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# Developments in the Machinery Installations of Lifeboats of the Royal National Lifeboat Institution.

READ

By A. C. BUTCHER (Member) at a Meeting of the Junior Section.

*On Thursday, March 19th, 1936 at 7 p.m.*

CHAIRMAN: MR. E. W. CRANSTON (Associate).

AS an introduction to this paper the Author would explain that he has endeavoured to give a general idea of the evolution and trend in development of the machinery of motor lifeboats as constructed and operated by The Royal National Lifeboat Institution. No apology is made for its descriptive nature. Fundamentals and basic technicalities are not generally entered upon, as in this respect it will be appreciated that much relative matter exists which could of itself form the subject of several specialized papers. It is hoped that the information given will suggest to those engaged in the light marine industry some points of useful application to other craft.

A petrol engine was first installed into a 38ft. × 8ft. pulling and sailing lifeboat in 1904. The machinery was experimental and of a very auxiliary nature, and dependability of service rested primarily upon sails. Valuable experience was gained in the operation of this boat and in 1909 the first boat specially designed for petrol engine propulsion was laid down. Gradual progress was made in the application of motor installations and at the commencement of the Great War 17 boats had been equipped and put into service. During the War construction was suspended, but by the end of 1920 the number of motor lifeboats in the fleet had grown to 25. Since then many of the early boats have been replaced, and others of various types have been built. The first twin-screw boat was put into service in 1923, but it was early 1935 before the first full-powered boat, entirely devoid of sailing gear, was commissioned. At the present time there are 131 motor lifeboats in service on the coast of Great Britain and Ireland and in addition three reserve boats are kept fully equipped and ready for immediate duty. There are also a further nine boats in course of construction, seven as replacements for existing stations, and two for the establishment of new stations.

The geographical location of stations and the full speed radius of action of the various boats is shown in Fig. 1.

The purpose of a lifeboat is to save life from shipwreck and, since shipwrecks usually occur in difficult positions and in the most adverse weather, it will readily be understood that the service conditions of operation of a lifeboat's machinery differ from those of the ordinary motor boat inasmuch as, generally speaking, when it


FIG. 1.—Chart of stations and radius of action.

becomes necessary for a lifeboat to go out, other craft by choice either remain in or run for sheltered anchorage. Therefore super-reliability in the machinery equipment of a lifeboat is essential and, in consequence, every detail necessitates special consideration.

It is admitted that the operating time of a lifeboat's machinery does not compare with that of commercial craft, but whereas the former usually carries out its service under the very worst possible conditions, the latter is rarely and certainly not habitually called upon to perform such strenuous duty.

The evolution of the small marine motor produced some very unsuitable designs and the earlier adaptations of car and commercial vehicle engines have now given way to engines specially designed for ordinary marine use. In early motor lifeboats, engines were installed which were admittedly conversions of vehicle engines and their operation gave much useful data for the improvements embodied in subsequent designs.

To meet the requirements of the present-day lifeboat the engines and equipment can scarcely be termed ordinary, since they have been designed and built especially to fulfil extraordinary conditions.

In all modern lifeboats it is considered essential that the machinery be capable of submersion to well above the water-logged level of the boat, without in any way affecting its functioning and general efficiency. It is unlikely that a boat would be holed in every compartment including the engine room at the same time, but even in such an extreme case the engine and all accessories must continue to function. The engine must also be capable of starting under this condition, since in the excitement of the accident causing its flooding it might inadvertently be stopped. The machinery must function under extreme conditions of motion and be so arranged as to withstand the effect of the boat receiving the most severe buffeting, not only from the sea, but in emergency from sandbanks and wreckage. It is not unknown for lifeboats to charge down the bulwarks and over the decks of wrecks.

It will be realised that in shore lifeboats, operating as they do on mud and sandbanks, and usually in shallow and very disturbed water, circulation of sea-water directly through the jackets and pipework would be conducive to failure of pumps and choking of jackets, since efficient filtration would be impracticable. To eliminate these risks, all the Institution's motor lifeboats operate on a completely closed fresh-water cooling system.

Control of machinery must be from the deck in all cases, as although reasonable room is allowed for getting round the engine for inspection and maintenance, the additional space necessary to accommodate mechanics cannot be afforded; moreover in really bad weather it would be an unfair tax on the physical endurance of anyone unfortunate enough to be shut down below.

Controls must be simple and positive, as in many cases the operator is unskilled.

Launching from and returning boats to slipways, carriages and beaches, demands special consideration of machinery equipment, whilst local conditions and the operation of similar installations at widely differing stations also affects the general compromise.

In self-righting boats, automatic means of stopping the engine, cutting off the fuel supply, closing the water, oil and exhaust circuits, must also receive attention.

Electrical apparatus and radio introduce their own special problems, which under conditions of lifeboat operation are problems of some anxiety.

Propellers rotate in tunnels primarily to give protection from wreckage; this necessitates them being kept well in from the end of the boat and allows them to remain completely immersed under extreme conditions of pitch. It does not, however, make for maximum propulsive efficiency, the slip being from 35 per cent. to 45 per cent., according to the type of boat and the power installed.

High speed is not a feature of a motor lifeboat, the relatively slow but sure progress being controlled by the form of hull, which is designed for maximum stability. Speeds vary from about 7 knots for the smallest class to about 9¾ knots for the largest class.

The types of motor lifeboats in the fleet, excluding one special purpose boat designed primarily for service to aircraft casualties, range from 32ft. to 61ft. in length, the various post-War boats being powered with five types of petrol engines and two types of Diesel engines. The petrol engines include a 12 b.h.p. flat twin, running at 2,500 r.p.m. reduced to 660 r.p.m., a 35 b.h.p. 6-cylinder, running at 3,300 r.p.m. reduced to 900 r.p.m., a 40 b.h.p. 4-cylinder, running at 1,200 r.p.m. reduced to 600 r.p.m., a 60 b.h.p. 6-cylinder, running at 1,200 r.p.m. reduced to 600 r.p.m., and an 80 b.h.p. 6-cylinder, running at 800 r.p.m. direct speed. The Diesels are a 40 b.h.p. 4-cylinder, running at 1,200 r.p.m. reduced to 600 r.p.m., and an 80 b.h.p. 6-cylinder, running at 1,600 r.p.m. reduced to 800 r.p.m. All these engines are watertight and fully submersible, the petrol engines being of the Institution's own design, and the Diesel engines designed by contractors to the Institution's specifications.

In the larger classes of boats, weight of machinery, within reasonable limits, is not important. In the smaller classes which have to be manhandled and transported, it becomes a matter of consideration. For equal powers and safety factors, twin-screw are heavier than single-screw installations, although this may be somewhat discounted by reduction in sailing gear.

Engines complete with their water-tighting arrangements and all attached accessories, vary from about 50lb. per horse power for the larger types, to about 20lb. per horse power for the smaller types.

The total weight of machinery installed ranges from 128lb. per shaft horse power for a 61-ft. boat, to 67lb. per shaft horse power for a 32-ft.

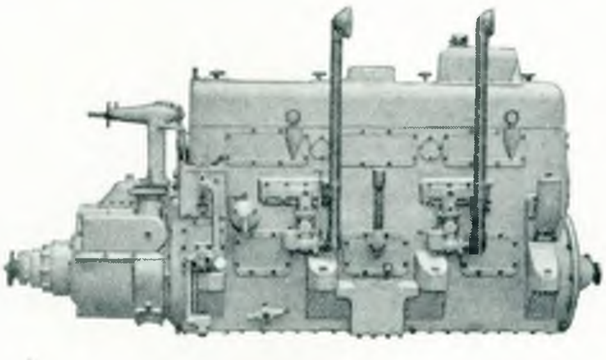

FIG 2.—80 b.h.p. petrol engine.

boat. The percentages of total displacement for the two types are respectively 20·7 and 20·6.

Until 1923 all motor lifeboats were single-screw propelled, with a full sail plan as auxiliary or supplementary equipment. The first twin-screw boat to be built was one of the largest type used in the service, being 60ft. long by 15ft. beam, with a displacement of 42¼ tons and powered with two 80 b.h.p. petrol engines. Later boats of this type have been expanded to 61ft. in length with the same beam, and the displacement increased to 44 tons.

In this type of boat both propellers rotate in the same direction, for the reason that at the time the engine with which these boats are equipped was designed it was not contemplated that twin-screw installations of this size would be required and no arrangements were made for handing the various parts necessary for a reversal of rotation. In view of the tunnel operation of the propropellers and the enormous deadwood between them, it was considered that the detrimental effect of this, if any, on the qualities of the boat would be very slight and insufficient to justify the construction of special parts, and therefore identical engines were used on both shafts. Fig. 2 is a photograph of this engine.

Actually it was found, in each of the four boats built, that the port engine was doing slightly more than its fair share of work, there being approximately 3 per cent. reduction in revolutions at full throttle due to the effect of a slight amount of helm necessary to correct a starboard turning tendency caused by the rotation of the propellers being in the same direction.

Twin-screw boats had been proposed for the smaller types long before the construction of the above boat, but considerable trepidation existed as to the effect on the safety of small boats in exposing a double tunnel to a heavy following sea, it being considered conducive to over-ending the boat.

The obvious advantages to be derived in propulsive reliability if duplicate machinery could safely be adopted and in consideration of the satisfactory performance of the big boat, the Committee of Management of the Institution decided to have constructed two experimental boats of similar dimensions, viz., 45ft. × 12ft. 6in., one to be fitted with twin 40 b.h.p. engines geared together to drive a single screw in a tunnel, the other to be fitted with twin engines each driving separate screws in separate tunnels.

The comparative trials of the two boats dispelled the doubts as to the safety of twin tunnels, and proved that for general sea-worthiness there was little or nothing to choose between the two types. The results of the trials carried out with

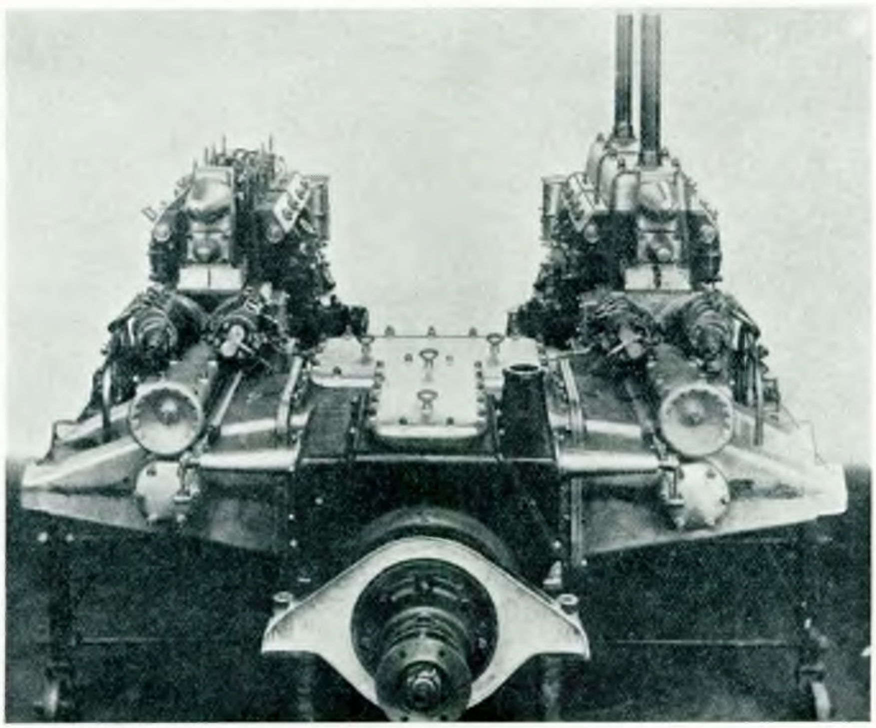

FIG. 3.—Twin-engine single-screw outfit.

these boats determined the subsequent policy of twin-screw installations wherever practicable.

The experiments with these boats were intended primarily to prove the relative qualities of the two forms of hull and only in a very secondary sense concerned the machinery equipment. They gave, however, very useful experience in the coupling together of two parallel engines on to a central shaft. Fig. 3 is a photograph of the machinery used for this purpose. The engines are connected to work together through the medium of torsional damping clutches, on to the main clutch and reverse gear unit, this latter being part of the normal equipment of a standard 80 h.p. installation. The drive from the two engines to the central shaft is through the medium of silent chains, two chains from one side driving between two from the other to reduce the bending moments on the shaft and the individual weight of single chains. The clutches are capable of disengagement by hand wheel and worm control gear to allow either engine to be independently started, adjusted etc. and to carry on propulsion if the other is damaged. The throttle gear of each engine is synchronized and automatically controlled, so that when operating as a twin outfit both engines are opened up and closed down to the same speed. No trouble of any kind has been experienced with this mechanism since it was put into service some 8½ years ago.

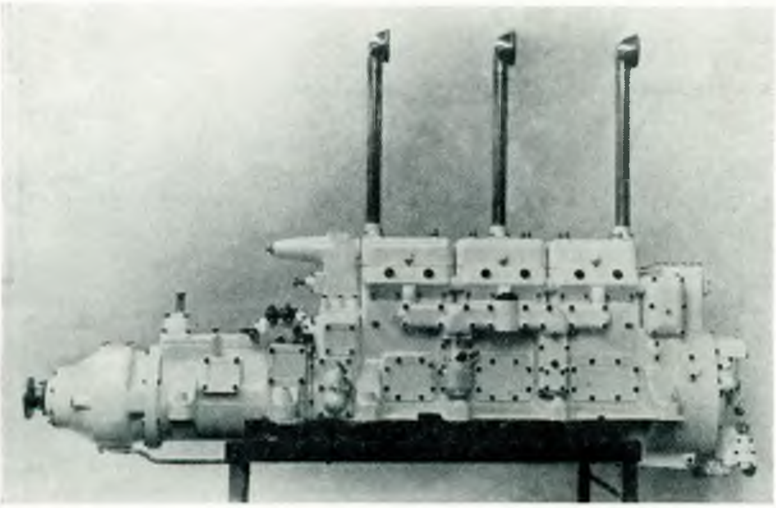

Fig. 4.—60 b.h.p. petrol engine.

The introduction of twin engines into boats previously taking a single 80 b.h.p. engine necessitated, in addition to the installation gear, the design and construction of suitable engines, and as a further type of boat was contemplated requiring twin engines of 60 b.h.p. each, it was arranged that the design should be such that a 4-cylinder and a 6-cylinder engine having the same principal dimensions and running at the same datum revolutions should satisfy both requirements.

A considerable number of engines of both types have been installed into boats, and as the designs have been described in the technical press it is not intended to give a detailed description of them in this paper. There are, however, some interesting features to which reference may advantageously be made. Fig. 4 is a photograph of the 60 b.h.p. engine.

In the first place both the 4-cylinder and 6-cylinder engines are arranged so that the same elements for either type can be assembled to construct, without any other special parts, either right-hand or left-hand engines, with the controls and auxiliaries either inboard or outboard as required. This permits of a symmetrical assembly of pairs of engines, the components of each engine being symmetrically displaced about the boat's longitudinal centre line. A special adaptation of the "Burn" reduction gear is embodied in the design, allowing the engine components to be kept small and light and a suitable ratio to be used for the propeller. To minimize the number of parts required for the two types, the reverse and reduction gear is made interchangeable and to carry safely the output of the 6-cylinder engine. Two camshafts are employed to operate the push rods and rockers of the overhead valve mechanism. The rockers are mounted on grease-packed roller bearings and no wet lubricant is carried to the head. The uni-directional rotation of the camshafts and auxiliary drives, when reversing crankshaft rotation, is obtained by transposing, in a fore and aft direction, a cage carrying a bevel crown wheel. Connected to the bevel wheel is a spur pinion for driving the camshafts, the bevel wheel being driven from either the fore or aft side of a vertical bevel pinion driven by the crankshaft. Two magnetos are provided for each engine, which are kept uni-directional by driving the bevel wheels from either above or below the magneto shaft line, the magnetos being driven from opposite sides of the bevel pinion; each rotates the same hand.

The crankshaft for the 6-cylinder engine is arranged symmetrical about its lateral centre so that it may be turned end for end and retain the same firing order and relative displacement of cranks in either direction of rotation. The cylinder heads and ports into the jacket boxes are symmetrical, allowing the heads to be reversed and the piping transposed as required. The carburettor has its jets centrally disposed to the float and maintains a constant petrol level at all angles. Air for the carburettor is drawn in through pipes attached to the cylinder head covers, and is carried over the heads and into a box section of the crankcase

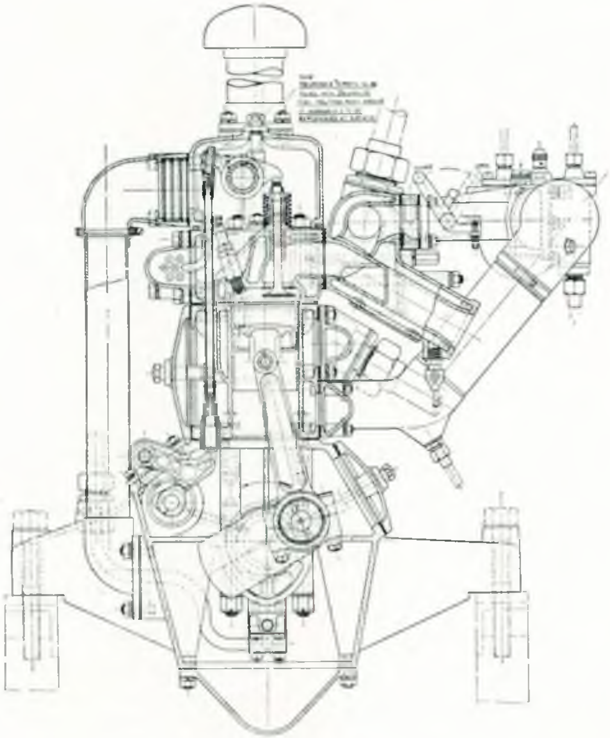

FIG. 5.—35 b.h.p. engine (cross section).

formed by the centre bearing webs. The carburettor is attached to the opening of this chamber on one side and the air pump on the other. The crankcase is vented into the cylinder head covers, with anti-flash screens interposed at the cylinder head joint.

A plate clutch is arranged at the forward end to transmit power for operating a capstan or winch. This clutch drives through an offset spur wheel and flexible coupling into a worm reduction box, the wheel shaft of which rotates the capstan head or winch pinion through a splined muff coupling.

The clutch is engaged hydraulically. The control cylinder is filled with oil from its surrounding reservoir through a snifting slot, any pressure leakage being made good by spring movement of the plunger each time the foot is removed. The power transmitted is limited by the pressure applied to the pedal, the full weight of a 12-stone man creating a pull at the capstan drum of approximately 2,300lb. at speed up to 200ft. per minute. Under similar conditions a pull of 4,000lb. and a speed of 100ft. per minute may be obtained from the winch.

Sea-water-resisting silicon-aluminium alloy is used for the main castings of the engine and for other engine room fittings. This material in itself is comparatively unaffected by sea-water, but any submerged, or even temporarily salt-wetted surface in contact with any dissimilar material, rapidly sets up electrolytic corrosion, it being no better under this condition than ordinary commercial aluminium alloys. Where this material is used in exposed positions it is desirable that all contacting fittings and fastenings be of similar material, and when this is not practicable it is essential that the surfaces be insulated from each other and wherever possible given the further protection of a coat of plastic enamel.

Where slipways or mooring for boats are completely ruled out, it becomes necessary to transport the boat over the shore and into the sea on a carriage hauled by a tractor or other means. Under such conditions it will be appreciated that there is a limit of weight that can be handled satisfactorily, and since the boat has to be motor propelled, the problem of weight is reflected in the machinery. The size and type of boat used is 35ft. 6in. × 9ft. 6in. self-righter, or a 35ft. 6in. × 10ft. 3in. non-self-righter, both of which weigh, without crew, approximately 6¼ tons, and require 35 s.h.p. to give a speed of approximately 7·4 knots. "Gill" shrouded type propellers are used as being less susceptible to damage of the blades by shingle, etc.

A comparatively high-speed high-efficiency engine, sufficiently detuned for reliable and continuous running, is used to produce, with a minimum of weight, the power required. This engine, a cross section of which is shown in Fig. 5, also has been described in the technical press and it is not intended therefore to give here more than a brief outline of its construction. It is a 6-cylinder

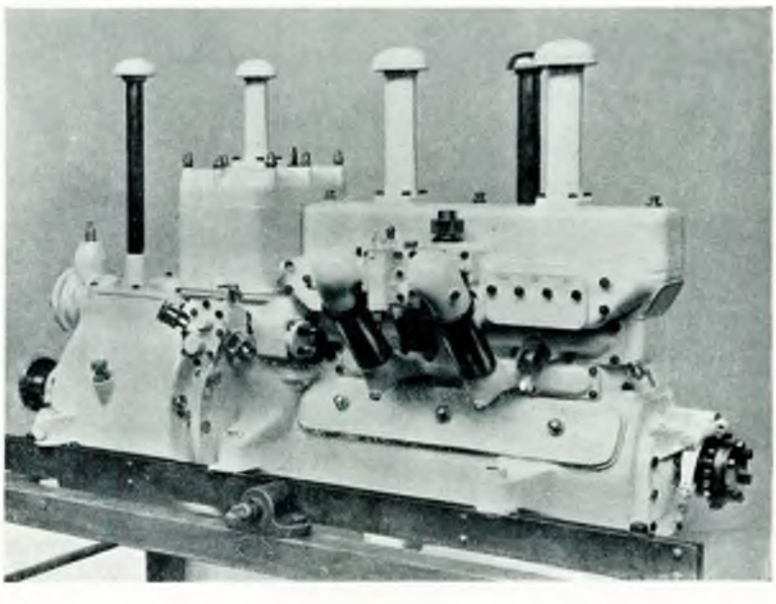

FIG. 6.—35 b.h.p. petrol engine.

mono-bloc unit with overhead valves operated from a side camshaft by push rods and rockers. The rocker mounting and lubrication are similar to that of the 40 h.p. and 60 h.p. engines, no wet lubricant being carried to the head. The six combustion chambers are contained in a detachable head with two 12 mm. sparking plugs fitted in each chamber, simultaneously igniting from two magnetos, vertically driven at the aft end of the engine. A cross shaft drives a duplex oil pump at one end and a water circulating pump at the other. It carries also an eccentric cam for operating the air pump. A further small oil pump is driven from a spiral gear to provide an independent lubricating system for the combined reverse and reduction gear, and a drive for a revolution counter is taken from a small bevel attached to the intermediate gear for the magnetos.

