bottom bolt, so that one bolt is locked by the other when the adjustment is made. The crankpin boxes are lined with Babbitt metal. The crosshead boxes are made of the best bronze.

The counterbalanced crankshaft is forged in one piece from the best quality of open-hearth steel, of high carbon to insure the greatest rigidity and tensile strength (Fig. 12). It is then slotted out and turned off. The diameter of the crankpin is in all cases as large or larger than that of the shaft. The discs and counterbalances are of cast iron and are in two pieces, the counterbalance being bolted to the disc. The counterbalanced discs are bolted to the throw of the crank in the manner shown. The throw of the crank as well as the slots in the discs are planed to make a driving fit, every care being taken to make a safe and sure construction and without weakening the crank. After the discs are fastened on they are turned and polished. An oil-hole is drilled through the wristpin and a catspaw is screwed into it on either side, through which the oil is fed from brass pipes leading from sight-feed oil cups mounted on standards on the engine bed. This oil is discharged through a connecting hole drilled down through the wristpin. In addition there is a grease cup on the top of the connecting-rod, thereby precluding any possible chance of hot boxes on this most troublesome bearing of an engine. The lower halves of the main bearings are cast solid with the bed. The boxes and caps are babbitted, and the babbitt is firmly hammered in place. The caps are separated from the lower halves of the boxes by metal liners, and the boxes are bored by a special jig attachment that insures alignment with the cylinder and guides.

By referring to Figs. 16 to 18, on page 575, the construction and operation of the governor will be readily understood. It is not only extremely simple, but, being situated on the outside of the balance wheel, is easy of access, either for adjustment or inspection. The eccentric (Fig. 22) is counterbalanced, and is keyed to a cross-shaft A, which shaft passes through the hub of the balance wheel, and is operated by the double-arm connection B keyed to its opposite end, which, in turn, is connected to the balance levers of the governor by the rods C C. These rods are made hollow for the purpose of lubrication. The governor weights, attached to the balance lever D D, rotate about knife-edges as centres, and are resisted by springs which are subjected to compression. These springs being placed radial to the crankshaft, are also subjected to the centrifugal force, which assists their operation in overcoming the force of the flying weights. By having the principal points of motion made as knife-edge joints, the friction is largely reduced, and the governor rendered extremely sensitive, so that the slightest variation in the load on the engine is immediately felt at the governor. The oiling device consists of a hollow disc E fastened to the end of the crankshaft, made with partitions, and from which radiate brass tubes through which the oil is carried by the centrifugal force to every bearing. These tubes are made telescopic in places, to allow for the movement of the working parts. This device insures complete and positive lubrication. The operation of the governor is such that as the load increases the point of cut-off becomes later in the stroke, sufficient to maintain a constant speed in the engine, and as the load decreases, the cut-off becomes earlier.

There was a large display of engines of this make at the Chicago Exhibition. The tandem engine particularly attracted a great deal of attention and favourable comment, on account of the neatness of its design and smooth running. It received a diploma and a medal.

THE NEW SPANISH BELTED CRUISERS.

WE begin the publication this week of a series of illustrations of the three Spanish belted cruisers constructed at the recently organised shipbuilding yard on the Nervion, near Bilbao. They are the largest and most formidably armed cruisers that have been built in Spain, and must prove a useful addition to the Spanish fleet. Moreover, they have been the means of the organisation of an establishment which may be compared to some of the best equipped of British yards. Conceived by patriotic Spaniards, ready to advance plenty of capital, laid out and equipped under the experienced guidance of Sir Charles M. Palmer, Bart., and a staff recruited from some of the largest private works in this country, the Astilleros del Nervion has, in the construction of these vessels, shown itself equal to any demand which the Spanish naval authorities may make upon it, for it has from the crude material constructed ship, guns, engines, &c., with the minimum of British assistance. The technical management, of course, has been largely British. The manager of the shipyard in the early years of the history of the works was Mr. J. P. Wilson, and subsequently Mr. James Clark has carried the construction of the cruisers to a successful issue. Mr. James McKechnie has been manager of the engine works from their inception. These managers have practically by their efforts created the works and brought to fruition the hopes of the Spaniards for a first-class Spanish armoured cruiser of great speed and power built at a private works. Indeed, this has been the signal for a renewed interest in the navy of an old-time maritime Power. For years it had been allowed to drift into the most deplorable condition, and up to quite a recent date the entire fleet consisted of but a few old wooden frigates and a few armoured vessels, the most efficient having been built abroad. The Government, therefore, in 1887, voted 10 millions sterling for the construction of new vessels, six of which are of the belted cruiser class. Three were ordered from the Government arsenals, and three from a firm organised for the purpose—Martinez Rivas-Palmer—the ambition of which, now realised, was the organisation of a works superior to any private yard in Spain. We do not forget that two works have for many years been engaged successfully on naval work—that at Barcelona and at Seville—but they lay no claim to the comprehensive or extensive character of the Nervion arsenal. It was through the influence of Mr. Martinez, one of the most enterprising capitalists in Spain, and that of his partner—Sir Charles Palmer, Bart., the experienced and vigorous head of the Jarrow firm, —that the building of three of the ships was intrusted to the Bilbao firm, one of the stipulations being that in every case preference must be given to Spanish material and industries, with the primary object of fostering national industries, and more especially those of the province of Vizcaya. It was a condition of contract that only 25 per cent. of the workmen should be foreigners; but, as a matter of fact, the ratio never exceeded 17½ per cent. The remaining 83 per cent. have been trained to the work, many of them being now almost as skilled as their English fellows.

In July, 1889, the contract between the Government and Don José Martinez de las Rivas for the construction of the three cruisers was signed, and immediately afterwards vigorous efforts were begun to transform what was nothing but a marsh on the banks of the River Nervion into an important shipbuilding, engineering, and ordnance works. English managers and leading workmen were engaged by Sir Charles Palmer, and after an enormous amount of labour, the various machine sheds, frame-bending sheds, and furnaces, joiners' shops, &c., were erected, expensive machinery was brought from England, and the actual building of the ships began. In previous articles we have dealt somewhat in detail with the general arrangement of the works and the machinery installed,* so that it is not now necessary to do further than indicate that the work done evidences their efficiency, especially when it is noted that in 13 working months the first of the three cruisers, the Infanta Maria Teresa, was launched with great *éclat* by the Queen Regent of Spain. Since then many untoward circumstances have checked progress. On May 1, 1891, the engine works, laid out in quite an ideal way, and fitted with the accumulated experience of English tool manufactures, was almost completely destroyed by fire. Many of the important parts of the engines for the cruisers were destroyed, some peculiar results being discovered as a consequence of the intense heat and subsequent rapid contraction owing to the playing of the hose. Three months, however, served to reconstruct the works. Financial considerations, too, have not always helped on the constructive work. In the beginning of 1892 the firm was constituted a limited liability company,† with a capital of 1,200,000*l*., with Don José Martinez Rivas remaining at the head as chairman, and Sir Charles Palmer as managing director. In April, 1892, difficulties arose, the works being temporarily closed. The ultimate result was that the Government took over the works with the view of finishing the cruisers, the English managers and workmen being retained on their old terms. As official director the Government sent General Cervera, one of Spain's most experienced naval officers, who has since taken a high position in the Government—Minister of Marine—his successor at the Astilleros being General Rocha. The work has since progressed, and now that the third cruiser is nearing her completion the subject of the ultimate destiny of the works is being discussed. Their importance to the district is appreciated, and no reason is evident why merchant vessels may not be constructed almost as economically as in Britain, since the plant is as efficient and labour as cheap. Consequently the local authorities are moving for a satisfactory settlement. The existing company have offered to hand over the concern, with all bonds, &c., to a new company, and already a syndicate is being formed to acquire the works, and with every prospect of success. But our concern is not with the creation of a competitor to British shipbuilders so much as with the design and construction of the cruisers. Probably, however, the digression, although long, is justifiable.

The principal dimensions of the cruisers may first be given:

	Measure. English	Measure. Metrical
Total length, taken between the extreme vertical tangents of the head and stern of the vessel...	ft. in. 364 0	metres 110.95
Length between perpendiculars (water-line) ..	340 0	103.63
Greatest width, measured outside	65 2	19.86
Greatest width, taken at the upper deck	62 3	18.97
Depth, taken from the upper face of the keel at the convex curve of the beams of the upper deck	38 0	11.58
Mean draught when laden	21 6	6.55
Displacement at above draught	Eng. tons. 6890	met. tons. 7000
Metacentric height in complete armament ...	4.96	1 512
Metacentric height after consuming coal, victuals, and ammunition ...	5.49	1.673
Speed at natural draught	18 nautical miles	
,, with forced ,,	20	,,

Having given the metacentric height, we reproduce the stability curve (Fig. 5), which may be specially interesting in view of the recent discussion on warship rolling. The Spanish cruisers are not fitted with bilge keels.

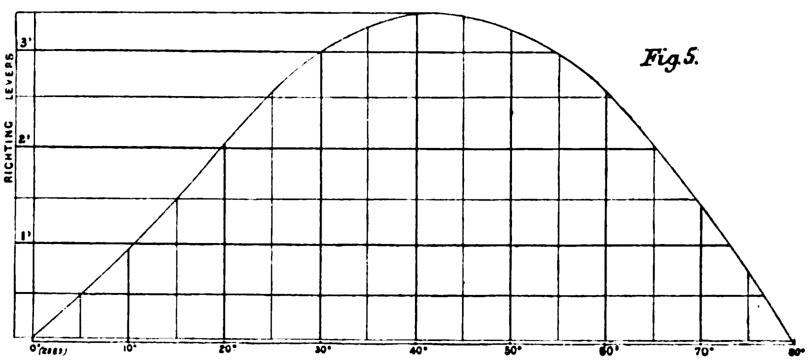


Fig. 5.

The belted cruiser type seems to have been discarded in the British Navy in favour of a protective turtle-back deck about the water line. The last cruisers of the type constructed for the British Navy were the vessels of the Australia class, seven in number, and completed in 1889. It is scarcely necessary here to enter at length into the objections against the belt for protecting a cruiser: That the advantages were not commensurate with the weight, which, added to machinery, would give greater speed—a primary desideratum; that its width or depth could not, consistent with weight allowable, preclude the under part of the ship being exposed when the ship rolled; and that, moreover, the thickness allowable would not keep out the shot, even from quick-firing guns at possible ranges. Whatever may be the value assignable to these objections, it is noticeable that the Blake and Blenheim, built subsequently as the first cruisers of the day, were without a belt, but had a 6-in. and 3-in. protective deck. A 5-in. deck was adopted in the first-class cruisers—the Edgars—of the Naval Defence fleet. And yet the belt system is not altogether discarded, as is shown by its adoption, not only in the Rurik, laid down by Russia some time ago, but also in the improved Ruriks, although no exact measurements are yet available. In the Infanta Maria Teresa and her five sisters the designers have, in some respects, anticipated these Russian vessels, as will be seen from the following Table; for, while the latter are longer and of greater displacement the Spanish

* The shipyard was described in ENGINEERING, vol. xlviii., page 504, and the engine and ordnance works in ENGINEERING, vol. l., page 317.

† See ENGINEERING, vol. li., page 127.

DETAILS OF SOME REPRESENTATIVE BELTED OR ARMOURED CRUISERS.

—	Spanish. "Infanta Maria Teresa."	British. "Australia."	French. "Dupuy de Lome."	Russian. "Rurik."	British. "Terrible." †
Length	364 ft.	300 ft.	374 ft.	396½ ft.	500 ft.
Breadth	65 ft. 2 in.	56 ,,	51¼ ,,	67 ,,	71 ,,
Draught	38 ft.	22½ ,,	23¼ ,,	26 ,,	27 ,,
Displacement ..	6890 tons	5600 tons	6297 tons	10,923 tons	14,200 tons
Coal carried ..	1100 ,,	900 ,,	900 ,,	2,000 ,,	1500 ,,
Armour, length ..	315 ft.	About 210 ft.	*	—	—
,, depth ..	5 ft. 6 in.	—	*	—	—
,, thick. ..	12 in.	10 in.	4 in.	10 in.	—
Protective deck ..	3 in. and 2 in.	3 in. and 2 in.	2 ,,	2½ ,,	6 in.
Battery	10 in.	12 in.	4 ,,	—	—
Armament ..	Two 28-cm., ten 14 cm., two 7-cm., all Hontoria; eight machine, two Nordenfelts and eight Hotchkiss, eight torpedo tubes	Two 22-ton, ten 6-in. 5-ton, six 6 pounder quick-firing, ten 3-pounder quick-firing, six machine, four torpedo tubes	Two 19-cm. 11 ton, six 16 cm. quick-firing, four 6-pounder quick-firing, four 3-pounder quick-firing, eight machine	Four 8-in. 13½-ton, sixteen 6-in. 6-ton, six 4.7-in. quick-firing, eighteen small quick-firing and machine, five torpedo tubes	Two 9.2 in. breech-loading guns, twelve 6 in., and twenty-eight smaller quick-firing guns
I.H.P.	13,500	8500	14,000	13,250	25,000‡
Speed	20 knots	18.5 knots	20 knots	18.5 knots	22 knots‡
Cost	600,000*l*.	258,320*l*.	416,000*l*.	About 850,000*l*.	About 700,000*l*.

In all cases we have given the designed power and speed, as only in the first two instances have official trials been completed.

* The Dupuy de Lome has 4 in. armour over the whole of the hull proper. She has three propellers.

† The Terrible is not a belted cruiser, but we have given her for comparison with the others, as she is intended to be the fastest cruiser in the British Navy.

‡ The power and speed of the Terrible are under natural draught; the others are under forced draught.

vessels have the same speed and equally heavy armour, if not also armament. The objections to the Australia class, too, are partly overcome in increasing the length of the belt proportionate to the length of the vessel, while the speed is considerably greater. But the many points of comparison will be readily appreciated from a glance at our Table, in which we have included the new British cruisers Terrible and Powerful, although they have not side armour. We may, therefore, confine ourselves now to a description of the Spanish vessels.

We have already given the principal dimensions. The profile on our two-page plate shows very clearly the construction and arrangement. It may be incidentally noted that Fig. 3 overlaps Fig. 4, as will be seen from the numbering of the frames and the bow of the corvette, and this remark also applies to the plan of the upper deck, given on page 582. The hull is built with longitudinal and transverse framing. The centre longitudinal web girder is 3 ft. deep, and is built up of plates and angles, while on either side are four similar girders, but lessening in depths towards the bilge, where they are 2½ ft. deep. There are the usual intercostals, and plating on inner and outer sides. This double bottom construction, formed on the cellular principle, extends up the side of the ship to near the water line, where the fourth girder forms a shelf 3 ft. wide to support the armour belt of 12 in. thickness, on the top of which again is the protective deck of 3 in. and 2 in. thickness. The armour belt extends for a distance of 315 ft. amidships, and is 5 ft. 6 in. broad. The plates, supplied by Messrs. Cammell, Sheffield, are 12 in. thick, and are secured by 3½-in. bolts, the backing of teak being 6 in. thick. For additional protection coal bunkers are arranged on either side of the ship, in the wake not only of the boilers, but also of the machinery. The capacity of these bunkers is 45,000 cubic feet, capable of carrying 1100 tons of coal. There are eleven main transverse bulkheads, as shown on the profile, the boilers being fitted in two separate compartments, while the two sets of engines, driving the twin screws, are also separated by a bulkhead running longitudinally. In addition, the principle of water-tight flats has been adopted, and in this connection it is interesting to note that the bulkheads are fitted with a hinged water-tight door, the invention of Mr. James S. Clark, manager of the shipbuilding yard, and described in a previous volume of ENGINEERING.* The arrangement of the door—which, by the way, is manufactured in this country by Messrs. Mechan, Glasgow—is such that by the working of one lever fitted on the door, it can be locked or unlocked at all parts. Usually there are six, eight, or ten catches to turn ere a door can be fastened, and the danger which makes it imperative sometimes urges even a disciplined seaman to turn only one or two levers. The hinged door is, therefore, a great advantage, especially as it does not interfere with freedom of action on the deck on which the door is situated. Of course, greatest dependence is placed, in action, on the protective deck, which extends from stem to stern, curving down aft and forward to considerably below the water line. This deck is 2 in. thick on the horizontal parts, and 3 in. on the sloping parts, and covers the under-water structure, which, as we have already pointed out, has two outer skins separated by 2½ ft. to 3 ft. of space. Under this deck, of course, are all the vitals of the warship, as shown on the profile—the stores, the magazines, steering gear, and the machinery—but the tops of the cylinders project a short distance above the level of the deck. The deck, however, is raised locally as shown, and, instead of being of double thickness of steel plates, as in other parts, the protection is of 6-in. compound armour-plates.

* See ENGINEERING, vol. lv., page 347.

Dealing now with the navigation of the ship, a word may be said of the accommodation for the crew, in explanation of the profile. The berths are entirely on the main deck, which runs in an unbroken line fore and aft. The commander's cabin is, of course, aft, with the usual stern walk, the officers being further forward, while the engineering officers are immediately aft the machinery, the firemen and crew being forward, although several baths have been provided over the boiler spaces. The ship is navigated from the bridge, or from the conning tower below it. This latter is protected by compound armour 12 in. thick, and is fitted with engine and steering Chadburn telegraphs, steam steering wheel, and voice tubes to all parts of the ship, and all other apparatus necessary for working and fighting the ship when in action. The telegraphs, &c., are duplicated on the navigating bridge, placed above the conning tower. The steering gear, which is supplied by Messrs. Caldwell and Co., Limited., Glasgow, formerly Messrs. Muir and Caldwell, can be worked by hand and steam, the steam steering engine being of sufficient power to put the helm from hard-a-port to hard-a-starboard in 30 seconds, when the vessel is proceeding at full speed. The steering engine can be controlled from the conning tower, the navigating bridge, or, in the event of the conning tower being disabled, from a protected position on the platform deck immediately below the tower, and also from the tiller compartment. The rudder, which is of wrought iron, is of the ordinary rectangular form, and has an area of about 160 square feet. The rudder head extends only a few feet within the vessel, just high enough for the attachment of a steel crosshead giving connection to the steering tiller, so that the whole of the steering gear is entirely below the protective deck. The ship was subjected to severe turning trials at 10 and 16 knots speed, and they established the efficiency and ease with which the vessel could be handled. The following are the results of the turning trials:

	Deg.		Knots.		Yds.
Rudder	20	Speed	10	Diameter of turning circle	=1540
,,	30	,,	10	,, ,, ,,	= 940
,,	20	,,	16	,, ,, ,,	=1040
,,	35	,,	16	,, ,, ,,	= 840

The propeller shafts are supported on cast-steel A-struts, pear-shaped, which are strongly riveted to the steel framing of the ship. Forward there is a powerful capstan, and a large warping winch aft (Fig. 1). The principal ground tackle consists of two 90-cwt. and two 30-cwt. ordinary anchors, two 80-cwt. stockless, and two kedge anchors of 14 cwt. and 8 cwt. respectively. The pumping arrangements and ventilation of the ship have been well looked after, and throughout the whole ship a proper and complete system of voice-pipe arrangements has been installed. The necessary fire pumps, with their connections and hose, have been provided as usual. As to stores, it may be stated that under the boiler compartments there is capacity for storing 490 tons of fresh water, while at various points on the main deck are water tanks, &c. Navigating stores and chain lockers are, as usual, forward.

