposit of the ammunition on the bracket can be made whilst the turntable is moving, as a circular way F is provided concentric with the tube, and suspended under the protective deck. On this the ammunition is slung, and can be traversed to follow the movement of the tube.

The charge carrier itself is provided with three pockets, each vertically above the other. In the uppermost pocket E^2 the projectile lies, and in the lower pockets E^3, E^4 the half-charges. An extension of the frame holding these pockets carries two rollers e, e^1 on each side of the charge carrier. These rollers work in the channel guides d fitted in the tube, and control the position of the charge carrier in its ascent and descent. The hydraulic presses E^1 actuate the charge carrier by means of ropes f, led over pulleys f^1, f^2. The operating valve controlling these presses is shown at J on the platform.

When the charge carrier has been raised so that the projectile is about in line with the bore of the gun, it is allowed to rest upon a stop catch g, so fixing the true axial position of the projectile with the axis of the gun. The projectile is then rammed home by the hydraulic rammer G, which we shall describe later. As soon as the rammer is withdrawn, the charge carrier is caused to ascend until the first pocket E^3 of the half-charge is brought into position. It again rests upon a stop g^1, and the charge is pushed into the gun. A further ascent takes place, and the remaining half-charge E^4 is brought into line, the carrier resting upon a third stop g^2. These stops are actuated b~ a pedal H on the platform A^1, conveniently placed for the foot of the man actuating the hoist valve handle J. The whole charge being now pushed forward into the gun, the carrier, as soon as the rammer is withdrawn, is allowed to descend to the loading station again ready to receive another charge. Here it may be mentioned that the gear is so interlocked that it is impossible to operate the carrier until the gun is fully run out and the breech open; it is impossible to move the carrier whilst the rammer is in operation; it is impossible to use the rammer unless the carrier is in correct position, resting on one or other of the stops; and it is impossible to elevate the gun during the operation of loading. These safety appliances we shall describe in detail later.

The gun mounting proper consists of a cradle K provided with grooves k^1, k^2 which receive the collars of the gun previously referred to. The gun is secured therein by the keys h, h^1. The cradle is of cast steel, and on its lower front carries a boss K^1, which receives the brake piston-rod L as shown on the detail drawing (Figs. 12, 13, and 14). The cradle is provided with two sliding faces K^3, K^4 lined with gun-metal rubbing strips, and is fitted with slide clips K^5. It slides upon two forged steel beams M pivoted at their front ends to a bracket N carried on the fore end of the centre section of the turntable A. These beams are rigidly tied together by a steel casting, which forms the brake cylinder O (Fig. 13). This cylinder is securely joggled and bolted, and receives the brake piston L attached to the boss of the cradle. The brake we shall describe later. The slides are supported near their centre by two rams P, P^1, which work in cylinders Q, Q^1 attached to the turntable. The raising or lowering of these rams effects the elevation or depression of the slides, and therewith the gun. The rams are double-acting, though the centre of gravity of the oscillating weight is slightly behind the centre of oscillation. At the rear of the slides there is fitted a tank m, Fig. 8, which receives the dirty water from the washing out of the gun and delivers it by a pipe j on to a part of the turntable whence it can be led by pipes to suitable drains. The slide beams M and carriage K are supported on the cast-steel trunnion bracket N provided with pivots n. The bracket is bolted to the platform A^1, and secured thereto by clips o, which resist the tendency to lift, and reduce the strain on the securing bolts. Clips A^2 are also bolted to the front side of the turntable; these clips engage with the lower roller path b, their object being to prevent any lifting action of the turntable when the gun is fired.

The shield is carried on a platform by a structure and framing Z, covered with skin plating Z^1, to which is attached armour Y having a thickness of 3.149 in. It completely incloses the barbette and all the mechanism. It is dome-shaped except for the portion in the centre Y^1, where it is raised to form a tunnel allowing for the recoil of the gun at extreme depression, and at the extreme rear there is a tower Y^2, which is armoured like the rest of the shield. This tower incloses the platform A^3, from whence the commandant controls the elevation and training of the gun. He also sights the gun from this position, the fore sight Z^2 being bolted to the shield, and the rear sight Z^3 with its tangent bar being in the tower.