Air for the carburettor is supplied through pipes attached to the cylinder head cover, being drawn across the head, through the tappet chamber and cylinder block, and fed to the carburettor via tubes attached to a door casting. The crankcase is vented to the cylinder head cover, the entrance being protected by anti-flash screens. Fig. 6 is a photograph of this engine.

The combined reverse and reduction gear, Fig. 7, forms a unit with the engine and is of somewhat unconventional design. It is the "Garrard" patented friction roller type gear and was designed in conjunction with the Engineering Staff of the R.N.L.I. to reduce the engine speed from 3,300 r.p.m. to a propeller speed of 900 r.p.m., ahead or astern.

Roller surfaces replace what normally would be the teeth of pinions of an ordinary epicyclic gear. The primary sun rollers are parallel, but the planetary rollers are formed with taper surfaces enclosed by a pair of radially ground rings. Circular inclined planes are formed on the facing sides of these rings, one pair of which is provided each for the ahead and astern motions. These engage mating planes on a free centre ring and in their effort to separate against the torque re-action, when either the ahead or astern drum is arrested, automatically apply the pressure necessary to transmit the load. A series of light springs are interposed between the pairs of rings to give initial pressure to the roller surfaces, and immediately the slightest slip occurs between the held ring and the rollers the opposite ring moves forward. In so doing, it is arrested by the ramps which increase the pressure and provide adhesion necessary to transmit the engine power at the required speed reduction fixed by the diameters of the rings and rollers selected.

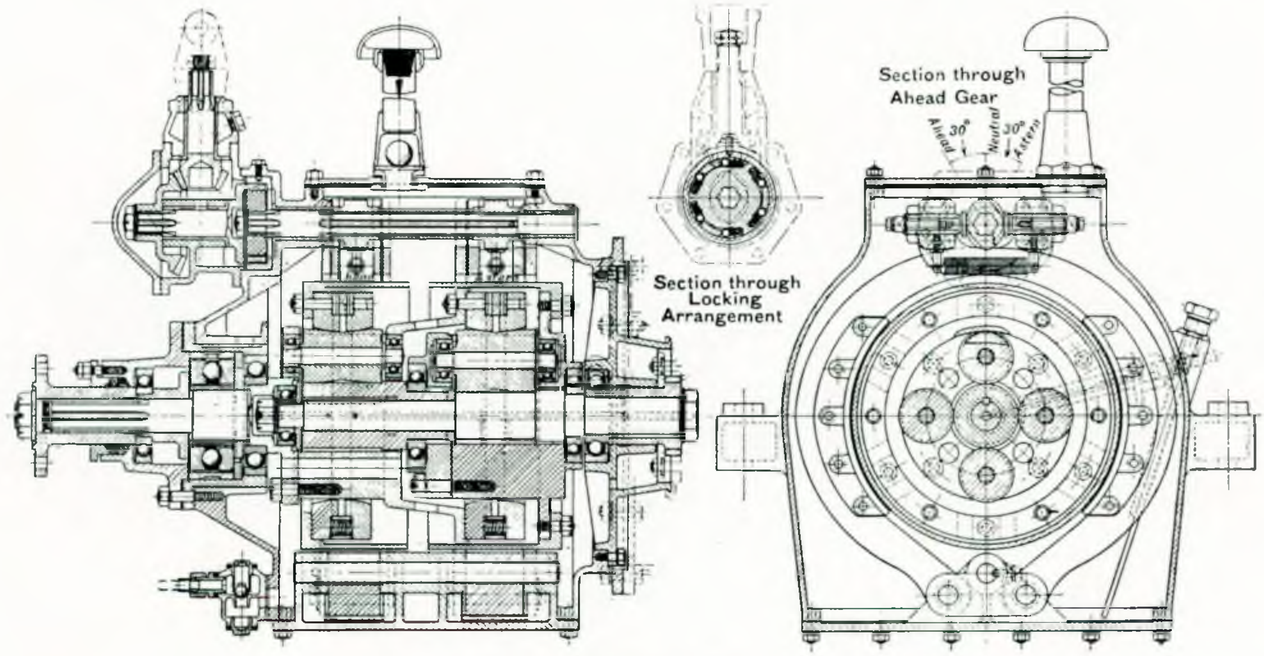


FIG. 7.—"Garrard" gear.

Balanced nut-cracker type brakes are provided for arresting the drums, relieving practically all side pressure from the carrier bearings. Duplex snail cams, splined on to a twisting shaft, apply load for closing the brakes, the cams being of reverse hand for simultaneously arresting the ahead and freeing the astern drums respectively and *vice versa*. Motion is transmitted to the control shaft through bevel wheels and a double-direction roller ratchet clutch. All the shafts are mounted on ball journal bearings and a heavy-type single-ball thrust washer is provided to take thrust in both directions.

Fig. 8 illustrates the machinery layout of a

46ft. × 12ft. 9in. Watson cabin type boat, which may be taken as a typical example of a modern motor lifeboat installation. This boat is equipped with two 40 b.h.p. engines driving twin propellers at approximately 600 r.p.m. The displacement is 20·8 tons and the speed 8·2 knots.

Both engines are in a common engine room, but the two sets of machinery are entirely separate and independent. The starboard engine drives a capstan and both engines drive permanently running bilge pumps, the suctions of which are controlled to clear either the engine room or cabin.

A service oil tank and an emergency tank, each about 4 gallons capacity, are provided for the lubricating system of each dry sump engine, reverse and reduction gear unit. The pumping arrangements on the engine provide for a gear type triple oil pump, the after one being a service pump to the bearings, the others being scavenge pumps for clearing oil from the forward end of the engine and after end of the reduction gear respectively, as, although the interior of the engine and gear casings forms a common reservoir, it is necessary, owing to the limitations of the boat not permitting of a common central suction with a 1 in 4 drain from each end, to have a fore and aft suction, to counteract the motion and trim of the boat and also to accommodate the varying conditions of slipway operation. Ball type foot valves are fitted in the scavenge pump suctions to ensure constant and automatic priming of the pumps, whilst a positive head is maintained on the service pump by the positioning of the tank. A semi-rotary hand pump is connected into the service, with non-return valves and change over cocks, allowing oil to be pumped direct to the bearings from either tank before starting up, and for filling the service tank from the emergency supply if required.

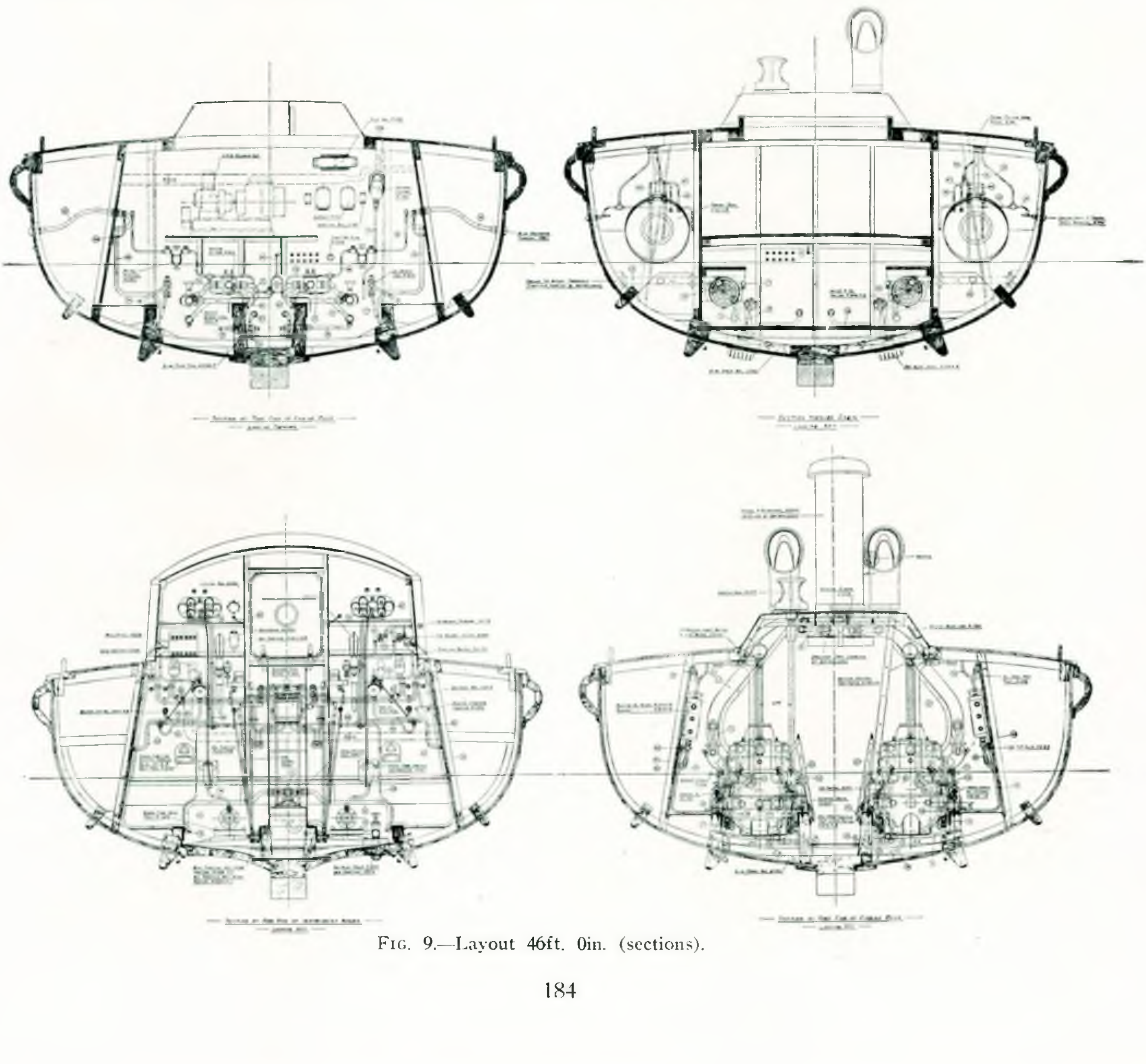

FIG. 9.—Layout 46ft. 0in. (sections).

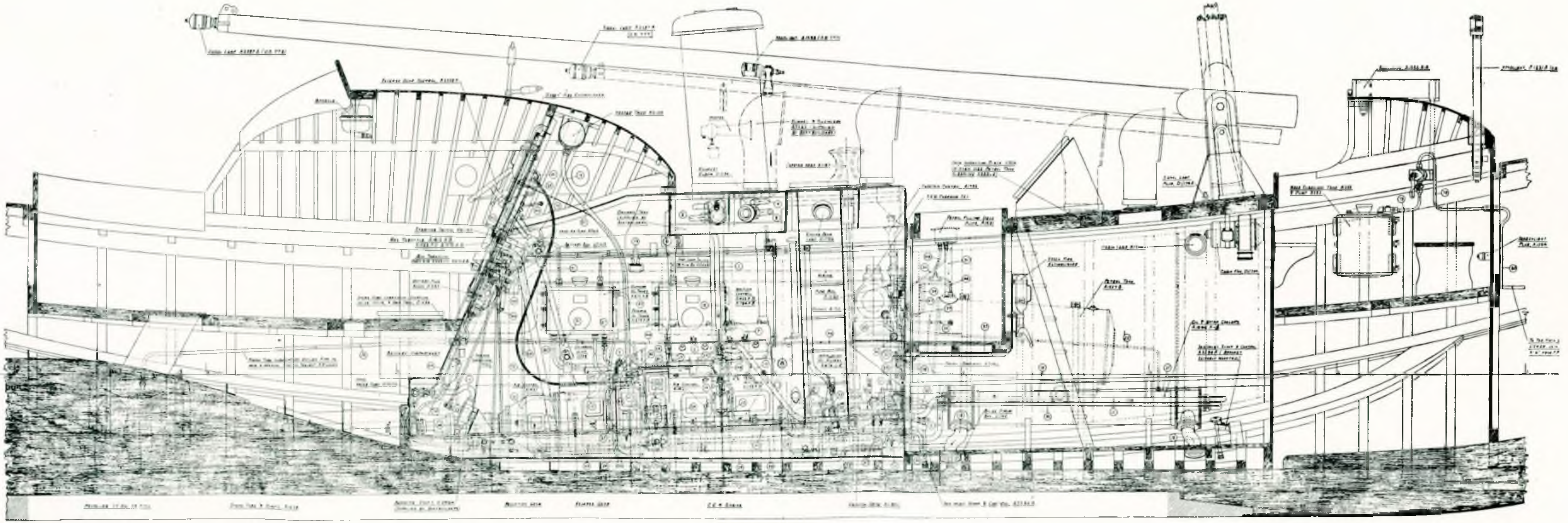

Fig. 8.—Layout 46ft. 0in. (longitudinal).

Immediately forward of the engine room is a cable well and a cabin, and forward of this is a cockpit protected by a rigid shelter. The cabin houses the water and oil coolers located under each side bench, a motor driven fan for ventilating the cabin and holds and, when carried, the radio-telephony installation.

The forward cockpit contains a 4-gallon wave

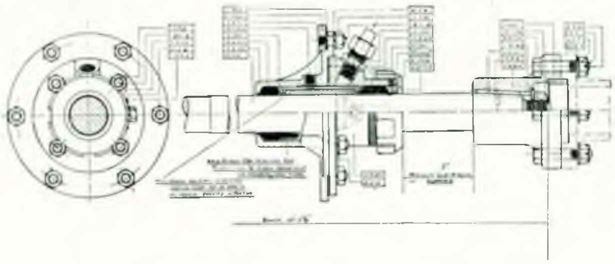

FIG. 10.—Inter bulkhead fitting.

subduing oil tank, coupled to a semi-rotary pump for discharging oil through spring loaded spraying nozzles fitted in the bows of the boat. Petrol tanks are carried in compartments abreast of the engine room. Aft of the engine room is the main cockpit which forms the control station of the boat and which is protected also by a rigid shelter.

Fig. 9 illustrates sections of the boat and athwartship positions of the machinery. There are two throttle controls for each engine, one determining the maximum speed and the other the minimum speed. The minimum control is set to an idling speed sufficient to prevent the engine stalling when picking up from neutral and never need be touched except to speed up the engine when required for operating the capstan.

Embodied in the engine is automatic mechanism consisting of a system of linkage whereby a single way movement is imparted to the throttle rod for a two-way movement of the control shaft. When the control is operated from the neutral position either to ahead or astern the throttle is automatically opened up to a predetermined maximum which may be anywhere between dead slow and full speed and upon disengagement is returned to its pre-determined minimum setting, the actual operation of control being confined simply to movement of the wheel.

An ignition control, an air strangler, and a starting switch constitute the remainder of the control mechanism, these latter being confined to the initial operation of getting the engine running. Other fittings such as auxiliary hand pumps, switch-box, gauges and indicators, are attached to the control board for convenience and centralisation.

A glazed instrument frame for each engine carries a revolution counter, pressure gauges, temperature indicators and an ammeter. A series of small cartridges containing calcium chloride are introduced from the engine room side of the frame to absorb moisture from the interior.

Illumination of the board is effected by shielded festoon lamps fitted directly over the instruments. In addition, the essential indicating points of the instruments are highly luminised.

In boats which lie afloat a small $\frac{1}{2}$-kiloWatt generating set is installed for battery charging, as although dynamos are fitted to the main engines, the running done by them is insufficient to keep the batteries in efficient condition. The dynamos on the main engine are capable of supplying the total load, and under service conditions the auxiliary

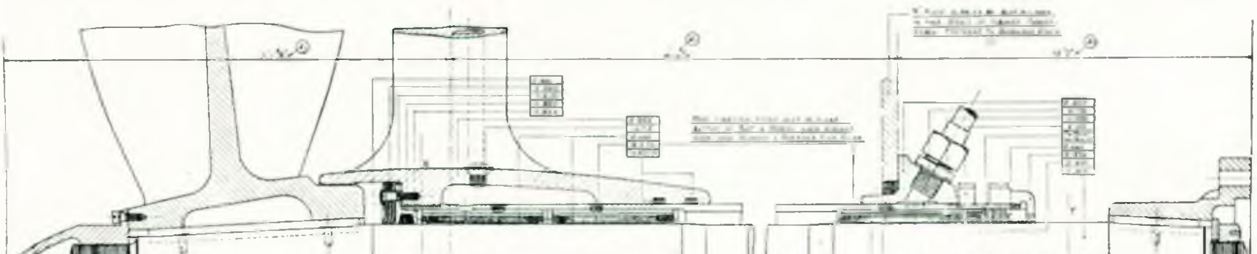

FIG. 11.—Stern tube (white metal bearings).

set is not required to be run. This set is not submersible but the main engine dynamos would maintain the electrical service if the engine room was flooded.

The batteries are located in a separate watertight compartment aft of the engine room, but in some boats of this class they are contained in lead-lined watertight boxes fitted in the cabin. The compartment and boxes are ventilated to the atmosphere to relieve hydrogen accumulation when charging. 12 volts is the pressure used in this and all other boats except the largest class. Current is taken to and from the batteries by way of a plug and distribution box. This box contains a pair of heavy double-pole conical-seated spring-loaded plugs, together with two main feed and distribution bus bars, and is arranged with glands for all cables and for the plug control rods. These plugs are used as main isolating plugs to either or both batteries, and as parallelling plugs when required. They carry a starting current up to 400 amperes. The bus bars are connected to a polarised plug attached to the side of the box for use in charging when required from an auxiliary or external supply. The various load circuits are protected by single-pole fuses and the complete circuit by double-pole main fuses, all of the glass cartridge type and contained in a submersible casing.

Fig. 10 illustrates the bulkhead bearing used when an intermediate shaft is necessary. It comprises a white-metal shell bush, with a packing gland at each end, the compression of both packings being simultaneously applied from the engine room side only. Propeller shafts and intermediate shafts are of high tensile manganese bronze.

The standard type of stern gear Fig. 11 is fitted with white-metal shell bushes, and carries a normal three-bladed open propeller. It is lubricated with a semi-grease, the tube primarily being filled and afterwards fed through the inboard end bush by an air-locked screw-down grease compressor. The tail end of the tube is piped back to a spill valve located beside the compressor. Fig. 12 shows a similar design of tube fitted with "Cutless" rubber bearings and used for some of the larger boats which lie permanently afloat. The inboard and outboard bushes are carried in the tube and the outer end of the sleeve piece or bracket is formed into a propeller guard to prevent ropes, etc. being worked up around the shaft. Despite the tunnel protection of all lifeboat propellers, ropes, etc. are picked up occasionally. Therefore, scuttles are arranged in the deck directly over each propeller, through which an obstruction may be removed while the boat is afloat.

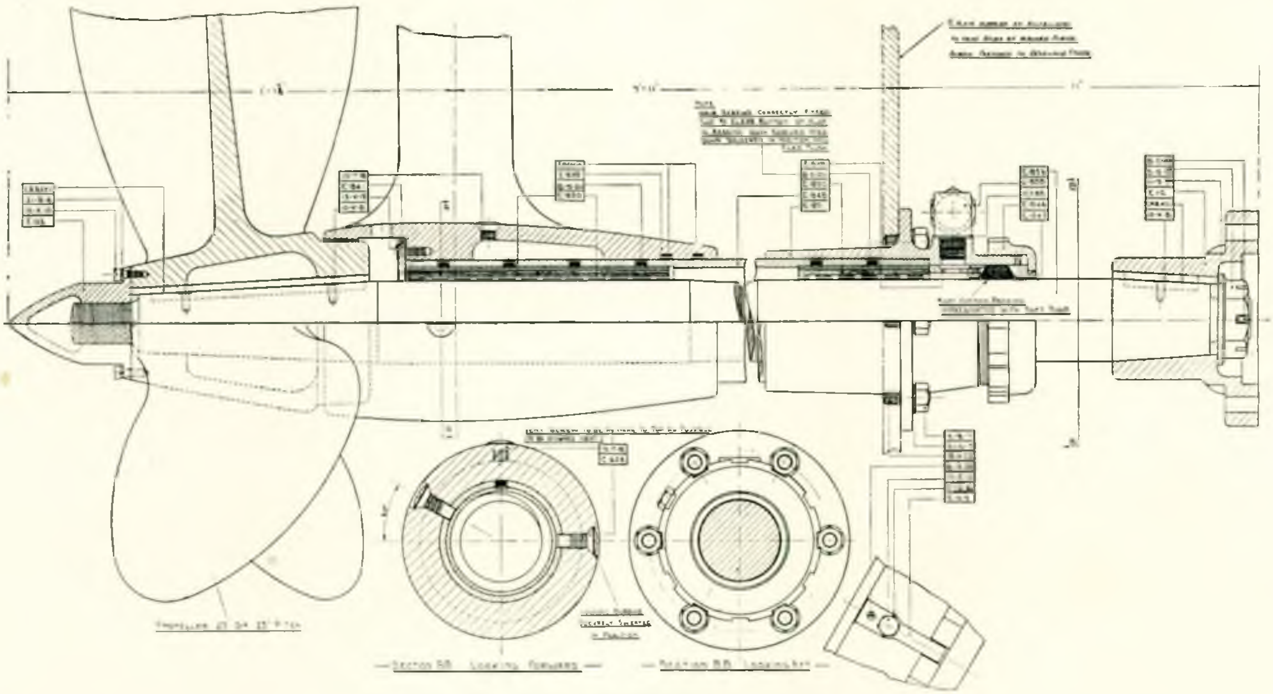

Fig. 12.—Stern tube ("Cutless" bearings).

The cooler for the enclosed fresh-water cooling system is illustrated in Fig. 13 and consists of an outer circular shell of copper tube with flanges connected to cast end boxes embodying tube-plates which are drilled and tapped to accommodate standard ⅝in. condenser tubes and ferrules. The oil cooler is combined with the water cooler and is arranged concentrically and occupies the central pack of tubes. Similar coolers extended in length are used with the 60 h.p. and 80 h.p. engines in larger boats.