The installation of the electric light has been carried out by the electrical department of the firm, the major part of the plant being supplied by the Brush Electric Engineering Company. The wiring is carried out on the usual return-wire system, all the cables throughout being incased in lead. The dynamos and engines are placed below the protective deck at the aft end of the ship. The engines are of the vertical type, and at 225 revolutions the dynamos give an output of 300 ampères and 80 volts each. There are three powerful search lights of 24,000 candle-power each, and over 400 incandescent lamps of 16 candle-power each, distributed throughout the ship. There are two cargo lanterns, with eight 50 candle-power lights in each, also a complete system of signalling on the Ardois system.

As indicated on the plan, and partly on the profile, the vessel carries a large number of boats—twelve in all—as follows: A 60-ft. 17-knot vedette boat, four large sailing pinnaces, a 30-ft. gig, 28-ft. whaleboat, two dingies, a 25-ft. canoe, and two 30-ft. 8-knot steam launches, the machinery of the latter being constructed in the Astilleros. The engines of the two steam launches have cylinders 4¾ in. and 9 in. Each launch has a boiler 4 ft. by 2 ft. 10 in. The boiler is worked, under forced draught, on the closed ashpit system. They are also fitted with a donkey pump complete. The vedette boat, which has a speed of 17 knots, has cylinders 10 in. and 20 in. by 10 in. stroke.

Coming now to the ship as a fighting machine, it should be stated at the outset that the ram, which is of steel, is strengthened by longitudinal plate girders (Fig. 4), while the protective deck, which slopes downwards at the fore end towards the ram, materially strengthens the bow for ramming purposes. The vessel has a flush upper deck without bulwarks, with a breastwork within which the 6-in. quick-firing guns are installed. In a subsequent article we purpose illustrating the hoists and some other features in connection with the armament, and need only here refer generally to the armament in explanation of the profile plan. Within the extremities of the belts are the two barbettes, one at each end, these being built of compound armour 10 in. thick. The protection to the ammunition tubes, which are of a conical form, rises from the protective deck, and is made of steel armour-plates 8 in. thick. The barbettes are of circular section (Figs. 1 and 2), and stand about 6 ft. above the upper deck, with a strongly protected roof-plate 4 in. thick. Each barbette contains a 28-centimetre breech-loading Hontoria gun. The gear for training the guns and hoisting the ammunition is situated below the protective deck. The turntable upon which each 28-centimetre gun is mounted is constructed of steel plates and angles strongly built. It is supported upon cast-steel rollers travelling on a cast-steel roller path at the level of the deck. The carriage, mountings, hydraulic machinery, &c., for training the guns, also the ammunition hoists and tubes, are supplied by Messrs. Sir Joseph Whitworth and Co., Limited. Between the barbettes on the upper deck is a superstructure or breastwork, within which are all the openings to the deck below. At each end of the breastwork is an ammunition hoist for the 14-centimetre quick-firing guns, which is worked from below the protective deck, and will greatly facilitate the work of serving the guns. The ship has in all eight torpedo tubes, and the principal armament is as follows: Two 28-centimetre guns, one forward and one aft, mounted in barbette turrets; ten 14-centimetre guns, two 7-centimetre guns, eight 57-millimetre Nordenfeldts, two 11-millimetre Nordenfeldts, and eight Hotchkiss. The forgings for these guns were sent from England, but they were turned and finished in the Astilleros Gun Factory, all the employés of which are Spaniards. This department is managed by Colonel Albarran, who has had considerable experience in the Government gun factories.

(To be continued.)

HYDRAULIC PUMPING ENGINE: ERRATUM.—By a printer's error the low-pressure cylinder of this engine, described on page 544 of our last issue, was described as 13 in. in diameter instead of 19 in.

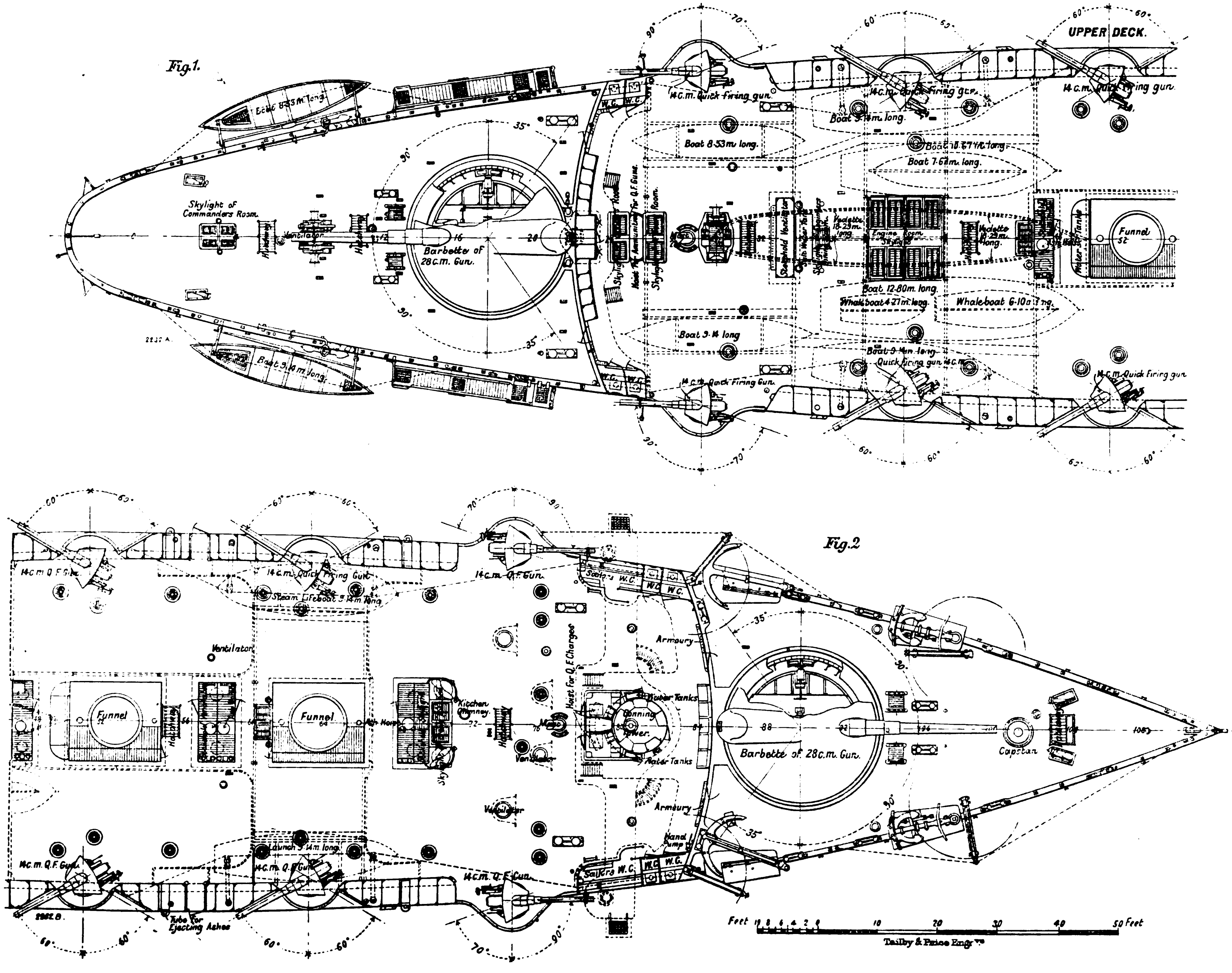
THE SUEZ CANAL.—The transit revenue collected by the Suez Canal Company in March amounted to 287,600*l*., as compared with 260,800*l*. in March, 1893. The aggregate collection in the first three months of this year amounted to 1,744,090*l*., as compared with 1,720,643*l*. in the corresponding period of 1893. The number of vessels which passed through the canal in the first three months of this year was 850, as compared with 871 in the corresponding period of 1893.

BLAST FURNACES IN THE UNITED STATES.—The number of furnaces in blast in the United States at the commencement of April was 144, their aggregate weekly productive capacity being 126,732 tons. The corresponding number of furnaces in blast at the commencement of January, 1894, was 130, their aggregate weekly productive capacity being 99,087 tons. The corresponding number of furnaces in blast at the commencement of October, 1893, was 114, their aggregate weekly productive capacity being 83,895 tons. The corresponding number of furnaces in blast at the commencement of July, 1893, was 220, their aggregate weekly productive capacity being 153,762 tons. The corresponding number of furnaces in blast at the commencement of April, 1893, was 255, their aggregate weekly productive capacity being 178,858 tons. The corresponding number of furnaces in blast at the commencement of January, 1893, was 246, their aggregate weekly productive capacity being 173,068 tons. It will be seen that the severe depression of last autumn is passing away, and that a considerable recovery is now observable in the output.

THE SPANISH ARMOURED CRUISER "INFANTA MARIA TERESA."

CONSTRUCTED AND ENGINED BY LA SOCIEDAD ANONIMA DE LOS ASTILLEROS DEL NERVION, BILBAO.

(*For Description, see Page 576.*)



THE SPANISH ARMOURED CRU

CONSTRUCTED AND ENGINED BY LA SOCIEDAD

(*For Descr*

Fig. 3.

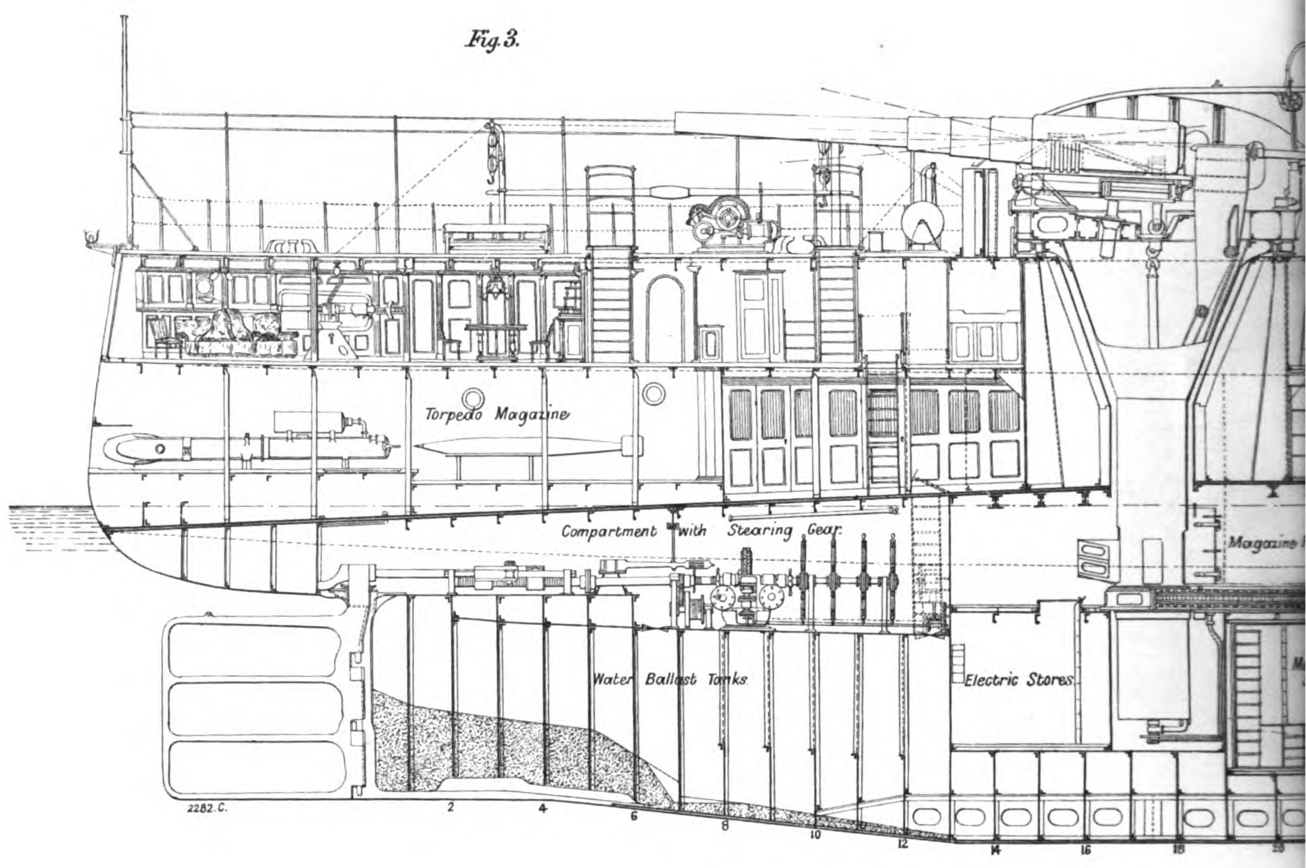
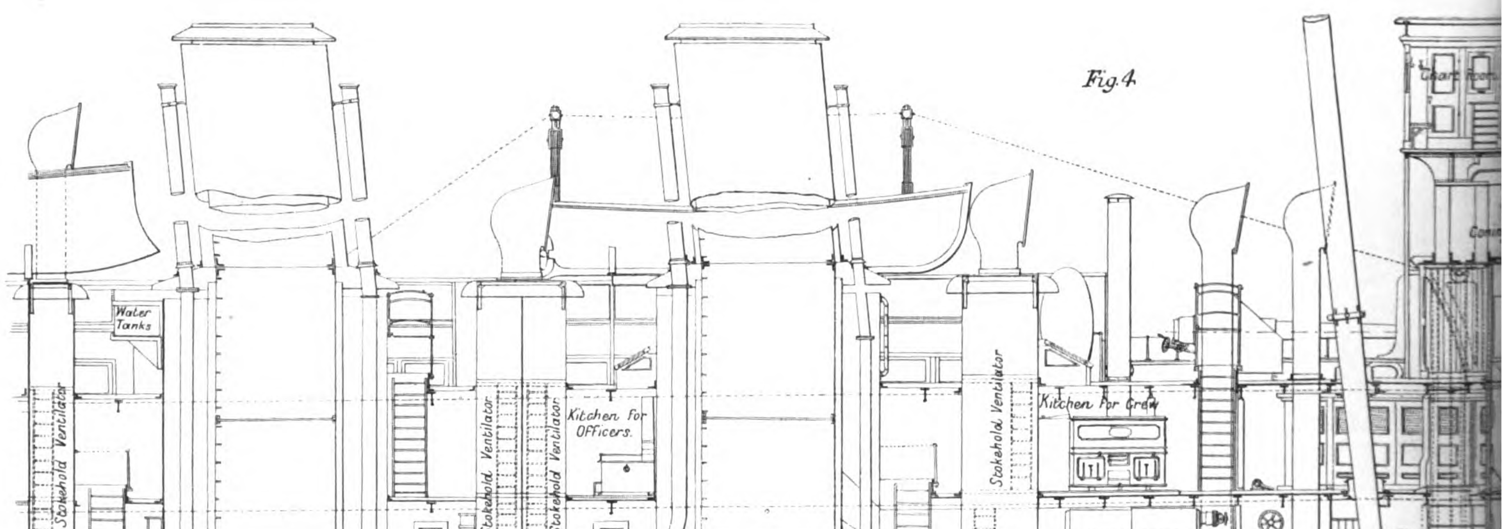


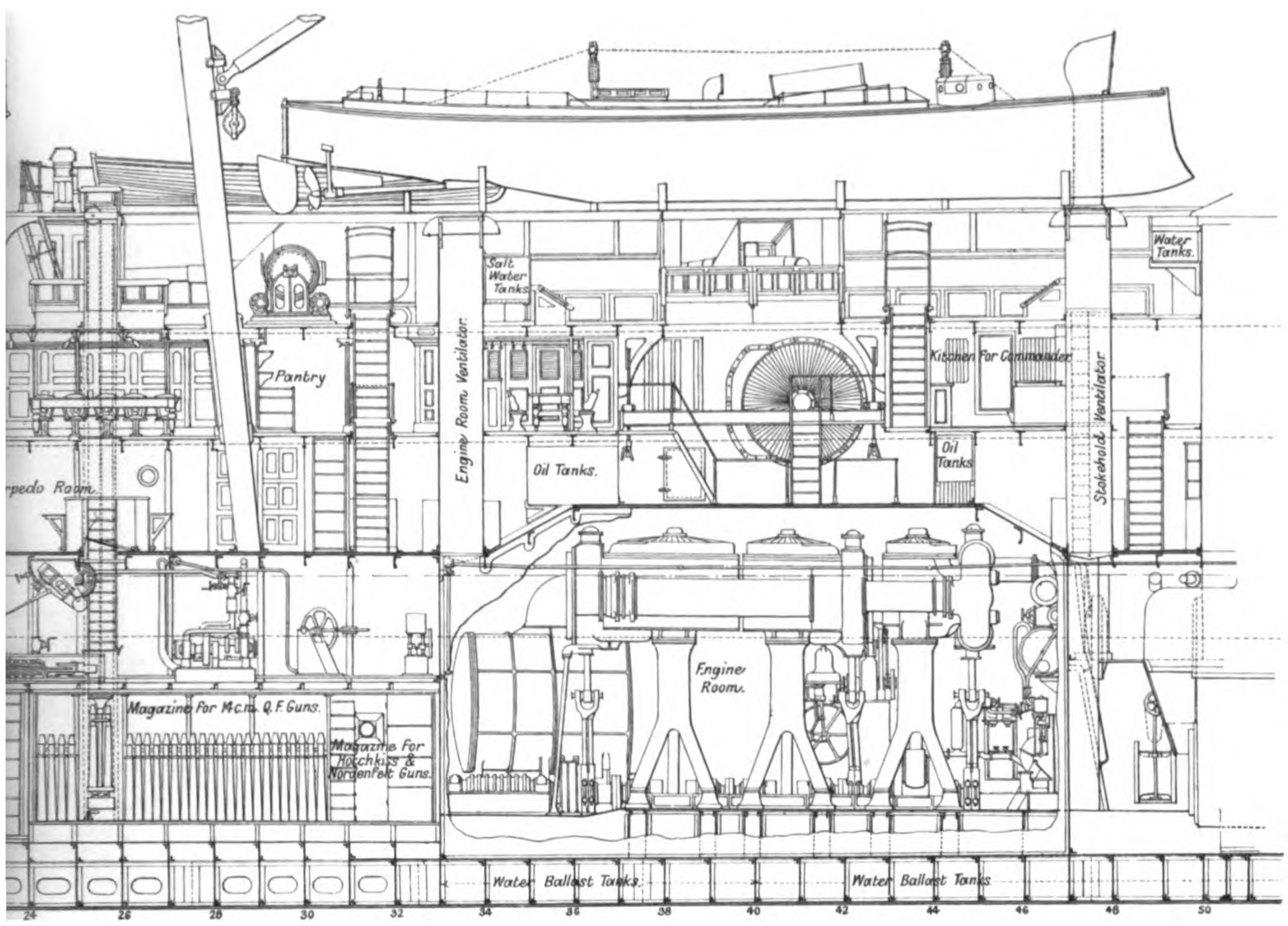
Fig. 4.

