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Compressors and Blowers for Marine and Industrial Use.

By E. MARKHAM, Wh.Ex. (Member).

Abstract of a lecture delivered to a Joint Meeting of the Junior Section of The Institute and Students of the Central Polytechnic, Croydon, at the Polytechnic on Thursday, December 2nd, 1937.

THE author presented a survey of a wide range of types of compressors and blowers for marine and industrial use and discussed the methods which should be adopted for their operation and supervision in service. After referring briefly to the fundamental relationships between the power required and the suction and delivery pressures, he defined the essentials of a good compressor or blower as follows :—

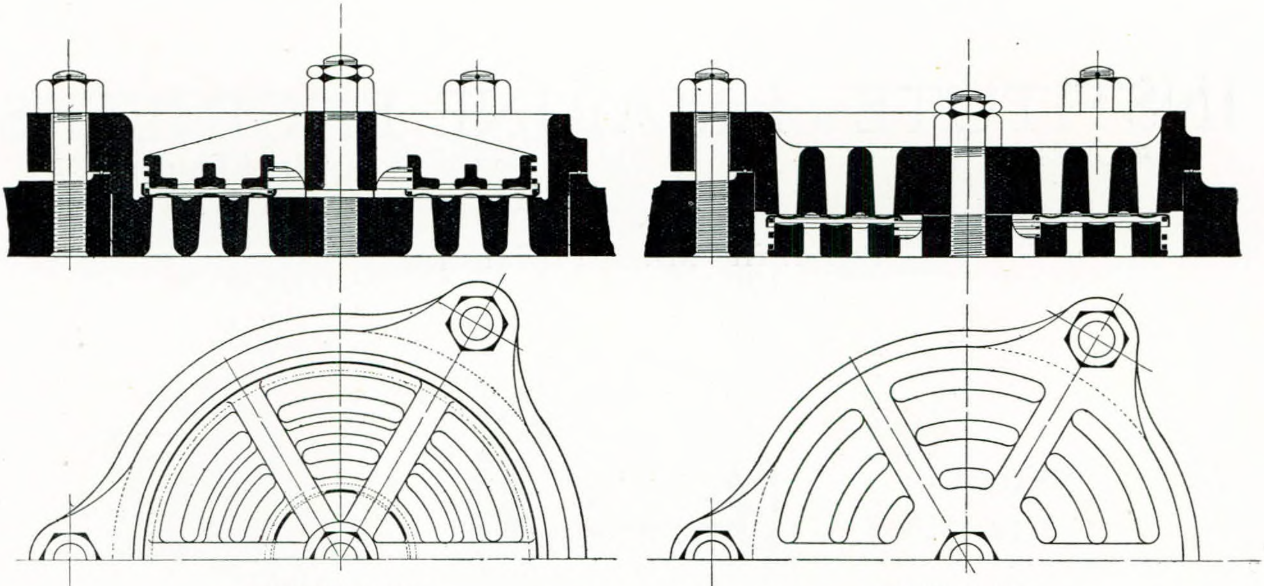
(*a*) Absence of valve or other mechanical troubles, even with continuous running under the heaviest loading conditions, i.e., bearing pressures, stresses, and temperatures should be kept low;

(*b*) Reasonable margins on cylinder sizes, power of driving unit, etc., to enable the machine to perform the specified duty in conditions less favourable than those obtaining on the test bed;

(*c*) High mechanical and compression efficiencies: The former calls for forced lubrication of the working parts and for efficient lubrication of the bearings, a reversal of the loading being desirable; to reduce frictional losses non-delivery or idle strokes should be eliminated wherever possible, so that double-acting are preferable to single-acting cylinders; leakage of compressed air on which power has been expended should be minimised and in multi-stage machines each stage of compression should be performed in a separate cylinder designed specially for the duty performed therein. High compression efficiency calls for efficient cooling during compression and between stages, free gas entry and exit to and from the cylinders, absence of throttling, large areas through valves and passages, light valve springs, and as little preheating of the suction gas as possible; lowest cylinder clearances consistent with safety, and multi-staging should be employed if such results in reduction of running costs;

(*d*) The initial cost should be as low as considerations of efficiency, reliability, and safety will permit;

(*e*) To ensure safety and ease of operation, clearances should not be cut too fine, large relief valves should be fitted to each stage and water



—OUTLET VALVE— —INLET VALVE—

Fig. 1.—Sectional views and half plans of inlet and outlet valves.

space, bursting discs should be fitted to water spaces liable to any entry of compressed air, adequate drain valves should be fitted at the lowest points and air cocks at the highest point of the water spaces;

(*f*) The machines should be as light as possible without sacrifice of accessibility and rigidity;

(*g*) They should be easy to accommodate;

(*h*) They should be silent, vibrationless, and smooth running. The first calls for an efficient silencer, forced lubrication, and cushioning in both directions by having compression effected during both strokes. Smoothness in operation is obtained by arranging for as even a turning moment as possible, so that machines of the double-acting or balanced up and down loaded types, preferably having two or more cranks, are the best;

(*i*) To facilitate easy overhaul all bearings, valves and coolers should be accessible;

(*j*) Considerations of minimum wear and tear again call for forced lubrication; a reversal of the direction of loading on the bearings is desirable; excessive cylinder lubrication should be avoided and bearing pressures be kept low;

(*k*) If variable speed is required, the flywheel effect should be large enough to enable the machine to run steadily at low speeds.

An examination of existing compressors and blowers indicates a great variety of types produced by the combinations of the following design features: Cooling (air or water) arrangement (vertical, horizontal, V – L or radial type); staging (single, two or multi); action in cylinders (single, double, or combined); mechanism (reciprocating or rotary); drive (chain, rope, belt, etc., direct coupled or geared straight line or tandem, lever); the unit as a whole may be fixed, semi-portable, or portable.

Referring to stages of compression, the author stated that no hard and fast rule can be made for the number of compressions that can be effected per stage. This may be up to 30 or more for very small outputs, up to about 12 for smallish sized, up to about 8 for medium sized, and up to about 6 for large cylinders, but it is usual to keep well within these limits, to avoid high delivery temperatures.

By multi-staging a saving in power is usually effected, provided that the number of stages is not unduly increased, and in addition the following advantages are obtained: (1) lower delivery temperatures resulting in less valve trouble, better lubrication on a smaller oil consumption, less wear and tear, higher mechanical efficiency, and lessened danger of explosions; (2) reduced stresses in work-

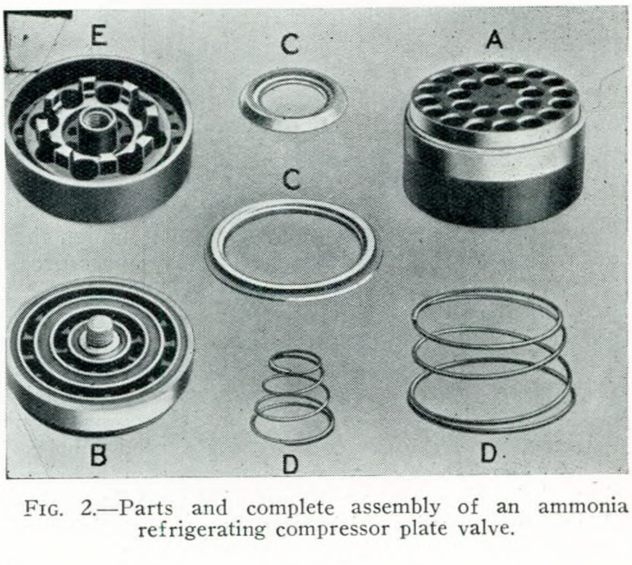


Fig. 2.—Parts and complete assembly of an ammonia refrigerating compressor plate valve.

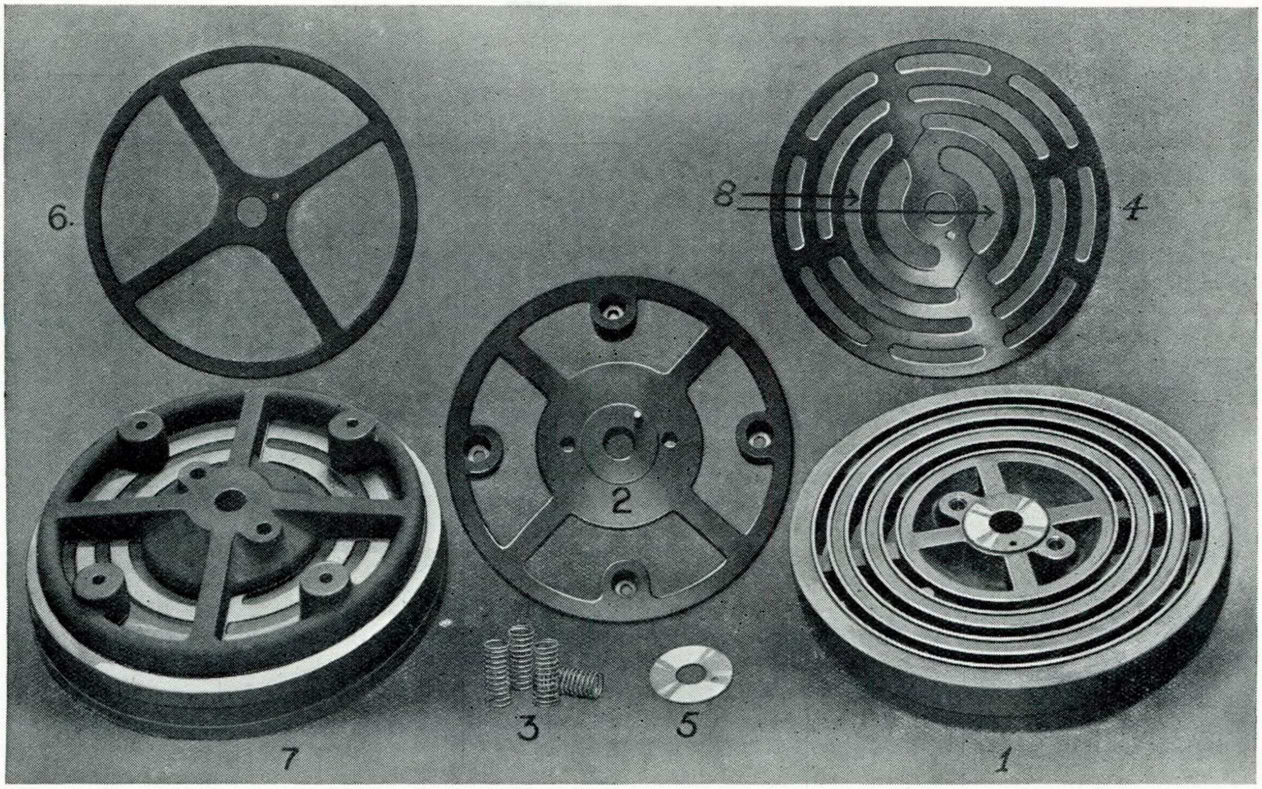


FIG. 3.—Complete assembly of a Rogler Hoerbiger valve.

ing parts, as the higher pressures can be confined to smaller cylinders; (3) greater volumetric efficiency for equal clearances, or greater clearances and hence greater safety for the same volumetric efficiency; (4) increased dryness of the air delivered as most of the moisture is removed in the intercoolers; and (5) reduced leakage past piston rings and valves.

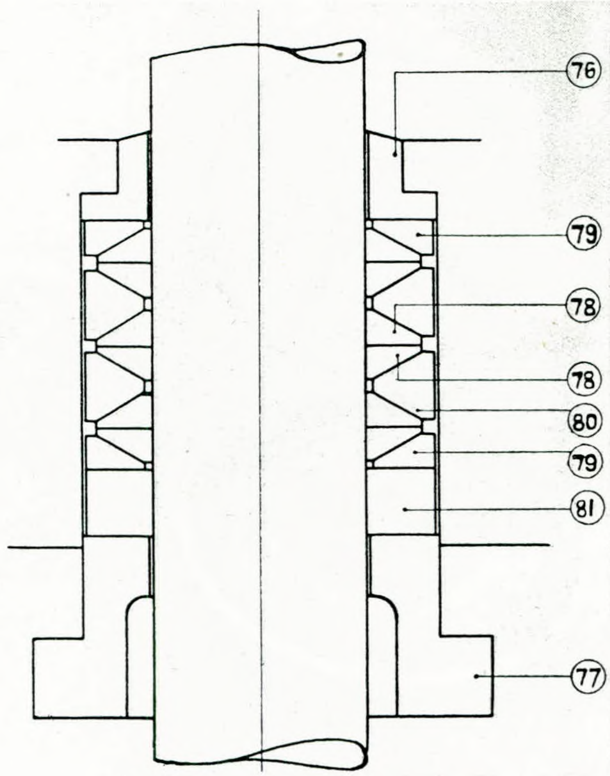
The majority of compressor *valves* are of the plate or disc type, because of their light moving parts, large port area, and automatic action (*see* Figs. 1, 2 and 3). Other valves used are: Simple flat plate automatic valves; feather or strip automatic valves (in Worthington-Simpson compressors); Meyer rectangular automatic valves; mushroom and thimble valves, particularly for high pressure stages; automatic ball valves; mechanically-operated sleeve and mushroom valves; and mechanically-operated Corliss and slide valves.

Packings may be soft, semi-metallic or all metallic. Two special high-pressure metallic packings as used on Brotherhood compressors are shown in Figs. 4, 5 and 6. Pairs of wedge-shaped white-metal rings are frequently used to pack glands, longitudinal tightening of which causes the outer to press against the back of the gland and the inner against the piston rod.

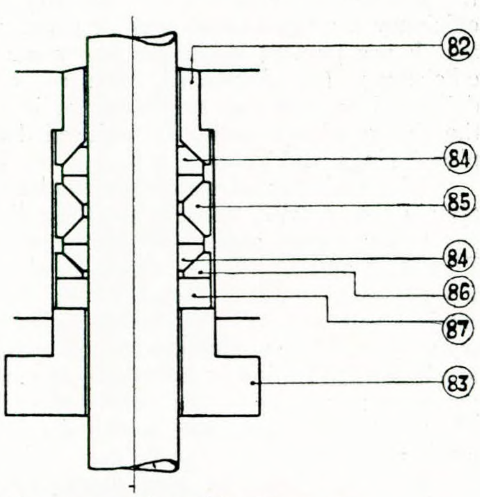
In the *installation* of compressors it should be remembered that the initial air or gas must be as cool as possible, as apart from the fact that there is a loss of capacity of 1 per cent. for every 5° F. rise, the temperature rise itself, for a given ratio of compressions, is the greater the higher the temperature at the beginning of the compression stroke. The coldest place should therefore be chosen for the intake, and hot surfaces be avoided. Suction piping should be of adequate area and as free as possible from bends, and air should be taken in as dry as possible, as excessive moisture tends to wash the lubricating oil off the cylinder walls, besides increasing erosion in the intercooler coils or tubes. In steam-driven units, special attention should be paid to the drainage of steam and exhaust pipes; branches for supply steam should be taken from the top side of the steam mains. Circulating water discharge pipes should not be taken into other discharge pipes at right angles, as this may impede the flow of one of the supplies. Particular care should be taken to see that the direction of rotation is correct, as whilst the machines themselves may operate all right in either direction, the oil and water circulating pumps are not likely to do so.

In emphasizing the importance of correct lubrication, the author considered that the root cause of most compressor troubles lies in excessive lubrication. For efficient lubrication, the oil has not only to provide a seal for the piston rings to reduce air leakage, but it has also to maintain an unbroken film on the rubbing surfaces, to reduce friction and wear. The best practice is to fit a lubricator to the intake of each cylinder, and these should be of a type which allows the amount of oil fed to be varied and which can be worked independently by hand. If too much oil is used, the delivery valves will be coated up with carbonised oil or will be very wet, whilst oil will still be lying about the piston rings on opening up for inspection. Overlubrication is also indicated by the presence of oil on the surface of the moisture drained off the coolers or separators. If there are signs of excessive wear, in spite of evidence of an adequate supply of oil, then the quality of the oil is unsuitable. The best place to look for wear is the top of the h.p. cylinder. In the event of the delivery valves being quite clean and the piston rings dry, then the supply of oil should be increased until it is found that the top piston rings appear to be dry and the bottom ones just wetted with oil, and the water drained off the coolers has a milky appearance. It is not, as often thought, necessary to use oil having a high flash point, as such oils, having a tendency to thicken, are inclined to gum up the valves.

The author described the procedure to be fol-

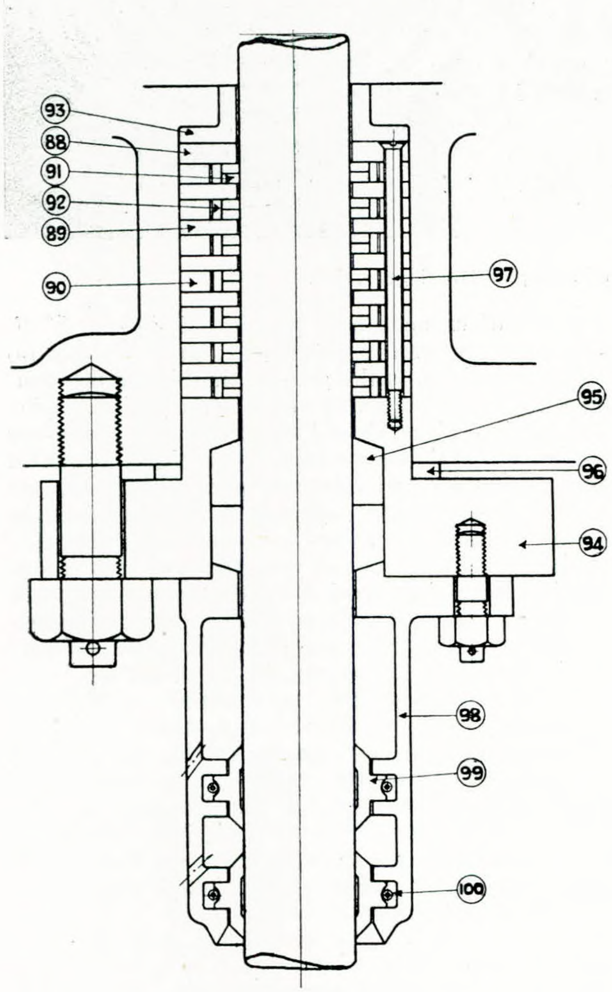


ENLARGED SECTION OF PISTON ROD PACKING.



ENLARGED SECTION OF VALVE ROD PACKING

FIG. 5.



PISTON ROD PACKING

FIG. 4.

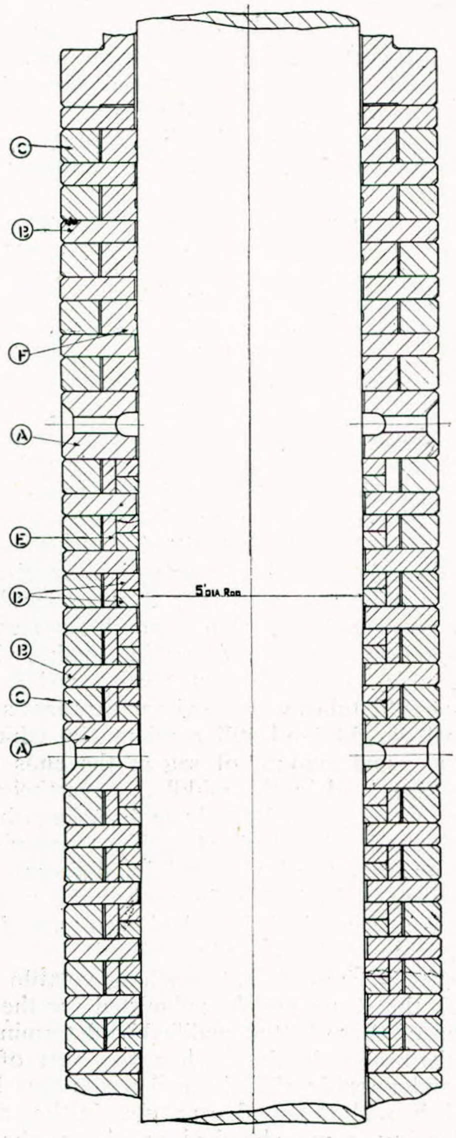


Fig. 6.

lowed in starting up a new machine or one that has just been overhauled, and indicated the inferences that can be drawn from high, low, or oscillating pressure gauge readings with respect to faults in the suction and delivery valves and the reaction of these faults on the working of the machine. He discussed the effects produced by leaky pistons and of air leakage into water spaces, and pointed out that an idea of the condition of intercoolers, after-coolers, and water jackets can be obtained from the temperature of the air discharged while the engine is running. This will be above normal when the cooler or jacket are choked and their cooling capacity is thus reduced, and below normal if the cooling effect has increased owing to wear of the coils or tubes. For testing valves, he recommended the practice of using a stethoscope or, if no such instrument is available, of listening to the sound while holding one end of something metallic between the teeth and putting the other to the part being tested, at the same time plugging up the ears. After briefly referring to the causes of reduced capacity (choked inlet, leaking or sticking valves, leaky piston rings, drains, gauges, etc.) and of falls in oil pressure in forced lubricated machines (faulty pipes, choked strainers and gauges, low oil level, loose or faulty bearings, water in oil, or oil which is either unsuitable or too hot, faulty pumps), the author discussed the use of indicator cards in finding faults. For comparison with an almost ideal card, he reproduced cards taken from compressors having (1) a leaky delivery valve, (2) a leaky suction valve, (3) a suction valve binding, (4) too strong springs on suction valve, (5) a choked suction valve or port, (6) a delivery valve binding, (7) too strong a spring on delivery valve, (8) choked delivery valve or port, (9) leaky piston rings, (10) excessive clearances, and (11) underloaded valves.

In conclusion, he gave a brief description of the principal types of refrigerating compressors and of rotary compressors, both of the positive and of the centrifugal types.

Condenser Tube Corrosion—Some Trends of Recent Research.

By R. MAY, A.R.S.M.

(This paper was published in the September, 1937 issue of the Transactions, Vol. XLIX, No. 8, pp. 171-176, and the contributions to the discussion received by correspondence, together with the author's reply, are published below).

Discussion.

Mr. Sterry B. Freeman, C.B.E., M.Eng. (Vice-President), wrote that prior to January, 1929 his Company had heavy expense in the constant renewal of condenser tubes. Over a long period full particulars were kept as to the number of tubes which failed, the character of the failures and the steps which were taken to combat the trouble. These were exhaustively analysed without definite conclusions appearing as to the cause of the trouble. The two main causes of failure were dezincification, or the absorption and redeposition of copper, and corrosion due to air impingement attack.

The former trouble was cured by the use of arsenical copper in the tubes and an amount of not less than ·02 per cent. of arsenic was included in the specification.

The latter trouble disappeared when they abandoned their previous mixture of 70 per cent. copper, 29 per cent. zinc, 1 per cent. tin and adopted an alloy of 76 per cent. copper, 22 per cent. zinc, 2 per cent. aluminium. Previously they had had considerable success in reducing the amount of air impingement damage by fitting a plate on the initial entrance side of the water box with 1 inch drilled holes, closely spaced. This plate broke up the bubbles and largely reduced the damage. Particulars of these figures were given at a meeting of The Institution of Naval Architects in 1927, in the discussion on Sir Charles Parsons' paper on "Condenser Tubes".

The spraying of tubes with bitumastic enamel was also tried, but the resulting reduction in vacuum was considerable and the method was abandoned.

A system for plating the tubes with chromium was developed and tried in a number of ships, but any failure completely to cover the surface resulted in extra rapid attack and this method was also given up.

The protection by electrical devices to put a definite charge in the condenser, etc., was also tried and found to fall short of complete protection. Large copper bars were fastened to the ends of the condenser across the doors in the hope that providing a path for electric currents might have some effect. This was not based on any definite reasoning, although it was claimed to be successful in certain instances. In their case it was found ineffective.

Large air pipes had been fitted from the condenser doors up to the deck level to remove any surplus air which might collect in the water spaces. In the design for new ships every care had been taken to straighten out the flow as much as possible from the ship's side for discharge into the condenser water box. The water flowed in a number of his Company's ships from the top of the condenser downwards, the coldest water meeting the incoming steam, but since the War this practice had been reversed, the water flowing into the bottom of the condenser first. No appreciable difference had been found in the life of the tubes as a consequence of this reversal. The sea-water scale was removed from the interior of the tubes by circulating water with 4 per cent. by weight nitric acid thoroughly mixed with it. This acid mixture was colourless, so a close watch could be kept on the circulating tank to observe when a green stain appeared which indicated that the metal of the tubes was being attacked. The exterior of the tubes was cleaned by the use of trichlorethylene which was evaporated in a vessel below the lower door, rose through the tube space, condensing out on the tube surfaces, washing the grease off and in the course of a short time completely removing the grease. After the condenser or heater was full of vapour, cold water was circulated through the heater. The vapour was condensed and the liquid trichlorethylene carrying the dissolved grease ran into the heater and could be reconditioned for future use.

Since January, 1929, the condensers of 21 steamers had been fitted with aluminium brass tubes of the 76 per cent. copper, 22 per cent. zinc, 2 per cent. aluminium alloy with ·02 per cent. arsenic in the copper. The number of these tubes now in use was in the region of 60,000 and at the time of writing no single tube of this alloy had failed.

Mr. John W. Henry (Member) wrote that the following experience was an instance of another possible cause of condenser tube failure. Just as there were generally two sides to a question, so also he submitted there were two sides to a condenser tube. During war service at a naval base it became necessary to draw condenser tubes of two trawlers within a month for cleaning, etc., no modern degreasing/descaling methods being then available. When cleaned it was found that the majority of the tubes were to all appearances sound, of normal weight, and still resilient (by which he meant the usual amount of sag at the ends when the tube was held in the middle); nevertheless, if the tubes were gripped firmly and shaken sharply they broke with a brittle fracture like a rotten stick. Both boats were locally owned by different firms and enquiry elicited that in each case, prior to Admiralty charter, the boilers had been treated with the same make of descaling boiler fluid.

Experience showed that anything volatile came over with the steam and he submitted for the consideration of those better qualified to determine the matter than himself that, when the heat of any impure and possibly slightly acid steam was being absorbed through the condenser tubes in the process of condensing, some chemical or electro-chemical action aided mechanically by the slight "whip" of the tubes might cause a change in the structure of the tube metal.

