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Marine Propulsion.
Evolution in North Atlantic Liners.

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(Abstract of a Lecture given before the Engineering Section of Liverpool University).

It is not my intention to revert to very earliest accounts of both the application and advancement of steam in marine propulsion, but a passing reference would not be out of place to earlier liners of the then important companies, as referred to in the advertising columns of the "Liverpool Times", December, 1852, namely D. and C. MacIver, 14, Water Street, Liverpool, and the Collins Line, New York, whose agents here then were Brown, Shipley and Company.

In regard to the first-mentioned company, the above journal gives a description of the new ocean steamer "Arabia" as the largest addition to the noble Cunard fleet, being 285 feet keel and fore rake, length of deck 310 feet, beam 41 feet, depth of hold 28 feet, Custom House measurement, 2,393 tons, an immense and imposing promenade deck extending over the deck houses from stem to stern 310 feet of unbroken line, while the diagonal bracing of the vessel, in order to secure a strength commensurate with her enormous length was in similar style to that of the "La Plata".

THE engines and machinery were manufactured by that eminent engineer, Mr. Robert Napier, of Glasgow, and were the largest afloat, being of the side-lever type, their power being 950 h.p., with cylinders 103in. diameter, with a 9ft. stroke. There were two sets of tubular boilers, one to the fore and the other abaft the engine-room, each having a separate funnel, boiler pressure about 15lb., and a daily coal consumption of about 38 tons. These boilers were fired athwartship. The paddle-wheels were 37ft. in diameter with fixed wooden floats 11ft. long by about 3½ft. broad, and their maximum revolutions were 18 per minute. With regard to speed, several nautical experts expressed the opinion that she would be the fastest craft afloat and was in reality a clipper, while one of her seamen described her as "first cousin to the railway". During the passage round from Glasgow she averaged 14 miles per hour.

The above description was made at a period when the "Great Britain" had created a deep interest and was spoken of as the leviathan steamer; consequently great things were expected of the Cunarder "Arabia".

The Collins Line, the great opponents of the Cunard Line, had a fleet of four wooden vessels, biult in 1849-50 in New York, U.S.A. The "Liverpool Times" gives a full list of their anticipated sailings with their commanders' names, but there is one interesting point over and above all others, viz., these steamers were named "Atlantic", "Pacific", "Arctic" and "Baltic", and their loading berth was the west side of the Waterloo Dock, a strange coincidence when it is remembered and known that the first White Star Line steamers bearing similar names used the same dock as their appropriated loading berth some 20 years later. These four vessels were almost all of similar

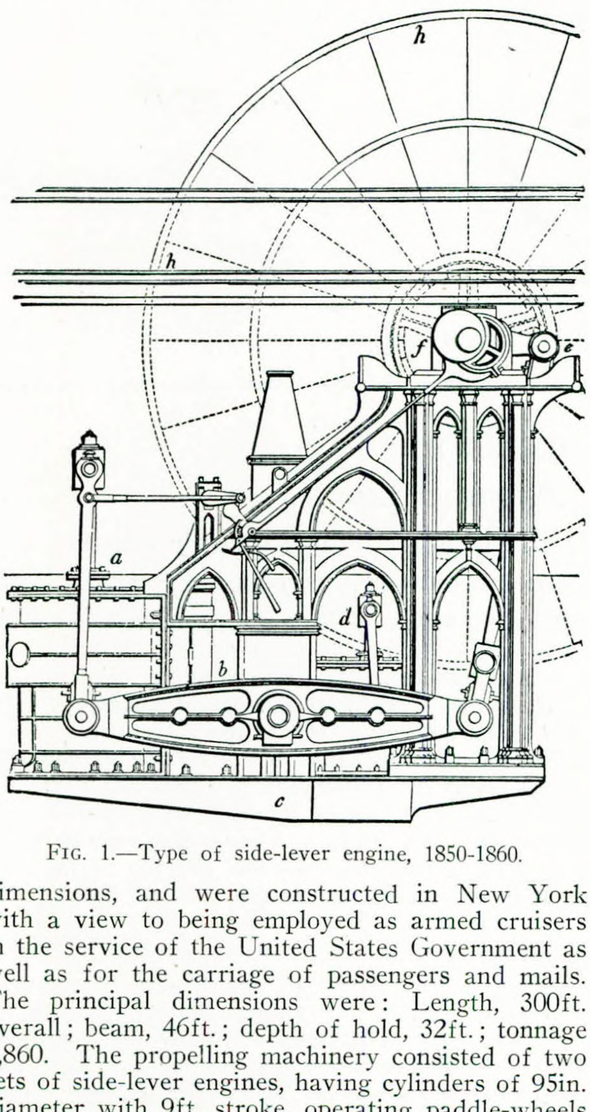


FIG. 1.—Type of side-lever engine, 1850-1860.

dimensions, and were constructed in New York with a view to being employed as armed cruisers in the service of the United States Government as well as for the carriage of passengers and mails. The principal dimensions were: Length, 300ft. overall; beam, 46ft.; depth of hold, 32ft.; tonnage 2,860. The propelling machinery consisted of two sets of side-lever engines, having cylinders of 95in. diameter with 9ft. stroke, operating paddle-wheels of 35ft. diameter. The boilers were rectangular in shape and four in number, equally divided at each end of the engines, while the furnaces were arranged in rows one above the other, and provided with a large number of 2in. vertical tubes. The working pressure was 17lb., with a consumption of 85 tons per day and a combined horse-power of 2,000 i.h.p., giving a speed of 12·5 knots.

These steamers outstripped all the best passages of the Cunard Line, and the "Baltic" is recorded as having made the passage from New York to Queenstown, 3,054 miles, in 9·5 days.

Not content with the above, the "Adriatic" was added to their fleet some four years later, and was a still further advance in size and speed, she being the last of these wooden paddlers 50ft. beam and 35ft. depth of hold, and 3,670 tonnage.

Owing to financial difficulties, coupled with the total loss of two of their steamers, namely, the "Arctic" and the "Pacific", the company ceased operations in January, 1858, and the "Adriatic" never ran on service. In answer the Cunard Line in 1862 brought out the "Scotia", an iron-built paddle-steamer of increased dimensions, 379ft. length, 47·8ft. beam and 30·5ft. depth of hold and 3,871 tons, fitted with the same type of side-lever engines, having an i.h.p. of 4,000, with a consumption of 165 tons per day, and speed of 13·5 knots. It may be interesting to note here that the Dock Board, owing to the increasing beam of the paddle Atlantic liners over their sponsors, had to construct suitable docks to cope with the rapidly-growing requirements, so they constructed in 1857 what is now known as the Canada Lock, as can be noted from the engraving date on the masonry. This dock served the double purpose of both a wet and dry dock.

Advent of the Screw Propeller.

Owing to advantages of the screw propeller for propulsion over paddles, after the year 1860 it was rapidly adopted and applied to the Merchant and Naval services, so that with the "Scotia" and "Persia" paddles passed away after quite a short period of service of not more than ten years.

At this period the engineers were in the throes of advancement and advocacy with regard to the most efficient form of propulsion, similar to what is now going on. It would here be as well to refer to the particular type of marine engines in use as found in a "Rudimentary Treatise on Marine Engines", by Robert Murray, C.E., 1852.

> *High-pressure Engines.*—Are not favoured on account of high fuel consumption as compared with condensing engines and their presumed danger to passengers arising from explosion or escape of steam, but they possess the countervailing advantage of cheapness and tightness.
>
> *Side-lever Engine.*—Its construction was such as to have several advantages which enabled it to resist innovation, principally on account of the weights of the moving parts being so balanced, that is, the one piston against the other, so that it lent itself to very easy starting. Another good feature was the long connecting rod. Its power transmission was done in an equable and effective manner with

less friction and wear than any other kind of engine. However, in spite of this, objection was made to its massive weights and lack of compactness of form.

Direct-acting Engine.—Principally adopted in the Royal Navy owing to the shortening of the length of the engine-room by one-third, also giving a reduction in weight of machinery of two-fifths as compared with the side-lever engine.

Murray states: "It happens (unfortunately we think) this kind of engine is capable of almost endless variety, each manufacturing engineer introducing his own child into the Navy, where scarcely two pairs of direct-acting engines are to be found alike. At this period it is an interesting feature to note the outstanding general lack of confidence in steam propulsion as shown by the strong arguments advanced by high officials in giving their testimony before a select House of Commons Committee in regard to the practicability of providing by means of the commercial steam of the country a reserve steam Navy available for national defence.

Dragging of Screw.—It does not always follow the engines are no longer useful after speed attained by the sails is equal to the progression of the screw, but the engineer should under these circumstances watch the thrust of his propeller shaft very narrowly, as there must be a limit to this in all vessels carrying a large spread of canvas. *If he found the thrust to cease, he will then know the screw is dragging and recommend his commander to discontinue the use of the engines as being no longer serviceable.* Direct evidence of the screw 'dragging' has been obtained by the fact of a propeller having been carried away by the strain brought upon it by the velocity of the ship due to the sails exceeding the velocity of the screw. The rupture clearly showed that the blade, which was of iron plate riveted upon a wrought iron arm, was torn off backwards by the drag brought upon it.

Lifting the Screw Out of the Water.

"In the case of some vessels such a contingency was provided for by disconnecting the screw and raising it entirely out of the water when the vessel was under canvas, a hollow trunk being provided over it in the vessel's stern. Or when the screw was capable of being disconnected from the engine, it was left to revolve freely by the action of water upon it from the motion of the vessel. Mr. Pitcher, of Northfleet, who lately built two vessels for the P. & O. Company, stated they would steam 11 knots and would sail better than most vessels in the Navy because they were longer in proportion to their breadth, while their water tanks give them the necessary stability to carry sail".

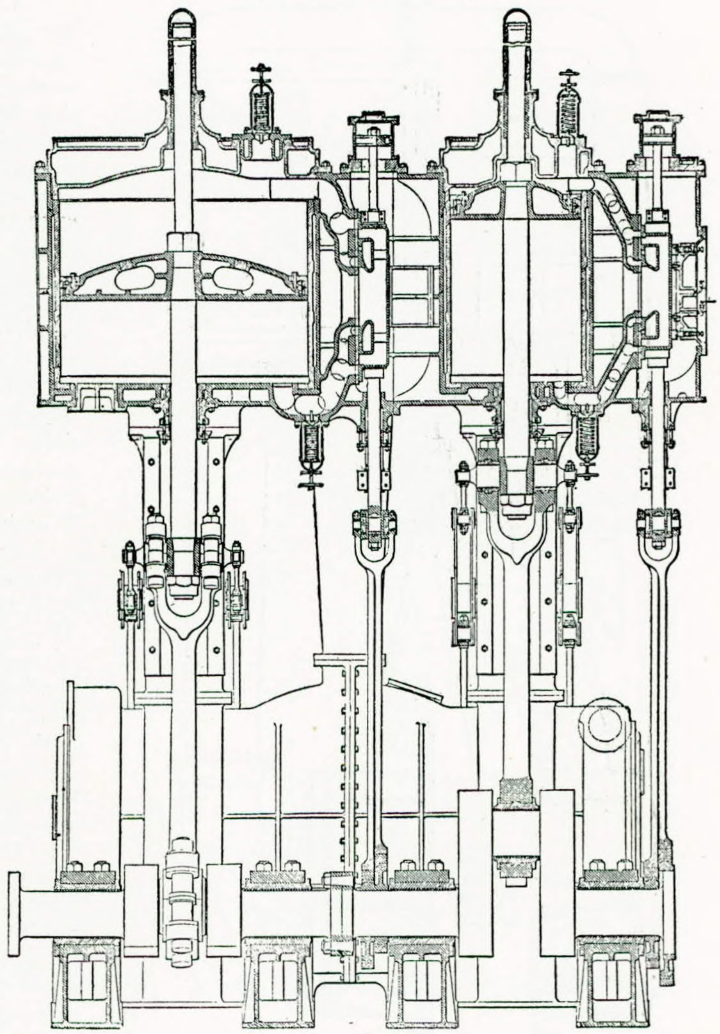


FIG. 2.—Compound two-cylinder engines, 1870-1879.

Mr. J. R. Engledue, engineer superintendent of the P. & O. Company, stated there would be no difficulty in giving merchant steamers the same masts, spars, yards and sails as similar vessels in the Navy, as their speed would certainly not be less, and quoted his experience of running down the Channel at 13 knots for a time of six to seven hours with a steamer under canvas alone.

The introduction of surface condensers after 1860 permitted an increase of boiler pressure from about 35lb. up to about 60lb. With the resultant drop in temperature of steam expansions in a single cylinder, owing to its alternate heating and cooling, constructive engineers soon realised the advantages to be gained by not limiting the steam expansion in the one cylinder, and so discharged or exhausted the steam directly into two or more cylinders, thereby producing the compound engine and establishing an economy in coal consumption of something like ·1·86lb. per i.h.p., as against 4·5 to 5·5. Consequently this engine was very attractive to owners, and there was a rush to convert and re-engine many steamers running with the old type of engine.

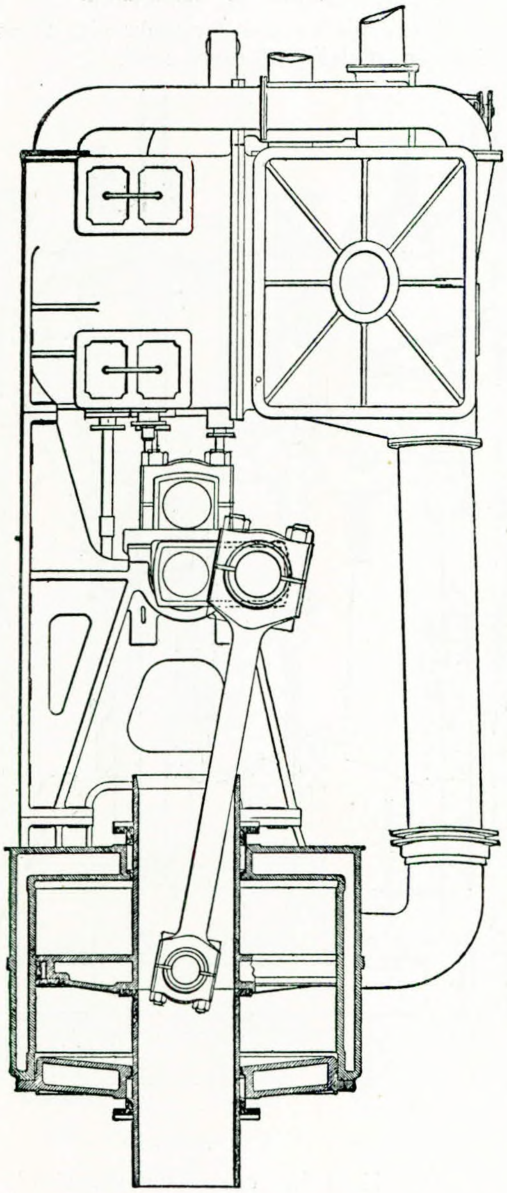


FIG. 3.—Trunk engines as fitted in 1st "City of Paris". 1860-1865.

The two steamship companies competing in the later 'sixties were the Cunard Line and Inman Steamship Company. The latter was bringing out new vessels fitted with horizontal trunk engines, which were making speed records, but at a rather high rate of coal consumption.

Advent of White Star Steamers.

The advent into the North Atlantic service of the White Star Line steamers in 1871 to 1874 created immense interest, owing especially to their tandem compound inverted four-cylinder engines, that is, the high-pressure cylinder immediately above the low-pressure cylinder, but separated by a suitable distance-piece or stool so arranged as to give easy and free access to the piston-rod glands, each engine having its own independent crankshaft. Thus two independent sets of engines were formed, which was considered a novelty as reducing the possibility of failure to a minimum. Large surface condensers of circular shape placed in position on end was another important feature attracting much attention. Steam was supplied by 12 single-ended boilers, having 24 furnaces and 65lb. pressure, the daily consumption being about 80 tons. The machinery was built by Messrs. Maudsley, Son & Field, London, and Messrs. George Forrester & Co., Vauxhall Foundry, Liverpool.

In 1874 and 1875 came the epoch-making "Britannic" and "Germanic", larger vessels fitted with the same type of engine, but more powerful. They had eight double-ended boilers with 32 furnaces, and a boiler pressure of 75lb., also circular condensers, but placed horizontally athwartships abaft the engines. All these steamers came out with McFarlane's steam steering gear, which was also another feature of safety, as compared with their competitors, which had only hand-steering apparatus.

In passing, I would like to refer to the "Britannic", which came into service with a lowering propeller in view of her being a long ship liable to pitch in a heavy sea. It was thought that the vertical motions of the waves would injuriously affect the action of the propeller if fitted in the ordinary manner, and would cause the engines to race heavily and so reduce the vessel's speed. The propeller is shown in the accompanying sketch in its normal position, where it remained throughout deep-sea service, but on reaching shallow water it was raised by suitable lifting gear provided so that the points of blades revolved above the level of the keel. A further advantage was claimed that lifting up the propeller boss clear of the water when in dock simplified the replacement of a damaged blade. After a few voyages this arrangement was taken out, being found impracticable for a steamer of such dimensions, though on some small craft it had proved satisfactory. Another interesting innovation was the introduction of a system of discharging the stokehold ashes through the ship's bottom. This was later thought a dangerous arrangement, and, moreover, choked the condenser tubes on the inlet water side. Some 35 years later ash expellers on improved lines were fitted in the double bottom of a number of the White Star Line steamers, and were most successful.

The principal trans-Atlantic companies, inclusive of the National, Leyland, Guion, and Inman Steamship Companies, during this decade re-engined and boilered a considerable number of their smaller passenger steamers, causing great activity, particularly in this city, where all the principal engineering firms' resources were put to their utmost capacity to meet the owners' demands.

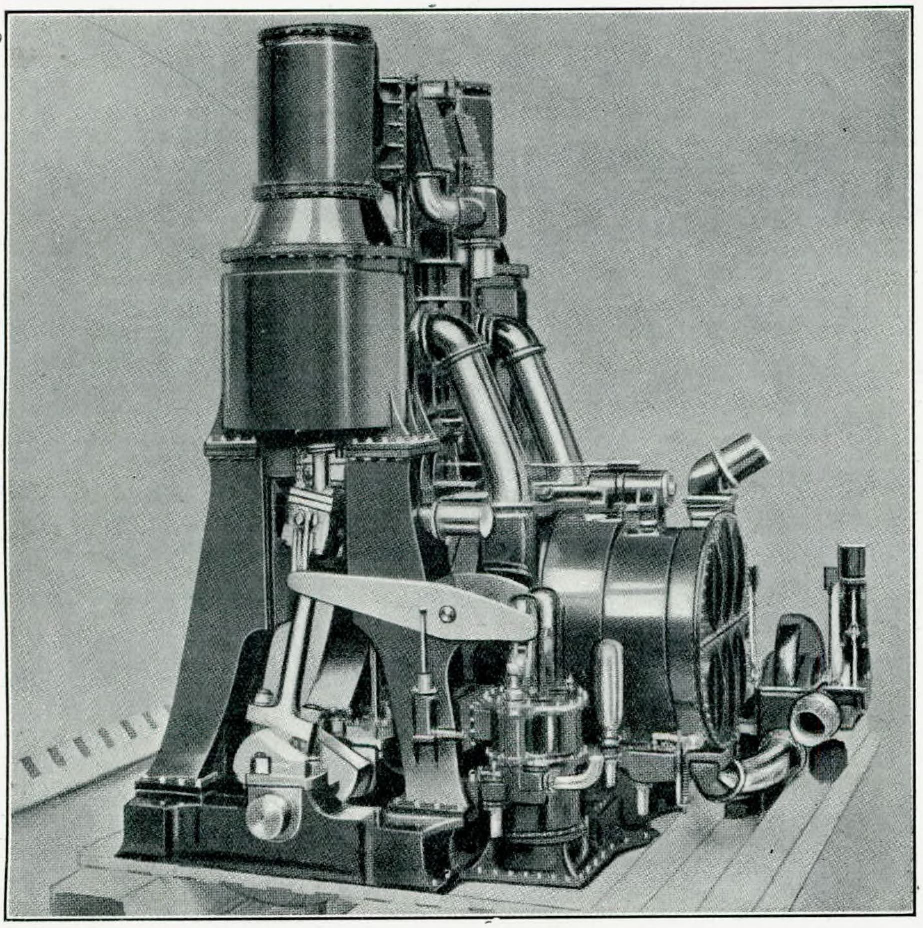


FIG. 4.—Four-cylinder tandem inverted compound engines. S.S. "Britannic" and "Germanic", 1874-75.

A Unique Engine.

I would particularly like to draw your attention to a specially-designed inverted tandem compound engine to cope with restricted head-room with which I was concerned. The h.p. cylinder rests immediately on top of the l.p. cylinder, practically forming its cover, while its piston-rods are on each side, passing on the outside of the h.p. cylinder into a suitable crosshead, which in turn secured the tail-end of the h.p. piston-rod in the ordinary manner. This rod traversed upwards instead of downwards, as in the usual arrangement. Finally, the l.p. rods were secured to a specially designed crosshead with an opening in its centre, through which the gudgeon-pin passed, serving the double purpose for both connecting rod top end and air pump drag links. These engines were quite unique, and caused considerable interest, and as far as I know were quite successful.

With the year 1880 the Cunard Line brought out the "Gallia", having but one advance on the engineering side, namely, engines of the three-cylinder type, that is, one h.p. cylinder at the forward end and two l.p. cylinders arranged consecutively aft of this. Following close upon this the Allan Line brought out the "Parisian" with the same class of engines, the only difference being an increase of boiler pressure to the extent of 5lb. over that of the "Britannic", an indication of their caution in adopting higher pressures.

In 1881 two White Star steamers, "Arabic" and "Coptic", came out, their hulls being partially constructed of mild steel. This was a new departure and caused much spirited argument for or against. The classification societies did not at this time accept steel, with the result that the owners procured certificates from the Underwriters' Registry, Liverpool. The engines were of the compound inverted tandem type, having each two large diametered boilers made of steel, for a pressure of about 90lb.

About this time the Hill or Twin Screw Line inaugurated a service by placing four twin-screw steel steamers on service between London and New York, being the pioneers in this respect, their slogan, "make assurance doubly sure", being freely used. These steamers were "Tower Hill", "Richmond Hill", "Notting Hill" and "Ludgate Hill". Their engines were of the compound two-cylinder tandem type, having each its own single crank-shaft, and were something like the "Great Eastern" in that they came out before their time. Owing to frequent machinery derangement and inadequate steam supply, they were unsuccessful, and were eventually bought by the Allan Line.

The Guion Line, whose spirited policy of enterprise was responsible for many developments and improvements, brought out the "Arizona" at the latter end of 1879, her machinery being similar to the "Gallia's", except that the h.p. engine was arranged with its l.p. engines on either side of it, while boiler pressure was 90lb. She soon gave a good account of herself and wrested from the "Britannic" and "Germanic" both outwards and homewards record passages.