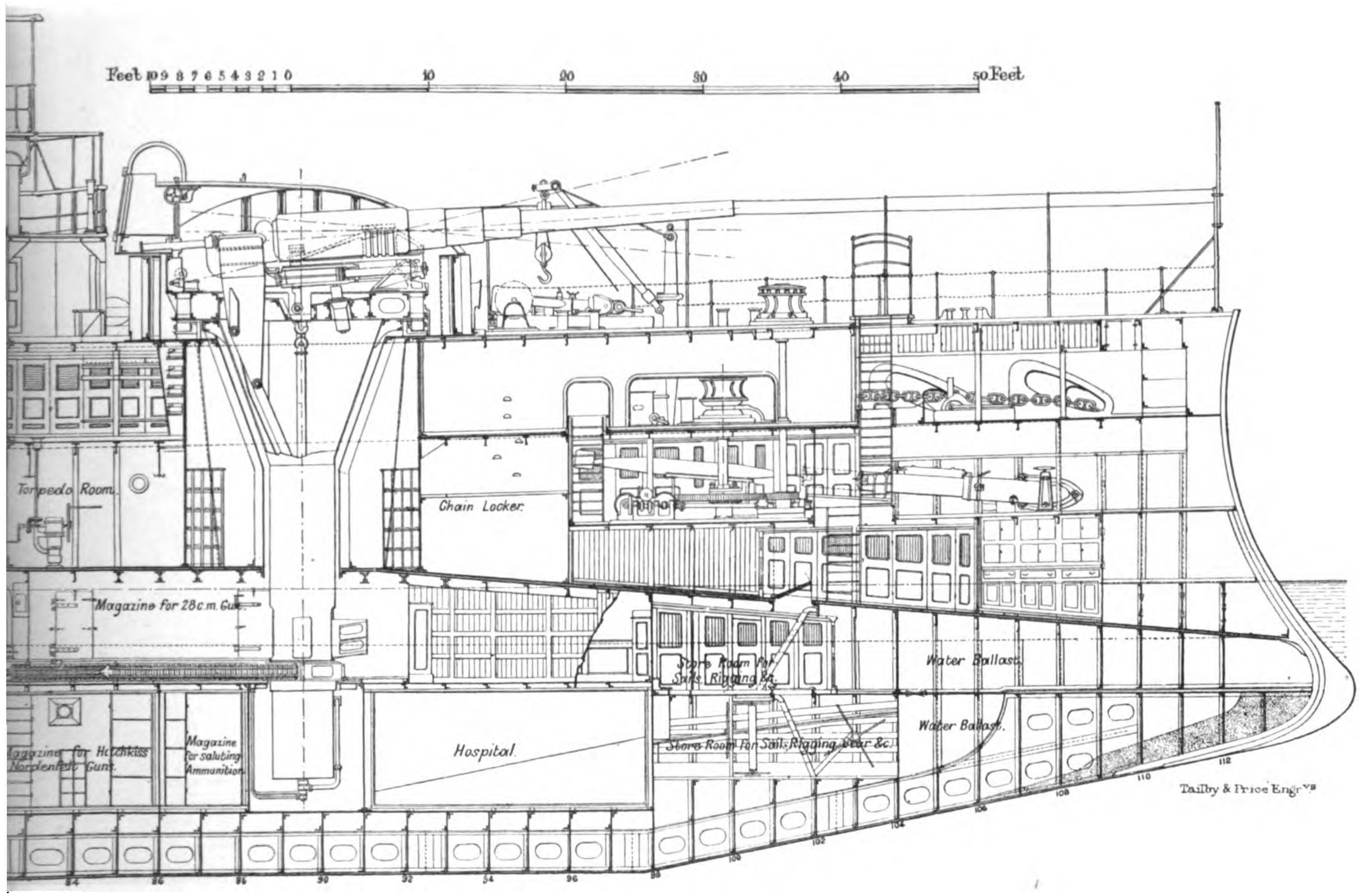


ER "INFANTA MARIA TERESA."

IA DE LOS ASTILLEROS DEL NERVION, BILBAO.

Page 576.)





turning trucks; the baggage car is provided with sliding doors, and the passenger car, though severely simple, is on the lines of the modern vehicle.

MILITARY ENGINEERS AND CIVIL APPOINTMENTS.

To the Editor of Engineering.

SIR,—I rarely see ENGINEERING, but I happened to see it yesterday, and to notice several references to an article in the *United Service Magazine* on the employment of Royal Engineer officers.

As the several writers who refer to that article make in some cases a partial use of it, I venture to send you this letter. The general drift of the article (so far as it views the matter from the point of view of the efficiency of the organisation for the execution of barrack works) is that the Royal Engineer Department is wastefully and detrimentally over-centralised, and that there is a good deal too much "figure-head" responsibility, even of local officers; that this is partly due to the insufficient training of local officers; that it is necessary to the efficient and economical conduct of barrack works that there should be further decentralisation, and that all nominal responsibility which is not real responsibility should cease; hence that either (1) Royal Engineer officers should have a longer training as subalterns on barrack works, and that more officers should be employed on those works at all times; or (2) that the works should be carried out by a competent permanent department; *that the officials of this department should be obtained from the same, or as good, sources as are the Royal Engineers, and undergo the same, or as good, training, having regard to morale, status, and soundness and scope of elementary education.*

From this it is, in my judgment, a far cry to the glorification of the "Assistant Surveyor" and the "Sanitary Engineer" who write to you.

The latter designation may be adopted by any one who has a knowledge of the latest sanitary jargon and the latest pattern sheets of the makers of sanitary fittings, patent traps, and such-like, although his work shows that he fails to grasp the elementary principles on which all drainage depends, or to discriminate in the application of the various types to suitable cases.

I doubt very much whether there are any principles involved in sanitary engineering which require a specialised branch to deal with or apply them; a maker of sanitary fittings is one thing, but a sanitary engineer is, or ought to be, another.

Specialisation has its advantages, and a certain amount of specialisation is necessary, having regard to the average capacity of individuals; but I remember well a speech of Sir Lintorn Simmons to the cadets at Woolwich, in which he said that a Royal Engineer officer to be efficient must acquire, and, from the habit of dealing with a variety of subjects, ought to acquire, the power of grasping the essential principles of each subject, and that such a grasp would inevitably tell upon his work.

That numbers of Royal Engineer officers have proved the truth of this remark I need not point out to any well-informed and fair-minded person, whether in England or India.

To the fair-minded and well-informed, however, the writer who signs himself "Assistant Surveyor" does not belong.

You will see that in order to confute in an effective manner the several instances of inefficiency of Royal Engineer officers alleged by him, a man must give a good clue to his identity, and this would be a very foolish thing for an officer to do, if he were still serving—the regulations being as they are; it is, at all events, safe to say that the average Royal Engineer officer is better qualified by education and experience to carry out the *survey of a piece of country* than the average assistant surveyor, and that if the case he quotes is correctly stated, it is exceptional and proves nothing.

I also say, without fear of effective contradiction, that "Assistant Surveyor" misstates matters when he says that the civilians do most of the work of the department; outside the War Office, at all events (I know nothing much of the inside), the military foremen of works do *by far* the greater part of the work. I allow they are more numerous than the civilian foremen and surveyors, that much of the work is in repairs, and the requisite estimates and measurements.

I avoided all personal and invidious comparisons in my paper in the *United Service Magazine*, and spoke of the *system*, and here, too, I give only *general* replies which involve nothing personal or invidious, as between officers and soldiers and civilian employés.

You will see that the public press is not a place in which it is possible to discuss such matters, because one side has its mouth shut.

For the same reason I will not make any comparison between "military foremen of works" and "assistant surveyors," though such considerations are essential to a full understanding of the question.

I know nothing of architects except what one of them told me himself about his own profession, and what I know of the doings of some persons who I suppose would call themselves engineers, architects, or clerks of the works, according to the nature of the office they were endeavouring to fill, but I would insist on the importance of the requirements for officials of a barrack department which I have indicated in italics in this letter.

I have not commented on the disagreeable tone of the letter of "An Inquiring M.I.C.E.," but his representation of the Royal Engineers as a body of men sticking to posts they are not fitted to hold for the sake of the spoils of office is a gross misrepresentation, as is his remark that "one of their number has been obliged to allow in the *United Service Magazine* that their position is untenable;" I certainly did not write that article in the consciousness that any one had been attacking the Royal Engineer Department or the Royal Engineers either.

Royal Engineer officers do the barrack works because the works are part of their duties, and are by no means so generally anxiously to get into the "Royal Engineer Department" as "M.I.C.E." supposes.

On the other hand, I do not doubt that when a really suitable Engineer officer is selected for a civil post, many envious civilians less suitable for the post decry the grasping Engineers. As to India, I am far from believing that our work on the public works, carried on under very different conditions as to training, responsibility, and exercise of power from the barrack work at home, is inferior to anybody's.

Your obedient servant,
THE WRITER OF THE ARTICLE IN THE "UNITED SERVICE MAGAZINE."

To the Editor of Engineering.

SIR,—As the relative strength of officers to men in the Royal Engineers has been mentioned in this correspondence, I thought it would not be uninteresting to your readers to know the exact strength of the corps of Royal Engineers, officers and men. I have taken my figures from the Army Estimates for 1894-5, pages 6 and 9. The figures give the strength, therefore, for the current financial year. Table A, subjoined, states the exact numbers:

TABLE A.

	Officers.	Non-Commissioned Officers and Men.
Great Britain and Colonies	588	6635
India	350	3
Total	938	6638

This gives about one officer to every seven men.

For comparison I should now like to give the ratios between officers and men in the other corps and regiments of the Army. It would, perhaps, take too much space to place before your readers the exact numbers for each corps, as shown in Table A. I have worked out the numbers, and any one caring to check my ratios can do so by consulting Army Estimates 1894-5. Table B, subjoined, gives ratios as worked out from the authority quoted:

TABLE B.

Royal Engineers	1 officer to	7 men
" Artillery	1 "	27 "
Cavalry	1 "	22 "
Infantry	1 "	33 "

These ratios are as close as can possibly be calculated for round numbers without going into fractions. It is on the face of it strange that one scientific corps can do with a normal number of officers, and the other requires an abnormal and much greater number. But when one has read the valuable letters on the subject in your influential journal, the mystery vanishes, and we find that we are drawing our professional *commanders* from the corps of Royal Engineers. This may be a good thing for the *commanders*; is it good for the *commanded*, or the long-suffering B. P.? I think not.

I remain, &c.,
AD REM.

To the Editor of Engineering.

SIR,—With regard to the work *not* connected with the Army which is performed by officers of the Royal Engineers, I think, on reconsideration, that the attack would be answered more effectively and satisfactorily if undertaken by some officer who possesses personal experience in such work, rather than by one who performed nothing but Army work during his 23 years' service.

I cannot, however, refrain from criticising the cowardly spirit in which this correspondence has been conducted on the part of the attack, which appears to be mainly actuated by feelings of intense jealousy.

Most of the letters bear this construction on the face of them. The writers, therefore, must belong to that great class labelled *failures*, for a civil engineer who regards 1000*l*. a year as a "fat appointment" must be a failure. The successes have incomes of five figures, and are far too well occupied to find time to bestow on a petty paper warfare. If there were any real bottom to this agitation, cases would be cited galore, and questions asked in Parliament. Nothing of the kind occurs. The letters are usually full of vague but offensive generalisations, and when cases are cited they are ridiculously inconsequential. Failures occur in every profession, but a small percentage proves nothing. The fall of the Tay Bridge did not show the general inefficiency of British civil engineers. A collision at sea does not prove that Englishmen are bad sailors. It is really wonderful to find that a paper of high standing should print many of the remarks which have recently appeared in ENGINEERING in this anonymous correspondence. In former times, certainly within the century, such publications concerning a regiment in Her Majesty's service would have produced a very considerable number of personal encounters between the officers and the writers, whose names would have been forced from the editor; and even at the present day nothing of the kind could be done in any other country but England without entailing very unpleasant consequences to those concerned in promulgating the exceedingly offensive remarks made by many of your correspondents. It appears, however, that in free and enlightened England any amount of anonymous scurrility may be published by a leading journal with perfect *sang froid*, as if the officers of a regiment were a herd of sheep or cattle for any cur to bark at from the far side of the hedge and at a safe distance.

"Alma Mater," in his letter which you published recently, wrote, "lamentable disasters, such as Isandlwana, have occurred through incompetent officers taking command." This sentence carries by implication two falsehoods: one that the late Colonel Durnford, R.E., was an incompetent officer; the other that Isandlwana was lost through any act of his. At Rorke's Drift, immediately afterwards, Lieutenant Chard, R.E., as senior officer present, conducted the defence.

"Incompetent" in war!
Thus "Alma Mater" filches our good name,
Robs us of that which not enriches him,
And makes us poor indeed.

Yours truly,
J. T. BUCKNILL.

P.S.—If the accuracy of your correspondents can be gauged by the manner in which they distort the evident meaning of words, the value of their strictures must approach a vanishing quantity. Thus, my contention that an early selection for military and for non-military work produces increased efficiency, has been falsely converted into an argument that "a Royal Engineer officer who, under the present system, has done no actual soldiering for years, would at any moment, if called upon, perform such duties better *because* of his employment in the meantime in a civil capacity." Certainly my words never conveyed anything of the kind; nor is it true to imply that anything of the kind is of frequent occurrence. Fortunately for the corps, H.R.H. the Commander-in-Chief strongly disapproves of such transfers. There have been notable exceptions, but the results obtained have usually shown how desirable it is to reduce their number to a minimum.

J. T. B.

ENGINE-ROOM COMPLEMENTS OF WARSHIPS.

To the Editor of Engineering.

SIR,—In ENGINEERING of May 18, page 661, a letter appears by a naval engineer, signed "Impartial," which has proved everything that I intended to prove: (1) That the artificer is not the finished article he and others interested would have us believe. (2) That a good chief stoker is worth two indifferent artificers. (3) That all the old leading stokers are gone (worse luck!), and their places filled by boilermakers, fitters, turners, coppersmiths, &c., many who have never seen a ship of war before, and are in no way fitted as all-round men—a very necessary thing in time of war. (4) Cannot conceive how a chief stoker can be as useful as an artificer at refitting; 12 years ago the foreman fitter counted me as three (all-round). (5) About airs—the only difference is that the chief stokers put on airs sometimes, the artificers always keep theirs on. (6) As to teaching, he says that the artificer or the engineer teaches the stoker; that may be, but the chief stokers have something to do with the teaching of the green and fresh-caught artificer and engineer. My motive for writing that (bombastic) letter was to stop the holding up to ridicule and contempt the men who have to decide the next naval war—not engineers, as some would have us believe—and I think it has done its work well; in fact, I thought we were to have no more of it, but feel glad the tone is changed for the better.

As to position, I may inform "Impartial" that I have held the highest position, also the highest pay, I believe, of any stoker in or out of Britain in the merchant service and on warships (chief over all), and highest pay 10 *guineas* a day. I trust that will satisfy "Impartial."

CHIEF STOKER.

Glasgow, May 29, 1894.

BALANCING OF LOCOMOTIVES.

To the Editor of Engineering.

SIR,—I have been somewhat surprised, after reading all the letters which have appeared *re* balancing locomotives, that no one seems to have thought the Heilmann combination worth mentioning.

These letters all show that the wear and tear of permanent way, and of locomotives, is nearly wholly due to the wobbling and steam-hammer action of the locomotive as at present constructed, and that our railway engineers are striving their utmost to produce a locomotive with something approaching a decent balance. But how is it that none of these engineers go to the root of the matter? What they do now is simply making the best of a bad job by trying to balance their engines in an impossible way, the result being they smash up their permanent way and weaken their bridges.

Now would it not revolutionise a railway company if all their locomotives were suddenly replaced by perfectly balanced 30 per cent. more economical engines? What would the enormous gain in reduced repairs amount to? Would it not far and away pay for maintenance of locomotives on the Heilmann system? For has not Mr. Heilmann given us a locomotive which is not only perfectly balanced and driven by a high-speed economical compound engine, but can gear its engine to the driving wheels within reasonable limits, and so can thus run up very heavy gradients with its engine running full speed?

Now as this locomotive has already, from what I have heard, shown itself from 20 to 30 per cent. more economical in fuel than the ordinary type, engineers can have no objections on this ground. The only one left is extra complication. There is, I think, no doubt that an electrical engineer relies as much on his dynamo and motor to run without breaking down, as a railway engineer does on his engine; and that dynamos and motors, as now made, are not simply a combination of copper wire, shellac, and string, but reliable machines.

The whole thing is simply a matter of figures. Will the extra saving on permanent way and rolling stock pay for

ENGINES OF THE SPANISH CRUISER "INFANTA MARIA TERESA."

CONSTRUCTED BY LA SOCIEDAD ANONIMA DE LOS ASTILLEROS DEL NERVION, BILBAO.

(*For Description, see Page* 711.)

Fig. 13.