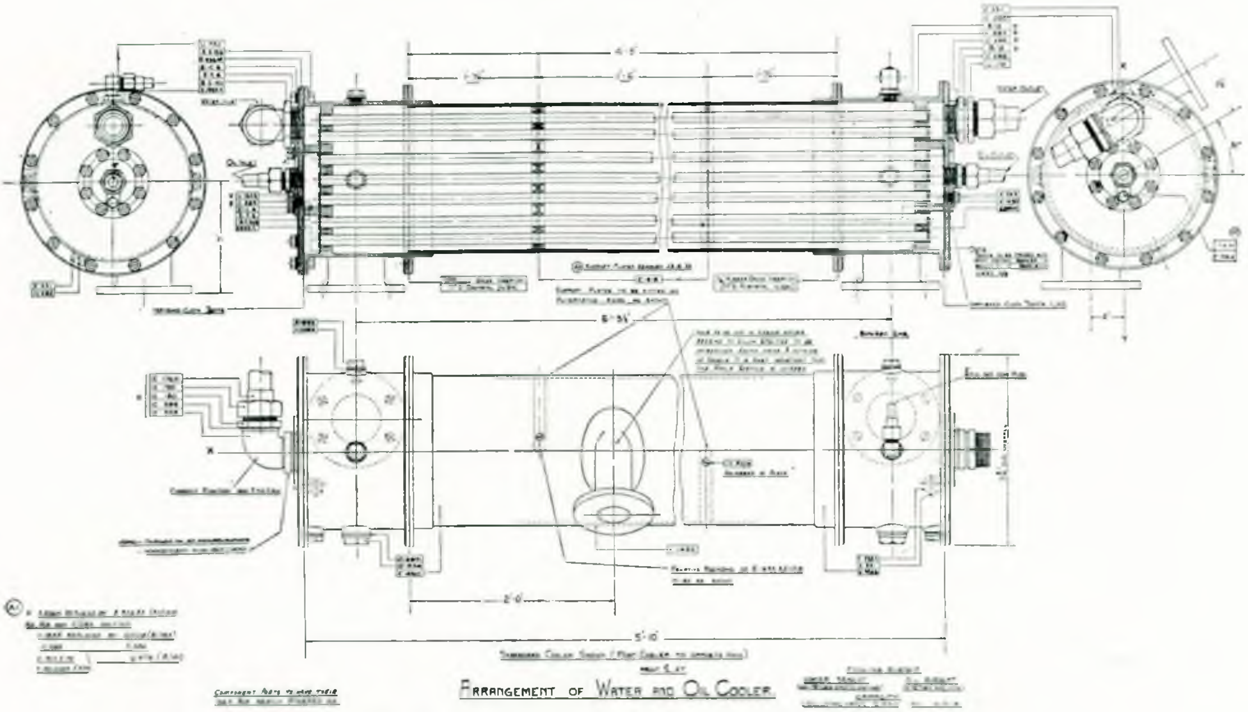


Fig. 13.—Combined water and oil cooler (C.E.4 type).

Fresh water or oil is circulated through the tubes and sea water flows around them, this being induced by large scoops in the form of renewable grids attached to the bottom of the boat. In boats which lie afloat these grids are provided with full-way valves which can be closed when at moorings to prevent accumulation of silt and deposition of animal and vegetable growth. Both the sea inlet and outlet are arranged at the bottom of the cooler in order that, when the boat is under way, any sand and mud will be washed through. An additional outlet is provided at the top, mid-way of the length of the cooler casing, to allow natural circulation of the sea water through the casing when the boat is stationary and the engine running. Each cooling system is provided with a controllable bypass allowing any desired temperature adjustment between full cooler capacity and jacket service only. The circulating water is delivered to the extreme end of the exhaust circuit, through the jacketed exhaust piping and manifold, into the cylinder jackets and head, thence around the induction manifold, and finally to the cooler via the bypass and a filter. A small make-up tank acts as an air vent to the system and is connected into the pump suction. This tank maintains a positive head over the whole circuit under all conditions. An emergency sea circuit is provided by a semi-rotary hand pump connected via a non-return valve into the pump discharge pipe.

Thermostatic control was embodied in the 80 h.p. engine, which was the first post-War design, but, despite balanced valves and a relatively large thermostatic element, the troubles experienced were such that this system was discarded and hand adjustment by bypass was introduced instead. Elements failed from vibrational fatigue and although slack clearances were given, the valves

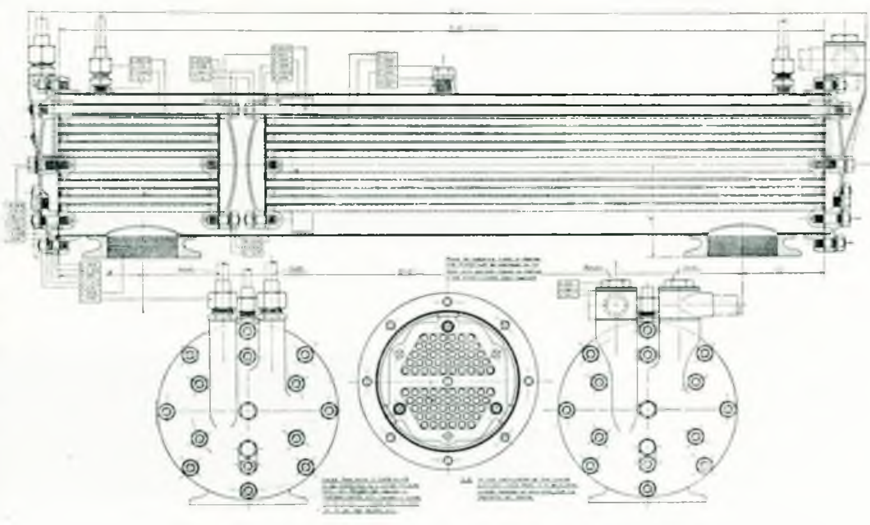

Fig. 14.—Combined water and oil cooler (F.2 type).

and spindles periodically set fast.

In the oil service, a bypass is arranged to isolate the cooler in case of emergency and to allow easier warming up of the oil in cold weather. It has no intermediate control, being either open or closed to the cooler.

A full-way safety valve set to operate at twice the normal working pressure is embodied in the engine filter casing to protect the cooler against abnormal pressure under extreme viscosity conditions.

Fig. 14 shows a combined water and oil cooler of smaller and lighter construction as used in conjunction with a 12 h.p. engine in a 32ft. boat and similar to that used for a 35 h.p. engine in a 35ft. 6in. boat. In this type of cooler the tubes are sweated into the tube-plates and are of different lengths for water and oil cooling.

With a limited supply of fresh water and restrictions on the dimensions of coolers, it is necessary that the circulating pump and pipework be of much greater capacity than with a plain sea circuit. Pipe velocities are arranged to be 5 to 6 feet per second for water and 4 to 5 feet per second for oil.

The volume of water circulated, detailed construction and general application have considerable effect on the area of cooling surface required. A cooler of the type as shown in Fig. 13 will maintain a maximum temperature of about 145° F. with ·9 of a square foot per h.p. and a circulation of approximately ·3 of a gallon of fresh water per h.p. per minute. With the type of cooler illustrated in Fig. 14, ·9 of a square foot per h.p. will maintain, under similar conditions of circulation, approximately 125° F.

For engine oil cooling about ·25 of a square foot per h.p. is allowed when circulating ·1 of a gallon per h.p. per minute, this effecting a heat exchange of approximately 20° F.

Coolers of honeycomb or similar construction, utilizing much thinner tubes and water layers, undoubtedly would give more efficient results, but such form of construction is not sufficiently robust and the types used are considered best for their particular purpose.

In the glanded type cooler considerable trouble has been experienced in tube corrosion, but the sweated up type has been immune in this respect. Various classes of brass tubes were originally used and the trouble was fortuitous and inconsistent. Expert investigation and research proved this corrosion to be the result of anodic deterioration from contamination with oil. Oil from packings, initial handling, or drippings when removing tubes for examination, subsequently became protected from normal hydrolysis by a coating of mud, and started through the sea water as an electrolyte an attack on the metal immediately beneath the oil. The resultant corrosion products washed away, leaving the tube with an affected area, but with no indication of the original cause. Experiments were carried out showing decomposition actually in process, and the run of oil and drip positions were positively identifiable as causes of corrosion. Oil was actually recovered from corrosion pits in tubes twelve months after their initial fitting in coolers. When the cause of the trouble was suspected various metals were subjected to trial and although some were slightly less affected than others, the action of the localised mud-covered patch was so virulent that one was forced to the conclusion that no metal or alloy, whatever its composition, could entirely withstand such acute form of anodic

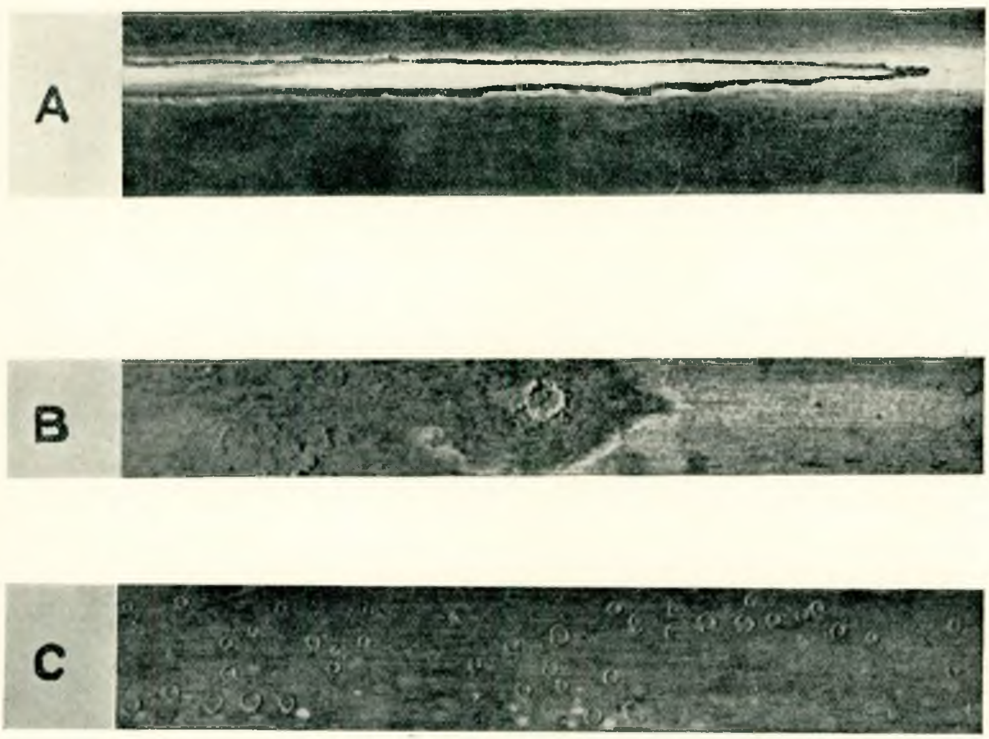


FIG. 15.—Cooler tube showing oil corrosion.

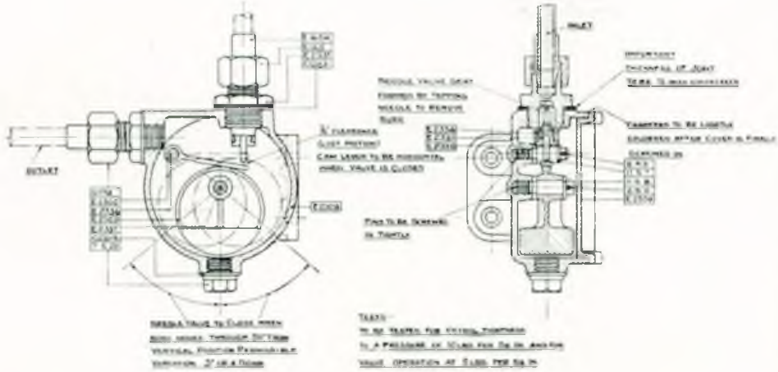

FIG 16.—Petrol capsizing valve.

attack. Fig. 15A illustrates the attack from a "run" of oil and Figs. 15B and 15C show the effect of "spotting".

With the exception of four boats of the largest type, the fuel supply on all petrol-engined boats is pressure fed. The tanks are circular in section and constructed of tinned copper. They are located in separate compartments, the position of which is determined by the type of boat, but in all boats the tanks are in duplicate and interconnected so that either or both engines of a twin engined boat can be served by either or both tanks. All tanks are arranged with a substantial sump at the lower end, fitted with a blow out pipe connection to the top, for the removal of accumulated water, etc.

The tank filling connection is taken through the deck by way of a fitting normally covered by flush deck plate. To allow for the relative movement between tank and deck the filling pipe is taken through a stuffing box machined into the fitting, the outer diameter of the pipe being flexibly connected through a packed gland. The deck fitting houses a supplementary filling vent and is provided with an overboard drain.

Air pressure is maintained by engine-operated pumps, while hand pumps interconnected to the pipe lines provide initial pressure and serve for emergency use. Release cocks are fitted to each air line, which vent the tanks to the atmosphere outside the shelter. "Auto-Klean" strainers are used in the petrol service. In self-righting boats, an automatic pendulum-actuated cut-off valve, Fig. 16, is embodied in the petrol line near to the carburettor to stop the flow when the boat is heeled beyond 50° and an invertible inkwell type of reservoir is provided to collect the initial spill from the carburettor.

In the four largest type lifeboats, the petrol feed is by gravity and the supply from storage to service tanks by "Autopulse" electric pumps supplemented by auxiliary semi-rotary hand pumps. The three galvanised steel storage tanks are located in an athwartship compartment and are shaped to the contour of the boat. Rectangular copper service tanks are located in the same compartment immediately above the wing storage tanks.

Funnel exhaust is adopted wherever possible, as in addition to confining the piping to the engine room, this form of outlet eliminates from the hold and air cases, the risk of rot which is induced by the temperature rise from under deck piping. In self-righting boats, funnels are impracticable, and stern outlets therefore are adopted. The piping is water jacketed throughout and provided with expansion joints at bulkheads. The tail pipe is formed into an inverted "U" tube and the terminal skin fitting, which discharges above water line, carries a pendulum operated valve, Fig. 17, which closes the exhaust outlet if the boat is heeled beyond 60° with the engine stopped. Once this valve has operated it remains closed until reset by exhaust pressure when the engine is again running on an even keel.

Under-water exhaust is used only in the smallest class of installation, where extreme lightness is essential. In this case, the gases are taken from the engine into a junction box which forms an inverted "U" tube on the engine room side bulkhead, the discharge pipe being taken out through the boat's bottom. The top of the inverted "U" tube is fitted with a permanently open vent terminating in a small silencer fitting on the outside of the engine casing. A small scoop feeds sea water into the short unjacketed discharge pipe to keep cool the bulkhead connection.

All motor lifeboats are of timber construction,

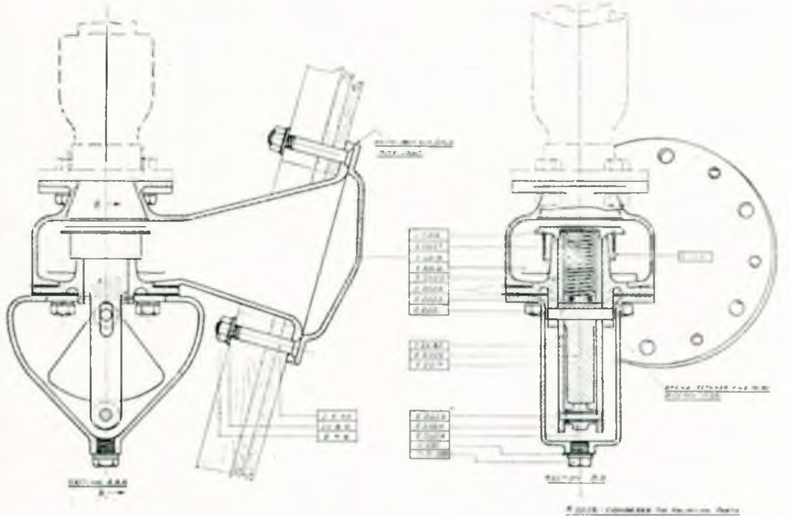

FIG. 17.—Exhaust capsizing valve.

but in a number of them steel bulkheads are used, at least for the two ends of the engine room. Where engine room bulkheads of timber are employed they are copper lined throughout and until comparatively recently the floor was padded out and similarly treated. Any leakage under the floor coppering gave rise to rot, whilst the padding between timbers made location of a leak extremely difficult. Moreover, to remove the coppering invariably necessitated the removal of the engine and numerous fittings. In view of these troubles floor coppering has been discarded and fire protection given by treatment of the wood and the application of fireproof enamel.

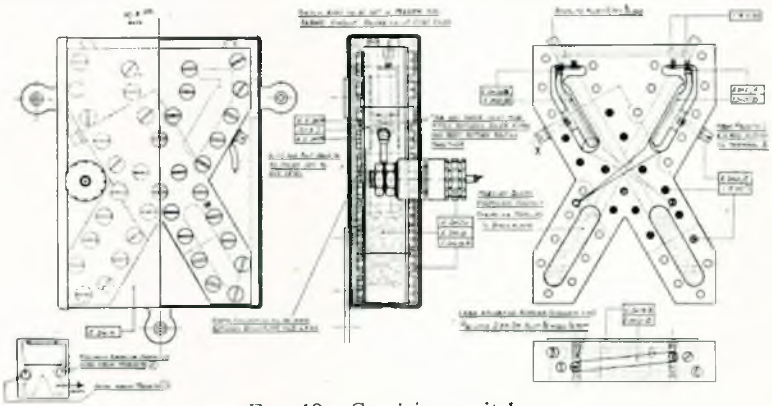

Fig. 18.—Capsizing switch.

The risk of fire and explosion is an ever-present menace to any boat carrying petrol, and rigorous precautions are necessary to prevent any accumulation of gas and exposed spirit. Until about three years ago the engines in a number of the Institution's boats obtained their air supply via the hold of the boat. Non-flooding valves were fitted to the end boxes, through which air was drawn into the hold and around the air cases, feeding the engine through holes in the bulkhead. With hatches battened down and the engine running, this method of air supply gave excellent ventilation to the whole of the hull. A somewhat serious explosion in a similarly constructed foreign lifeboat made it imperative to discard this method of hull ventilation and to isolate the engine rooms in all boats. The explosion occurred as a result of petrol evaporating in a warm engine room from a leaky cock or flooding carburettor, the vapour percolating into the hold of the boat through the bulkhead air passage. The petrol cock was inadvertently left on all night and the boat became full from end to end with an explosive mixture. When attempting to start in the morning, a flash back through the carburrettor, or a spark across the contact breaker or from a loose wire, gave the necessary ignition for an explosion which blew off the deck and practically the whole of the planking of the boat. Fortunately fire did not ensue.

Various types of fire extinguishing apparatus have been installed, but a multiplicity of small hand machines of the C.T.C. pump type and methyl bromide in hermetically sealed flasks are now entirely relied upon. The former are purely portable extinguishers and are located at convenient points throughout the boat. The latter also are portable and are located on the outside of engine room bulkheads and piped inside to nozzles at suspected danger points, whilst they can be detached instantaneously and used anywhere. In some boats bulk storage of C.T.C. with pump and controlled pipe line distribution has been installed, but the difficulties with corrosion caused by acid formation from absorbed moisture, condensation, and the possible introduction of sea water in filling, etc. decided the dropping of this system. $CO_2$ machines of the powder ejection type have also been used, but discarded on account of diffusion of the liquid $CO_2$ propelling charge and of moisture caking of the powder. $CO_2$ drenching apparatus with the liquid contained in hermetically sealed bottles may appear a desirable system for the larger boats, but the bulk and weight and maintenance of relatively high pressure bottles is somewhat against its use. The method of protection provided is reliable and efficient, and excludes all risk of false security.

All electrical fittings are specially designed for total submersion and are made of non-ferrous materials throughout. Considerable trouble has been experienced in the past in endeavouring to utilize standard fittings, as invariably these were found to contain springs, pins, screws, etc. of steel, which rapidly corroded.

A complete two-wire system is provided for all circuits fed from the main batteries. Earth returns are avoided wherever possible, but where it is essential that they be used independent batteries are provided to feed them. On no account whatever is the wiring of any electrical circuit allowed to pass through the petrol compartments of a boat.

For self-righting boats a mercury type capsizing switch, Fig. 18, is arranged in the magneto primary circuit to earth the magneto when the boat has rolled either way to a predetermined angle. This switch cuts out instantaneously but re-opens the circuit only after a delay of one minute. This ensures immediate stopping of the engine in the event of a capsize, and upon self-righting, when the crew may possibly be in the water, prevents automatic re-starting by momentum of the flywheel. Two switches are embodied in the one mercury chamber to control the two magnetos of each engine.

A portable and submersible searchlight is provided for all electrically equipped boats except the 61ft. type, which is fitted with a comparatively high power pedestal arc light. The portable light is approximately 9½in. diameter and utilizes a parabolic reflector and a 48-Watt gas-filled lamp. It has a glanded focussing control and is provided with a neck lanyard and hand-grips for directing the beam. In some cases it is provided with a swivelling fitting for shipping into a socket on the shelter. A 30-ft. cable stowage is arranged round the outside of the lamp, the end terminating in a watertight connection which can be plugged into sockets arranged fore and aft of the boat. This lamp gives a very useful beam capable of picking up a man in the rigging of a wreck at a 100 to 150 yards distant. Its weight complete with cable and a Morsing shutter is 17lb.

A mast-head signalling lamp is fitted to boats where a skilled operator is a member of the crew. The Morsing switch for this lamp is a portable hand-grip fitting which can be carried on a flexible cable to any convenient position in the cockpit.

Fig. 19 illustrates the switchboard and wiring diagram which controls the 80-volt circuit used for power and lighting in the largest type boat, also the supplementary 12-volt supply for ignition apparatus, etc. The engines for this class of boat operate on both low and high tension ignition. The diagram shows the various circuits dealt with and the arrangement of the switchboard gives some idea of the reduced space into which so many instruments and number of power points can be condensed with safety and efficiency. Also is illustrated the method of connecting up from the engine room through watertight terminal boxes.