Speaking from memory the tubes in question were short tubes about six years old. He did not know their composition or that of the cylinder oil the deposit of which somewhat heavily coated them. He also did not precisely know the cause of failure but merely cited the facts which led to the retubing of two condensers.

Since the war he had been supervising cargo steamers and, with the exception of one steamer on the "skin" return system of electric wiring, had had comparatively little trouble with condenser tubes, apart from external wastage in way of packings due to age. Incidentally, every endeavour was made to maintain clean boilers by ordinary methods, and to change the water as often as possible; sparing use was made of best class internal cylinder oil, and condenser tubes were not allowed to become unduly foul.

Dr. S. F. Dorey (Vice-President) wrote that the author's paper fitted in well with the condenser troubles experienced in marine practice and left little to be added that could increase the knowledge already contained in the paper.

In contributing to this discussion an endeavour had been made to obtain more precise information regarding water speeds, and it was evident both from the paper under discussion and from practical experience that water speed was of vital importance. It was a fact, however, that this particular question regarding condenser design had not received the attention of operating engineers that it deserved. In other words there had been a lack of co-operation in this respect between designers and operators of steam plant.

The following was a brief summary of the information available from operating engineers :—

(1) The tendency of design was towards smaller condensers and it was in these that wastage of the tubes was most common.

(2) The inference to be drawn from (1) was that with normal condenser tube material the increased water speeds had increased the wasting of the tubes.

(3) (*a*) Trouble always occurred at the inlet end of the tube; (*b*) this was most acute with the old type of square aperture ferrule made for the introduction of the square-headed screwing key; (*c*) similarly it had been found that with streamline ferrules as shown in Fig. 1 with the tube end and ferrule butting, reduced wasting resulted as compared with Fig 2 with incorrect direction of flow; (*d*) where lead liners had been fitted at the inlet ends of tubes, wasting had occurred in the tube just at the end of the liner, due apparently to eddies occurring as a result of the liner becoming displaced.

(4) The conclusion to be drawn from (3) (*a*), (*b*) and (*c*) was that water must enter the tubes with a minimum of eddy formation.

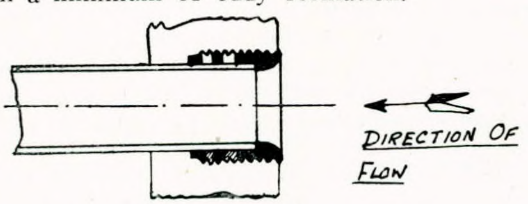


Fig. 1.

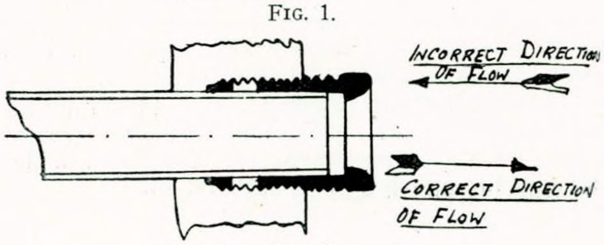


Fig. 2.

(5) With the smaller types of condenser with higher water speeds the following information had been derived from practice: (*a*) trouble had been experienced in some instances with cupro-nickel tubes due to pitting, the pit holes occurring at the inlet end about 18in. from the tube end and the diameter being about $\frac{1}{16}$in. The trouble appeared to be less apparent where soft iron corrosion plates had been fitted. Another source of trouble had been due to longitudinal cracking of cupro-nickel tubes, the cracks being non-continuous and appearing at various parts of the circumference of the tube; (*b*) more trouble had been experienced with turbine than with steam reciprocating machinery; (*c*) in some turbine installations cupro-nickel tubes had had a life of ten years.

(6) Complete absence of trouble with condenser tubes appeared to be the case where suitable aluminium brass was used in conjunction with cupro-nickel streamline ferrules having the correct direction of flow indicated by Figs. 1 and 2, i.e., with tube and ferrule butting at inlet end. Material for the ferrule was important because of the necessity of providing a material tough enough for screwing and unscrewing and one which would resist wasting or electrolytic attack in service. Although many cases were known of the above practice as being completely successful, only in three cases were the water velocities known, and these were 6·5, 3·2 and 11·6 ft./sec. At the same time, in the latter case precautions had been taken to free the air from the water inlet at both the return box and water box ends.

(7) One case was known of failure of what was termed aluminium brass. Upon investigation, however, this was found to be Admiralty brass. These tubes had been replaced by aluminium brass with complete success. Many cases were known where aluminium brass tubes had been successful where others of normal condenser tube material had failed.

(8) There seemed quite definite information to indicate that not only was aluminium brass very much cheaper than cupro-nickel, but that it was also superior in service.

From the foregoing it seemed that (6) above formed an entirely satisfactory solution to condenser troubles, provided that, until more information was forthcoming regarding limiting water speeds, moderate speeds were maintained.

Mr. R. Jobling (Melbourne Steamship Co., Ltd.) wrote that he had read this paper with interest and would like to report that the experiences of his Company of condenser tube troubles had been very few indeed, and only on three occasions had they suffered with condenser tube leakages. On each occasion this was after having treated the tubes with some cleaning fluid. Most probably the leakages were due to this fluid, which, he believed had a hydrochloric acid base.

Mr. H. Topley wrote that he had been greatly interested in the paper, and in his capacity as works superintendent of the Halifax Corporation Electricity Department he had recently had an experience of tube trouble. The cause of failure of the tubes appeared to be dezincification, but it was isolated pitting which had been the direct cause of failure. (Mr. Topley had sent samples which were being examined).

The Author's Reply to the Discussion.

Mr. Freeman's eminently practical contribution gave information which would be welcomed by all interested in condenser tube corrosion. The author had not realised the thoroughness with which Mr. Freeman's Company had attacked the problem, nor the success which had been achieved. Mr. Freeman's notes on tube cleaning, and particularly on the use of dilute nitric acid for removal of unwanted scale, called attention to a side of the problem which might well receive wider attention. At the present time the British Non-Ferrous Metals Research Association did not know what methods were being generally adopted by engineers for this important operation, and it was to be hoped that others would join Mr. Freeman in giving details of the procedure which they had found best for their special requirements. The success which Mr. Freeman had had with aluminium brass tubes was encouraging; evidently such tubes were very suitable for his particular conditions of service.

The author was grateful to Mr. Henry for calling attention to an interesting type of condenser failure which ought perhaps to have been mentioned in the paper, i.e., embrittlement of the tubes. It was not unusual to find that 70 : 30 brass or 70 : 29 : 1 alloy tubes, in which dezincification had progressed to an advanced stage, were brittle and broke as described by Mr. Henry, but, in such cases, examination of the fracture showed at once the nature of the trouble. Dezincification could produce even more marked embrittlement of two-phase brasses, such as the naval brass and 60 : 40 brass, often used for ferrules. With these alloys the action penetrated in the beta solid solution leaving the alpha solid solution which formed the bulk of the alloy intact. The result was that the appearance of the alloy was little changed even when the loss of strength was serious. Probably the embrittlement which Mr. Henry encountered was of another type, fortunately rare, due to the presence of substances which caused true intercrystalline attack and embrittlement without any change in the appearance of the metal. Of these substances metallic mercury was extremely active, even in traces such as might come from a broken thermometer. Usually the damage was done from the steam side, mercury being very readily carried by the steam into the condenser, but the author had also examined several cases in which mercury came into contact with the water-side of the tubes and caused failures.

Ammonia was another substance which could cause intercrystalline fracture of stressed tubes, but in practice this action only appeared to occur in exceptional conditions.

Possibly other substances which encouraged corrosion of an intercrystalline type, e.g., certain organic sulphur compounds, might cause embrittlement given the right conditions; such substances tended to cause failure by local corrosion before embrittlement penetrated to any depth.

The author's thanks were due to Dr. Dorey who, with his first-hand knowledge of the subject, had filled in many practical details which were lacking in the paper, and had supported a number of views which were tentatively expressed therein. There was much in Dr. Dorey's contribution which stimulated thought; certainly there was much which the author found interesting. For example, the nature of the pitting experienced with cupro-nickel tubes. The author had seen very few failed cupro-nickel tubes from service and was anxious to ascertain whether such failures were related in any way to the presence or absence of certain minor constituents. The use of cupro-nickel ferrules with aluminium brass tubes was new to the author; it was interesting to learn that the combination was highly satisfactory and that aluminium brass was giving such good results in marine service.

The author thanked Mr. Jobling for his contribution which raised the important question of tube cleaning. The probable explanation of leakages occurring after cleaning the tubes with an acid cleaning fluid was that the tubes were already suffering from a fairly advanced stage of dezincification but were kept watertight by the strong scale of zinc salts produced by the attack. The cleaning fluid would dissolve the scale so that leakage could then occur through the porous copper plugs at places where dezincification had penetrated the wall. Cases had been known in which the removal of the zinc oxychloride scale from a dezincified tube had allowed some of the plugs of re-deposited copper to drop out leaving holes which had often been ascribed to true pitting action.

The author also thanked Mr. Topley for calling attention to the interesting case of corrosion which he had experienced, and for the samples showing the attack and its distribution.

Preparing a Diesel Engine for Sea.

By JOHN LAMB (Member).

There is little doubt that, generally speaking, a Diesel engine works under more severe conditions when manœvring a ship in and out of port than under normal conditions at sea. The stresses set up in the various intricate castings must be great indeed on these occasions, and although no apparent damage may result at the time, yet there is not the slightest doubt that the foundations of many troubles that eventually occur are then laid.

It is so often said that one of the greatest advantages of the Diesel engine is that it can be prepared for sea at a moment's notice. A Diesel engine can, of course, be prepared for operation many times while steam is being raised even in a water-tube boiler, but if the various parts of the engine are to be subjected to the minimum heat and other stresses and be absolutely reliable, the port work must be completed in a reasonable time to allow an engine to be properly prepared for sea.

As the best use must be made of the short time available in port, especially in the case of bulk oil carriers, the purpose of this paper is to indicate the essential points to be observed when preparing an engine for sea and the manner of attending to the various points in order to ensure the best results.

Temperature of Engine Room.

In ports where the temperature is likely to reach 32°F. and below, and means are not provided to keep the temperature above freezing point, care must of course be taken to see that the cooling water is drained from the cylinder jackets, pistons and the entire pipe system in order to prevent fracture of castings and bursting of pipes. Drain cocks and valves are generally provided for this purpose, but all parts containing water should receive consideration, and if there is a doubt about the water not being completely drained out the necessary steps should be taken.

In the case of ships having steam-driven auxiliaries, the temperature of the engine room is never likely to fall to freezing point, but it may on occasion be advisable to keep all openings into the engine-room closed, and set in motion steam-driven machines that are not really required for the work in hand. The best safeguard against damage by frost is to provide arrangements to enable the cylinder jacket cooling system being circulated by warm water discharged from the condenser or the auxiliary oil engine. This will keep the whole engine-room warm and prevent water in pipes situated in every part of the engine room from freezing and causing serious damage. Even if warm water is allowed to circulate through half the total number of cylinders the temperature of the engine-room will be maintained at such a temperature that freezing is most unlikely. Such an arrangement allows the work of overhauling parts of cylinders to be proceeded with.

Fuel Settling Tanks.

Not only must these tanks be full upon leaving port, but the strainers or filters situated between the tanks and the main engine fuel pumps must be quite clean in order that there will be no undue resistance to the flow of fuel when the engine is set in motion. Many involuntary stops have occurred and very serious situations arisen when leaving port, owing to the engine fuel pump suctions running dry after ten minutes or so. The cause of this is generally due to the settling tank running dry or to choked strainers, but on occasions the cause has been due to the low temperature of the fuel. Everything in this direction may appear to be in order when a ship arrives in port, but then the fuel is warmer and will more readily flow through a partly choked strainer. When leaving port, however, the fuel is colder and more viscous, and a partly choked strainer may not allow sufficient fuel to flow, with the result that when the engine has consumed the fuel in the pipe connecting the strainer with the fuel pumps, the engine stops for want of fuel. The fact that there appears to be a sufficient supply of fuel when the engine fuel pumps are being primed is not a sure indication that the supply will be sufficient when the engine is set in motion.

Fuel settling tanks, being generally placed out of sight high up in the engine-room, are apt to escape attention until a ship has put to sea and begins to roll. The engines may then begin to work irregularly due to fine grit which not being allowed to settle on the tank bottom owing to the movement of the ship finds its way to the engine fuel pumps. Efficient strainers may be provided, but somehow fine grit finds its way to the engine in spite of them, and while the particles of grit may not be large enough to interfere with the working of the engines, they will have a bad effect upon the valve faces. When in port it is therefore advisable to open up, steam out or well air, and then thoroughly clean these tanks occasionally.

The steam heating coils, when fitted, should be examined for corrosion, and while the tank is open the coils should be tested by admitting steam at the full working pressure. Steam heating coils are invariably located so low that the sediment which accumulates on the tank bottom can only be removed with difficulty, and in some cases the tank can be properly cleaned only by removing the heating coils. This of course would be unnecessary if the coils are located not less than six inches from the bottom of the tank and there is no reason why they should be located lower than this.

Cylinder Head Valves.

If the cylinder head valves or any part of the operating gear have been changed overhauled or simply removed for access to some other part, it will be necessary to check, and re-adjust if required, the clearances between the rocking lever rollers and the plain part of their respective cams. Before carrying out this operation it is advisable to insert a crow-bar under the roller end of the rocking lever, and prise open the valve two or three times, allowing it to reseat smartly to make sure that it is working freely and reseating properly. A slight upward pressure should then be exerted on the roller end of the lever by means of the crow-bar whilst adjusting the roller clearance in order to take up all slackness in the operating gear. The clearance must always be checked again after the locking nut on the adjusting screw has been tightened, as this operation very often has the effect of altering the clearance.

Even though the air inlet and exhaust valves have not been disturbed since the previous run, it is advisable to prise them open a few times with a crow-bar to make sure that they are free to open to their fullest extent and reseat properly, and so make certain so far as these parts of the engine are concerned, of the engine starting properly. The starting valves also should be tested in the same way and for the same reason, while the indicator cocks should be shut to prevent escape of starting air and loss of compression when the engine is started. Open indicator cocks are frequently the cause of a false start.

After making sure that all valves are free and in working order, a careful inspection of the cylinder heads should be made for tools or the like that may become jammed under the rocking levers, or fall when the engine is started. All parts of the valve gear should then be lubricated.

In some makes of engines, the fuel injection valve rocking levers work on eccentrics mounted upon a fulcrum shaft, which is rotated through a certain angle, usually 180 degrees, during the reversing operation. In such cases, the eccentrics naturally wear mostly on one-half of the circumference only—i.e., the half which takes the load during ahead operation—so that to maintain uniform timing of the valves for both directions of rotation with the same roller clearance, the eccentrics require to be trued up occasionally. The extent of wear, if any, is readily ascertained by measuring the roller clearance with the reversing gear in the ahead and then the astern position. Generally, as wear takes place and the desired roller clearance for ahead operation is maintained, the clearance with the gear in the astern position becomes less and less, and if not attended to, the roller will eventually ride on the plain part of the cam when the engine is operating in the astern direction. If the parts are properly lubricated, the wear rate will not be great, but it should nevertheless be checked from time to time, particularly in the case of airless-injection engines with mechanically-operated fuel injection valves, as a reduction in the roller clearance means earlier admission and later cut-off and, consequently, higher cylinder pressures when working in the astern direction.

Piston Cooling System.

After opening and closing the various valves as necessary to cause the cooling oil or water, as the case may be, to flow in the desired direction, the standby piston cooling pump will require to be put into operation, and the flow from each piston observed. The fluid should issue from each outlet in a steady stream. If the presence of air is indicated by bubbles or an unsteady flow, the whole of the pump output should be passed through one piston at a time until all air has been expelled and the desired condition of flow obtained, after which a final examination should be made to make quite sure that the valves are in their correct working position, and that each piston will receive its proper supply when the engine is started. It is wise to keep the standby pump working until the "full away" order is received.

After the cooling medium is circulating properly at the normal working pressure, the drain tank should be sounded and replenished if the pump suction is not well covered. When adding to the contents of the piston cooling tank with the pumps in operation, it must be remembered that space must be left for the fluid in the system, otherwise when the pump is stopped the tank will overflow and much lubricating oil or fresh water, as the case may be, will be wasted.

The practice of some engineers is to bye-pass the piston cooler until the engine has been working some time, and the cooling medium has approached normal working temperature, the object being to facilitate starting and reduce the stresses set up in the pistons due to temperature difference. There is no doubt that this practice has both these effects to a small extent, and would be commendable if it were unaccompanied by any objection. The objection is that, as a rule, the change-over to the cooler must be made when all hands are fully occupied manœuvring the engine and attending to the thousand and one things that require attention when a ship is leaving port, with the result that the rising temperature of the piston cooling medium may be unnoticed. When lubricating oil is the medium employed this would be a serious matter. In view of this, and the fact that modern engines start readily enough with cold pistons, the wisest plan is to start with the piston cooler in operation. Moreover, the design of modern pistons is such that the additional stresses arising from circulating the pistons with cold water or lubricating oil are so very small that they are not worth consideration.

The mechanism conveying the cooling medium to the pistons should then be examined for leakages. When of the telescopic type, the glands and the joint between the pipes and the pistons should be carefully examined. As telescopic pipes sometimes break at the point where they join the flange, or pull out of the flanges, it is wise to tap each pipe lightly with a hammer or similar tool. The sound produced will indicate if the pipe is firmly attached to its flange. If telescopic pipe glands are found leaking, it is not advisable to tighten them too much, as the leakage generally takes up when the fluid and the parts concerned become heated. Should the glands be tightened when an engine is at rest and the parts are cold, there is a danger that when the engine is working normally the telescopic pipes will be gripped with undue pressure, and may be damaged at the point where they are joined to their flange. Many telescopic pipes have been broken or pulled out of their flanges in this way.

Telescopic pipes which work through packing should always be well lubricated before an engine is set in motion. The best time to do this is when the engine is being turned just prior to disengaging the turning gear. These pipes tend to become dry in port, and if the engine is started with the pipes in this condition, a strain so great will be set up at the point where they are attached to the flanges that the pipes may be broken or pulled out of their flanges. The very quick acceleration natural to Diesel engines is responsible for many leakages which occur at the upper end of telescopic pipes, so prevent this as far as possible by not nipping up the glands too tightly and lubricating the pipes before an engine is set in motion.

Cylinder Cooling System.

The standby jacket cooling pump will then require to be set to work after all necessary valves in the system have been opened and closed as required. The flow through each cylinder jacket should be observed, and care taken to see that the exhaust pipes, air compressors, etc., if fitted and water-cooled, are being properly circulated. It is an advantage when the flow from each cylinder can be viewed, as then there is no fear of the engine being set in motion until all air has been expelled from each cylinder jacket. In cases where the flow from each cylinder jacket cannot be seen it is advisable, especially when the jackets have been emptied, to circulate one jacket at a time and observe the water as it is discharged overboard. If a good steady flow through a particular cylinder jacket cannot be obtained, presence of air will probably be the cause. In such cases, partly closing the outlet valve to create a pressure in the jacket will doubtless dislodge the air.

The inlet cooling water valves provided at the lower end of each cylinder jacket should always be full open while an engine is in operation, and the amount of water circulating varied by regulation of the outlet valves. After the water has been made to circulate properly through each of the cylinder jackets, the outlet valves should be shut down until they are from one-half to three-quarters of a turn open, and then regulated as necessary to give the required outlet temperature after the engine is set in motion. Whilst on the subject it would be as well to point out once again the great importance of making quite sure that the valves are properly fitted, i.e., that the water approaches the valve from the underside of the lid, where this is of the globe type. Where sluice or gate valves are used, the valve should be located in such a way that in the event of a gate becoming detached from its spindle it will not fall and stop the flow of cooling water. These regulating valves are generally, but not always, fitted in the right way when an engine leaves the builders, but during subsequent repairs they are sometimes re-fitted wrongly. It is quite an easy matter to arrange the bolt holes in the flanges of such valves in such a way that they must be fitted in the right way, but some engine builders do not yet fully appreciate the importance of guarding against these valves being re-fitted in the wrong way and causing a sudden stoppage of cooling water to a cylinder jacket.

The practice of merely opening up the various cooling water valves and allowing the sea-water to flow by gravity into the system is very unwise, even when a ship is fully loaded, as one can never be sure that the whole of the air has been expelled. Such a practice is particularly dangerous if the cylinders are to be preheated, as local overheating is likely to occur, and damage to some of the parts result, when an engine is set in motion and the main cooling water pumps begin circulating. Always, therefore, make sure that the whole of the cooling water spaces are completely filled and the water circulating properly through each cylinder jacket before an attempt is made to start an engine.

In very cold weather it is advisable, although not usually necessary, to preheat the cylinders. The preheating operation should be stopped when the chill is off the cylinder castings. There is nothing to be gained by preheating to a higher temperature. All circulating valves should be left open during the operation, as there is no point in closing them, while it is just possible that one may be overlooked until after the engine has been set in motion. Even when a ship is in ballast, the water cannot drain from the cylinder jackets because of the pump discharge valves. The cooling water should begin circulating immediately the engine is set in motion. The practice of preventing the pumps from delivering until the engine has been operating for a few minutes is unwise and unnecessary. Air or steam might accumulate in these few minutes and interfere with the flow of water when the pumps begin delivering. The quantity of water to be circulated depends, of course, upon the speed of the engine. The quantity should be small until the temperature begins to rise, but so long as the water is moving, trouble arising owing to local overheating is not likely to occur.

Lubricating Oil System.

The standby lubricating oil pump should really be the first auxiliary machine to be set in motion when preparing an engine for sea, in order that time is allowed for the solid impurities in the oil to be separated and collected in the strainers before the engine is required to operate. Whenever the crankcases have been opened for the overhaul of internal parts, a great deal of dirt is carried in, and in addition to cleaning out the crankcases it is advisable to arrange to begin circulating the lubricating oil continuously for 12 hours before the engine is started, cleaning the strainers as required meanwhile, so that when the engine is started the pressure of the oil at the bearings will not be reduced owing to dirty strainers. Heating the oil to about 100°F. whilst it is circulating will facilitate the separation of the impurities, and prevent greasy matter depositing on the cooler tubes. Raising the temperature of the oil in cold climates greatly assists the pumps also, especially if the oil has been in use for a long time and is comparatively viscous.

Lubricating oil strainers should always be provided with pressure gauges connected in such a way that the condition of the cartridges can be seen at a glance. The best practice is to provide a pressure gauge at each side of the discharge strainers, and a vacuum gauge at the pump side of the suction strainer. When the cartridges of the discharge strainer are clean, both pressure gauges will register the same pressure, but when dirt collects the gauge connected to the pump side of the strainer will register a higher pressure than the one on the outlet side. In the case of the suction strainers, dirty cartridges will be indicated by a higher vacuum reading.

The dirt accumulates on the outside of the cartridges, so that they require to be carefully removed from the strainer in order not to allow any of the dirt to fall back into the strainer. The best way to clean these cartridges is to immerse them in fuel contained in a drum larger in diameter and length than the cartridge, and after the dirt has been brushed off compressed air should be blown through the gauze from the inside of the cartridge. For the supply of compressed air it is generally possible to connect a hose-pipe to some part of the starting air system.

In nine cases out of ten when a standby lubricating oil pump fails to lift the oil from the double-bottom tank or maintain a steady pressure, the cause is either due to the oil being too cold and viscous, or to leakage of air into the suction pipe. Slight leakages in these pipes sometimes pass unnoticed until the oil is cold, and a higher vacuum must be created in the pipe to cause the oil to flow to the pump. Because of this it is wise to test these pipes by hydraulic pressure occasionally. In the case of new engines, all bolted joints should be tightened soon after the lubricating oil has attained its working temperature. The tanks in which the new lubricating oil is stored are usually located high up in the engine room, and the oil in them can be used to test the lubricating oil pump suction pipe. As a rule these pipes are connected to the pump suction pipe, in which case all that is necessary to test the suction pipe is to shut the valve at the extreme end of the suction pipe, in order to stop the new oil from passing into the double-bottom tank, and admit the new oil to the suction pipe. When making such a test, however, see that all air is allowed to escape from the suction pipe. This can usually be arranged for by simply opening the air release cock generally provided on all such pumps.

The lubricating oil in the system should be examined and, if considered necessary, purified. Most engineers will have an idea of the condition of the oil before port is reached. If not, draw off a sample of the oil while it is circulating, and test it by adding to it twice the amount of paraffin and pouring the mixture through a piece of blotting paper. The amount of sediment left on the blotting paper will convey an idea of how much solid matter is contained in the oil.

When the principal bearings are lubricated by a constant stream of oil, it is usual to have a large quantity of oil in the system or, to be more correct, a small quantity in circulation compared to the quantity in the drain tank or sump. This is conducive to proper lubrication, since the longer the oil can remain in the sump before being circulated through the bearings, there is a better chance for the impurities to separate from the oil and fall to the bottom of the sump out of reach of the pump suction. The not uncommon practice, therefore, of keeping only sufficient oil in the sump to cover the pump suction pipe is not good. Some seem to think that they save oil by keeping the absolute minimum in the system. Such reasoning is difficult to understand. Actually the consumption will, if anything, be higher, since the smaller the quantity of oil in circulation, the higher will be the working temperature, and consequently, the greater will be the amount of vapour produced in the crankcases. Therefore, while there is no advantage whatever in "starving" the system, there are three disadvantages, namely, the impurities are given less time to settle out, more oil is vaporized and lost, and as oil in vaporized form is more easily oxidised the oil will deteriorate more rapidly.

The end of the pump suction pipe, and the end of the return pipe from the engine, should be as far away from each other as possible, and the end of the latter pipe should be well beneath the working level of the oil in the sump. The object of this is to ensure that as little as possible of the impurities coming from the engine will be delivered back to the bearings. It must be remembered that there are many injurious impurities in the oil which will not be collected by the common form of gauze strainer, but which will settle out in the sump if time is allowed for them to do so. The best arrangement is to lead the returned oil to a point near the bottom of the sump, and to draw from a point as high as practicable. The pump should always be provided with a high and a low suction, the former being used generally, and the latter only in cases of emergency, or when it is necessary to empty the tank for cleaning or other purposes. The desired results will be obtained if the high suction ends about one foot from the bottom of the tank, and the low suction from half to one inch.