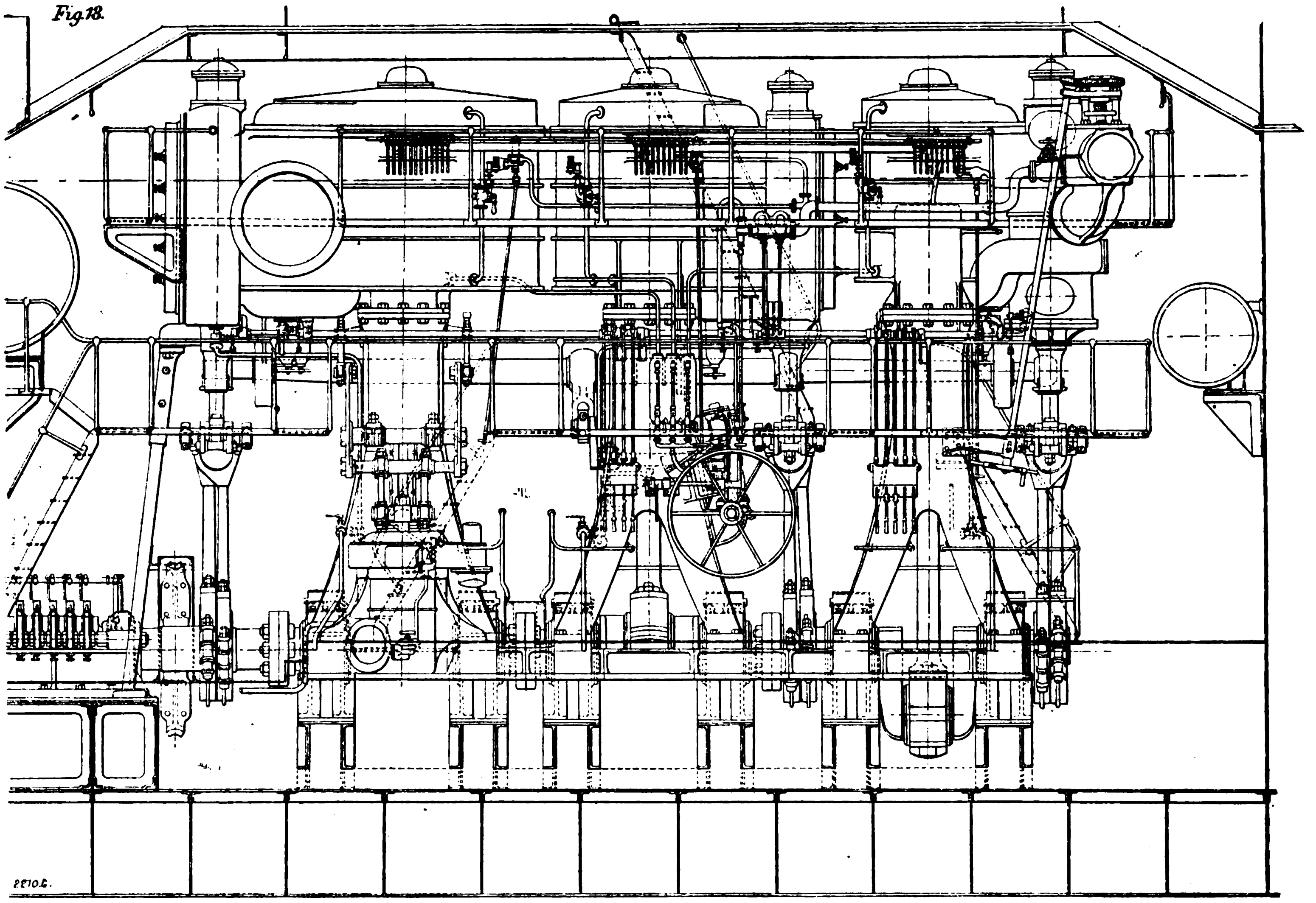
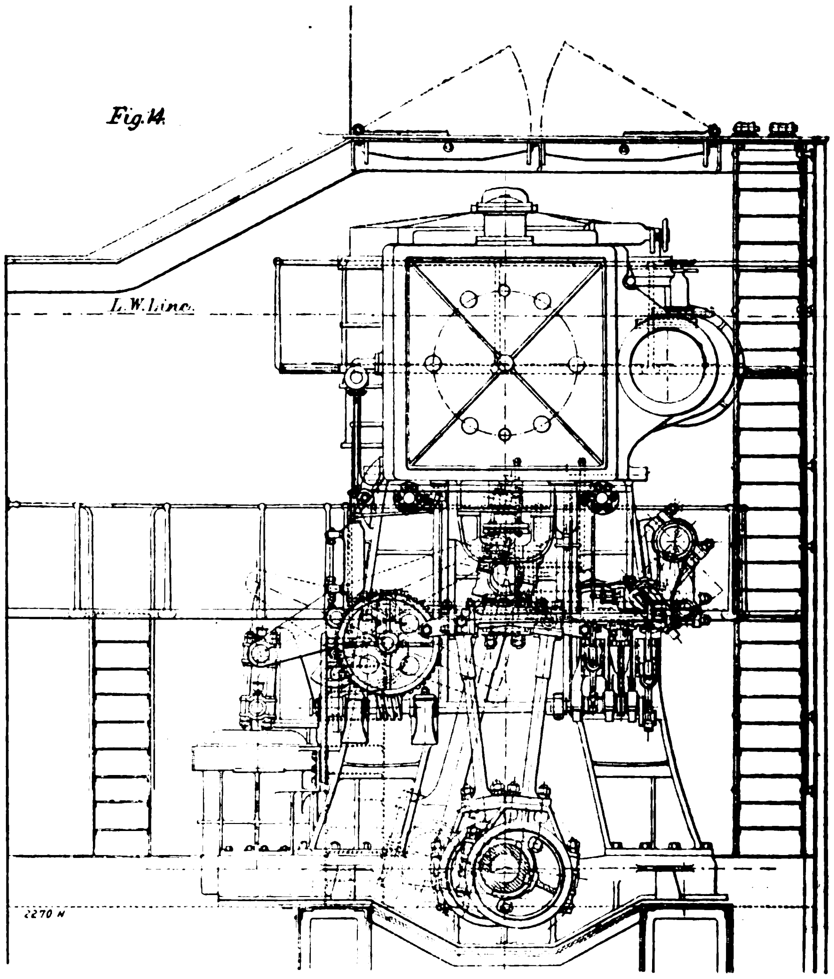


Fig. 14.



the maintenance of the electric portion of these locomotives? In addition, however, we have the great advantage on making a new railroad of using heavier gradients, thus saving expensive cuttings and costly tunnels.

I might ask, through your valuable paper, if locomotive and railway engineers will not go a little deeper into a subject which, hitherto, has received such scant attention, from all appearances, in England, and give some figures as to what they think the saving effected by a balanced locomotive would amount to.

Yours, &c.,
H. CLARKE.

Baden, May 25, 1894.

MASONRY DAMS.

TO THE EDITOR OF ENGINEERING.

SIR,—Will you kindly allow me space in your columns for a brief criticism of a discussion on "Impounding Reservoirs," which appears in a recent volume (vol. cxv.) of the Minutes of Proceedings of the Institution of Civil Engineers, but more especially of that portion relating to the design and construction of masonry dams? The publication to which I refer is in many ways a useful addition to the literature of the subject, but I think there are certain matters which were not treated with all the precision that appears desirable.

In a paper devoted to the design of masonry dams a method is proposed by which it is suggested that "trials may be dispensed with," and a mathematical solution "gradually arrived at." It is difficult to see any radical difference here, especially as further on in the paper it is intimated that a certain equation "may be solved by trial." It was claimed for this paper by a correspondent in the discussion, that it "completed the consideration of the subject from the analytical standpoint," but I think that this claim is a somewhat exaggerated one; and I was rather surprised to find that no mention was made of a paper by Mr. Williot, which appeared in the *Genie Civil* in 1888, and which in my opinion goes further towards a practical solution of this particular part of the question, than anything hitherto written.

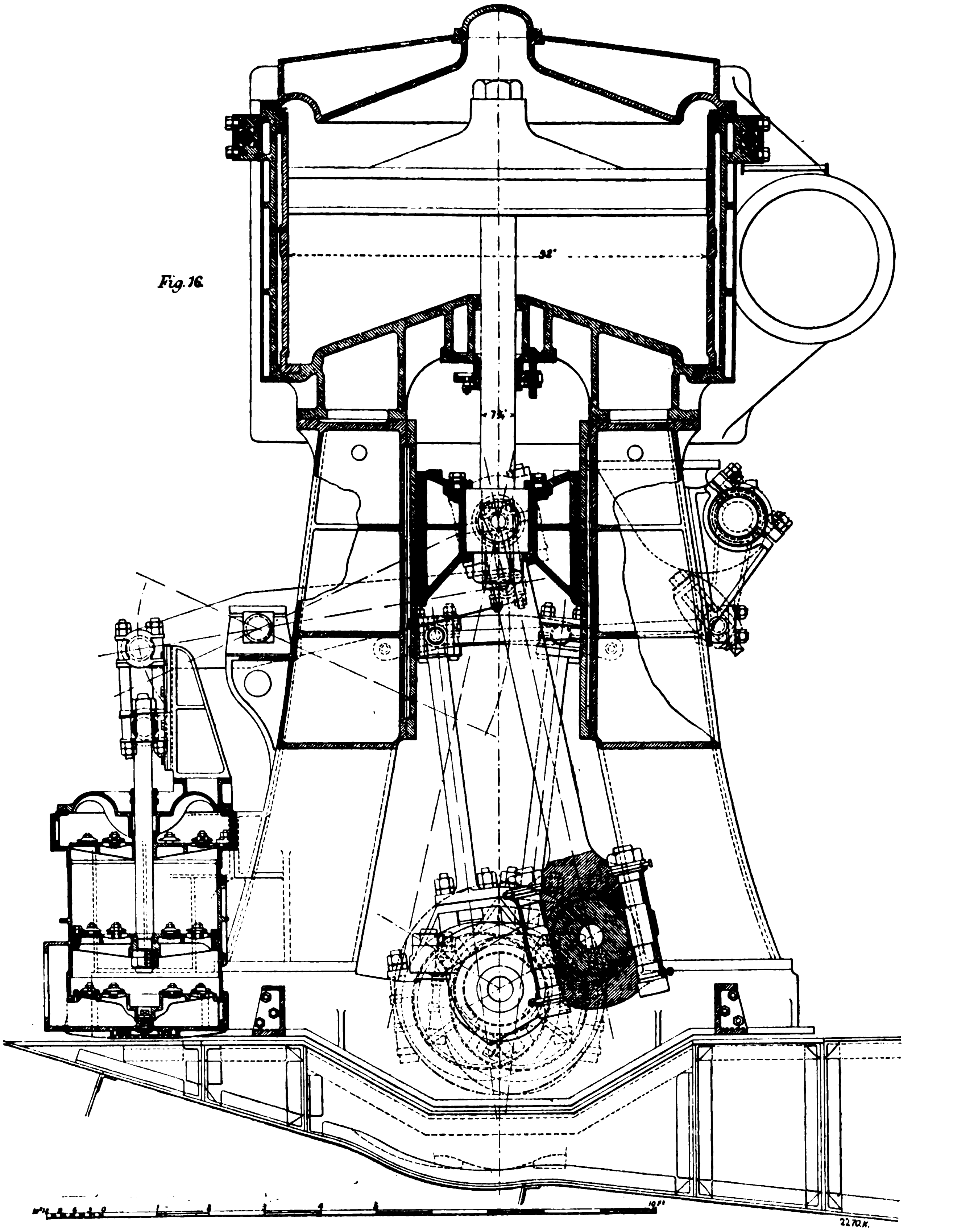
In the course of the discussion an empirical formula was given, for determining the dimensions of a dam, which was said to be "applicable under all sorts of different conditions," whereas, in point of fact, the formula in question provides no means of varying the profile for different values of the specific gravity of the masonry—a

ENGINES OF THE SPANISH CRUISER "INFANTA MARIA TERESA."

CONSTRUCTED AT THE ASTILLEROS DEL NERVION, BILBAO.

(*For Description, see Page* 711.)

Fig. 16.



rather important factor in the upper portion of a dam. It is a useful formula for rough estimates, but if correct for, say, granite or any igneous rock having a specific gravity of 2.80, it would be an unsafe formula for sandstone or limestone with a specific gravity of 2.30.

Further on we are told that the Gilleppe dam is much thicker than theory would determine, thereby "imposing an unnecessary additional pressure on the masonry," but after all, I believe I am correct in saying that the maximum calculated pressure in this dam is only about 6½ tons per square foot.

In the course of the same discussion it was stated incidentally (though the particular bearing upon the subject of masonry dams is not very clear) that in at least 90 per cent. of all the arches in the kingdom the curve of pressure is outside the middle third of the arch, and this is brought forward as an argument against Rankine's teaching that in such a case an arch would be (? might be) in a precarious condition; but it seems a pity that no explanation was given as to how this lamentable state of things was ascertained. Another suggestion is that the "most convenient and practical way" of determining the average value of the modulus of elasticity of the masonry in arches is "by noting the settlement which occurred when the centres were struck." There is evidently some confusion here between *settlement* and *elastic deformation*, and though I say nothing as to the convenience of the method, my experience is that it will not be found a very reliable one, as it is practically certain that something in the nature of a permanent set occurs when the centres of an arch are struck (see a paper by Professor Hartig in *Der Civil Ingenieur*, 1893). It was also suggested that the modulus of elasticity might be obtained by noting the "rise and fall of arches from changes of temperature." This method might, no doubt, be employed to form a rough estimate of the *coefficient of expansion* (or contraction) for temperature, though the calculations required are rather unwieldy, and a straight piece of masonry would, with less labour, give more exact results, since the deflection is not exactly proportional to the length of the arch; but I think it will be found rather difficult to deduce from an experiment of this kind any practical conclusion as to what the *modulus of elasticity* is.

The question of the elasticity of materials seems likely to play an important part in the engineering practice of the future, and we have already entered upon a stage where some of the ways and means adopted by the old-fashioned "practical engineer" will soon have to be discarded.

Another speaker recommended "caution" in using Rankine's or Bouvier's methods for calculating the stresses in the outer face of a dam; but there is no real necessity for caution, since, if there is any error in these methods, it is on the safe side.

There appears also to be a little confusion as to the meaning of the term "factor of safety." This perhaps arises from the fact that in designing a high masonry dam there are really two factors of safety employed—one (applicable to the upper portion of the dam) representing a certain relation to the moment of the thrust of the water; and the other (applicable to the lower portion of the dam) representing a certain fraction of the crushing strength of the masonry. The statement that the Vyrnwy dam possesses a "factor of safety of 2" is therefore somewhat indefinite, and, moreover, I believe that it is not quite correct, and that this elephantine structure is actually in a far more stable condition than is claimed for it.

Another speaker drew attention to the relative cost of the water impounded in the Quaker Bridge and Bear Valley reservoirs, and suggested "that if an efficient dam could be made between such wide limits as 1*l*. 8s. 3d. per million gallons and 26*l*. 8s. 10d. per million gallons stored, there must be still ample room for engineers to display their skill in the design and construction of storage reservoirs." I should like to mention that the cost of the water retained by a very celebrated masonry dam is about 100*l*. per million gallons stored, but are we to believe that all the engineering skill of Great George-street could materially alter the state of things referred to? It would be interesting to learn the precise connection between the cost of a dam and the configuration of the country above it, for this is the principal reason why one reservoir contains proportionately so much more water than another, and consequently supplies it at a cheaper rate. There is an instance of this in the Furens and Villar reservoirs, both formed by masonry dams of the same height, and not differing very much in size, whilst one reservoir contains 13 times as much water as the other.

Practical engineers, of course, know how to sift remarks and statements of the kind I have referred to, but I may, perhaps, be doing young engineers a turn in pointing out the necessity here and there of the proverbial "grain of salt."

I am, Sir, your obedient servant,
JARAMAR.

CAPITAL AND LABOUR.

TO THE EDITOR OF ENGINEERING.

SIR,—In "Subscriber's" letter which appeared in your issue of April 27, he evidently does not look at my argument *re* the man and the umbrella from the same point of view as I was doing in my letter. Of course we cannot tell when a man is getting abnormal profits; but we can all cultivate the art of spending money to the best advantage, and of not allowing ourselves to be "had."

There is a certain class of people, and this a very big class, who will not have a thing unless they pay a heavy price for it, and this, of course, creates another correspondingly big class who will impose upon them by adding to their already paying price another increment to please their foolish customers. This is the abnormal profit of which I spoke, which is simply passing money from one to another without doing any one any good.

With regard to the luxurious man, he may or he may not be a "giddy fool;" as, of course, may or may not be the case with any man of any other class. Luxury is only a comparative term. The most homely live in luxury as compared with some others. Everything beyond bare food, clothing, and roof enough to keep body and soul together is a degree of luxury. The man, therefore, who is living "up to date," is only availing himself fully of the benefits of civilisation, nothing more. Whether he is a "giddy fool" or not is another question, but both will be doing good to the community in the way I mentioned.

I agree with "Subscriber" that the working classes do think more of the amount and regularity of their wages than they do of the mercantile value of, and the chances of selling, the work which they produce. This is just where education comes in. "Subscriber" says that a little education is better than none at all; but I maintain that unless the education is in the right direction, it is worse than useless. A man may be educated to be a thief and a robber, or he may receive a highly moral education. In the same way he may receive any kind of education lying between these two extremes, which may, perhaps, prove beneficial, and perhaps detrimental to him. What I believe with regard to the School Board is simply this, that although the teaching has been very beneficial in a great many ways, yet it has done harm in others, by not paying enough attention to the training of the reasoning powers in an unbiassed direction. This also applies to schools and colleges of every other class.

If the science of ethics had been made the first and most important subject for the past 25 or 30 years, in my opinion there would not have been half so much dissension between the classes as we are experiencing at the present day. The simple fact of capital and labour being at war proves selfishness or want of moral education on both sides.

Ethics, up to the present time, has been taught in the schools simply through the medium of religion, which never has been, or can be, much taught on account of there being so very many beliefs.

One parent will not have his child brought up to the Church of England ritual, while another will not have his brought up to the Church of Rome; consequently religion will always remain rather a ticklish point. The science of ethics, however, there can be no doubt about, and no parent could possibly object to his child being thoroughly trained in this all-important subject.

A. Hanssen puts the question of landowning and royalties very clearly in the same issue of April 27, and I quite believe he is correct in his reasoning, though he appears to rather overdo it, and that something might be done to alter the state of things in this direction, which would greatly help to avoid commercial depressions. But no alteration of this kind will ever, in my opinion, permanently benefit the working classes and the "submerged tenth," unless, first of all, the minds and morals of the people have been suitably trained.

Yours truly,
F. W. B.

TO THE EDITOR OF ENGINEERING.

SIR,—A week or two ago you had A. Hanssen figuring as an anti-rent correspondent; now you have "F. G. W." posing as an anti-capitalist. Each of these theorists, by their respective fads, propose to cure the world of all its ills. "F. G. W." asks your readers a number of questions, but it has been well said, "A fool can ask as many questions in five minutes as it would take a philosopher five days to answer." "F. G. W.'s" first question is, "If capitalism is the saving grace of modern times, how is it it is so signally failing in America?" Who said capitalism had failed in America? His second question is like unto his first, namely, "What, then, is fundamentally wrong with capitalism?" Who said there was anything wrong with it? "F. G. W." says: "In America, with enormous concentration of capital, they are face to face with industrial disorganisation on an alarming scale." There are many reasons for this disorganisation; the principal cause of it is selfishness. But this vice is by no means confined to the capitalist. Labour has at least an equal share of it. The people of America, instead of allowing the working men of other nations to compete for a share of the work to be done, have selfishly placed a heavy tariff on all goods entering the United States. This selfish act is carried out in order that capitalists may get large profits, and that labour may receive high wages. The result of said selfish dealing has, as might have been expected, ended in disaster to both classes. "F. G. W." says, "To define the rule on which capital is based, a current phrase, I think, covers it: Do, do, do; always be up and doing; never mind whom you do, how you do it, or when you do it." This phrase, as put by "F. G. W.," is merely a string of words without meaning, and could with as equal justice be applied to labour as to capital. By way of a sneer "F. G. W." says, "The best of fathers feels no shame in recommending his son to study the life and methods of self-made men—men who started life with a shilling and die with a fortune." Surely there can be no harm in a father recommending his son to follow the example of the man who by industry, perseverance, and thrift has made a fortune. "F. G. W." further says, "If you start with a shilling, use it to do some one out of a penny, and so make it 13d.; keep to this course, and you are a made man." There need be no case of "do" in the transaction. If by my labour and thrift I save 12d. or 12*l*., I am surely entitled to receive interest for the loan of it from the party who receives the use of the said money. Does he propose that no encouragement shall be given to well-doing; or does he mean that the lazy, the drunken, and the wasteful shall have equal advantages with the industrious, the temperate, and the thrifty? If "F. G. W." had had any knowledge of the subject on which he wrote, he would have known that while capital never received less interest than now, labour never has got higher wages than at the present time. "F. G. W." informs your readers that he has a scheme for nicely adjusting the wealth of the world, but that within the compass of a letter it would be idle to draft his scheme. Let him, however, keep in remembrance that "the best-laid schemes o' mice and men gang aft agley."