The board is attached to the cabin side of the engine-room aft bulkhead and all connections to the board are made within or through the watertight terminal boxes on the engine room side. All connections to the cabin side of the board are made on the front and each of the four panels with their instruments and fittings are demountable without removing the chassis of the board from the bulkhead. To protect the batteries in the event of the cabin side of the board being submerged, the main fuse is isolated from the general circuit and placed in a specially constructed watertight housing.

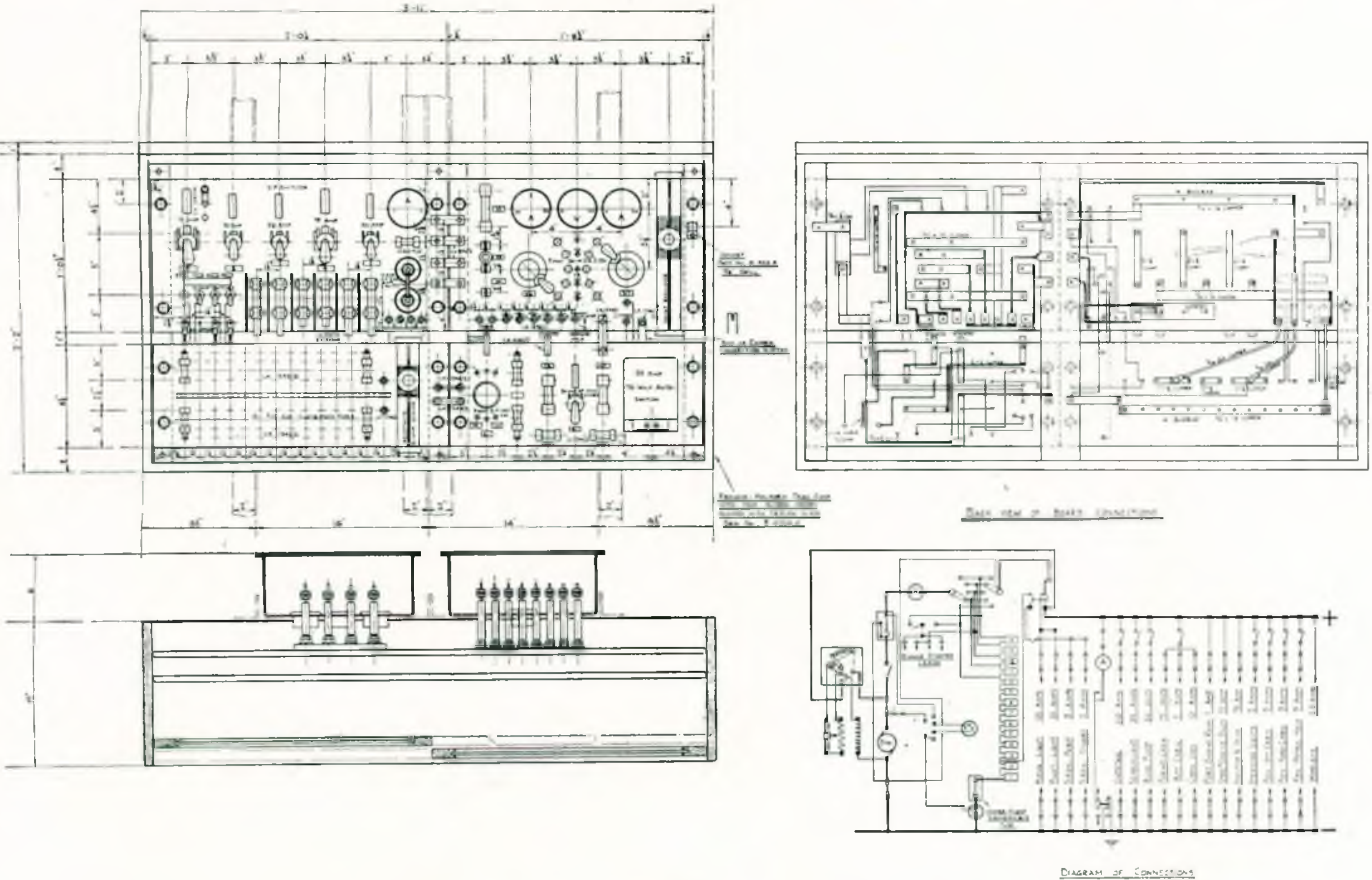

FIG. 19.—Switchboard (61ft. 0in. boat).

The use of wireless in lifeboats is necessarily confined to such boats as have stations in the vicinity with which to communicate, and where a transmitting set is employed a cabin is essential to contain it. Wireless was first installed in a lifeboat in 1929, the set being a telegraphy transmitter and receiver. Very little trouble has been experienced with it, but its use calls for the service of a qualified whole-time operator. In 1929 three boats were equipped with radio telephony transmitting and receiving sets, an additional two were installed in 1931, and in December last a further one was fitted. In 1930 a receiving set was built and installed in a boat by the mechanic in charge, whilst in 1934 a party of amateurs built and fitted up a receiving set for use in an open-type boat. Considerable troubles were experienced with the receivers of the earlier sets due chiefly to the inability of components to withstand the atmospheric conditions, but these troubles have now been eliminated. Transmitters have given practically no trouble, and with receivers also trouble free, it may be considered that, functionally, radio telephony is now satisfactory for lifeboat use.

With one exception the engines and electrical apparatus in all boats equipped with wireless are inherently screened by their watertighting arrangements, but despite this, inductive troubles with receivers on some boats have occurred, necessitating the fitting of condensers across magneto contacts and dynamo brushes. In the special purpose boat, which has entirely open ignition and electrical apparatus, it was necessary before satisfactory results could be obtained to provide suppressers for all sparking plugs and high tension contacts and completely to screen all cables.

As to the utility of wireless, of the nine sets in use there has been, so far, one occasion when a boat, being out of visual signalling distance, was given the correct location of a wreck. On another occasion a boat was guided to a wreck, but this could have been done by visual signalling. Four times boats have been recalled when their services were no longer necessary, and several occasions have arisen when boats could have been recalled, had they been fitted with receivers and had there been shore stations to transmit the necessary information.

Once only has a transmitter been useful and this was in conveying messages for medical assistance for a man in a stranded vessel. It is questionable therefore whether transmitting apparatus is of real use, or is likely to justify the complications involved. There is no doubt that a receiver can be of assistance and although, up to the present, this has been of little help, in the future it may be of inestimable value. There is very little doubt that as shore facilities increase, the use of receivers will be extended.

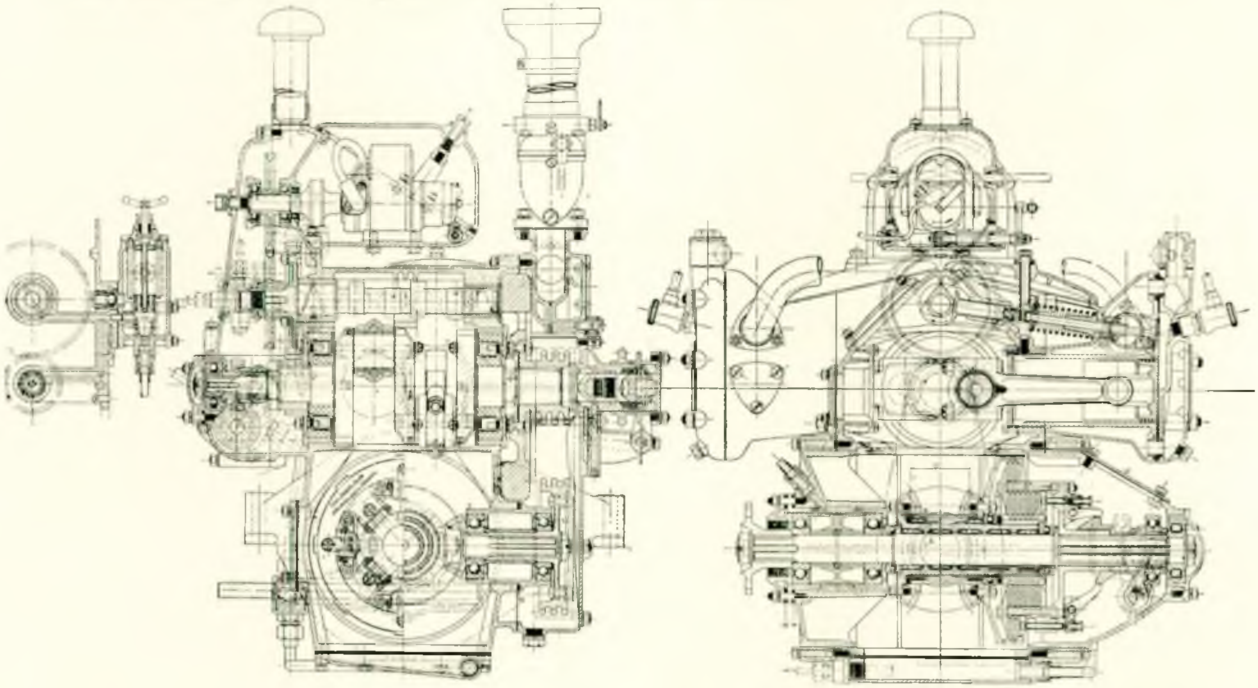

FIG. 20.—F.2 engine sections.

The smallest class of boat is, at the moment, of a very experimental nature. It is 32ft. long by 9ft. beam, and in complete service condition weighs 3¾ tons. Two of these boats have been built and recently placed in service, one of them equipped with twin screws, the other with two independent tandem sets of "Hotchkiss" internal cone propellers.

Each boat has been designed to give the best advantage to the particular form of propulsion adopted, and the machinery installation has been specially designed for them as nothing of a suitable nature existed. They are for use in surf and are intended to replace the smallest type of pulling and sailing boat. Weight is an all-important feature since launching from the beach has to be rapidly accomplished.

For this class of boat the "Hotchkiss" system gives the advantage of a better form of hull, the tunnel construction being eliminated. Also it is capable of earlier propulsive effort, since immediately water covers the inlet gratings, which for one set of cones are forward of the centre of boat, propulsion becomes effective. In the screw boat considerably more water is necessary before effective propulsion is assured. The propellers are of the Gill shrouded type to give as much protection as possible from shingle, etc., but they incur a risk of damage to which the "Hotchkiss" system is not liable.

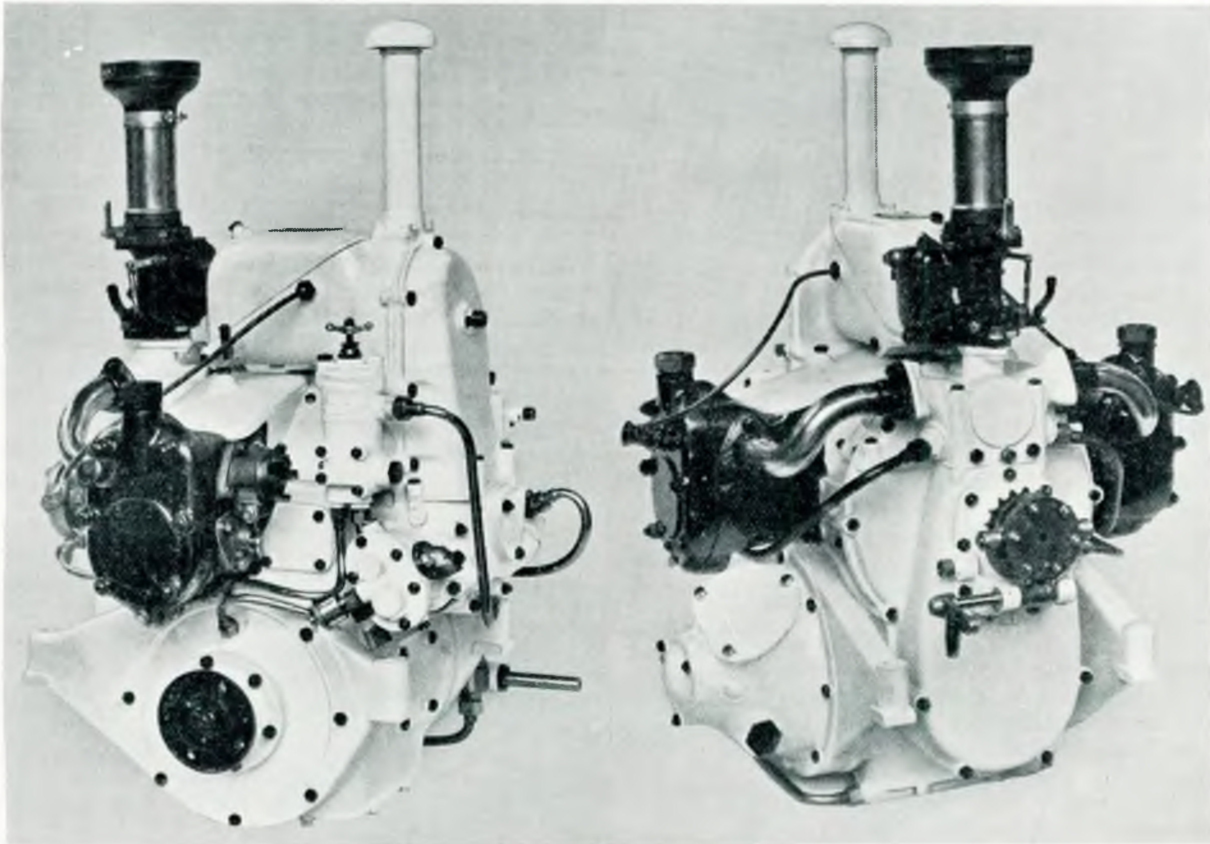

Fig. 21.—F.2 petrol engine.

Comparative trials under equal power output showed the screw boat to be approximately 9·5 per cent. faster, 7·47 knots being obtained, against 6·82 knots with the "Hotchkiss" boat, the percentage difference being practically constant over the whole speed range. Whether this loss of efficiency is outweighed by other considerations remains to be seen, and only prolonged trials under service conditions can determine this point.

The horizontally-opposed flat-twin engine used for this class of boat is illustrated in Fig. 20. A double-reduction gear is embodied consisting of a chain reduction from the crankshaft to an intermediate shaft and a bevel pinion drive to the ahead and astern clutches, giving a total reduction of approximately 4 to 1. The cylinders are arranged in a fore and aft direction, and the crankshaft athwartship. The crankshaft is carried on heavy-duty roller bearings, the connecting rod big-end bearings being white-metalled shells. Pressure lubrication is provided for the crankshaft and camshaft bearings, and jet lubrication from the same system is provided for the remainder of the working parts. The ahead and astern motions are obtained by engaging one or other of the plate clutches attached to constantly meshed bevel wheels. The complete unit is arranged for symmetrical handing for twin-screw installation, the only different parts necessary to effect the change in rotation being the camshaft and drive gears for the magneto, the latter being spur gears in one case and chain wheels in the other. The cylinders carry side valves and are fitted with detachable heads, whilst the tappet mechanism is enclosed by removable doors. A submersible down draught carburettor is fitted to a distribution box embodying a hot spot heated by exhaust gas. The magneto is enclosed in a split casing, the top half of which is readily detachable for examination or removal of the magneto. A water circulating pump and a

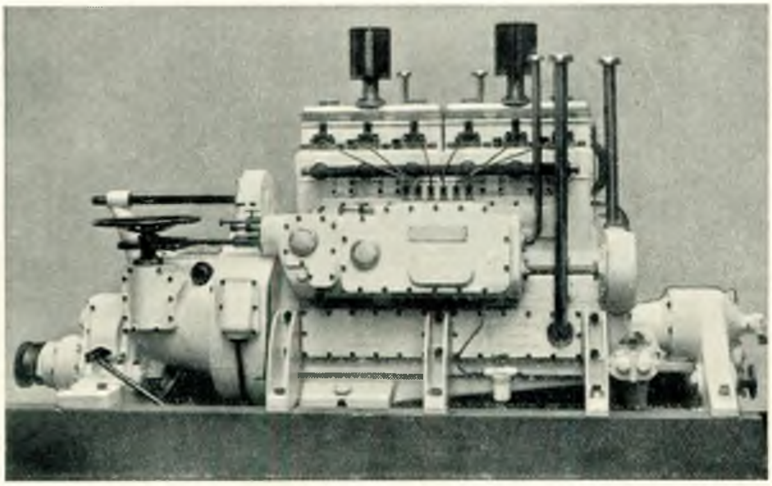

FIG. 22.—6-cylinder Diesel engine.

new boat to be built for the purpose. These engines have been completed and the bench trials satisfactorily carried out and so free were they from trouble that two further pairs have been ordered for another two boats now being built.

Fig. 22 is a photograph of the 80 h.p. engine. This engine has air cell combustion chambers cast in two sets of three each. Injectors are fitted in the tops of the cells and primary electric heating plugs in the sides. A side camshaft is used with push rods and rockers. The reduction gear is of the double helical type with the shaft line stepped directly below the crankshaft. Water and oil pumps are driven from a cross shaft at the forward end with oil pumps vertically

duplex oil pump are driven from opposite ends of a spiral-driven cross shaft, and an eccentric cam is carried on the end of the camshaft to operate the air pump for the fuel system. A revolution counter is driven from the end of the magneto drive shaft. This engine and gear is designed for continuous operation at 3,000 r.p.m., but actually it is loaded down to a maximum of 2,500 r.p.m., at which speed 13 b.h.p. is delivered at the coupling. Fig. 21 is a photograph of this engine.

The designs of the two types of Diesel engines which have been built were the results of specifications drawn up by the Institution and issued to various firms to enable them to tender. Essential features were stipulated such as the horse-power, revolutions of propeller shaft at which the power had to be developed, weight, extreme dimensions, completely submersible operation, automatic control of throttle, materials to be used, etc. Certain other features were rigidly fixed, but a reasonably free hand was left to the individual contractors in the determination of details. The 80 h.p. engine was installed into a boat from which a similarly powered petrol engine had been removed. This boat was put into experimental service early in 1934, and for three months it was run daily. It afterwards did relief duty during the refit of boats at two stations, and subsequently took over full service duties at another station, where it still remains. This was the Institution's first experience of a Diesel engine in a lifeboat, and the trials and experimental running having proved satisfactory, it was decided to have constructed a pair of 40 h.p. engines for installation into a

beneath. Only a maximum speed governor is fitted, and an automatic throttle control gear performing similar functions to that on the petrol engines is provided. Electric and hand starting arrangements are embodied, but hand starting from cold is extremely difficult. This is partly due to the type of head used, but chiefly to the inability to turn over sufficiently fast. Decompressors are fitted but owing to the limitations of flywheel dimensions sufficient energy cannot easily be stored to make the use of this adjunct of any great assistance to starting.

Fig. 23 is a photograph of the 40 h.p. engine. It is very similar in general layout, but many detail improvements are embodied. Open combustion

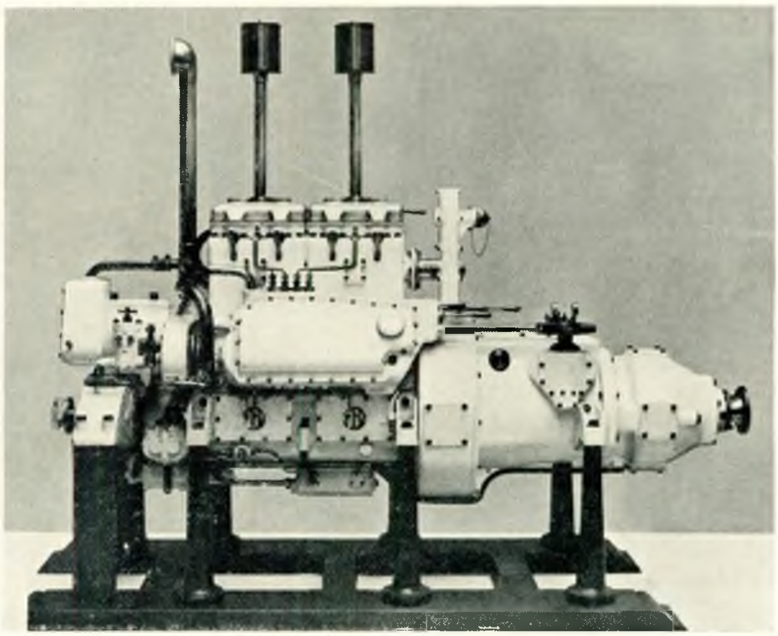

FIG. 23.—4-cylinder Diesel engine.

chambers are employed with masked inlet valves for giving the required air swirl, and the heads are cast in pairs. A maximum and minimum speed governor is fitted and in addition to normal hand and electric starting gear there is also a hand operated inertia starter. With the inertia mechanism starting from cold is easy and certain, whilst a cold start can also be guaranteed by direct hand cranking. The reduction gear is the Burn/R.N.L.I. type as used with the petrol engines. During bench trials of this engine it was observed that injection pressure had a somewhat critical relation to fuel dilution of the lubricating oil. Three hole sprayers are used and with a pressure of 150 atmospheres dilution occurred up to 6 per cent. in 13 hours. By increasing the pressure to 200 atmospheres dilution became practically negligible, being only ·6 per cent. in a similar time which included four hours light running.

The commercial inducement to the use of Diesel engines does not apply in the case of a lifeboat, since the amount of fuel used is a negligible factor. The increase in cruising range due to the lower consumption is an advantage, but the main consideration is the reduction, if not complete elimination, of risk from explosion and fire. Other things being equal, this fact alone would amply justify the increased initial cost and probable additional maintenance cost of the Diesel installation. The inability to obtain, so far, a very small engine of the same type for the auxiliary generator set is a handicap to the adoption of Diesel engines for boats lying afloat, since it is obviously futile to eliminate petrol for the main engines if it is necessary to carry even a small quantity for the auxiliary set.

The likelihood of obtaining a suitable Diesel engine for this purpose appears very remote, but a solution may be found in a low compression engine cold starting on Diesel fuel, and the possibilities of the design for an engine of this type are being investigated.

It is not anticipated that Diesel engines will be generally adopted for all classes of lifeboats, and it is probable that the petrol engine, with its lower operating pressures, and for equal safety factors its better power-weight ratio, will remain for many years the power unit for the small classes of lifeboats.