The common practice is to use part of the ship's double-bottom as a drain tank for the main engine lubricating oil. This forms an ideal receptacle, as the cooling effect of the sea helps to maintain the oil at a moderately low temperature. The maximum temperature of oil in continuous circulation should not be allowed to exceed 140°F., as at temperatures greater than this most oils deteriorate rather quickly, and excessive wear in the bearings may take place. The lubricating properties of oil decrease as the temperature rises, until at about 300°F. its lubricating properties are not much greater than that of water.

Crankcase Inspection.

After the piston cooling water and lubricating oil are circulating at the normal working pressure, the crankcase doors should be opened, and all pipes and fittings conveying these mediums carefully examined for leakages.

Lubricating oil should issue from the ends of every bearing fed from the pressure system. As a rule, if oil issues from the ends of the crosshead bearings, it may safely be assumed that the crankshaft and crankpin bearings will get sufficient oil, since the oil must pass through these bearings before it reaches the crosshead bearings. It is, however, more satisfactory to see the oil flow from each end of all bearings, and this can generally be brought about, providing, of course, that all the passages are clear of obstructions, by turning the engine with auxiliary power while circulating the oil.

All pipes in engine crankcases should be firmly secured in order to prevent them vibrating while the engine is operating. Copper pipes should be annealed periodically as they tend to become brittle and may fracture. Pipes used to convey oil to the camshaft driving chains should also receive attention. While these pipes must sometimes be led to within a few inches of the chain in order to deliver the oil where it is wanted, they must not be so near that they will foul in the event of the chain becoming slack through stretching.

Priming the Fuel Injection System.

One of the most important operations of preparing an engine for sea is the priming of the fuel pumps and fuel injection valves, as it is a fact that more false starts are due to insufficient attention being given to this than any other cause. Much has been written upon the subject so that it is not necessary to say more here than to impress upon readers the vital importance of continuing the priming operation until all air has been expelled, and the fuel flows from the various vents provided on the pumps and valves in a steady stream and its natural colour. When the fuel issuing from the vents is a light brown colour, it generally indicates the presence of air. Pressure resulting from a priming valve being only partly open will cause the issuing fuel to be a light colour also, but it is, of course, presumed that these valves are fully open before the priming operation is begun.

Cylinder Lubrication.

Not only must the cylinder lubricators begin delivering oil into the cylinders immediately an engine is set in motion, but a certain amount of oil should be contained between the piston rings when an engine is set in motion. When a ship is entering port, a great deal of manœuvring is generally necessary, and the moist starting air admitted on these occasions tends to wash the oil film off the cylinder walls and leave them more or less dry. For this reason it is advisable to adjust the lubricators to discharge about three times the normal quantity whilst manœuvring into port. Moreover, during the time a ship is in port, the oil film oxodizes, and there is no doubt that more cylinder liner and piston ring wear takes place during the time a ship is leaving port than takes place during many hundreds of hours of normal running at sea.

The cylinder lubricators and the pipes connecting them with the cylinders must therefore be fully primed prior to starting, and some oil injected into the spaces between the piston rings if the engine has been idle for more than a couple of days. The best time to do this is when the engine is being turned to make sure that all is clear before the turning gear is disengaged, the lubricators being worked by hand during the period when the oil injection holes are covered by the piston.

When working the lubricators by hand, observe that the ball valves are functioning properly. If in doubt, the pipes should be disconnected from the cylinder, and the lubricator plunger worked while a finger is pressed against the end of the pipe. If the valves and all other parts are in good order, it will be impossible to stop oil issuing from the disconnected end of the pipe. If oil is showing in the sighting glass, that is oil which has displaced water or glycerine—whichever is used—it indicates that one or both of the joints at the ends of the sighting glass are leaking. If the joints have become hard they should be renewed, as undue pressure on the securing nut will probably break the glass if it is of tubular form. These joints are made of leather, and must be fairly thick in order that only moderate pressure on the nut holding the parts together will ensure fluid-tightness. When one of these joints becomes defective, it is wise to renew the joints at both ends of the glass.

The lubricators should be set to deliver from three to four times the normal quantity before an engine is started, and allowed to continue doing so for the first three hours or so that the engine is operating at full power. When the cylinder liners are new, the amount of oil delivered should be reduced to the normal amount very gradually over a period of three to four days, but in the case of old cylinder liners the amount delivered can be adjusted in one operation.

Injection Air Compressors.

When the engines are of the air-injection type, the compressor cylinder lubricators require the same attention as those feeding the main engine cylinders. It is not, however, necessary to do more than make sure that the whole of the pipes connecting the lubricators and the cylinders are fully charged with oil, so that delivery into the cylinders will take place immediately the engine is set in motion.

Because of the very small piston end clearances in air compressors, one of the greatest dangers to be guarded against is the starting of an engine with water in the cylinders. Very serious damage has resulted on occasions due to this. When preparing an engine for sea, therefore, an important duty is to open fully the cooler drains and observe if water flows from them and examine the bottoms of the cylinders for the presence of water. If no water is observed, it may be taken for granted that the coolers and cylinders are free of water, but as there are usually pipes connecting the various stages in which water can collect, and which is dislodged only when the compressor is set in motion, the cooler drains should be left open until after the engine has made a few revolutions, and there is no doubt about the compressors being entirely free of water.

Even small quantities of water will wash the oil film off the cylinder wall and result in excessive wear. Moreover, as an injection air compressor absorbs about 10 per cent. of the total output of an engine, the opening of the air compressor drains facilitates starting by reducing the load to be overcome by the starting air.

Starting Systems.

The starting air compressor will require to be set to work at an early part of the proceedings, in order to ensure that all tanks are fully charged some time before the main engines are required. If the main engines are of the air injection type, the injection air bottles will also require to be fully charged. The usual pressures are 350 and 1,000 lb. per sq. inch respectively, but the most suitable injection air pressure depends upon the power developed by the engine; the lower the power the lower should be the injection air pressure required to give the best results.

While the starting air tanks are being pumped up, the drains should be opened momentarily to make sure that the tanks are free of water. The drains on the starting air manifold pipe should also be opened for the same reason. As corrosive liquids are liable to collect in these pipes, it is wise always to keep these valves slightly open and prevent accumulation of these undesirable liquids. The valves will require more frequent overhaul if left slightly open, but it will prevent corrosion in the starting air manifold which is a much more serious matter. The amount of air that will leak through the partly open valves is of no account, whilst if they are not opened too much the noise produced will not be objectionable when starting.

The safety devices on the starting air system must be in good order, as when starting an engine there is always the possibility of a starting valve jamming and causing an abnormally high pressure in the starting air manifold. If bursting diaphragms are employed, one must be sure that they are not weakened by corrosion, as should these diaphragms rupture the engine will be out of commission, so far as manœuvring is concerned, until a new diaphragm has been fitted. And since it takes time to fit a new diaphragm a serious position may easily arise. One must, therefore, be quite sure that the bursting diaphragms will not rupture unless it is to relieve an abnormally high pressure and so prevent damage to the starting air pipes and fittings.

As the starting air automatic valve, or relay valve as it is sometimes called, is liable to become dry owing to moisture in the starting air and may jam, one must be satisfied that this valve is in good order before an engine is set in motion. The construction of these valves varies considerably, but in most cases it is possible to test the valve for being free without disconnecting or dismantling any part. All such valves are generally provided with means of injecting grease to the rubbing surfaces, and a little should be injected each time an engine is made ready for sea. When no such provision is made, the moving parts of the valve should be removed occasionally and lightly greased.

The cylinder decompression valves are an important part of the manœuvring mechanism, and they must therefore be in proper working order. If they do not open owing to operating gear being incorrectly adjusted, the air inlet or exhaust valve rocking levers may be broken, or should one or more of the valves jam in open position, it will be necessary to stop the engine to free them.

These valves are generally operated mechanically from the reversing shaft or some other part which is set in motion during the reversing operation, and the rods and levers employed to transmit the motion are generally arranged in such a way that when the reversing gear is in either extreme position the decompression valves are closed, the open period occurring for a few degrees at each side of the mid-position of the reversing gear.

The conditions under which these valves work are such that they tend to become dry and may jam in open position. They should, therefore, be opened up occasionally and overhauled, as the consequences of a valve that will not function properly may be the cause of a false start. In some engines the cylinder relief valve or the exhaust valve is made to serve as a decompression valve.

In the case of two-cycle engines, there are not air inlet or exhaust valve rocking levers to break in the event of the decompression gear failing to function, but unless the pressure in the cylinders is released during the reversing operation there is a possibility of the engine not starting when the starting gear is operated. Suppose, for instance, that two cranks of a multiple cylinder engine are diametrically opposite, and that upon stopping the engine comes to rest when these two cranks are in horizontal position; in the cylinder whose piston is moving upwards will be air under pressure, and the other cylinders will contain burnt gases also under pressure. If the engine remains at rest long enough the gas in both cylinders will escape and the pressure be reduced, but if the engine is to be instantly reversed it means that the piston which was moving downwards during the preceding run will now have to move upwards. As this cylinder will contain burnt gases under pressure, and any upward movement of the piston will compress them and increase the pressure still further, it will be seen that considerable resistance will be offered to the turning effort of the starting air in the active cylinders. If the starting air is at its maximum working pressure the resistance may be overcome, and the only effect be sluggish starting and an increased consumption of starting air, but if the starting air pressure is less than the maximum, the probabilities are that the engine will not start.

The starting air valves in the cylinder heads should also be tested for being free, care being taken to see that starting air cannot enter the cylinders whilst doing so. All such valves can generally be prised open by means of a crow-bar. Any valve that does not re-seat smartly should be removed and freed, as it is almost sure to jam when an attempt is made to start the engine. It is not advisable to rotate such valves when testing them for being free, or at any other time, as this causes them to leak. The leakage is not noticed until the engine has been operating on fuel for a few days, when the valve faces will be found burnt, or the valve lid may even be cracked.

Starting and Reversing Gears.

All rubbing surfaces of these gears should be well lubricated, and run over several times before the engine is required to operate. The action of the reversing gear should be carefully observed, and any stiffness or jerkiness of movement investigated and the cause removed. The brake or buffer cylinder of the reversing gear may require replenishing with oil, or some of the reversing shaft bearings may have become dry.

The starting gear of a Diesel engine cannot, unfortunately, be tested like that of a steam engine, so that it is necessary to know that every single part of the gear is in proper working order. The compressed air for operating the starting gear is generally taken from the starting air tank side of the automatic valve, and this valve can be closed by hand. With such an arrangement the starting gear can be operated and its action carefully observed without admitting starting air to the working cylinders.

Thrust Blocks.

This part should be filled with clean oil up to about one inch from the shaft, and the sump tested for the presence of water. If the block is lubricated by a continuous stream of oil under pressure from the bearing oil system, see that the oil is flowing properly when the standby lubricating oil pump is started up.

Thrust blocks are generally provided with oil level indicators. These should be tested occasionally by letting the oil run out of the glass and allowing it to fill up again immediately to make sure that they are registering correctly. When these indicators are located under the floor level, as they very often are, and the oil in them is not clearly visible, it is wise to convert them into level indicators of the dip-stick type. On occasions the tubular glasses of these level indicators have broken for no apparent reason, allowing the oil to escape and the thrust block to run dry, causing serious damage before being noticed.

Speed Governors.

This part should also be given attention before the engine is set in motion. The governor itself and the working joints of the various links and levers should be lubricated and tested for being free to function correctly in the event of it being required to act during the voyage.

Turning Gears.

The final part of the operation of preparing a Diesel engine for sea is to start the turning gear and turn the engine two complete revolutions, after which the turning gear should be disengaged. On occasions the disengaging of the turning gear has been forgotten and, as can be imagined, serious damage done. To many, such a lapse of memory may seem unforgivable, but those who are fully aware of the arduous duties of engineers in charge of such vast and complicated machinery, and the mental strain imposed upon them on occasions, realise that there can be extenuating circumstances.

On the other hand, the damage done may be due to want of proper thought or to gross carelessness. For instance, on one occasion it was necessary to stop a main engine at sea to investigate a slight knock in the crankcase, and while some of the staff were attending to this others were instructed to take the opportunity to change a fuel injection valve. The turning gear had been engaged, as it always ought to be when men have to enter the crankcase no matter how long the examination or repair is likely to take, or whether or not it is necessary to turn the engine by auxiliary power, and the reversing gear was run over to its mid-position with the object of opening the decompression valves. This is a very necessary precaution to take on such occasions as it obviates the possibility of pressure accumulating in any of the cylinders owing to starting air or fuel injection air valves leaking.

The work of changing the fuel injection valve was finished first, and those engaged upon it decided to test the valve faces by injection air. To carry out such a test it was necessary to shut the automatic starting air valve, or rather prevent it working automatically, in order to prevent starting air reaching the cylinders, and to run the starting gear over to the normal working position to allow injection air to pass to the fuel injection valves, the reversing gear remaining in the mid-position. This is of course the correct procedure with air injection engines, and nothing untoward would have happened had those responsible put the starting gear back to its stop position after the testing of the fuel injection valve had been carried out. This, however, was not done, with the result that when one of the engineers, who was unaware of the starting gear having been moved from its stop position, prepared to re-start the engine, he failed to notice that the starting gear was in its normal working position and operated the lever which put the reversing gear into the "ahead" position. This had the effect of opening one of the fuel injection valves and allowing injection air to enter the corresponding cylinder. The engine was immediately set in motion, the turning gear completely wrecked and many of the teeth in the flywheel broken. Fortunately, the last man had just climbed out of the crankcase.

In modern engines the starting and reversing gears are interlocked, so that it should not be possible to operate the reversing gear until the starting gear is in its stop position, but it must be remembered that owing to neglect or structional weakness such safety devices may fail to function, and a serious accident, such as the one just described, happen unless proper thought is given to the possible consequences of such foolproof devices not serving the purpose intended.

INSTITUTE NOTES.

CORRESPONDENCE.

Mr. S. S. Cook's paper "Modern Marine Steam Turbine Design".

To the Editor of the Transactions.

Dear Sir,

Although Mr. Cook confined himself to what might be considered as good reliable practice, the few words which he devotes to the question of materials for blading hardly seem to give a true reflex of the position in respect of those materials. Monel metal and stainless iron certainly give good service in general. Cases are nevertheless sufficiently frequent and important in which serious trouble is experienced, particularly by corrosion from salty steam. To quote a distinguished engineer of one of the large shipping companies, "When one considers the extent of the damage which may be caused by the failure of a single blade in the turbines of a large steamer, and the consequences which may ensue, one can only pray for better and still better material, improved methods of attachment, and more rigorous tests". Improved materials more suitable for the cases which give trouble are in fact available and are being used, though to too limited an extent. These improved materials, and others suitable for other parts—including superheater tubes—of the steam installation, have the further advantage of providing what is necessary in any advance to higher steam temperatures than 750°F. in marine turbines. The use of these improved materials is now well established for such higher temperatures in land use.

Yours, etc.,

S. A. Main, B.Sc.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, 7th March, 1938.

Members.

James McLean Anderson, 8, St. Margaret's Court, Aldersbrook Road, E.12.

Archibald John Berry, 1, Victoria Avenue, Sunderland.

John Brighouse, 27, Heath Drive, Upton, Birkenhead.

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John Jamieson, 27, New Hall Lane, Preston, Lancs.

Thomas Lightley Miller, 38, Mount Ararat Road, Richmond, Surrey.

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Stanley George Christensen, 251, Hoe Street, Walthamstow, E.17.

Robert William Reader, Wh.Sc., 6, King's Avenue, Rochester, Kent.

George Alexander Wood, 6, Taylor Gardens, Leith, Edinburgh.

ADDITIONS TO THE LIBRARY.

Purchased

Department of Scientific and Industrial Research, Report for Year 1936-37. H.M. Stationery Office, 3s. net.

Notes on the Grants to Research Workers and Students. H.M. Stationery Office, 2d. net.

The National Maritime Board Year Book, 1938. The National Maritime Board, 3d. net.

Report of Sub-committee on Oil from Coal. H.M. Stationery Office, 1s. 3d. net.

Presented by the Author.

Metallurgy and Its Influence on Modern Progress. By Sir Robert A. Hadfield, Bt., D.Sc., D.Met., F.R.S., F.I.C.

Faraday and His Metallurgical Researches: with special reference to Their Bearing on the Development of Alloy Steels. By Sir Robert A. Hadfield, Bt., D.Sc., D.Met., F.R.S., F.I.C.

Presented by the Publishers.

Report on Heavy Oil Engine Working Costs. Diesel Engine Users Association.

The following publications of the Combustion Appliance Manufacturers' Association:—

"The Domestic Open Fire: A Survey of Research Prior to 1937", by Thring.

"Can the C.U.C., C.A.M.A. and J.C.B. help you to increase your sales?" by Havinden and Fortman.

"Co-ordination in Advertising", by Wren.

Bulletin of the Research Department, Vol. II, No. 1. Review of Literature on the Grinding of Coal.

The following British Standard Specifications:—

No. 782-1938. Electrodes for Metal Arc Welding in the Construction of Ships.

No. 781-1938. Wrought Iron Chain Slings and Rings, Links alternative to Rings, Egg Links and Intermediate Links.

(This specification forms one of a series which comprises terminal fittings, for chain and wire rope, to be used for lifting purposes. The components specified have been designed primarily for use with wrought iron short link crane chain and the specified proof loads conform to those laid down in B.S.S. No. 394-1936. Subject to the provision that in no case shall the working load exceed one-half the proof load, the components specified are equally suitable for use with wire rope. As the specified components will generally be used for assembly into slings, their proportions have been so arranged that the most widely used types of slings can be made up from the minimum number and types of components. Chain slings of the more usual types assembled from the specified components are included in the specification. These represent sufficient variety for the majority of normal purposes.)

The Motor Ship Reference Book, 1938. Temple Press, Ltd., 289 pp., 95 illus., 5s. net.

Diesel-engined tonnage to the extent of over 13 million gross register is now in service and the bulk of it finds a place in the records which comprise this volume, whilst the types of engine used for the propulsion of the different classes of motor ship afloat are tabulated and in many instances described and illustrated. The customary exhaustive annual revision of the book has been carried out, and care has again been exercised to ensure that the information given is accurate and up-to-date, and that the volume remains in the handy size in which it has appeared since its inception 14 years ago.

"The Motor Ship Reference Book" has been of great interest and utility to the shipbuilding and marine engineering industries, and as the present edition deals with over one million gross tons of motor ships more than did the previous volume, the wisdom of not neglecting to renew one's copy will be appreciated.

Stainless Steels. By Percy H. Miller. Oxford University Press, 95 pp., illus., 3s. 6d. net.

The use of stainless steel is gradually extending, its technical suitability for a great variety of services rendering it desirable that designers and estimating staffs should be aware of the properties and commercial possibilities of this material in the various forms in which it is now marketed.

This little book appears to cover the subject in a very comprehensive manner, complete as it is with a number of tables giving rates per pound for plates, sheets, bars, sectional material, casting and made up fittings of different types, and also with chapters detailing how the material is made, its different types, and how it should be machined, manipulated and brought into successful and economical service.

An interesting chapter is devoted to a brief survey of other corrosion-resisting alloys and pointers given which will be of assistance to any designer anxious to solve some particularly troublesome problem.

The subject-matter of the book is by no means an inexpensive material, rather the reverse. The book itself, however, appears well worth the very moderate price.

Magnetism and Electricity. By A. E. E. McKenzie, M.A. Cambridge University Press, 379 pp., 294 illus., 5s. net.

This is the last of a series of school certificate physics textbooks by the same author. As stated in the preface the book is "a readable book for the boy". The reviewer would go further and say that it is a very readable book for anyone, irrespective of age or sex.

No apology is needed for the introduction of historic detail, as it only tends to make the volume more interesting and valuable. The contents include the elementary principles of magnetism and electricity, Ohm's law, magnetic and heating effect, instruments and measurements, electrolysis, cells, motors and dynamos, the grid, telegraphy and telephony, electrostatics, and discharge through gases. Answers to arithmetical examples and an index somewhat too brief complete the book. At the end of each chapter is a most useful summary followed by a large number of carefully selected questions. The book can be recommended as an introductory textbook for all types of students in school and college.

In order to cover the various prescribed syllabuses in this subject, authors tend to enter the domain of what might be termed electrical engineering. As a result, the reviewer is convinced that in many cases the teaching is very much in the abstract and there is much to be unlearned later by those taking up electrical engineering as a profession.

In the book under consideration the reviewer notes the following:—On page 169 the definition of the efficiency of a lamp is misleading; small "i" is used as the symbol for current; and the term "alternating current dynamo" which is rarely used. It is also to be doubted very much whether the majority of youthful readers will really understand Fig. 165 or the deduction and use of $V = \frac{1}{\sqrt{3}}$ on page 248. Also a "motor generator" is meant by the term "rotary converter" on page 229. Since electric heating on a large scale is referred to, the reviewer suggests that the British Thermal Unit be introduced in an example on page 165.

The above are merely suggestions and constructive criticism, and must not in any way be taken as being derogatory to an excellent book. The reviewer has nothing but praise for the production of a very handy book of nearly 400 pages, clearly printed and illustrated, and issued at a very reasonable price. He would not be at all surprised to learn of the early issue of a second edition.

The Principles and Practice of Lubrication. By A. W. Nash, M.Sc., and A. R. Bowen, Ph.D., D.Sc. Chapman & Hall, 2nd edn., 345 pp., illus., 18s. net.

As lubrication is an important factor in the operation of practically everything mechanical, and we are now living in an age where things mechanical are increasing daily, an authoritative book on lubrication is a most useful asset to all those engaged in mechanics. The reviewer would particularly commend the above work to those engaged upon the design and building of prime movers and machinery generally.

Since the publication of the authors' first edition on this subject the range of available lubricants has changed very extensively and the science of lubrication has also advanced considerably. The most important factor, however, is the advance in prime movers and machinery since that time, so producing many lubrication problems. For these reasons this new and up-to-date work is very necessary.

The chapter on mechanical friction testing machines is of particular interest to oil technologists and those engaged in laboratory research work, and the subject has been treated at some length. The operating engineer and those responsible for the purchase of lubricants must, however, regard tests made with such apparatus as laboratory instruments, results obtained with them often having little or no comparison with those obtained in actual service. It is not uncommon for data obtained from these instruments to be used as sales propaganda and so to become misleading. The conclusive test of any lubricant is its performance in service.

The authors are to be commended upon the manner in which they have dealt with the subject of the design and lubrication of bearings. This chapter contains much information of practical value. The chart reproduced on page 91 is of particular interest to the designer and those responsible for selecting lubricants to meet specific operating conditions. A study of chapter 10—The Care of Lubricants—will well repay those responsible for lubrication and lubricants. This chapter could, with advantage, have been slightly amplified to cover the subject of handling and storage, a matter sadly neglected by many users of lubricants.

The book contains a store of valuable information upon a subject treated casually by a large number of engineers. Its study will be well repaid, particularly in the case of the marine engineer who by virtue of his calling is left largely to his own resources.

A Short History of Naval and Marine Engineering. By Eng. Capt. Edgar C. Smith, O.B.E., R.N. Cambridge University Press, 376 pp., illus., 18s. net.

Just one hundred years ago the "Sirius" crossed the North Atlantic from Cork to New York under her own steam, and this comprehensive volume of 376 pages comes opportunely as an appropriate centenary reminder of that epoch-making event. No one is better fitted than the author to compile such a history for, as members of The Institute are well aware, he was for some years after retiring from H.M. Navy, Curator of the marine section of the Science Museum at South Kensington, and had access to rare exhibits and documents that but few are privileged to see.

Every marine engineer must be more or less keenly interested in the origin, evolution and development of propelling machinery, and here for the first time all the important stages in that specialised line of progress are clearly set out in proper perspective by one who has lived with and evidently loved marine engines all his life.

Few people realize that the idea of moving vessels by mechanical power dates back another hundred years earlier than the first voyage of the "Sirius". It is recorded that Jonathan Hulls of Campden, Gloucestershire, on 21st December, 1736, secured a patent and in 1737 published a *Description and Draught of a new-invented Machine for carrying Vessels or Ships . . . against Wind or Tide or in a Calm,* detailing his invention of the principle of steam navigation. Many years elapsed before the idea was actually tried and put into practice, but after Fitch in America and Symington in Britain demonstrated its possibilities towards the close of the 18th century things began to move in more senses than one.

Captain Smith's book provides vivid pictures, not only of these events, but of subsequent developments right up to the present day. Nowhere else is such a vast accumulation of authoritative information to be found within the covers of a single volume. Three score illustrations add to the book's attraction, although one is tempted to register a mild protest at the recurring "courtesy of" accompanying the captions. Boilers from atmospheric pressure up to over 3,000lb. per sq. in.; engines, paddle and screw, from before the time of Bell's "Comet" to the last of the triple and quadruple installations; condensing plant from Watt's separate jet condenser to present day practice; the birth and growth of iron and steel shipbuilding; the introduction and evolution of the marine steam turbine; internal combustion engines for ship propulsion; auxiliary machinery and appliances; all these and many other subjects of technical and historical interest to the marine engineer come under review.

Should anyone be at a loss as to what kind of a gift to present to a friend in the profession, Eng. Capt. Smith's "Short History of Naval and Marine Engineering" can be confidently recommended. The reviewer is taking no chances—he is presenting himself with a copy.

One Hundred Years of Transatlantic Steam Navigation, 1838-1938. By H. P. Spratt, B.Sc. Copies obtainable from the Science Museum, South Kensington, London, S.W.7, or from H.M. Stationery Office, 24 pp., illus., 6d. net, postage extra.

As mentioned in the previous review, it is one hundred years ago since the paddle steamer "Sirius" crossed the Atlantic under continuous steam power and won for herself the honour of being the pioneer transatlantic steamship. On the occasion of the centenary of this notable achievement, a special exhibition entitled One Hundred

Years of Transatlantic Steam Navigation has been assembled in the Science Museum, to illustrate in outline the history and development of the Atlantic Ferry since the advent of the steamship.

The period covers the transition from wood to iron and from iron to steel as the material for ship construction, and from paddle-wheel to single, twin, triple, and quadruple screw propulsion; the change from simple to compound, triple, and quadruple expansion reciprocating engines; the development of the Parsons direct drive, single and double reduction geared turbines; and an enormous improvement in passenger accommodation, from the time when Charles Dickens crossed on the first Cunard liner "Britannia" in 1842, to the present standard of comfort in the R.M.S. "Queen Mary". The increase in size of ships can be gauged from the fact that the "Britannia", shorn of her masts and funnel, would fit into the restaurant and foyer of the R.M.S. "Queen Mary".