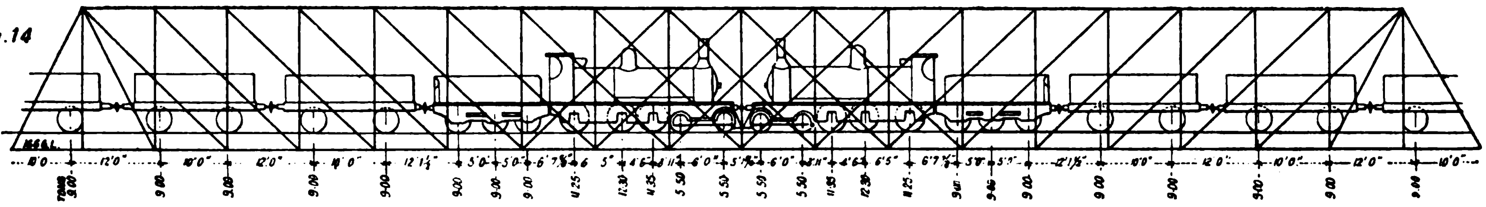
The training of the turret is effected by means of

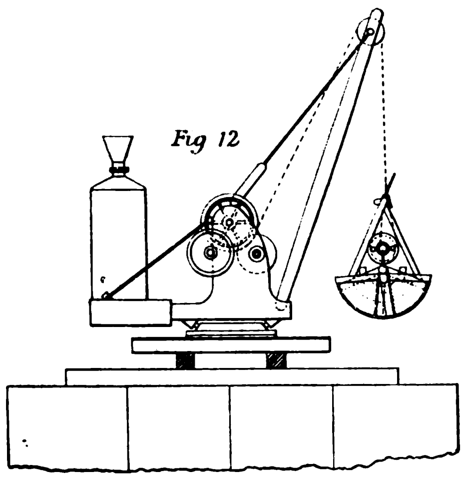
THE SHER SHAH BRIDGE OVER THE RIVER CHENAB, NEAR MULTAN, PUNJAB.

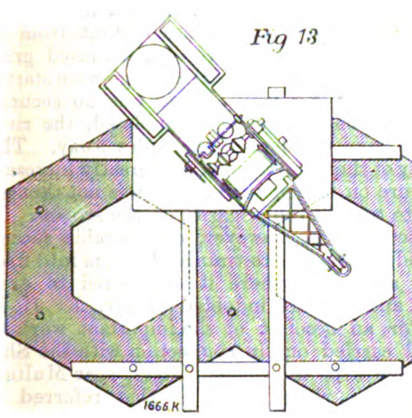
MR. J. R. BELL, ENGINEER.

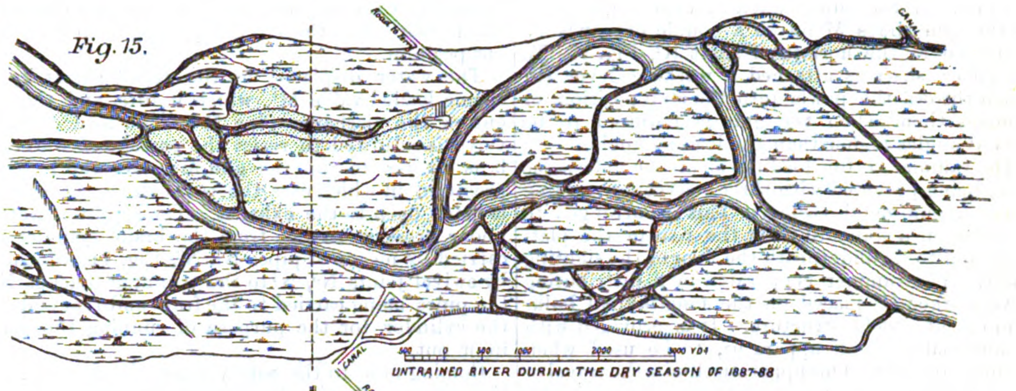
(*For Description, see Page* 320.)