Acknowledgment is accorded to the authorities of the Royal National Lifeboat Institution for permission to read this paper and for the illustrations used, to the Weyburn Engineering Co., Ltd., for photographs of petrol engines, to the Ferry Engine Co., Ltd., for photographs of Diesel Engines, and to Barronia Metals, Ltd., for photographs of cooler tubes.

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The following contribution by Mr. F. J. Bullen, O.B.E., M.A., with reference to the Author's comments on tube corrosion trouble in coolers is published on account of its special interest and value.

"Mr. Butcher has dealt very comprehensively with a wide subject. He made a brief mention of tube corrosion trouble in the coolers, and remarked how the search for its cause proved a lengthy process. As it provides an outstanding example of corrosion attack by an agent which, having done its nefarious work, disappears without trace—or almost without trace—the members may be interested to hear a little more about it. There is an answer to most problems relating to the corrosion of metals provided the cause can be found. Once found, steps can be taken to eliminate it.

It was some three years ago when the cooler trouble first made its appearance, and though its incidence was not particularly severe, it was essention to eliminate it having regard to the severe conditions under which the lifeboats operate. The general location of the corrosion on the tubes was near the baffle plates and the end plates; a feature noticed quite early on when any one corroded area was critically examined was that the attack had become dormant. This was in sharp contrast with general experience of corrosion of metals by sea water, which is generally a continuous process, more or less rapid according to circumstances.

In making a general survey of the problem throughout the fleet it was noticed that only those boats kept permanently afloat experienced trouble. Seeing that the coolers were below the water line it followed that they were always full of water. As oxygen played so vital a part in corrosion, the first line of investigation was on dissolved air—for this reason. It was the routine in the motor lifeboats for the engines to be tested every day, and this would result in a rise of temperature in the cooling water, and dissolved air would be driven out and, adhering to the tubes, set up differential aeration, with resultant corrosion. A model cooler in glass was built to test this reasoning, and although the results justified the removal of the baffle plates in the coolers as a precaution, it could not be inferred that dissolved air was the complete answer. Patches of corrosion could be observed on the tops of the tubes where mud and silt settled. The attack might therefore be akin to that known in connection with condenser tubes as 'deposit attack'.

At this stage Mr. Butcher conducted a survey to find out whether the attack on the tops of the tubes was located more in one part of a cooler than in another. One would expect heavier attack on the tubes lowest in the nest where silt and mud would be more prevalent. The results of this survey were negative.

The next feature which made itself plain was that the corrosion trouble only occurred in boats where the tubes were fitted by means of packed glands and ferrules. There was no trouble in boats in which the tubes were sweated in, even although these boats, like the others with trouble, were permanently afloat. Experiments were therefore carried out on the packing of tubes with the lace tape soaked in linseed oil—the standard practice—and it became plain that if the packings contained any excess of oil this was squeezed out by the ferrule and seeped along or down the tubes. This proved a really 'live scent' in this particular corrosion hunt, particularly when, after countless negative examinations, a linseed oil residue coinciding exactly with a corrosion patch was found.

Whilst this oil was undoubtedly the source of the corrosion of the tubes near the end plates—as will be explained later—it seemed unlikely that the amount of oil squeezed from packings could account for the corrosion patches along the tops of tubes at some distance from the end plates. Was it possible that this latter trouble was due to leakages of engine oil past the glands? To test this, the Campbelltown boat on its annual survey had her coolers taken down under close observation; it was found that the packing had been so well done that the chance of oil leaking past was negligible. But in watching the starboard oil cooler stripped one source of oil was easily established. As selected tubes were withdrawn for inspection residual oil leaked from the following end and dropped on to other tubes in the cooler—ready to cause more trouble when the boat again went afloat. The port cooler was therefore stripped under test conditions, whereby no extraneous oil could possibly find its way on to the outside of the tubes. Yet when samples of the deposit on the tops of tubes were removed for examination, these, on extracting with ether, gave a residue of oil. Then oil was identified in the deposit from the tops of tubes in the water coolers! Omitting many details of the concluding stages in this elusive search, the presence of this oil was eventually established as arising from the handling of new tubes by fitters busy with oily packings, and therefore having oily hands.

It will be appreciated that if there is oil on a tube, when it meets sea water it will hydrolise and disappear, *save where it is protected.* As the lifeboats kept at moorings are in shallow water, often in muddy harbours, silt and mud very quickly settle on the cooler tubes and thus protect any oil from hydrolysis by the sea water, thereby preserving it to cause the troubles which have been described.

It was felt that these observations accounted for all the phenomena collected over three years, and to test this conclusion Mr. Butcher selected the Walton lifeboat—a bad boat for corrosion—and fitted her coolers under test conditions whereby no extraneous oil was allowed on to the tubes—with the exception of eight tubes which were purposely smeared with engine oil. After a year's service the cooler was taken down and all the tubes were found to be in excellent condition (in strong contrast to the normal experience) except the eight which had been smeared with oil. These could be picked out even at a distance.

The writer hopes that the foregoing remarks may be of interest, but if any member doubts his conclusions, it is suggested that he should conduct a simple experiment for himself by taking a sheet of polished metal and on it place a ring of plasticine (a mixture of clay and vaseline), inside of which is put sea water, slightly acidified with hydrochloric acid to hasten the attack. If the sample be stripped after two or three days the metal beneath the plasticine will be found to have corroded quite deeply. Should it be thought that the plasticine has corroded the metal, then a duplicate ring, but this time filled with oil, can be run side by side. In this case no corrosion at all will occur under the plasticine.

The whole thing reduces itself to simple terms. If one has a piece of metal, one part of which is greasy and the other not greasy, and it be immersed in an electrolyte, such as sea water, the greasy part becomes anodic to the other and immediately corrodes. The action with an oil smear such as Mr. Butcher illustrated in one of the slides is first to attack the metal beneath the edges of the smear, as shown by the deep grooves in the photograph. The action then proceeds inwards, and when all the oil has been used the whole thing drops off, and no evidence is left of what has occurred.

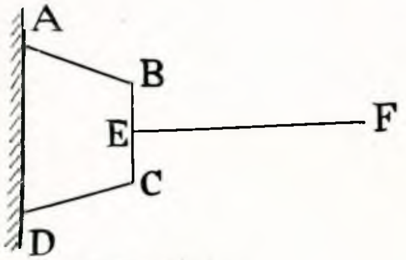
## ASSOCIATE MEMBERSHIP EXAMINATIONS.

*The following are the Papers set for the May Examination:—*

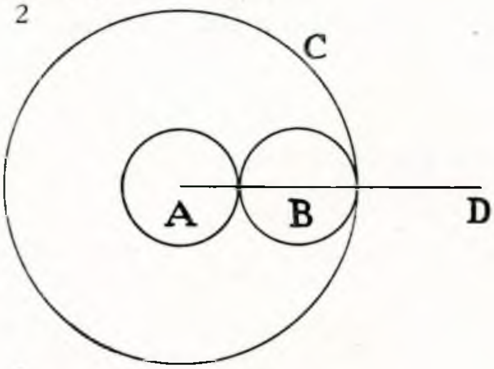
### APPLIED MECHANICS.

Monday, May 18th, 1936. 10.0 a.m. to 1.0 p.m.

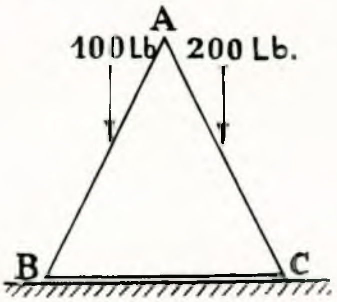
Not more than *six* questions to be attempted. All questions carry the same marks.

1. 


The figure shows an arrangement of hinged bars forming a simple mechanism. AB, BC and CD are each 6 inches long. AD is 9 inches long. EF is rigidly attached to BC. In the position shown when the arrangement is symmetrical about a horizontal line through EF find the vertical force at F necessary to prevent distortion of the mechanism if a downward load of 100 pounds is applied at C. EF is 12 inches long.

2. 


An epicyclic gear consists of an annular wheel C, a pinion B, and a spur wheel A concentric with C. The arm AD carries the axis of B. If A runs at 150 revolutions per minute anticlockwise and C runs at 200 revolutions per minute clockwise, find the angular velocity of the arm AD in magnitude and direction. Find also the angular velocity of the pinion B. A and B have 30 teeth each and C has 90 teeth.

3. 


A double step ladder consists of two equal legs AB and AC each 10 feet long with a pin joint at A. A load of 100 pounds is suspended at the mid point of AB and a load of 200 pounds at the mid point of AC. The ladder rests on a smooth floor and the legs are connected by a rope BC at the ground level. If BC is 5 feet long, find the tension in the rope and the shearing force in magnitude and direction on the pin at A.

4. In order to obtain the brake horse power of an engine a belt is passed over the flywheel. One end of the belt is attached to a spring balance and the other supports a weight of 250 pounds. The spring balance records a pull of 130 pounds. The engine makes 300 revolutions per minute and the flywheel diameter is 5 feet. Calculate the brake horse power. Give a short account of any special difficulties in carrying out a test of this character, preferably based upon your personal experiences.

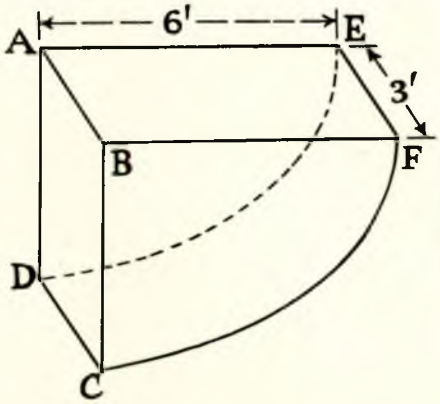
5. A steel rod of uniform section and 6 feet long is hinged at one end to the top of a rotating vertical axis. The hinge allows it to swing out freely and as it revolves the rod describes a cone of base angle 60 degrees. Find the speed of revolution of the system about the vertical axis.

6. Using either construction or calculation obtain the acceleration of the piston of an engine, crank 1 foot long, connecting rod 4 feet long, when the crank makes an angle of 60 degrees with the inner dead centre. Engine speed is 400 revolutions per minute. Give an outline proof of the accuracy of your method.

7. Explain how a model may be used in an experimental tank to determine the probable horse power needed to propel a ship at a particular speed. Give also the fundamental principles underlying the method.

8. State and prove Bernouilli's theorem for stream line flow for water.

Water is flowing in a pipe line. At one place the pressure is 2,000 pounds per square foot, and at another 100 feet lower the pressure is 1,000 pounds per square foot. What is the loss of energy due to friction between the two places per pound of water flowing. The pipe is uniform in diameter.

9. 


A tank is made with vertical flat ends ADE and BCF shaped as quadrants of circles 6 feet radius. The tank is 3ft long and the rectangular side ABCD is vertical. If the tank is filled with water, find the magnitude, direction and position of the resultant pressure of the water on the curved portion EFCD.

10. A solid cylinder of wood 16 inches in diameter and 12 inches long is placed in water. Find its least specific gravity, assuming that it is greater than 0·5, if it can float with its axis vertical. Give an outline proof of any formula you use.

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## PROPERTIES AND STRENGTH OF MATERIALS.

Monday, May 18th, 1936. 2.0 p.m. to 5.0 p.m.

Not more than *five* questions to be attempted. All questions carry the same marks and credit will be given for orderly statements showing how the numerical results are obtained.

1. From consideration of the action of stress on a perfectly elastic material establish the relation between Young's Modulus and the Modulus of Rigidity, introducing any other elastic constants which may be necessary for the purpose of the proof.

2. A single overhung crankshaft is $6\frac{1}{2}$ inches diameter. The distance between the centre lines of the crank pin and main bearing is 18 inches. The engine stroke is 32 inches. If the load on the crankpin is 12,000 pounds in the position of maximum torque, find the major and minor principal stresses in the shaft and the angles made by the planes of principal stresses.

3. Find the maximum stress in a beam which has a span of 16 feet and is freely supported at the ends. It is 10 inches deep and carries a load of 2 tons per foot run on half its length from one end to the span centre. The I about the neutral axis is 350 $(\text{inches})^4$. Derive the formula you have used, stating any assumptions you have made.

4. A beam of 20 feet span has both ends fixed horizontally and at the same level. It carries a load of 5 tons situated at 8 feet from one end. Sketch and dimension the bending moment and shear force diagrams and calculate the points of inflexion.

5. Describe fully some form of torsionmeter. If the angle of twist in a 20 feet length of shaft was 1·75 degrees and the revolutions per minute 480, find the shaft horse power. The shaft was 7 inches diameter. Take the co-efficient of rigidity as $12\times10^6$ pounds per square inch.

6. Show how to find an expression for the deflection of a close coiled helical spring under an axial load if the dimensions of the spring and the necessary elastic constant are known. What stress would be produced in such a spring of mean diameter 3 inches, wire diameter $\frac{1}{4}$ inch, if there are 10 free coils and the axial load is 20 pounds. Take $C=12\times10^6$ pounds per square inch.

7. Derive a formula for the intensity of stress produced in a thick cylinder due to internal fluid pressure in terms of the thickness of the material, the internal diameter and the intensity of internal pressure. Show by means of a sketch how the stress varies across the section.

8. Describe the Izod testing machine or any other machine designed to carry out tests of a similar nature. What working quality of the material is such a test intended to ascertain? What is its practical significance?

9. What is known of the combined effects of a corrosive fluid, such as sea-water, and alternations of stress in producing fatigue fractures of mild steel? Make reference to the work of any investigators with which you are familiar.

## HEAT ENGINES.

Tuesday, May 19th, 1936. 10.0 a.m. to 1.0 p.m.

Not more than *six* questions to be attempted.

Callendar's Steam Tables, Temperature-entropy charts, and Total Heat-entropy charts are supplied for the use of candidates.

1. A quantity of air occupying a volume $V_1$ at an absolute temperature T is compressed adiabatically until its volume is $V_2$. It is then allowed to cool at constant volume until its temperature is again T. Finally it is expanded isothermally until its volume is again $V_1$. Sketch the pressure-volume and the temperature-entropy diagrams for the cycle, and show that the work done on the air per pound is

$$RT\left[\frac{1}{\gamma-1}\left\{\left(\frac{V_1}{V_2}\right)^{\gamma-1}-1\right\}+\log_e\frac{V_2}{V_1}\right]$$

where R is the gas constant for air. Prove any formula you may use for finding work done.

2. One pound of water at 69·4 degrees Centigrade (156·9 degrees Fahrenheit) is heated and converted into steam at 200 pounds per square inch absolute, dryness fraction 0·85. It is then expanded adiabatically until its pressure falls to 20 pounds per square inch absolute. Calculate as accurately as the steam tables permit (*a*) the heat required to convert the water into wet-saturated steam, (*b*) the total change in entropy, and (*c*) the dryness fraction at the end of adiabatic expansion. Illustrate your answer by sketches of the process, as far as possible, on the T-$\phi$ and H-$\phi$ diagrams supplied.

3. The following observations were made on a trial of one hour's duration on a single cylinder, four stroke, single acting Diesel engine (piston diameter 24·5 inches and stroke 39 inches); revolutions per minute 125; indicated mean effective pressure, 92 pounds per square inch; shaft torque, 8,670 pounds feet; fuel consumption, 87·2 pounds; weight of cooling water, 8,880 pounds; rise in temperature of cooling water, 37·7 degrees Centigrade; exhaust gas temperature, 317 degrees Centigrade; engine room temperature, 17 degrees Centigrade; estimated weight of exhaust gases, 29·1 pounds per pound of oil; horse-power to compress blast air, 15; calorific value of the fuel, 10,750 C.H.U. per pound. Make out a heat balance sheet for the engine showing the various items in C.H.U. per minute. Assume the specific heat of the exhaust gases is 0·25.

4. A twin cylinder, double acting steam winch running at 320 revolutions per minute has a hauling speed of 120 feet per minute when the load is 5 tons. The steam pressures at admission and exhaust are 100 and 15 pounds per square inch absolute respectively, and the cut-off takes place at 75 per cent of the stroke. Calculate the cylinder dimensions for a stroke to bore ratio of 1·5. Assume hyperbolic expansion, a diagram factor of 0·85, a mechanical efficiency of 70 per cent, and neglect the effect of clearance.

5. What is the object of intercooling in a multi-stage air compressor? Describe in detail how you would carry out a test on a compressor in order to determine its capacity, i.e., its delivery of free air in cubic feet per minute.

6. The following data apply to a Vulcan-geared Diesel engine tug :—Full speed, 13½ knots; propeller thrust, 18·13 tons; propeller efficiency, 65 per cent; propeller shaft speed, 90 revolutions per minute; Vulcan gear speed reduction ratio, 4·67 to 1; gear efficiency 96 per cent.; number of cylinders, two sets of eight geared to one propeller shaft; bore, 450 millimetres; stroke, 420 millimetres; the engines are single acting and operate on the four stroke cycle. Find the brake mean effective pressure in pounds per square inch.

7. Explain the terms "velocity compounding" and "pressure compounding" as applied to steam turbines. The first pressure stage of an impulse steam turbine has two velocity stages, and the jet velocity is 2,275 feet per second. The nozzle angle is 20 degrees and the blade exit angles are 1st moving, 22 degrees; fixed, 24 degrees; 2nd moving 35 degrees. If the mean velocity of the blades is 435 feet per second, find the horse-power developed in the stage for a steam consumption of 10·2 pounds per second. Assume no reduction in steam velocity due to friction in both moving and fixed blades.

8. A fuel oil has the following percentage by weight:—carbon, 85; hydrogen, 12; sulphur, 1·5; oxygen, 1·3; and ash, 0·2. Estimate the minimum weight of air required for the complete combustion of one pound of oil. If 100 per cent excess air is supplied determine (*a*) the percentage composition of the products of combustion by weight, and (*b*) the percentage composition of the dry exhaust gases by volume.

(Molecular weights are $H_2$, 2; $O_2$, 32; $N_2$, 28; C, 12; S, 32. Air contains 23 per cent. $O_2$, and 77 per cent of $N_2$ by weight).

9. The ratio of the weight of air to fuel supplied to a Diesel engine is 50 to 1. The oil has a calorific value of 16,200 B.Th.U. per pound. The temperature of the air at the beginning of compression is 80 degrees Fahrenheit, and the ratio of compression is 14 to 1. If the oil were completely burnt and all the heat added at constant pressure as in the theoretical cycle find the point in the stroke

at which heat addition would cease and estimate the temperature at this point. Assume $\gamma = 1{\cdot}4$ and that the specific heat of air at constant pressure is constant and is 0·238.

10. Describe the theoretical cycle for an ammonia compression refrigerating machine by reference to a temperature-entropy diagram.

Determine (*a*) the ideal coefficient of performance, and (*b*) the pounds of ice, from and at 32 degrees Fahrenheit, that can be made in 8 hours when the compressor is driven by a motor of 40 brake horse power. Assume the ammonia is dry saturated at the end of adiabatic compression, and make use of the following data:—

Temperature at the end of compression, 90 degrees Fahrenheit.
Temperature during evaporation, 15 degrees Fahrenheit.
Temperature to which the refrigerant is cooled in the condenser, 80 degrees Fahrenheit.
Specific heat of liquid ammonia, 1·1.
Latent heat of ammonia at t° F. = (566 − 0·8 t.) B.Th.U. per pound.
Latent heat of ice 144 B.Th.U. per pound.
Mechanical efficiency of compressor 70 per cent.

$$\frac{\text{Actual coefficient of performance}}{\text{Ideal coefficient of performance}} = 0{\cdot}6$$

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## ELECTROTECHNOLOGY.

Tuesday, May 19th, 1936. 2.0 p.m. to 5.0 p.m.

Reference to tables, pocket books or note books is not permitted. A pamphlet containing Mathematical Tables is supplied for the use of each candidate. At the close of the examination it must be given up with the candidate's answer book. A sheet of drawing paper is provided for each candidate. Candidates are permitted to use slide rules and drawing instruments. The maximum number of marks is the same for each question.

Not more than *six* questions to be attempted.

1. What do you understand by the terms "Vacuum" and "Gas Filled" as applied to metal filament lamps?

Two 230-volt metal filament lamps rated at 15 watts and 150 watts respectively are connected *in series* across a 230-volt supply.

(*a*) What effect would this have upon the brightness of each lamp?
(*b*) What current would flow through each lamp?
(*c*) What would be the voltage drop down each lamp?
(*d*) What power would be taken by each lamp and by the whole circuit?
(*Assume the resistance of each lamp to be equal to that when burning normally*).

2. Make a simple line diagram of a 3-way, double-pole, fuse board, and from it show the connections to the following separate circuits:—

(*a*) four lights, controlled by one switch;
(*b*) three lights, each having its own switch control;
(*c*) one light, capable of being switched "on" and "off" from each of two switch positions.

Indicate the polarity of the supply leads in every case.

3. Define the terms Reactance and Impedance as applied to a circuit possessing resistance and inductance.

A coil having a resistance of 10 ohms and an inductance of 0·025 henry is connected as follows:

(*a*) across a D.C. supply of 230 volts pressure;
(*b*) across an A.C. supply of 230 volts pressure, 50 cycles.

Calculate the current flowing and the power supplied by the circuit in each case.

4. What is meant by the *back e.m.f.* of a motor? A motor connected to a 460-volt D.C. supply takes an armature current of 120 amperes. The resistance of the armature circuit between terminals is 0·55 ohm. Calculate the value of the back e.m.f. of the motor at this load.

5. Make a diagram of a main switchboard showing the connections of two compound-wound D.C. generators connected in parallel to the same bus bars. The diagram must show the wiring of the instruments, switches, cut-outs, etc., necessary for the control of the two machines. Assuming that both generators are feeding on to the bus bars, explain in detail how you would transfer all the load to one machine, and shut down the other.

6. Explain the general construction and method of application of some form of immersion heater. Such a heater is required to raise the temperature of 20 gallons of fresh water from 54 degrees Fahrenheit to 180 degrees Fahrenheit. If the heater is rated at 2·5 kilowatts and the whole apparatus has an overall efficiency of 85 per cent., how long will it take to perform the operation? (1 kilowatt-hour = 3410 B.Th.U. 1 gallon of fresh water weighs 10 pounds).

7. What are the relative advantages of direct current and alternating current in regard to the transmission and utilisation of electrical energy?