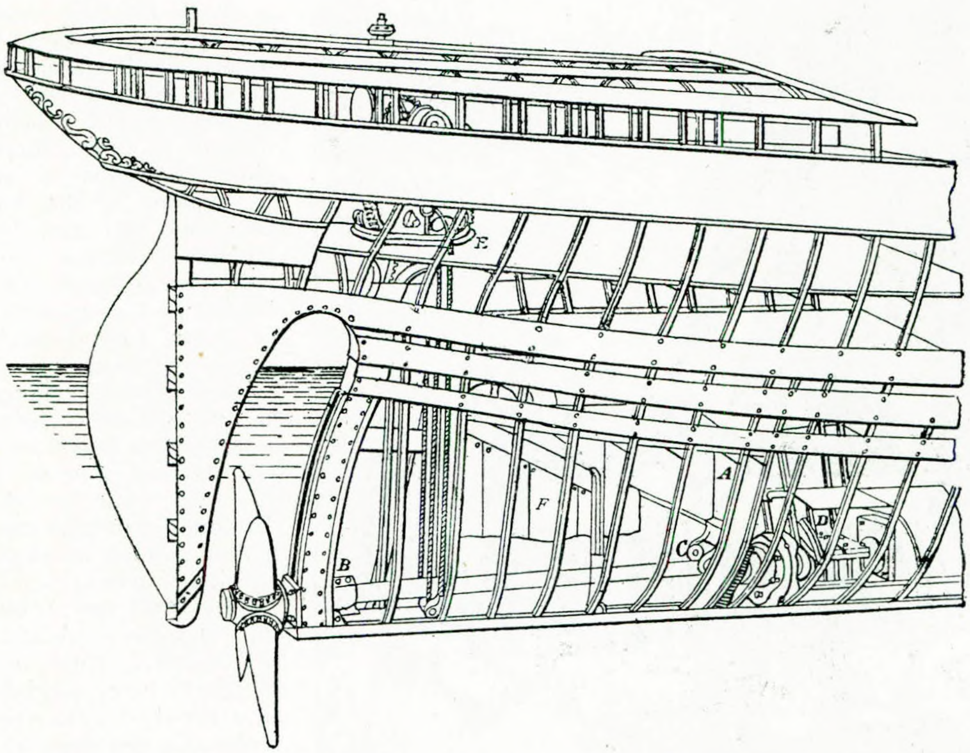


FIG. 5.—S.S. "Britannic (1)" Lifting and lowering propeller, 1874.

During the next ten years many large steamers were built by the various companies and put into service, each being somewhat in advance of its predecessor owing to the gradual improvements embodied in the early vessel's machinery. The "City of Rome", built at Barrow about 1881, had three-crank triple-inverted engines with the following arrangement of cylinders to the number of six in all, viz. :—h.p. over l.p. at forward end, centre i.p. over l.p., and aft i.p. over l.p. which gave the required power in a minimum space. There was no increase in boiler pressure, which was 90lb.

Close upon this steamer, in answer to the Inman Company's challenge for passage records, came the Cunard Line's "Servia" and "Aurania", which were fitted with three-cylinder compound engines capable of developing 10,500 i.h.p. They never made any records, and had a somewhat unenviable but short reputation on the Atlantic service.

The Guion Line in 1884 put the "Alaska" on service with machinery similar to the "Arizona", and she was followed by the "Oregon", having more powerful engines of the same type, but the boiler pressure had now been raised to 110lb.

The National Line and Cunard Line about 1884-5 brought out the "America", "Umbria" and "Etruria" respectively, all fitted with three-cylinder compound three-crank type, that is, one high-pressure and two low-pressure cylinders common to three cranks, the last two steamers being credited with having the largest single-screw engines ever constructed up to this date, while the boiler pressures were 90 and 110 respectively.

Changes in Rig.

At this point it is interesting to note all the foregoing steamers were mostly four-masted and square-rigged on three or two pole masts as the case might be. In 1888-89 the Inman Line produced the twin-screw steamers "City of New York" and "Paris" with no square-rig on their pole masts, while in 1889-90 the White Star Line replied to this challenge by commissioning the "Teutonic" and "Majestic", and with these steamers finished the extensive sail power as before fitted. The engines in the "Cities" were two sets of three-crank triples with boilers under forced draught in a closed stokehold, and having a pressure of 150lb. The White Star vessels were built to link up with the British Navy as "armed cruisers", and the efficacy of this decision matured in 1914 in the Great War, when the "Teutonic" was fitted out as such and gave a most estimable account of herself during the whole period of the war. In the case of the "Majestic" this was impracticable owing to her being partly dismantled and in process of being broken up when asked for by the Government. The engines were also three-crank triples of the very finest design and construction, while the boilers carried 180lb. pressure and worked under forced draught of the closed ash-pit system. After 32 years' service of the most exacting conditions the "Teutonic" passed out of service, with her original machinery and boilers carrying their original pressure, showing the excellent workmanship in the first instance and the close and careful attention bestowed upon her during her long and exhaustive career.

In the next ten years, 1890-1900, the advance made in machinery and boilers was not so rapid, and experience served to show the necessity of providing against recurrence of

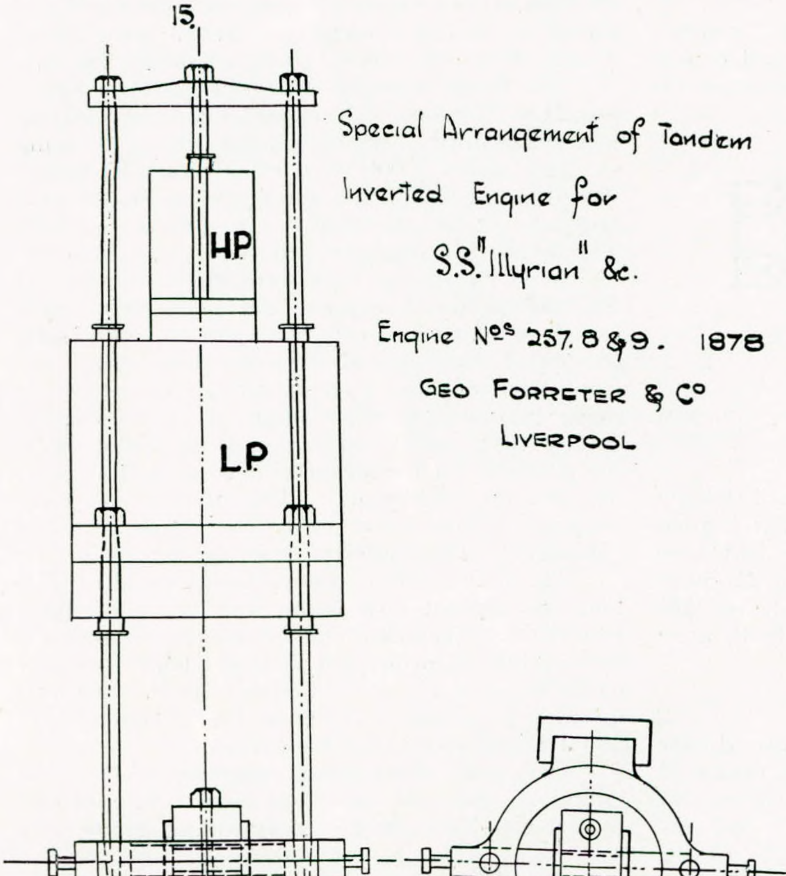


FIG. 6.

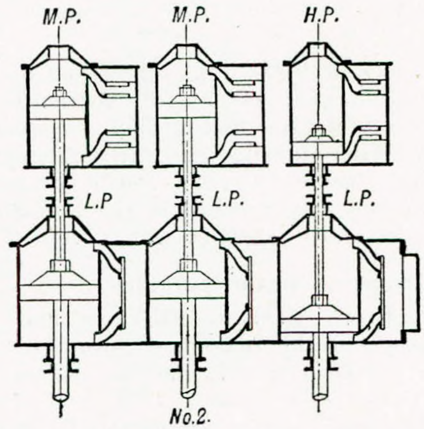


FIG. 7.—Three crank triple expansion inverted engines. S.S. "City of Rome", 1881.

machinery derangements. During this period the Cunard Line built the express twin-screw steamers "Campania" and "Lucania", hoping to wrest the blue riband of the Atlantic from the Germans. They were fitted with twin triple-expansion engines, each having five cylinders, that is, two h.p. cylinders over two l.p. cylinders with the intermediate cylinder in the centre on either side of the two tandem engines, while the combined i.h.p. was about 30,000, steam being supplied by 13 boilers whose pressure was 165lb., with a coal consumption of approximately 500 tons.

The American Line built at Philadelphia about 1895, the "St. Paul" and "St. Louis", which had two sets of quadruple-expansion four-crank engines, arranged so that two h.p.'s over two l.p.'s work on the two forward cranks, while the first i.p. is working on the after crank and the second i.p. operates the third crank. The boiler pressure was 200lb. and forced draught was fitted on the closed ash-pit system.

The White Star Line put the second "Oceanic" in commission in 1899 with machinery and boilers consisting of two sets of four-crank triple-expansion engines of 30,000 i.h.p., the result of much thought based on years of careful experience. The engines proved highly efficient, but the power had been somewhat curtailed and she only steamed 21 knots. This steamer was an armed cruiser during the war and was wrecked in the Pentland Firth after a very short length of war service.

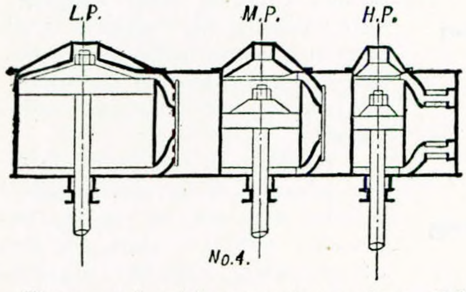


FIG. 8.—Three crank triple expansion engines. S.S. "City of New York" and "Paris", "Teutonic" and "Majestic", 1888-89.

Advent of Steam Turbines.

From 1900 to 1910 we find some drastic changes in the methods of propulsion, by reason of the application of Parsons steam turbines for vessels. The years 1894 and 1897 saw the "Turbinia", a small steamer of 100ft. length, having a displacement of 44½ tons, with turbine machinery, developing 2,300 horse-power, and giving a speed of almost 33 knots. Her machinery as finally fitted consisted of three lines of shafting, each with its own propeller; the high and intermediate turbines were coupled to the outer shafts and the low pressure with its reversing turbine to the central line of shafting. At Queen Victoria's Diamond Jubilee Spithead Review, this little pioneer steamer created a great sensation by steaming at high speed in and out the representative liners anchored there to witness the ceremony of inspection by her Majesty, justly earning for herself and her system of propulsion a never-dying reputation.

The successful evolution eventually culminated in Sir Charles Parsons' firm and the noted shipbuilders Messrs. Denny, of Dumbarton, and Mr. Williamson (Glasgow and South Western Railway Company) deciding to build a passenger turbine steamer for coastal service, and in 1901 the turbine-driver steamer "King Edward" was put into commission, and was a most convincing proof of the suitability of this method of marine propulsion, in future to be applied to Atlantic liners. Her machinery consisted of compound turbines, of the parallel flow type, of 4,000 to 5,000 shaft h.p., and so arranged that the high pressure worked the central shaft, while the two l.p. turbines were connected to the outboard wing shafts. The latter were the manœuvring engines having the astern turbines placed in the exhaust casings. When going ahead these turbines idly rotated in the condenser vacuum.

The boiler pressure was 150lb. and the speed was 21 to 22 knots. A very high rate of revolutions was maintained, namely, central 750, both wing or outer shafts 1,000 to 1,100 per minute, and it should be noted that the outer or wing shafts were originally fitted each with two propellers, but later on changed for single propellers of large diameter.

Most interesting tests were made later by the Midland Railway Company, who built four steamers exactly similar, except that one pair was fitted with compound turbines and the other pair with four-crank triple-expansion reciprocating engines. When these steamers were running on cross-Channel service their results gave convincing proof as to the reliability of the steam turbine to meet all sorts of weather conditions. The names of these steamers respectively were the "Antrim" and "Donegal", "Londonderry" and "Manxman".

The first turbine steamer had a speed of 21·6 knots as against 20·6 knots, and based on these results the "Manxman" had certain modifications to her machinery, principally a higher boiler pressure of 200lb., with the result that her speed was three-quarters of a knot more than the "Londonderry" and 1·1 knot more than the "Antrim".

Over and above these comparative tests the Admiralty about the same time were making experimental tests between the reciprocating engine ship "Topaze" of 9,000 i.h.p. against the "Amethyst" turbine engine, but with the same boiler power, resulting in an increased speed of 1·29 knots and reduction in coal consumption of 10 per cent., giving a greater radius of action, and, what was most important, freedom from vibration.

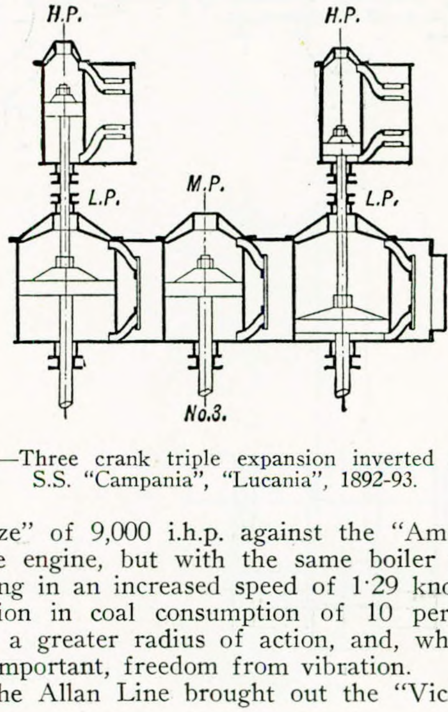


FIG. 9.—Three crank triple expansion inverted engines. S.S. "Campania", "Lucania", 1892-93.

The Allan Line brought out the "Victorian" and "Virginian" in 1905 with twin compound turbine engines, each driving its own propeller, and these two steamers were the pioneers in the North Atlantic fitted with the new type of propulsion. Their manœuvring qualities were poor, however, owing to the inadequate supply of steam for astern power.

"Caronia" and "Carmania".

The Cunard Line were building two intermediate passenger vessels on the Clyde, namely, the "Caronia" and "Carmania", the former to be fitted with quadruple four-crank reciprocating engines and Scotch boilers, while the latter was to have compound turbine engines, and eventually she came into commission in 1906. No doubt the Cunard Line and the builders were enabled to draw some very valuable conclusions from the results of the two vessels' performances, which were in the future to be of a most valuable character in the case of more extensive building, which in due course resulted in the super steamers "Lusitania" and "Mauretania" coming out in 1907, having a shaft horse-power of 70,000 and a speed of 25 to 26 knots. Briefly, the propelling machinery consisted of high pressure turbines driving the outboard or wing shafts, and low pressure turbines driving the inner or centre shafts, on which were the manœuvring propellers; steam at 195lb. was generated by 25 boilers now oil-fired. The four propellers were of turbadium metal and solid.

It is worthy of very careful note that the marine steam turbine, within a period of not more than seven years, developed from 5,000 s.h.p. to 70,000 s.h.p., whereas it took 25 years to develop the reciprocating engine's horse-power from 5,000 to 30,000, as in the "Oceanic". Sir Charles Parsons was working at the development of the marine turbine for 15 years before he was able to achieve success and establish it as a method of propulsion; in fact, all his first and original patent rights had lapsed.

"Laurentic" and "Megantic".

At this period the White Star Line had not entirely accepted direct-driven turbines, but considered that the steam turbine at the high pressure end was somewhat less efficient than a well-designed reciprocating engine; the low-pressure turbine, however, working in a high vacuum of 28 to 29in., would abstract the very last unit of power out of the steam, and accordingly they adopted the combination system of four-crank triple-expansion engines, exhausting into a centre low-pressure turbine, and to test this out on its merits built two sister steamers of equal tonnage, namely, the "Laurentic" (1) and "Megantic". The former was fitted with the combination arrangement of machinery, but with the same number of boilers as the "Megantic", which had two sets of four-crank quadruple-expansion engines on the Yarrow-Schlick-Tweedy method of crank balancing and a boiler pressure of 215lb. The "Laurentic" had three propellers against the "Megantic's" two.

These two steamers were operated in the same trade and had the same displacement and class of coal for a period of two years, with the result that the gain in economy by the use of the turbine was 21 per cent., considerably over the most sanguine expectations of Messrs. Parsons, who looked for 14 per cent. at the most. The "Laurentic's" low-pressure turbine developed as much shaft horse-power as one of the sets of her triple-expansion engines, i.e., some 4,800. These results decided the type of machinery which was to be fitted in the new high-powered steamers of the "Olympic" class then just laid down.

With regard to reciprocating engines, the quadruple expansion with crank shafts balanced on the Yarrow-Schlick-Tweedy system had the cylinders arranged in the following sequence counting from forward h.p. 1st intermediate, 2nd intermediate and low-pressure right aft.

The White Star Line from 1901 to 1907 placed in commission four 25,000-ton steamers of the "Celtic" class, all being fitted with the above class of twin-screw engine of 15,000 i.h.p., having Scotch boilers and a pressure of 215lb., giving an average speed of 16½ knots on a very low fuel consumption of 1·4 for all purposes.

Mechanical Reduction Gearing.

It was evident that the high revolutions of a steam turbine were necessary to establish the economy claimed, while the propeller efficiency is not as satisfactory at this high speed, therefore, a compromise becomes necessary to allow it to compete favourably with the reciprocating engine's comparatively speaking slow running and efficient propeller. In view of this, Sir Charles Parsons brought out mechanical gearing, and in 1909 practically applied gearing for propulsion to the now well-known "Vespasian". In the first instance, she was run with her original triple-expansion engines on a number of trials for the purpose of collecting data for future comparisons with the geared turbines which were fitted later.

These engines were then removed, but both boilers and the propeller were allowed to remain, and single reduction geared turbines were fitted. The trials showed a definite gain of 20 per cent. in coal consumption and an increase in speed of 20 per cent., while the mechanical efficiency of the gear was stated to be 98½ per cent.

During the period of 1911-20 in some directions marine engineering received a slight set-back, yet, on the other hand, certain developments were accelerated as meeting the needs of the stirring times more or less caused by enemy submarine action.

The "Olympic".

In the year 1911 the White Star liner "Olympic" came out fitted with combination system machinery based upon the "Laurentic (1)" and "Megantic" with two sets of four-crank triple-expansion engines each common to its own wing shaft and exhausting into the largest low-pressure marine turbine ever constructed actuating the centre shaft at 200 revolutions with a combined horse-power of 50,000, consuming 850 to 900 tons of coal, and giving an open sea speed of 21 knots average.

Her boilers are of the Scotch type to the number of 24 double-ended and 5 single-ended, having a pressure of 215lb. At the time of reconditioning after the war in 1920 they were converted to oil-burning with most satisfactory results, equal to a saving of 27 per cent. as oil is to coal, and owing to the steady maintenance of pressure throughout the steaming periods, the speed was increased to 22 knots which average is constantly kept up year in and year out.

For all purposes the oil consumption is recorded as ·855 per s.h.p., and so leaves very little between such performances and those of later day steamers with all-turbine machinery carrying much higher boiler pressures. I may here say that her reciprocating engines are the largest ever made, and are the limit in size in regard to the human element in matters of adjustment, etc.

This great pioneer of the combination system was followed at intervals by the ill-fated "Titanic" and "Britannic (2)", the former lost on her maiden voyage, and the latter sunk by enemy submarine attack when on hospital duty going to Salonica. Both the "Belgic" and "Regina", having combination machinery, were completed for trooping and freight in 1918, also the "Vedic" and "Rimouski" as cargo steamers.

Electric Propulsion.

In respect to the last two named vessels of 9,000 tons, the company had a certain object in view so as to keep pace with development and in accordance with their progressive policy of gathering reliable data by minimised application before embarking on the large-scale development. They had been closely considering the possibility of electric propulsion, and about 1913 it was decided to build three cargo steamers of the same tonnage, one to be propelled by compound single-reduction geared turbines, one by quadruple-expansion reciprocating engines, and the other by Ljungstrom turbines operating electric generators supplying current for the motors on each line of shafting, each ship to have two propellers and a horse-power between 4,500 and 5,000. Though the two first methods of propelling power matured and the two steamers were built, unfortunately, owing to demands for other tonnage, in January, 1921, it was decided to abandon the third steamer, termed by the late Viscount Pirrie "The Willett Bruce Ship". To say the least of it, this was most unfortunate from both the company's point of view and also from the engineering side.

The "Aquitania".

Turning now to the Cunard Company in 1914, they placed on the Liverpool and New York service the "Aquitania", the result of many examples of concentrated development arising out of concrete experience collected from the "Lusitania" and the "Mauretania". The machinery consisted of triple-expansion direct-acting turbines placed in three compartments, that is the h.p. turbines on port side coupled to the outer or wing propeller, the two l.p. turbines arranged in the centre space and each turbine driving its own centre propeller, while the l.p. turbine is situated on the starboard side and coupled to its own outer or wing propeller. Each turbine has its astern turbine making all four propellers available for going astern.

The boiler installation then consisted of 21 double-ended Scotch boilers, coal-fired under

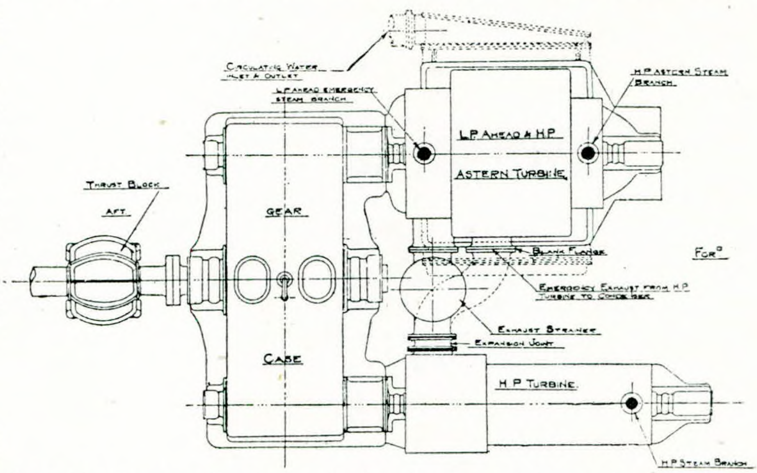


Fig. 10.—Compound turbines single reduction. S.S. "Vedic", "Doric", etc., 1918-25.

Howden's forced draught system, with a working pressure of 195lb. The collective i.h.p. is 62,000, giving a speed of 23½ knots. Some seven or eight years later the boilers were converted for the consumption of oil fuel, which resulted in slightly increased speed.

Ex-German Liners.

The Cunard Company acquired, through reparations, the "Imperator", an ex-German steamer, built in 1913, also fitted with triple turbines driving four propellers, developing 62,000 i.h.p., and giving a speed of 22½ knots, while the 46 boilers were of the Yarrow-Vulcan water-tube type arranged for coal-burning, the pressure being 225lb. As soon as possible, owing to unsatisfactory results during their short experience of running her, she was sent to the Tyne to have the boilers retubed and furnaces converted to oil-burning, and was re-named "Berengaria". With the "Berengaria" came the introduction of water-

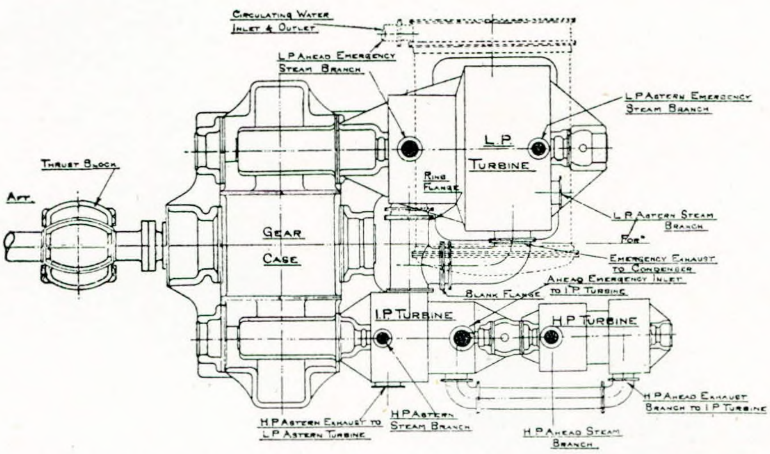


FIG. 11.—Triple turbines double reduction. S.S. "Franconia", "Altonia", "Samaria".

tube boilers into service on British Atlantic liners, which is epoch-marking. This company, a reasonable time after the termination of the war, placed extensive orders for new tonnage for cabin and for intermediate class of steamers such as the "Francona", "Altonia", "Samaria", etc., all fitted with double reduction geared turbines of about 13,000 s.h.p., and Scotch boilers having a pressure of 220lb. and 200 deg. of superheat, their speed being between 15 to 16 knots. These boilers are all oil-burning. The results have been entirely satisfactory in regard to both economy of fuel and run with a minimum of upkeep expenditure.