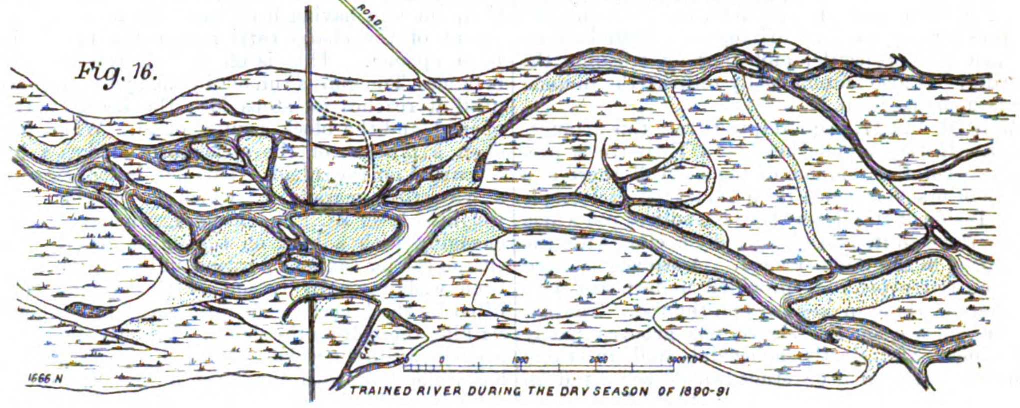
Fig. 14

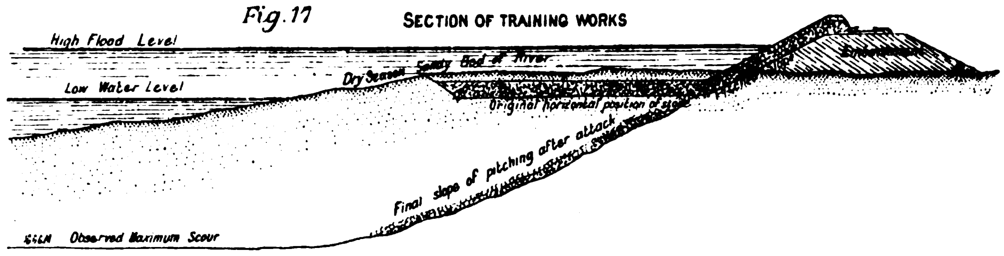






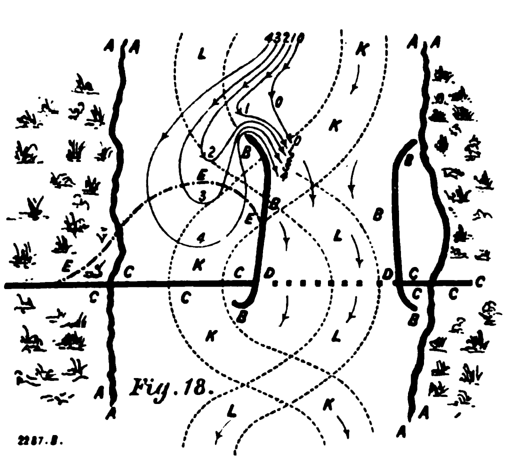






two hydraulic training presses X, X^1 bolted to the platform deck. These rams actuate a pitch chain x which partly surrounds a toothed wheel W fixed on the central tube, and by their movement they give to the turret the rotation required for the maximum angle of training = 250 deg. The tension of the chain is assured by an auxiliary tension press x^1. The rams X^2, X^3 are controlled from a handwheel V fixed in the sighting tower and working in a horizontal plane, geared so that the movement of the turret follows the movement of the handwheel. This handwheel actuates shafting V^1 geared with a distributing slide valve U. This latter is connected by the pipes numbered 22 and 23 carried down the central tube to the central pivot box B^2, where they are fitted with swivels u, u^1, which lead to the training presses X, X^1. The central revolving tube being attached to the turntable, rotates the latter by the action of the pitch chain x on the toothed ring W. Automatic cut-off gear is provided tending to neutralise the action of the handwheel in the sighting tower, so that for continuous movement the handwheel V must be continually turned, and in this way the gun can be trained very slowly or quickly and at once to the desired direction.