In what type of electric ship propulsion is direct current more appropriate, and in what type is alternating current more appropriate?

8. Describe the construction and principle of operation of a simple transformer. How many turns would be required on the primary and secondary windings of an ideal 6,600 to 460-volt, 50-cycle, step-down transformer, if the maximum value of the core flux was 3·5 megalines?

9. Accumulators or secondary batteries are used for various emergency purposes on ship board. Explain in detail, with the aid of diagrams if possible, one method of maintaining such a battery fully charged. Describe the tests you would make to assure yourself that the battery was in the required condition.

10. What is meant by *Power-factor,* and why is it desirable to maintain it as near unity as possible? A 460-volt single-phase feeder has a maximum current carrying capacity of 130 amperes. What is the maximum horse-power which can be safely transmitted by this feeder if the power-factor is 0·65? By how much could this load be increased without overloading the cables if the power-factor were improved to 0·95?

11. What are the essential characteristics of a motor for a cargo-winch? State the type of motor used for this purpose, and explain the methods of control whereby the necessary requirements are fulfilled.

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## NAVAL ARCHITECTURE.

Tuesday, May 19th, 1936. 2.0 p.m. to 5.0 p.m.

Not more than *eight* questions to be attempted. All candidates should attempt at least one from each section.

### Section I.—Elements of Ship Construction.

1. For a given specimen of mild steel how are the following properties determined :—

(*a*) Ultimate strength.
(*b*) Elastic limit.
(*c*) Modulus of elasticity.
(*d*) Hardness number.

2. A mild steel beam, 30 feet in length, simply supported at its ends, is built up of top and bottom plates 12in. by 0·50in., a web plate 30in.×0·50in., and four angles 4in.×4in.×0·50in.

Neglecting the weight of the beam, estimate the maximum concentrated load which this beam can safely carry at its mid-point, indicating the factor of safety assumed.

3. A vessel on load trial is found to vibrate excessively. To what possible causes may this be attributed? What steps would you take to discover the cause and to remedy the defect?

4. Make an outline pencil sketch of *either* (*a*) *or* (*b*) showing the essential features :—

(*a*) A transverse section of an engine seating suitable for a marine Diesel engine of about 1,800 b.h.p.
(*b*) A propeller shaft bracket for a light twin screw vessel with machinery of about 1,800 s.h.p., showing how you would secure the bracket to the hull.

5. Discuss the different structural systems adopted for ship-building, and distinguish between transverse and longitudinal methods, indicating the merits and demerits of both. State for what types of ships one or the other system may be preferred and give reasons.

### Section II.—Stability and Trim.

6. Define block co-efficient, prismatic co-efficient and midship section co-efficient, and show that if any two are known, the third can be determined.

A vessel of 1,740 tons displacement has a block co-efficient of 0·536 and a midship section co-efficient of 0·831. The area of the midship section is 315 square feet and the ratio of breadth moulded to draft moulded is 3·43. Determine the length, breadth and draft of the vessel.

7. The tons per inch immersion of a vessel at drafts of 9ft., 11ft., 13ft. and 15ft. are 18·61, 19·30, 19·98 and 20·69 tons respectively. Calculate the displacement in tons of this layer.

An oil tanker of 12,000 tons displacement carries on a certain voyage 8,000 tons of oil of specific gravity 0·96 on a mean draft of 26ft. If the tons per inch immersion is 48·45, calculate the change in draft on the next voyage, carrying an equal volume of oil of specific gravity 0·92.

8. Explain the importance of an inclining experiment.

An inclining experiment is carried out on a vessel of 2,500 tons displacement. By shifting the weight of 3 tons a distance of 25 feet across the deck, a deflection of 10 inches is obtained on a 15ft. pendulum. The draft is 13ft. 8in., the centre of buoyancy is 5ft. 6in. below the L.W.L. and the transverse metacentre is 4ft. 3in. above the centre of buoyancy.

Calculate the height of the centre of gravity above the keel.

SECTION III.—PROPULSION.

9. A proposed vessel has a length of 400 feet, and speed 12 knots. The residuary wave resistance of a 10 foot model of the ship tested in the tank at the corresponding speed was 0·435 pounds.

Calculate the residuary E.H.P. of the ship.

10. What data would a superintendent, responsible for a fleet of 8,000 ton deadweight cargo steamers with different hulls and machinery, obtain from the ships to enable a comparison to be made of their relative performance? In what form would the comparative results be tabulated?

11. Define and explain the following terms:—

(*a*) Propeller pitch.
(*b*) Wake.
(*c*) Real slip.
(*d*) Apparent slip.

Under what conditions would you expect to find "negative" apparent slip?

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## MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, May 20th, 1936. 10.0 a.m. to 2.0 p.m.

Not more than *one* question to be attempted.

Drawings are to be finished in pencil. In marking the papers the quality of draughtsmanship will be taken into account. All calculations are to be handed in with the drawings.

*Either*

1. A marine reciprocating engine has a connecting rod to crank ratio of 4·25 to 1, and carries a piston load of 38,000 pounds as shown in Fig. 1 (*a*) of the accompanying sketch. Determine

(*a*) the slipper dimensions "B" and "L" allowing a bearing pressure of 60 pounds per square inch between the slipper and the guide;
(*b*) the small end bearing diameter of the crosshead allowing a bearing pressure of 850 pounds per square inch between the crosshead and the small end bearings.
(*c*) the diameter "d" of the piston rod allowing a maximum safe stress of 6,250 pounds per square inch in the material of the rod at the bottom of the thread.

Calculate the maximum stress in the crosshead as designed due to bending, assuming concentrated loading and simple supports. Make a fully dimensioned drawing of the relative parts, shown in Fig. 1, completely assembled. A detailed drawing of the white metal pads showing the method of attachment to the slipper should also be made. The main drawing should consist of three co-related views in orthographic projection.

*Or*

2. The exhaust valve of a four-stroke cycle marine oil engine running at 120 revolutions per minute is to be operated by a cam and lever. The valve is 6 inches in diameter and the lift is 1½ inches. The arm of the lever operating the valve is 20 inches long and its axis is horizontal when the valve is closed. The arm operated by the cam is 15 inches long and its axis makes an angle of 140 degrees at the centre of the fulcrum shaft with the axis of the valve arm. The line joining the centre of the cam roller and the centre of the cam is at right angles to the axis of the cam arm of the lever when the valve is closed. The pressure in the engine cylinder at the point of release is 45 pounds per square inch, the load on the valve due to the spring is 5 pounds per square inch of valve area, and the equivalent weight of valve and lever at the axis of the valve is 40 pounds.

The valve opens during 60 degrees rotation of the crank shaft and closes in the same period. It is open in all for 210 degrees rotation of the crankshaft. In calculating the inertia load during the period of opening uniform acceleration may be assumed.

The cam profile is made up of tangent straight lines and circular arcs, the minimum radius of the cam being 4 inches, diameter of cam shaft 4½ inches, and the diameter of the valve lever fulcrum shaft 3¼ inches.

The valve tappet is to be suitably pivoted to the lever with provision for lubrication, and bushes fitted for all bearing pins.

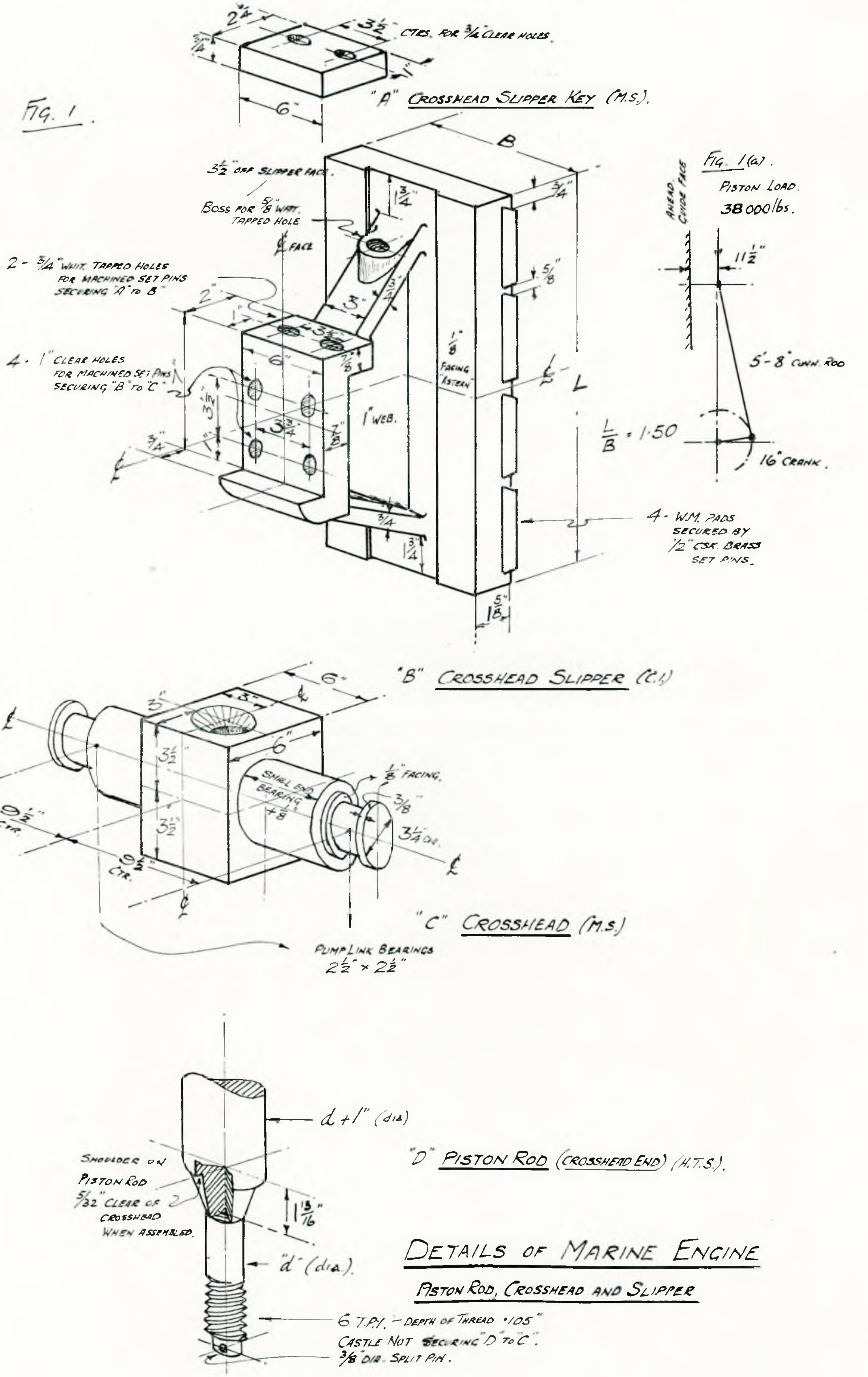
Design and make working drawings of the cam and lever in accordance with the following assumptions:—

Maximum permissible bearing pressure on fulcrum shaft 800 pounds per square inch.
Maximum permissible stress for cast steel lever 6,000 pounds per square inch.
Diameter of roller 1/3 minimum diameter of cam.
Width of cam and roller 1/6 minimum diameter of cam.
Maximum permissible pressure on roller pin 500 pounds per square inch.
Maximum permissible stress on tappet 5,000 pounds per square inch.

All other assumptions must be clearly stated.

**MARINE ENGINEERING DRAWING AND DESIGN.**

Wednesday, May 20th, 1936. 10.0 a.m. to 2.0 p.m.




DETAILS OF MARINE ENGINE

PISTON ROD, CROSSHEAD AND SLIPPER

## MARINE ENGINEERING KNOWLEDGE.—Morning Paper.

Thursday, May 21st, 1936. 10.0 a.m. to 1.0 p.m.

Not more than *four* questions from Section A and *two* questions from Section B to be attempted. All questions carry equal marks.

### Section A.—Boilers.

1. Describe in detail the process of raising steam in a cylindrical multitubular marine boiler from cold, commencing with the fitting of the doors after cleaning. What attention is necessary during the process? What length of time do you consider essential? What is the danger of reducing this time? What is your opinion of the practice of blowing down a boiler at the end of a voyage, and what would you suggest as an alternative?

2. In which direction in the shell of a cylindrical multitubular boiler are the stresses due to internal pressure the greatest? Show how the longitudinal and circumferential strengths are determined. Sketch part of a longitudinal seam and a circumferential seam, giving in each case the approximate pitch and diameter of the rivets, the number required per pitch, and the thickness of plates suitable for a boiler of the multitubular type 12 feet 6 inches in diameter, having a working pressure of 200 pounds per square inch.

3. Show clearly by means of separate sketches, the various ways in which the flat surfaces of a cylindrical multitubular marine boiler are supported against the internal pressure.

4. Describe a modern spring loaded safety valve suitable for a marine boiler. How is the valve adjusted and what means are employed to prevent subsequent overloading? What is the action of a safety valve lip, and what do you understand by "accumulation of pressure"? What is the usual allowance for this accumulation?

5. Sketch the cross sectional view through a marine water-tube boiler showing the drum, or drums in cross section. Indicate by arrows the path of the water in circulation and also the path of the products of combustion. In a separate sketch show how a tube is fitted to a drum.

6. Compare the advantages and disadvantages of the cylindrical multitubular and water-tube types of boilers employed for marine purposes. Which type would you select to withstand a working pressure of 500 pounds per square inch? Give reasons for your choice.

### Section B.—Reciprocating Engines.

1. Draw a section through a piston valve and liner. What engine usually employs this type of valve and what are its advantages? What is the object in cutting the steam ports in the liner obliquely?

2. Make a sketch of the upper part of a marine reciprocating engine connecting rod of the "open" type. Indicate how the top end bearing bolts and nuts are secured, and give a list of the materials used, briefly indicating the reasons for their choice.

3. Describe an arrangement for taking the propeller thrust on a single collar, and compare the pressure per square inch of surface with that carried on a multi-collar thrust block. Give figures for the usual pressure allowed. Explain carefully the principle involved in the design of the single collar thrust to ensure efficient lubrication.

4. Describe the process of placing a main engine bedplate into position on the tank top. How is the true alignment of the crankshaft, intermediate shafting and propeller shaft obtained? Mention how the bedplate is secured to the tank top. State how the main bearings are held in position, and in the event of a main bearing bolt breaking, briefly detail the work entailed in its renewal.

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## MARINE ENGINEERING KNOWLEDGE.—Afternoon Paper.

Thursday, May 21st, 1936. 2.0 p.m. to 5.0 p.m.

Not more than *three* questions from Section C or Section D **and** *three* questions from Section E to be attempted. All questions carry equal marks.

### Section C.—Internal Combustion Engines.

1. Describe a carburetter, an atomiser and a vaporiser as used for internal combustion engines. Give their functions, and state the type of engine in which each is used. How is ignition obtained in each of the engines you mention?

2. Give sketches of two types of piston employed in internal combustion engines. Show in the one case the top of the piston rod, and in the other case the top of the connecting rod, attached to the piston, and indicate how each is secured. In the sketch of the former type show a method of cooling by means of a liquid.

3. Show, by a diagrammatic sketch, how the valves of any four-stroke cycle Diesel engine are operated. Name the valves operated, and indicate clearly in the type selected how reversal is effected.

4. Distinguish clearly between the terms: "pulverisation", "penetration" and "turbulence" used in connection with the efficient combustion of oil fuel in Diesel engines. Describe fully two methods employed to inject fuel oil into the cylinder, indicating in each case the devices employed to achieve these ends.

5. Sketch a cylinder head suitable for a four-stroke cycle Diesel engine. Name and indicate the position of all the valves in the head, and show the provision made for the flow of cooling water. Show the method of making the joint between the head and the cylinder gas-tight. (Two views are required).

Section D.—Turbines.

1. Give an outline sketch of the plan of a marine turbine installation fitted with double reduction gear. Indicate the position of the flexible couplings and the provisions made for reverse running.

2. Sketch a section through the forward portion of an impulse turbine along the line of shafting, showing the adjusting block, the steam gland, and the first two stages of the turbine.

3. Compare by means of suitable sketches the types of blade in reaction and impulse turbines. Explain the reasons for the difference in design. Show in each case one method of securing the blades into the casing and rotor.

4. Give the reasons for using reduction gears in marine turbine installations. Describe briefly the arrangement of a set of double reduction gear. State how the alignment is maintained, how the teeth are lubricated and what special provision, if any, is made for lubrication when running in the reverse direction.

5. Give an outline diagram of the system of lubricating a marine steam turbine. Show the filters, the cooling arrangement, the gravity tanks, the oil pumps, and the method of controlling the pressures. State the usual oil pressures at the bearings and gearings.

Section E.—Auxiliaries.

Attempt *three* questions.

1. Show by means of a sketch how the motion of a vertical reciprocating steam steering engine is transmitted to the rudder. What is the maximum angle through which the rudder can move from its mid position and what limits this movement? Indicate in the sketch how the shock of a sea striking the rudder is absorbed, and prevented from damaging the transmitting mechanism.

2. Describe the necessary precautions against the risk of fire to be taken on ships burning oil fuel. Describe a portable chemical fire extinguisher and explain how it functions.

3. Give an outline plan of an engine room of a cargo steamer of about 7,000 tons displacement, using reciprocating engine propulsion, and show the positions of the necessary auxiliary machinery.

4. Sketch the valve gear of a duplex ballast pump. What is the object of the "lost motion" and how is the cushioning of the piston at each end of the stroke provided?

5. Describe an evaporator for producing fresh water for boiler feed. Where is the reduced orifice and what is its function? What is the usual density maintained in the evaporator? Give a reasoned explanation for this figure.

# INSTITUTE NOTES.

## Visit to Battersea Power Station.

By the courtesy of Sir Leonard Pearce, C.B.E., D.Sc., Engineer-in-Chief of the London Power Company, Ltd., a party of 30 members of the Institute visited Battersea Power Station on the afternoon of Saturday, June 6th, 1936. A complete tour and inspection of the station was made under the guidance of two members of the operating staff, Messrs. Holfield and Dullingham, who spared no effort to render the visit most interesting and instructive.

Mr. F. A. Hunter (Member), at the conclusion of the tour, expressed the thanks of the Council and the members of the party for the privilege so kindly afforded by the Engineer-in-Chief and particularly to the above-named members of the station staff for the courtesy and attention accorded to the visitors.

## ELECTION OF MEMBERS.

List of members elected at Council Meeting held on Monday, 8th June, 1936.

**Members.**

Reginald Thomas Benn, 1, Coniston Gardens, Ilford, Essex.

Andrew Dick Beveridge, 4, Raeburn Avenue, Bromborough, Ches.

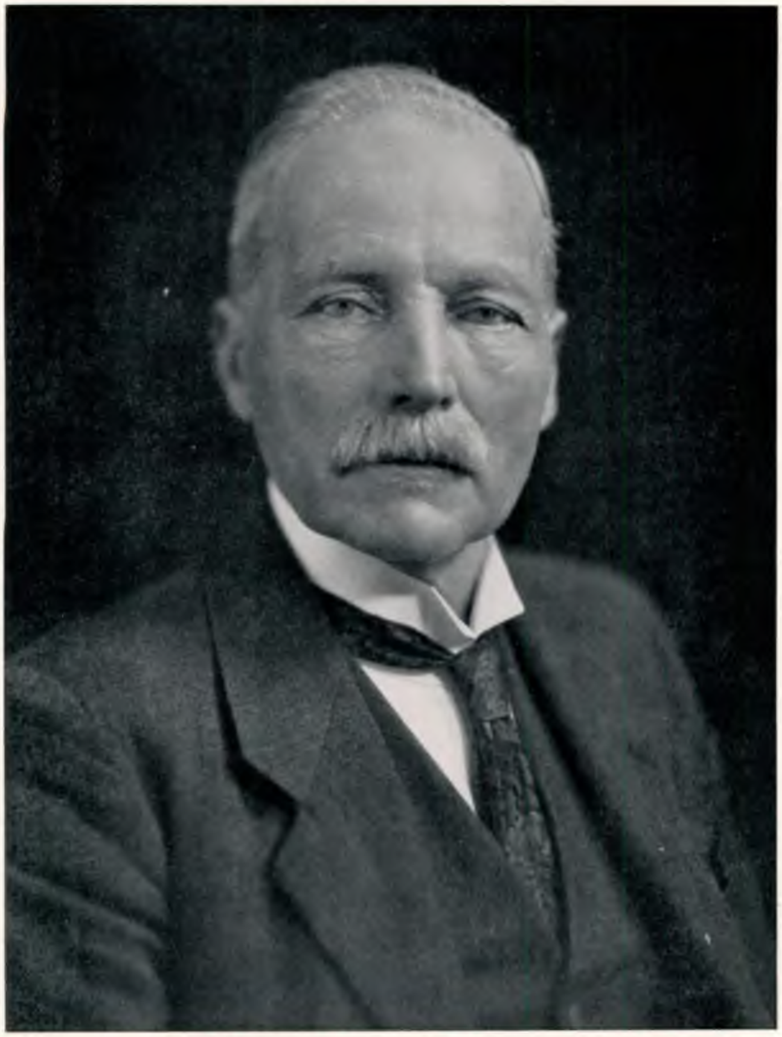
Arthur Henry Hodges, 18, Dursley Road, Shirehampton.

Edgar Allan Robinson Jackson, 13, Avenue Chevalier Van Ranst, Vieux Dieu, Antwerp, Belgium.

Edward Kyffin, 131, Fairfax Avenue, Hull.

Norman McKay, Military Road, Sydney, N.S.W., Australia.

Robert Thomas Oxburgh, Selworthy, St. Michaels Road, Blundellsands, Liverpool, 23.



The late Mr. JAMES SHANKS.

*Portrait by]* *[H. J. Whitlock & Sons, Ltd.*

# OBITUARY.

## Mr. James Shanks.

It is with deepest regret that we record the death of Mr. James Shanks, who passed away suddenly on Friday, May 8th, at his home at Leytonstone, London, E.