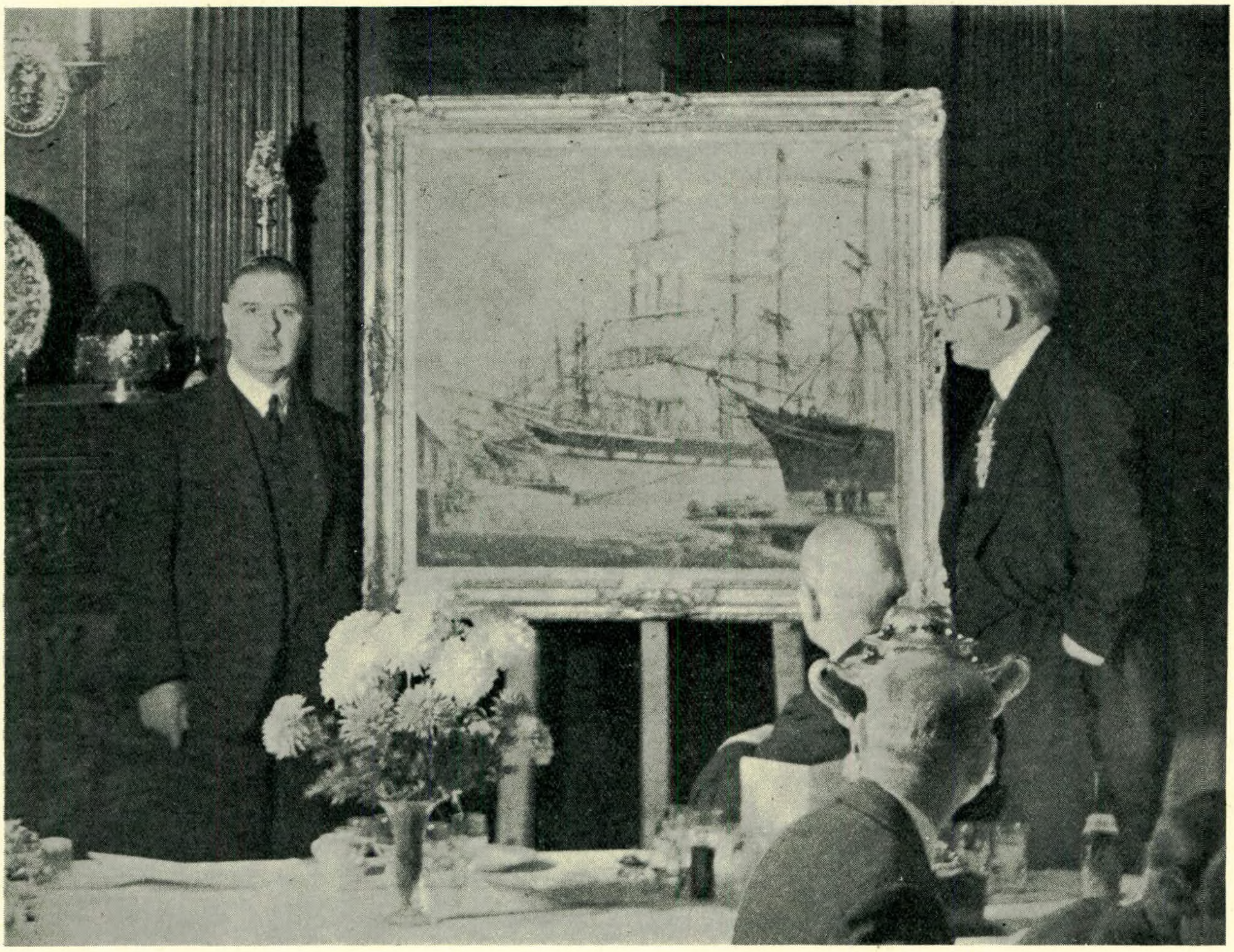
In 1922 the White Star Line acquired, also through reparations, the German-built steamer "Bismarck", launched in June, 1914. The propelling machinery consists of triple expansion direct-acting turbines arranged in series. The ahead h.p. turbine is coupled to port centre shaft with astern turbine aft of this. The ahead l.p. turbine is coupled to starboard centre shaft with astern turbine forward of this. Two l.p. turbines are coupled to port and starboard outer shafts and have their astern turbines immediately aft.

Steam is generated by 48 Yarrow-Vulcan water-tube boilers, the pressure 253lb., while the s.h.p for a service speed of 22½ knots is 65,000. This machinery is operated at 75,000 to 80,000 for a speed of 24 to 24-25 knots on a consumption of oil of 850 to 900 tons. She can be further pressed up to 100,000 s.h.p., but only for very short periods, but this is by no means advisable or is it recommended, not only in view of unduly pressing the machinery, but owing to the abnormally greater fuel consumed.

Last of the Combination Type.

In 1924 this company arranged to build a steamer of 187,000 tons having triple-screws and named after the pioneer "Laurentic No. 1". This vessel's completion was very considerably delayed owing to the coal strike, nine to ten months being entirely lost, but she sailed on her maiden voyage in November, 1927. Combination machinery was fitted of a combined horse-power of 14,649, the low pressure turbine being responsible for 5,282, which was slightly greater than the three-crank triple engines, each set being 4,683 i.h.p. The boilers are both double and single-ended, ten in all, with 36 furnaces coal-fired. The pressure was 215lb., and 200 deg. of superheat was arranged for. The greatest temperature used on any voyage was 518 deg., and a vacuum of 28·75in. The coal for all purposes worked out at 1·224, and for main engines only 1·045.

It is worthy of note that this steamer, owing to the advancement made in the application of higher pressure up to 550lb., during her construction, will in the case of Atlantic liners be the last of the combination three shaft engines, as her predecessor of the same name was the first of this type.



The Presentation.
Sir R. Burton Chadwick (right) receiving the picture from the President.

The Luncheon.

INSTITUTE NOTES.

Presentation of an Oil Painting to the Honourable Company of Master Mariners.

Following upon the announcement of his intention at the conclusion of his Presidential Address in September, our President, Mr. John H. Silley, has presented to the Honourable Company of Master Mariners a picture of "The Wool Fleet in the East India Dock, 1890", painted by Captain Maurice Randall, and the painting was formally handed over at a luncheon held at the Mercers' Hall, Ironmonger Lane, London, on Tuesday, the 3rd October, 1934. The painting, which is in oils, depicts a line of wool clippers in the East India Dock, with the "Cutty Sark" in the immediate foreground and the "Harbinger" lying next alongside. Sir Burton Chadwick, Deputy-Master of the Honourable Company of Master Mariners, presided.

Others present were: Mr. John H. Silley (President, Institute of Marine Engineers), Mr. Alfred Robertson (Hon. Treasurer, Institute of Marine Engineers), Commodore Sir Bertram Hayes (Prime Warden, Master Mariners' Company), Mr. Neville Dixey (Chairman of Lloyd's), Sir Philip Devitt, Captain P. F. W. Blake (Mariner Warden), Mr. Richard H. Green, Captain Maurice Randall, Mr. Charles Cowan, Mr. John Macmillan, Commander G. P. Lewis, *Mr. T. R. Thomas, Lieutenant-Commander W. T. Clifford, Colonel Frank D. Watney (Clerk of the Mercers' Company), Commander Sir Edward Nicholl, Commander H. W. Wise, *Mr. A. F. C. Timpson, Captain W. H. Coombs, *Mr. E. F. Spanner, Lieutenant-Commander J. J. Cameron, Mr. B. C. Curling (Secretary, Institute of Marine Engineers), Mr. W. T. C. Smith (Clerk of the Master Mariners' Company), Commander R. J. Noal, Mr. Robert Corry, Captain J. W. Harris (Mariner Warden), *Mr. S. N. Kent, Captain R. E. Thomas, *Mr. R. Rainie, Captain C. E. Mumford, *Mr. J. Calderwood, Lieutenant-Commander N. Woolcock, Lieutenant-Commander W. de Burgh Thomas, *Mr. H. S. Humphreys, Commander H. Strong, and Commodore H. Stockwell (Mariner Warden).

In presenting the painting, Mr. John H. Silley (President of The Institute of Marine Engineers) asked Sir Burton Chadwick "to accept on behalf of your Company this oil painting of famous sailing ships which were trading to the various parts of the British Empire during the latter years of the 19th century, as a token of good-will from the President, Vice-Presidents, Council and Members of The Institute of Marine Engineers". They had watched with great interest and sympathy, he added, the inauguration and progress of the Company. It was their sincere desire that its influence should be widely extended, and that they should have in this great city of the Empire an institution that would carefully watch over the destinies of our Merchant Navy and all who went over the sea in ships.

That presentation and that luncheon made a date of great importance in British shipping history, he added. It was the beginning of a new spirit of co-operation and understanding between the engine-room and the deck officers.

The fine painting they saw before them was the work of one of their own members who had sailed the sea in that type of ship. He trusted that the generation of shipmasters to come would look back upon that painting, when it hung in the hall of the Master Mariners Company, and visualise the part taken by their forefathers in the building up of the Empire.

The toast of "The Institute of Marine Engineers" was proposed by Sir Burton Chadwick. After expressing the thanks of the Honourable Company of Master Mariners for the picture, he said that as far as he knew it was the first time that the two great administrative elements in the ship—the deck and the engineer officers—had met in such a representative corporate manner. He hoped that it might be the first of many such gatherings, and that the bonds of friendship, mutual understanding and esteem might thereby be strengthened.

They had to maintain a high standard in the Merchant Navy, and the status of the officer, both engineer and deck officer, was a matter of great importance.

They were very proud to have Mr. John Silley with them, a marine engineer of over 50 years' experience, and a member of The Institute of Marine Engineers for 42 years. He was not only a famous marine engineer, but carried on the most valuable work in benevolent operations for all kinds of ship workers.

Only a week ago they had watched that great engineering triumph at Clydebank, and, as he looked at the picture presented to them, he realised that the changes that had taken placed in their own lifetime were vastly greater than during the previous 300 years. The progression from each new scientific discovery into new spheres was quite incalculable, and the changes that their boys would see would completely dwarf even the startling changes that had been seen during the past 30 or 40 years. In all that development England still remained an island, and, notwithstanding science, the "old sea" would continue to present to seamen the problems that it had presented for thousands of years. Seamen and marine engineers must keep pace; they must become more and more necessary to the shipowner as he in turn progressed, and they must so equip themselves that instead of ranking with subordinate ratings ashore the shipowner would

* Member of Council, Institute of Marine Engineers.

come to acknowledge them at his own level in the administration of the shipping industry.

That was the ideal The Institute of Marine Engineers and the Company of Master Mariners kept before them. (Cheers).

In conclusion, Sir Burton Chadwick referred to the help the Master Mariners' Company had received from Lloyd's in their early days. At the moment when it meant most to them, he said, Lloyd's held out the hand of friendship and allowed them to hold their first Court in the Committee Room at Lloyd's, a room which had not been open before to any but the Committee. (Applause).

Mr. John Silley, replying to the toast, felt proud to recall that the early meetings of the Company of Master Mariners had been held at The Institute of Marine Engineers. At no time was it more necessary than at the present for the master mariners and the engineers to work together. We were living in difficult days, with the spread of nationalism extending all over the world and the determination of the different countries to have their own mercantile marine, and they must admit that the figures of British tonnage as far as percentage was concerned appeared to have diminished. In that way, the master mariner, ship's officer and ship's engineer, as well as those who built ships, and engineers, had a great responsibility. On the Continent countries were forging ahead with great efficiency and great economy. He had recently returned from a trip to the Continent, and he was amazed at the money and time that was being devoted to research and investigation, all with a view to having machinery which would place their countries in a good position to compete with our Merchant Navy. While we were pre-eminent in steam, he did not think we could quite claim that we still had the same lead in the development of the internal combustion engine. It was essential that shipowners should take stock from time to time, and that everything necessary should be done in the way of research to keep our Mercantile Marine on such a basis as to give the shipowner service which would enable him to hold his proper place in the world. (Applause).

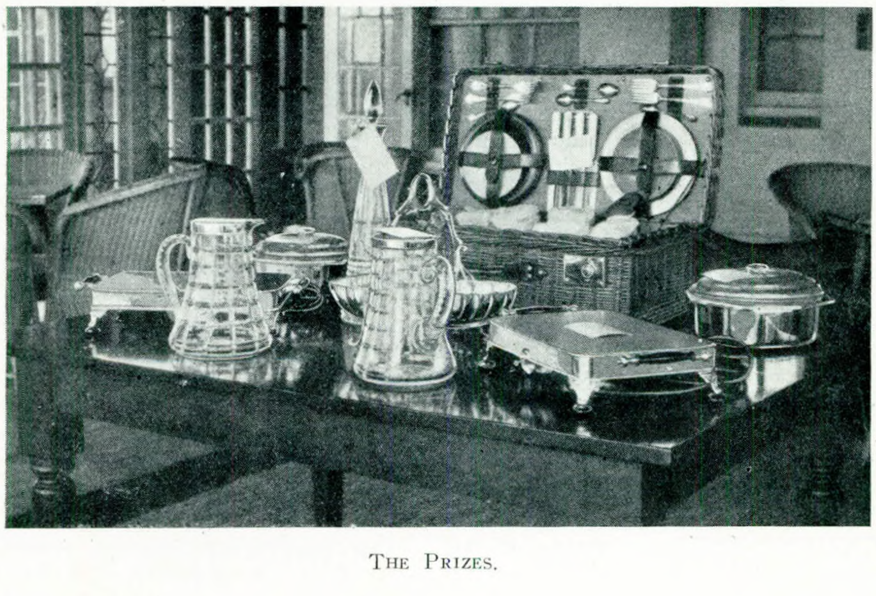
The Chairman of Lloyd's (Mr. Neville Dixey) who also spoke, said that, as they all knew, Lloyd's was primarily interested in all matter concerned with ships. They were very glad to have been of assistance to the Master Mariners' Company, and if Lloyd's, as an old Corporation, could be of any assistance to them as a new Corporation they would be only too delighted. (Applause).

In conclusion he offered a toast to Sir Burton Chadwick, which was accepted with enthusiasm.

AUTUMN GOLF MEETING.

At the conclusion of the Annual Golf Competition in June last a suggestion was put forward and unanimously approved by the members present, that the Council be asked to arrange an additional golf meeting in the autumn. This suggestion was adopted by the Council and in due course a meeting was held at Sundridge Park on Monday, September 24th, 1934, by kind permission of the Sundridge Park Golf Club Committee.

The programme consisted of a Medal Competition in the morning and a Four Ball Greensome in the afternoon. Twenty-six members took part in both events, the results being as follows :—



THE PRIZES.

Medal Competition.—The first prize, a silver plated biscuit casket, presented by J. Robinson, Esq., was won by Mr. A. Walker, with a net score of 76. The second prize, a wicker luncheon basket, presented by Major W. H. Dick, was won by Mr. T. C. Riddell with a net score of 77. The third prize, a decanter, presented by T. A. Crompton, Esq., was won by Mr. F. H. Farthing with a net score of 78.

Four Ball Greensome.—The two first prizes, two silver mounted cut-glass jugs, presented by The Hon. J. K. Weir, were won by Messrs. F. H. Farthing and J. A. Rhynas, who finished all square; the second prizes, two electric table heaters, presented by Messrs. E. F. J. Baugh and A. Walker,

THE AUTUMN GOLF MEETING.
Some of the Players after the Prize Distribution.

were won by Messrs. R. M. Gillies and J. Robinson, who finished 1 down. For the two third prizes, two casserole dishes, presented by Messrs. W. L. Roxburgh and W. Wallace, two pairs of players tied, namely Messrs. F. M. Burgis and J. H. Williams and Messrs. W. H. Dick and R. Julyan. The issue was decided by drawing lots, the two first-named being the winners.

The prizes were presented at the close of play by Mr. A. Robertson, C.C., Convener of the Social Events Committee, after a short speech in which he expressed the Committee's gratification on the success of the meeting, notwithstanding the inclement weather. On his proposal it was unanimously resolved that a hearty vote of thanks be conveyed on behalf of the Committee to those who had so generously contributed to the day's enjoyment by presenting the very handsome prizes. He further expressed the Committee's appreciation of the excellent arrangements which had been made on their behalf by the Committee and Secretary of the Sundridge Park Golf Club. On the proposal of Mr. R. Rainie, M.C., a vote of thanks was accorded to Mr. Robertson and the Secretary for their part in the day's proceedings, to which they suitably replied.

The members present included Messrs. W. Adamson, E. F. J. Baugh, F. P. Bell, F. M. Burgis, T. A. Crompton, B. C. Curling, W. H. Dick, J. M. Edmiston, F. H. Farthing, R. M. Gillies, J. A. Goddard, A. N. Harnett, R. E. Huggan, E. B. Irwin, R. Julyan, W. Marshall, E. E. Mees, R. N. Orren, S. Pearson, R. Rainie, J. A. Rhynas, T. C. Riddell, A. Robertson, J. Robinson, H. J. Savage, H. B. Tostevin, W. W. Tennent, A. Walker, and J. H. Williams.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, October 1st, 1934.

Members.

Ronald Allan, 204a, High Holborn, W.C.1.

Sidney Goddard Ball, Parsons Mead, Beaulieu, Hants.

Leonard Ernest Boyes, 18, Wordsworth Avenue, South Woodford, E.18.

Patrick Charles Card, Eng.-Lt., R.I.M., R.I.M. Headquarters, Bombay, India.

William Colling, 59, Wellington Street, Hebburn-on-Tyne.

Thomas Robinson Dumble, 2, Leafield Road, Sutton, Surrey.

Stewart Henry Hambling, Heathfield, Plymstock, Plymouth.

Robert Arthur Holmes, c/o Mrs. Atkin, 16, Edward Street, Stapleford, near Nottingham.

John Edward Victor Hood, 89, Wansbeck Avenue, Cullercoats, Northumberland.

Nathan Irvine, 41-07-157th Street, Flushing, Long Island, New York, U.S.A.

George H. Jett, 24, Clinton Street, Brooklyn, N.Y., U.S.A.

Robert Johnston, 15, Erroll Road, Romford, Essex.

Arnold Muir Keith, 18, York Avenue, Great Crosby, near Liverpool.

Gosta Evald Andreas Lundqvist, 11, Wildwood Road, N.W.11.

John McKinlay, 212, Bement Avenue, West New Brighton, Staten Island, New York, U.S.A.

Oswald Herbert George Kerr Moseley, Fairacre, Farningham, Kent.

Herman Theodor Pyk, Saltsjo-Duvnas, Sweden.

Thomas Cockburn Riddell, 78, Finnart Street, Greenock.

Charles George Strapps, China Navigation Co., c/o Messrs. Butterfield & Swire, Shanghai, China.

Associate Members.

Frank William Ludlam, B.Sc., Kopaci, Mayfield Road, Falmouth.

Francis Henry Peck, 33, Bishopton Road, Grove Hill, Middlesbrough, Yorks.

Alexander George Steele Watson, 9, Fallows Street, Middlesbrough.

Associate.

David Joseph Thompson, The Hollies, 22, Burdett Avenue, Dun Laoghaire, Co. Dublin.

Student.

Joseph McPherson, 4, Adam Street, Gourock.

Transfer from Associate Member to Member.

John Livingstone Barr, c/o Marine Engineers Association, 776, Barking Road, Plaistow, E.13.

James P. M. Ferrier, 47, Union Street, Greenock.

John Edward Marten Payne, 25, Boileau Road, Ealing, W.5.

Transfer from Associate to Associate Member.

Edwin Cottingham, 36, Wilson Street, Lincoln.

Edgar Hamilton Gibson, 3, Central Buildings, Westminster, S.W.1.

Transfer from Student to Member.

Alexander John McKeand, 298, Burdett Road, E.14.

Transfer from Student to Associate.

William John Brand, 243, Elm Road, Leigh-on-Sea, Essex.

Gilbert Atwood Chamberlain, Cape Technical College, Cape Town.

Royston Herbert Clark, 11, Rolleston Drive, Wallasey, Cheshire.

Frederick Robert Franklin, 34, Regent Road, Edgerton, Huddersfield.

Eric Greenfield, Terringes, South Street, West Tarring, Worthing.

Stanley R. Rose, 23, Vansittart Street, New Cross, S.E.14.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

Lloyd's Register of Shipping. Report of the Society's Operations during the year 1933-1934.

Lloyd's Register of Shipping. Rules and Regulations, 1934/35.

The British Electrical and Allied Industries Research Association:—Technical Report J/T84, Summary Report from the National Physical Laboratory on work on Steels for use at High Temperatures completed during 1930/33. Sub-Committee J/E, Joint Committee; Steels for High Temperatures—Determination of Creep Properties of Metals for Engineering Purposes (Memorandum from Mr. R. W. Bailey). Corrosion in Superheated Steam. Development of Steels.

Ohio State University Bulletin No. 83. High-Speed Belt Drives.

Transactions of The Institution of Mechanical Engineers, Vol. 126, 1934, containing the following papers:—

"The Evolution of Invention", by Dickinson.

"The Inventor", by Hatfield.

"Provisional Patent Protection and Patent Claims", by Jarratt.

"The Development and Exploitation of Inventions", by Gledhill.

"The Development of Automatic Control Systems for Industrial and Power Station Boilers", by Hodgson and Robinson.

"Some Factors in the Design of Surface Condensing Plant", by Guy and Winstanley.

"The Mechanics of Electrical Switchgear", by Trencham.

"The Stresses in Thick-walled Cylinders of Mild Steel Overstrained by Internal Pressure", by Cook.

"The Mechanics of a Locomotive on Curved Track", by Porter.

"Design of Connecting Rods for High-speed Internal Combustion Engines", by W. Cowburn Durney. The Draughtsman Publishing Co., Ltd., 2s. net.

This pamphlet is one of a series on design of various machines and machine parts issued by the Association of Engineering and Shipbuilding Draughtsmen.

The author starts by giving a description of the designs of top end, shank and bottom end in most common use in high-speed engines. Following this is the necessary theory for calculating bearing loads and the stresses in the various parts. Finally, there is a number of tables of useful data. The author puts his material forward in a clear and simple manner, and his treatise should be valuable to students and designers who have not met with the problems of the high-speed engine.

"Mechanical Vibrations", by J. P. Den Hartog. McGraw-Hill Book Co., 390pp., 282 illus., 30s. net.