This controlling gear, illustrated by the detail view, Fig. 15, on page 314, consists of a rack v fixed to the lower roller path b, with which engages a pinion v^1 on a vertical shaft v^3 carried by brackets on the turntable. This shaft at its upper end carries a spurwheel v^4, which is geared with the spurwheel forming part of the threaded



sleeve v^5 working upon a screwed spindle v^6 having at its upper end the handwheel V in the sighting tower. This sleeve is provided with a collar y, which receives the end of a forked lever y^1 keyed on to a horizontal shaft y^2, which by means of another lever y^3 operates the slide valve U. Thus any movement of the screwed shaft v^6 by means of the handwheel V traverses the sleeve v^5, and thereby actuates the valve U. Immediately the turntable begins to revolve, the fixed rack v on the roller path b drives the pinion v^1 geared with the pinion on the sleeve v^5, and causes the sleeve to travel upon the threaded shaft, thereby partly neutralising and cutting off the movement given to the sleeve through the shaft by the handwheel V.

The elevation of the gun is also controlled from the sighting station in the tower by means of a handwheel T mounted on a horizontal axis, and so geared with the elevating valve S that the movement of the gun follows the movement of the wheel—thus the turning of the wheel towards the operator raises the muzzle of the gun, and, turning the other way, results in the depression of the muzzle. On the horizontal axis is a pitch wheel t (Fig. 10), and on a screwed sleeve s^2 on the valve spindle s^1 is another pitch wheel t^1 connected with the handwheel axis by a chain t^2. Movement of the screwed sleeve s^2 causes the valve to travel in the direction to elevate or depress the gun. Immediately that movement of the gun takes place, an arc T^1 bolted to the gun slide M actuates a pinion r, and through shafting r^1 and bevel gears r^2 (Fig. 9) drives the screwed shaft s^1 on which the sleeve s^2 works, causing the sleeve to move in the opposite direction, exactly on the same principle as described for the training movement, and, as in that case, neutralising the action of the handwheel. The sequence of the movements is the same as in the training apparatus, and by means of this continuous cut-off gear the slowest possible movement can be made. This is particularly desirable in the case of guns which can be kept pointed towards the enemy whilst being loaded, and are only required to follow any movements of the enemy.

From the distributing slide valve S pipes Nos. 20 and 21 lead to the elevating presses, which consist of two steel cylinders Q, Q^1 9 in. in diameter, fixed on the turntable A underneath the gun slides. In these cylinders the hydraulic pressure is against the trunk pistons q^1, q^2, the rods of which are hollow, and are connected to the gun slide by links P^2, P^3 pivoted to the gun slide at p, p^1, and working in spherical hollows p^2 in the piston-rods, as shown on Fig. 12, page 314. The water acting on the underside of the pistons q^1, q^2 depresses the gun, and acting on the top side elevates the gun, bringing it to the desired position for range. When loading, the angle of the gun is fixed by bringing stops R on the gun slides M on to a couple of pawls R^1 keyed on to the horizontal shaft R^2, Fig. 9. To the latter shaft is attached a working lever R^3, which throws the pawls into the stop position, or removes them when the gun is required to be fired at angles higher than the loading angle.

The rammer G for loading is of the telescopic type, being provided with three telescopes working inside a gun-metal casing. This is arranged to swivel upon a standard G^1 at the rear of the platform, and to lie underneath the floor of the sighting tower. The rammer is operated by a distributing valve marked G^2 placed on the longitudinal bulkhead of the shield structure. It is provided with an automatic cut-off apparatus, to be used when ramming powder. This apparatus limits the travel of the rammer-head G^3 to a predetermined extent, and so prevents the rammer driving the charge hard up against the projectile, and thereby crushing the powder. It also automatically returns the rammer to its home position.

Figs. 16 and 17, page 314, illustrate this arrangement. In the rammer head G^3 a T-groove is provided. On the rammer casing at β β^1 there is a series of brackets which form guides for a telescopic rod. Inside of this latter there is a square rod which slides through it, and engages by a claw with the T-groove in the rammer head. A sleeve ζ is fitted on the telescopic rod, provided underneath with feathers working in keyways on the rod. The exterior surface of the sleeve has grooves partly rectilinear and partly helicoidal, and in these grooves work pins or studs which are fixed in another outer sleeve. These two sleeves are carried in bearings β^2 on the rammer casing. The sleeve with the grooves has no end movement, and the outer sleeve is free to move to and fro by means of the operating lever for the valve. It has grooves which slide between guides and prevent its rotation. When ramming a projectile the movement of the operating lever causes the outer sleeve to slide in the straight part of the grooves of the inner sleeve, and therefore does not cause any rotation of the telescopic rod. The action of moving the lever admits water under pressure to the rear side of the rammer pistons, and the rammer runs out to its full extent, carrying with it the projectile to its chamber in the gun. For ramming the powder the valve handle is then reversed, and the outer sleeve slides over the helicoidal grooves in the inner sleeve, causing the latter to rotate and carry with it the telescopic rod. The claw on the end of the inner rod then engages with the T-groove in the rammer head. Water being again admitted to the rear side of the rammer piston, the rammer, as before, runs forward, carrying with it the charge. But as the rammer head is then engaged with the claw to the telescopic rod, it drags the rod with it until a buffer θ at the rear end of the telescopic rod strikes a sleeve on a part which protrudes from the bar, and thereby moves the sleeve and returns the actuating lever to its neutral position.