Glasgow. J. M.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. David Macdonald has not answered my question. If he advocates robbing landowners of betterment, does he advocate a repayment to them by the State for worsement? It is a very simple question. He can take his Glasgow example for the first, and the Essex landowners for the second; and then, if he can, he might show how he would meet the two cases in the same honest and logical manner.

I must ask for space to utterly repudiate the implication placed on my words by "Civil Engineer," wherein he accentuates the word *their* in the sentence, "the planters in Jamaica were paid for their slaves when we freed them." Thank God we have had no slavery in England for many a century.

The late Lord Bramwell's ethics on the abolition of private capital are on a par with the late Professor Clifford's mathematical conception concerning the possible existence of a *fourth* co-ordinate in space. They may each be true, but we know them not; and it is better neither to talk nor write about the unknown.

"Civil Engineer" resumes his tirade against what he terms waste of energy in all matters connected with trade. According to his ideas, if two or three good hounds can kill their fox, he, as an M. F. H., would consider it wasteful to employ 16 or 18 couple in his pack. He may be quite correct, but I would rather hunt with some one else. *Efficiency* from a human point of view is that state of affairs which will support the greatest number of people.

Evolution produces this—by laws which are far too complicated to analyse, and by forces which are evidently stupendous in their magnitude.

When the faddists, socialists, anarchists, and other "ists" can turn these matters upside down, they will prove themselves to be strong indeed.

J. T. BUCKNILL.

TO THE EDITOR OF ENGINEERING.

SIR,—May not capital and labour, or the capitalist and labouring classes, be broadly divided into those whose income is principally derived from the labour of others, and on the other hand those whose income is, after paying tribute to capital, derived from their own labour? And are not the interests of these two divisions, according to our every-day practice, diametrically opposed to one another?

The practice of the capitalist is:	The practice of the worker is:
To pay the smallest possible wage.	To ask for the largest wage.
To ask the longest hours or the maximum output.	To ask the shortest hours or the minimum output.
To do all possible work by automatic machinery.	To do all possible work by hand and resist machinery.
To get one person to attend to two or more machines.	To have a separate person to each machine.
To introduce boy labour to supplant men. To employ women instead of men, and young girls instead of women.	To oppose the introduction of boy labour, also of women and girls, whether in works, factories, or offices.
To buy the brains of managers, book-keepers, draughtsmen, foremen, inventors, &c., at the lowest possible rate.	To sell the brain at the highest obtainable figure.
To extend their own holidays and cut down their employés'.	To get a holiday if possible without losing the pay.
To crowd as many workers as possible into a given space, and to limit expenditure on buildings, sanitation, and prevention of accidents.	To demand air, space, daylight, ventilation, safety, and healthy surroundings.
To crowd factories and shops into towns, and pack workmen's dwellings in the smallest possible space, so that people are compelled to be either in the street or the public-house when not in the factory.	To ask that factories and shops shall be located in villages or near roadside stations, so that dwellings may have a few roods of land at hand where a man may profitably employ his leisure or an idle time.
To move men about the country from job to job, and engage and discharge them regardless altogether of their human lives, relationships, or happiness.	To endeavour to obtain permanent situations, so that a *home* can be got and kept together and an interest taken in human affairs.
To discharge or refuse employment to all old men, as a principle.	To maintain that an old workman is as much good as an old master, as a principle.
So to direct and control education that children shall at an early age become efficient producing machines, and to manipulate technical night schools so as to make them serve in lieu of an apprenticeship to a trade.	To endeavour to introduce a little life into existence in the way of art, music, literature, science, entertainment, out-door sports, &c., and to protest against turning the capitalist mill by night as well as by day.
To try to raise the bogey of foreign competition, and make Englishmen the slaves of the world's workshop.	To maintain that all *workers* are of one nation, and ask large consumers to become producers.

Will some of our leaders, and would-be leaders, kindly say how these opposing forces and interests are to be reconciled and brought into line? A man may be well educated or a good craftsman, a professional man, a schoolmaster, a curate, an M.A., or a labourer, but he cannot insure a living nor a comfort. Is there no method by which energetic, competent, capable men can get to windward of the mere capitalist?

Yours, &c.,
May 29, 1894. A. B. C.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to Lieutenant Rooper: First, if Protection and silver are the causes of the distress in America, then we ought to be free from distress in England, as these questions are practically *nil* in this country. I fully admit that these two heads do cause great distress wherever they exist. Our Creator never furnished man with the attributes of idleness and the other vices referred to. These are mere fungi, the outgrowth of our indifferent systems, private capitalism among others. Second, as to his remarks that one man's gain is not another's loss. I have myself worked all my life as conscientiously as most men, and am little or nothing ahead in spite of best endeavours. I have produced far more than I have received, and I say my loss *has been* some one's gain. If I am in the same position when I reach old age, and a little of this gain would see me to the end of my days, where can I get it? *At the workhouse.* This is no fallacy. Third, the question as to doctors, &c. This is where Lieutenant Rooper stumbles, because he is now discussing another point, viz., what the producer will do with the whole of his produce when he gets it. He will part with the whole of it in satisfying his wants, and if these include always occupied the same position as the "true and first inventor," the fact, of course, being that under the common law the inventor had no claim to a special privilege except as the introducer of a new industry. A perusal of the early monopoly grants of Elizabeth proves that most, if not all, of these were issued either to foreigners or to natives associated with a foreigner, or to native importers of foreign manufactures. In the recital of a grant to George Cobham, who had introduced certain new dredging machines from abroad, the Queen declares her hope that the favourable treatment of this patentee "will give courage to her subjects to study and seek for the knowledge of like new engines and devices," thus corroborating the view that the rights of the native inventor were derived from those previously enjoyed by the foreign importer. The circumstances which led to the insertion of the monopoly clauses in these instruments can here receive but brief notice. It is probable that the suggestion was made at the instance of the foreign experts who were brought over early in this reign, and that the policy was adopted by the Queen as the only alternative to starting the new industries under State supervision and at State expense. The latter assumption is justified by the close connection which existed between the Crown and the early monopolists of saltpetre, alum, copper, brass, and other manufactures which were successfully established under the new system. On the former point direct evidence exists in a petition addressed to the Queen in 1559 by one Acontius, an Italian inventor, who therein urges the value of a general prohibition as a means of rewarding the inventor. Acontius was undoubtedly acquainted with the existence of similar monopolies on the Continent, traces of which are to be found in the Papal monopoly of alum, and the exclusive and hereditary privileges of the French glass-makers. This letter was reprinted in full by the *Antiquary* of 1885, in a series of articles on "Early English Inventions." The statement that no patent was granted on this appplication is erroneous, for in the seventh year of the reign, when the policy of the patent system had been definitely adopted, Acontius received a privilege of 20 years.

Turning now to the first patent of monopoly, Stow informs us that soap-making was first established in London about 1542 by John Lame, of Gracechurch-street, "before which time the City was served of white soap in hard cakes called Castell and other, and of grey soap speckled with white, very sweet and good, from Bristol." The latter apparently was a soft potash soap, for we are informed from other sources that at this period the "soda of England was not good." The foreign soap, on the other hand, was made with the alkali obtained from the ash of barilla, a marine herb growing near Alicante, and largely employed in the Spanish and Italian glass industries. In the absence of any direct tradition respecting this grant, coupled with the fact that the process was repatented in 1622, we must conclude that the attempt to introduce this industry resulted in failure.

De licencia pro Stephano Groyett et Antonio le Leurier.

Elizabeth by the grace of God, etc. To all our Justices officers Ministers and subjectes whatsoever greeting. Knowe ye that we for dyverse weightie causes vs moving of our speciall grace and of certen knowledge and mere mocyon have geven and by thes presentes graunted vnto Stephen Groyett and Anthony le Leuryer full priviledge and auctoritie that they and every of them and the survivor of them and not any other by them selves and there servauntes whereof tow at the least shalbe of our leges and subjectes borne within our Realme of Englond for the space of tenne yeares next ensuyng the date hereof in place and places convenient within this our realme of England not beinge within our Citie of London nor nere to anie the places or mansion houses of vs our heires and successors or of any our nobilitie or Councell at thes present builded to the anoyance of the same shall and may worke and make within this our realme of England white harde sope aswell in greate as in small cakes to be like of goodnes fynes and puritie as the sope is which is made in the sope house of Triana or Syvile in Andelizoi And therefore we do by these presentes straightly charge and comaunde and also prohibitte all other our subjectes aswell denizens as not denizens at theis presentes not vsing within this our Realme the makinge of the saide whitte harde sope that they nor any of them during the said terme of tenne yeares shall within this our realme make or attempte to make any white harde sope upon payne of imprisonment and forfeiture of all suche sope as shalbe made by them or any of them contrary to the tenor hereof The one moitie of whiche forfeiture shalbe to the vse of vs our heires and successors And the other moitie thereof to the partie that will seaze the same or sue for the same in any our Courtes of recorde by informacon writte bill playnte or otherwise Provided alwayes and our pleasure is that all suche sope as by vertue of this our graunte or privilege shalbe made within three Miles of our Citie of London shall and may be viewed and tried from tyme to tyme by the order and appointement of the Mayor and Aldermen of London for the Tyme being And that all suche sope as by vertue hereof shalbe made in any other place of this our Realme more then three myles distaunt from the said Citie of London shall and may be viewed and tryed from tyme to tyme by the order and appointement of suche as the Lorde Chauncellor or keper of the grete seale of this our realme for the tyme being shall assigne and appointe And if any of the said sope made and offered to sale shalbe founde defectyve vntruly or deceitfully made or wrought contrary to the entent of these presentes that then and from thenceforth this our graunte and privilege shall furwith cease determine and be voide anie thinge before mencioned to the contrary hereof in anie wise not withstanding Wherefore we will and straightly charge all our said Justices officers Ministers and subjectes to be ayding and asisting for the due obseruacion of this our graunte and privilege in all things according to the tenor of the same. In witness whereof etc. Witnes the quene at Westm the third day of Januarie.

per breve de privato sigillo etc.

Patent Roll. 3 Eliz., p. 13, memb. 34.

THE NEW SPANISH BELTED CRUISERS.

(*Continued from page* 712.)

In continuation of our illustrations of the machinery of the new Spanish belted cruisers, we reproduce this week the drawings of the boilers, and of the screw propellers, the former on our two-page plate, and the latter on page 807. We have already given a general description of these details in our previous article on the propelling machinery; but it seems specially appropriate to associate these illustrations with a narrative of the exhaustive series of steam trials of the Infanta Maria Teresa, the first of the three Nervion-built vessels to be completed. For, after all, in high-speed steamers the most uncertain element is the efficiency of the steam generator when hard pressed under forced draught, and only successful results attest the quality of the boilers. Again, the speed got from a given power is materially affected by the form of propeller used. Before entering upon the trials, however, we propose giving such data as to the ship and machinery as will enable the reader to appreciate the results obtained. As to the ship, the following indicates the condition on trial:

Length on water line	340 ft.
Beam " "	65 ft. 2 in.
Draught on trial, forward	20 " 6 "
" " aft	22 " 6 "
" " mean	21 " 6 "
Displacement on trial...	6890 tons
Immersed area (*i.e.*, wetted surface)	27,000 sq. ft.

The weight of the vessel (displacement) is made up as follows:

Hull (excluding armour)	3639 tons
Armour (including the belt, 216 ft. long, 5 ft. 6 in. deep, and 12 in. thick)	943 "
Machinery (including boilers with water supply)	1230 "
Coal in bunkers (at 21 ft. 6 in. draught)	420 "
Armament, ammunition, &c. ...	456 "

Stores, &c., bring the total to the designed displacement, 6890 tons. It may be added here, however, that the vessel has bunker capacity for 1000 tons of fuel.

The appearance of the vessel ready for trial will be seen from our engraving on page 814. The two 28-centimetre guns, which form the principal armament, although now mounted one forward and one aft, were not in position when the photograph, from which our engraving has been prepared, was taken. The 14-centimetre Hontoria guns, five on either broadside, with their projecting shield, are prominent features in the view.

Engines:

Diameter of cylinders...	42 in., 62 in., and 92 in.
Stroke	46 in.
Condenser cooling surface	14,600 sq. ft.

There are two sets of engines, each driving separate screws. The above gives the surface of the two condensers.

Boilers:

Four double-ended (Figs. 17 & 18)	Diam., 15 ft. 3 in. Length, 16 ft. 3 in.
Number of tubes in each	1072
Heating surface in each	5067 sq. ft.
Grate area in each	169 "

Of the tubes, 280 are stay tubes of $\frac{3}{16}$-in. metal, and 792 plain tubes of No. 8 B.W.G., the external diameter being $2\frac{1}{2}$ in., and the length 6 ft. 3 in. between plates.

Two single-ended boilers (Figs. 19 to 23)	Diam., 15 ft. 3 in. Length, 10 ft. 6 in.
Number of tubes in each	536
Heating surface in each	2825 sq. ft.
Grate area in each	84.5 "

Of the tubes, which are the same size as those in the double-ended boilers, there are 140 stay and 396 ordinary tubes. The proportion of stay to ordinary tubes is about the same as in the double-ended boilers, 1 to 2.83. These are the boilers for propulsion purposes, the total number of furnaces being 40, each 3 ft. 3 in. in mean diameter, with 6 ft. 6 in. length of firebar.

Total tube surface	22,270 sq. ft.
" heating surface...	25,920 "
" grate area	845 "

In addition there are two separate boilers for auxiliary machinery—electric light, steering, pumps, &c., boat and ammunition hoists, &c. These are illustrated by Figs. 24 to 26, on our two-page engraving. They are 8 ft. $10\frac{1}{4}$ in. long by 7 ft. 9 in. in diameter. They have 24 stay and 58 common tubes—in all, 82 tubes. There are two furnaces in each, the internal diameter being 2 ft. 5 in., and the length of firebar 5 ft. 3 in. The grate area in the two boilers is 50.7 square feet, and the heating surface 916 square feet.

The propellers are illustrated by Figs. 28 to 36, page 807, and are shown with the propeller brackets on the engraving, Fig. 27, on page 806. The A-struts, pear-shaped, are of caststeel, and are riveted to the steel framing of the ship. The two torpedo-ejecting tubes in the stern are very prominent features in this view, while the run of the ship is shown to be very fine. Each propeller, it will be seen, has three blades; the port propeller is left-handed, and the starboard propeller right-handed; and the blades slew round to enable the pitch to be varied from 19 ft. 3 in. to 22 ft. 3 in. On trial the most successful results were got with a pitch of 20 ft. 6 in.

Diameter	16 ft. 5 in.
Pitch, uniform, mean...	20 " 9 "
Surface of one blade	24.24 sq. ft.
" three blades	72.72 "

The propellers were used as the log on the official trials. The speed of the ship was guaranteed, instead of the power of the engines as in the case of British warships, and the method of arriving at the result was as follows: A measured distance of 1.412 miles at the mouth of Ferrol Harbour was run over four times, twice in each direction, and the mean number of revolutions corresponding to a nautical mile ascertained. The sea trial was then made, and the revolutions divided by the number corresponding to a nautical mile as ascertained. This number, by the way, was 349.5 under forced draught and 347 under natural draught. These are the mean results, and it may be stated that the slip was 15.2 per cent. and 14.5 per cent. under forced and natural draught respectively. This number, again, was checked after each of the trials by the vessel going again four times over the measured distance, as at the beginning. There can, therefore, be no doubt as to the accuracy of the result.

The Spanish Government was represented by a large Commission, including several eminent naval constructors, and these attended all the trials, and most vigilantly studied the performance of the engines, superintending the taking of diagrams and data, and the measuring of the coal. The results we give are those subsequently prepared by this Commission, and it may here be stated that the successful issue of the exacting contract conditions well merited the compliments paid by the Commission to Mr. McKechnie, the designer and constructor of the machinery. Included in the Naval Commission were His Excellency Vice-Admiral Diego Mendez Casariego, President of the Commission; His Excellency Commodore Marcial Sanchez; Señor Don Pablo Perez Sesane, superintending engineer, Ferrol Arsenal; Don Leoncio Lacaci, assistant engineer, Ferrol Arsenal; Don Davio Bacas, chief engineer of Ministerio de Marina, Madrid; Don Candido Garcia Cantalejo; Don Secundino Armesto; and Captain Miguel de Goitia, the last-named three representing the resident inspecting commission of the Astilleros.

The natural-draught trials were run on September 18, 1893, the duration of trials being six hours; but prior to this run, and after it, the vessel went four times over the measured distance, for the reason already given. The vessel was, therefore, under full steam on this trial for fully eight hours. The guaranteed speed was 18 knots, and the contract condition was that it must not fall under $17\frac{1}{2}$ knots, otherwise the ship could be rejected. For each complete tenth part of a mile per hour under the guaranteed speed there was a penalty of 80,000 pesetas = 3000*l*. But the speed was exceeded by half a nautical mile per hour, having been 18.5 knots, notwithstanding a heavy Atlantic swell. The maximum was 18.8 knots, and at no time did the speed fall below 18 knots. The results are tabulated, so that there is no need to give them fully here. The fans, described in a previous article, were kept running merely for efficiently ventilating the stokehold, the pressure recorded by water gauge being $\frac{3}{16}$ in. The steam pressure was 140 lb., and the mean power, worked out from records taken every 30 minutes, was 9499 indicated horse-power, with the engines averaging 107 revolutions. The starboard engine contributed 4632 and the port engine 4867 indicated horse-power.

There is a remarkable closeness in the power developed in the respective cylinders, and even this closeness in the mean results was excelled in several of the series of diagrams taken during the run.

The forced draught trials were run on October 14, 1893. Six runs were first made on the measured distance, and thereafter two hours' steady running to sea, concluding with four runs again on the measured distance, the total duration of trial being, therefore, 4½ hours. During the whole time the machinery worked exceptionally well. The average speed of 118 revolutions was kept up steadily, the highest revolutions counted being 120. The steam never fell below 140 lb., and maintained nearly throughout a uniform pressure of 145 lb., any excess of which the contract forbade. The mean air pressure in the stokehold was only 1 in. At the beginning of the trial it did not exceed ¾ in., and only in one stokehold was there at any time 1¼ in. This was but for a limited period, instructions having been given that it was not to exceed 1 in., although 1½ in. was allowed by contract. The total power developed was 13,722 indicated horse-power, of which 6819 was developed by the starboard, and 6903 indicated horse-power by the port engines. This power was worked out from diagrams taken every 30 minutes during the run. The speed worked out to 20.25 knots, a quarter of a knot over the guarantee. This might have been exceeded, of course, with the full air pressure, but it was deemed advisable to get the contract power without excess. There was no premium, but the conditions of the contract were that for every tenth of a mile per hour below the guaranteed speed of 20 knots, the firm were liable to a penalty of 26,666 pesetas = 1000*l*. If the speed had been under 18½ knots, the vessel could have been rejected. As we have indicated, however, the forced draught speed of 20 knots was easily exceeded with a power of 13,722 indicated horse-power.