As most authors, assuming that their readers are already conversant with the fundamental principles of the subject, have treated special problems in great mathematical detail, there is very little literature on vibration suitable for the student. The volume under review, however, is intended for students and is so excellently written that it adequately achieves its purpose. It covers the general principles of vibration, dealing first with simple and then with more complex systems. Following the general treatment of the subject, the problems of multi-cylinder engines and of rotating machinery (turbines, etc.), are dealt with. Finally, there are chapters on self-excited vibration and on systems with non-linear characteristics. It will be seen, therefore, that most vibration problems which the engineer is likely to meet in practice are treated in this volume, and the student is led up to the more difficult material in a simple and straightforward manner.

There is one type of problem to which the author might have devoted more space, i.e., the vibration arising from a periodic displacement instead of a periodic force. This is the type of vibration liable to be caused by errors in the wheels or pinions of a geared system, and the problem presents special features that have been almost entirely neglected by writers on vibration. A section treating this problem might well be added to future editions of the book. In one or two places the author has used methods that, though generally accepted, are not strictly scientifically accurate; in such cases it would seem advisable to add a note warning the student that the methods are convenient approximations. The reviewer puts forward these criticisms in the hope that the author will, in future editions, make these slight improvements to a work which is already of outstanding value.

The theories in the book are illustrated throughout by examples of their use in practice. Each chapter contains a large number of questions for the student to work out, the answers to these being given at the end of the volume. A list of symbols—a valuable feature often omitted from technical books—is also included. Vibration is a problem of increasing importance to engineers, and for those who wish to make themselves thoroughly familiar with the subject, the author has produced an excellent book.

"The Thermodynamics of Electrical Phenomena in Metals", by P. W. Bridgman. Macmillan & Co., Ltd., 200pp., illus., 16s. net.

This book consists of material drawn from papers published by the author between 1919 and 1932. These papers have been welded together by means of an introductory chapter in which he illustrates the methods used in dealing with the effects produced by electric charges and currents carried by conductors.

The author then goes on to deal in turn with various electrical phenomena. He takes first the thermo-electrical effect and examines the energy equation for the thermocouple circuit, accounting for the electrical energy produced by the heat energy absorbed at the hot junction and the temperature distribution in the leads. In a similar manner he considers the Volta effect, thermionic emission and other lesser known phenomena.

The book deals entirely with the advanced physics of the subject which is treated in a highly mathematical and abstract manner. It will appeal to few but those deeply interested in one of the subjects touched upon.

"Accumulator Charging, Maintenance and Repair", by W. S. Ibbetson. Sir Isaac Pitman & Sons; 136pp., illus., 3s. 6d. net.

Commencing with a definition of most of the electrical units and symbols, the author shows in a definitely practical way how they are connected together to form Ohm's Law. The voltmeter and ammeter are described in detail and the methods of connecting the various types clearly indicated. The standard electric lamp is described and the author shows how easily it may be used for a resistance and at the same time still perform its normal function of illumination. A detail description of resistance wires is given, together with very useful tables dealing with size and length of wire suitable for charging any type and number of accumulators. A further table dealing with cost of charging is very useful. The lead acid accumulator is fully described, and it is shown how two lead plates immersed in sulphuric acid can be charged to alter the composition of the plates and thus form a simple voltaic cell.

The chapter on battery charging is perhaps the most valuable in this very useful book. Very good methods of testing the polarity of the supply mains are given, including the ammeter, the compass needle, and the lead plate tests. Connections for charging more than one cell are clearly shown and in some cases a combination of series and parallel wiring is given. Connections for charging wireless batteries at home are given and should be welcomed by wireless amateurs. The author's first method, however, is not to be recommended. He states that a cell may be connected simply across the lighting switch the correct way round. This would certainly charge the battery, but if the light switch were switched on the battery would be shorted and, apart from ruining the battery, there would be danger of a fire. Many well-tried and effective methods of garage charging are clearly explained, and an excellent paragraph is devoted to laying up an accumulator. The problem of laying up has to be dealt with sooner or later by all those who use batteries, as a great deal of harm can befall a battery if it is not properly attended to before going out of commission.

Alternating current is now supplied to 80 per cent. of electricity consumers, hence charging from alternating current has now become more important than charging from direct current. The various rectifiers are explained and the methods of connecting these are clearly described. The chapter on repairs deals fully with the various ills which befall accumulators. Refitting new plates is a comparatively easy operation, while repairing the original plates is fully described. The chapter on the alkaline cells should be useful, as the nickel-iron cell is becoming increasingly popular owing to its sturdy construction which resists vibration.

The fact that this book is now in its fourth edition is an indication that it meets the needs of those interested in the charging and upkeep of accumulators for wireless work, motor cars, emergency plants, etc., for whom it is intended.

"International Quarantine Directory". Obtainable in this country from Dr. M. T. Morgan, Ministry of Health, Whitehall, S.W.1. 21s. post free.

We have been requested by the Mercantile Marine Department of the Board of Trade to call the attention of our Members to the new (English) edition of the "International Quarantine Directory" (previously called the Quarantine Annual) which is now on sale. While the Directory is of special interest to Port Sanitary Authorities and Port Medical Officers in connection with their quarantine and other duties, the Board think it may also be useful to shipowners, shipmasters and ship surgeons, etc. The book contains in a convenient form information as to port sanitary dues, costs of fumigation, quarantine anchorages, board stations, arrangements for medical treatment and many other details of the health organisation of ports at home and abroad.

"Elementary Dynamics", by R. C. Gray. Macmillan & Co., Ltd., 211pp., illus., 5s. net.

After an introductory chapter on units, the author first deals with speed and velocity. Throughout the book the calculus, as such, is not used, but instantaneous velocity is shown to be $\frac{\delta s}{\delta t}$. Furthermore the notation $\dot{x}$ and $\ddot{x}$ for velocity and acceleration is used. The third chapter deals kinematically with acceleration, the usual formulæ being derived. Next, uniform circulation motion is considered and simple harmonic motion is introduced. The simple pendulum is considered, but one feels that this ought to have been postponed since the acceleration of the bob towards its mid point cannot be satisfactorily obtained without a knowledge of Newton's second law. The subject of force is then considered, and although both systems are treated, the author leans to the dynamic derivation rather than the gravitational one. The usual problems in the dynamics of a particle are considered, a chapter is devoted to friction, and another to work, energy and power. The properties of the centroid and the motion of a rigid body are then considered in a concise though sufficient manner, such as is not common to elementary books.

Chapter 14 deals with parallel forces and couples. Some of this is statics and might have been dealt with earlier, but the dynamics is in its proper place and well treated. The section on impulsive motion is interesting and adequate. The last chapter has for its subject the gyroscope. The treatment, as would be expected in an elementary work, is brief. The usual proof for precessional torque is given, in which it is assumed that moment of momentum is a vector quantity.

The subject as a whole is well treated, and criticism generally must be directed to the sequence of the work rather than to the manner of its presentation.

"Mechanics and Applied Heat with Electrotechnics", by S. H. Moorfield and H. H. Winstanley. Edward Arnold & Co., 6s. 6d. net.

This book has been written with the object of providing in one volume a course in engineering science which will prepare a student for his entry upon the final year of the Ordinary National Certificate Course. As the name implies, it comprises chapters on force, moments, friction, machines, motion, etc., together with others on heat, properties of steam, fuel and combustion, properties of gases, and the production of power. An appendix (occupying sixty-four pages) deals with magnetism, electric currents, resistance and electrical measuring instruments.

There has been a growing tendency to include in mechanical engineering courses some reference to electrotechnics. This tendency has been encouraged by the action of examining bodies, including our own Institute, of insisting upon a knowledge of the principles of electricity and magnetism. One is glad to note, therefore, that engineering science is being regarded as not only mechanics and heat but also electrotechnology.

The writer has been in the happy position, for a reviewer, of having been able to try out this volume in his classes. The results have been equally happy. The book is extremely well written, the diagrams are clear and well drawn, and the text leaves very little to be desired. The treatment of mechanics follows the most usual and successful method with engineering students, i.e., that in which force and conceptions of force are dealt with primarily, the more difficult dynamics being left until later. The chapters on the production of power deal with the oil and steam engine, including boilers. The treatment is more than adequate. The work on electrotechnics forms an admirable introduction to the subject, and leaves one desirous of more.

Candidates for Board of Trade Certificates (other than the Extra-First Class) will find it invaluable as a text book which works from first principles, and which will enable them to understand the solutions of many problems set in the practical mathematics and engineering knowledge papers. The reviewer cordially commends the book. It is reasonably priced and should prove an excellent text book for evening students. It more than covers the work required for the first two years of the Senior Course and, further, it should make a strong appeal to those preparing for the Studentship Examination of The Institute.

BOARD OF TRADE EXAMINATIONS.

List of Candidates who are reported as having passed examinations for certificates of competency as Sea-going Engineers under the provisions of the Merchant Shipping Acts.

For week ended 13th September, 1934 :—

Name.	Grade.	Port of Examination.
Atkinson, Edward	2.C.	Newcastle
Close, Anthony	2.C.	Newcastle
Henry, Peter	2.C.	"
Reay, Harold M.	2.C.	"
Huntley, John F.	2.C.M.	"
Purvis, Edward G.	2.C.M.	"
Cottingham, Edwin	2.C.	Liverpool
Staniford, Herbert E.	2.C.	"
Williams, John W.	2.C.	"
Wylie, Samuel J.	2.C.	"
Sinclair, John	2.C.M.	"
Lewis, Geoffrey R. H.	2.C.	Cardiff
Thomas, Norman W.	2.C.	"
Trenchard, Lewis D.	2.C.	"
Wickett, Hector G.	2.C.	"
Fraser, Alexander D.	2.C.	London
Goodier, James B.	2.C.	"
Hartery, James	2.C.	"
Skakle, John A.	2.C.	"
Armstrong, William	2.C.	Glasgow
Hope, James	2.C.	"
Titterington, Thomas	2.C.	"
Livingstone, Donald	2.C.M.	"

For week ended 20th September, 1934 :—

Name.	Grade.	Port of Examination.
Barr, John L.	1.C.	London
Edwards, Stanley W.	1.C.	"
Oliver, Reginald J.	1.C.	"
Payne, John E. M.	1.C.	"
Gillan, Francis D.	1.C.M.	"
McDonald, Leslie B.	1.C.M.	"
Norie, John W.	1.C.	Cardiff
Brady, Edward J.	1.C.	Liverpool
Carmichael, D.	1.C.	"
Geary, James A. G.	1.C.	"
Keith, Arnold M.	1.C.	"
Williams, Harold L.	1.C.	"
Bennett, Allan M.	1.C.M.	"
Thomas, Arthur S.	1.C.M.	"
Oliver, John	1.C.	Newcastle
Robson, John	1.C.	"
Munton, Rupert	1.C.M.	Newcastle
Adam, James	1.C.	Glasgow
Crawford, Charles S.	1.C.	"
Moodie, William	1.C.	"
Raeside, Charles	1.C.	"
Whitley, Henry T.	1.C.	"
Kerr, Colin F	1.C.M.	"
Miller, John G.	1.C.S E.	"
Hannah, Ralph A.	1.C.M.E.	"
Wright, Stanley B.	1.C.M.E.	Newcastle
McGill, James	1.C.M.E.	"
Nicholson, John S.	1.C.M.E.	Cardiff

For week ended 27th September, 1934 :—

Name.	Grade.	Port of Examination.
McFall, George K. V.	2.C.	Dublin
Griffith, John E.	2.C.	London
Richmond, Norman W.	2.C.	"
Strong, Harry D.	2.C.	"
Davidson, Hubert A.	2.C.	Liverpool
Redmond, William E.	2.C.	"
Timmis, George H.	2.C.	"
Cannell, Douglas H.	2.C.M.	"
Grant, Donald B.	2.C.M.	"
Kirby, William H.	2.C.M.	"
Shearman, William	2.C.M.	"
Brown, Thomas A.	2.C.	Glasgow
Cumming, Robert T.	2.C.	"
McMillan, John	2.C.	"
Robertson, William A.	2.C.	"
Storie, George A. T.	2.C.	"
Mackay, William C.	2.C.M.	"
Stewart, John	2.C.M.	"
Byerley, Frank A.	2.C.M.	Newcastle
Haines, James W.	2.C.	"
Miller, Walter P.	2.C.M.	"
Shevchenko, Alexander	2.C.	"
Bottomley, William	2.C.M.E.	"

ABSTRACTS.

The Council are indebted to the respective Journals for permission to reprint the following abstracts and for the loan of the various blocks.

Blackwall History.

"Engineering", 21st September, 1934.

"So we took barge and went to Blackwall, and viewed the dock, and the new West Dock, which is newly made there, and a brave new merchantman which is to be launched shortly, and they say to be called the 'Royal Oake'." Thus Samuel Pepys, turning aside from one of his official visits to the dockyard at Woolwich, takes note of the small and not conspicuously beautiful region that was for so long the heart of English merchant-ship building.

Pleasant enough it was, doubtless, in his day. Wooden shipbuilding dealt gently with its environment, as do most forms of craft woodworking, and of what that environment once was, there is evidence yet in the adjacent "Orchard Yard", though all warrant for the name has vanished under the great tide of Victorian brick-and-mortar. Now, as a birthplace of ships, Blackwall is as dead as Buckler's Hard; but the memory of former prowess is always worth preserving, and Mr. John H. Silley, delivering his presidential address on September 11th, to The Institute of Marine Engineers, had little need to apologise for its historical prelude. The tale stands re-telling, and the more familiar chronicle of later developments benefits by the aid to perspective.

Presidential addresses, of their very nature, cannot be easy to compose, and not only because so many have been delivered before them. The fierce light that beats upon a throne is not more intense than the spot-lighting of a presidential chair. The illumination is penetrating, for while kingship can be the lot of very few, presidency, as Beau Brummell said of holes in stockings, "may happen to any gentleman", if qualified and willing to undertake it.

Herein, perhaps, is one main reason for the historical tendency so frequently evident in such discourses, and sometimes unthinkingly contemned. The recounting of experiences that many can parallel in whole or in part has always the merit of assuring a wide appeal; which, on reflection, is a curiously contradictory state of affairs, for the average technical man, whatever his brand of technology, can seldom be brought to admit that there can be any virtue in dwelling upon the past.

Some of the most dependable sources of information on the work and the methods of earlier generations of engineers are to be found in presidential addresses, and so long as the story continues to be told at first hand, the practice has everything to commend it, and the interest will never flag. Some repetition and overlapping there must be, and often an earnest but misguided effort by an author to keep his own personality strictly in the background leads to omissions that future readers would give much to be able to supply, but some fragments of personal reminiscence usually manage to creep in, to gladden the heart of the comparative historian.

History, it has been said, is the executioner of human conceit, and hence it is neglected as a study. One may endorse the first part of the apophthegm without necessarily subscribing to the second, at least in its relation to the study of engineering history by engineers. That this is a neglected study is, unfortunately, beyond question, but it is hardly a neglect of established authorities, and is due much less to the conscious desire to maintain an exalted conceit than to unsound extrapolation from the principle that an engineer, to be worth his salt, must above all things be "practical". Looking backward is not "practical"; and as history consists in looking backward, for this reason so runs the implication, it is no fit subject for the engineer. Such interest as he may take in it is at best held to be an amiable weakness, to be confessed, if at all, with apologetic diffidence.

The argument is specious and widely supported, but it will not stand examination. True history is not looking so much backward as looking around; taking in the backward view as well, but keeping the foreground always in focus. The greatest neglect, however, is of the foreground, the history that is daily in the making. Whether it is felt that the topical is usually trivial, or whether the senses have been dulled by the heralding of so many "trends of development" that have belied their early promise, the fact remains that technology has never been sufficiently supplied with chroniclers of the stamp of Pepys and Defoe, who were not afraid to fill their notebooks with the little details of the working life around them.

Thus craftsmanship is forgotten, whole trades languish and pass away, and the world must make the best of belated and incomplete obituaries in default of living biography. Nor can it be said that the various societies interested in the history of technology entirely repair the omissions. They have done much good work in this direction, but the greater part of their published papers still incline to strengthen the common impression that there is not much to choose between the respective functions of the historian, the antiquary, and the archæologist.

The Society for Nautical Research, it is true, has treated at some length of the steam warships of the "Up screw! Down funnel!" era, but only in relation to their design, rig, and service performance. Never, we believe, has it discussed the development of iron ship construction, or the gradual changes in shipyard equipment, personnel, and practice as ships grew in size and iron succeeded wood. Marine engineering, though not specifically excluded from its purview, it is content to leave as an historical subject to the Newcomen Society; which, taking all industrial technology as its province, may be supposed to have some interest also in the methods of shipbuilding and repairing.

Only a fraction of the evolutionary process has yet been recorded, and so much accelerated is the present rate of change that the leeway will be very difficult to recover. Figurehead-carving is virtually extinct; the trade of the caulker is dying, for even decks of wood are becoming noticeably fewer; the expert rigger has ever less opportunity to display the finer points of his craft; and all the while new arts, such as welding, and the gas-testing of oil tanks, are arising to take the places of the old.

On the engineering side there is the same story of slow but remorseless change. A good engine-fitter, especially in the repairing yards, still recalls something of the old-time enginewright by the variety of his skill, but the complex metallurgy of the more advanced marine engineering is setting new and restricted bounds to his utility. Elaborately heat-treated materials cannot be cobbled by a handy mechanic in the easy fashion of the simpler irons and steels and bronzes. Like the delicate gear of modern electrical engineering, they demand the apparatus and the services of specialists when crucial operations must be performed.

The dock that Pepys saw has disappeared. The London and Blackwall Railway was carried over a part of it a century ago, and now the railway is abandoned and derelict. The topography of the yard itself has altered materially, and its activities are largely transferred to more convenient situations on Thames-side. Some of these things were recorded when Henry Green and Robert Wigram, 53 years ago produced Part I of "The Chronicles of Blackwall Yard". Part II never appeared, and although it would be pleasant to think that somewhere the notes for it are still extant, preserved like the "Naval Minutes" that were to have been the basis for Pepys' own unwritten book on the Royal Navy, we do not know whether such may be the case. There has been material enough for a Part III in the present century. It is still accumulating; and, inevitably, it is still wasting away.

These reflections have wandered some way from their origin in Mr. Silley's address to The Institute of Marine Engineers. We return to it, having reflected, with full appreciation of its scope and detail, but with a measure of regret that, while recognising all the major marine engineering advances of the last fifty years, and the men behind them, it touched so rarely upon the work of Mr. John H. Silley, which none could have reviewed with a surer judgment.

A Team of Experts.

Naval Architect and Marine Engineer.
Making of a Master Mariner.

From a Correspondent.

"The Times", 25th September, 1934.

"It is anticipated that No. 534 will maintain an average speed somewhat greater than 28 knots on the Atlantic crossing"—not a thrilling announcement, it conveys so little.

If a sports car shot out from the courtyard of the Houses of Parliament, circumnavigated the roundabout, and then sped up through Whitehall at 32 miles an hour, even the casual pedestrian would take note of the happening, the traffic constables probably a more permanent record. "Going too fast!" would be the general comment. But suppose that the entire venerable structure itself broke away from its foundations and, disdaining the traffic instructions, cut directly across and went careering after the sports car—at the same speed! The idea may seem fantastic, but it is not so far removed from certain realities.

The 70,000-ton bulk of No. 534 is hardly less enormous in its perspective than are the Houses of Parliament, and when the ship is thrusting forward at the rate of 28 knots she will actually be travelling at over 32 miles an hour. Further, when travelling at this speed she will be forcing her way through a depth of water of nearly 40ft., and will virtually be dragging with her a mass of water weighing an added 70,000 tons. These are the simple facts underlying that first bald announcement. Ships in the distance are so difficult to size up, and they travel so slowly when one is on board, at least so it seems, for they make far less fuss than a sports car. The performance recorded by the new ship, when this is analysed, will doubtless astonish all—save the men who design, engine, and handle fast vessels: the naval architect, the marine engineer, and the master mariner.

Course of Study.

For a maritime people we are remarkably ignorant of the national importance of this team of experts, to whose quiet and persistent work was originally due the creation of our modern maritime supremacy, to whose imagination and far-sighted initiative the future prestige of British maritime interests must inevitably be entrusted. Be the vessel naval or mercantile, the final successful outcome of any new design depends upon the combined genius of these men, each responsible for branches of theoretical and practical endeavour complementary to one another—together producing great ships as No. 534 will be when presently she sets out across the Atlantic.

To take a worthy place as a junior in either of these three professions a youth, after he has absorbed sufficient elementary training to qualify him to leave school with credit, should, beginning at 16, spend some eight years gaining detailed insight into the scientific and practical aspects of work he is to attempt to undertake. It will be convenient to trace the types of studies which beginners in these professions will have to take up in the order in which the professions have been named, because in the development of high-speed ships the basic requirement, a good ship form, falls within the province of the naval architect, without the marine engineer the best form imaginable could not be driven at speed, while long before either naval architecture or marine engineering became complicated sciences, the British master mariner had already thoroughly established his supremacy in every one of the Seven Seas.

The great importance to the prospective naval architect of a thorough grounding in mathematical and scientific subjects was recognised long years ago by the British Admiralty, and it was due to the foresight of the Lords of the Admiralty that study of the science of naval architecture was placed upon a sure foundation in this country, so that, while the vessels of the British Navy were still under sail, the form designs of those vessels, and their constructional perfection, were already being considered along scientific lines. At the present time this country is well equipped for the training of naval architects, although the long period of intensive study required, coupled with the restriction of output from which British shipyards have suffered during the past decade, has greatly reduced the numbers of students.

In the Dockyards.

In present circumstances an outline of the character of the tuition given at the Government Dockyards will best serve to indicate the extent of the training considered essential. Primarily it is necessary that a naval architect should have a very sound grasp of the practical side of his profession —that he should be familiar with the tools with which ships are built, able to understand the general sequence of the detail work necessary and possessed of a proper sense of proportion in regard to the fundamental principles underlying the practical constructional work. In short, it is desirable that he should be, first and foremost, a reasonably competent craftsman having served his time as an ordinary apprentice. While he is occupied with the absorption of such practical knowledge, the scientific side of his education is being catered for by tuition in the principles of mechanics and dynamics, electricity and chemistry, heat and hydrostatics, with mathematics, gradually increasing in scope and difficulty, as a constant and inevitable background to the whole curriculum. With further progress in applied mechanics, strength of materials, hydraulics, hydrodynamics, metallurgy, practical analytical chemistry, thermodynamics, and electrical engineering—these two last in broad but fairly complete outline only—the student will begin to feel that in due course he will be able to determine for himself answers to the complex problems which beset the path of the practising naval architect.

And of what do these problems consist? Of designing steel structures capable of being thrust through the water at high speed with a minimum of resistance, able to carry a maximum weight of cargo a maximum distance on a minimum weight of fuel, able to sustain underwater damage without sinking or capsizing, able comfortably to accommodate a vast crowd of people careless of everything but their personal enjoyment—able to do a thousand and one other of those things which may be required of a No. 534, a cargo tramp, a line-of-battle ship, a paddle steamer, or any other of the vast fleet of craft which take the water every year. Fundamentally, the same training was at the back of the designs of those midget tugs which will presently coax No. 534 to her berth as was necessary to ensure complete understanding of the larger scale problems involved in the design of the big ship herself.

A Practical Man.

Of all professional men using steel as the most important element in their work, the naval architect must be thoroughly competent in his attack upon problems involving the calculation of strength and stiffness, for, of all men, he is the most daring in pitting the practical result of his calculations against great natural forces, while it is yet untried. It is possible to put a "proof load" upon a bridge, a crane, a boiler, the section of a dam—but it is literally impossible to do the like with a ship which is to cross the Atlantic. Failure under such "proof load" as the Atlantic itself may impose must spell disaster.