The hydraulic brake, illustrated in detail by Figs. 13 and 14, acts in the following manner. At the commencement of the recoil the piston L^1 is forced into the cylinder O by the movement to the rear of the gun. In doing this the water in the cylinder must pass through orifices l^1 in the piston to the front side thereof. Owing to the piston-rod L entering the cylinder, a certain portion of the water equal in volume to that of the rod is displaced from the cylinder, and passes through a discharge valve to an exhaust-box. The orifice l^2 in the piston through which the water passes from one side to the other, is controlled by a bar of a gradually tapering form O^1. This bar is attached to the rear cover O^2 of the cylinder, and works within the piston-rod L. As the piston passes over the bar, the orifice for the escape of the water is varied by the changing form of the bar, which is so arranged that very shortly after the commencement of the recoil the orifice is greatest, and thence until the end of the recoil it is continually diminishing until the whole of the energy of the recoil has been absorbed, and the gun brought to rest in a distance of about 45 in. The piston is provided with five valves l^3, which open under the action of recoil, but which close when pressure is put on the front side of the piston. After recoil has taken place, the hydraulic pressure is admitted to the rear side of the piston and to the front side also; but the area of the piston on the rear side being greater than the area on the front side by reason of the diameter of the piston-rod, the piston is caused to run forward, and thereby carry the gun to the run-out position.

The water displaced by the recoil passes by a spring-loaded valve M^1, which it lifts, and thence enters the discharge pipe M^2. The load on this valve is adjusted to resist the passage of water if it is desired to run the gun in under the service pressure, in which case the rear side of the piston is made open to the exhaust. The supply of water under pressure to and from the brake cylinder is carried by means of pipes N^1, N^2, Fig. 11, attached by swivel joints N^3, N^4 to the trunnion bracket N, the pipes being carried to the front and rear end of the cylinder for the purpose of running the gun in or out.

Coming now to the safety gear, the first operation, the gun having been fired, is to prevent the ascent of the charge carrier until the breech has been opened. This is effected in the following manner: The gun is run out by the hydraulic power until it reaches its stops M^5; the breech is then opened and the block swung round. When fully open a portion of the mechanism strikes a bolt Z^6 carried on the shield. This bolt is connected by a wire rope marked Z^5 which is attached to a weighted lever Z^4. The lever again carries a bolt engaging with a bolt on the hoist lever. The charge carrier cannot be raised unless the bolt has been withdrawn by reason of the weight being lifted by the breech mechanism when fully opened striking the bolt on the shield. Directly the breech is closed again the weight comes into operation, and locks the bolt with the hoist lever. The carrier valve lever J being set free, and the carrier brought to the rear of the gun, safety gear in connection with the rammer G allows the latter to be swivelled round in line with the bore. As has been stated, the gun when being loaded rests on stops R, which determine the loading angle; but to prevent any accident by the accidental elevation of the gun whilst the projectile is being pushed home, the carrier is made to interlock the screwed sleeve S^2 of the elevating valve S, so that no movement can be given to the elevating valve whilst the carrier is in position. To prevent the movement of the carrier whilst the rammer is in operation, the rammer valve G^2 is interlocked with the hoist valve J, so that this latter cannot be moved while the rammer is in operation. Therefore, by the fact of the carrier being in the loading position, the gun cannot be elevated, and the rammer can only then be operated. Immediately the rammer is withdrawn the carrier can be moved, and immediately the carrier is clear the gun breech can be closed. The system of interlocking is, indeed, similar to that adopted for railway signals and points.