The purpose of the handbook under review is to set forth in very brief outline the history and development of the Atlantic Steam Ferry, and at the same time to serve as a guidebook during the run of the Exhibition. For the benefit of those readers who wish to make a deeper study of the subject, a list of references to the relevant literature is given on page 21.

JUNIOR SECTION.

Deep Sea Diving and Salvage Operations.

On Thursday evening, 17th February, 1938, Captain G. C. C. Damant, C.B.E., R.N. (ret.), delivered a lecture under the above title to a crowded audience at Woolwich Polytechnic. The Principal of the College, Dr. E. Mallett, occupied the Chair.

The exceptional lecturing ability of Captain Damant, who was deputizing for Sir Robert H. Davis, his unique practical experience, and a collection of very instructive and interesting slides, combined to make this lecture one of the most notable of the series.

On the proposal of Mr. L. Bernhardt (Talks Secretary of the Polytechnic's Engineering Society) Captain Damant was enthusiastically accorded a vote of thanks for his lecture, and Mr. E. F. Spanner (Member of Council) voiced The Institute's thanks to Dr. Mallett for his chairmanship and the excellence of the arrangements made to welcome the visitors.

ABSTRACTS OF THE TECHNICAL PRESS.

Modern Applications of Welding to Ships.

The author refers particularly to semi-automatic and automatic welding, including the Union-Melt process, as developed in America. Hand welding is retained for vertical welding at the ship, stepwise (pilgerschritt) working being adopted for butt welds, with two welders operating symmetrically, so as to avoid distortion. In general, machine welding under cover is adopted as far as practicable, however. The constancy of length of arc and other conditions give more efficient welding than hand work. The high current used and consequent great heat generated ensures good penetration, increases speed and reduces cost, but tends to increase distortion. In place of the 60° vee with a small clearance at the bottom usual for hand welding, a 45° vee extending only to $\frac{1}{4}$in. from the bottom of the plates, and with no clearance between the two plates, is used. The semi-automatic welding head, with automatic feed of the wire, but guided by hand, is widely used. Bare and cored electrodes are largely used in Germany, but coated electrodes are preferred in America. Overhead welding presents no difficulties. Fully automatic welding demands suitable structural design and the use of special appliances for manipulating the relatively large units fabricated. The process is applied to the preparation of complete sections of bulkheads and outer plating, together with stiffening. Assembly prior to welding is effected with the necessary accuracy with the help of large presses forcing together the surfaces to be united. The Union-Melt process is notable for the speeds obtained and strength of the resulting weld. Some of the results on mild steel butts are summarized below:—

Plate thickness in.	Angle of Vee deg.	Electrode diameter in.	Current amps.	Speed of welding, ft. per min.
0·25	60	$\frac{3}{16}$	775	2·4
0·5	60	$\frac{1}{4}$	1125	1·8
1·0	35	$\frac{5}{16}$	1550	0·9
2·0	30	$\frac{1}{2}$	2800	0·46

R. Schmidt, "Schiffbau", 1st February, 1938, p. 39-43.

Geared Diesels with Hydraulic Couplings.

The author describes the advantages and application of the Vulcan system, which he states has been installed to a total of over a million b.h.p. in oil-engined ships, in addition to some 400,000 h.p. in vessels with Bauer-Wach combined steam reciprocating and turbine machinery. The losses in the coupling do not exceed 3 per cent., and those in the gearing 1·5 per cent. The coupling is placed between the engine and pinion, and from one to four engines may be geared to the same propeller shaft through a single gearwheel. One gain lies in the fact that the smoothed-out torque enables the screw shaft to be reduced in diameter. The engine is isolated as regards torsional oscillations, resulting in an increase in natural frequency of the crankshaft system, and a wide separation from the working r.p.m. The possibility of decoupling has advantages from the point of view of reduced-power working, when one or more engines can be stopped, and it also enables an engine to be overhauled at sea. There is an increase in the horse-power which can be applied to a single screw, and the latitude as regards choice of propeller speed resulting from the use of gearing enables a low speed favourable to efficiency to be selected. The hydraulic coupling serves to damp out speed fluctuations of the screw shaft in very heavy weather, racing being largely eliminated. Finally, by allowing an increase in the engine r.p.m., the weight and space, particularly headroom, occupied by the machinery is reduced. In a particular instance, two six-cylinder engines of the two-stroke trunk-piston type developing a total of 3,600 h.p. were geared to a single propeller shaft running at 85 r.p.m., the engine speed being 230-240 r.p.m. The speed of the ship was 14 knots, and the fuel consumption 0·35 to 0·37 lb. per b.h.p.-hr. Installations have been designed and built for a total of 17,000 h.p. on a single shaft, 8,500 h.p. per coupling. Rapid decoupling is achieved by allowing the oil which forms the working fluid to escape from the coupling, and in special circumstances abnormal slip in the coupling, and correspondingly low propeller r.p.m. can be obtained by partial emptying. As regards the construction of the couplings, the earlier type of cast-iron or cast-steel rotor has been superseded by built-up welded construction, employing forgings and plate. For very high speeds, rotors are machined from the solid forging. Recent special applications of the system include a shallow-draft tug for the Danube, which has, on account of restricted propeller diameter, four screws geared in pairs to two engines; a twin-engine, single-screw trawler; a number of single-engine single-screw installations for small cargo boats; some ungeared sets for vessels liable to meet ice, where the coupling is introduced as a means of protecting the propeller from damage; and other cases where the coupling is used primarily as a safety clutch, as for instance in the pump drive of suction dredgers and for certain stern-wheelers operating in waters where there may be floating debris.—*G. Bauer, "Schiffbau", 1st February, 1938, p. 33-39.*

The Yield Point in Mild Steel.

The author discusses the various factors influencing the stress at yield as determined in various alternative ways. He distinguishes between the "upper yield stress", as found from an ordinary tensile test, and the "lower yield stress", which may be found by arranging that the time rate of strain does not suddenly increase at the initial yield. The load then falls by 20 to 30 per cent., and remains steady at the lower value. Both higher and lower stresses are appreciably influenced by speed of loading, increasing as the speed is increased. With suitable precautions, the yield in compression can be observed, and is found to be similar to that in tension, and to occur at the same stress. With non-uniform stress distribution, as in bending or torsion tests, there is an apparent rise in the upper yield point, as compared with that for uniform stress; the lower yield stress cannot be observed directly, but can be deduced from the shape of the load-strain curve, and is found to be in agreement with that determined from tensile tests. The value of the torsion-shear yield stress is half that of the direct yield stress, in agreement with the shear theory of failure. The author presents results of tests on thick-walled tubes under internal pressure, which also support the theory of the constancy of the lower yield stress. These tests, which show a consistent scale effect, the yield stress rising as the size of the tube falls, suggest that the stress gradient affects the yield, but there is no confirmation of this from torsion or bending tests.—*G. Cook, Transactions of The Institution of Engineers and Shipbuilders in Scotland, February, 1938.*

Cavitation of Propellers.

The author presents results of thrust and torque measurements and of photographic observations on three screws in the low-pressure tunnel at Washington. All had three blades with ogival sections; one had a mean-width ratio of 0·2, and thickness-diameter ratio of 0·06, whilst the other two had 0·5 mean-width ratio and 0·05 thickness ratio, one having a straight blade centre-line, and the other a straight leading edge. The pitch ratio was 1·25 for the first propeller, and 1·30 for the others. Curves of thrust and torque plotted against the square of the r.p.m. at constant slip and pressure show the gradual departure from the linear relationship as cavitation extends over the blade, the curve flattening out and then beginning to rise again when the whole blade is cavitating. Similarly, curves of thrust and torque coefficients for varying pressures indicate the pressure at which cavitation becomes appreciable. This pressure corresponds with about 12ft. head of water for the narrow-bladed screw of 7in. dia., at 1,800 r.p.m.; the corresponding figures for the wide-bladed propellers, of 7·2in. dia., at 1,600 r.p.m., are 6ft. for the normal blade and 8ft. for the blade having a straight leading edge. These figures apply to 35 per cent. slip. The author distinguishes between bubble cavitation and laminar cavitation and states that the latter is always associated with the tip vortex.—*L. P. Smith, A.S.M.E., June, 1937; "Engineering", 18th February, 1938.*

Annual Load Line Surveys.

Since 1932, ships have been subject to annual survey to ensure that the conditions of freeboard assignment have been maintained. The survey covers such matters as the state of hatches and securing appliances, exposed ventilators and air pipes, machinery casings, openings in superstructure bulkheads, gangways, and guard rails, in addition to the actual freeboard markings. Previously classed ships were not surveyed for load line purposes after the initial assignment of freeboard, although unclassed ships were liable to survey every four years. As regards hatch cleats, the author suggests that parallel cleats are as likely to be effective as tapered ones. Defects are frequently found in the closing appliances for internal hatches, under superstructures, and superstructure doors are also often faulty.—*J. F. King, Transactions of the Institution of Engineers and Shipbuilders in Scotland, March, 1938.*

Shipbuilding Practice Abroad.

Particular points mentioned are: development of mechanical transporting appliances of various types and the introduction of cranes sufficiently powerful to allow pre-fabrication of large units; divergences of drawing office practice, and planning systems; amount of material prepared from templates, without reference to the ship; speeding-up of production; use of drilling, one-man and multiple punching; relative use of hand, hydraulic and pneumatic riveting; amount of furnacing, flame-cutting and joggling; development of safety precautions; use of welding, particularly large diameter electrodes, higher welding speeds, and automatic welding machines; variation in launching methods, particularly in tideless waters; special types of keel blocks, and methods of supporting staging.—*J. Montgomerie, Transactions of North East Coast Institution of Engineers and Shipbuilders, February, 1938.*

Standard of Strength of High Speed Motor Boats of the Glider Type.

The object of the paper is to arrive at a standard of strength in the design and construction of motor boats of the above class. The problem of the motion of high-speed hydro-gliders is of a very complex character and has been little investigated up to the present time. The taxi-ing, taking off, and landing conditions of seaplanes, and to a certain extent their construction, are somewhat similar to that of a hydro-glider running on the surface of the water. It is therefore assumed that the practical data for seaplanes may be adopted in calculating the strength of the hulls of hydro-gliders. The results given in the paper are based on experiments for landing stresses on the hulls of seaplane floats (also on overload coefficients for hydro-gliders) carried out by the Central Aero-Hydro-dynamic Institute. Hydro-gliders are divided into two classes—seagoing and river-going—fitted with either air or water propellers. Strength calculations are carried out for the following parts of the boat: longitudinal and transverse framing; deck, side and bottom planking; motor installation (seating, etc.); rudder and steering arrangement; lifting and towing fittings; shafting and shaft brackets; the connecting bridge in gliders with two boats or floats; and the fastening of the fuel tank and sundry equipment. A method is described for calculating strength coefficients for various types and loads, and a formula is given for strength calculation of seagoing gliders. Basic calculations are furnished for a number of cases where seagoing gliders strike the surface of the water at different parts of the hull; illustrations are given for each separate case. A method of calculating the force of blows on the bottom skin of a river glider on striking the river bank is also shown. Formulæ are given for calculating the local strength of various parts of the hull. In the summary it is stated that the standards given in the paper are far from being perfect and many alterations in the future may be anticipated; at the same time the use of the formulæ will enable constructors of this class of motor boat to avoid radical errors.—*A. I. Martinov, Trans. of the Scientific Technical Society of Shipbuilding and Marine Engineering of the U.S.S.R., Vol. II, 1936.*

The Improvement and Future Development of Marine Reciprocating Engines.

The development of marine engines is described from the time of high-pressure steam engines to the introduction of the steam turbine and the Diesel engine. The results are given of several systematic tests carried out on a large number of modern marine engines by the Central Research Institution of the Water Transport Department. The paper is divided into ten parts, viz.: (1) introduction, (2) superheated steam, (3) steam pressure, (4) pressure in condensers, (5) the construction of details of marine engines (with subdivisions for the degrees of steam expansion, the number of grades of steam expansion, high-pressure engines, steam distribution systems, and the insulation of cylinders), (6) combined reciprocating and turbine engines, (7) condensing equipments, (8) steam boilers, (9) auxiliary machinery, and (10) conclusions. The present practice in marine engineering on the subjects as indicated is discussed in each of the above parts, and in conclusion the following suggestions are made to designers of future marine engines for the purpose of increasing the economic efficiency of the engines by reducing the consumption of fuel:—

(*a*) *Steam engines.*—To employ the highest requirements in the construction of engines, especially in regard to the compactness of the steam distributing system, and using the most suitable cylinder oil. The application of superheated steam of a temperature not less than 300° C. in all future installations. The adoption of the combined reciprocating and turbine engine when the horse power is 1,000 and above. Constructing experimental installations of high initial pressure and temperature.

(*b*) *Steam boilers.*—Increasing the temperature of heated air. The application of a steam drying and moisture separating plant. The introduction of mechanical stoking for Scotch boilers. Constructing an experimental installation with water-tube boilers of high steam pressure with mechanical stoking.

(*c*) *Condensing equipment.*—The adoption of regenerative condensers and steam jet air ejectors.

(*d*) *Auxiliary machinery.*—The electrification of all auxiliary machinery which is required to work continuously, the power being derived from generators driven direct from the main engine or by engines using exhaust superheated steam. The use of high-grade feed-water heaters.

(*e*) *The reserve power* of the whole of the installation should be limited to 25 per cent. above that required for normal working.—*V. A. Semeka. Transactions of the Scientific Technical Society of Shipbuilding and Marine Engineering of the U.S.S.R., Vol. II, 1936.*

Condensation in Cargo Spaces.

Discussing in a lecture given before the Royal Society of Arts the condensation which takes place in cargo spaces, Mr. S. J. Duly, M.A., states that this phenomenon, which is commonly known as "ship's sweat", is of too complex a nature to be controllable by natural draft ventilation. He points out that actually it is the cargo which "sweats" although he considers that the amount of damage directly attributable to the condensation of moisture from the ventilating air is less than might be suggested by observed differences of dew-points and cargo temperatures, the reason being two-fold. In closely stowed general cargoes, the gentle air currents produced by ordinary cowl ventilators, flow over the top of the cargo without percolating through its mass; in the case of bulk cargoes, the outer layers absorb the moisture and the air which penetrates beyond these is dried to a point at which it no longer loses water, and each parcel creates in its vicinity what the author calls its storage temperature which remains relatively stable in normal circumstances. The problem of sweating becomes acute when the moisture content is caused to evaporate by a rise in temperature which may result with grain and many other commodities even when they are commercially "dry". The transfer of a saturated atmosphere by well-intentioned but too liberal ventilating to some other part of the hold or of the ship where the temperature is even slightly less, inevitably causes some of the vapour content to be precipitated as moisture which subsequent inquiry may find some difficulty in attributing to its true source. The author considers that bulk stowage is to a great extent a safeguard against condensation, as the outer layers protect the inner mass. For the protection of general cargo, arrangements should be made to avoid potential contact with warm surfaces by such means as cofferdams and cleading, no steam pipes should be carried through the shaft tunnel, and the effect of artificially cold surfaces should be guarded against by careful location or proper covering. Only with a uniformly cool ship and a dry cargo could the avoidance of condensation be reasonably assured by careful readings of the cargo temperature and of the dew-point of the air together with a suspension of ventilation whenever the dew-point exceeded the temperature of the holds.—*"Engineering", 4th February, 1938, p. 127.*

Special Steels and Their Application to Engineering and Shipbuilding.

A survey is made of metallurgical developments of recent years which covers carbon steels, low alloy steels, wrought iron, more highly alloyed steels of special interest in engine construction and the special characteristics of stainless steels. Dealing with the first group of materials, special reference is made to their properties with respect to corrosion, weldability, and physical properties such as embrittlement in its various forms (viz.: strain age, quench age, annealing and caustic embrittlement), fatigue and notch sensitivity. To convey in a useful form the basic information necessary to bring out the special characteristics of alloy steels, the author reproduces a set of typical tensile and impact tests scheduled in ranges of tensile strength. In connection with the higher alloyed steels he discusses the available methods of surface hardening and the properties exhibited by various steels intended for use at elevated temperatures with respect to the essential requirements of permanence of dimension, i.e., creep resistance, and resistance to deterioration by scaling and corrosion, particularly pitting. He gives particulars of materials suitable for turbine through bolts, valve cover and steam-pipe range flange bolts and superheater tubes. In discussing stainless steels, special reference is made to the relative resistance to attack by seawater respectively of the ferritic, martensitic, and austenitic types. Particulars are given of stainless faced materials, of several varieties of stainless steel used for turbine blading and exhaust valves, and of the so-called heat-resisting steels, which generally speaking are also stainless.—*T. Swinden, D.Met., Trans. of the N.E.C. Institution of Engineers and Shipbuilders, February, 1938.*

Prime Movers at the 1938 Leipzig Spring Fair.

The writer gives particulars of the principal exhibits in the sections of the Leipzig Spring Fair devoted to Diesel engines, producer gas installations for marine purposes, and small petrol engines. He makes special reference to the following stands: (1) M.A.N.: This includes a six-cylinder 520mm. dia. × 700mm. stroke single-acting two-cycle airless-injection engine which forms part of a set of six engines to be installed in the Diesel-electric installation of the cruising liner now under construction for the Strength through Joy Organisation. Being intended for a Diesel-electric drive these engines, which develop 2,050 b.h.p. at 235 r.p.m. are non-reversible. Positive blowers supply air for the port scavenging system which is arranged on the return flow principle. The fuel injection nozzles consist of needle valves which are automatically operated by the fuel pressure. The cylinders and their covers are sea-water cooled. In addition, the M.A.N. exhibit a 200 b.h.p. marine oil engine running at 1,000 r.p.m. fitted with oil pressure operated reversing gear. (2) The Mannheim A.G. Motor Works exhibit the principal types of their pre-combustion chamber engines for power outputs ranging from 15 to 2,000 b.h.p. at 750 to 1,500 r.p.m. designed on the air storage system. Owing to their light weight these are specially suitable for yachts and speed boats, reversing and 2 : 1 speed reducing gears being added for these purposes. (3) Krupps show a six-cylinder four-stroke engine developing 310 b.h.p. at 500 r.p.m. designed for the drive of a generator, together with a four-cylinder 65 b.h.p. at 1,000 r.p.m. unit for generator or compressor drive. The former operates on the jet atomisation principle without pre-combustion or air storage chamber. (4) The Deutsche Werke Kiel A.G. exhibit the following units: A stationary six-cylinder gas engine developing 360 b.h.p. at 375 r.p.m. supplied with gas generated from lignite coke in a Körting producer; an airless-injection direct-reversible six-cylinder marine Diesel engine developing 180 b.h.p. at 375 r.p.m.; and a four-cylinder engine specially designed for the drive of drilling installations in oilfields which can be changed over from operation on oil, when it develops 120 b.h.p. at 375 r.p.m., to operation on gas when it develops 90 b.h.p. at the same revolutions. (5) The Güldner Motor Works show a completely-enclosed vertical four-stroke engine type (suitable for small vessels) built with 3 to 8 cylinders and developing 100 to 300 b.h.p. at up to 750 r.p.m., each cylinder being fitted with a Bosch injection pump. (6) Two-stroke marine sets fitted with positive blowers and developing 25 to 250 b.h.p. are shown by the Darmstadt A.G. Motor Works, driving A.E.G. d.c. generators and Balcke air compressors. (7) The Humboldt-Deutz Motors A.G. exhibit a 300 b.h.p. six-cylinder marine Diesel set together with a new design of a four-cylinder two-stroke engine developing 260 b.h.p. at 400 r.p.m., capable of adjustment down to 115 r.p.m. and fitted with positive blowers and direct injection of the fuel. A light-weight 100 b.h.p. marine Diesel engine designed on motor car engine lines and suitable for yachts is also shown. (8) The Junkers Diesel Engine Works of Chemnitz show their opposed-piston type engine, which is built for small power outputs not exceeding a few hundred b.h.p. A marine producer gas installation is shown by the Humboldt-Deutz Motoren A.G., which have already equipped 20 vessels with this type. These installations comprise gas producers, purifiers, gas conveyors, and four stroke motors, the producers being started in about 10 to 20 minutes by induced draft fans driven either by small Diesel or petrol engines or by electric motors supplied with current from storage batteries. So soon as sufficient gas is being generated the gas engine is started by means of compressed air in the usual manner. As regards the economy of the gas drive, the writer states that operation at the rate of 3,000 hours per annum indicates a saving of 10 per cent. in comparison with the Diesel drive, fuel cost ratios per b.h.p./hour for gas, Diesel, and steam drive being in the ratio 1 : 2 : 2·5.

A number of small Diesel and petrol engines developing down to 2 b.h.p. suitable for outboard arrangement are shown by the Horst Steudel Motor Works, including a two-cylinder two-stroke set developing 6 b.h.p. at 2,500 to 2,800 r.p.m. and weighing 64lb. This is designed to be fitted at the top of a well at or near the stern of the vessel, a horizontal plate acting as a water-tight cover being arranged below the motor.—*Dipl. Ing. Aster. "Schiffbau", Vol. 39, No. 5, p. 80, 5th March, 1938.*

A New Giant Floating Crane.

The author gives a detailed description of the Diesel-electric Voith Schneider propelled giant floating crane commissioned at the Wilhelmshaven dockyard in the autumn of 1936, of which the principal particulars are as follows: The maximum outreach measured from deck edge is 36ft. at 100 tons lift, and 105ft. at 50 tons lift; the highest and lowest positions of the hook are respectively 157ft. above and 39ft. below the surface of the water, the maximum height of the crane with topped up jib being about 249ft. above the water surface. The crane is of the double luffing and slewing type, the head of the jib being articulated and guided in such a manner that the head rollers will move on a horizontal path during the luffing operation. On the two 50-ton main hooks up to 25 tons can be lifted at a rate of 23ft. per minute and 25 to 100 tons at 13ft. per minute. On a 10-ton auxiliary hook the lifting speeds are 98ft. per minute for lifts up to 5 tons and 56ft. per min. for lifts of 5 to 10 tons. In slewing, a complete revolution can be performed in about five minutes; luffing can be effected at the rate of about 33ft. per minute. The main machinery installation consists of two sets of seven-cylinder four-stroke Diesel engines developing 450 b.h.p. at 400 r.p.m. each coupled to one generator supplying the winding motors together with a double generator serving on one side the luffing and slewing motors and on the other the auxiliaries, excitation, lighting, etc., connections being arranged on the Ward Leonards system. The auxiliaries include a Diesel-driven centrifugal bilge and fire pump capable of delivering 110 tons per hour against a head of about 345ft., and a 400-ton salvage pump. For fire-fighting purposes a line of pipes is arranged for the discharge of water from the head of the jib. For propulsive purposes the main Diesel engines are connected with the shafting of the Voith Schneider propellers by means of friction couplings. During propulsion and manœuvring trials in a depth of water of about 49ft., speeds of 7·4 knots and 4·85 knots ahead and astern respectively were obtained on a power output of 900 collective b.h.p.; a complete turn round was effected in 53 sec., and the vessel could be brought to rest in another 20 sec. The time required to bring the vessel to rest from full speed was 45 sec., the distance travelled through during this period being 262ft. At a towing trial a stationary pull of 10 tons was obtained.—*Dr. Ing. E. Kemna, "Werft, Reederei, Hafen", p. 13, 15th January, 1938.*

Attack of Superheated Steam on Steels.

Many large power stations operate with steam at 480-500° C. at 1,400lb./in.^{2} while the reaction between steam and iron can be used at 650° C. to produce hydrogen commercially. Six different steels have been investigated in U.S.A. for scaling resistance, (*a*) for 14 days at 595° C., (*b*) for a *further* seven days with temperature varying between 650° and 230° C., with steam at 175lb./in.^{2}, superheated in austenitic tubes. Attempts to measure the rate of attack by direct determination of the hydrogen evolved were unsuccessful owing to the presence of appreciable amounts of hydrogen in the incoming steam, and to vitiation by diffusion through the walls. The scale was therefore weighed directly, being detached from the tube by immersion of the latter in concentrated HCl, containing 2% Sb_2O_3 and 5% $SnCl_2$ as inhibitors. The attack follows the exponential law $M = 556 \times 10^7 e^{(0 \cdot 011)\theta}$, where θ is the temperature in °F., up to 595° C. It is unaffected by pressure but accelerated by increased velocity of steam flow. Rate of attack with alloy steels is about two-thirds that with mild steel, and is not much affected by heat-treatment. In similar researches carried out at the N.P.L. similar but lower results have been obtained, the scale thickness being determined by measurement of photomicrographs of sections. New work in progress aims at determining the rate of oxidation when thin-walled tubes are subjected to live stress as a result of internal steam pressure. The results promise to be valuable in high-pressure boiler design.—*"The Metallurgist", (Suppt. to "The Engineer"), 25th February, 1938.*

Investigations on Landing Impact of Seaplanes.

Particulars are given of the methods adopted by the Hydro-Experimental Department of the Central Aero- Hydro-dynamic Institute when carrying out experiments on seaplanes. Interesting results were obtained from the tests by means of micro-recording instruments at present used by the above Department, which include a dynamic tensiometer for synchronous measurement of deflection, an accelograph for overload measurements and a stress recorder for measuring the pressure on the hull skin. Illustrations are given of the various instruments employed in carrying out the experiments. The most interesting instrument is the accelograph which has a range of acceleration from 130 units per second (1 variant) to 250-300 units per second (2 variants); this high acceleration permits the overload stresses produced by outside forces as well as the vibration to be recorded with great accuracy. Overload graphs are given of a seaplane when landing.—*A. S. Povitzky, Trans. of the Scientific Technical Society of Shipbuilding and Engineering, U.S.S.R., Vol. II, 1936.*

History of the Safety of Life at Sea—The Assignment of Load Lines to Seagoing Merchant Vessels in the Middle Ages.