However, the naval architect is ably supported in his task by the marine engineer, whose training generally differs but little in its essentials from that of the naval architect. Serving his apprenticeship by spending short periods in the machine shop, the smithy, the foundry, the pattern-maker's shop, the boiler shop, the erecting shop, on the test bed, out on ship machinery trials, and in the drawing office, the budding marine engineer completes one phase after another of his practical training the while his theoretical tuition is following a very similar course to that already outlined for the naval architect. It is essential that he, also, should be fully alive to the physical reasons for the behaviour of the material with which he works, and should understand every step of the mathematical path along which theory has passed in producing the intricate *formulæ* with which he is called upon to work in determining the size of shafts and the thickness of boiler shells—to mention but two of an infinite variety of dimensions and scantlings. The marine engineer must have an answer to every "Why?" that can be put in connection with his machinery designs before he is content to take responsibility for passing those designs as suitable for the engining of a vessel which is to venture to sea with passengers, with a valuable cargo, or carrying the White Ensign.

In one sense the marine engineer is a much more practical man than his team-mate, the naval architect. Before he is permitted to use the title he must actually spend some time at sea, working in the engine and boiler rooms of a steamship, or taking equivalent duty in the Diesel engine room of a motor-ship.

Time at Sea.

The spending of time at sea is reckoned an essential part of the early training of all young naval architects in the Admiralty service. It is also recognised as of importance by shipowning companies having naval architects on their staffs, but even so, the sea time which must be put in by the man who wishes to qualify as a full-fledged marine engineer is a much more serious matter. Not only must such an aspirant satisfy the Board of Trade that he has had a sound training, such as should ensure that he will eventually be capable of assuming the responsibilities of his profession, but he must sit for and pass an examination searchingly directed to the discovery of weaknesses in his mental and practical equipment before he can receive his first official badge—his "Second's Ticket". A further examination, following a further period at sea, must be passed before he can receive his "Chief's Ticket", and yet a further examination must be passed, of a very high theoretical standard indeed, such, in fact, as would not easily be passed by a man having an extended university training, before he can gain the coveted "Extra Chief's Ticket".

In the circumstances it is not surprising that, among those municipal and other authorities whose officials are fully acquainted with the character and extent of the qualifications possessed by the certificated marine engineer, there is insistence that all responsible posts in connection with power plant or generating stations should be placed, by preference, in the hands of men possessing Board of Trade certificates. Not only is it the fact that, in making such a ruling, those responsible for the appointments are safeguarding themselves behind the searching ordeals instituted by the Board of Trade to ensure that only competent men should receive certificates, they are also looking to benefit from the enormous experience and sense of individual responsibility and sufficiency which comes only to men who have had the task of maintaining power output at sea in stress of weather, and under circumstances such as would daunt the bravest. These were the men who kept our ships running throughout the war. They worked in grimy stokeholds and stifling engine-rooms—very often battened down in heavy weather, with but the bare ghost of a chance of safety should submarine attack be driven home.

For sheer breadth of scope there is no branch of engineering ashore which is comparable with the range of work which comes within the ambit of the marine engineer in charge of the machinery of a modern liner. On shore there is a definite tendency to specialise—a man becomes a turbine expert, a boiler designer, a Diesel engineer, a specialist on turbo-generators, a past master on condenser problems, a refrigerating engineer, an encyclopædia on fuel economy—that is unless he is marine engineer to a shipping company, and in that case he must be prepared to discuss any and all of these matters with a knowledge very little less detailed than that of the specialist himself. As for the marine engineer who is actually serving at sea in a ship having plant of every one of the above types actively functioning on board, there can be no question as to the need that he should be a thoroughly competent, scientifically minded, intensively trained and shrewdly ingenious personality.

Wide Knowledge.

These qualities are forced from the man by the immense responsibilities he carries—the extraordinary thing being that it is only of comparatively recent years that adequate recognition has been extended to those following the profession of marine engineering. The fact has to be faced that within the past 20 years a revolution has taken place in marine engineering following the introduction of Diesel machinery which, by its competition speeded up the development of every other type of power generation and transmission until there are now a dozen and one different ways of propelling a ship. These vast changes have found the marine engineer competent to meet every demand, to rise to every contingency and in many cases alert to extend boundaries afresh, almost before they had been defined.

And what of the master marine—master whether he be of warship or merchant vessel? There are no longer jealousies between executive officers of the naval and mercantile marines—the war cemented a lasting respect and friendship on both sides. If it takes eight or nine years to turn out a naval architect or a marine engineer, it takes every bit as long to equip a man to qualify for a footing among the juniors of those who aspire some day to the command of a "big ship". Here, as with the marine engineer, the British Board of Trade takes great pains to ensure that none but the fully competent shall be able to boast possession successively of their certificates as "Second Mate", "First Mate", "Master" and "Extra Master". Training to be a master mariner follows a less restricted path than applies in the case of the naval architect or marine engineer. Different shipping companies and the Admiralty itself have a varied routine for those who seek the highest distinctions, a routine not less intrinsically difficult, but perhaps less intensively scientific than that which must be mastered by the men who are to design and build the ships and engines the master mariner is to handle.

If it be permissible to draw a sweeping distinction between the basic character of the training of the master mariner and that of his colleagues, it would be by suggesting that while the training of the naval architect and the marine engineer is directed to giving them complete mastery of the materials in which they work and from which they create the ships and engines which serve their chosen purposes, the objective towards which, perhaps unconsciously, the training of the master mariner is directed is that of giving him power to employ forces which are either uncontrollable or else of a character which will not come within the scope of rigid rules and formulæ. Fundamentally the duty of the master mariner is to "take command"—and that he can never do successfully unless he has been long trained in the development of a tactful strength of mind. It is hardly too much to suggest that the men who rise to eminence, as admirals in his Majesty's Service or as commodores in one or another of the great shipping companies, are possessed of qualities not shared out equally among the majority of men. While, therefore, it is possible to set down a series of special navigation and kindred subjects which must be thoroughly digested by the prospective candidate for the formal Board of Trade certificates, including a fairly comprehensive knowledge of the principal features of ship design and construction and a working understanding of the more straightforward elements of the main and auxiliary machinery, it is not possible to set down all that must be learnt by those candidates who are to pass finally into the highest positions. It needs the hard school of deep sea experience to ensure the ability needful to cope with the extraordinary emergencies which arise at sea in the handling of ships and men.

There are other aspects of the training of a master mariner which deserve especial mention. He must be skilled in commercial maritime law, have a wide knowledge of the Merchant Shipping Acts or their equivalents for all the countries to whose ports he takes his vessel, be familiar with a variety of emigration and immigration laws, competent to assess dues of various kinds, understand how to stow and handle cargo of infinite variety—above all, able at all times to maintain a wise and just discipline under circumstances which endow him practically with the power of "absolute government".

Tradition and Science.

Tradition plays a far greater part than science in the training of such men, and will continue to do so, no matter how much is done to ease the burden of command by installing one scientifically perfect instrument after another on the front of the bridge or in the semi-seclusion of the chartroom. The greatest comfort passengers enjoy when stress of weather dispels all thought of the inherent strength and safety of the vessel in which they are lies in their utter confidence in the ability of the master mariner to whose quiet tones every other officer and man on board is instinctively responsive.

Within a few years notable distinctions have come the way of master mariners, naval architects, and marine engineers. A livery has been granted the Honourable and Worshipful Company of Master Mariners, of which the Prince of Wales is Permanent Master. The Worshipful Company of Shipwrights now has the Duke of York as its Permanent Master, while this year there has been granted a Royal Charter to The Institute of Marine Engineers, a body whose transactions contain extraordinary evidence of the tremendous growth which has been recorded in marine engineering during the past two decades.

Adjustable Blade Turbines.

"The Engineer", 28th September, 1934.

A new unit added to the U.S. Government's hydro-electric plant at the falls in the St. Mary's River at Sault Sainte Marie, U.S.A., consists of a 114in. propeller type vertical shaft adjustable blade turbine rated at 3,000 h.p. with 20ft. effective head, running at 128 revolutions and directly connected to a generator of 2,500 kva. It differs from the earlier Kaplan adjustable blade system, in which the adjustment of the blades is synchronised automatically with the movement of the guide vanes, transmission of the movement being accomplished by oil pressure. In the new Saint Mary's River unit electrically operated mechanism adjusts the tilt of the blades to give maximum efficiency under varying conditions of head and gate opening. The movement is not made automatically, but is controlled by push buttons at the main switchboard of the power plant. The position of the blades at all times is registered by means of a potentiometer enclosed in the housing and electrically connected with the switchboard. Besides adjusting the blades to meet changes of head and load so as to produce power at approximately the maximum efficiency at the best head and gate opening, a reduction of wear on the bearings is effected by making no adjustment of tilt for minor variations in load, over which the change in efficiency is negligible. The operating mechanism consists of a train of electrically operated gears at the top of the hollow turbine shaft and driving an interior solid shaft which carries at its lower end the apparatus for transmitting the adjustment motion to the blades of the runner. This apparatus includes self-locking gears which hold the blades positively at the position in which they are set, until rotation of the solid shaft shifts them to a new position, in which they are again locked. The motor and gears are built into the shaft and revolve with it, power being transmitted to the motor through slip rings. In the draught pit beneath the turbine is a concrete hydraucone of 32ft. diameter over its outer edge.

Thermal Control of Boilers.

Application to Ships' Stokeholds.
Co-ordination of Controlling Factors.

"Journal of Commerce", 13th September, 1934.

At the third French Congrès du Chauffage Industriel, M. Roger Martin read a paper entitled "General Considerations on Thermal Control in Boiler-rooms and its Application to Marine Installations".

Thermal control, he stated, was little used in industry. Many factories possessed the plant, but did not employ it; neither could it be denied that in many instances the installation of thermal control brought with it a reduction in fuel consumption, a diminution of physical effort and a greater facility of operation. There was, therefore, an anomaly arising out of the fact that the setbacks experienced were generally due to a misinterpretation of the real meaning of the term "heat control".

In order to be efficient in questions of firing heat control must be introduced, and this term used in the wide sense means the scientific organisation of the boiler-room. It served, as a matter of fact, no purpose to know that the heat losses were very high if one could not reduce them. It was no use blaming the stokehold, but it was necessary to try and find out if there was a possibility of improvement, and to see afterwards that the firemen had the necessary means at their disposal. In a boiler-room the object aimed at was to produce steam at a given pressure and temperature with as small a fuel consumption as possible.

The Operations Analysed.

The factors influencing operations could be divided into three groups:—

1. Feed factors: The nature of fuel, the ambient temperatures and pressures, the total steam requirements, the temperature and quality of feed water. Those factors had in general to be kept in mind by the operating staff.

2. Operation factors, including the quality of the feed water, the steam pressure, superheating temperature, water level, evaporation rate, rate and conditions of combustion. The personnel had an indirect influence on these factors in the sense that it had to effect adjustments as necessary to obtain their correct value.

3. Adjustable factors, consisting of the air supply, feed-water supply, fuel supply, draught and the cleanliness of the heat exchange surfaces. The personnel had a direct influence on those factors.

The installation of recording apparatus to control each of the factors mentioned did not suffice to ensure thermal control. It was found, in general, with that method that the results were poor. The number of variable factors at stake was too large, and they reacted the one on the other.

To solve the problem it was necessary first to separate the operating and adjustable factors upon which the personnel had a direct or indirect action, and these factors had to be divided into two groups.

(*a*) Those which were independent, that was to say, which might vary without inducing a direct repercussion on the other factors; they were, water level, quality of purified water, superheating temperature.

(*b*) Those which directly affected the combustion conditions, and in which any action on one of them brought about a variation in all the others, and rendered the value of control very problematic. Heat control adjustment consisted in effecting and maintaining in equilibrium the three regimes:—

Triple Control.

1. Temperature regime.
2. Pressure regime.
3. Oxydising or atmospheric regime.

The temperature regime could be defined as the record of the temperature curve along the course of the products combustion.

The pressure regime was a similar curve giving the pressure at the different points of the course of the combustion products.

The atmospheric regime was expressed generally in CO^2 per cent., oxygen per cent., CO per cent., at the different points of the furnace and uptakes.

These three rates were perfectly distinct, and had to be studied separately to obtain satisfactory working conditions, but they were not independent the one of the other, but were really in close relation.

As a matter of fact, with careful observation methods, it was possible to separate a certain number of factors which, without being absolutely independent, could be considered as such within the limits of variation.

After having separated the operating factors into figures capable of being considered as independent, the adjustment factors were separated by the same process. A certain number of them were then fixed until those capable of independent adjustment were equal to the number of determined independent operating factors.

The adjustable factors and the operating factors were then grouped two by two, and the work of organisation having been carried out, there only remained to grade each adjustable factor as a function of the different values that the corresponding operating factor might take.

The rules might then be condensed into the form of simple instructions which would occasion no difficulty regarding their interpretation. This method had sometimes enabled extraordinary results to be obtained, because:—

1. It became possible to determine with accuracy the best values at which the different rates had to be fixed.

2. The variations of the operation factors, as

a result of the variations of the feed factors, might be immediately compensated for by an action on the corresponding adjustment factor.

Two typical examples of tests carried out in steamships were quoted by M. Martin, and in both instances there was no change made in any part of the installation. In the first example, the vessel dealt with was a cargo vessel of 9,000 tons arranged for hand-firing, coal with 30 per cent. of volatile matter being used, forced draught and airheated by the Howden system, superheated steam, normal power 1,500 h.p. The average speed was increased from 8 to 10 knots, that was to say, an increase in speed of 25 per cent. for the same fuel consumption, the thermal control being carried out during a period of four months.

The other test was taken in a modern liner, oil fired, with water-tube boilers, steam slightly superheated, normal power 9,000 h.p. For the same service speed, the fuel consumption before the change exceeded by 35 per cent. the present consumption. The control of fuel consumption was carried out for a period of six months.

Meter of Refrigerating Capacity.

Linear Scale with Large Dimensions.

By R. Heiss.

(Communication from the Refrigeration Institute, Karlsruhe). "Ice and Cold Storage", September, 1934.

Any measuring device showing the capacity of a refrigerating installation must fulfil the following conditions :—

(1) Its insertion must not disturb the normal working of the plant.
(2) Its range must be as great as possible.
(3) The scale should be linear.
(4) Simplicity in use.
(5) Space occupied and price must be as small as possible.

The condition that the measuring apparatus shall not affect the quantity passed is a fundamental rule in the technique of measurement. It is to be expected that in layouts which require a large quantity of refrigerant or a considerable fall in pressure, it can only be fulfilled if the apparatus can be permanently installed.

The importance of a linear scale with large divisions is obvious.

The necessity of a low price is brought home by the fact that a meter is not an absolutely necessary piece of equipment. This does not lose sight of the fact that the various measuring devices generally installed with refrigerating plant, such as gauges, thermometers, etc., cannot give the necessary results in a quick and simple manner. The determination of the load and through it, the performance, is very important, but the personnel of the majority of plants are not capable of indicating compressors or of evaluating any indicator diagram.

The float type of meter fulfils the conditions set out above and a model marketed under the name of the Frigorota or Rotameter was placed at the disposal of the Institute. The principle of measurement is the provision of a restriction in the liquid circuit so that a difference in quantity passed produces a difference of pressure, which can be indicated on a scale; alternatively this scale can be calibrated for refrigerating effect according to the refrigerant used.

The measuring tube is in communication at

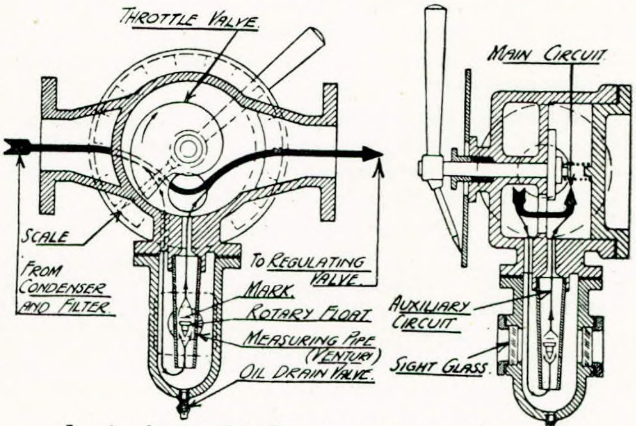


Fig. 1. Section of the Frigorota measuring valve

both ends with the spaces before and after a throttle and a portion of the flowing liquid is led through it. A constant pressure difference in this tube is indicated by a stationary position of a sharp-pointed float which can move up and down therein. The top rim of the float has inclined grooves which give it a rotary motion without departing from its axis, when liquid is flowing upwards past it, therefore the float cannot rub on the glass.

The throttle is adjusted so that the float is in suspension opposite a mark on the sightglass, and the quantity of fluid passing hourly with that position of the float and different positions of the throttle is marked on the scale, which is also calibrated to give the corresponding values for hourly refrigerating output.

As compared with the direct float meter, a

Comparison with Heat Balance Method.

	Water.			Condenser.			Evaporator.		Quantity.		
	Temp. deg. F. in.	Temp. deg. F. out.	Galls./hr.	Temp. deg. F. in.	Temp. deg. F. out.	lb./sq. in.	Temp. deg. F.	B.T.U./hr.	Calculated from heat balance.	Indicated by Frigorota.	Discrepancy per cent.
1	52·2	67·6	668	125·3	55·4	127	11·75	93,500	182·9	189·3	3·5
2	52·8	68·6	551	108·6	57·8	128	8·71	79,400	156·9	162·0	3·2
3	52·3	65·4	593	114·8	55·8	121	3·2	68,200	133·3	137·5	3·1
4	52·7	64·8	169	86·3	58·5	116	0·29	18,200	36·8	37·7	2·6

slight disadvantage of this indirect measuring value is that the main stream (indicated by a heavy arrow in Fig. 1) must first be in action. This is offset by many advantages. The measuring tube is very small so that it can be made quite accurate without difficulty; it is protected by a metal hood which is fitted with sightglasses of suitable strength for the refrigerant measured.

The measuring tube is under practically the same pressure inside and out. The throttle plate, in the body of the apparatus, is shaped similar to an Archimedes spiral (Fig. 1). This enables linear divisions to be employed, whereas with a direct type of float meter a uniform change of annular surface is accompanied by a parabolic change of orifice.

The relative accuracy throughout the range is consistent; the direct type serving for small quantities.

The float is lifted by the flowing liquid to such a height that its own weight, less its static buoyancy, accurately compensates for the pressure drop in the annular clearance.

When A_f=the projected surface of the float.

Δ_p=the pressure drop in the annular clearance.

W_f=the weight of the float.

V^f=the volume of the float.

γ =the specific weight (density) of the liquid.

Then the balanced condition is expressed by

$$A_f \Delta_p = W_f - V_f\gamma \quad \text{.........................(1)}$$

When W_1=the weight of liquid passing through the measuring tube per second.

W_2=the weight passing through the body of the valve per second.

a_1 and a_2 the respective flow constants.

A_1=the section of the measuring tube at the mark.

A_2=the area of the opening at the throttle plate. then, if the measuring valve is correctly installed:

$$W = W_1 + W_2 = [a_1 (A_1 - A_f) + a_2 A_2] \sqrt{2_g \gamma A_p} \text{...(2)}$$

in lb./sec.

Substituting the value for A_p from equation (1)

$$W = [a_1 (A_1 - A\ ) + a_2 A_2] \frac{\sqrt{2_g \gamma (W_f - V_f\gamma)}}{A_f}$$

The investigations were carried out on a metering valve constructed for an ammonia plant of 8 tons refrigerating capacity. The ammonia passing through under working conditions would, alternatively, be calculated by taking the heat balance of the counter-current condenser and deducing therefrom the heat exchanged.

The thermometer, pressure gauges and water meter were all calibrated before the test and the greatest error possible in W through their combined inaccuracies was ±0·5 per cent. A liquid level indicator was fitted to the condenser and a Hampson meter to the evaporator in positions enabling them to be read accurately, near the regulator.

The liquid level in the condenser was maintained in the connecting piece between two pipes so that a small change of volume caused a relatively greater difference of height. The pipes leading to the sightglass were insulated, to avoid the liquid level being affected by heat ingress or sub-cooled liquid.

The next question centres around the possibilities of errors in working, as the setting of the regulator seldom gives a constant weight of liquid on the condenser or the evaporator side of the plant; these usually rise and fall. The weight of gas sucked by the compressor does not therefore agree with the quantity of liquid passing the regulator, but is either greater or smaller.

It is fundamentally necessary to provide at least the condenser with a liquid level indicator, also independently from the quantity measurement, an easy means of ascertaining the liquid condition in the plant for correct charge; for the latter reason it is always desirable to provide the evaporator also with a liquid level indicator.

Simple errors in reading occur, as the following deliberation shows, not especially in weight. The pulsating flow will, due to the volume of the condenser, be damped down, but may in some cases cause an error of ±1mm. Oil films on the glass tube may give a false reading up to 0·5mm. Both errors can be suspected by small differences from normal operation. There is also a possibility of error due to differences in extent of undercooling; this is negligible.

These errors lie within the limits of tolerance set for a guaranteed performance by standard codes.

The Frigorota may also be used on individual circuits of an installation as a check on charge and performance.

The Surface Condenser. Part I.

"The Engineer", 24th August, 1934.

Although the condenser is as old as the steam engine—for the earliest forms of that prime mover relied for their motive power on the fact that the condensation of steam within an enclosed space created a vacuum—it may be said of the surface type that its real development to a high state of efficiency had to wait upon the coming of the steam turbine. Improvements began to be made about 1900, and finality has not yet been reached.

Essentially, a surface condenser consists of a shell either of cast iron, or a built-up steel structure, into which the steam is passed and is condensed by contact with a nest of tubes maintained at a lower temperature than that of the steam by the circulation of cooling water. The shell is usually more or less circular or boat-shaped in cross section, and the tubes are laid along its length and supported at each end in a tube plate. Intermediate "sag" plates may support the tubes between the tube plates. A space beyond the tube plate at each end forms a water-box from which the cooling water can gain access to the interior of the tubes, or into which the water may emerge from the tubes.

These water-boxes may be so divided as to force the cooling water to pass through the condenser once, twice, or several times. Steam from the exhaust of the prime mover usually enters the space around the exterior of the tubes from above, and the condensate is, of course, withdrawn from the bottom. The small proportion of air and incondensible gases that comes over with the steam is withdrawn by an air pump.

With certain reservations the foregoing description of a modern plant could be made to do duty for a typical design of thirty years ago. Indeed, as far as a general description is concerned, it may be said that all surface condensers are the same, and that their design has not altered greatly since they were first developed. In the detail of interior arrangement, however, it is probable that the designs of the various manufacturers differ from each other more to-day than they ever did before the opening of the present century. Until about 1900, in fact, little attention had been directed towards the improvement of surface condensing plant, and it was usual for a consulting engineer merely to specify that the condenser for a certain installation should have so may square feet of cooling surface, his calculation being based upon the empirical assumption that so many pounds of steam could be condensed by every square foot per hour. Little heed was paid to possibilities of heat conservation. The significant coincidence of dates suggests that it was the advent of the turbine which brought about a change of attitude. Much larger condensers began to be required than had ever been built before, and higher vacua became desirable. Manufacturers then discovered that if they founded their calculations on the results obtained with smaller plant the performances of their bigger productions did not accord with expectations, and the anomaly that by the removal of tubes and a consequent reduction of cooling surface the performance could be improved led them to put in hand experimental researches whereby the reasons for the discrepancy and the anomaly might be discovered. Many years had to pass, however, before the old "so many square feet per horse-power" theory was discredited, and before it became the practice to specify the duty of the condenser and to leave the manufacturer to design it in any way that he considered fit.