When the vessel is sailing in peace time the gun will lie fore-and-aft in the ship, and the turntable will be secured in position by two locking bolts D^1 placed one on each side, engaged with sockets d^1 attached to the barbette wall. At each side of the gun slides on the platform are brackets, which serve as lateral guides for the rear ends of the slides, and at the same time stays M^6 are attached to the gun cradle and to the brackets, securing the gun against any vertical movement on the stops. The opening between the barbette wall and the shield is covered by a canvas apron, attached to the shield by a band, and secured to the barbette wall by a series of dog screws.

We have now described the principal organs for working the turrets, and there but remains to describe the source of power—the hydraulic pumping machinery. Each turret has its own engine, which in each case is of the direct-acting differential type. It is placed on the platform deck and connected with the turret by a service of pipes to the swivel box B^2, at the bottom of the revolving central tube. The exhaust water from the turret is carried by a pipe numbered 2 to the tank M* near the engine. The diameter of the steam cylinder is 16 in., and the stroke 12 in., while the diameter of the pump piston is 3.5 in., and the piston-rod is 2½ in. Each engine will deliver 45 gallons per minute, at the pressure of 80 kilogrammes per square centimetre (1138 lb. per square inch), and while working at 60 revolutions with a steam pressure of 57 lb. per square inch. Under these conditions the engine will train the turret at the rate of 250 degrees per minute. The engines are fitted with hydraulic governors and a steam speed governor. The latter limits the speed to 90 revolutions per minute, while the former controls the speed of the engine by the pressure of the water delivered. In addition to the steam pumping engines, each turret is provided with a hand pump with three-throw cranks and handles, for moving the various organs in the installation for cleaning purposes.

The wash-out of the gun is taken from the main water service, and is actuated by a pedal valve λ on the platform, which conveys the water through a hose to the bore of the gun.

The design and construction of the mounting and the apparatus was carried out by Sir Joseph Whitworth and Co., Limited, Manchester, who are the manufacturers of gun mountings on the Canet system in England.

THE SHER SHAH BRIDGE, PUNJAB, INDIA.