Indicated horse-power per square foot grate area:	
Natural draught	11.24
Forced "	16.24
Indicated horse-power (forced draught) per ton of total weight of machinery	11.16

The fuel consumption trials were run on October 18 and 19, 1893, the weather being very fine, but with a slight swell on the sea. The vessel was, according to condition of contract, to be run for at least 12 hours at a speed of 10 knots. The coal was to be put in bags to facilitate the calculation of the consumption, which, at 10 knots speed, might "vary, without giving rise to the imposition of fines, between 635 and 680 grammes per hour and horse-power indicated, developed by the principal engines and the auxiliary apparatus connected therewith." The vessel started at 3 o'clock in the afternoon, and six runs were made on the measured distance of 1.412 knots, the cruiser thereafter continuing out to sea until 6 o'clock on the following morning—October 19. The coal was carefully weighed in the stokehold by the Arsenal experts, and put into bags, each of 165 kilogrammes, and men were stationed at each of the bunker doors to prevent more coal being taken out than had been weighed, so that the results are accurate. One single-ended and two double-ended boilers were employed to supply the steam to the main engines and to the auxiliary engines connected therewith, and for the auxiliary engines (*i.e.*, steering gear engine, electric light engine, auxiliary circulating pumps, and bilge pumps) one of the single-ended boilers was used, but without any connection to the main engines. The consumption of the coal was carefully recorded for 12 hours in the case of the main boilers, and for eight hours in the case of the auxiliary boiler. The result was that the coal consumption for the propelling machinery was found to be 650 grammes or 1.43 lb. per indicated horse-power per hour, the engines meanwhile running at a mean of 55 revolutions and developing 1231 horse-power. From the results

Spanish Cruiser "Infanta Maria Teresa."
Official Trials at Ferrol.

—	Natural Draught. September 18, 1893.	Forced Draught. October 14, 1893.	Coal Consumption. October 18, 1893.
Revolutions per minute	107	118	55
Indicated horse-power, starboard high-pressure cylinder	1592	2069	259.38
Indicated horse-power, starboard intermediate-pressure cylinder	1553	2290	211.38
Indicated horse-power, starboard low-pressure cylinder	1487	2460	120.14
Indicated horse-power, port high-pressure cylinder	1626	2075	273.65
Indicated horse-power, port intermediate pressure cylinder	1606	2515	190.00
Indicated horse-power, port low-pressure cylinder	1685	2313	176.65
Total	9499	13,722	1231.2
Steam pressure .. .. .. lb.	140	143	110
Vacuum, starboard .. .. in.	27	27½	26½
" port .. .. .. "	27	27	27
Receivers, starboard high-pressure lb.	117	134	33
Receivers, starboard intermediate-pressure .. .. lb.	36	52	3 lb.
Receivers, starboard low-pressure "	7	13	9½ in. vacuum
" port high-pressure .. "	112	140	34
" " intermed.-pressure "	38	50	2 lb.
" " low-pressure .. "	7	15	10 in. vacuum
Mean pressures, starboard high-pressure.. .. .. lb.	46.2	54.4	14.7
Mean pressures, starboard intermediate-pressure .. .. lb.	20.7	27.6	5.5
Mean pressures, starboard low-press. "	9.0	13.5	1.42
" port high-pressure "	47.2	54.6	15.45
" " intermediate-pressure .. .. lb.	21.4	30.4	4.9
Mean pressures, port low-pressure "	9.9	12.7	2.08
Cut-offs, high-pressure .. per cent.	62.5	73	55
" intermediate-pressure "	70	75	60
" low-pressure .. "	70	75	67½
Speed.. .. .. knots	18.5	20.24	10
Duration of trials .. .. .. hours	6	4	12

Mean air pressure in stokeholds at forced draught trial = 1 in. of water.
Coal consumption per indicated horse-power per hour = 650 grammes = 1.43 lb.

THE CRUISER "INFANTA MARIA TERESA."

CONSTRUCTED AT THE ASTILLEROS DEL NERVION, BILBAO.

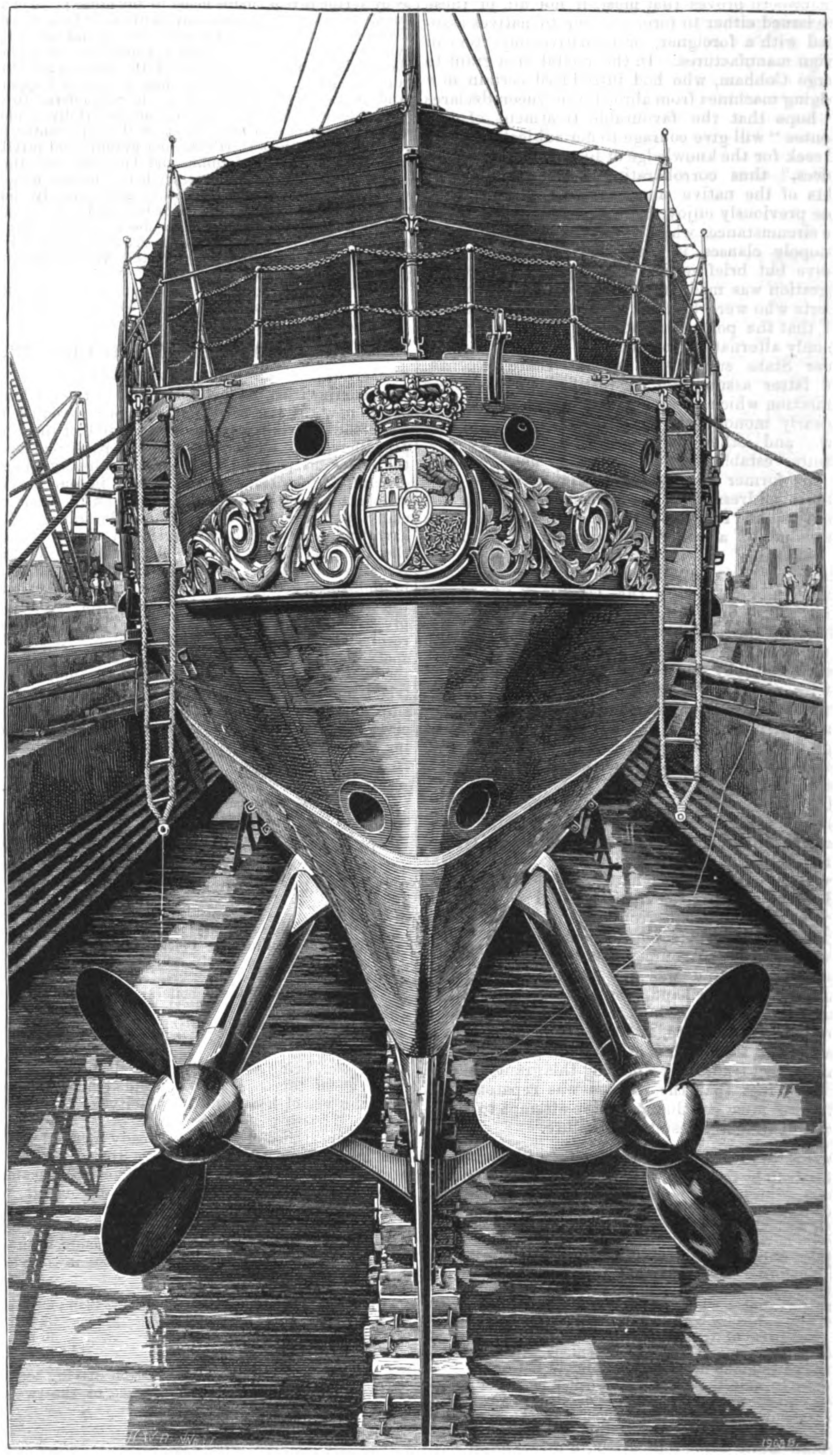
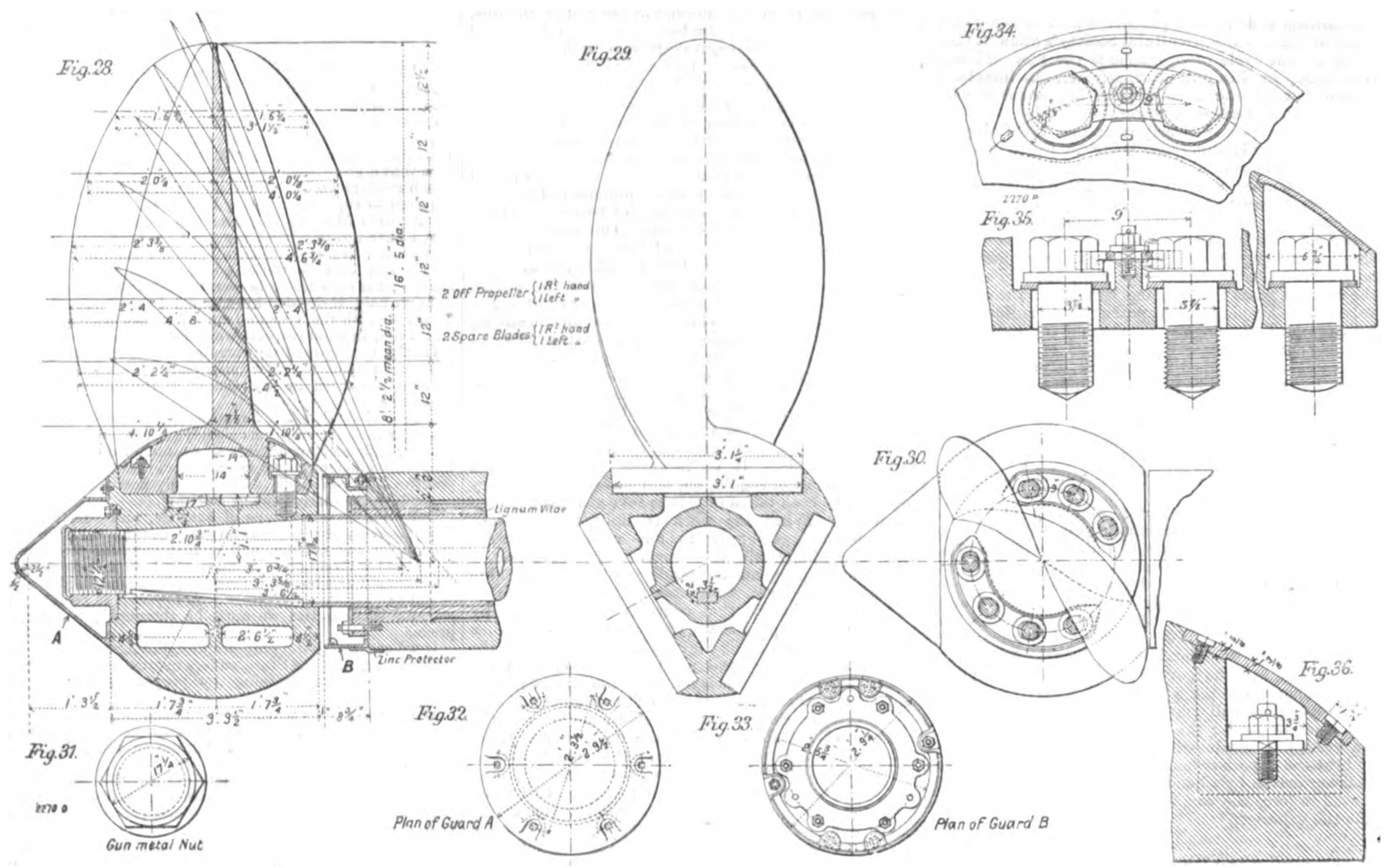


Fig. 27.

SCREW PROPELLERS OF THE SPANISH CRUISER "INFANTA MARIA TERESA."



of this trial the radius of action of the cruisers was determined according to the bunker capacity, and this was found to be 9800 nautical miles at 10 knots speed. The details of the engine performances are given in the Table on the opposite page, with those of the natural and forced draught speed trials.

One single-ended boiler supplied steam to the following auxiliary engines: Two auxiliary circulating pumps, two fire and bilge pumps, steering gear engine, electric light engine, and auxiliary feed pump, the total horse-power developed being 197. The total coal consumed per hour in the single-ended boiler was 239.5 kilogrammes, which gives 1.22 kilogrammes or 2.68 lb. per indicated horse-power per hour. The auxiliary engines above referred to are single-cylinder engines, with the exception of the electric light engine, which is compound, having cylinders 7½ in. and 13½ in. in diameter by 8 in. stroke.

The contract further stipulated for a trial with one screw, the rudder being thrown over to maintain a straight course, and the guaranteed speed being 12 knots. This trial, under natural draught, was run on October 19. The port engine was used, the rudder being from 12 deg. to 15 deg. over. The mean speed of three runs on the measured mile was 12.56 knots, with the engine running at 85 revolutions. Steam was supplied from one single-ended and two double-ended boilers.

On the same day the starting, stopping, and reversing trials were gone through, with the following results: From "full speed ahead" to "stop," 7 seconds; from "full speed astern" to "stop," 6 seconds; from "full speed astern" to "full speed ahead," 7 seconds.

The contract also stipulated for a trial of the engines to ascertain the least number of revolutions required to enable the engines to work with perfect regularity with the valves sufficiently closed, with the normal vacuum in the condenser, and with 145 lb. boiler pressure. This proved to be 13 revolutions, equal to a speed of ship of about 2½ knots. At this speed the engines were kept running for about 10 minutes.

The Naval Commission, after the trials were completed, expressed themselves as being highly delighted with the results of the severe and exhaustive tests to which the machinery had been subjected, and expressed the opinion that no navy in the world had a finer ship, or machinery which had been put to such severe tests, and with such excellent results.

(To be continued.)

CROSSLEY'S PORTABLE OIL ENGINE.

AMONG the oil engines which are being tested this week at Cambridge by the Royal Agricultural Society of England, is a portable motor of 7 horse-power (nominal), constructed by Messrs. Crossley Brothers and Co., Limited, of Openshaw, near Manchester. An engraving giving a perspective view of this engine is published on page 811. Its weight is 3¼ tons, and it develops on the brake 11 horse-power.

The engraving gives a clear idea of the framing. The plan of mounting the engine on three wheels leaves everything clear in front for the belt, and renders it easy to place the engine in position for work. A speed of over 200 revolutions can comfortably be attained without vibration, owing to the crank and reciprocating parts being carefully balanced in each of the two flywheels, and to the centre of gravity of the entire engine being comparatively low.

The oil is carried in an oil tank below the main axle. From there it is pumped by a small pump into a special measuring apparatus, for which a patent has been recently applied for. This measure gives a slightly increased charge of oil for the working stroke immediately following idle strokes cut out by the governor. The oil is sucked into the vaporiser together with a little air, being thus formed into vapour, which during a suction stroke of the engine is drawn in, together with fresh air, to form a combustible mixture. In the lower part of the vaporiser is an ignition tube; this, together with the vaporising surfaces, is kept at a suitable temperature by a lamp, which burns without any wick or working pump. The lamp will run for hours without requiring any attention, and is smokeless.

A special and novel feature of these engines is the arrangement for governing. A sensitive rotary governor is used, which operates the vapour valve whenever a working stroke should be made. At other times the vapour valve is not opened, and idle strokes follow exactly to suit the requirements of the work to be done. This, in combination with the measurer, insures great economy, especially at intermediate or light loads, and with no load a working stroke is succeeded by several idle revolutions, just the same as in the Crossley gas engine.

The cooling water is carried in the large tank under the framing, through which a current of air is maintained. The quantity of water required for several hours' working is small, and the cooling is so effective that with a maximum load on the engine the temperature of the water does not exceed 120 deg. Fahr.

SPRING MOUNTED TRACTION ENGINE.

ON page 811 we illustrate a spring mounted traction engine constructed by Messrs. Aveling and Porter, of Rochester, which is being exhibited at the Royal Agricultural Society's Show at Cambridge. In this arrangement of spring mounted traction engine there is overcome the difficulty generally experienced with spring engines, viz., the alteration of centres and the use of links, joints, and universal couplings between the intermediate shaft and the main driving axle. It avoids the sideway motion in the teeth of the spurwheels and pinion, an objection hitherto found in all previous arrangements, causing great wear and tear on the teeth of gearing, and the altering of the pitch lines when the engine is running. The springs on either side of the engine work independently of each other, and therefore come into action at whatever position the road wheels may be in.

In Fig. 1, A is a countershaft from which motion is communicated to the driving axle C by means of a pinion gearing into the spurwheel B. This wheel revolves upon the steel tube D, and is connected to the driving axle by means of a loose plate E with four lugs at right angles. Two lugs on this plate work free in slots in the spurwheel centre B, and the other two lugs, at the back of plate E, work free in two slots (at right angles to the slots in spurwheel centre B) in the driving boss F, which is keyed to the main driving axle C. The axle-boxes are attached to the springs H by the bolts I; the axle-boxes are left free to slide up and down in the guides K. The motion of axle and axle-boxes in no way affects the centres of the gearing, as the guides and steel tube D are bolted to the hornplate, keeping the centres in a fixed position, and preventing any sideway motion of the teeth in the spurwheel and pinion due to the action of the springs. The hornplates are well stayed with cross-plates L and M, which are riveted to the hornplates and front plate of the boiler, and prevent any sideway motion of the hornplate.

THE CORINTH CANAL.—Experts consider that the passage of steam vessels through the ship canal across the Isthmus of Corinth is not without possible danger. At certain points there is considered to be risk of landslips.

Blackett and Hedley, and Stephenson all had vertical cylinders and arrangements of beams more or less adopting the idea of a stationary engine; and Stephenson's engines of 1816; the one he built for the Duke of Portland, 1817; for the Hetton Colliery, 1822; and the celebrated "Locomotion" which opened the Stockton and Darlington Railway, September 27, 1825 (and still preserved at Darlington), were all of the same design, as were also the sister engines on the Stockton and Darlington line, named "Hope," "Black Diamond," and "Diligence," built 1826.

The "Experiment" (Fig. 4).—The "Experiment," of 1826, built for the Stockton and Darlington Railway, is an engine which contained several very important improvements, and shows that at that period Stephenson made a new departure, and broke away from stationary engine practice. He saw, and in the new "Experiment" avoided, the inconvenience of the vertical cylinders, and decided to attach the connecting-rods direct to crankpins on the driving wheels, and the whole of the six wheels were coupled together by outside coupling-rods working upon crankpins upon each wheel; this was the first engine to have coupling-rods applied to six wheels. The cylinders were 9 in. in diameter, 24 in. stroke, wheels 4 ft. in diameter, boiler 10 ft. long and 4 ft. in diameter, containing two fire-flue tubes 18 in. in diameter. The exhaust steam was conveyed from the cylinders to the chimney by two blast pipes, one for each cylinder. This engine was a remarkably good one in its day, 1826; and Wood's book on "Railways," published in 1838, shows that in the year 1833 the "Experiment" cost only 0.053 pence for repairs per gross ton carried one mile on the level.

It should be observed that the "Experiment" was built and in daily work in 1826, or a year before the "Royal George" was placed upon the line by Timothy Hackworth in October, 1827, which latter some writers have thought to be earlier than the "Experiment," instead of a year later.