As a result of researches carried out before and since the war, cooling surfaces in condensers have been reduced from about 2 square feet per kilowatt to 1 square foot, and the pressure drop through the tube nest on the steam side between the steam inlet and the air suction branch has fallen from about 1in. to one-half or one-third of that figure. At the same time the overall rate of heat transmission from steam to circulating water expressed in B.Th.U. per square foot per degree Fahrenheit per hour has, of course, risen very appreciably.

In spite, however, of the amount of experimental work that has been done, and the great improvement that has been effected, it would be idle to suggest that any finality has been reached. Every manufacturer, for instance, has his own opinion as to what constitutes the best tube plate arrangement; it is by no means settled whether it is most advantageous to withdraw the air from the top, the bottom, or the middle of the condenser, and experiments have demonstrated that the rates of heat transmission in different tubes of the same condenser may vary enormously in relation to one another. Nor has it ever been satisfactorily explained how it is that, in modern regenerative condensers, the temperature of the condensate has frequently been found to be several degrees higher than that corresponding to the vacuum.

With these points in view, therefore, it is the object of this series of articles to review present-day practice in the design of surface condensing plant, and to examine in what manner the designs and opinions of different manufacturers are opposed to one another. In addition, we have found on many occasions that there is among those who have seldom, or never, come into contact with the design or operation of condensing plant a certain lack of that interest an engineer should feel even in the fields of endeavour which he has not made specifically his own. This lack of interest can only be ascribed to a belief that there is nothing worthy of much attention in the design and operation of condensers, and it is our hope that these articles may do something to correct an erroneous impression which has, perhaps, been fostered by the great apparent importance of the boilers and turbines in a modern power plant; by the immobility of the condenser itself, and by the unimpressive appearance of its auxiliaries.

Condition of Steam at High Vacua.

Before entering upon a description of the various plants manufactured by the different makers, it may be both instructive and interesting to obtain a clear conception of what the functions of a surface condenser are, of what limitations are imposed upon its design by external factors, and of the kind of conditions that exist within it when it is in operation. For this purpose the steam tables provide an excellent starting point. In Table I there have been abstracted from Callendar's steam tables a number of figures illustrating the condition of steam under low absolute pressures:—

TABLE I.—*Barometer* 30 *inches.*

Vacuum, in. Hg.	Abs. pressure, lb./sq. in.	Saturation temp., deg. Fah.	Latent heat, B.Th.U./lb.	Volume, ft.³/lb.
27·0	1·469	114·9	1,025·8	231·9
27·5	1·224	108·6	1,029·2	275·4
28·0	0·979	101·0	1,033·3	339·8
28·5	0·735	91·6	1,038·3	445·2
29·0	0·490	78·9	1,045·1	653·0
29·5	0·245	58·6	1,055·8	1,257·0
29·6	0·196	52·5	1,059·0	1,554·0

These figures demonstrate a point that is not always clear to those unused to condenser problems. In all large turbine installations to-day—and in the

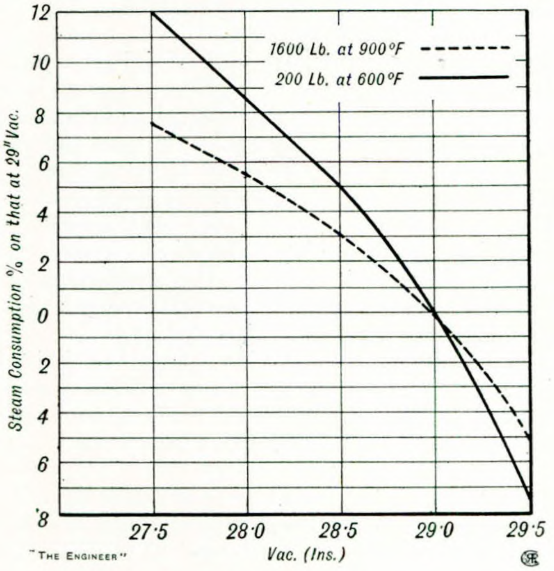


FIG. 1.—Vacuum and Steam Consumption.

greater number of small ones as well—the steam arrives at the condenser in a wet condition. It follows, therefore, that, presuming air to be present only in very small quantity, as it usually is, the temperature of the steam may be deduced from a knowledge of the vacuum. In fact, so closely and definitely are the vacuum and the temperature interrelated that it is common to compare a temperature with that corresponding to the vacuum. If in any part of the steam space of the condenser there is a discrepancy between the actual and the vacuum temperature, the amount of air present at that point can be deduced from Dalton's Law of Partial Pressures. To take a definite example, suppose the vacuum to be 29in. and the temperature to be 75 deg. Fah. From Table I it will be seen that the "vacuum" temperature is 78·9 deg. Fah., so that there is a discrepancy of 3·9 deg. Fah. The temperature of steam being 75 deg. Fah., it can be found from the steam tables that the corresponding vacuum must be 29·18in. of mercury, and, therefore, since the actual vacuum is 29in., air is exerting a pressure equal to 0·18in. of mercury. Knowing thus the temperature of pressure of the air, and knowing also by Dalton's Law that it occupies the same volume as the steam, it is easy to calculate the weight of air per pound of steam.

As the steam arrives in a wet condition it cannot be assumed that the figures of latent heat given in the fourth column truly represent the amount of heat that must be removed to condensate it. For very rough estimates the good round figure 1,000 B.Th.U. per pound may be used. But in fact, as the figures in Table II* will show, this number is very far from being correct. According to the original steam conditions and the size of the plant, the heat to be removed to condense 1lb. of steam ranges from 875·4 B.Th.U. to 967·25 B.Th.U., although in very small plants—200 to 500kW.—it may exceed 1,000 B.Th.U.

TABLE II.

Steam conditions.	Heat rejected to circulating water, B.Th.U. per lb. of condensate. Small plant.	Large plant.
1,400lb. per square inch :		
800 deg. Fah., 29in. vacuum ...	912·47	877·10
800 deg. Fah., 28in. vacuum ...	908·37	875·40
600lb. per square inch :		
800 deg. Fah., 29in. vacuum ...	967·25	913·25
800 deg. Fah., 28in. vacuum ...	965·65	914·15
200lb. per square inch :		
550 deg. Fah., 29in. vacuum ...	948·18	905·18
550 deg. Fah., 28in. vacuum ...	947·08	907·08
150lb. per square inch :		
500 deg. Fah., 29in. vacuum ...	952·50	896·50
500 deg. Fah., 28in. vacuum ...	950·90	899·94

The rapidity with which the volume of dry saturated steam per pound increases as the vacuum becomes greater may also be observed by a study of Table I, although it must be borne in mind that as the steam will be wet the actual volumes to be dealt with will be somewhat smaller than those shown. By the increase of vacuum from 28in. to 29in., for instance, the volume is nearly doubled, and a further increase of vacuum to 29·6in. more than doubles it again. Herein can be found the explanation of the fact that reciprocating engines seldom exhaust to high vacua. For in order to accommodate the great volume of the steam at these low pressures the dimensions of the engine become swollen out of all proportion to the extra power developed. In the turbine, however, it is a matter of no insuperable difficulty to provide passages of ample area, and, since every increase in the vacuum to which the steam exhausts has a very considerable effect in reducing the consumption, it is, as far as the turbine itself is concerned, well worth while to design for the highest vacuum obtainable.† On the assumption that the actual heat converted into useful work varies proportionately with the heat drop available, the curves in Fig. 1 have been plotted to show the effect of changes of vacuum on the steam consumption. The full-line curve refers to a turbine taking steam at 200lb. per square inch and 600 deg. Fah., and the other to a machine operating with steam at 1,600lb. per square inch and 900 deg. Fah. In both cases the datum vacuum is assumed to be 29in. A drop of 1in. in the vacuum, it will be observed, brings about an increase

* Taken from "Some Factors Influencing the Design of Surface Condensing Plant", by H. L. Guy and E. V. Winstanley, Institution of Mechanical Engineers, 1934.

† Always presuming that the turbine is designed for the higher vacua. G. H. Clark, "Proc.," I.C.E., CCV, p. 445, discusses limiting vacuum as applied to a particular turbine.

in the steam consumption of 8·7 per cent. in the one and 5·5 per cent. in the other, while an increase of ½in. results in reductions of the steam consumption by 7 per cent. and 5·0 per cent. respectively.

Limitations of Vacuum.

But although from a thermal efficiency standpoint there are great advantages in designing a turbine to exhaust to the highest attainable vacuum, and although mechanically the difficulty of dealing with the very large volumes of steam can be overcome, many other factors have to be reckoned in the account, and usually these latter set a limit to the degree of vacuum it is desirable to obtain. This question covers too wide a field to be discussed at length in a series of articles which are intended to be largely descriptive, but some of the factors which have a direct bearing upon condenser design and operation may be mentioned.

The vacuum obtainable in any particular installation depends upon the outlet temperature of the cooling water, which itself is determined by the inlet temperature and the rate at which the water can be pumped through the tubes. Under ideal conditions the temperature of the outlet cooling water would be equal to that of the incoming steam; but in practice there is a difference of 3 deg. to 10 deg. Fah. between them. Bearing this interval in mind and referring again to Table I, it will be seen that to obtain a vacuum of, say, 29in. the outlet cooling water temperature must not by much exceed 70 deg. Fah. Even in this country, in the summer, the temperature of many sources of water supply available for use will exceed this figure (even before passing through the tubes), so that automatically a limit is placed upon the vacuum obtainable. But even though the temperature of the supply be considerably less than 70 deg. Fah., the question as to whether a vacuum of 29in. can be held depends upon the adequacy of supply. An average steam consumption of 11lb. per kWh. is by no means unusual in a modern power station. It will be seen from Table II that to condense each pound of steam about 900 B.Th.U. must be transferred to the cooling water. Thus for each kWh. 9,900 B.Th.U. must be rejected from the steam to the cooling water. Assuming the temperature of the available supply of cooling water to be 55 deg. Fah., and that a vacuum of 29in. is to be held, the rise in temperature of the water must be limited to 15 deg. Fah. Then, to absorb 9,900 B.Th.U. 660lb. or 66 gallons of cooling water will be required for every kWh. Using this figure in connection with a power station generating 20,000 kW., it becomes clear that water must be circulated through the condensers at the rate of 1·32 million gallons per hour. The normal summer flow of the Severn at Worcester is less than ten times this amount, while the figure exceeds the corresponding flow of several of the less important rivers of this country. Thus, if the power station is now situated where the supplies of water are ample, the vacuum that can be held may be severely limited. Even, however, supposing that ample supplies of cold water are available, the degree of vacuum it may be desirable to adopt may be limited by economic considerations rather than those of thermal efficiency. Against the annual saving brought about by decreased steam consumption when exhausting to a high vacuum there must be balanced the extra capital cost and annual running costs of the pumping plant and piping necessary to accommodate the greatly increased flow of cooling water. The vacuum to be adopted in any specific instance, in fact, depends upon numerous factors, the influence of each of which must be carefully estimated before the final decision is made.

Condensate Temperature and Pressure Drop.

The actual difference of temperature between the inlet steam and the outlet circulating water involves no direct wastage of heat‡ so long as the temperature of the condensate can be maintained at that corresponding to the vacuum. Thirty years ago a depression of the condensate temperature of as much as 20 deg. Fah. below that corresponding to the vacuum was by no means unusual, but in the modern regenerative surface condenser the ideal of coincidence is almost always attained. In the older type of condenser two "solid" nests of tubes intervened between the turbine exhaust and the surface of the condensate, whereas in a modern condenser the arrangement of the tubes is such that large passages are left open along which the steam can flow to impinge directly on the condensate, thus ensuring that the temperature of the latter shall be as high as possible. At the same time the arrangement is such that the pressure drop across the tube nests from the turbine exhaust to the surface of the condensate approximates to zero. A large proportion of the total cooling surface—as much as 30 per cent. in some modern examples—is divided off from the rest to act as a cooler through which the air pump draws out the air that comes over with the steam. This cooler, by reducing the temperature of the air considerably below that in the rest of the condenser, expels from it much of the vapour with which the air pump would otherwise have to deal. On account of this efficient cooling the pressure drop across the air cooler may be as much as 0·4in. As the quantity of air leaking into the condenser increases this pressure drop may fall. In the interests of keeping the condenser dimensions as small as possible it is desirable that the average rate of heat transmission per square foot of cooling surface should be high. In comparatively recent years this rate has been nearly doubled. Condenser designers achieve the three objects of maintaining the condensate tem-

‡ If the temperature of the steam could be reduced to that of the outlet cooling water there would, however, be an increase in the thermal efficiency.

perature at that corresponding to the vacuum; of keeping the pressure drop across the main tube nests as near zero as possible; and of gaining a high average rate of heat transmission by different methods, all of which, as far as test results can show, seem equally effective.

The Water Side.

The velocity of flow of the circulating water through the tubes of a condenser has a very considerable influence on the rate of heat transmission obtainable. Roughly speaking, the rate of heat transmission varies as the square root of the water velocity.§ For any given surface area the water velocity will be raised by lengthening the condenser and reducing the number of tubes, but obviously this practice cannot be carried too far. Instead, the water may be made to flow through the condenser in two or more passes, since in effect this practice is equivalent to doubling up upon itself a very long condenser. Since the rate of heat transmission obtainable is so very dependent upon the water velocity, it might be thought desirable that there should be a multiplicity of "flows" of the circulating water. But unfortunately the design of the circulating water side of a condenser must be a compromise between two conflicting requirements. As against the advantages of a reduction of size and first cost which follow upon an increase of the rate of heat transmission must be balanced the compensating disadvantages that a high water velocity through the tubes demands a greater pumping power, so that this running cost may easily outbalance the saving in capital expenditure; and that it expedites corrosion and erosion of the tubes. With the object of reducing the necessary pumping power, the water boxes, and particularly the entry ends of the tubes, are frequently so designed as to minimise "shock" losses.

Another matter of considerable importance on the water side is that access to the interior of the tubes shall be easy. He is, indeed, a fortunate power-house engineer who can claim that his circulating water is clean. Dirt or grease collecting on the interior of the tubes adversely affects the rate of heat transmission, with the result that the temperature difference between the steam and the outlet cooling water increases. Then, either the vacuum must be allowed to drop or the quantity of cooling water flowing through the tubes must be increased. Since dirt will almost inevitably be deposited in the tubes, it behoves the condenser designer so to construct his product that as little time as possible will be wasted in removing the condenser water-box doors so that the tubes may be cleaned.

§ Orrok, "Proc." Amer. Soc. Mech. Engineers, 1910, suggests that Kw varies as $\sqrt{Vw}$, where Kw is the rate of heat transmission from tube to water, and V the water velocity. Hoeffer, *Zeitschrift für das Gesamte Turbinenwesen,* 1914, makes K vary as $V^{0.82}$. Other powers of V are suggested by other investigators. The square root, however, seems fairly generally accepted.

The Surface Condenser. Part II.

Comparison of Test Results.

"The Engineer", 31st August, 1934.

In any consideration of the various designs of surface condensers produced by the different manufacturers, it must be borne in mind that, although test results can give an impression of the performance of a plant, those from one installation cannot necessarily be compared with those from another without a complete knowledge of the manner in which the tests were carried out and of the state of the plant at the time. Condensers for large power stations, for instance, can seldom be tested in the makers' works, owing to their great capacity, and in such circumstances only results obtained in service are available. "Acceptance" tests, of course, are always carried out on site, but it is by no means unusual for this task to be undertaken several months after the condenser actually entered service. And although an endeavour is always made to ascertain that the tubes are clean, the exigencies of service may necessitate that the cleansing operation shall be carried out so rapidly that its thoroughness cannot be guaranteed. Again, in power station work it is next to impossible to secure a steady load on the plant for any length of time, and the best must be made of one that fluctuates. Over and beyond these more or less external matters influencing the reliability of the results, the actual measurements taken during the tests are not always beyond a suspicion of inaccuracy. It has, for instance been demonstrated more than once that readings obtained from one part of a condenser may differ appreciably from those obtained from a corresponding part which appears in every degree to occupy a similar situation. Thus measurements of vacuum observed around the periphery of the inlet can frequently be found to vary according to the situation. The rates of heat transmission in the various tubes are different, so that the outlet cooling water is composed of a mixture of streams at different temperatures, and even though the greatest care is taken it may happen that a temperature too high or too low is recorded according to the degree of mixing that has occurred and to the position of the thermometers.

Most engineers, too, will be aware of the difficulty of obtaining a really accurate measurement of the rate of flow of very large quantities of water. As an example of the possibilities, the recorded occurrence of condensate temperatures higher than those corresponding to the vacua may be instanced. It has been suggested that such temperatures do not, in fact, occur in practice, but are only found owing to inaccuracies in the testing of the plant or inconsistencies in the steam tables used for calculation. Every condenser designer is handicapped in drawing conclusions from test results by the "scattering" of points that may be brought about by small variations in the cleanliness of the tubes, by small changes of load and by the inevitable inaccuracies in testing. It is not improbable that the relative slowness with which the surface condenser has developed to its present state of high efficiency can be traced to this high degree of indeterminacy and the reserve with which the results of one test must be compared with those of another.

In no other factor must caution be more observed than in the comparison of the rates of heat transmission in different condensers. The mean value of K, the rate of heat transmission in B.Th.U. per square foot of cooling surface per degree Fahrenheit difference of temperature per hour, has been found to be as high as 1,000 and as low as 400 in condensers which were entirely suited to their circumstances. Some authorities suggest that K should be used as a figure of merit for the comparison of condenser performance. But the wide divergences between the values found in different modern plants rather suggest that other factors also must be taken into account. In a plant, for instance, that is to operate for long periods without cleansing of the tubes, it may well be that in order that the performance may not be unduly affected by the collection of dirt, the designers have provided a wide margin of redundant area. Then a test on the clean condenser, when, from a practical standpoint, much of the area can be regarded as doing no work whatever, will suggest the existence of a low mean value of K, although, in fact, the arrangement is advantageous. In the same way, in a condenser which can be frequently cleaned, advantage can be taken of the fact to provide only a small margin for dirty tubes, and the value of K revealed by test results will be high. It should be noted, however, that K is closely related not only with the surface area that must be provided to hold a specified vacuum, but also with the quantity of circulating water. When K is high, the mean temperature difference between the steam and the cooling water may be low, with the result that the outlet temperature of the latter may approach more closely the temperature of the steam. Thus, since a larger temperature rise of the cooling water is permissible, its quantity may be reduced. It is only permissible to use K as a figure of merit if the condensers to be compared have a similar duty to perform, and are tested under conditions closely approximating to those for which they were designed. If, for instance, a condenser designed for cooling water at 60 deg. Fah. is tested when the temperature of that water is only 50 deg. Fah., due allowance must be made for the discrepancy after the value of K has been calculated. In fact, the value found for K must be considered in relation to all the other factors that go to make up the performance of a condenser, and by itself is no complete criterion for comparison.

Misconceptions.

Many of the schemes put forward and ideas patented in the past with regard to the design of condensers would never have gained acceptance had not certain misconceptions been held, even by manufacturers themselves, as to the real conditions existing within a condenser while it is in operation. Together with the enormous difficulty of obtaining truly comparative tests and a true figure of merit, these misconceptions have dogged and delayed the development of condenser design. One of the early erroneous beliefs—the so many square feet per horse-power theory — died a natural, though lingering, death during the years immediately following the opening of the twentieth century. But others still exist. There is, for instance, the idea that since air is more weighty than steam, it will tend to fall through the mixture and that, therefore, the natural position in which to place the air suction is at the bottom of the condenser. That so influential a man as Mr. H. L. Guy, of the Metropolitan-Vickers Electric Company, Ltd., should have thought it worth while recently to refute any such theory is sufficiently a demonstration that the misconception is still held to be true in some quarters. In fact, the "draught" of the air pump is so strong as to overcome any such gravitational effect. Full account, in fact, must be taken of this "draught" in other ways. Directed upwards, for instance, it has been suggested that it is even capable of delaying the fall of the condensate from the tubes above, so that a water blanket is formed around them. Any such effect must inevitably have an undesirable resultant upon the rate of heat transmission. The sheer force of the "draught", too, must be taken into account. In a case which will be mentioned later, a lightly constructed tray-like structure installed in the body of a condenser in connection with the reheating of the condensate was literally "blown to pieces" by the violence of the gale.

But it is perhaps in the study of the rate of heat transmission that the greatest difficulty lies. When the interior of a condenser is observed through a glass window, drops may be seen forming upon the tubes, coalescing and falling. Such observations seem, at first sight, effectually to dispose of any theory that a film of moisture resistant to the flow of heat exists upon the outer surface of the tubes. Such a film has been assumed to exist by many of those who have experimented upon the subject. But, to look at the matter in another way, it must be remembered that the lower tubes of a condenser are subjected to a continual bombardment of drops falling from those above, and that the rate of this precipitation is anything up to ten times more heavy than that accompanying a thunderstorm. Under such conditions it is impossible to believe that condensation can take place by the leisurely formation of drops and their coalescence. Whereas it is less difficult to conceive

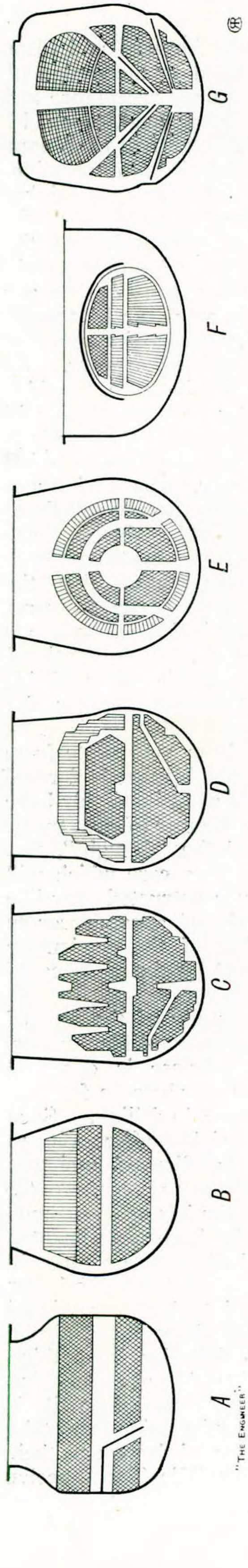


FIG. 2.—Surface Condenser Tube Plate Arrangements.

of the existence of a more of less permanent film.

Thus, somewhat picturesquely, the conditions within a condenser in operation may be likened to a rainstorm almost more violent than it is possible to imagine. The "barometer" is unimaginably low; the rain falls at a rate beyond anything we can conceive happening in Nature, and the severest of hurricanes blows at over 200 miles per hour. In such a welter, and with such obstructions as the tube nests and the baffles offer, there must be violent swirls and eddies, although the main wind drives always towards the air suction. Any proposals, for the use of queer-shaped tubes, for instance, or for some unusual tube plate arrangement, or positioning of the air pump suction, must be considered carefully in the light of these conditions. A demonstration, by means of a few tubes in a small model condenser, of the occurrence of certain phenomena is no more reliable evidence that the same phenomena will occur among the hundreds of tubes in a full-sized plant than would be an artist's conception of the occurrence on a drawing board.