Various notes are given on the history of load-line regulations. The practice of the present load-line regulations extends over less than a century; the marking of load lines was made compulsory only about 50 years ago. It is possible, however, to trace the fact that assignment of freeboard was instituted by mediæval Mediterranean maritime states; detailed freeboard regulations were provided by maritime laws of Genoa and Venice, and similar requirements were included in the laws of Ancona, Marseilles and Barcelona. The Genoese load-line regulations were drawn up by the committee *Officium Sazanæ* founded on the 26th November, 1313; the last act on this subject was issued in 1441. Provisions were made for the assignment of freeboard for galleys and sailing ships, and for certification of assigned load lines by iron marks; the inspection of ships by special surveyors was established, as well as penalties for breach of law. The manual *Capitulare Nauticum* of 1255 contains the Venetian load-line regulations. Special provisions were made by the Ancona maritime laws regarding the carriage of timber cargoes, loading to the ordinary load line only being permitted. It is of interest to note that there were similar regulations of the Iceland and Hansa Union. Illustrations and sections are shown of different types of galleys and sailing ships from the 14th century.—*I. Smorgonsky, Trans. of the Scientific Technical Society of Shipbuilding and Engineering, U.S.S.R., Vol. II, 1936.*

A Method of Calculating Intricate Statical Indeterminable Systems.

The usual method of calculation for a statical indeterminable system is based on the assumption that the unknown elements are independent and variable. This may be considered as arriving at an informal solution of the system. A general method of solution may be developed by treating the unknown forces as functions independent of each other, and considering the potential energy as a component function of them. This permits deriving a system of equations with a gradual reduction of the numbers of the unknown by application of the principle of least work. The last equation will contain only one unknown element, thus permitting its value to be determined; the general solution may be then gradually obtained by the method of substitution. Where there are a large number of unknown elements the calculation may be simplified by dividing the system into parts and by the application of the above method to each separate part.—*P. A. Minjaev, Trans. of the Scientific Technical Society of Shipbuilding and Engineering, U.S.S.R., Vol. II, 1936.*

EXTRACTS.

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

Research Into Ship's Refrigeration.

"The Motor Ship", March, 1938.

From the standpoint of shipping, the most interesting feature of the recently issued report of the Department of Scientific and Industrial Research is that relating to refrigeration in ships for the transport of fresh fruit. A system that has been developed as a result of research is based on the rapid circulation of air over an external cooler and vertically through the cargo, combined with a "jacket" through which the air passes on its way back to the cooler. The disturbance of temperature due to the leakage of heat through the walls is thus avoided.

Tests carried out during the year in one ship showed that, in a particular hold with a stack of nearly 50,000 cases, the temperature was maintained uniform after cooling, with a variation of approximately 1° F. on each side of the mean. It is remarked in the report that:—

"In the present state of biological knowledge there is a margin of uncertainty of about 2° F. in specifying the best temperature for the carriage of a mixed cargo of apples. It may, therefore, be said that, with recent advances, a point has been reached where in the best of modern ships the precision of control has come abreast of or even surpassed the precision of biological definition".

Corrosion, Liner Wear and Fuel Specifications.

"The Motor Ship", March, 1938.

To what extent cylinder liner wear is due to corrosion resulting from the attack of combustion products on the liner is not generally agreed. But it is not denied by any engineer that the influence of corrosion is considerable. Many are of opinion that with large marine Diesel engines it is the most important factor.

The application of chrome hardening to cylinder liners has been shown beyond dispute to result in a smaller liner wear than with normal cast-iron liners, and it is believed that the main reason is the immunity of the chromium from corrosive action. If that is so, then it would appear that a wider range of fuels may be employed, which may be of considerable advantage to the owner whose ships call at bunkering ports deriving supplies from different fields.

It is claimed, too, that poorer qualities of fuel may satisfactorily be employed, on the theory that it is not the combustion process in a Diesel engine which limits its application, but the increased liner wear that results. If the latter disadvantage is overcome, the wider adoption of lower-grade fuels may be possible, especially if chrome hardening be applied to fuel pumps and valves. This, as already stated in "The Motor Ship", is now being done in some of the Hamburg American Line motor ships. The view is taken by some shipowners that they must of necessity anticipate the use of a wider range of fuels in the future, and if chrome hardening permits of such a development its importance may go beyond the technical fact of a reduction of liner wear.

Water-hammer.

"Shipbuilding and Shipping Record", 24th February, 1938.

We have frequently had occasion to draw attention in these notes to the risk of water-hammer when a vessel in harbour with a list is being prepared for sea. An accident due to this cause occurred recently on an American ship with the result that, apart from the material damage, four lives were lost. In the monthly "Bulletin" of the U.S. Bureau of Marine Inspection and Navigation, attention is drawn to the ways and means whereby such accidents might be prevented, and these recommendations are worthy of being summarised here. Apart from the usual suggestion regarding the fitting of drains, the recommendation is made that these should also be located where water can accumulate under different conditions of trim of the vessel. Further, on large steamships, where the diameter of the pipe exceeds 6in., the stop valves should be provided with small by-pass valves for equalising the pressure and warming up the pipe line before opening the main stop valves. Marine inspectors are called upon to see that the pressure gauges on the individual boilers are accurate as opening up a boiler before the pressure is equal to that on the main steam pipe line is a frequent cause of explosion. Finally, the operating engineers are called upon to see that the pressure gauges are maintained in a condition to ensure accuracy and to make sure that the pressure is equalised on all boilers before they are "cut into the line". The necessity of seeing that all drains are open before so doing is not mentioned, probably because it is such an obvious precaution.

Feed Inlet Position.

"Shipbuilding and Shipping Record", 10th February, 1938.

It is well known that in the vicinity of the feed-water inlet of a boiler, there is generally an excessive wasting of the plates due to the corrosion engendered by the molecular friction caused by frequent expansion and contraction. There must, of course, be a feed inlet, but the choice of a suitable position for this may have a considerable effect on the extent of the wastage. This interesting fact was referred to by Mr. G. P. Cumming during the course of the discussion on Mr. Wilson's paper "Boiler Maintenance and Repairs in Cargo Steamers", read a short while ago before the North-East Coast

Institution. In a fleet of cargo steamers, Mr. Cumming found that after eight years there were invariably many combustion-chamber stays to renew, extending from the feed inlet valve—which was placed about halfway up the inside wing—to the two bottom stays on the outside wing back. The plate of the back end was also badly wasted in way of the stays and on the corner of the wrapper plate with the result that it was frequently necessary to cut out pieces of a length of 4ft. and a breadth of 15in., and this proved to be a very costly repair. Mr. Cumming noticed, however, that there was very little or no corrosion above the check valve, and it was subsequently decided upon to move the valves to a position above the top of the combustion chambers and to fit an internal pipe. This, he states, entirely stopped the excessive corrosion and eliminated the trouble referred to.

Starting Conditions.

"Shipbuilding and Shipping Record", 10th February, 1938.

An interesting insight into the starting conditions in the cylinder of a diesel engine was given by Dr. J. Small during the course of his paper "Vagaries of Internal Combustion", which was read a short time ago before the Institution of Engineers and Shipbuilders in Scotland. The author obtained indicator diagrams of the Farnborough type during the starting-up of a single-cylinder heavy-oil engine the normal speed of which is 300 r.p.m. The speed of the engine under its starting air was 145 r.p.m., and a diagram was taken when the fuel pump and cylinder valves were brought into operation, the jacket temperature of the engine being only 20° C. (68° F.). This showed a maximum pressure of about 900lb. per sq. in. The cycles immediately following the first also exhibited high pressure with a marked constant volume, i.e., explosive effect, and it was only when the engine had been running for some time, so that the jacket reached a working temperature of 62° C. (143·6° F.), that the diagram indicated an approximation to constant-pressure burning and the pressure at the end of compression climbed to its proper value of about 580lb. per sq. in. Various theories can be advanced to account for this vagary of combustion, notably that there is a long ignition lag arising from the low temperature of the air at the end of compression in the cold engine; but whatever the cause, the effect is undoubted, and it shows that the engine must be designed to withstand conditions far more severe than those associated with normal running.

Metal Filters.

"Shipbuilding and Shipping Record", 10th February, 1938.

One of the disadvantages associated with certain types of lubricating oil filter is the frequency with which the filtering medium has to be renewed, this being particularly the case if for any reason it is subjected to excessive pressure. To surmount this disadvantage a metal-pack oil filter has been designed in which the filtering medium is built up of sheets of metal stamped with an inner and outer periphery of star form, these peripheries being flanged in opposite directions and ground flat, giving a working face of about ⅛in. width. To prevent lateral displacement when the sheets are assembled to form the pack, they are threaded on the guide rods which pass through lugs formed on the plates external to the outer edge. The fineness of filtration is regulated by the degree of tightness of the joint between the flanges and this is controlled by a spring provided with an adjusting nut carried on the single central bolt which carries the pack in its containing vessel. To facilitate dismantling for cleaning purposes, the containing vessel is carried beneath the casting on which are the oil inlet and outlet connections and to which the single central bolt is secured so that it is unnecessary to break either of the pipe joints. The peculiar double star formation of the peripheries of the plates ensures the largest possible filtering area while the number of plates employed in building up the pack determines the capacity of the filter as a whole.

Non-ferrous Castings.

"Shipbuilding and Shipping Record", 27th January, 1938.

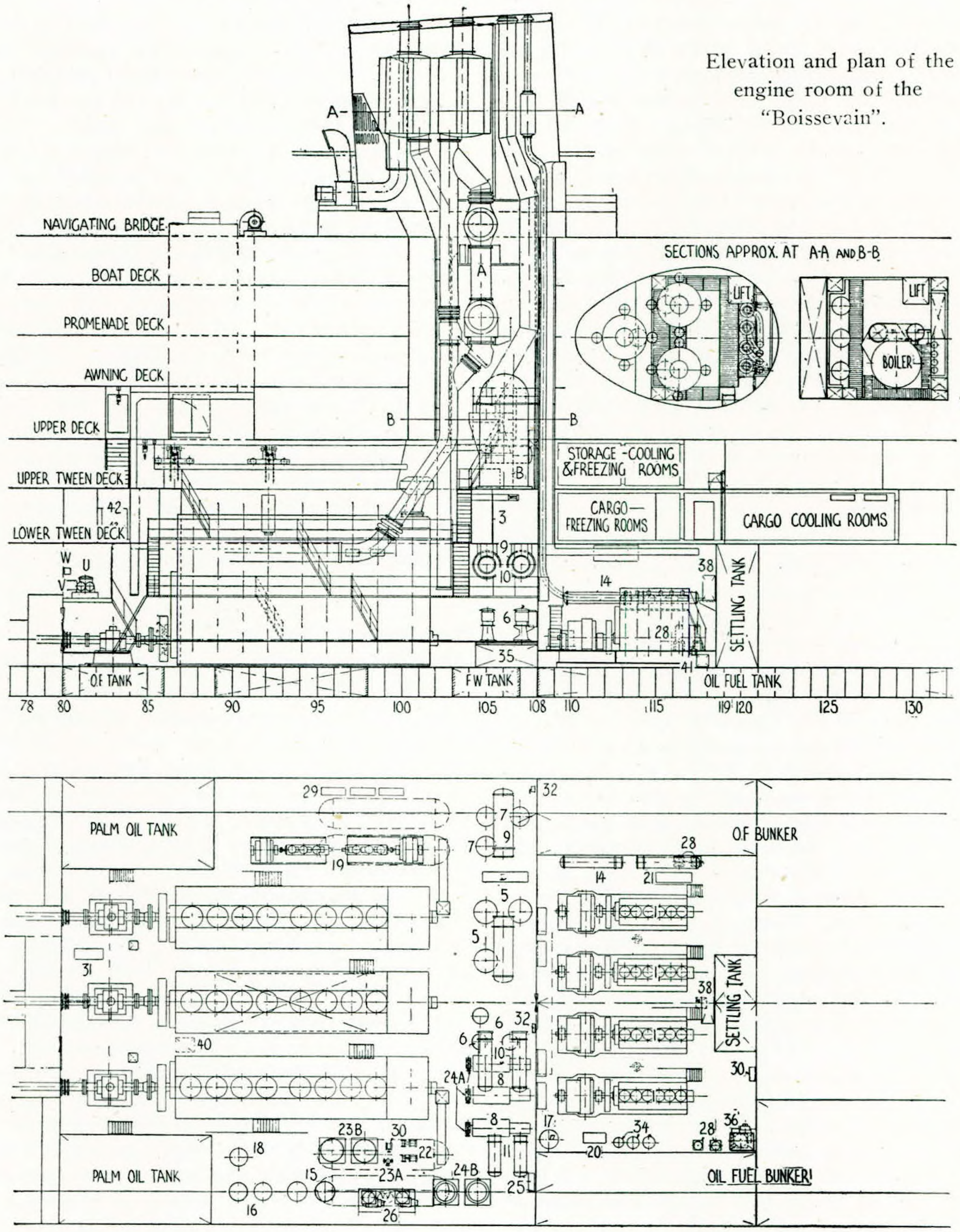
Castings made from non-ferrous metals find many applications, particularly in marine engineering practice. In a paper entitled "Modern Non-Ferrous Castings and their Engineering Interest", recently read before the Institute of Mechanical Engineers, the author, Mr. F. Hudson, suggests that the use of these alloys is being hindered by the fact that sufficient data relating to properties, applications and manufacturing technique are not readily available to the engineer and founder. He sets out to remedy this defect, dealing with castings in three groups of alloy, viz., bronze, high-tensile brass, and copper-base bearing metals, and the data given shows that modern practice has produced alloys possessing strength properties equal to those of cast iron, with the added advantage of resistance to corrosion. The addition of small quantities of nickel is shown to yield an all-round improvement in mechanical properties, while in what are termed high-nickel bronzes, that is, bronzes containing from 20 to 50 per cent. of nickel, a yield point of 30 tons per sq. in. and a maximum stress of 40 tons per sq. in. is obtainable. High-tensile brass, in which must be included the so-called manganese bronzes (which are really manganese brasses) so extensively used in the production of ships' propellers, is greatly improved by the addition of small quantities of nickel up to 3 per cent., particularly as regards its resistance to cavitation erosion.

K.P.M. Triple-screw Motorship "Boissevain".

"The Marine Engineer", January, 1938.

One of the most interesting motorships to be finished during 1937 was completed almost at the close of the year. We refer to the triple-screw

Elevation and plan of the engine room of the "Boissevain".



Ref. No.	Description.
1—4	main diesel-generators
2—1	emergency diesel-gen. (emergency gen. room)
3—1	main switchboard
4—1	emergency switchboard (emergency gen. room)
5—3	main cylinder cooling water pumps
6—3	main piston cooling water pumps
7—3	main circ'l'g pumps
8—3	main lubricating oil pumps
9—2	main coolers for cyls.
10—2	main coolers for pistons
11—2	main lubricating oil coolers
14—2	cooling water coolers for diesel-generators
15—2	sanitary pumps
16—2	gen'r'l service pumps
17—1	emergency fire and bilge pump
18—1	auxiliary bilge pump
19—2	main air compressors
20—1	aux. air compressor
21—1	fuel transfer pump
22—2	auxiliary fuel pumps
23a—1	fuel filter (Lolos)
23b—2	fuel filters (Stream-Line)
24a—3	lubricat'g oil filters for main engines
24b—2	lubricat'g oil filters for main engines (Stream-Line)
25—1	Stream-Line filter pump
26—2	purifiers for lub'g oil
27—1	fuel purifier
28—4	Stream-Line filters for diesel-generators
29—3	fresh water pumps
30—2	hand fuel pumps
31—1	lub'g transfer pump
32—1	hand fresh water pump
33—4	main starting-air vessels
34—2	starting-air bottles for diesel-generators
35—1	main cooling water collecting tank (for piston cooling water)
35a—1	main cooling water collecting tank (for cyl. cooling water)
36—1	auxiliary cooling water collecting tank
37—1	main fuel supply tank
38—1	aux. fuel supply tank
39—1	emergency fuel supply tank (emergency gen. room)
40—1	waste fuel tank for main engines
41—1	waste fuel tank for diesel-generators
42—3	lub. oil storage tanks
A—1	waste heat boiler
B—1	donkey boiler
U—1	palm oil pump
V—1	distributing chest
W—1	drain distributing chest

motorship "Boissevain", which Blohm & Voss, of Hamburg, have built for the Koninklyke Paketvaart Maatschappy, of Amsterdam. The vessel is the first of three similar 16-17 knot motorships which the Royal Packet Navigation Company intend to place in their Far East-African service in the near future. The ship which forms the subject of the present article has been built by Blohm & Voss and engined by Sulzer Bros., Winterthur, Switzerland; the other two vessels are the "Tegelberg", building by the Netherland Shipbuilding Co., and the "Ruys", which the De Schelde yard at Flushing are building.

All are to have Sulzer single-acting engines.

The "Boissevain" has been built to Bureau Veritas classification and has the following leading particulars: length overall, 560ft.; length between perpendiculars, 530ft.; breadth moulded, 72ft.; depth moulded to upper deck, 40ft. 6in.; deadweight capacity, 9,000 tons, including 1,800 tons of fuel oil and 1,000 tons of fresh water. The refrigerated capacity is about 21,000 cub. ft. and the palm oil tanks have a capacity of 20,000 cub. ft.

The passenger arrangements are very good, the majority of the first-class passengers having private bathrooms; these passengers are accommodated in single and two-berth cabins. There are 80 intermediate and 500 steerage passengers. Excellent public rooms are provided and there is a swimming bath with verandah café and bar.

Machinery.

As the plan view shows the three engines are arranged abreast. Each has eight cylinders 650mm. in diameter by 1,200mm. stroke and develops 3,600 b.h.p. at about 112 r.p.m. The engines are of the latest Sulzer single-acting crosshead type, with tandem double-acting scavenge pump driven off each crankshaft forward end.

Particular note should be made of the fact that the *actual* revolutions per minute of the engines (propellers) are different from the mean figure (112 r.p.m.) given above. The idea has been to eliminate, or at least minimize, vibrations caused by synchronism between the main engines and between the propellers. For this reason the starboard engine runs at about 108 r.p.m., the centre engine at 112 r.p.m., and the port engine at 116 r.p.m. respectively for full speed. For the same reason the centre propeller is four-bladed, whereas the wing propellers, having the greatest difference in speed, are three-bladed. The speed trials of the ship have proved, so far, that the results have come entirely up to expectations, as the ship ran practically without vibration at any speed. Incidentally, the employment of these relatively low engines is useful from the standpoint of headroom and minimum interference with the passenger accommodation arrangements.

Cylinder jackets and pistons are fresh-water-cooled, the cooling water systems for both services being completely separated with its own cooling water pumps, collecting tanks, and coolers. The principal auxiliaries for use with the main engines are as follows:—

Three vertical-spindle circulating sea water pumps of the centrifugal type, each driven by a Siemens electric motor; capacity 350 tons per hour each.

Three cylinder jacket cooling pumps, capacity 240 tons per hour, consisting of vertical-spindle centrifugal pump driven by Siemens electric motor.

Three piston cooling pumps, 75 tons per hour, of the vertical-spindle self-priming type, each driven by Siemens electric motor.

Three lubricating oil pump units, each consisting of a Siemens electric motor directly-coupled to a 50 tons per hour circulating lubricating oil pump, at one end, and to a crosshead lubricating oil pump, capacity 8 tons per hour, at the other end; the pressures for these duties are, respectively, 45 and 270lb. per sq. in.

Two pumps of each duty are of ample size for running at full power, one being held in reserve.

In addition, there are two two-cylinder manœuvring air compressors, capacity 400 cub. m. per hour, maximum working pressure 30 atm. at 450 r.p.m., made by Linke Hoffman and driven by Siemens electric motors. Miscellaneous engine room auxiliaries include the following: three self-priming fresh water pumps; three sanitary pumps; one general service pump; one emergency fire and bilge pump (in auxiliary engine room); two Stream-Line filters for lubricating oil; two Stream-Line filters for fuel oil; one de Laval fuel separator; two de Laval lubricating oil separators; one fuel transfer pump; and one lubricating oil transfer pump. Two hydraulically-operated watertight doors between main engine room and tunnels and between main and auxiliary engine room.

All starters for engine room auxiliaries have been supplied by Brookhirst Switchgear Ltd., Chester.

When lying in port steam for heating purposes is supplied by one Cochran boiler to the palm oil tank, Thermotank installation, laundry, domestic services, and fuel settling tanks. At sea steam is generated in a waste-heat boiler of the Schelde type, mounted in the funnel uptake; through this boiler the exhaust gases of the two wing engines are passed. At sea the two boilers work in conjunction, the Cochran boiler not being fired but serving as a steam accumulator; the necessary feed- and boiler-water circulating pumps, condenser, and feed water filter tank are installed in the engine room.

The refrigeration machinery is located in a separate engine room on the starboard side of the main engine room between the upper deck and the upper 'tween deck. There are three NH_3 compressors, by Borsig, each being driven through reduction gears by Siemens electric motors; two sets are normally used and one serves as a stand by. The whole installation is designed on the three-temperature system, working with brine of $-20°$ C., $-10°$ C. and $-5°$ C. respectively for freezing and cooling purposes and has been carried out by Blohm & Voss, according to designs supplied by the K.P.M.

The electrical installation is on the double-pole system. The main switch-board in the main engine room is arranged for running the generators in parallel and automatic protection by non-preferential circuits is provided in case one of the generators fails. An emergency generator of 48kW. capacity is placed on the boat deck.

Separate electrically-driven fans on the boat deck supply fresh air and others extract foul air from the main, auxiliary and refrigerating engine rooms. The main engine room is so arranged that the ventilation is not influenced by the main scavenging air pumps, there being a separate air duct through which the scavenging air pumps draw directly from outside the engine room. The electric motors of these various fans are controlled on a uni-start system designed by Blohm & Voss.

Recent Development of Steam Propulsion in Japan.

Combination and reciprocating machinery are discussed, together with a special form of turbo-compound engine using a high-speed geared reciprocator.

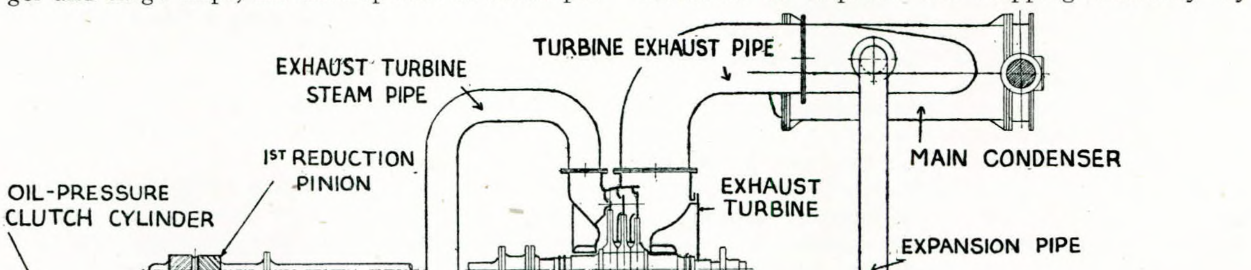
By Y. Taji, M.Eng., etc.

"The Marine Engineer", December, 1937.

Although the recent remarkable progress in marine diesel engineering and motorship construction in Japan endorses general sentiment in the economy of diesel engines for ocean-going passenger and cargo ships, the development of steam propelling machinery cannot be overlooked in view of the fact that the amount of natural oil products in Japan is too small to maintain a necessary minimum number of oil engines running even in peace time. Consequently, the price of diesel oil in Japan is not only comparatively high, but its sufficiency in time of national emergency cannot optimistically be expected. On the other hand, the production of coal in this country and Manchukuo is abundant, the situation somewhat resembling that in Great Britain.

Exhaustive researches are being made in connection with the liquefaction of coal, synthetic production of oil, exploitation of new oil resources, application of alcohol, liquefied air, and natural gas, to internal-combustion engines, etc., in order to secure a sufficiently independent supply of fuel oil and its substitutes in the near future. Coal is, therefore, a very important fuel for marine purposes in Japan, and various systems have been developed for the economical operation of coal-burning ships, particularly those engaging in the Far Eastern trade. Of these, exhaust steam turbine systems combined with triple-expansion or compound reciprocating steam engines; high-pressure, high-superheat steam turbines of the geared impulse type; and Götaverken-type exhaust turbo-compressors, working in conjunction with triple-expansion engines and Howden-Johnson boilers, may be mentioned. The boilers are generally of the marine cylindrical type, but various coal-burning processes, such as pulverized fuel, mechanical stokers, etc. are being employed, while in some ships belt conveyors are used for coaling bunkers and stokeholds.

Japan has taken, and is still taking, drastic measures to improve her shipping efficiency by



Arrangement of reciprocator, exhaust turbine, and reduction gearing according to the combination machinery arrangement developed by the Uraga Dockyard.

scrapping old tonnage and facilitating new construction under subsidy. Up to some two years ago, the majority of the new ships built in Japan were propelled by diesel engines, but now a fairly large number of vessels recently built and under construction are steamships equipped with improved machinery of the most up-to-date type.

Uraga combination engine.

Apart from the shortage of diesel oil in Japan, the reciprocating steam engine has many advantages, such as low initial and repair costs, easy and dependble manœuvring, etc. With these facts in mind, the Uraga Dock Co., Ltd., introduced a few years ago a combined system of a triple-expansion engine and exhaust turbine, which has been adopted in the "Shinkyo Maru" and "Seikyo Maru" of the Chosen Yusen Kaisha, Ltd. Each vessel has a length of 295ft., a gross tonnage of about 2,600 tons, and a dead-weight of about 4,100 tons. The propelling machinery comprises a triple-expansion engine with poppet valves and an exhaust turbine with double-reduction gearing, mechanical flexible coupling, and friction clutch. The main engine develops 1,000 i.h.p. normally with the exhaust turbine in use at about 70 r.p.m. of the propeller. The maximum output of the main engine and turbine is 1,760 i.h.p. at 89 r.p.m., of which 1,100 i.h.p. is developed by the reciprocator and 660 i.h.p. by the exhaust turbine; the maximum output when the turbine is disconnected is about 1,300 i.h.p. The h.p. and i.p. cylinders of the triple-expansion engine have inlet and exhaust steam valves of the double-beat poppet type, while the l.p. cylinder has an ordinary flat slide valve. Usual Stephenson's link motion valve gear with double bar links, is employed, the poppet valves being operated by cams and sliding segments which allow of easy adjustment of the cut-off of the cylinders.