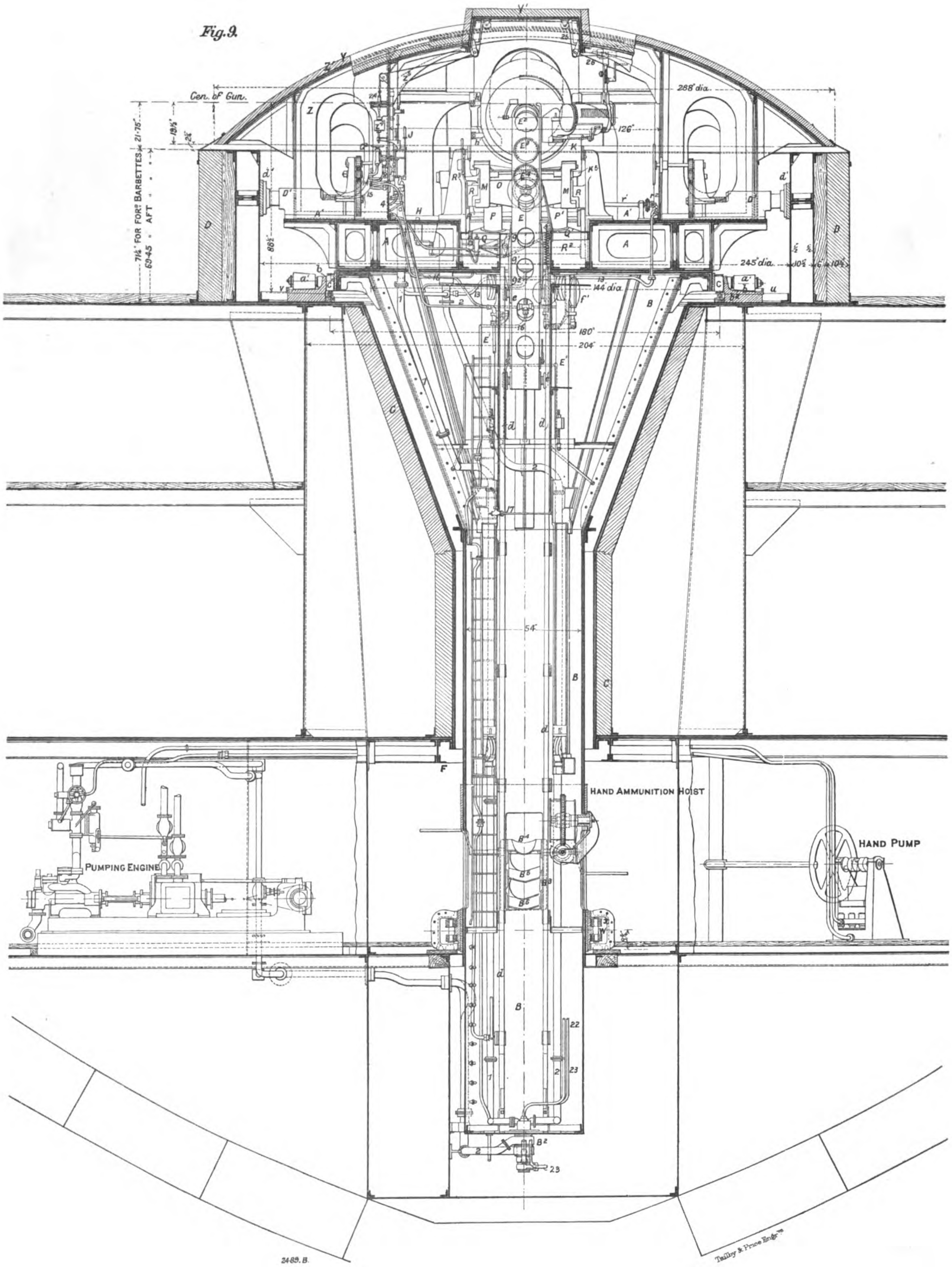
ONE of the most remarkable features of Indian rivers is the want of stability of their courses. Many of them flow through flat valleys of great width. Successive floods deposit silt along the banks, and finally the bed itself is raised until, as has been stated on good authority, the river itself occupies the highest ground in the valley, as proved by levels taken across it. Then if an exceptional flood comes, the river may breach its banks, and, flowing into the lower ground, form a new waterway there, possibly some miles distant from its original course. Such vagaries have caused great trouble to Indian engineers. If a bridge were started across a river at one point, there was no security that, when the bridge was completed, the river would not have wandered some miles away. This instability of the waterway led to a greatly increased expenditure on bridge work, as it was not thought possible to control the vagaries of the stream. In more recent years, however, considerable success has attended attempts to train such rivers into fixed channels at points where it is desired to erect bridges, and we are indebted to Mr. F. J. E. Spring for an account of the important work of this kind carried out in connection with the Sher Shah Bridge over the Chenab River, near Multan, Punjab. This river, which is that referred to by the Greek historians of Alexander's conquests as the Sandarophagus, or as the Asekines, is a typical river of Northern India, and is 700 miles long between its source and its junction with the Indus at Mitankot. Between October and May it is a comparatively gentle stream about one-third of a mile wide and 10 ft. to 12 ft. deep; but when the snows melt during the summer months, it is subject to enormous floods, becoming some two miles wide, and rushing along at a velocity of from 4 ft. to 10 ft. per second. Its bed, for a depth of 60 ft. to 100 ft., is composed of fine silt and sand, through which the river easily cuts a fresh course. Thus, at the commencement of the floods, the deep-water channel may be found near the right-hand bank, and later on at the left-hand bank, some 1½ to 2 miles distant from the first position. Like most rivers flowing through a flat country, its course is very sinuous, and it is continually breaking through the necks of the bends and taking short cuts over shallows; the old course then rapidly silts up. When the first bridge was erected across this stream in the "seventies," it was thought necessary to bridge the maximum width of the river, which was done by 64 spans of 145 ft. each. Since then, however, it has been possible to train the stream, and a number of the spans have been permanently closed.

In designing a new bridge across the river at Sher Shah, Mr. J. R. Bell determined to reduce the untrained width of the stream—some 8000 ft.—to 3600 ft. by means of artificial banks, and to

MOUNTING OF THE 28-CENTIMETRE HONTORIA

CONSTRUCTED BY SIR JOSEPH WHITWOR

(*For Descr*



'S IN THE SPANISH BELTED CRUISER "VIZCAYA."

) CO., LIMITED, OPENSHAW, MANCHESTER.

(*e Page* **317**.)