Historical.

It was early in the present century that the defects of the surface condenser as then designed began to take on a new importance, owing, probably, to the advent of the turbine. It seems almost incredible to engineers of the present day, brought up to believe in the conservation of every possible B.Th.U. of thermal energy, that early practice should have favoured the "drowning" of the last few rows of the condenser tubes by the condensate with the object of making the duty of the extraction pump less onerous, and that pressure drops of the order of 1in. of mercury across the tube nests should have been tolerated for so many years. Attempts to reduce the depression of the condensate temperature were brought about by a realisation of the loss of heat involved. The water level was not allowed to rise so high as to drown the lower tubes, and a small proportion of the tubes was baffled off from the rest to act as an air cooler or some alternative means of cooling the air was adopted. At the same time individual tube heat transmission tests demonstrated conclusively that it was the outer rows of the tube nests that condensed nearly the whole of the steam, and the practice of leaving steam lanes free of tubes, leading deep into the nests, was generally adopted. By this means a greater number of the tubes could be made to occupy the favourable "outer" position. These improvements had the effect of increasing the temperature of the condensate and reducing the pressure drop, but, nevertheless, the depression of the condensate temperature remained considerable. One of the earliest devices to overcome this loss of heat was adopted in the condenser for the Chicago turbine built by C. A. Parsons & Co., Ltd., in 1913. After extraction the condensate was pumped through a screen of tubes arranged across the steam entry to the condenser. The scheme was, in fact, more akin to modern methods of feed heating by means of bled steam than to a true development of condenser design. An interesting device approaching closer to modern methods was that adopted by another company. A two-stage centrifugal extraction pump was used, the first stage of which raised the condensate from the bottom of the condenser into "trays" arranged at the top. Here the water was acted upon directly by the steam, and thence it was drawn by the second stage of the pump for delivery to the feed tank. Practically the scheme was a failure, for the "draught" in the condenser was such that the trays were literally "blown to pieces", and theoretically it was a somewhat clumsy device. Nevertheless, it contained the germ of the true method of raising the condensate temperature by allowing the steam to come into direct contact with it.

The next step therefore was to extend the lanes through the tube banks to the very bottom of the condenser, so that some of the exhaust steam might blow right through from top to bottom without condensation, and to increase the size of the air cooler in order that the air pump might not be overloaded with vapour. But before this practice was adopted, other means of bringing the steam and the condensate into contact were tried. One manner of achieving this object is to cause the steam to enter the condenser at the bottom and to rise through the tube banks towards the air suction at the top, since by this means the "rain" of condensate must fall through the rising current of steam. So strong, however, was the upward draught that a certain delay occurred before the drops descended from the tubes, and the water blanketing of the latter thus brought about had its effect upon the rate of heat transmission. Since at least one experienced condenser manufacturer—Parsons—has developed an inverted condenser more or less of this type, it is to be supposed either that earlier experimenters were mistaken in their reading of the results obtained or that subsequent improvements of design have overcome this defect. Generally speaking, however, it was found that wide deep lanes leading the steam freely to the bottom of the condenser had the desired effect, while the provision of baffles along the lower sides of these lanes was also sometimes found advantageous. Thereby the condensate falling from the tubes above was at one and the same time prevented from coming into contact with the cold tubes below and brought into intimate contact as it ran down the baffle with the steam travelling in the same direction along the lane. In effect, not only was the condensate temperature made to coincide with that corresponding to the vacuum, but also the pressure drop across the condenser from the exhaust flange to the surface of the condensate became almost inexistent. In Fig. 2 a series of diagrams is reproduced to show the stages in the development of condenser design from that—A and B—with the two "solid" nests to those typical of the present day—E, F and G. With the discovery of the harmful effects upon boilers of aerated feed water, the points just mentioned have assumed a new importance in that theoretically if the condensate temperature coincides with the vacuum temperature no air can be dissolved in the water—and, in fact, in a modern installation commercial tests are unable to detect more than the slightest trace of free oxygen in the condensate.

This short historical sketch would not be complete without a reference to the invention of a device which, by separating the two functions of withdrawing the condensate and removing the air, did more to ensure the ultimate development of the surface condenser to a state of high efficiency than any other single improvement. The air ejector first made its appearance as a "vacuum augmenter", and rapidly developed until it alone is now responsible for the removal of the air in most large modern plants. It has the great advantage that all the heat in the steam it uses is conserved by being rendered up to the condensate. Several types of air ejector will be described in these articles.

As to the greater number of condenser auxiliaries, it seems better to regard them as units in the boiler feed system rather than as being connected with the condenser. In this view the bottom of the condenser becomes the "sump" from which the feed water is drawn by the extraction pump. Some justification for this point of view is provided by the modern practice of passing all the "make-up" feed through the condenser before it enters the circuit in order that it may be thoroughly de-aerated. The circulating pumps, of course, are definitely condenser auxiliaries. But, though important, their function is much that of any low-lift, large-capacity pumping plant, and a description of their design would be better fitted for inclusion in an article on centrifugal pumps than one on condensers. In passing, as it were, reference will be made to such plant, but no detailed attention will be directed to it.

Condenser Types.

In a series of descriptive articles such as this, it is nearly always a convenience if the subject can be divided up into sections. Fortunately, steam surface condensers, although they all act upon precisely the same principles, and have precisely the same objects in view, can be arbitrarily classified by the arrangement of the tube plate and in particular by the position of the air suction. Thus, there is what may be termed the "Downflow" type, Fig. 2G, of which the "Contraflo" designs may be taken as examples, and in which the air suction is at the side and near the bottom, the "draught" being downwards. The "Radial-Flow" class, Fig. 2E, which has the air suction centrally placed, is exemplified by the larger Metrovick productions; while, closely connected with the name of "Parsons" and only recently brought to perfection, there is the "Inverted" type, Fig. 2F, which has the air suction at the top and the steam inlet to the tube nests near the bottom.

Two Steamers with Boilers on Deck.

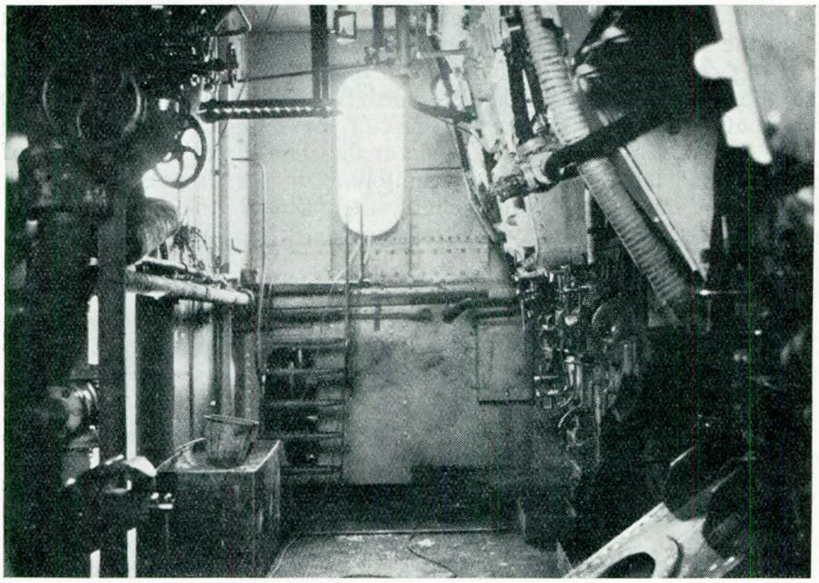
Novel Stokehold Arrangement Introduced by the Fredriksstad Yard.

"Shipbuilding and Shipping Record", 23rd August, 1934.

Two steamers which have an unusual arrangement of the boilers have been built by the A.S. Fredriksstad Mek. Verksted. One is the "Felix-Henri", a refrigerated banana carrier of 3,700 tons deadweight, which was delivered last November, and has now made nine round trips to Konakry, during which time she has been exposed to very severe gales in the Bay of Biscay and has kept her scheduled time satisfactorily. The other is the "Bencas", which has just completed trials.

The "Felix-Henri" is oil-fired and the "Bencas" coal-fired, and in each case the vessels have the patent boiler arrangement of the builders. This is shown in the drawings on *page 198 while the two stokehold arrangements are illustrated on this page. Direct entrance is obtainable from the deck by a few steps leading down to the stokehold flat and there is full access of light and air. It is interesting, in this connection, to note that the stokehold photographs in each case were taken in

* Not reproduced.



Stokehold of the "Felix-Henri".

daylight through the normal illumination of the stokeholds. Experience in the tropics has shown that the temperature of the stokehold was only about 7° F. above the temperature on deck.

It is claimed for this arrangement that there is a gain of cubic capacity of the holds of something between 6 and 10 per cent., and in the case of wood cargoes a larger proportion of the cargo is stowed under hatches thereby securing a higher rate of freight. It is also claimed that the heat from the boilers does not corrode the tank top. Consequently not only is this source of wastage avoided but plates and floors need not be increased in thickness. In the case of the coal-burning steamer, by arranging the bunkers as shown in the drawing of the "Bencas", on page 198, the whole of the double bottom is available for water ballast. No ash hoist is needed the ashes passing overboard through a shoot from the stokehold. The ventilators can be arranged so as not to obstruct the smoke-box doors.

Calculations have shown that stability conditions are improved because the cargo, filling the space where the boilers usually are, as a rule weighs not less than the boilers and in ballast condition the excessive stability is materially reduced thus giving a considerably easier rolling motion. Moreover, it is possible to increase the beam of the ship, thereby increasing also the carrying capacity at shallow draughts.

The officers' accommodation can be arranged in a compact and airy structure.

In case of damage and leaks, steam for pumps, steering winches, dynamos, and so on, may be kept up until the last.

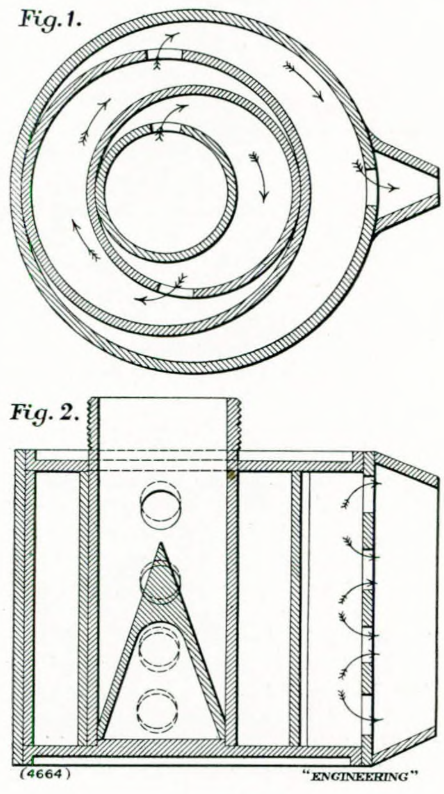
The cost of building the ship is not increased, because of the compactness of the structure, and for a given cubic capacity the principal dimensions of the ships are reduced in proportion, causing a direct saving of building expenses as well as reduction of engine and boiler power. As a consequence, the fuel consumption is reduced, hence a smaller bunker volume is sufficient.

The ships are propelled by the firm's special type of engine, which has a fuel consumption rate of 0·95lb. of coal per I.H.P. per hour, running very smoothly, and having exceptional manœuvring power. The design, by Mr. W. Olsen, is on conservative lines.

Silencer for Pneumatic Tools.

"Engineering", 7th September, 1934.

The recent regulation, an important public amenity, made by the Minister of Transport, prohibiting the use of motor horns during certain hours, has directed attention to the possibility of reducing other street noises, and as stated on page 229 of our last issue, a Committee has been appointed to study the question in so far as it relates to noises made by motor vehicles. It has been pointed out by various writers in the Press, however, that cars and lorries are by no means the only offenders in the matter of noise, and that pneumatic tools employed on road repair work, in particular, create a



barely-tolerable din while they are in use. So far, no practicable suggestion has been made for eliminating the metallic sound of the piston striking the anvil in such tools, but actually this is comparatively unobjectionable, the majority of the noise being produced by the exhaust. It might be thought at first sight that the design of an efficient silencer for the exhaust air would offer no particular difficulty, but a consideration of the conditions to be met show that the problem is by no means a simple one. Briefly, while being sufficiently strong to preclude any possibility of bursting or becoming damaged in rough handling, the weight, size and shape of the silencer must not inconvenience the operator. It must reduce the noise to the required degree without increasing the back pressure to an appreciable extent, and, finally, it must be low in cost, with a simple and reliable method of fixing.

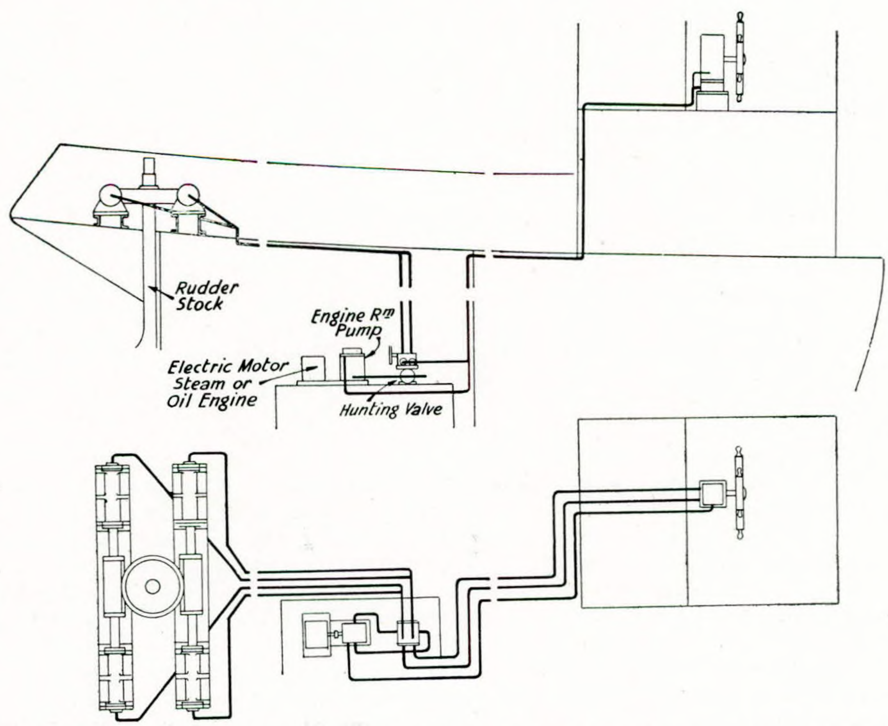
Repeated efforts have been made to develop a suitable silencer, and it is claimed by Messrs. Holman Bros., Ltd., of Camborne, that the "M.S.T." model, which they have introduced as a result of numerous experiments, meets all the requirements outlined above. The construction of this silencer is illustrated in Figs. 1 and 2, annexed, and it will be seen that it is composed of a series of heavy-gauge tubes of increasing diameter, each being disposed eccentrically with respect to the next, to which it is securely welded. Rows of apertures are arranged, so that the exhaust air, which is actually at a considerable pressure, travels in a spiral path from the smallest tube to the outlet in the circumference of the outer casing. The air entering the inlet tube encounters a cone, shown in Fig. 2, which breaks up the incoming stream and initiates a whirling motion. It then expands evenly and gradually, as it passes through the successive crescent-shaped chambers, leaving the outlet in a smooth, continuous, and practically silent stream. Both ends of all the tubes are welded to the end plates. The weight of the silencer is only 5½lb., and as its diameter is only 5in. and its length 4½in., it can easily be fitted to the tool without in any way interfering with the manipulation of the latter. Tests have been made to demonstrate that the fitting of the silencer reduces the speed of penetration by less than 5 per cent., and that the volume of sound is reduced by at least 60 per cent. All Holman tools have a threaded exhaust outlet on which an adaptor can be fitted, the threaded projection on the silencer, shown in Fig. 2 being screwed into the adaptor and secured by a lock nut.

New Hydraulic Steering Gear for Small Vessels.

"The Marine Engineer", September, 1934.

A new type of steering gear has been specially designed by Gemmell & Frow, Ltd., Hull, for use on trawlers, tugs and coastal vessels. The object of the designers has been to provide a gear which would be simple to work and understand and to eliminate, where possible, cumbersome structure in the wheelhouse and on deck. This they claim to have done in their new patent hydraulic steering gear which is made for hand steering only, or combined hand and power. The gear in the wheelhouse consists of an ordinary teak wheel, and a pump of the oscillating ram type with three rams. A similar pump, driven by a single-cylinder-governed steam engine, electric motor or other prime mover, is fitted in the engine-room. This pump is connected by means of copper pipes to the change-over cocks and hunting valve, which are one separate unit, and placed in any convenient part of the engine-room.

A system of oil-hydraulic rams on the deck operates the rudder through racks and double quadrant, the gear at the after end of the deck being



Diagrammatic layout of the new Gemmell & Frow hydraulic steering gear for small vessels.

suitably covered by a wooden casing. The after gear can, providing the design of the ship is suitable, be placed underneath the deck, thus leaving an absolutely clear deck. The rams are placed athwartships, two driving a rack on the forward side of the rudder stalk, and two similar rams on the after side. All rams are solid forged and specially treated to prevent pitting and salt-water corrosion. The function of the hunting valve is to direct the flow of oil, circulated continuously by the engine-room pump, to the appropriate rams for port or starboard motion of the rudder according to the movement of the handwheel, which is in hydraulic connection with the valve. When the handwheel is stationary, the oil from the engine-room pump circulates freely without the system being subjected to the pressure necessary to move the rams.

The advantages of this type of gear are numerous. The change over from hand to power or *vice versa* can be effected, with the rudder in any position, merely by a few turns of a handwheel. There are no chains or fittings on deck, a special advantage in trawler work. The gear is noiseless and vibration is eliminated. There is very little weight in the wheelhouse, no steam to affect the windows, and the space required is very small. The steam engine or motor, change-over cocks and hunting valve are situated in the engine-room, and therefore under the observation of the engineers. During recent trials, the gear was subjected to severe tests, being run from hard over to hard over continuously for some twenty minutes, while the ship was driven astern at full speed. The tests gave entire satisfaction.

Old Soldiers . . .

A Sulzer 20 B.H.P. Engine has run 12/16 hours per day for over 30 years at Tweedmouth and is still in active service.

"Gas and Oil Power", September, 1934.

From time to time the question of the useful life of Diesel engines crops up. Particularly is the subject one which the advocates of steam power are fond of discussing, generally, of course, from the standpoint of the inferior durability and heavier depreciation of the Diesel plant as compared with steam power. Those who are conversant with oil engine practice are aware, however, that from the point of view of longevity and moderate depreciation the Diesel engine is a prime mover which any power user can adopt with confidence. Whether, of course, some of the early examples of heavy-oil engines will show the extraordinary durability of some of the pioneer beam type and other early patterns of steam engine is a moot point, but one of no great commercial importance, in view of the high economy and moderate cost of a Diesel plant. From time to time, however, there is evidence, usually of an interesting character, to show that the manufacturers of some of the early Diesel engines "builded better than they knew". Such a case has recently been brought to our notice by a North Country power user who points out that one of the first, if not *the* first, Diesel engines sold in this country has been in continuous service at Tweedmouth since 1903.

Knowing something of this old engine, we approached Sulzer Bros. (London), Ltd., whose parent firm in Winterthur supplied the engine, to be good enough to investigate the history of this engine for us, and to let us have some particulars of its operation. The engine in question is in the L.N.E.R. locomotive works at Tweedmouth, and drives a reciprocating water pump drawing water from the River Tweed. Normally, the engine runs from 16 to 18 hours per day and has done so for over thirty years. After thirty years running the unit had actually completed the very excellent record of 134,000 hours of service without a serious breakdown or mechanical defect; at the present time it has run nearly 140,000 hours. Perhaps it would be best to give the particulars concerning this engine, which incidentally is illustrated on the next page, in the actual words of the engineer in the Diesel engine department of Sulzer Bros. (London), Ltd., who gathered together the information for us. Before giving this brief report, however, it may not be out of place to mention that the engine is a single-cylinder four-stroke cycle unit of 20 B.H.P. at 250 r.p.m. having a cylinder diameter of 220 mm. and a stroke of 330 mm., and drives the water pump through a belt. Air injection is, of course, employed, the two-stage injection air compressor being driven by a special form of link gear off the small end of the connecting rod. The compressor is accessibly located on the "A" frame at the back of the engine.

The engine was examined in August and its general condition was found to be good, which speaks well for the care in attendance and overhaul that it has received from the personnel responsible for its upkeep. Details of the condition of various parts and also particulars of renewal of parts since the installation of the engine are interesting.

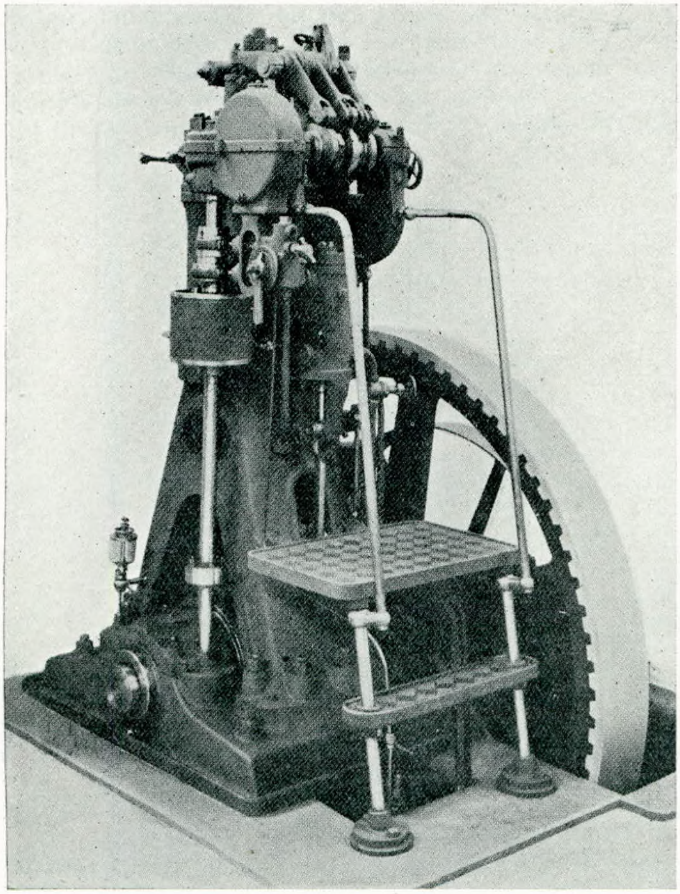
The piston was found to be in good condition, the rings were free in their grooves, and none required renewal. This piston was fitted 5 years before the date of opening up, this being the second time the piston had been replaced.

Liner Wear and Life.

The cyinder liner, which was also renewed with the piston, for the second time, 5 years before the examination, was in excellent condition, the surface having a polish like a mirror, whilst the amount of wear was moderate. The useful life of each piston and liner so far taken out of the engine has been exceptionally long, averaging 12½ years.

The top-end bearing had worn to an extent that four "thous" had to be taken up by the removal of shims, whilst the bottom end bearing was normal and required no adjustment. The main bearings and crankshaft were in good condition, but the flywheel bearing was running a shade warmer than normal at the time of dismantling; no trouble had been experienced from this cause, however.

The governor required minor adjustments to give the correct running speed, whilst the governor drive did not call for any adjustment, the clearance between the teeth of the driving wheels being 0·6 mm.