Mr. Shanks was born at Gartsherrie, Coatbridge, in 1858 and served his apprenticeship with Messrs. James Bain & Co., Harrington, Cumberland and Messrs. Andrew Barclay & Sons, of Kilmarnock, afterwards gaining experience in marine work with the Fairfield Shipbuilding & Engineering Co., Ltd. and the Pacific Steam Navigation Co. In 1879 he went to sea in the service of Messrs. Nelson, Donkin & Co. of Newcastle-on-Tyne, with whom he rose to the position of chief engineer. After obtaining his Extra-First Class Board of Trade Certificate in 1886, he joined the staff of the Wallsend Slipway & Engineering Co. and was chief engineer of the first British steamer, the s.s. "Elbruz", built to carry oil in bulk.

In 1890 Mr. Shanks was appointed to the Board of Trade as a ship and engineer surveyor, and in 1895 was promoted to the position of assistant to the Engineer Surveyor-in-Chief. He left the Board of Trade in 1897 to become superintendent engineer to Messrs. W. Lund & Sons and Messrs. J. & C. Harrison, a capacity in which he served for some fourteen years. He retired from the post in 1912 to become an active partner and director of Messrs. R. Walber, Ltd., Millwall.

Mr. Shanks, who was also a member of The Institution of Naval Architects, joined the Institute in 1891. In 1915 he was elected a vice-president and two years later he was appointed a member of Council for the three-year period 1917-18-19. As a result of his enthusiasm and ability his colleagues on the Council elected him as their chairman for the 1918 session. From then until 1928, when he was compelled to give up active work on behalf of The Institute on account of his health, Mr. Shanks rendered continuous service either as a vice-president or member of Council. From 1916 to 1929 he represented The Institute on the Merchant Shipping Advisory Committee. He is survived by his wife and two daughters.

The funeral took place at the City of London Cemetery, Manor Park, on Tuesday, May 12th, The Institute being represented by Messrs. George Adams, J. C. Mitchell, F. Tingle, H. J. Vose and the Secretary.

John Thomas Page, West Mount, Cockett Road, Sketty, Swansea.

Hugh Proudfoot, 92, Wanstead Lane, Ilford, Essex.

William Clapham Sutcliffe, 37, Shirley Avenue, Southampton.

William Whyte, P.O. Box No. 303, Sekondi, Gold Coast, West Africa.

**Associate Member.**

Howard Vincent Campbell, c/o 52, Randolph Road, Glasgow, W.1.

**Associates.**

Thomas Berry, 86, Rockfield Road, Anfield, Liverpool.

Frederick Bourne, Killingworth, Holystone Avenue, Whitley Bay.

John Bernard Norris, 41, Ennismore Avenue, Chiswick, W.4.

Promode Behari Purkayastha, Shillong, Assam, India.

Donald Fisher Ross, 7, Airmyn Avenue, Boothferry Road, Hull.

Alexander Angus Sommerville, Private Residence, Town Hall, Balmain, Sydney, N.S.W.

Alexander Thain, 218, Caulfield Road, East Ham, E.6.

Edwin Kenneth Winhall, 90, Walpole Road, S. Woodford, E.18.

**Students.**

Francis David Clark, 27, Robeson Street, Burdett Road, Bow, E.3.

Henry Charles Newberry, 8, Batson Street, E.14.

Terence Rowan, 21, Latimer Road, East Ham, E.6.

**Probationer Student.**

John Charles Fenner, 1, King's Avenue, Ashford, Kent.

**Transfer from Student to Associate.**

Ernest Northcott Cady, 18, Wansbeck Avenue, Cullercoats, Northumberland.

Herbert George Kimber, 4, Redvers Road, Chatham, Kent.

## ADDITIONS TO THE LIBRARY.

Purchased.

Board of Trade (Mercantile Marine Department), Staff of Surveyors, Inspector of Ships' Provisions, etc. H.M. Stationery Office, 2d. net.

King's Regulations and A.I. Amendments (K.R. 4/36). H.M. Stationery Office, 3d. net.

"The Director of Directors for 1936". Thomas Skinner & Co., 25s. net.

Presented by the Publishers.

"Liquid-Propellant Rocket Development", by R. H. Goddard. Smithsonian Institution.

"Practical Mathematics for Marine Engineers, First Class", by P. Youngson, B.Sc., and T. A. Bennett, B.Sc. James Munro & Co., Ltd., 12th edn., 602 pp., illus., 12s. 6d. net.

"Practical Mathematics for Marine Engineers, Second Class", by P. Youngson, B.Sc. and T. A. Bennett, B.Sc. James Munro & Co., Ltd., 12th edn., 502 pp., illus., 12s. 6d. net.

"Informal Discussion on High-Speed Diesel Engines". Diesel Engine Users Association.

British Standard Specification No. 163-1936 for Galvanised Steel Wire for Signalling Purposes (Galvanised Steel Wire Strand and Galvanised Solid Steel Wire).

Proceedings of The Institution of Civil Engineers, Vol. 239, containing the following papers :—

"The Evolution of Various Types of Crushers for Stone and Ore, and the Characteristics of Rocks as Affecting Abrasion in Crushing Machinery", by Miller and Sarjant.

"Lambeth Bridge", by Groves.

"Construction of a Submergible Road-Bridge over the Nerbudda River near Jubbulpore, Central Provinces, India", by Dean.

"The Perak River Hydro-Electric Power Scheme", by Hellstrom.

"The Construction of the Chenderoh Water-Power Plant of the Perak River Hydro-Electric Power Scheme", by Rennie.

"The Construction of Silvan Dam, Melbourne Water-Supply", by Kelso.

"The Water Supply of Murree and its Recent Extensions", by Bromage and Sethi.

"The Construction of the Silent Valley Reservoir, Belfast Water Supply", by McIldowie.

"The Construction of Haifa Harbour", by Buckton.

"The Development and Construction of the Port of Beira", by Frampton.

"Saint John Harbour, New Brunswick", by Gray.

"The Development of the Parsons Steam Turbine", by R. H. Parsons. Constable & Co., Ltd., 420 pp., copiously illustrated. 42s. net.

Those of us who are old enough to remember the inception of the Parson steam turbine know that the marine turbine with which we are now so familiar was a development of Sir Charles Parson's rotary steam motor on the turbine principle, originally patented by him in 1884, and designed mainly for driving electric generators. Thirteen years were to elapse before the Spithead Naval Review following three years of intensive experimental work. Thereafter, land and marine turbine practice advanced side by side until nowadays there is no intrinsic difference between them—except that the latter is governed by limitations of weight and space which do not arise in land installations.

The present noble volume is a reprint of a series of articles which appeared in "The Engineer" in 1934/5. No attempt is made to deal with the special application of the turbine to marine propulsion, a subject vast enough to demand a volume to itself.

The Author starts at the very beginning of Sir Charles Parsons enterprise and describes his first steam turbine—an axial double-flow unit which developed 7.5 kW. at a speed of 18,000 r.p.m.! It ran for many years on saturated steam of 80lb. per square inch and exhausted to atmosphere; the consumption under those conditions being 129lb. per kW. hour. That historic machine is now preserved in the Science Museum, South Kensington.

Five years after the original invention, when some 300 turbines had been made, the largest being 75 kW., Parsons temporarily lost his patent rights to the manufacturers and with characteristic energy and courage started *de novo* with his radial flow turbine on which the firm of Messrs. C. A. Parsons & Co., Ltd. at Heaton, Newcastle-on-Tyne, was founded. He regained control of his axial flow patents in 1894 and, since then, all Parsons turbines have been built on that principle.

It is interesting to note that the first Parsons geared turbo-alternator was introduced as far back as 1896. That was a machine of 150kW., supplied to the Newcastle and District Electric Lighting Co. The turbine ran at 9,600 r.p.m. and drove its alternator at 4,800 r.p.m. through a 2 to 1 double-helical gearing.

Space does not permit of following the various developments of tandem turbines, successive expansions, methods of blading, labyrinth packings, multiple shaft and cross compound turbines, or the ingenious relay and governing valves introduced to meet varying conditions of steam pressure, superheat and speed. All these are fully described and illustrated. Suffice it to say that every essential detail is represented and that it is an education in itself to turn over the 410 pages merely to admire and study the 341 figures shown, many of these being folding plates produced with the beautiful clearness to which we are accustomed in the weekly issues of "The Engineer".

Mention should be made of the final chapters dealing with turbo-blowers and centrifugal air-compressors which are, of course, merely reverse turbines in which the blades do work on the air or gas like a screw propeller slicing through the water.

It must not be supposed that this is a textbook enabling one to design a steam turbine. Readers are presumed to be fairly familiar with the subject and it is for just such people that this historical record of fifty years progress has been written. But as already pointed out, no engineer can fail to be impressed by the number and completeness of the sectional drawings, or to learn something each time from a close inspection, preferably with a reading glass, of the details of design and construction.

"Rubber Latex", by H. P. Stevens, M.A., Ph.D., F.I.C. and W. H. Stevens, A.R.C.Sc., F.I.C. Issued by The Rubber Growers' Association, Inc., 19, Fenchurch Street, E.C.3. 4th edn., 224 pp., illustrated.

This book deals *inter alia,* with the properties, composition, coagulation, concentration, manipulation and compounding of latex and latex pastes, and its stabilisation for industrial purposes. The vulcanisation of latex and latex products, dipping and electro-deposition and the marketing and applications of latex are also discussed. A final chapter deals with a selected list of nearly 1,000 recent British patents and testifies to the growing importance which is attached to the direct application of latex. Indexes to the text and to the patents, together with a very full bibliography of books of reference and literature are included and should prove very useful.

Copies of this book may be obtained free by Members of The Institute on application to the publishers, who will also be pleased to supply a small quantity of latex for investigatory work.

"Electricity and Fire Risk", by E. S. Hodges, F.C.I.I. Sir Isaac Pitman & Sons, Ltd., 10s. 6d. net.

The principles, ideas, suggestions, and above all the practical experience set forth in Mr. Hodges' book would, if kept in mind by marine engineers, and all in charge of electrical installations, greatly reduce the fire danger from the use of electricity. The book is not addressed directly to marine engineers. There are no details of how the principles are to be applied to ships, but this can well be left to common sense and the use by the marine engineer of his specialised knowledge. For instance the danger of shorts to earth in a steel ship is more acute than, say, in dwellings or factories ashore. Vibration is greater on shipboard than in a power station, and there is increased danger of damage to insulation from heat, oil and water.

The book must not be taken as a textbook of electrical engineering. It does not describe, for instance, electrical machines and the method of construction or operation. Mr. Hodges, however, does supply a serious need in electrical literature by pointing out in exact detail fire dangers and the remedies therefor in almost every circumstance of practical generation, distribution, and the use of electrical energy.

In connection with generating station practice, the modern conditions of the use and consequent dangers from large quantities of oil in transformers, switches, oil-filled cables and also turbine lubrication, including the circulation of hydrogen in place of air for cooling generators, are discussed, and fire and explosion dangers clearly pointed out. The book proceeds to deal with conductors, insulators, etc., most of the latter being regarded as inflammable. Each is taken separately and the fire hazard discussed. The Author passes on to internal wiring, fuse boards, joints, looping-in, connectors, and very special warning is given in respect of the workmanship, cheap material, cheap wire, cables and fittings, together with careless and bad erection, which are held to be causes of a large proportion of fires of electrical origin. As equal blame might be placed on careless use and neglect, periodical inspection is enjoined.

The merits and demerits of systems of wiring such as "hard sheathed", "tough rubber compound covered", "screwed conduit", are reviewed. Outdoor and underground wiring, and special situations such as amidst chemical fumes, explosive vapours or dusty atmospheres are included. Heating appliances, and motors in similar dangerous situations, and the special types of appliances to be used when explosive danger is present are clearly set forth.

A whole chapter is devoted to earthing, now considered much more necessary in view of the almost universal use of alternating current ashore with the attendant danger to life. The tendency to advocate alternating current for use at sea is worthy of consideration, and should repay study. The testing of insulation resistance, continuity, and resistance of earthing connections, also the polarity of switches are discussed in an interesting manner. A further chapter is devoted to accumulator charging from which one might be led to hope that no celluloid accumulators are used on shipboard. Fire extinguishing appliances are dealt with including carbon tetrachloride, carbon dioxide, and methyl bromide.

The foregoing gives a mere outline of a volume of nearly 400 pages, but is intended to indicate that it is a most valuable treatise of fire dangers of electrical installations. It is a very useful book because of the tendency for the public and even engineers to minimize these very definite hazards and thus endanger life and property which might be saved if the suggestions and precautions in this book were adopted. Throughout the work are extracts from publications of the Factory Department of the Home Office, Electricity Supply Regulations, and other sources giving actual facts in respect of fires to emphasize points of hazard. Extracts from reports of the Senior Electrical Inspector of Factories, and regulations of the Institute of Electrical Engineers are cited for the same purpose, and the valuable inclusion of the Author's own practical experience. It is an up-to-date book which can be recommended to both sea and shore staffs.

"Principles of Combustion in the Steam Boiler Furnace", by A. D. Pratt, Messrs. Babcock & Wilcox, Ltd., 35, Farringdon Street, London, E.C.4.

It is generally accepted that the efficiency of heat absorption in modern boilers is high and that therefore the economical production of steam depends more on the efficient generation of heat in the furnace than on anything else. In other words, it is only in this part of the boiler where appreciable improvement can be effected. This book should be welcomed by furnace operators as it places at their disposal the broader principles involved in the combustion of many different types of fuel—the Author does not confine himself to coal.

The laws of chemistry and physics as applied to combustion are clearly set out and a good explanation of "higher" and "lower" heating values of fuels is given Several well-known and frequently used formulae are derived from first principles and their limitations stated. The value of flue gas analysis is stressed and the errors to be guarded against in taking samples are pointed out. The chapter on combustion losses is very complete and smoke is dealt with in an interesting and instructive way. The remarks on the computation of combustion data will repay careful study but some experimental figures such as certain ignition temperatures are perhaps given to too great a degree of accuracy.

"The Structure of Metals and Alloys", by William Hume-Rothery, M.A., D.Sc. The Institute of Metals, 120pp., illustrated.

So diverse is the knowledge essential to the present-day metallurgist, and so rapid has been the development of modern knowledge in respect of the fundamental electronic principles governing the crystalline structures of pure metals and of their alloys that this lucid survey of the work done during the past fifteen years should prove as interesting to metallurgists in general as the Author's previous publication "The Metallic State. *Electrical Properties* and Theories".

While present knowledge of the relationship between the atomic arrangements in the crystal lattices and the physical properties of metals or their alloys is admittedly imperfect, there is definite evidence that a close relationship exists, and no metallurgist or engineer can ignore the importance of radiographic research in the investigation of the properties of materials. The published information in respect of such research is dispersed so widely, however, throughout the technical press of the world that it is difficult for the metallurgist—unless specifically engaged in research—to keep abreast with recent progress, and to such a one this concise summary should prove of absorbing interest.

The Author's deliberate selection of a single point of view in presenting controversial matters in no wise detracts from the value of the book, and, assisted by the comprehensive bibliography appended to each section, should stimulate reference to the original publications.

The information is presented to the reader clearly and progressively, the review being divided conveniently into six parts which consider :—

I. The electronic structures of free atoms, the forces which become operative when atoms are bound together to form molecules, and the relation between such forces and those which hold atoms or molecules together in solid crystals.

II. The crystalline structures of the elements—particularly those which are metallic—in relation to their position in the Periodic Table.

III. The atomic radii of the elements and the interatomic distances in their crystal lattices.

IV. The crystal lattices of those metallic solid solutions forming the end phases in equilibrium diagrams (designated primary solid solutions) and the factors that either by favouring or by restricting the formation of such solid solutions affect the forms of the liquiders, the soliders and the solid solubility curves.

V. The crystalline structures of intermediate phases in alloy systems or "electron compounds", in the light of the "electron concentration rule".

VI. The effect upon the physical properties of crystals of structural abnormalities or imperfections.

"Tanker Technique 1700—1936". By B. Orchard Lisle. World Tankship Publications, 616, Cecil Chambers, Strand, London, W.C.2, 84 pp, illus., 2s. net.

This manual will meet with special interest, as it fulfils the purpose of recording the history and development of the tanker from its earliest instances to the current year. It has been carefully compiled and contains much original information which has never before appeared in print. Shipbuilders in the United Kingdom, Continental Europe and the United States of America as well as officials of principal oil companies, have been consulted freely during its compilation. It undoubtedly supplements other books on tankshipping and is an excellent work of reference. It is well illustrated with pictures, and the many diagrams are clear. The book contains statistics of no little interest—not the least of which is the table of the world's tanker construction for the entire period covered by the book. It is particularly timely inasmuch as it comes out in the year of the Golden Jubilee of the tanker in its modern principle of design. The "Gluckauf", constructed in 1886 in an English yard, was the first.

"Elementary Practical Chemistry", by Arthur I. Vogel, D.Sc., D.I.C., F.I.C. Blackie & Sons, Ltd. 220pp., illus., 3s. net.

Dr. Vogel has produced a very useful book. It is intended for use by beginners up to Matriculation standard and has been specifically written for elementary students in technical colleges and similar institutions. As such it serves its purpose admirably.

The book opens with chapters on preliminary operations, measurements of mass and volume, solution and mixtures and compounds and goes on to deal with the chemical laws, equivalents, air, oxygen, hydrogen, carbon, the halogens, nitrogen sulphur and acids, bases and salts. The final chapters give an introduction to volumetric analysis (acidimetry and alkalimetry) followed by some miscellaneous experiments, while a useful appendix includes tables and notes on the treatment of accidents. Brief descriptions of underlying theory reveal the aims of experiments and these are described in satisfactory detail.

A little constructive criticism may be appreciated. Expt. 5 and 46 : the reviewer feels that mention of a burette here is rather mixing the accuracy. Expt. 39 and 51 : it is extremely difficult for inexperienced students to avoid loss due to "bumping" when liquids are taken to dryness in crucibles and often even in open hard glass tubes. A previously heated and weighed asbestos plug in a constricted hard glass tube helps to overcome this difficulty. Expt. 50 : better results are obtained if the magnesium nitride, formed with the oxide, be decomposed with water and heating continued (after this interruption) to constant weight. This modification is also instructive and adds a little interest to the chemistry of relatively inert nitrogen. Expt 54 : the heavy copper precipitate may be more quickly washed by decantation twice with water and twice with alcohol. Expt. 93 : the silver nitrate test for acetylene might have been mentioned.

A few minor errors occur.

P. 74 l. 5 : "break the thread". How?
P. 82 l. 15 : for "32·8" read "31·8".
P. 142 l. 10 : print "brown" under "$2NO_2$".
P. 178 ll. 11-13 : rather confusing.
P. 193 l. 20 : "100" omitted from numerator.
P. 206 l. 7 : for "0·991440" read "0·91440".

The author is, however, to be congratulated upon a carefully written book with good diagrams and pleasing arrangement. The book may be recommended without the slightest hesitation.

## Visit to the Fuel Research Station. East Greenwich.

The annual visiting day at The Fuel Research Station, East Greenwich, occurred this year on Tuesday, 9th June. Twelve members of the Institute were accorded the privilege of being included in the large party which was present, and the visitors keenly appreciated the opportunity of inspecting the laboratories and large-scale experimental plants and of obtaining an insight into the whole range of the research work of the Department. The cordial thanks of the Council and of the above-mentioned members have been conveyed to the Director of Fuel Research for being allowed to participate in this visit.

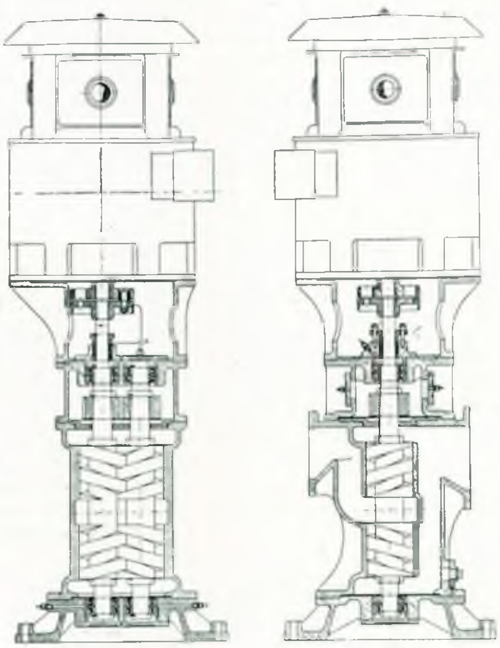
## ABSTRACTS.

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

### A Screw Displacement Pump.

"The Motor Ship", April, 1936.

In order to meet the requirements of the lubricating-oil service in the engine-room of a modern motor ship, it is generally agreed that the pumping unit should be of the vertical pattern occupying little space, and that it should be capable of running continuously, maintaining volume output and pressure under varying conditions of suction lift and delivery head. It is quite usual for the pump to be set up with its suction branch between 8ft. and 10ft. vertically above the level of the oil in the ship's double-bottom tank. The circulation of the lubricating oil through bearings and in the cooling of pistons causes considerable aeration, and in certain cases the end of the suction line may be momentarily uncovered due to the movement of a ship. It is often necessary that the lubricating-oil pump be capable of working uninterruptedly, drawing from the double-bottom tank large proportions of air, and at certain times, perhaps, to exhaust air only until such time as the suction pipe is immersed in the body of the oil.



Sectional elevations and plan of the pump.

For this purpose Stothert and Pitt, who, for some years past, have built pumps for bearing-oil and piston-cooling services, have now developed a screw displacement pump of a vertical design, as indicated in the accompanying illustrations.

Special tests have been made to prove the efficiency of this pump under the foregoing conditions. The tests included the running of the pump with lubricating oil under a static suction lift of 8ft. to 10ft. against a discharge pressure of 50lb. per sq. in., and during pumping proportions up to about 90 per cent. of air to oil were admitted through a snifting valve in the suction line. Under this condition the pump continued to run quietly, exhausting the mixture of air and oil.

A further test was made with the end of the suction pipe raised to the surface of the oil in the source tank, so that a heavy vortex was created round the pipe end and a large proportion of air drawn in. During this trial the pump continued to run smoothly, dealing with the mixture of air and oil and maintaining pressure on the discharge gauge. Special observation was made of the effect produced by intermittently opening and closing the main valve in the suction line, so as to imitate the condition which might be met on board ship, when in a heavy sea the oil might leave the suction pipe temporarily uncovered. It was noted that, however rapidly the suction valve was manipulated, the pump continued to run smoothly without vibration or hammer rising from cavitation, and pressure was maintained at the discharge gauge until the flow ceased, due to the suction valve being completely closed.