The exhaust turbine is of a three-stage impulse type with stainless steel blading. The exhaust steam discharged from the low-pressure cylinder first passes through an oil separator, and by means of a two-way valve is delivered either directly into the main condenser or, alternatively, through a steam strainer into the turbine, which can be automatically shut off whenever the main engine has to be reversed. The reduction gearing is of the double-helical type with a total reduction ratio of 50 to 1; a layout of the machinery is shown in the first illustration.

The coal consumption in service is from 10 to 15 tons per day, when the machinery develops from 700 to 1,100 i.h.p. This gives a fuel coefficient (displacement$^{2/3} \times$ speed$^3 \div$ tons of fuel per day) of about 25,400, which may be considered a good result. This system was first designed in consideration of reconstruction and improvement of the existing steam engine, and is suitable for vessels up to about 4,000 tons dead-weight capacity and 10 to 11 knots of service speed.

Confirming Mr. White's views.

It has been necessary, however, to develop a new type of machinery which is suitable for a much higher output and for newly constructed ships. After exhaustive research, the Uraga Dock Company succeeded in introducing a new system in combination with a high-speed double-compound steam engine and a low-pressure turbine,[1] the device being patented in Japan. This new system was first adopted in the "Rakuto Maru", "Daido Maru", and "Ryuko Maru" of the Osaka Shosen Kaisha, Ltd., and the results of actual sea trials were superior to those of the previous ships.

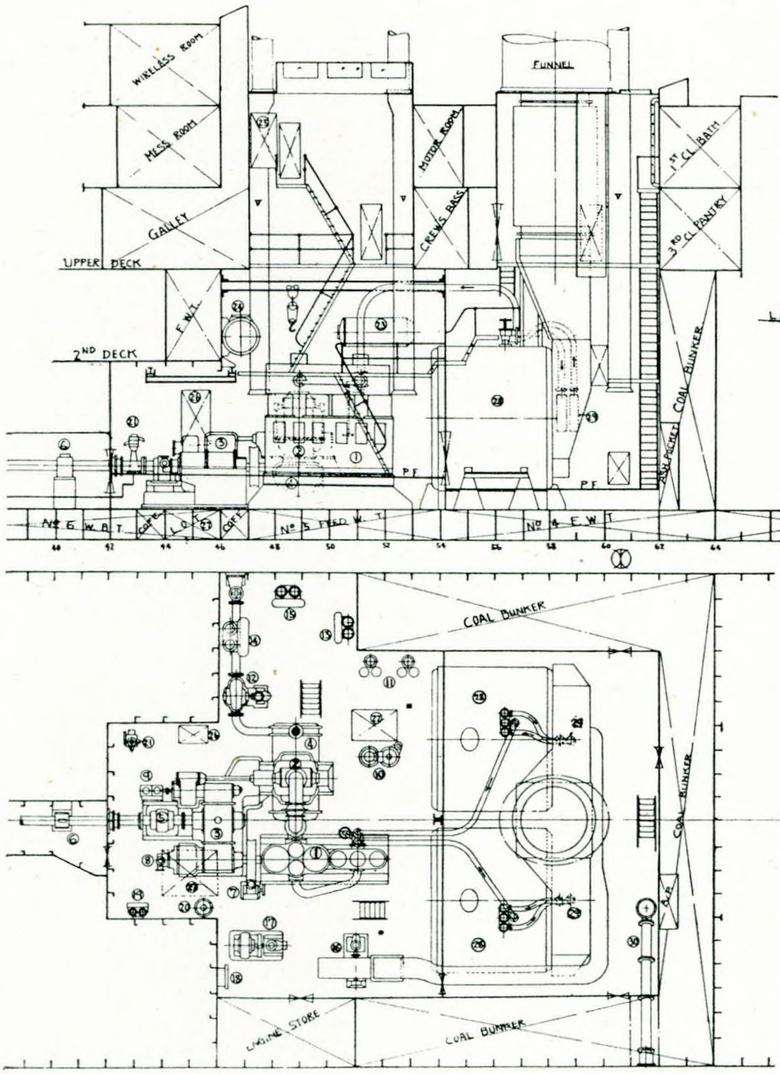
In this system, the reciprocating engine is employed for the high-pressure stage and the steam turbine, of course, for the low-pressure stage, the output of each being designed to be nearly equal. So far as the efficiency of this type of machinery is concerned, it is obvious that the reciprocating engine is superior for the high-pressure end, while the turbine is better for the low-pressure portion, while, at a light load the efficiency of the reciprocator is superior to that of the turbine. Consequently, the complete machinery is not only high in its efficiency under normal conditions, but the drop of efficiency at light load or an overload is very little. The relation of s.h.p. and coal consumption of the main system, as taken from the official sea trials of the "Rakuto Maru", are as follows:—

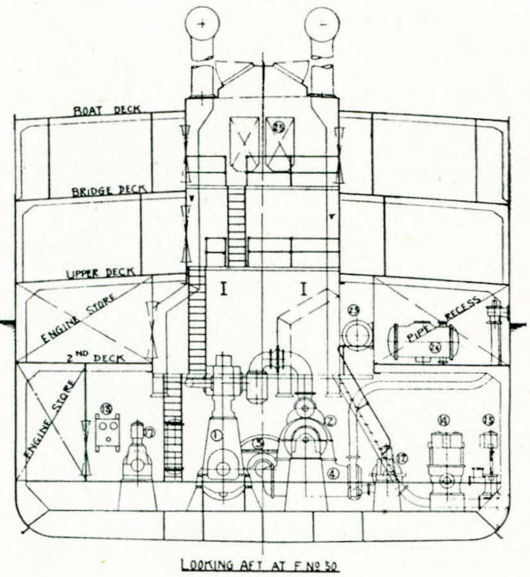
	Light load.		Normal.	Over-load.
Total s.h.p.	650	980	1,200	1,860
Coal consumption, in lb. per s.h.p. per hour	1·188	1·144	1·139	1·192

The efficiency is raised by using superheated steam, and the mechanical efficiency is increased by adopting the high-speed double-compound engine with a forced lubrication system. The high condenser vacuum, produced by efficient air pumps, raises the efficiency of the impulse-type turbine, the net result of these being a most economical layout.

The manœuvring device is a patented design of the builders, the operation being easy and quick. In the reduction gearing, the builders' patent mechanical coupling is provided. The complete system of propulsion developed by the Uraga Dock Company is shown in the vessel in the illustration overleaf. It is claimed by the builders, that the increase in the total efficiency obtained with this machinery has enabled a considerable reduction of the coal and steam consumptions with a consequent reduction of the size of the boilers. The good balance and steady running of the complete machinery has reduced wear and upkeep. At the same time, the accuracy and simplicity of the manœuvring device have resulted in a reduction in the number of engine-room staff.

(1) "Journal of the Society of Naval Architects of Japan", December, 1936, Vol. LIX—"Uraga Systems of Combination of Reciprocating Engine and Low-pressure Steam Turbine for Marine Propulsion and Practical Data of the Installations Completed", by C. Ono.





1 Main engine
2 L.P. turbine
3 Reduction gear
4 Main condenser
5 Thrust bearing
6 Plummer block
7 Turning engine
8 L.O. gear pump
9 Bilge and sanitary pump
10 Air pump
11 Feed pump
12 Cir'g. pump
13 G.S. pump
14 Ballast pump
15 Ash ejector pump
16 Fan engine
17 Dynamo engine
18 Switch board
19 Lub. oil pump
20 Lub. oil cooler
21 Lub. oil purifier
22 Feed filter
23 Feed heater
24 Aux. condenser
25 L.O. head tank
26 L.O. reserve tank
27 L.O. drain tank
28 Main boiler
29 Super heater
30 Ash ejector

Machinery arrangement of the "Rakuto Maru", which has Uraga turbo-compound machinery.

The reciprocating engine is of the double-compound type with four cranks, two high-pressure and two low-pressure cylinders of 290 and 520 mm. in diameters respectively. The engine bed-plate and frame are built up with steel plates electrically-welded together. As a result, the engine is very compact, of comparatively small size, and smart in appearance, the weight being reduced to about one-half of that of the ordinary slow-speed steam engine of the same output. Comparatively speaking, the cut-off in the high-pressure cylinders is small and the compression ratio large so as to attain a high efficiency, while the cylinder ratio is also small in order to ensure uniform distribution of the output between the h.p. and l.p. cylinders. Owing to the high speed of the engine, piston valves are used instead of the poppet valves which were employed in the previous Uraga engines. A specially designed simple piston valve is fitted between each pair of h.p. and each pair of low-pressure cylinders (they are arranged together as the plan shows) in order to operate the two cylinders simultaneously, this having enabled the designer to shorten the engine and reduce heat and mechanical losses at the valves. The crankshaft is a single-piece forging, and the crank angle is 180° between the same size cylinders and 90° between the high- and low-pressure cylinders respectively, a balanced weight being fitted to each crank-web.

The low-pressure turbine has four stages for ahead running, with a single stage for astern running, all being of the impulse type. The reasons for the adoption of the impulse type are that the size and weight of the turbine can considerably be reduced due to its high speed; the light weight of the rotational parts and the consequently small inertia energy due to rotation, renders stopping and reversing of the engine easy and reduces wear and damage to gearwheel teeth and flexible couplings. The number of blades is considerably reduced and the possibility of trouble due to wet steam is claimed to be less and the rotor which often takes place in a reaction turbine is avoided; the initial building cost is, furthermore, low.

Steam to the ahead or astern turbine can be changed-over by a special valve fitted on the steam chest. Simultaneous with the starting, reversing, or stopping of the engine, the steam is automatically interchanged to the ahead or astern steam chest or directed to the condenser. Peripheral velocities of the blades are as high as is permissible, the condenser vacuum is maintained as high as 97 per cent., and the use of initially superheated steam have all resulted in a high efficiency from the turbine.

Single-reduction gear is employed for the reciprocator, while a double-reduction gear is used for the turbine. The coupling is of the mechanical flexible type, in which a number of helical springs are fitted in order to absorb torque irregularities between the reciprocator and the turbine, while a frictional disc clutch is provided for connecting and disconnecting the second gear pinion and the first reduction wheel; the clutch discs are spring loaded and are provided with asbestos linings. This system has already been adopted for more than five ships, and already a number of other vessels under construction or on order with the Uraga Dockyard are to be equipped with similar machinery.

Mitsubishi-Bauer-Wach exhaust turbines.

The Mitsubishi-Bauer-Wach exhaust turbine system was first adopted in the reconstructed ship "Konan Maru" over five years ago, the vessel having a length of 400ft. and a gross tonnage of about 5,230 tons. The main propelling machinery comprises one set of triple-expansion engines with a high-pressure cylinder of $27\frac{5}{16}$in., an i.p. cylinder of $44\frac{3}{4}$in., and an l.p. cylinder of $75\frac{1}{32}$in. the stroke being 48in.; the normal output is 1,400 i.h.p. The exhaust turbine is of the reaction type with seven rows of blading, the rotor having a diameter of 650mm. There is the usual Vulcan-type hydraulic coupling (of 1,200mm. in diameter), and double-reduction single-helical gearing which gives a total reduction ratio, in two steps, of 65·784 to 1.

The modifications carried out to the existing engine in adding the exhaust turbine include the enlarging of the exhaust steam pipe to the main condenser and a certain alteration in the exhaust steam piping; the air pump and circulating water pump remain the same as with a reciprocator only. The service full load design particulars for the installation are as follows:—

Main engine	1,400 i.h.p.
Exhaust turbine	600 i.h.p.
Total	2,000 i.h.p.
Propeller speed	56 r.p.m.
Exhaust turbine speed...	4,060 r.p.m.

Various sea trials were carried out by the builders as well as by the ships' engineers. It was confirmed that some 19·4 per cent. of coal has been saved by using the exhaust turbine, when the fully loaded sea speed was about 10 knots with 1,507 i.h.p. This is well below the designed output of 2,000 i.h.p., at which power the fuel saving would probably be higher than the figure quoted. Apart from the reconstructed vessel "Konan Maru", the first new ships equipped with Bauer-Wach exhaust turbines and pulverised fuel installations are the "Nagoya Maru" and "Johore Maru", each 410ft. long and of 6,200 gross tons. The main engine is a triple-expansion unit having cylinders 26in., 44in., and 74in. in diameter by 51in. stroke, and a normal output of 4,000 i.h.p. at 75 r.p.m. In combination with the Bauer-Wach exhaust turbine, the normal i.h.p. is 4,800. The exhaust turbine has seven stages, and drives the propeller shaft through a Vulcan coupling and double-reduction gearing. Steam is generated in three Scotch boilers with Clarke Chapman pulverized-fuel equipment. The average coal consumption in sea trials was 1·22lb. per i.h.p. per hour, when the engine output was 4,228 i.h.p. and the displacement 8,251 tons. The quality of coal was about 30 per cent. inferior to a fair hand-firing coal. The saving in fuel consumption, as compared with the consumption when hand-firing is used, is estimated at 15 to 20 per cent.

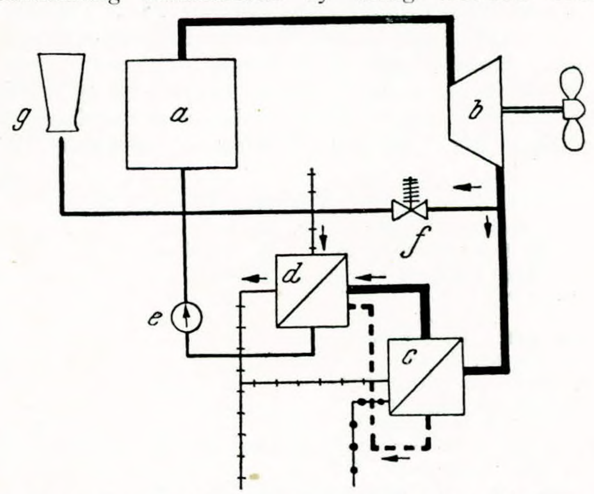
Exhaust Steam Evaporators for Tugs.

Results from Trials with a 250 H.P. Installation.

"Shipbuilding and Shipping Record", 13th January, 1938.

Though tugs are often fitted with non-condensing or jet-condensing engines for the sake of simplicity, both of these arrangements are open to the serious practical objection that the supply of feed water (mostly river water) contains scale-forming salts and suspended solids which quickly foul the boiler heating surfaces. Frequent interruptions of service for boiler cleaning are inevitable under such circumstances, and owing to the difficulty of access to the tubes in cylindrical boilers, the scale is usually only partly removed and tubes have to be frequently renewed.

The use of surface condensers avoids these troubles, but they can also be prevented in non-condensing installations by using distilled feed



Arrangement of exhaust steam evaporator installed in tug.

water. In the system developed by Meyer & Oestreich, Hamburg, only such part of the exhaust steam is taken to the funnel blast-pipe as is needed for the maintenance of the requisite draught. Up to about 40 per cent. of the steam is needed for this purpose, and the remainder, at a pressure of 18·5 to 21·5lb. per sq. in. absolute, is used in the heating circuit of an evaporator. The evaporator is fed with the warmed cooling water of the condenser used to condense the steam or vapour generated, and as 1¼lb. of exhaust steam evaporates about 1lb. of raw water, the condensed exhaust together with the condensed vapour from the evaporator furnishes an ample supply of pure feed water for the boiler. Moreover, by suitable regulation of the cooling water supply to the evaporator-condenser, it can be ensured that the feed water is fed to the boiler at 95 to 98° C. (203 to 208° F.). The small increase in back-pressure resulting from the use of the evaporator, compared with non-condensing operation, is offset by the recovery of heat in the feed water and by the higher efficiency of the clean boiler.

On the other hand, conversion of jet-condensing equipment to the evaporator system of working involves a reduction in the utilised heat drop, and therefore in the power developed for equal boiler output, which is not fully compensated by the higher feed temperature and improved heat transmission alone. In many cases the improved draught, resulting from the exhaust blast available where an evaporator is used, adds substantially to the boiler capacity and efficiency of feed utilisation. A propeller fan is, of course, an alternative means of remedying defective draught.

Following the above general discussion of the conditions in this service, Karl Wetjen gives, in "Schiffbau", data from trials on an exhaust steam evaporator installed in a tug, 68ft. 7in. by 19ft. by 6ft. 10½in. draught, with a single-flue cylindrical boiler of 860 sq. ft. heating surface and 17¼ sq. ft. grate area, propelled by a compound non-condensing engine of 250 i.h.p., with cylinders 355 and 582 mm. (14 and 22⅞in.) diameter by 380mm. (15in.) stroke. This vessel, built in 1911 by the Maschinenfabrik vorm. Janssen and Schmilinsky, Hamburg, was fitted with an exhaust steam evaporator in 1926, the heat-flow circuit being as shown in the diagram on page 23E. In this drawing, *a* represents the boiler, *b* the engine, *c* the exhaust evaporator, *d* the distillate condenser, *e* the feed pumps and *g* the funnel blast pipe. The spring-loaded valve *f* was fitted before commencing the trials in order that a suitable pressure of exhaust steam might be maintained in *c*, even at low engine output. The engine was overhauled before the trials, which were carried out between Hamburg and Bremen and on the River Weser. The principal results of four trials, burning coal of 12,600 to 13,000 B.Th.U. per lb., are given in Table I.

The steam consumption of 23·1lb. per i.h.p.-hour (No. 3 test) corresponds to an indicated efficiency of 73·5 per cent., which is very favourable for an engine of this size and type. The grate loading during this five-hour trial was 32·4lb. per sq. ft. per hour, and the evaporation 5·57lb. per sq. ft. of heating surface per hour, corresponding to a heat transference of 5,730 B.Th.U. per sq. ft. per hour, notwithstanding which, the mean flue gas temperature was only 554° F. Combustion was specially satisfactory, owing partly to the large combustion chamber and partly to the good draught. Very little smoke was emitted, in contrast to the dense clouds often produced by tugs, and the measured CO_2 value of 7·8 per cent. is good for a hand-fired furnace burning bunker coal. The flue gas loss, calculated by Siegert's formula, was 21·5 per cent. The evaporation ratio of 8·64lb. steam per lb. of coal, and the coal consumption of 2·68lb. per i.h.p.-hour are good, considering the imperfect lagging, as judged by modern practice. Examination of samples of feed water, taken when the vessel was at sea, in brackish water and in the river, showed the distillate to be practically free from salts and oil under all circumstances. After several years' service, the boiler was still free from scale.

Dynamometer measurements of the pull at the bollard gave results summarised in Table II. The values 33·2lb. per i.h.p. at 172 i.h.p., and 29·6lb. per i.h.p. at 208 i.h.p., are very satisfactory. In a new vessel, the heating surface of the exhaust steam evaporator would be larger, with tubes of greater diameter to decrease the back pressure. The latter would then be, say, 18·5lb. per sq. in. (absolute), in which case, with the same boiler pressure and engine efficiency as above, the steam consumption would be 22·2lb. per i.h.p.-hour. Also with an evaporation

TABLE I.

Test No.	1	2	3	4
Boiler pressure lb. per sq. in. absol.	164·0	157·0	155·0	157·0
Exhaust back-pressure, lb. per sq. in., absol.	18·1	19·6	20·9	22·0
Mean high-pressure cut-off, per cent.	36·0	52·0	59·0	65·0
Mean r.p.m.	117·0	133·5	149·2	153·0
I.h.p.	118·0	168·0	207·0	224·0
Feed water, lb. per hour	2,570·0	4,090·0	4,800·0	5,130·0
Coal, lb. per hour	—	—	556·0	—
Lb. steam per i.h.p.-hour	21·7	24·4	23·1	23·0
Lb. coal per i.h.p.-hour	—	—	2·68	—
Feed water temperature, ° F.	205·0	203·0	199·0	199·0
Evaporation, lb. per sq. ft. heating surface per hour ...	2·98	4·75	5·57	5·98
Flue gas temperature, ° F.	496·0	534·0	554·0	568·0
Draught in front smoke chamber, in. w.g.	0·51	0·87-0·95	0·87-0·98	1·02-1·14
Draught above fire, in. w.g.	0·28	0·43-0·55	0·35-0·47	0·51-0·55

TABLE II.

Test No.	1	2	3	4
Boiler pressure, lb. per sq. in. absol.	158·0	158·0	158·0	158·0
R.p.m.	98·7	103·3	109·8	128·3
I.h.p.	104·0	141·0	172·0	208·0
Pull, lb.	3,527·0	4,740·0	5,732·0	6,173·0
Pull in lb. per i.h.p.	33·8	33·7	33·2	29·6

ratio of 9·0 and a boiler efficiency of 73 per cent., obtained by improved lagging, the fuel consumption would be 2·46lb. of coal (12,600 B.Th.U. per lb.) per i.h.p.-hour. Condensing equipment of course gives higher steam economy than non-condensing machinery with exhaust steam evaporator, but the latter effects substantial savings compared with non-condensing operation, and eliminates the boiler-fouling difficulties that arise from non-condensing or from the use of jet condensers.

Spraying of Steel.

"Shipbuilding and Shipping Record", 3rd February, 1938.

The idea of heating a metal until it reaches its point of liquefaction and then spraying it by means of high-pressure gas issuing through a suitably designed nozzle is far from being a new one and the metal-spraying process has been adopted in many industries.

A very interesting survey of the possibilities of the steel-spraying process was given by Mr. Richard R. Sillifant in a paper entitled "Recent Experiments in Connection with the Spraying of Steel" which was presented at a recent meeting of the Iron and Steel Institute. After first of all indicating the extent to which metal-spraying was already used in industry, the author gave a brief description of the type of "pistol" usually employed for the spraying of steel. This consists of two essential parts, the first of which is the wire feeding mechanism, the second being the gas head which is responsible for melting, atomising and propelling the resultant particles of metal. The wire feeding mechanism comprises a compressed air-driven turbine which drives a pair of wire-feed rollers through a series of reduction gears, while the second is composed of a taper valve for regulating not only the air supply to the turbine, but also the oxygen and fuel gas—usually acetylene or compressed coal gas—used for melting the wire, suitable posts being provided for conducting the air which is employed to atomise and impel the molten metal. The whole is contained in an aluminium casing about 4in. long by 3in. wide by 3in. deep attached to a suitable handle or grip, and the pistol is capable of handling wire of different sizes up to $\frac{3}{16}$in. diameter such as is used when heavy deposits have to be made. There are various ways in which this metal-spraying pistol can be employed, but attention may be drawn to the operation described by the author for the building-up of worn shafts.

In order to test the quality of the sprayed metal and its adherence to the base metal, a series of micrographs was made showing the structure of the two metals and the condition at the surface of contact. Under normal conditions, that is to say, when compressed air was used as the impelling medium, the micrograph showed that each particle of the sprayed metal is enveloped by a skin of oxide which is thinner on the striking face than on the outer face. This causes the sprayed metal to become artificially hardened up to the point of brittleness and tends to produce low tensile strength. But while for many normal applications this inclusion of oxide does not in any way affect the usefulness of the deposits, it was felt that the scope of usefulness of the process would be widened if the oxide could be minimised or avoided altogether and a more normal structure obtained. With this end in view, compressed nitrogen was employed as the impelling medium and a second series of micrographs prepared. These showed that the layers of oxide were almost entirely eliminated and that very intimate conditions occurred at the junction of the two metals. This was verified by taking a bar $\frac{3}{4}$in. diameter and 9in. long upon which was deposited a layer of steel $\frac{1}{8}$in. thick and bending it cold through an angle of 90° when no fracture or dislodging of the coating occurred. As an alternative to the use of inert impelling gases, the question of adding deoxidising agents such as silicon, aluminium, magnesium, etc., to the wire itself is being considered, but already it is felt that sufficient has been done to show that the spraying of high-grade steels yields a method whereby a hard and homogeneous layer of wear-resisting metal can be deposited upon castings and similar structures.

Propulsion of Quadruple Screw Vessels.

"Shipbuilding and Shipping Record", 17th February, 1938.

In the November number of the "Journal of the American Society of Naval Engineers", there appeared an interesting article by Lieut.-Commander Labberton on the determination of the proper pitch for the inboard and outboard propellers of a four-screw ship. The author points out that with identical propellers the outboard screws turn faster than the inboard screws, and that there is in consequence an unbalance on the power demand for the different shafts. He states that it is only recently that the question of balancing of power demand on the four shafts has become interesting to engineers. The desirability of doing this must be carefully weighed against the obvious advantage of having all propellers of the same diameter and pitch because of the expense of spares.

On the assumption that it is desirable to have this balance of power on all four shafts, the author proceeds to show how the pitches can be determined so that this may be obtained. He takes the case of a high-speed merchant ship capable of 30 knots speed, requiring 88,000 effective h.p. He further assumes that preliminary self-propelled tests have been made on the model, and that calculations therefrom indicate that the wake fraction inboard is 0·165, and the wake fraction outboard 0·075. From the preliminary calculations made, he finds that, on the basis of an average wake of 0·12, the average s.h.p. per shaft is 34,375. When calculations are made on the basis of 0·165 wake for the inboard screws, and 0·075 for the outboard screws, the s.h.p. are, respectively, 34,921 and 33,846, the foregoing applying to propellers 18ft. diameter and 18ft. pitch, with 192½ revolutions per minute. He concluded that since the inner shafts showed greater h.p. than the required average, "these shafts would tend to run at lower speed", and that the outer shafts, absorbing less than the average power, "would tend to speed up unless throttled". The author proceeds to determine the dimensions of the screws which would ensure equal distribution of power when revolving at 192½ revolutions. These were ascertained to be 18ft. 1½in. diameter and 17ft. 8in. pitch for the inner position, and 18ft. 1½in. diameter and 18ft. 8in. pitch for the outer position. The charts used for analysis and for design were those given in Taylor's latest "Speed and Power of Ships".

An examination of the methods used by Comdr. Labberton reveals no error in his work; nevertheless, it is rather surprising to find that the pitch of the outer screws becomes 1ft. greater than that of the inner screws. If the real slips are worked out, these show a wider difference than might have been expected from propellers of much the same dimensions when absorbing the same power.

The paper shows clearly that if an equal distribution of power is required from all four shafts, the propeller dimensions must be determined from considerations of the particular wakes prevailing in each position.

With regard to the importance of having a reasonable balance of power in quadruple-screw ships, it might be argued that this is of a secondary nature. In the case of the "Empress of Britain", the power put through the inner shafts was double that absorbed by the outer screws. Notwithstanding this unusual distribution of power, the propulsive results were quite satisfactory. In ordinary circumstances, when equal distribution is desired and the propellers are not specially designed to suit the particular wake conditions, there is sufficient flexibility in the turbine machinery to adapt itself to suit the propulsive conditions.