Early Sulzer engine of 20 b.h.p. at 260 r.p.m., as used at Tweedmouth.

The fuel injection pump plunger was renewed as it had been worn by the gland packing. This plunger has to be replaced about every two years, but on modern engines this trouble does not occur as it has been overcome by replacing the gland packing by a ground bush which is a very close fit on the pump plunger.

The fuel valve was in good condition and has not been replaced since the engine went into service in 1903. The inlet and exhaust valves have been replaced twice and three times respectively.

At the recent overhaul two piston rings were replaced in the blast air compressor which otherwise was in good condition.

The foregoing results are particularly interesting, especially in so far as liner wear is concerned. The moderate bearing wear is also interesting, and the observer is certainly forced to acknowledge that there is still something to be said for the old-fashioned slow-speed oil engine of the old school in which generous bearing surfaces are provided and moderate mean pressures are carried. It is only fair to add in connection with this Tweedmouth installation that the engine has received exceptionally careful attention throughout the whole of its long and eminently useful career, which shows no sign of terminating as yet. It would be interesting to know whether the fuel consumption has risen in 30 years.

Gearing for Dutch Motorships "Manoeran" and "Madoera".*

"Marine Engineer", September, 1934.

Readers will remember these two vessels which have been converted from steam to Diesel drive. They are of 14,000 tons, and by some alterations to the hull, along with an increase in total propelling power from 4,200 to 6,500 B.H.P., the speed has been improved from 12 to 15 knots. Each vessel has two Werkspoor-Sulzer single-acting two-stroke cycle engines of 3,350 B.H.P. at 225 r.p.m. The speed reduction from 225 r.p.m. at the engines down to 86 r.p.m. at the propeller is accommodated in sets of gearing supplied by the Demag A.G. of Duisburg. The present article reviews in detail these reduction gears.

Two considerations had to be kept to the fore in designing these gears, firstly to accommodate the new machinery in the existing space, and secondly to make it absolutely reliable; the second of these was the more difficult. Special Bibby couplings were fitted between engines, and the gearing so designed that either two, three or four springs (each consisting of six segments) could be used, the resulting elasticity varying according to the number of springs fitted. Fig. 1 shows the coupling, and the diagram in Fig. 2 shows the angular displacement in terms of torque applied. The Bibby coupling has the additional advantage that it requires so little attention; one filling with grease suffices for a considerable period of service. By removing the coupling covers the springs are readily accessible, so that in the case of breakdown of one engine the removal of the springs from the corresponding coupling would allow that engine to remain stationary whilst the remainder of the set carries on. As a further precaution against high stresses caused by possible torsional vibrations. Sandner-type dampers were fitter to the forward ends of the engine crankshafts. The general arrangement of the gearing is shown in Fig. 4: both wheel and pinion shafts are of annealed

* *See also* page 183 of the September issue of the Transactions.—Ed.

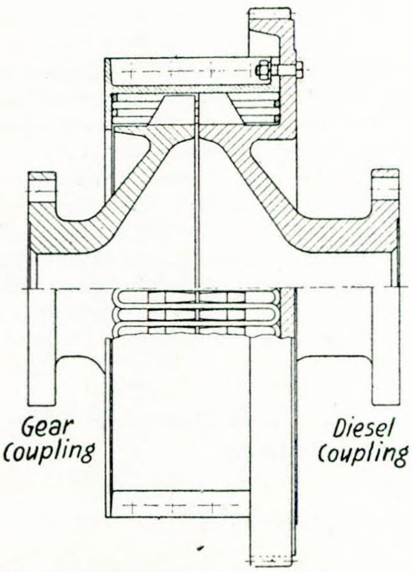


Fig. 1.—Bibby elastic coupling as used in the geared diesel installation discussed in this note.

S.M. steel of 32-36 tons per sq. in. ultimate and and 28-34 per cent. elongation. The rims (of rolled silicon-manganese steel) in which the teeth are cut are shrunk on to both the pinion shafts and the cast-iron wheel. This unusual construction of the pinions has the advantage of allowing an easier and more reliable forging. The pinion rims are heat-treated to 48-53 tons per sq. in. ultimate, and 33-37 tons elastic limit; the elongation varies between 20 and 28 per cent. The wheel rim is annealed, but has an ultimate strength and elastic limit lower than that of the heat-treated pinion rims. The working torsional stress in the weakest section of the pinion shafts and of the wheel shafts (all hollow-bored) amounts to 1,160 and 4,320lb. per sq. in. respectively. Tooth pressures were decided on Hertz's formulæ.

In the bearings used for the pinion and wheel shafts a lining of lead-free alloy was used composed of 80 per cent. tin, 10 per cent. antimony, and 10 per cent. copper. Lubricating oil is delivered by two independent gear-type pumps; one, quite separate from the gearing, is driven by a 7-B.H.P. electric motor; the other is driven through a speed-up gear from the main gear shaft. This latter pump is arranged with automatic reversing so as to continue to operate when the propeller is running astern. A further requirement of these sets of gearing was absence of noise at all speeds and load conditions, and one of the factors helping to secure quietness is the rigidity of the gear casing to ensure proper alignment of the shafts and satisfactory tooth contact even under abnormal conditions, such as one engine out of action or some cylinders not firing. Considerable attention was paid to the tooth design, and the article goes fully into this question and that of the methods of machining the teeth. Fig. 3 shows the

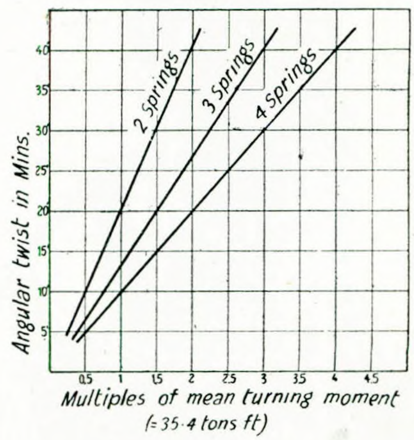


Fig. 2.—Angular displacement of coupling in terms of applied torque.

diagrams obtained during checking of the machining errors and it will be seen that these are well inside the maxima specified, namely :—

Individual tooth error $\frac{1}{1,000,000}$ × wheel dia.

Cumulative error $\frac{1}{100,000}$ × wheel dia.

After assembling, the gearing was run-in for some weeks in the works at low speed and load, the no-load power consumption being about 34 H.P. One complete set of gearing and two main engines were tested under load in the shops, but in the case of the second gear a loaded test was dispensed

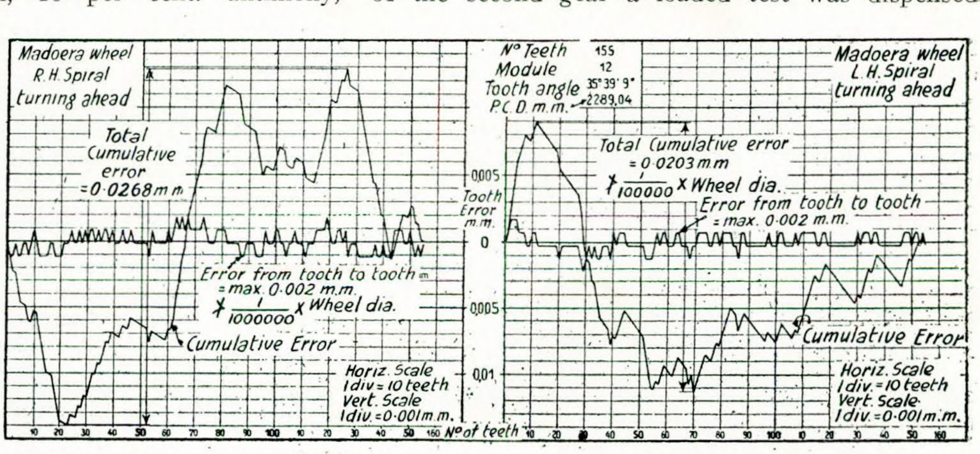


Fig. 3.—Diagrams showing tooth errors obtained with the "Madoera's" gears.

with. The motorship "Manoeran" has been in regular service on the Java-Pacific run since 31st October, 1933, and the "Madoera" on the Java-

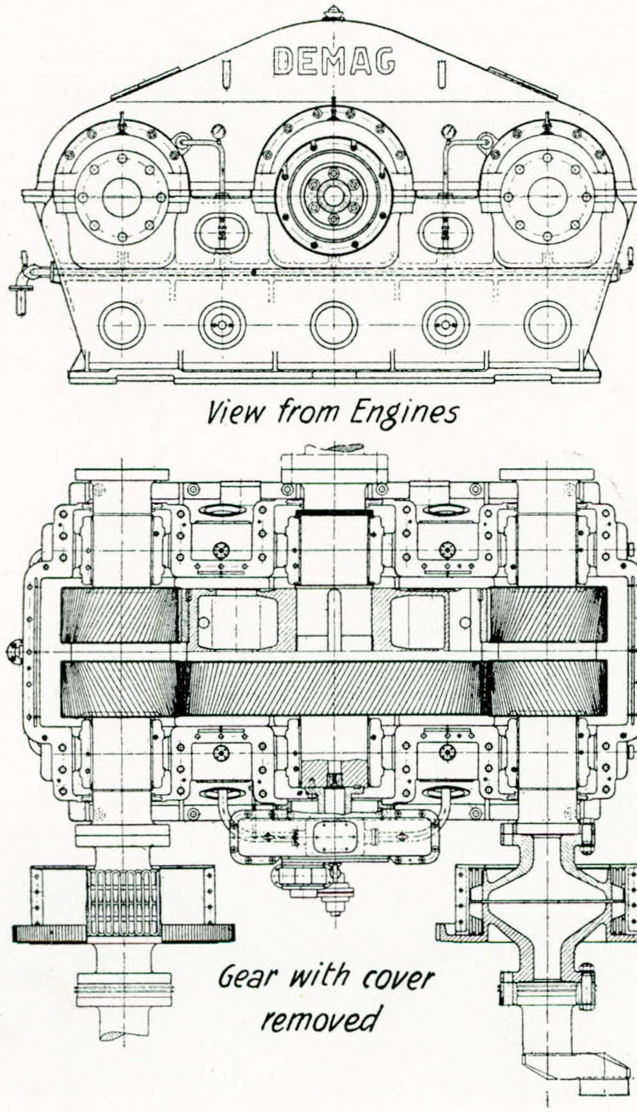


FIG. 4.—Layout of reduction gearing for the "Manoeran" and "Madoera" (*see* page 211).

New York run since 10th December, 1933. Reports show that the gearing has operated satisfactory, and the teeth appear perfect and show no signs of wear.—*A. H. Ysselmuiden, Amsterdam, Werft Reederei Hafen.* 15*th April,* 1934.

Value of Rejuvenation.

"The Marine Engineer", October, 1934.

An example of efficient direction and ship maintenance in the organisation of a shipping company was revealed at special meetings of shareholders of the Clan Line Steamers Ltd., held on September 14th, when Lt.-Commander Sir August B. T. Cayzer, Bt., chairman of the company, put forward proposals for an adjustment in the capital structure of the company. Debenture stock is to be redeemed, and as a result of new share issues and with the proceeds from the sale of an investment, funds totalling £850,000 will be obtained. The balance required to meet the debenture redemption will be provided from the company's surplus funds from the current year's trading.

The present satisfactory position of the company is largely due to reconditioning the machinery of the ships belonging to it and its two main subsidiaries, totalling 59 vessels of various types, with a total deadweight tonnage of 528,077 tons. The older vessels have been improved and brought up to date at various times, in some vessels by fitting Bauer Wach exhaust-steam turbine arrangements. Mr. Alexander Cross, chief superintendent engineer to the company, has also had fitted a patented form of piston and rod packing of his own design throughout the steamship fleet, we understand with excellent results. Attention has also been devoted to other small details of the engine and boiler-room equipment; and although individually the savings made by fitting improved packings, more efficient insulation, more efficient piston rings, and so on may not be great, in the aggregate they can often show a most attractive improvement in the daily fuel bill.

Twenty-three Years' Progress.

"Shipbuilding and Shipping Record", 13th September, 1934.

The Danish East Asiatic Company has lost no time in reviving the name of "Jutlandia", for no sooner has the famous pioneer been sold to interests in California than the new ship under construction at the Nakskov Yard is given the name as she leaves the ways. This not only affords an interesting opportunity of comparing the details of the two ships, the first one of the most famous of her type and the second yet to make her reputation, but the comparison is made all the more interesting by the fact that the East Asiatic Company is one of the most experienced of motorship owners; that the old "Jutlandia" was an absolute experiment; and that the trade for which both ships were designed is one that the company has built up for itself. It is a trade that, in ordinary circumstances, might be regarded as demanding less improvement than most ocean services.

	"Jutlandia", 1911.	"Jutlandia", 1934.
Builders ...	Barclay Curle	Nakskov Yard
Length ...	370ft.	425ft.
Beam	53·2ft.	81ft.
Deadweight ...	7,400 tons	10,000 tons
Passengers ...	22	59
Hatches ...	4	5
Winches ...	12 electric	16 electric
Derricks ...	13	17 (one 40-ton)
Engines ...	B. & W. four-stroke cycle diesels	B. & W. two-stroke cycle diesels
Power ...	3,000 I.H.P.	7,850 I.H.P.
Speed ...	10½-11 knots	16-17 knots

A Floating Ice Factory.

French Steamship "Tunisie" Equipped with Plant to Operate in Deep Water in the Tropics Under the Supervision of Professor Georges Claude.

"Shipbuilding and Shipping Record", 13th September, 1934.

Among the vessels that visited Cardiff for bunkers during last week was the French steamer "Tunisie", which has been fitted with a power plant using the difference in temperature of surface water and water at a depth of 700m. (approximately 380 fathoms) in tropical seas. Ice-making plant is installed to utilise the power generated.

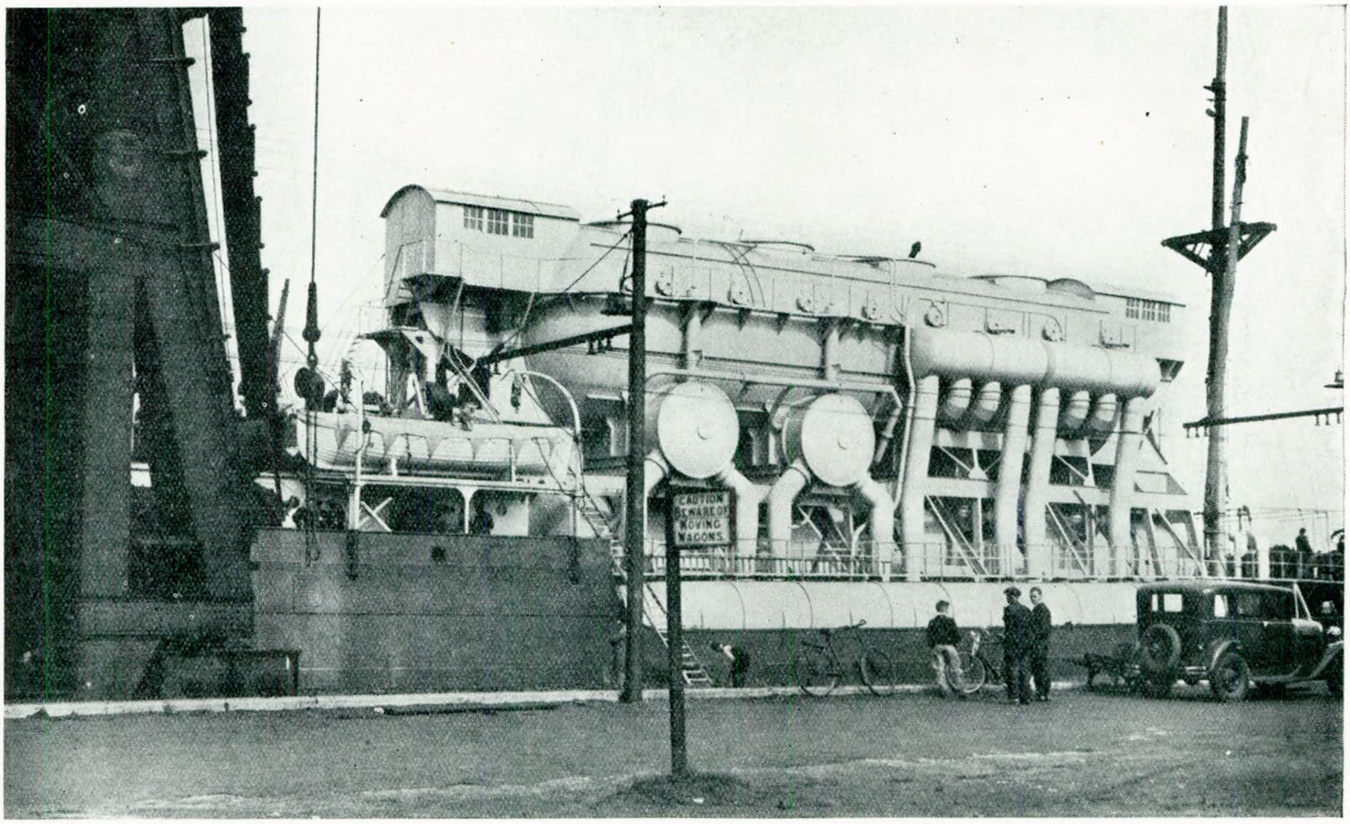
The vessel was bound from Dunkerque to Rio de Janeiro, where the inventor of the system, Prof. Georges Claude, the French scientist, would meet her on arrival. A view of the "Tunisie", with the plant erected on deck, is reproduced above.

The "Tunisie" was built in 1917 in Japan. She was bought by Prof. Claude for the purpose of having a Claude-Boucherot plant installed, the work being carried out by the Chantiers de France at Dunkerque.

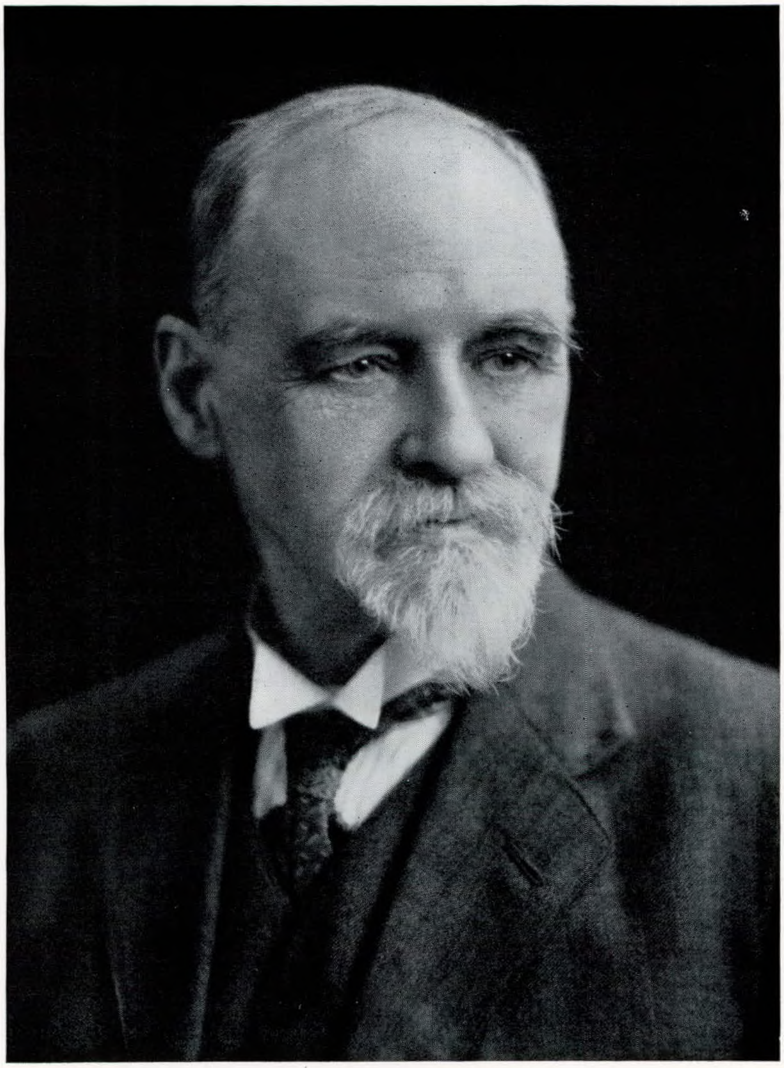
Prof. Claude had previously investigated the possibilities of Claude-Boucherot power plants on shore, successful tests having been carried out in Cuba. The advantages, however, of having the plants installed on what would be in effect floating islands were obvious, since a suitable depth of water could be readily secured in the immediate neighbourhood of the plant, and the necessary pipes could be vertical and therefore of the minimum length and weight for a given depth of water. Difficulties would have been experienced in using the power generated for electrical power supply purposes by means of cables to the shore, and the plan was adopted of utilising the power on board ship in the manufacture of ice.

The "Tunisie" is approximately 360ft. long and the power of the plant has, we understand, been limited voluntarily to 1,800kw., of which 1,200kw. can be employed in ice manufacture. It is estimated that 2,000 tons of ice will be produced per day when the ship operates in the tropical seas of Brazil, where she is to be stationed for one or two years, being anchored some miles from the shore. The process involves the pumping of cold water from the bottom in a long canvas tube.

It is expected that the ice will be produced at very low cost. It will be conveyed to a suitable port in small boats. The apparatus weighs about 250 tons.



Port side of plant installed on the "Tunisie"—a view taken in Cardiff Docks.



The late Mr. J. R. Ruthven.

OBITUARY—Mr. J. R. Ruthven.

We regret to announce the death of Mr. J. R. Ruthven, which occurred at his home, Upton Park, on Sunday, November 4th.

Born at Bridgeport, Connecticut, U.S.A., on August 31st, 1848, where his parents were on a business trip, Mr. Ruthven was brought to Edinburgh and registered as a British subject. His early days were spent in Edinburgh and Greenock, but at the age of 16 he came to London, where for some nine years he worked for his father. He subsequently held many posts in London, among the firms with whom he was employed being Messrs. J. & W. Dudgeon, of Millwall, Messrs. Caird & Rayner, Ltd., and Messrs. John Bellamy, Ltd. For the last thirty years of his working life he was employed in the Marine Department of Messrs. Babcock & Wilcox, Ltd. His vigour and ability will be appreciated when it is realized that on his retirement from this post in June, 1931, he had reached the age of 82 years.

Mr. Ruthven's death recalls the struggle of his family and himself to commercialise the invention known as "Ruthven's Hydraulic Propeller", which was the subject of a paper read by him before The Institute in 1890. This method of marine propulsion was the joint invention of his father and grandfather, and a considerable fortune was spent by the Ruthvens and their friends in an unsuccessful attempt to make it a commercial proposition.

Mr. Ruthven, who also read a valuable paper on the "Standardisation of Pipe Flanges" before The Institute in 1902, was among the first Members to enrol, his membership number being 33. He was a Member of the first Council of The Institute and, except for a short interval, served in this capacity until 1907, a difficult period of eighteen years during the early part of which he shared in the splendid pioneer efforts which have meant so much in the development of The Institute to its present eminent position.

His singularly attractive personality won him a wide circle of friends, by whom he is remembered for his keen sympathy, kindly sense of humour, and his optimism. All his life he maintained his great interest in the younger generation, whom he was ever ready to help, and is well-remembered for his endeavours to persuade his younger colleagues to maintain and increase their studies at evening classes.

The funeral took place on Wednesday, 7th November, 1934, at Woodgrange Park Cemetery, Manor Park.