The "America" (Fig. 5).—The Delaware and Hudson Canal Company, having heard of the success of the Stockton and Darlington Railway, sent over Mr. Horatio Allen to England early in the year 1828, with instructions to obtain information and purchase rails and four locomotives. He gave an order to Messrs. Stephenson for one, and to Messrs. Footer and Rastrick for three. Stephenson's engine was named "America;" it was built in 1828, and arrived in New York on board the ship Columbia about the middle of January, 1829. It was the first railroad locomotive ever seen in America. The following is the copy of the official description of the "America," being No. 12 in the books of Messrs. R. Stephenson and Co.:

Diameter of boiler	4 ft. 1 in.
Length "	9 ft. 6 in.
Dimensions of fireplace	4 ft. by 3 ft.
Diameter of cylinders	9 in.
Length of stroke	2 ft.
Size of chimney	1 ft. 8 in.
" hot-water pump	1½ in.
Length of pump stroke	2 ft.
Wheels (wood), diameter ...	4 ft.
Number of wheels	4
Angle of cylinders to horizontal	33 deg.
Size of tubes	1 ft. 7 in.
Number of fire tubes	2

Tubes were straight.

Some persons have contended that the iron-bar framing in general use in the United States was an American invention, or was sent out by Mr. Bury, but the illustration proves that both suggestions are incorrect, as the first bar frame in America was upon Stephenson's engine.

The "Rocket" (Fig. 6).—At the time when Stephenson and Co. were constructing the celebrated "Rocket" for the Liverpool and Manchester Railway, they had also an order for an engine for the Stockton and Darlington Railway, which was to bear the same name.

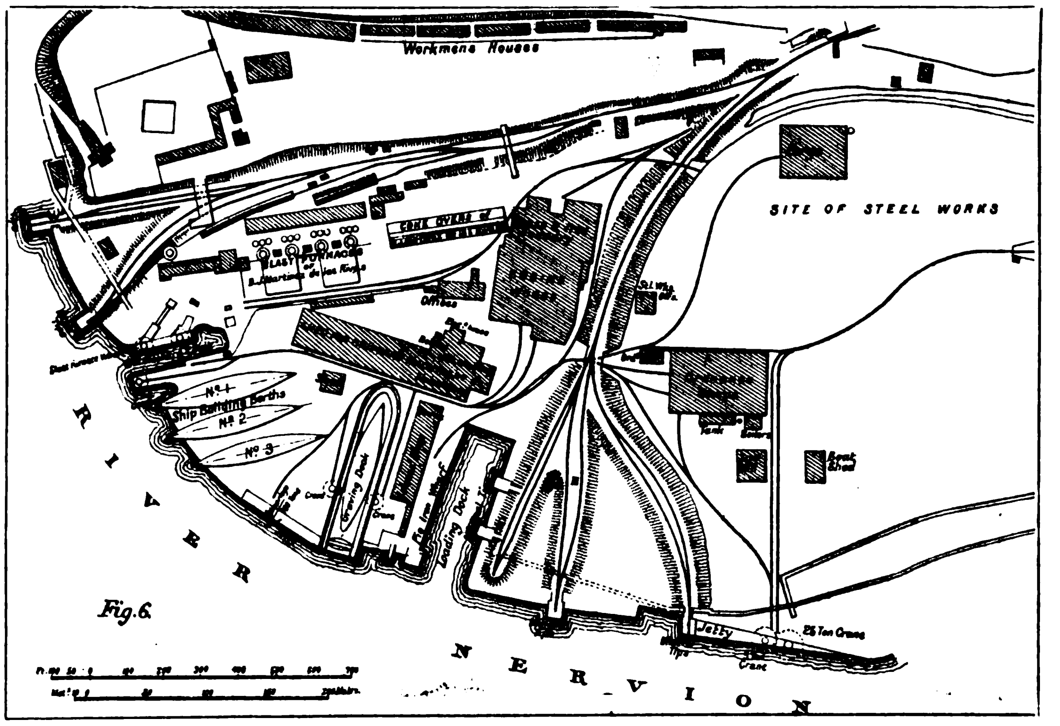
A glance at the illustration will show that the Stockton and Darlington "Rocket" was a six-wheeled, coupled, goods engine, very similar to the "Experiment" of 1826; it had wheels 4 ft. in diameter, with inclined cylinders 10 by 24, and a boiler with two fire flues.

THE NEW SPANISH BELTED CRUISERS.

(*Continued from page 577.*)

WE give this week an elevation and several sections illustrative of the general arrangement of the machinery of the new cruisers, and in subsequent issues we shall supplement these with engravings of the engines, boilers, &c. It is of special interest to note that the work is the production of the Astilleros del Nervion. When the contract was arranged originally with the firm of Martinez-Rivas-Palmer, it was intended to partly construct the machinery at Messrs. Palmer's works; but with the engagement of Mr. James M'Kechnie, formerly of the Clydebank Works, as engineering manager at the Nervion Works, this intention was departed from. Instead, it was decided to enlarge the engine works, which were originally projected on a very small scale, a scheme which approved itself to the Spanish authorities by virtue of the advantage of having a first-class marine engineering works. These works, laid out about four years ago, are admirably equipped, and it may not be uninteresting if we preface our description of the propelling engines of the cruisers with some reference to the installation of the machines by which the work was carried out. The plan of the works (Fig. 6) shows that the engine works, with the shipyard, cover 63,800 square yards. Of course all branches of marine engineering are represented, there being 11 distinct departments, and these are arranged to minimise the handling of the various parts in the process of manufacturing the finished engine from the crude material.

The main building in the engine works is 270 ft. long, and its width of 236 ft. is made up of six bays, varying from 46 ft. in width in the centre bays, decreasing towards the outside. The height to the underside of crane girder varies from 26 ft. to 19 ft., being largest, of course, in the centre bays, which are taken up the one by the fitting shop, and the other by one-half of the boilermaking department. In several of the bays there are galleries around part of the walls, notably in the brass and iron finishing shop. In this department there are eight 7-in. lathes, four 10-in. lathes, a radial drilling machine capable of both tapping and studding; screwing machines, milling machine, tube-testing machine, &c., as also a 10-ton hand-power overhead travelling crane. The machine shop takes up another bay 32 ft. wide, with a height of 19 ft. to the 20-ton overhead travelling crane, which is driven by rope gearing. Of the tools—slotting, planing, boring, &c., with lathes of all sizes—special notice should be taken of a powerful 30-in. sliding, surfacing, and screw-cutting lathe, by Sir Joseph Whitworth and Co., of Manchester. It is 82 ft. 6 in. long, with four headstocks—two fixed and two loose—fitted with fluid-compressed steel spindles, and having seven tools, which can be worked either simultaneously or independently. It is capable of turning up shafting from the rough forging to 25 in. in diameter and of 70 ft. length between centres. It is also fitted with a special arrangement for boring out hollow shafting. At the end of this second bay there is a testing house, fitted with a 50-ton testing machine, capable of making tensile, crushing, and bending tests. This machine is the product of the accumulated experience of the makers, Messrs. Buckton and Co., of Leeds. The fitting shop, as we have indicated, occupies one of the two central bays. It is 46 ft. wide, and the height to the crane is 26 ft. Here one finds several splendid tools. There is a massive vertical boring machine, by Messrs. Smith, Beacock, and Tannett, for working cylinders up to 120 in. in diameter. The horizontal planing machine, by Messrs. Hetherington and Sons, planes surfaces 16 ft. long by 7 ft. broad by 6 ft. high. A compound vertical and horizontal planing machine, by Messrs. Hulse, of Manchester, planes surfaces up to 16 ft. long by 10 ft. wide. A powerful and heavy 9-ft. chuck lathe, by the same firm, will turn the heaviest of crankshafts, or do any large surface work. A large horizontal boring machine, by Messrs. Campbells and Hunter, of Leeds, is also capable of screw-cutting. The working arm can be raised to a height of 12 ft., and can compass horizontally a distance of 15 ft.; the table is 15 ft. long by 12 ft. wide. In this department there is a 40-ton steam overhead travelling crane, with independent engine and boiler, by Messrs. Booth Brothers, of Leeds; and for driving the various machines there is a Tangyes coupled high-pressure engine, working direct on the main line of shafting.



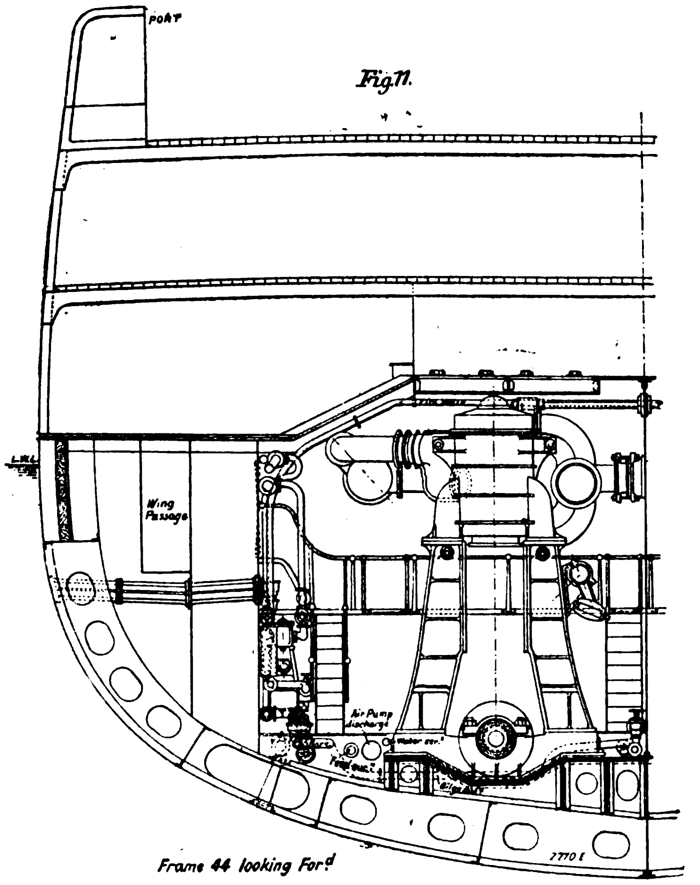
The boiler shop occupies two bays, both 224 ft. long. One is 46 ft. wide, and 26 ft. to the crane girder; the other 32 ft. wide by 19 ft. high. The hydraulic machinery in this department is on Tweddell's system, and is worked from an accumulator with a pressure of 1500 lb. per square inch. There is an hydraulic plate-flanging machine capable of flanging at one operation an entire combustion chamber tubeplate 7 ft. by 3 ft. by ⅞ in. thick. There is, of course, an hydraulic overhead crane attached. The hyraulic riveting machine takes boiler shells up to 16 ft. in diameter, and of any length, and suitable for the heaviest steam pressures that may be carried. One pair of powerful vertical rolls, driven by an independent engine, bends plates up to 1⅜ in. thick, and is capable of taking in a width of 10 ft. 6 in. This machine, which was supplied by Messrs. Campbells and Hunter, is also so arranged that a plate may be rolled to a complete circle. A pair of horizontal plate rolls works plates up to ⅜ in. in thickness with a width of 8 ft. The plate-planing machine planes simultaneously the side and end of the plates, and is capable of working a length of 30 ft. with a width of 8 ft.

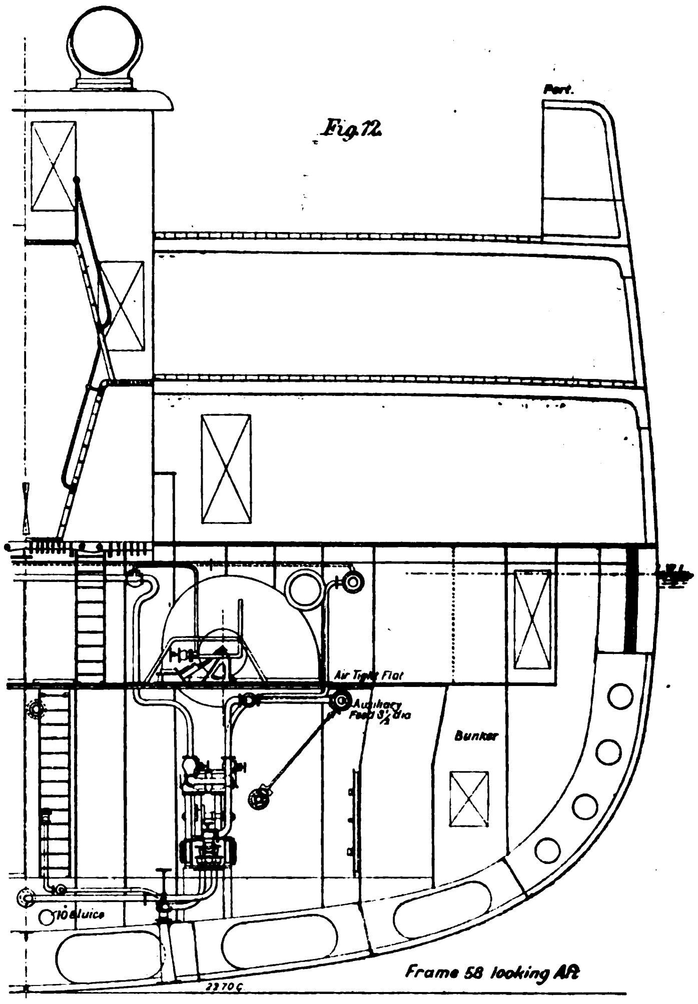
There is, too, an elliptical plate-cutting machine capable of cutting elliptical and round holes up to a size of 5 ft. It can bore both vertically and horizontally. It was supplied by Messrs. J. and G. Harvey, of Glasgow. There is a machine for boring shells of boilers 16 ft. in diameter by 19 ft. long; three radial drilling machines with radii of 6 ft.; and a multiple drilling machine capable of drilling four shell plates simultaneously. There are also punching, shearing, drilling, and tube and stay screwing machines, &c. The machines in this shop are, as in the fitting shop, driven by a Tangyes coupled high-pressure engine, working direct on the main line of shafting. The plate furnace, the door of which opens into the smaller bay of the boiler shop, can take in a plate 11 ft. wide. In the large bay there is a 40-ton steam travelling crane, and in the small bay a 10-ton crane, both with independent engines and boilers.

The sixth bay is divided into two storeys, the one 74 ft. by 42 ft., and the other 58 ft. by 42 ft. The former is occupied by general stores, and the latter by the bolt and rivet making department, where all kinds of bolts and nuts are both made and screwed. In a line with this department are the shop boilers, hydraulic pumps with accumulator, and a specially large fire pump. Forming part of the same large building, but running transversely along the ends of the six bays, are situated the iron foundry, brass foundry, and coppersmithy. The iron foundry consists of one large bay 240 ft. long, 47 ft. wide, and 27 ft. high (to the crane); a green sand moulding shed, 102 ft. long by 44 ft. wide, with a dressing shed 64 ft. long by 28 ft. wide. In the large bay are one 35-ton and one 25-ton overhead steam travelling cranes by Messrs. Booth Brothers, with independent engines and boilers, and two casting pits. One is 28 ft. long, 18 ft. wide, and 10 ft. 6 in. deep, and the other slightly less in dimensions. As they are below sea-level, special precaution had to be taken to make them thoroughly water-tight. They are lined with concrete. There

THE ENGINES OF THE SPANISH CRUISER "INFANTA MARIA TERESA."

CONSTRUCTED BY LA SOCIEDAD ANONIMA DE LOS ASTILLEROS DEL NERVION, BILBAO.





are also two cupolas on the Greiner and Erpf system—one capable of melting 9 tons per hour and the other 6 tons per hour—three drying stoves, sand-sifting machines, &c., and a powerful engine for driving the two cupola fans. The metal and coke are raised to the charging platforms of the cupolas by an hydraulic lift. The brass foundry is 120 ft. long by 36 ft. wide, and has an air furnace capable of melting 6 tons of metal. There is a 20-ton travelling crane, by Messrs. Hetherington and Sons, driven by rope gearing. The casting pit measures 14 ft. by 10 ft. deep. The coppersmithy is 90 ft. by 36 ft., and is provided with four Tangyes cranes.

One of the economical features of the works is a tool-fettling department, comprising tool store, grinding shop (with independent engine), smithy, and tool-repairing shop, all being under the control of one foreman. The repairing shop contains milling machines, special Whitworth lathes, special grinding machine for twist drills, &c., and in the tool smithy there is a small steam hammer and several fires. The tools requiring to be dressed are exchanged at the store for others ready for use, those handed in being sent to the grinding shop. This system enables the lathes and other large machines to be kept constantly at work, as the providing of tools always ready for use obviates the necessity for the men leaving their machines at any time to grind the tools. The repairs to machines are also made here, and all gauges, templates, &c., required for special work, thus insuring the accuracy essential for producing first-class work. At present the engine smithy is in combination with that of the shipyard, but a new smithy has been erected in connection with the hydraulic forge, and measures 180 ft. by 45 ft. It contains the usual cranes, as well as a Gorman re-heating furnace for light forgings. Foundations have been laid for one 20-cwt. steam hammer, one 13½-cwt., one 8½-cwt., and one 5-cwt. There is also a steam oliver, and a blowing engine for 20 smiths' fires.

The patterns are at present being made in a temporary shop, as the site of the old pattern shop has been taken up with an extension of the engine works. A new pattern shop is being constructed, and it measures 118 ft. by 48 ft. by 23 ft. 3 in., with a gallery along one side and two ends; the side gallery being 78 ft. by 14 ft., and the two at the ends 48 ft. by 20 ft.

A large forge has been erected, covering an area of 3400 square yards, and consists of three bays, the first containing the hydraulic pumping engines, accumulators, and boilers; the second, the hydraulic press and cranes; and the third, the smithy or light forging department. There is in the forge a 2000-ton hydraulic forging press, by Messrs. Whitworth, and a heavy pumping engine with accumulators, capable of working to a pressure of 3 tons to the square inch. For supplying steam, there are three Lancashire boilers, 8 ft. in diameter by 28 ft. long, with a working pressure of 150 lb. per square inch. Two large re-heating furnaces have also been erected, and are fitted with hydraulic arrangement for raising and lowering doors. The hydraulic press is capable of manipulating shafts for marine engines of the heaviest class, and forgings for 80-ton guns, and armour-plates if required. On either side of this press there is a 40-ton hydraulic crane, made by the same makers, and fitted with their special appliances for manipulating with ease and expedition the heaviest forgings.

The entire works are lighted by electricity with 120 6-ampere Brush arc lamps and about 700 100-volt incandescent lamps. The latter are run by a 30-kilowatt Mordey Victoria alternator. The whole of the different sections of lighting are controlled from the main switchboards. The vessels during construction, and even after launching, were lighted by electricity. For this, transformers were fixed at the dock and the quay side. The secondary mains were fitted with a pulley and weight arrangement, to prevent sag, &c., with the rise and fall of the tide. The current passed from the transformers through these secondary mains to main distributing boxes of 50 lamps each, fixed in different parts of the vessel, and from which concentric cables were run to branch distributing boxes of 10 lamps each. Each workman had his own portable lamp, and fixed it in any part of the vessel by means of a socket to a branch distributing box.