As a matter of history, it may be of interest to give the distribution of power in the "Mauretania" during her trials 30 years ago. The propellers used were all 17ft. in diameter and 15ft. 9in. in pitch. On her full-power trials the results obtained were as follows:—

	Port outer.	Port inner.	Starboard inner.	Starboard outer.
Revolutions ...	187·3	186·6	188·6	188·6
Shaft horse-power	17,350	20,650	20,650	18,600

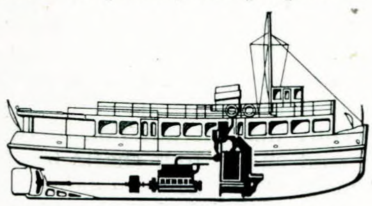
These results show that the inner screws were operating in a greater wake than were the wing screws, and that some adjustment in dimensions was required if an equal distribution of power had been thought necessary. Quite a number of quadruple-screw warships have now been built; some of these have had propellers in the wings of different dimensions from those in the inner positions, while others have been fitted with screws all of like dimensions. It cannot be said that any distinct advantage, from the propulsive point of view, lies in the attempt to obtain equal distribution of power.

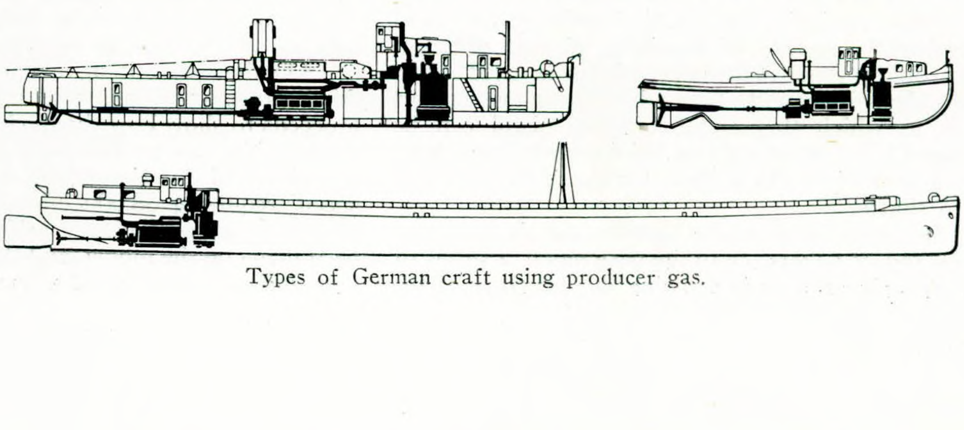
Undoubtedly, if the best possible balance of power is thought to be desirable, it is necessary to design the screws to suit the wake conditions, but some considerable gain would require to be shown for this preference before the distinct advantage of having to carry spare propellers which would suit either the outer or inner positions as the emergency demanded is outweighed.

"Gas Ships" in Germany.

"Shipbuilding and Shipping Record", 16th December, 1937.

Though the first tug propelled by gas engines burning producer gas was a radically new departure (*see* "Shipbuilding and Shipping Record", 19th December, 1935, page 689), the results obtained in service were so satisfactory, says "Hansa", that 17 gas-propelled vessels were in service or on order in July, 1937. The more extensive use of vessels of this type is held to be a matter of national importance, not merely because the propelling machinery is light, compact, relatively inexpensive and needs little attendance, but also because native fuel is employed. Moreover, coke and semi-coke can be used, so that the raw native fuel (coal) can be utilised to maximum advantage by the manufacture or recovery of by-products before applying the carbonaceous residue to ship propulsion. The full range of fuels already used in gas-producer vessels includes coke, anthracite, lean coals, semi-





Types of German craft using producer gas.

coke, brown coal briquettes, peat, peat-coke and wood.

The increasing use of large vessels on the inland waterways of Germany offers great scope for gas propulsion, and the accompanying drawings show typical layouts of equipment for passenger vessels (top), tugs (centre) and cargo vessels (bottom). Gas propulsion combines, it is claimed, the quiet and smokeless operation desirable for passenger service, the high tractive effort and manœuvrability required in tugs, and the minimum space and personal requirements important to the economical working of cargo vessels.

Vertical Water-tube Boilers.

"Shipbuilding and Shipping Record", 18th November, 1937.

Much has been said and written regarding the relative merits of the fire-tube and the water-tube types of boiler, and to the unbiassed mind it is apparent that each type possesses certain well-defined advantages. One of the great advantages of the water-tube type is its steaming capacity relative to its size, and it is claimed that this desirable property is obtained by a vertical cylindrical boiler, which has recently been placed on the market by a well-known firm of German engineers. The external drum and the furnace are not dissimilar from that of the normal design of vertical boiler, even to the usual large horizontal cross tubes, only instead of these constituting the only additional heating surface, each cross-tube is provided with a bank of smaller tubes connecting it with the furnace crown. The cross tubes are parallel to one another and are arranged in a diagonal plane across the furnace, the connecting tubes which are nearly vertical being staggered so as to compel the furnace gases to take a zig-zag path to the uptake, which is arranged at the side of the furnace near the top. The boiler is made in various sizes, ranging from 2·4 sq. m. (25·8 sq. ft.) up to 25 sq. m. (269 sq. ft.) of heating surface, and for different working pressures up to 12 atmospheres (175lb. per sq. in.), and it is claimed that with a draught of 5mm. w.g. (2in.) at the base of the chimney, the evaporation is from 25 to 35kg. per sq. m.—say, 5·12 to 7·16lb. per sq. ft.

Turbine Blade Clearance.

"Shipbuilding and Shipping Record", 18th November, 1937.

An important factor governing the efficiency of a marine steam turbine is the blade clearance, and every endeavour should be made to maintain as small a clearance as practicable when the turbine is in operation. This factor, of course, is fully recognised by designers and builders, and when a turbine leaves the shops for installation on the ship it can generally be assumed that when the rotor is set in the correct running position, the minimum clearances will exist between rotor and stator. It happens, however, that after the machinery has been in service, say, for a year or so, due to the slight distortion of the hull of the vessel and with it the foundations of the turbines, and also due to the distortion of the turbine casings consequent upon the effects of temperature changes, these clearances become sadly upset. We recently heard of a turbine which on being opened up for the first time showed that some of the edges of the shrouding had been in running contact with the casing and had been ground away, while on other rings of blades no contact whatever had occurred. It is suggested that after a year or so in service, by which time the distortions of both hull and turbine casing would have become permanent, the shrouding which had been in more or less severe contact could be skimmed down and the clearance of the rotor as a whole reset, with beneficial effect on the performance.

Popularising Marine Engineering.

"Shipbuilding and Shipping Record", 13th January, 1938.

Nearly everybody who travels by sea is interested in the machinery which is employed for the propulsion of the ship upon which he voyages. We have frequently commented upon the interest displayed by travellers on paddle-driven pleasure steamers in which the engine room is open to view, and on the regret often expressed by those journeying on the newer type of ship in which this pleasure is denied them. Such people, and many others, we believe, will therefore be interested in the movement which has just been inaugurated "to present to the public in suitable form, information concerning the science and practice of engineering, and its services to the public". The movement has been fostered by some of the leading engineering institutions in Great Britain, among which those especially interested in marine engineering and naval architecture are included. Lord Stonehaven presided at the luncheon at the Savoy Hotel, London last Thursday at which the project was officially launched. He suggested that to a generation mechanically minded as this is, it should not be a difficult matter to show what the community owed to engineers in almost everything that goes to make up its daily life, and in particular we would add that since the sea is the greatest heritage of the peoples of these islands, everything pertaining to it should be of special interest. We note that the plans already formulated include lectures for schools and colleges, and various other schemes are advanced for keeping engineers in the public eye.

High-speed Reciprocating Pumps.

"Shipbuilding and Shipping Record", 13th January, 1938.

The advent of the self-contained hydraulic press for operating flanging machines, riveters, etc., in place of the slow-speed central unit operating in conjunction with an accumulator has necessitated the development of a compact high-speed pump. Hitherto, reciprocating pumps have usually been associated with low speeds, while, on the other hand, the use of the rotary principle for high-speed pumps is limited to comparatively low pressures. In a paper by F. H. and J. M. Towler, entitled "Recent Developments in High-Speed Reciprocating Pumps", read at a recent meeting of the Institution of Mechanical Engineers, the authors describe the developments which have culminated in the production of reciprocating pumps having a working pressure of 5,000lb. per sq. in., and running at a speed of 1,500 r.p.m. A feature of the design is the high volumetric efficiency obtained, this, it is stated, being over 97 per cent., while the careful design of the mushroom-type valves, which close practically at the dead centre position, results in them being free from the hammering action usually associated with low volumetric efficiency, and hence they last for several years without attention. It is obvious that at such high speeds the pump is remarkably compact in relation to its output, and while the principle has, so far, only been adopted for various types of press used in engineering manufacture, the idea is worthy of being investigated in connection with other types of pump.

Chrome-hardened Injection Nozzles.

"The Motor Ship", February, 1938.

With the best fuels, coking at the injection nozzles is not to be feared, but all fuels are not of the best. If it is desired to use a poorer quality of oil, one of the troubles that may be encountered is this coking effect, which can be a source of considerable annoyance. From trials carried out over a lengthy period, it would appear that the deposition of carbon can be diminished, if not entirely dispelled, by subjecting nozzles to the chrome-hardening process, similar to that which is now being widely applied to cylinder liners. Any development which will enable Diesel engines to use fuel of substantially differing characteristics represents an advance which will be welcomed by the marine engineer and shipowner.

Wooden Fans.

"Shipbuilding and Shipping Record", 27th January, 1938.

The shipbuilder has long been familiar with the use of wood for the construction of the rotors of fans, particularly of the large low-speed type such as is fitted in the public rooms of passenger liners. The progress in the science of the design of propellers for aircraft in conjunction with the developments which are taking place in the use of plastics in engineering construction, has led to a well-known British firm which has hitherto specialised in the design and construction of airscrews placing on the market a type of wooden fan in which the same principle is employed in the design of the rotor as is used in that of the aircraft propeller. The fan is built up of a number of layers of wood firmly secured together and shaped to the correct size and form, the whole being finished by means of a covering of a special plastic material pressed into the wood under high pressure. It is stated that these fans withstand vibration and fatigue and that they remain free from distortion. Maintenance charges are non-existent, as the reinforced protective plastic covering which is impregnated into the wood is proof against both erosion and corrosion. In the axial-flow type with the fan direct-coupled to the driving motor, efficiencies as high as 85 per cent. can be obtained, and the makers guarantee the construction even when running at a top speed equal to that of sound.

Double-action Safety Valves.

"Shipbuilding and Shipping Record", 27th January, 1938.

The rapid increase in the steaming capacity of steam generators on board ship has led to the demand for a safety valve which, while being sufficiently sensitive to lift at any desired pressure, shall also be capable of opening fully at that pressure in order to avoid any undesirable accumulation of steam. This demand has been met by the introduction of the well-known high-lift type of valve, but, with a view to reducing still further the size of the fitting as a whole and to improve the sensitivity of operation, a new type of double-action safety valve has recently been placed on the market in which a small pilot valve situated in a by-pass from the pressure side of the main valve is used to control the supply of steam to an auxiliary cylinder in which is a piston directly coupled with the main valve. The pilot valve is adjusted to lift at a pressure slightly in excess of that on the main valve, so that if when the main valve lifts at the desired blow-off pressure there is still a tendency for the pressure to increase, the pilot valve then lifts, admitting steam to the underside of the piston, thereby lifting the main valve to its full extent, which is, of course, one-quarter of the diameter of the main valve. This, the makers claim, enables a safety valve of 1¾in. bore of seat to fulfil the conditions which would require an ordinary spring-loaded valve of 6in. bore.

The "Stratheden".

Built and engined by Vickers-Armstrongs Limited, Barrow-in-Furness, for the P. & O. service to Bombay and Australia.

"Shipbuilding and Shipping Record", 23rd December, 1937.

Trials were run on Friday, 10th December, of the latest liner, "Stratheden", built by Vickers-Armstrongs, Limited, at Barrow-in-Furness, for the express services of the Peninsular & Oriental Steam Navigation Company, between the United Kingdom, Bombay, and Australia. Her sister ship, the "Strathallan", is now fitting out at Barrow, and will be completed in the early spring.

The "Stratheden" has an imposing appearance, with her graceful lines, straight stem, cruiser stern, well-proportioned single funnel, and two pole masts.

She has been built to the highest class of Lloyd's Register and Board of Trade requirements, and conforms to the rules laid down under the International Convention.

The ship is sub-divided into 12 transverse watertight compartments up to the level of F deck. A continuous double bottom from the collision bulkhead to the after end of the shaft tunnels is fitted, and is divided transversely and longitudinally to provide a large number of tanks for fresh water, boiler feed water, water ballast, and oil fuel. From the forward oil fuel cross bunker to the after end of the engine room the vessel is protected by a complete double skin up to the water line, thus providing a maximum margin of safety at sea.

There are eight decks, alphabetically designated from the boat deck downwards, A to H, including the promenade decks. All are intended for the use of passengers.

The principal dimensions are :—

Length b.p.	630ft.
Length overall	664·5ft.
Breadth moulded	82ft.
Breadth overall	84ft.
Depth moulded to F deck	38ft.
Depth moulded to E deck	47·5ft.
Gross tonnage	23,400 tons.
Draught	30ft. 2in.
Passengers	448 First class.
	563 Tourist class.
Crew	563
Power	24,000 s.h.p.
Service speed	About 21 knots.
Mean on trials	21·8 knots.

Propelling machinery.

The "Stratheden" is propelled by twin screws, each driven by a set of Parsons turbines, through single-reduction gearing, each set comprising one high-pressure, one intermediate-pressure, and one low-pressure turbine, working in series and driving separate pinions engaging with the main gear wheel.

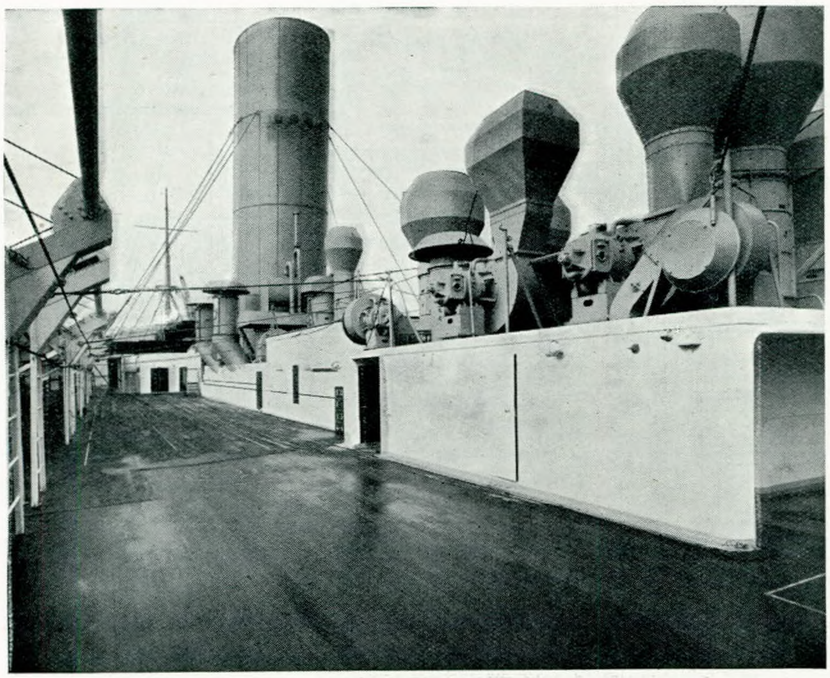
The high-pressure turbine is of the impulse-reaction type, the first stage consisting of an impulse wheel with two rows of blades, and the remainder of this turbine comprising six stages of reaction blading mounted on a solid drum of forged steel. The intermediate-pressure turbine is of the reaction type, having seven stages of blades mounted on a hollow-forged steel drum. The low-pressure turbine is of the single-flow type, having 16 rows of reaction blading mounted on forged steel disc wheels.

The astern turbines for each set comprise one high-pressure and one low-pressure, working in series.

The rotor shafts of all the turbines are packed with both labyrinth and carbon packing. Michell type of pivoted adjusting blocks are fitted to the turbines.

All the turbines are designed to run at 1,715 r.p.m., while the gear ratio is such that with this turbine speed, the propellers run at 112 revolutions, the total shaft horse-power developed on trial by the two sets of turbines at these revolutions being 24,000. The power developed astern is approximately 70 per cent. of the ahead power.

The nozzle vanes and blades forming part of the impulse section of the turbines are of special stainless steel supplied by the English Steel Corporation, Sheffield, which firm also manufactured the steel forgings for the main gearing, turbine rotors and propeller shafting.



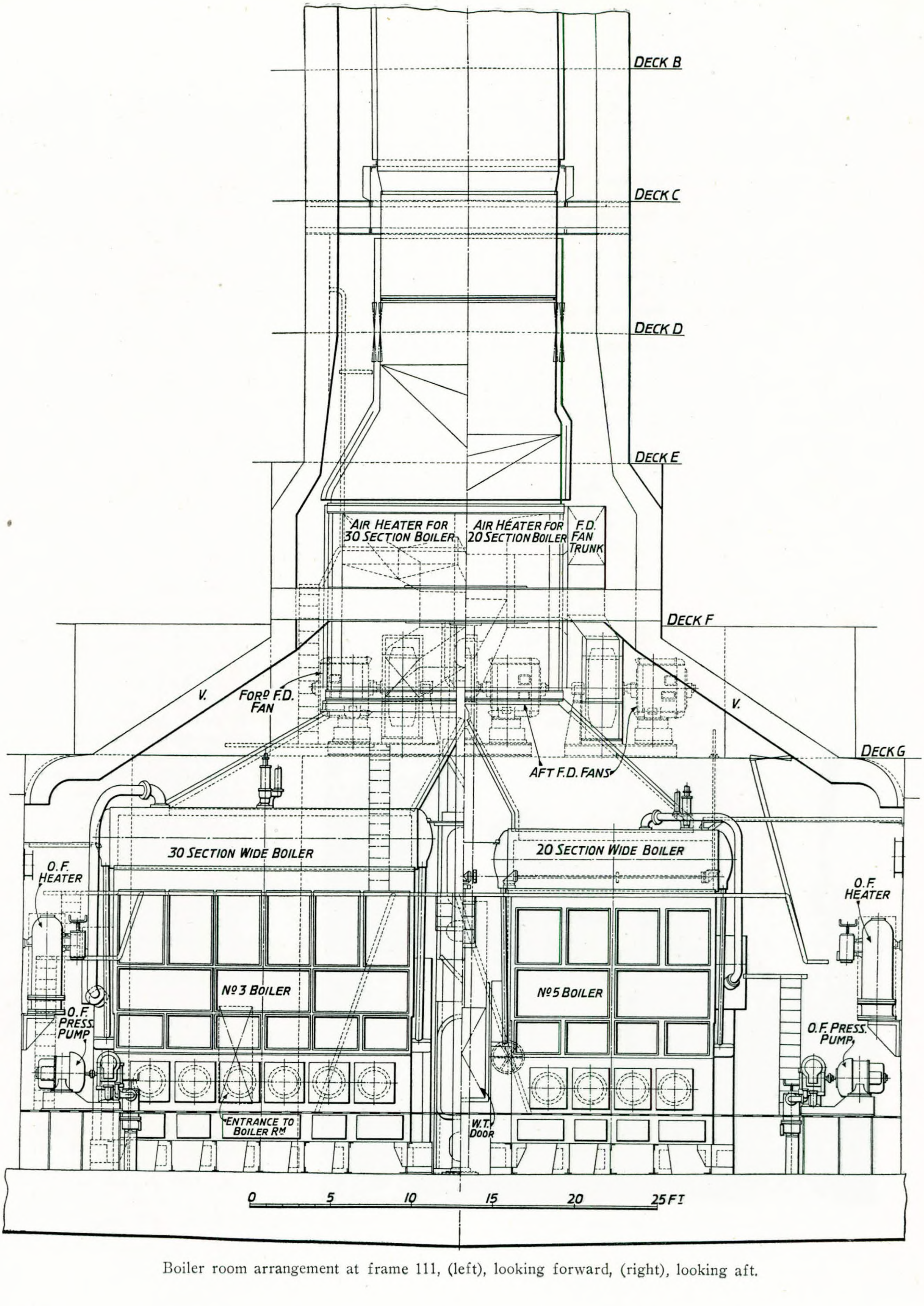
The boat deck, port side.

The turbines are connected by flexible couplings to nickel steel pinions, which engage with the main wheels on the propeller shafts. The gearing is of the double helical single-reduction type having gear tooth form of the all-addendum type. The gear wheels consist of cast-iron centres with forged-steel rims shrunk on, all securely fastened to the gear-wheel shaft. Central bearings are fitted to the pinion shafts.

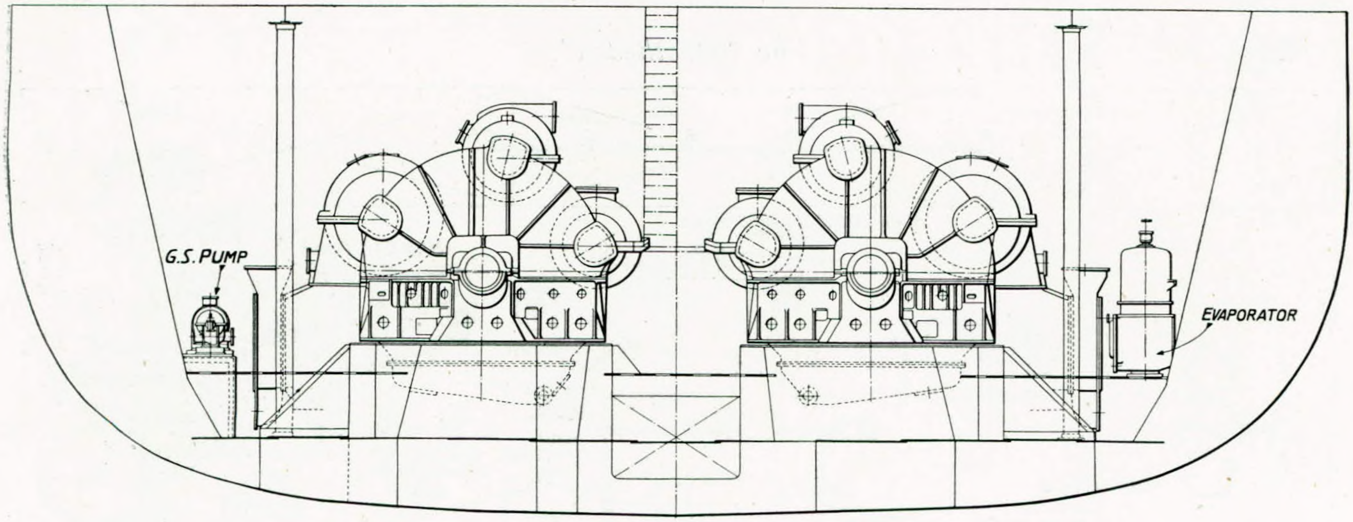
Lubrication.

The shaft bearings for both turbines and gearing are supplied with forced lubrication, and the thrust blocks, which are of Michell type, are placed on the shafts close up to the gearing.

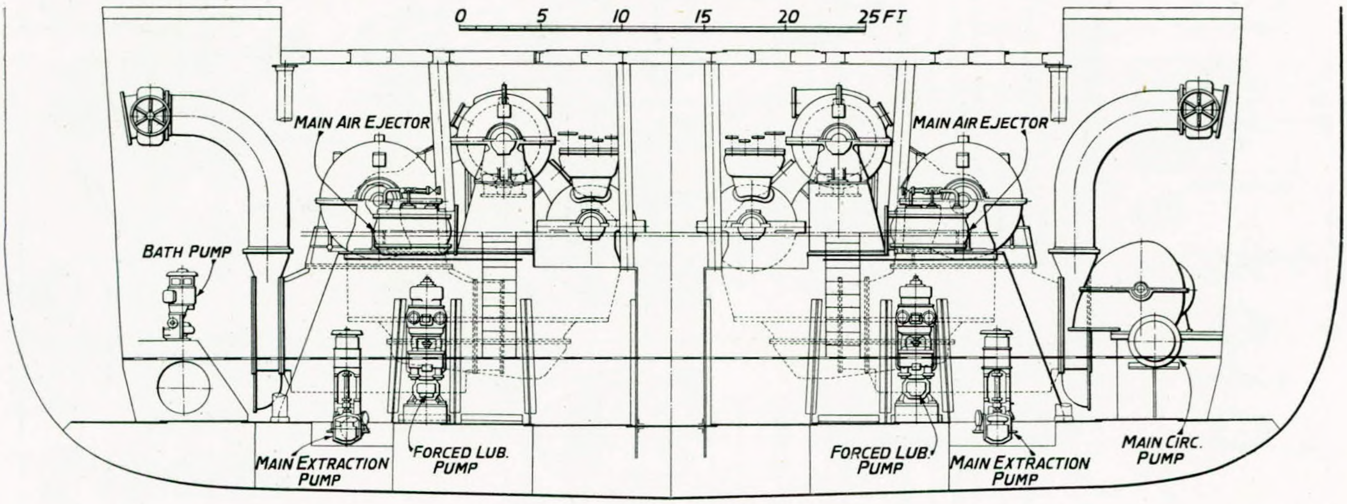
Two 24,000 gallons per hour Auto-Klean lubricating oil strainers are installed on the discharge from forced lubrication oil pumps. Each strainer has 250 square inches filtering area,



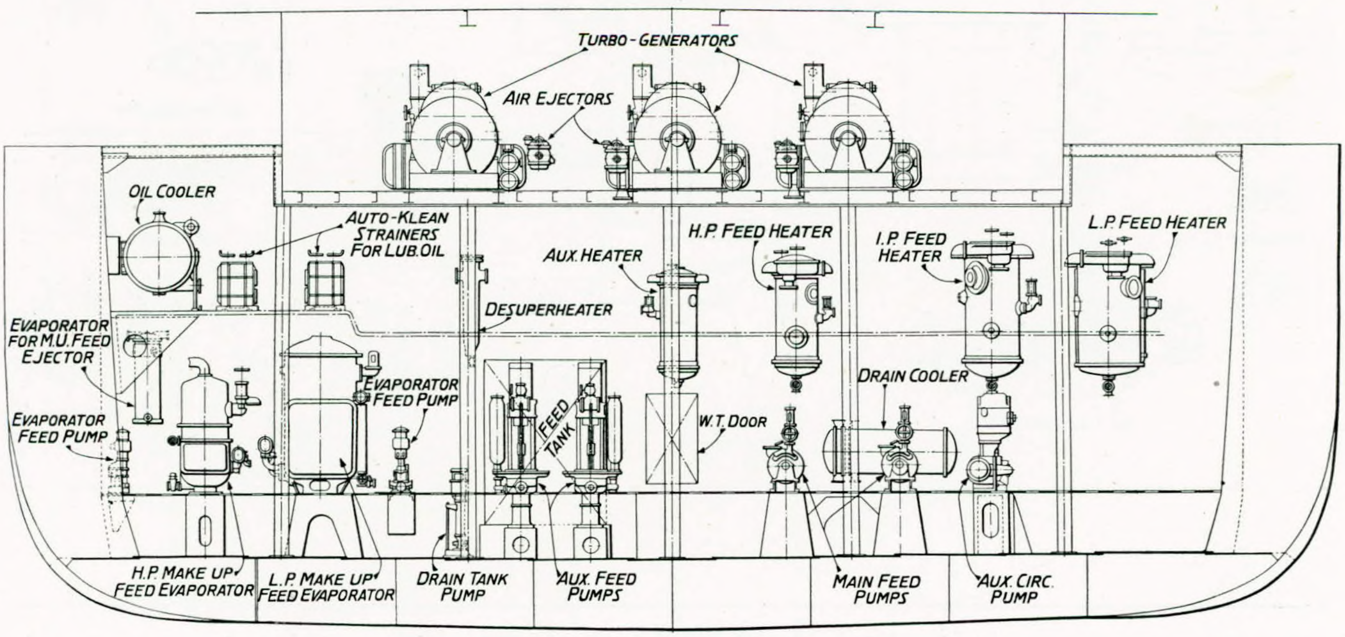
Boiler room arrangement at frame 111, (left), looking forward, (right), looking aft.