Before departing from the subject of the works, one or two remarks may be made in explanation of the arrangement of the shipyard, shown on Fig. 6. With the ordnance works we shall deal when describing the armament of the cruisers. The machine shed at the head of the building berths is 400 ft. long, with an area of 40,000 square feet. At one end are placed the frame furnaces and bending blocks, hydraulic flanging machines, manhole punch, and pump and accumulator, with fittings for supplying the portable hydraulic machinery on board vessels in course of construction. The other machinery comprises a 6-ft. plate-straightening roll, 11-ft. and 22-ft. plate-bending rolls, 27-ft. edge-planing machines, &c. A noteworthy feature is that each of the principal machines is worked by a separate engine. Adjoining is the boiler-house, with three Lancashire boilers capable of supplying the whole of the ship-building department. The electrical department is fitted up with engines and dynamos on the Brush system, and is run by a Babcock and Wilcox water-tube boiler. The smithy, forge, and finishing shop cover an area of 18,700 square feet. The primary consideration in laying out the several machines was to give the greatest amount of space possible to each, in order to assure freedom of working. The general store is 60 ft. long and is three storeys high, having a floor area of 7700 square feet. The paint shop, 40 ft. long, is on the basement, and the polishing shop, 60 ft. long, on the floor above. The joiners' department adjoins, with moulding-loft above, having an area of 12,000 square feet. In this erection is a complete set of woodworking machinery.

The graving dock has a length of 470 ft., breadth 105 ft., and depth 35 ft.; the depth of water on sill is 23 ft. 6 in. Tangyes centrifugal pumps are placed in a chamber within the walls at the entrance to the dock. They are capable of emptying the dock in about 4½ hours. The walls and the bottom of the dock are of concrete, the former being carried on cast-iron cylinders, sunk to a depth of 35 ft., and filled with concrete. The caisson was constructed in the works. Near to the entrance of the dock is the fitting-out jetty, with sheerlegs capable of lifting 100 tons, with separate arrangement for lifting light loads of 10 tons. The front legs are 102 ft. long centre to centre, and 27 in. in diameter at the top and bottom, and 39 in. in the centre. The back leg is of box form, 36 in. by 42 in., and is worked by a screw 8½ in. in diameter. The foundations are of concrete, the front legs being carried on cast-iron cylinders, sunk to a considerable depth, and filled with concrete. The building berths, at present, are three in number, arranged for vessels of 60 ft. to 70 ft. beam, but there is ample space for laying down five merchant vessels of ordinary breadth.

Coming now to the propelling machinery, it will be seen from the general arrangement on the two-page plate and above, that the engines are of the triple-compound vertical type, driving twin screws, and that

16 BRAKE HORSE-POWER OIL ENGINE FOR THE YACHT "LUCERNA."

CONSTRUCTED BY MESSRS. VOSPER AND CO., ENGINEERS, PORTSMOUTH.

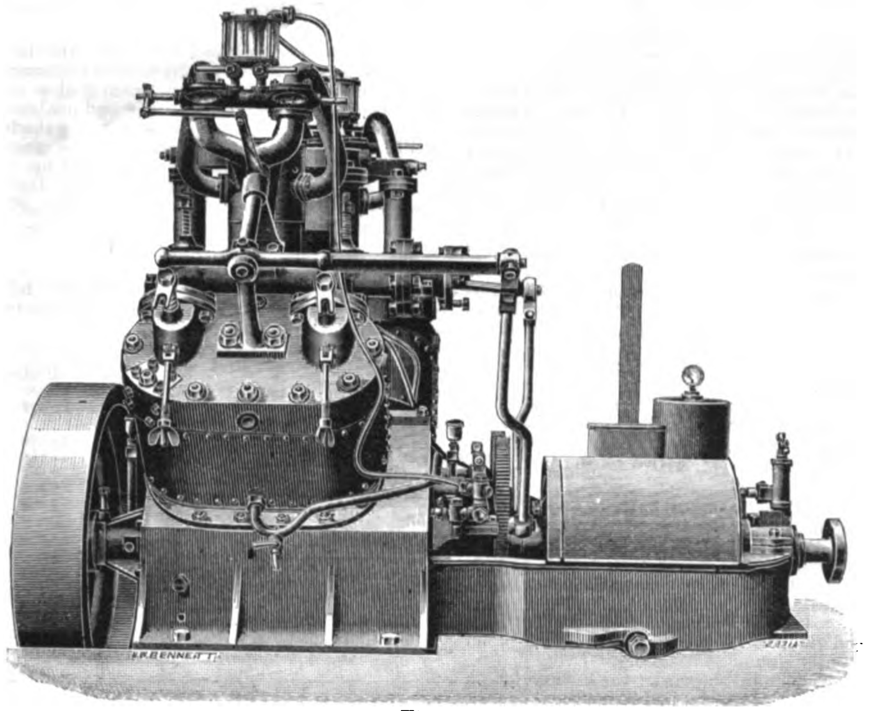


Fig. 1.

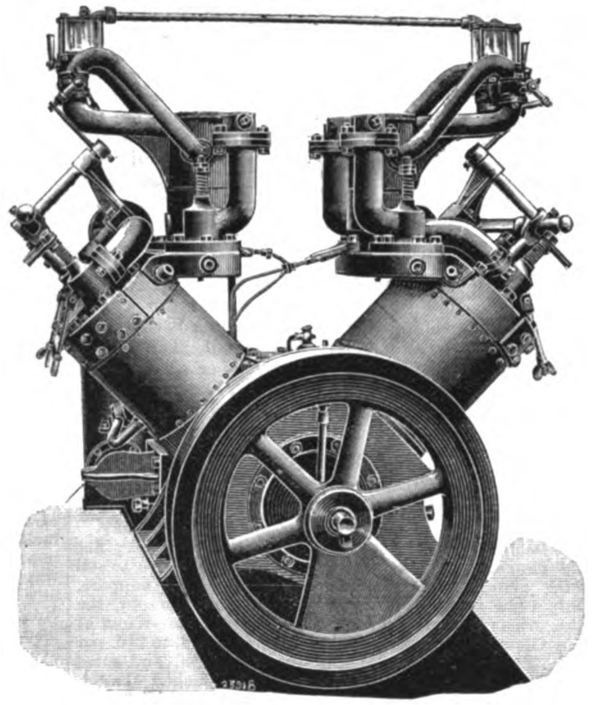
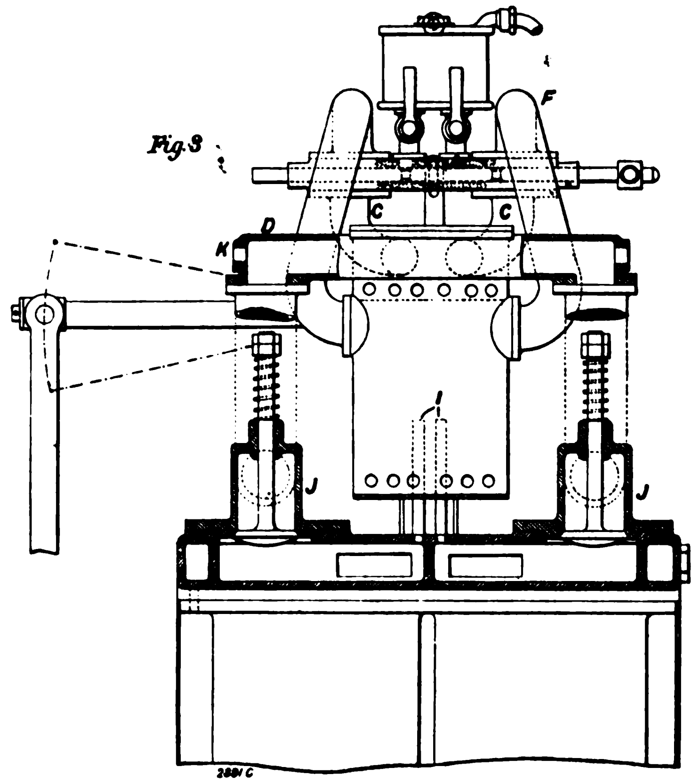
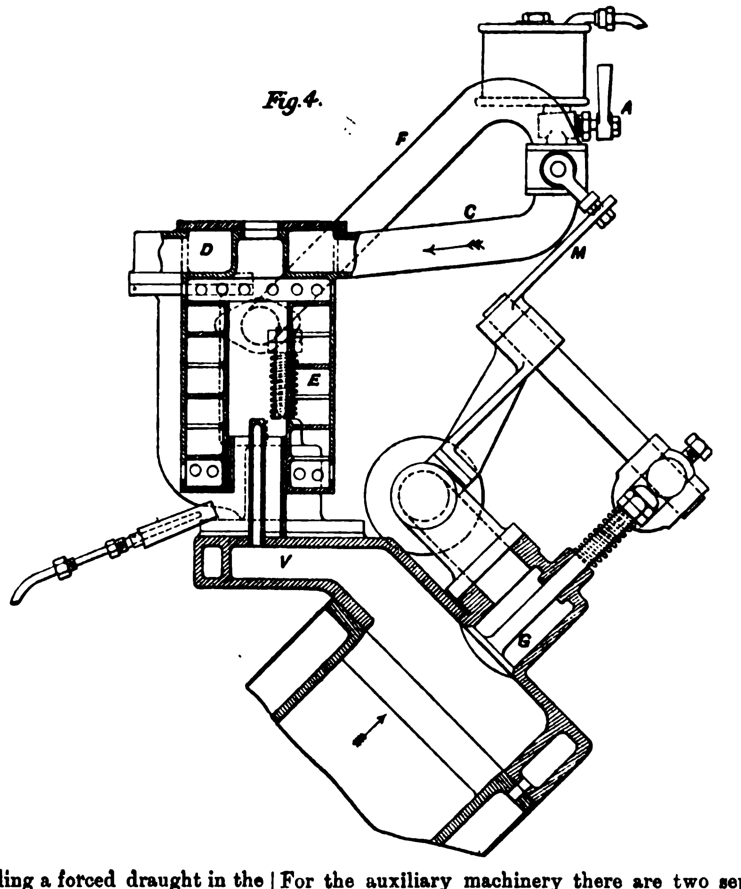


Fig. 2.





steam is supplied by four double-ended and two single-ended boilers. The boilers are placed in two separate compartments, separated by a thwartship bulkhead, and the engines are divided by a centre-line bulkhead, the whole being protected by the arrangement of the bunkers along either side of the ship, as shown in Fig. 8, while Figs. 9 to 12 also show the position of the 12-in. armour belt of 5 ft. 6 in. depth, with the teak backing. The arrangement of double bottom is also shown. Although no bilge keels are shown on the sections, we understand these have been fitted. The armoured deck is raised over the machinery as shown on Fig. 7, and 6-in. plates placed on the sloping parts. The auxiliary machinery is placed on the bulkheads, and on the side wings, as shown, and here it may be remarked that there are in the ship over 50 separate and auxiliary engines, the whole of which, excepting the windlass, steering gear, distillers, and vedette boat machinery, have been constructed in the Astilleros. They include two main circulating pumps, two auxiliary circulating pumps, nine fan engines for providing a forced draught in the stokehold, two auxiliary feed pumps, four fire and bilge pumps and engines, two main feed pumps on Weir's system, four ash-hoisting engines, two reversing engines, two turning engines, one boat-hoisting winch and engine with cylinder 9 in. in diameter and capable of lifting 18 tons, one warping winch and engine, one 12-in. ballast pump and engine, one workshop engine, two ammunition-hoisting engines placed one forward and one aft, one steering engine, two electric light engines, two fans and engines for ship's ventilation, one Worthington system feed-pump for auxiliary boilers, two feed-pumps for evaporators, one donkey pump for draining tanks, one fresh-water pump for filling reserve tanks from barges, two circulating pumps for distillers, two fresh-water pumps for distillers, and one windlass engine. The most of these are located in the engine or boiler compartments, and their position may be ascertained from the illustrations given this week, while the position of the others will be seen from Figs. 1 to 4 in our issue of May 4 last. For the auxiliary machinery there are two separate boilers and two separate condensers (Figs. 7 and 9).

(*To be continued.*)

VOSPER'S OIL ENGINE.

THE 16 brake horse-power oil engine made by Messrs. Vosper and Co., of Portsmouth, for driving launches, has, as illustrated above, four cylinders, and receives two impulses every revolution. To make the engine easier to start, three of the cylinders are thrown out of compression, and the engine is started with a single cylinder. As soon as the one cylinder causes an impulse, the others are thrown into gear. Another advantage of the four cylinders is that by shutting the oil off from one, the speed of the engine can be reduced about 40 revolutions. This is a great convenience in oil engines. The engine is fitted with two lamps, one to each pair of cylinders, each lamp heating its own vaporiser D and ignition tube I. The air is heated also by the same means by passing through a

GENERAL ARRANGEMENT OF THE MACHINERY O

CONSTRUCTED BY LA SOCIEDAD ANONI

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Fig. 7.

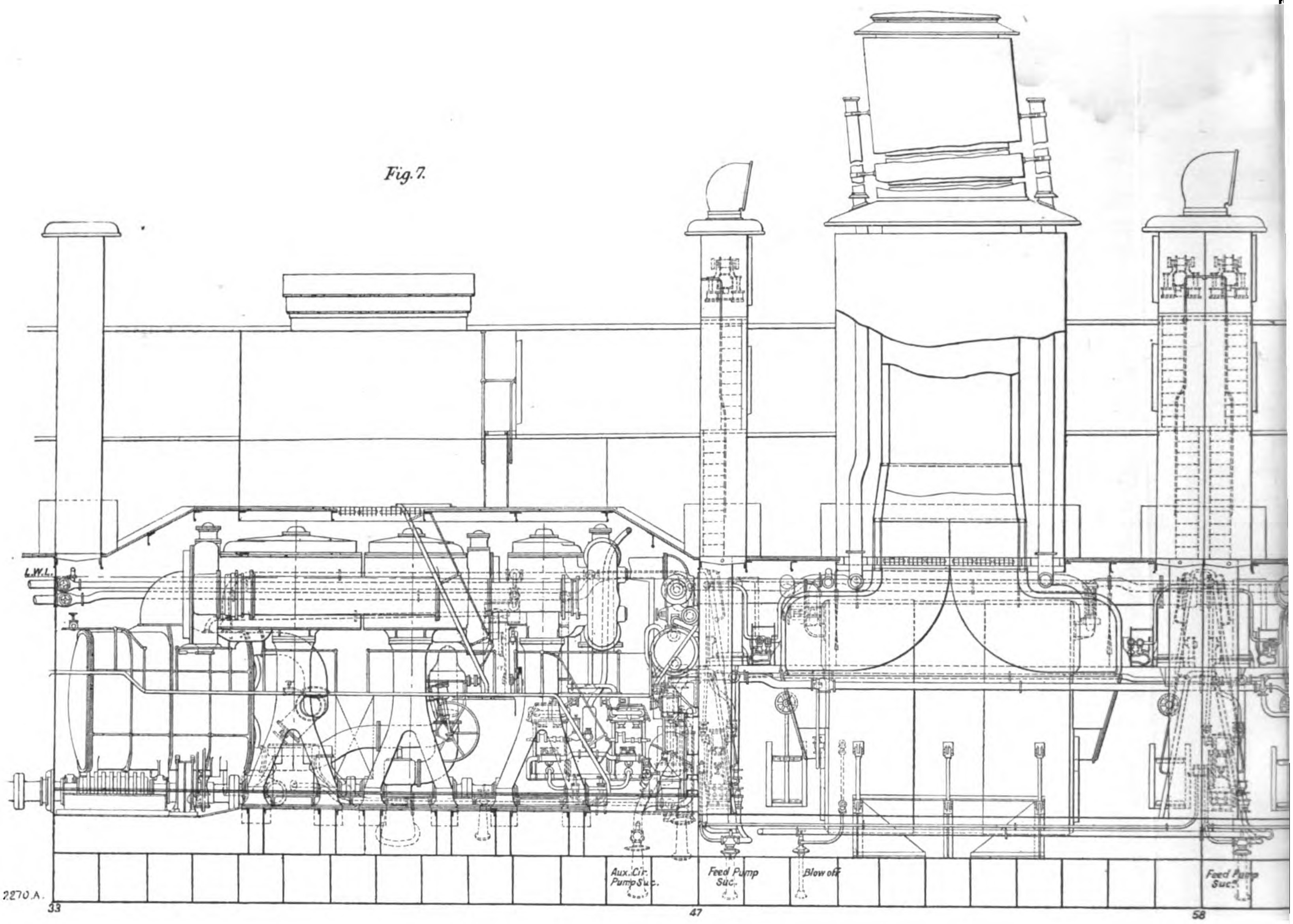
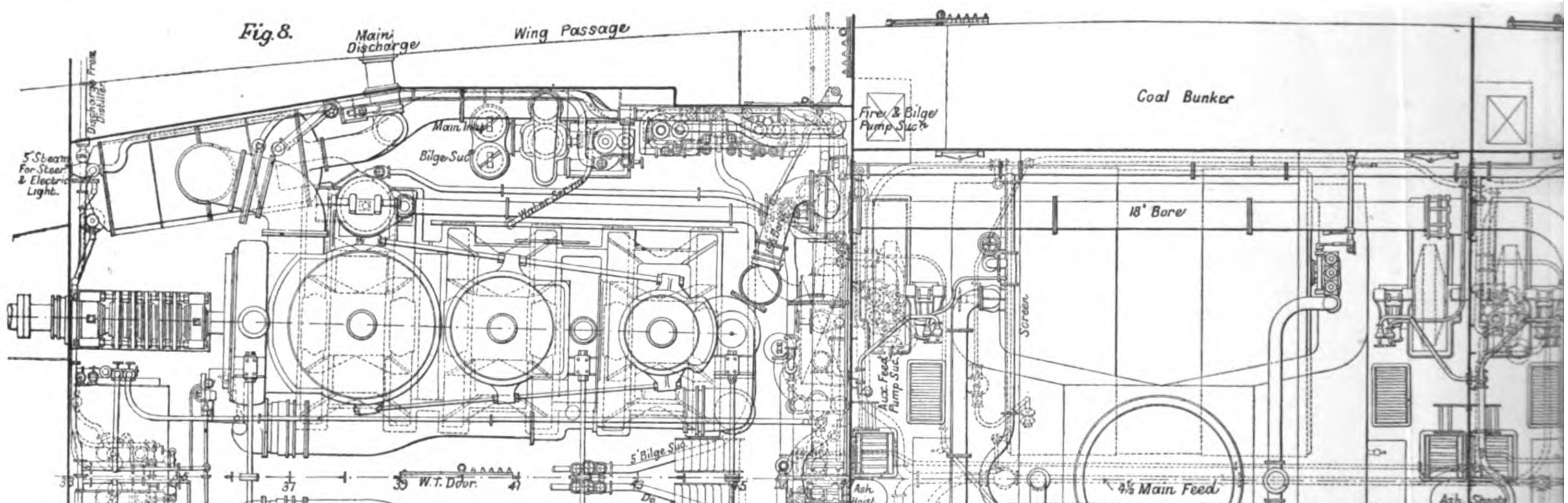


Fig. 8.



HE SPANISH CRUISER "INFANTA MARIA TERESA."

LOS ASTILLEROS DEL NERVION, BILBAO.

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