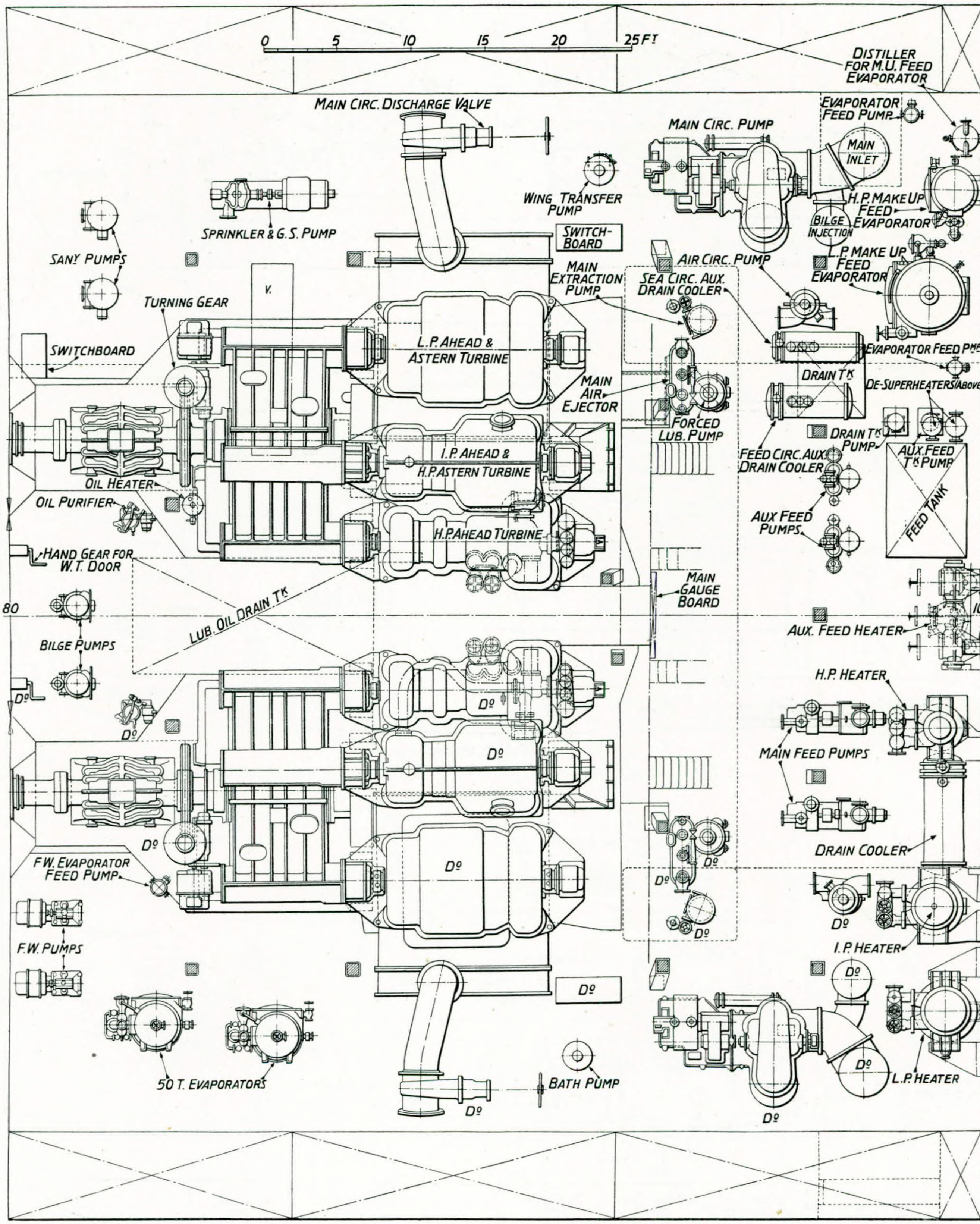
Section at frame 85 looking forward.



Section about frame 99 looking aft.



Section about frame 99 looking forward.



Plan of main engine room of the "Stratheden", showing the two sets of turbines, each comprising an h.p., i.p., and l.p. turbine, working in series.

equivalent to 80 × 80 gauze mesh. They are designed to deal with the full flow of oil to turbine bearings and gearing with a loss of pressure not more than 3½lb. per square inch and the only attention they will require at sea is that the cleaning handle shall be given a turn at the relief of each watch. Auto-Klean strainers are also fitted on the oil fuel system.

The propellers, about 19ft. in diameter, are of the built-up type, each having four blades of manganese bronze, secured to cast-steel bosses by mild-steel studs and gun-metal cap nuts. Ten blades were supplied by J. Stone & Co., Ltd., and made in Stone's bronze. Eight of these form the two working propellers, while two blades are carried as spares; each blade weighs over 3½ tons.

The main condensers are suspended from the low-pressure turbine casings, spring supports being fitted to relieve the load on the turbines.

The main feed water circuits are arranged on the Weir closed-feed system. This arrangement has been adopted on all the recent P. & O. ships, including the "Strathmore". "Strathnaver", "Strathaird", "Carthage", "Corfu", and "Viceroy of India", and will also be embodied in the "Strathallan".

The functioning of the system has been explained in detail in connection with the descriptions of previous vessels, but may be summarised thus: (1) Due to the efficient de-aerating of the feed by the regenerative condenser and the maintenance of the feed in closed circuit without contact with the atmosphere, corrosion in boilers and feed system, due to oxygen in solution, is eliminated. (2) The system is automatic at all powers and responds to changes without attention and without appreciable time lag. (3) The amount of space occupied by auxiliaries and their total weight are both minimised; the fact that rotary pumps may be used throughout, and that steam jet air ejectors maintain the condenser vacuum is of great importance in this connection. (4) A minimum pressure of, say, 10 to 15lb. per sq. in. at the suction of all feed pumps is assured. This ensures their satisfactory operation and prevents the entry of air through the pump glands.

Condensers.

In the "Strathallan" and "Stratheden", the main regenerative condensers have a surface of 12,500 sq. ft., and are capable of maintaining a vacuum of 28in. Hg. The base of each condenser is designed to form a well or reservoir for condensate, which is sufficient to provide the required elasticity in the circuit.

Attached to each condenser well is a Weir closed-feed controller, which incorporates overflow and supplementary feed valves, which are both operated by a single float.

The extraction pumps are of the Lo-hed vertical spindle motor-driven type, each capable of delivering 99,500lb. of condensate per hour (150,000lb. per hour in emergency). Variable-speed type motors are fitted.

The condensers are evacuated by sets of Weir steam jet air ejectors, each of which is circulated by the condensate discharged from one extraction pump. The ejectors are of the three-stage type with vertical inter-condensers.

On leaving the ejector condensers, the condensate passes through a drain cooler of 400 sq. ft. surface.

Two Weir turbo-feed pumps of the two-stage type are installed; each has a capacity of 240,000lb. feed water per hour, against a discharge pressure of 550lb. per sq. in. when supplied with steam at 450lb. per sq. in. at 725° F.

Feed Heaters.

The main feed pumps discharge through either two or three Weir Multiflow-type feed heaters, according to the load. The low-pressure heater has an area of 650 sq. ft., and is capable of raising 226,000lb. of feed water per hour from 120° to 215° F.; it is supplied with exhaust steam, in addition to the drains from the intermediate-pressure heater and evaporator.

This intermediate-pressure feed heater has 450 sq. ft. surface, and is designed to raise the temperature of the feed from 215° to 336° F., when supplied with steam bled at 160lb. per sq. in. abs., superheated 124° F.

The high-pressure heater has a surface of 200sq. ft., and is capable of raising the temperature of 199,000lb. of water per hour from 296° to 321° F., when supplied with bled steam at 140lb. per sq. in. abs., superheated 105° F.

The turbo-generator sets operate on the closed-feed system and Weir closed-feed control valves, extraction pumps, air ejectors and feed pumps are supplied.

Three motor-driven water-extraction pumps of the Pervac type are installed in each ship.

Vacuum is maintained in the auxiliary condensers by means of three Weir steam jet air ejectors, sea-water circulated.

The harbour system is provided with a drain cooler of 140 sq. ft., capable of dealing with 15,000lb. drains per hour.

The evaporating and distilling plant includes the following: One Weir low-pressure vertical evaporator for feed make-up, capacity 6,750lb. of vapour per hour; one Weir high-pressure vertical evaporator for feed make-up, capacity 40 tons per 24 hours; two Weir 50-ton vertical high-pressure evaporators for ship's use; Weir distilling condenser, capacity 40 tons of fresh water per 24 hours; for ship's use, two distilling condensers capable of distilling 50 tons of fresh water per day are installed. The low- and high-pressure make-up evaporators are both fed by an electrically-driven two-throw pump 2¼in. diameter by 2½in. stroke, fitted with variable-speed motor. The 50-ton ship's service evaporators are fed by similar two-throw pumps, 2¼in. diameter by 2½in. stroke.

The water-tube boilers are fitted with six sets of Mumford type low-level alarm gear, supplied by Weir's. These alarms are float-operated, and should the water level in the boilers fall to danger level, the float cuts off the supply of fuel to the burners and also sounds an alarm.

Two Weir electrically-driven two-throw pumps, 7in. diameter by 7½in. stroke, are installed for oil-fuel transfer duty; capacity, 60 tons per hour each. A two-throw water service pump, 2¼in. diameter by 2½in. stroke, capacity 2·2 tons per hour, is installed in the refrigerating machinery compartment.

Boilers.

The steam-generating installation consists of six Babcock & Wilcox high-pressure marine-type boilers. There are four large boilers and two small boilers, and all are fitted with superheaters and tubular air heaters. The blow-off pressure of the boilers is 450lb. per sq. in., and steam temperature 725° F. The steam drums of the boilers are of seamless steel, and were manufactured by the English Steel Corporation, Sheffield.

The total generating surface of the four large boilers is 29,860 sq. ft., with a total superheating surface of 4,600 sq. ft., the total generating surface of the two small boilers being 7,170 sq. ft., with a total superheater surface of 1,196 sq. ft. The air-heating surfaces for the large and small boilers are 32,000 sq. ft. and 8,000 sq. ft., respectively.

The boilers are arranged to burn oil only under the forced-draught closed-air duct system with open stokeholds. Air is supplied to the boilers by five double-inlet electrically-driven fans of Howden's make.

The oil-fuel installation consists of four units, each comprising one electrically-driven pump and one heater; one pair working and one pair standby.

Two oil-fuel transfer pumps of the electrically-driven two-throw type are provided, each having a capacity of 60 tons per hour, for transferring oil to the settling tanks. The tube-cleaning equipment for the boilers and air heaters includes Diamond-type soot blowers supplied by Babcock & Wilcox; also a small electrically-driven air compressor of 50 cu. ft. capacity against 60lb. per sq. in. is supplied.

Malone CO_2 recorders are fitted for the boiler plant, and Negretti & Zambra's temperature indicators of the thermocouple type are used for the funnel gases.

Two de-superheaters of Babcock & Wilcox's make are fitted, one of 30,000lb. and one of 15,000lb. per hour.

There are two Allen main circulating pumps of the turbine-driven centrifugal type, each capable of delivering 16,000 gallons per minute against 21ft. head.

The steam supply to the turbines passes through emergency valves fitted at the engine-room bulkhead. These valves can, in case of emergency, be closed instantly by hand and operate automatically in the event of either a failure in the supply of lubricating oil to the machinery or if the turbine speed rises above the specified figure. The turbines are also automatically stopped in the event of pressure accumulating in the main condensers.

The expansion of the steam mains in the boiler and engine rooms is accommodated by the introduction of corrugated steel pipes. The pipes range from 4½in. to 8½in. bore, and are manufactured by the Aiton patent corrugating process, being afterwards bent to the desired shape, the amount of corrugating necessary having been fixed to suit the working conditions of 450lb. per sq. in., 725° F. temperature.

By the use of corrugated bends and corrugated tangents, considerable saving in space is effected, and at the same time the thrusts on the fixed connections, such as bulkheads, manœuvring valves, etc., are kept to a minimum.

The electric generating machinery consists of three steam turbo-driven dynamos, each capable of producing 500/550kW. at 220 volts.

In the machinery spaces, Newtempheit and magnesia specialities in slab, sectional and plastic form have been used for the insulation of engine and boiler-room piping, boiler casings, hot-air ducts and uptakes, boiler drums, turbo-generators, and so on.

The trials were run under exceptionally severe weather conditions off the Isle of Arran in a blizzard, with a wind force varying between 6 and 8. Visibility at times was practically nil, but on sights of three runs, when it was possible to see the mile posts, a mean speed of 21·8 knots was recorded. On the way round to Tilbury salt was detected and a halt was made in Belfast Lough until the source, believed to be leakage in one of the condensers of the auxiliary generators, was detected and the trouble rectified. After that the "Stratheden" proceeded without incident to Tilbury except for some hours' delay in the Thames Estuary due to fog.

Economisers for Motorships.

"The Shipping World", 28th February, 1938.

The use of economisers ashore is a practice which has been followed for many years with great success. It is only recently, however, that the benefits which the economiser can confer have been fully appreciated by marine engineers and shipowners, though for some reason little headway has been made with the marine economiser in this country. British designers have, however, recognised its possibilities in connection with motorships employing waste-heat boilers. The economiser in this case is similar to a waste heat boiler in general construction, being a pressure vessel through which the feed water to the main waste-heat boiler or boilers may be passed on its way thereto. The economiser is heated by means of the exhaust gases from the auxiliary Diesel engines, the exhausts from the main machinery being confined to the waste-heat boilers proper. By employing an economiser of this type a considerable economy can be effected and the conditions of operation are improved for the main boilers. The plan seems particularly good for a tanker, where large quantities of steam are required both at sea and in port. With Diesel tankers, the boilers are usually large Scotch-type, which may be used either as composite or alternate-fired boilers. This latest method of extending the sphere of waste-heat recovery is likely to become extensively adopted and it is interesting to know that several large motor tankers now building in Italy for the Standard Oil interests are to have Clarkson economisers in conjunction with Scotch-type waste-heat and oil-fired boilers. These economisers are like the well-tried Clarkson waste-heat boiler in having thimble tubes. The economiser is a vertical unit with concentric twin shells, the space between the shells is provided with thimble tubes and the exhaust gases pass from the top to the bottom of the casing tangentially in three passes. The centre vessel and thimbles are entirely water-flooded. The brisk gyratory motion of the gases tends to throw any sparks and dust to the periphery of the shell and these fall to the bottom and are collected as necessary. Simplicity and, clearly, effectiveness are virtues of this interesting development of the economiser and it may be mentioned that accessibility has not been overlooked.

Noise and Vibration on Cross-Channel Ships.

"The Shipping World", 2nd February, 1938.

Attention was directed in these columns last week to the question of Diesel powering of cross-Channel ships. There are many problems associated with the application of the internal combustion engine to this type of vessel, and not the least among them is the question of noise from fast running machinery. On the two new ships built for the Irish Sea service, the "Leinster" and the "Munster", insulation has been fixed around the engine space, this being of special insulated blocks manufactured by Messrs. Newall, and fixed to the main and auxiliary engine casing. The blocks themselves are drilled partly through and it is considered that the holes are responsible to no little extent for absorbing the noise. Furthermore, in these vessels, for the first time in cross-Channel ship powering, special attention has been given to the mountings of the main engines themselves, the main engine bed plates being mounted on rubber tiled chocks, whereas the auxiliary Diesels are spring mounted and the pipes for every service in connection with these engines are flexible, being either of rubber or metallic tubing. Thus, as far as possible, it has been arranged that the reciprocating prime movers in the ship should have no rigid mechanical connection with the vessel. It will be seen that a good deal has been learned in the last few years in the Diesel powering of cross-Channel vessels and that Messrs. Harland & Wolff have been able to build up a valuable technique in this connection. The unique experience which Belfast has had in the building and powering of cross-Channel motor vessels may be said to have resulted in the production of a series of very successful ships, particularly as regards economical running and a complete absence of vibration and noise. The work done in these ships will be of considerable value for anything that is planned in the future.

Cold for Shrinking Steel.

"Ice and Cold Storage", November, 1937.

An interesting use of liquid oxygen is to be seen at the Ford Company's works at Dagenham, where it is employed for shrinking valve seats for insertion in the exhaust ports of the cylinder blocks, states "The Times" Trade and Engineering Supplement. For this purpose it is kept in liquid form in vacuum-jacketed containers which have a very small outlet at the top in order to prevent evaporation. The rings are submerged for a short time in the liquid oxygen which has the low temperature of 140° below zero C. (−220° F.). The rings contract sufficiently to enable them to be pressed into the recesses prepared for them in the cylinder blocks. As they return to a normal temperature they expand and become so tightly fitted that there is no danger of their ever working loose. Another shrinking process is used to install cylinder liners in engines returned under the reconditioned engine scheme.

British Coal Production.

"The Engineer", 18th February, 1938.

According to estimates, 241,183,000 tons of saleable coal were produced in Great Britain in 1937, of which 224,400,000 tons were disposable commercially and 40,352,000 tons exported as cargo. It is also estimated that during the year proceeds amounted to 15s. 10d. per ton disposable commercially.

Oil in Great Britain.

"The Engineer", 18th February, 1938.

At a meeting of the Royal Society of Arts, Mr. John Roberts said that there was little hope of oil being found in appreciable quantities in the east and north-east of England, where drilling is now in progress. He suggested that oil may be found along the "Backbone of Wales" and in the border counties west of the Pennines.

Noise Transmitted by Water Pipes.

"The Engineer", 4th February, 1938.

As a result of experiments carried out at the National Physical Laboratory it has been found that the noise transmitted by water pipes can be considerably reduced by the insertion of a length of rubber hose in the piping system. Tests showed that the high-pitched hiss of a tap can be cut out by a few inches of hose and the hum of a circulating pump by about a yard of hose.

Petrol from Coal in South Africa.

"The Engineer", 4th February, 1938.

On his recent return from Europe, Dr. Van der Bijl said that following his investigations in Germany, the South African Government is to adopt the Fischer-Tropsch process of producing petrol from coal. Transvaal coal is particularly suitable, and according to Dr. F. Fischer, South Africa can produce its own petrol and fuel requirements from local coal at prices equal to those ruling for imports.

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 27th January, 1938:—

Name.	Grade.	Port of Examination.
Reid, Robert	2.C.M.	Glasgow
Ferguson, Thomas	2.C.	Leith
Coupe, Douglas	2.C.	Liverpool
Gibbs, Sidney P.	2.C.	"
King, Lancelot S.	2.C.	"
Taggart, William R. ...	2.C.	"
Pettit, Norman T.	2.C.	London
Thompson, Douglas B. ...	2.C.M.	"
Fortune, Christopher H. ...	2.C.	Newcastle
Nicholson, John M.	2.C.M.	"
Sellers, John	2.C.M.E.	London

For week ended 3rd February, 1938:—

Name.	Grade.	Port of Examination.
Bevan, George G.	1.C.	London
Griffith, John E.	1.C.	"
Mason, Lawrence	1.C.	"
Verhoeven, William J. ...	1.C.	"
Cameron, Ian	1.C.	Newcastle
Grey, William	1.C.	"
Hall, William J.	1.C.	"
Heimbs, William A. ...	1.C.	"
Henderson, Ronald B. ...	1.C.	"
Sanderson, George	1.C.	"
Charlton, George D. ...	1.C.M.	"
Hunter, John J.	1.C.M.	"
Smith, John	1.C.M.E.	Glasgow
Grieve, George	1.C.M.E.	"
Chantler, Cyril R.	1.C.	Belfast
Stirling, Henry	1.C.M.	"
Jones, Hugh	1.C.	Dublin
Healy, Nicholas J.	1.C.M.	"
Muir, Frederick R.	1.C.	Leith
Bell, Thomas	1.C.	Liverpool
Whyte, Patrick F.	1.C.	"
Abbott, Benjamin W. ...	1.C.M.	"
Cameron, Donald	1.C.	Glasgow
Carrick, Peter	1.C.	"
McArthur, Donald	1.C.	"
McFarlane, William ...	1.C.	"
McGonigle, John J.	1.C.	"
Millar, James	1.C.	"
McKnight, John R.	1.C.M.	"
Shand, George H.	1.C.S.E.	Leith
Roberts, Owen D. M. ...	1.C.S.E.	Liverpool
Ainslie, Edward	1.C.M.E.	"
Bishop, Albert C.	1.C.S.E.	London
Wardropper, Magnus ...	1.C.M.E.	"
Warren, William W. ...	1.C.M.E.	London
Miller, John A. C.... ...	1.C.M.E.	"
Evans, William W.... ...	1.C.M.E.	"
Boddy, John F.	1.C.M.E.	"
Peck, Francis H.	1.C.S.E.	Newcastle

For week ended 17th February, 1938:—

Name.	Grade.	Port of Examination.
Reeve, Thomas N.	2.C.	London
Smith, Joseph P.	2.C.	"
Bullen, Thomas G.	2.C.	Cardiff
Alcorn, Robert	2.C.	Glasgow
Campbell, James N.	2.C.	"
Frame, John	2.C.	"
Shaw, John	2.C.	"
Urquhart, James McL. ...	2.C.	"
Bodle, Samuel	2.C.M.	"
Campbell, Hugh	2.C.M.	"
Curtin, Ronald N.	2.C.	Hull
Duke, George A.	2.C.	"
Hastie, Donald P.	2.C.	"
Rimmer, Edwin	2.C.	"
Soulsby, Henry G.	2.C.	"
Waite, Harry	2.C.	"
Blowers, William	2.C.M.	"
Carpenter, Frederick ...	2.C.	Liverpool
Jackman, William	2.C.	"
Peters, Wilfred E. H. ...	2.C.	"
Dawson, John H.	2.C.	Newcastle
Tennet, Robert	2.C.	"
Thompson, Norman ...	2.C.	"
Tynan, Joseph A.	2.C.M.	"
Dobell, Arthur R. W. W. ...	2.C.	London
Logan, Charles A.	2.C.	"

For week ended 24th February, 1938:—

Name.	Grade.	Port of Examination.
Young, Peter L.	1.C.M.E.	Glasgow
Lea, George	1.C.S.E.	Hull
Evans, William H.	1.C.M.E.	Liverpool
Joynson, William J. ...	1.C.M.E.	"
Rea, James H.	1.C.M.E.	"
Colquhoun, George	1.C.M.E.	London
Pacey, Oswald G. S. ...	1.C.M.E.	"
Pickering, Ernest	1.C.M.E.	"
Smith, Harold V.	1.C.S.E.	"
Winhall, Edwin K.	1.C.S.E.	"
Chambers, Norman	1.C.S.E.	Newcastle
Taylor, Robert F.	1.C.M.E.	"
Weightman, William E. ...	1.C.M.E.	"
Kneath, John R. L.	1.C.	Cardiff
Thomas, Glynn	1.C.	"
Armstrong, William ...	1.C.	Glasgow
Dick, James	1.C.	"
Smail, John	1.C.	"
Haley, Norman H.	1.C.	Hull
Corlett, William R.	1.C.	Liverpool
Filshie, James F.	1.C.	London
Seager, Noel L.	1.C.	"
Tibbles, Robert H.	1.C.	"
Forbes, John	1.C.M.	"
Squire, Alfred D.	1.C.	Newcastle
Seales, Gordon	1.C.M.	"
Langlands, Thomas B. ...	1.C.M.E.	Cardiff
Fraser, Charles F.	1.C.M.E.	Glasgow
McArthur, William	1.C.M.E.	"
McDougall, Donald G. ...	1.C.M.E.	"
MacDougall, Duncan ...	1.C.M.E.	"

For week ended 3rd March, 1938:—

Name.	Grade.	Port of Examination.
Wignall, Daniel McN. ...	2.C.	Glasgow
Campbell, Duncan	2.C.	Leith
Hayes, Eric C.	2.C.M.	Liverpool
Lewis, Frank N.	2.C.M.	"
Critchfield, Charles E. M....	2.C.M.	London
Todman, Charles A. ...	2.C.M.	"
Conlin, Thomas	2.C.M.	Newcastle
Johnston, John	2.C.M.	"
Perry, Cyril	2.C.M.	"
Dobell, Arthur R. W. W....	2.C.M.E.	London