New vertical rotary displacement pump.

An important feature of this design is that with a suction valve gradually closed until a vacuum reading of over 29in. of mercury is registered, the pump passes through the usual critical stage associated with cavitation with practically no hammer effect.

**Particulars of Modern Marine-Boiler Installations**

from Eng. Rear Admiral Whayman's Paper read before the Institution of Naval Architects, 2nd April, 1936.
"Engineering", 17th April, 1936.

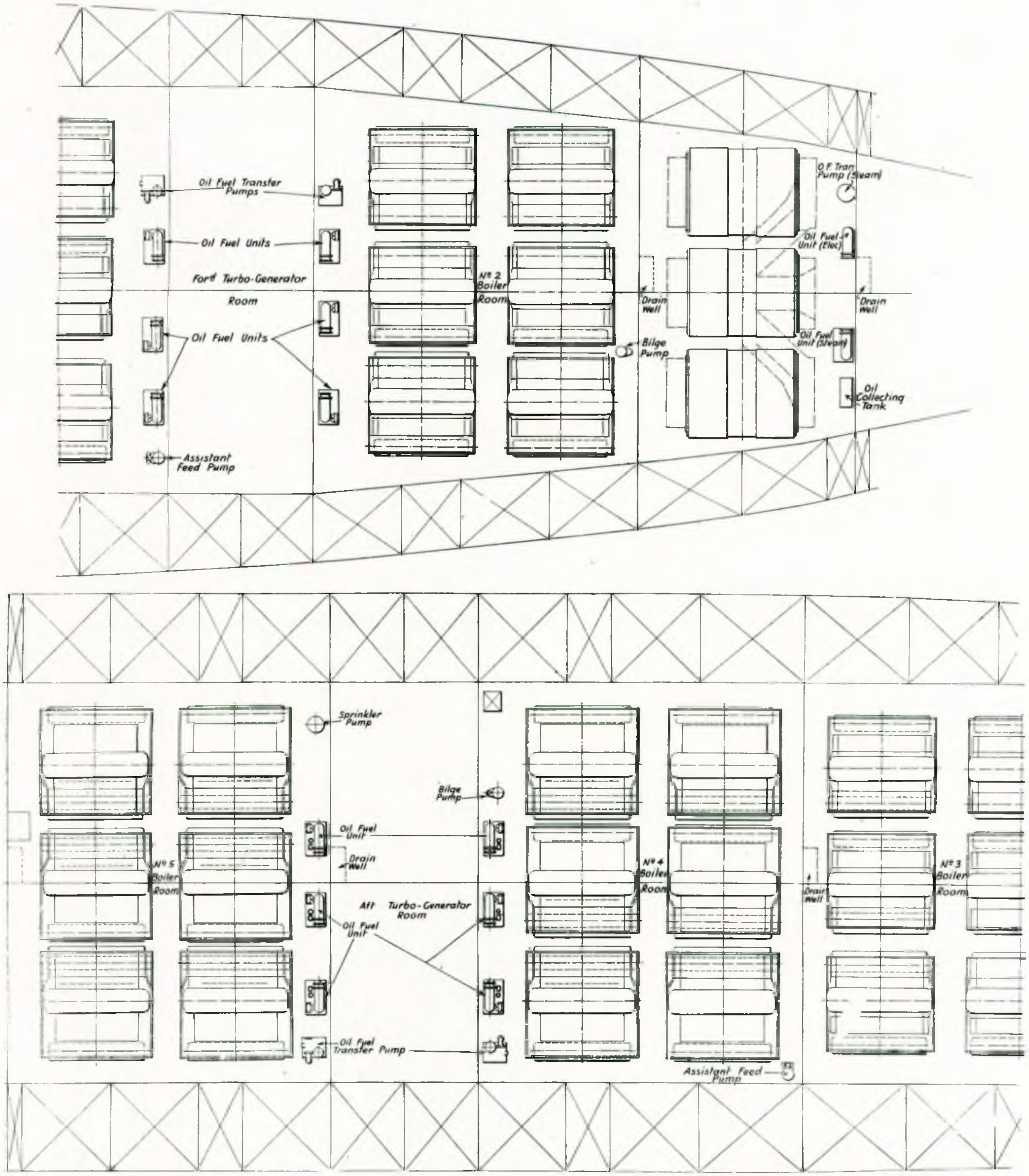
| Part. | Ship. | Year Commencing Service. | Boilers. | Total Boiler Generating Heating Surface. | Total Evaporation, Normal Load. | Evaporation per Sq. Ft. Boiler Generating Surface. | Total Weight with Water. | Total Floor Area of Boiler Rooms. | Evaporation per Ton Weight. | Evaporation per Sq. Ft. Area. | Steaming Conditions. | Number of Boilers in Use. | Outlet Pressure. | Saturated Steam Temperature. | Outlet Steam Temperature. | Degrees of Superheat. | Feed Temperature. | Total Evaporation. | Evaporation per Boiler. | Fuel per Boiler. | Fuel Value Gross. | Steam per Lb. Fuel. | Steam per Sq. Ft. Heating Surface. | Overall Efficiency on Gross Fuel Value. | Heating Surfaces, Sq. Ft. Total. Boiler. | Heating Surfaces, Sq. Ft. Total. Superheater. | Heating Surfaces, Sq. Ft. Total. Air Heater. | Gas Temperature, Deg. F. Out of Boiler. | Gas Temperature, Deg. F. Out of Air Heater. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sq. ft. | Lb. per hour. | Lb. per hour. | Tons. | Sq. ft. | Lb. per hour. | Lb. per hour. | | | Lb. sq. in. | Deg. F. | Deg. F. | Deg. F. | Deg. F. | Lb. per hour. | Lb. per hour. | Lb. per hour. | B.Th.U. | Lb. | Lb. | Per Cent. | | | | | |
| 1 | Statendam ... | 1929 | 6 Babcock | 42,960 | 210,000 | 4·9 | 744 | 4,278 | 282 | 49 | Service | 5 | 425 | 453 | 646 | 193 | 300 | 210,400 | 42,080 | 2,782 | 18,400 | 15·13 | 5·9 | 87·38 | 35,800 | 8,400 | 35,800 | — | 280 |
| | Empress of | 1931 | 8 Yarrow | 99,552 | 497,750 | 5 | 1,872 | 7,722 | 266 | 64·5 | Service | 8 | 420 | 452 | 740 | 288 | 300 | 440,000 | 55,000 | 3,022 | 18,500 | 14·56 | 4·43 | 88 | 99,552 | 52,616 | 117,032 | 550 | 240 |
| | Britain | | 1 Johnson | 6,841 | — | — | — | — | — | — | | (Yarrow) | | | | | | | | | | | | | | | | | |
| | Carthage ... | 1931 | 4 Yarrow | 25,200 | 138,800 | 5·51 | 392 | 2,780 | 354 | 50 | Service | 4 | 400 | 448 | 725 | 277 | 350 | 138,800 | 34,700 | 2,285 | 18,750 | 15·19 | 5·51 | 86 | 25,200 | 8,000 | 26,000 | — | 280 |
| | Conte di Savoia | 1932 | 10 Yarrow type | 134,400 | 880,000 | 6·56 | 2,720 | 11,760 | 323 | 75 | — | 10 | 448 | 458 | 725 | 267 | — | 880,000 | 88,000 | — | — | — | 6·56 | — | 134,400 | 70,960 | 166,600 | — | — |
| | Bremen ... | 1931 | 20 Yarrow type | 118,260 | 770,000 | 6·56 | 1,510 | 16,600 | 510 | 46·5 | — | 20 | 353 | 435 | 680 | 245 | — | 770,000 | 38,500 | — | — | — | 6·56 | — | 118,360 | 87,800 | | — | — |
| | Manhattan ... | 1933 | 6 Babcock & Wilcox Express type | 63,000 | 305,000 (trial) | 4·84 | — | 7,056 | — | 43·3 | Service | 6 | 400 | 448 | 670 | 222 | 300 | 305,000 | 50,833 | 3,508 | 18,500 | 14·5 | 4·84 | 84·47 | 63,000 | 15,042 | 49,242 | 523 | 335 |
| | Queen of | 1933 | 8 Babcock | 39,720 | — | — | 832 | 4,532 | 211 | 83·8 | Service | 6 | 390 | 445 | 590 | 145 | 310 | 175,000 | 29,167 | 2,026 | 17,500 | 14·39 | 5·9 | 84·4 | 29,790 | 13,380 | 15,840 | 500 | 350 |
| | Bermuda | | (6 steaming) | 29,790 | 175,000 | 5·9 | — | — | — | — | | | | | | | | | | | | | | | | | | | |
| | Alcantara ... | 1934 Conv. | 3 Johnson | 24,750 | 231,000 | 9·28 | 249 | 2,136 | 928 | 108·2 | Trial | 3 | 420 | 452 | 723 | 271 | 324 | 202,500 | 67,500 | 4,527 | 18,600 | 14·91 | 8·18 | 87 | 24,750 | 5,850 | 45,000 | 600 | 302 |
| | Normandie ... | 1935 | 29 Penhoët | 312,000 | 1,360,000 | 4·35 | 3,445 | 26,800 | 394 | 50·7 | Service | 25 | 400 | 448 | 662 | 214 | — | 1,360,000 | 54,400 | 3,370 | — | 16·2 | — | — | 268,950 | 44,925 | 147,950 | 428 /554 | 284 /338 |
| | Orion and Strathmore | 1935 | 6 Babcock (4 large, 2 small) | 37,030 | 240,000 | 6·47 | 666 | 3,564 | 360 | 67·5 | Trial | 6 | 425 | 453 | 725 | 272 | 330 | 240,000 | 48,400 / 23,200 | 3,190 / 1,530 | 19,000 | 15·2 | 6·47 | 86·25 | 37,030 | 5,534 | 40,000 | 500 | 300 |
| | Do. | — | — | — | — | — | — | — | — | — | Trial | 4 large | 417 | 452 | 732 | 280 | 320 | 177,000 | 44,250 | 2,880 | 19,000 | 15·15 | 5·93 | 87·2 | 29,860 | 4,280 | 32,000 | 550 | 320 |
| 2 | Scharnhorst... | 1935 | 4 Wagner | 27,976 | 316,800 | 11·3 | 398 | — | 795 | — | — | 4 | 737 | 511 | 878 | 367 | — | 316,800 | 79,200 | — | — | — | 11·3 | — | 27,976 | 53,720 | | — | — |
| | Potsdam* | 1935 | 4 Benson | 14,632 | 246,400 | 16·8 | 202 | — | 1,220 | — | — | 4 | 1,325 | 581 | 878 | 297 | — | 246,400 | 61,600 | — | — | — | 16·8 | — | 14,632 | 10,760 | | — | — |
| | Gneisenau ... | 1935 | 4 Wagner | 26,124 | 321,200 | 12·3 | 402 | — | 800 | — | — | 4 | 737 | 511 | 878 | 367 | — | 321,200 | 80,300 | — | — | — | 12·3 | — | 26,124 | 51,648 | | — | — |
| 3 | Design No. 1† | — | 6 Babcock | — | — | — | 900 | 3,692 | 334 | 81·3 | Service | | | | | | | | | | | | | | | | | | |
| | | | (5 steaming) | 38,600 | 300,000 | 7·78 | — | — | — | — | Full Power | 5 | 585 | 480 | 760 | 280 | 330 | 330,000 | 66,000 | 4,580 | 18,500 | 14·4 | 8·54 | 85 | 38,600 | 8,500 | 45,000 | 600 | 350 |
| | Design No. 2† | — | 6 Babcock SX | — | — | — | 834 | 3,328 | 385 | 96 | Do. | | | | | | | | | | | | | | | | | | |
| | | | (5 steaming) | 43,150 | 320,000 | 7·44 | — | — | — | — | | 5 | 800 | 520 | 750 | 230 | 330 | 354,000 | 70,800 | 4,700 | 18,900 | 15·02 | 8·2 | 85 | 43,150 | 9,650 | 50,000 | 600 | 350 |
| | Design No. 3† | — | 6 Babcock SX | — | — | — | 802 | 3,328 | 375 | 90 | Do. | | | | | | | | | | | | | | | | | | |
| | | | (5 steaming) | 43,130 | 300,000 | 6·95 | — | — | — | — | | 5 | 782 | 515 | 662 | 147 | 330 | 320,000 | 64,000 | 3,980 | 18,900 | 16·16 | 7·45 | 87 | 43,130 | 5,840 | 50,000 | 600 | 310 |
| | Design No. 4 | — | 4 Loeffler, main | — | 206,800 | — | 320 | 2,821·5 | 646 | 73·3 | Do. | 4 | 1,850 | 627 | 890 | 263 | 330 | 206,800 | 51,700 | 3,640 | 18,500 | 14·2 | — | 86·25 | — | 8,250 | 43,000 | 720 | 300 |
| | | | 2 small, starting | | | | | ... | | | | | | | | | | | | | | | | | | | | | |
| | Design No. 5 | — | 4 Sulzer | 17,200 | 198,000 | 9·2 | 124 | 1,800 | 1,600 | 110 | Do. | 4 | 1,420 | 590 | 840 | 260 | 330 | 198,000 | 49,500 | 3,230 | 18,500 | 15·3 | 11·5 | 86 | 17,200 | 4,300 | 10,800 | 600 | 300 |
| | Design No. 6 | — | 3 Velox | 2,910 | 285,000 | 98·0 | 195 | 1,200 | 1,460 | 238 | Do. | 3 | 450 | 459 | 825 | 366 | 210 | 285,000 | 95,000 | — | 19,000 | 13·0 | 20·0‡ | 87/88 | 2,910 | 4,710 | 6,780 | 310§ | — |

* Weight is without economiser and air heater.
† Space and weight for six boilers, including air heaters.
‡ Per square foot of total heating surface.
§ Out of economiser.

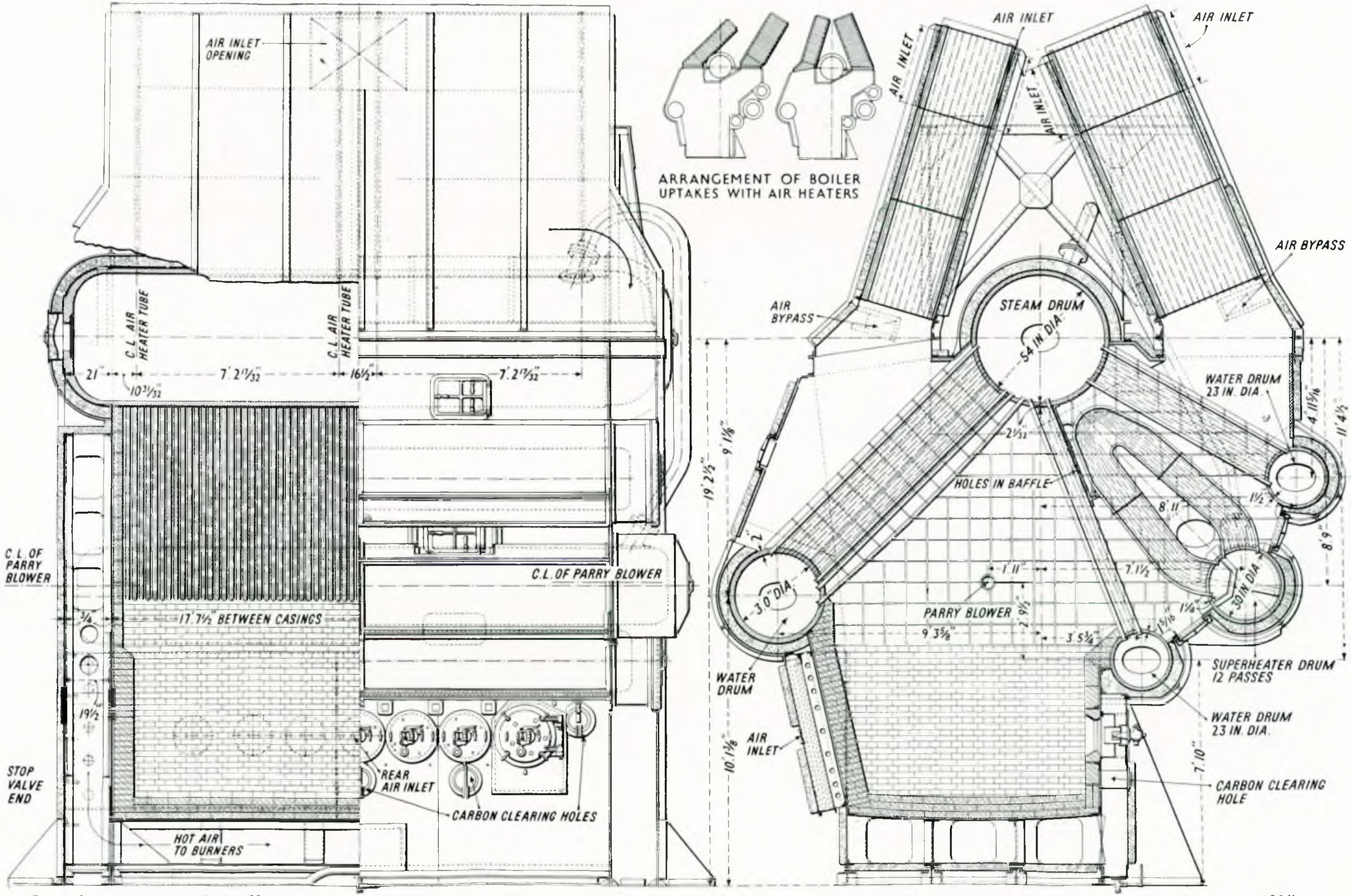
## R.M.S. "Queen Mary".

"Shipbuilding & Shipping Record", 21st May, 1936, and "The Marine Engineer", June, 1936.

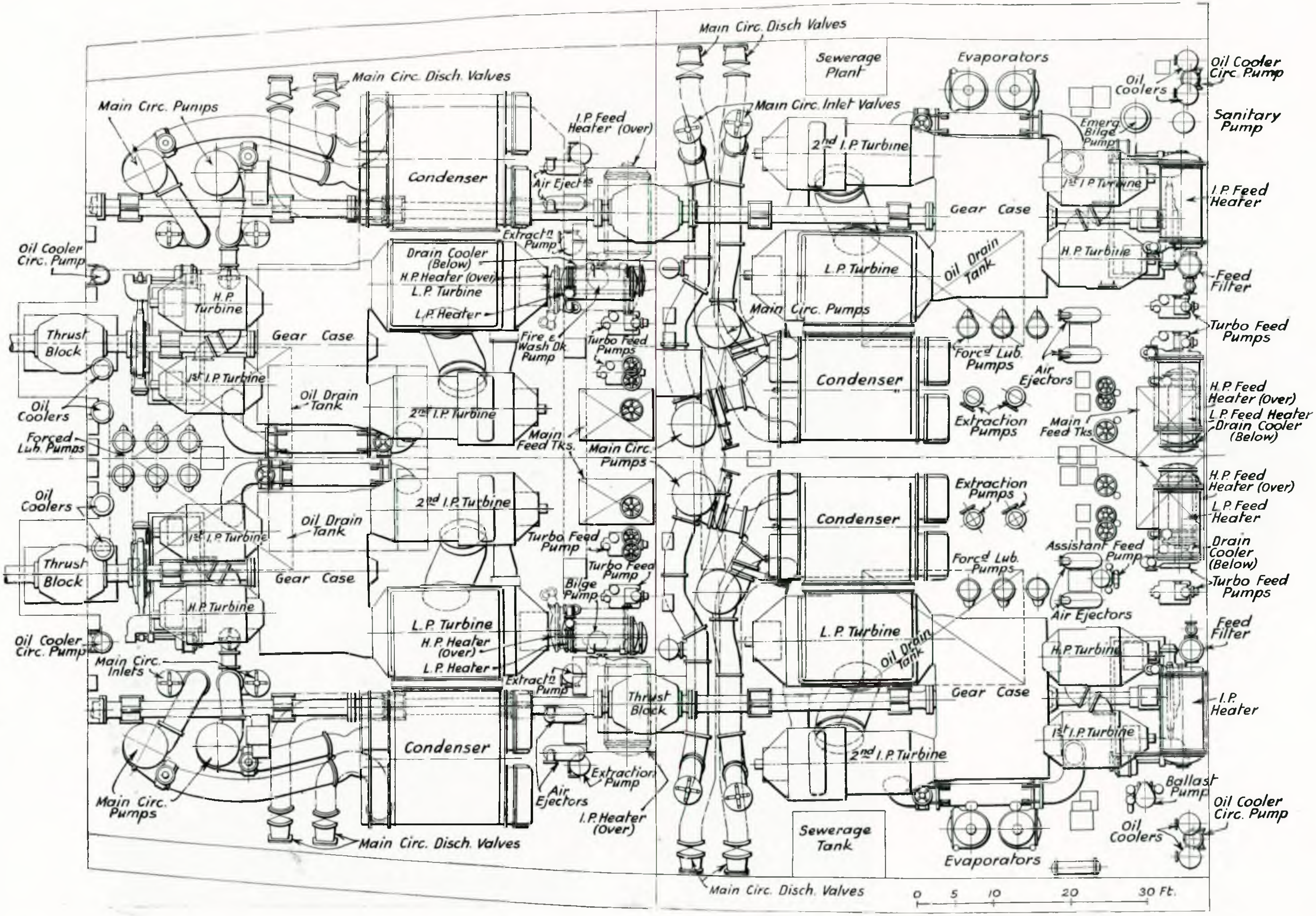
The following illustrations of the boiler and machinery arrangements of the R.M.S. "Queen Mary" are reproduced, by courtesy of the journals named, as being of special interest.




Plan of the boiler rooms of the "Queen Mary", showing the location of the three large double-ended Scotch boilers in relation to the 24 Yarrow-type water-tube boilers. (From "The Marine Engineer", June, 1936).




General arrangement of the Yarrow type water-tube boilers built at Clydebank for the "Queen Mary". (From "Shipbuilding and Shipping Record", May 21st, 1936).




Plan of the main engine rooms of the "Queen Mary", indicating the manner in which the shafts to the two outboard propellers pass between the low-pressure turbines and condens ers of the inboard sets. (From "The Marine Engineer", June, 1936).

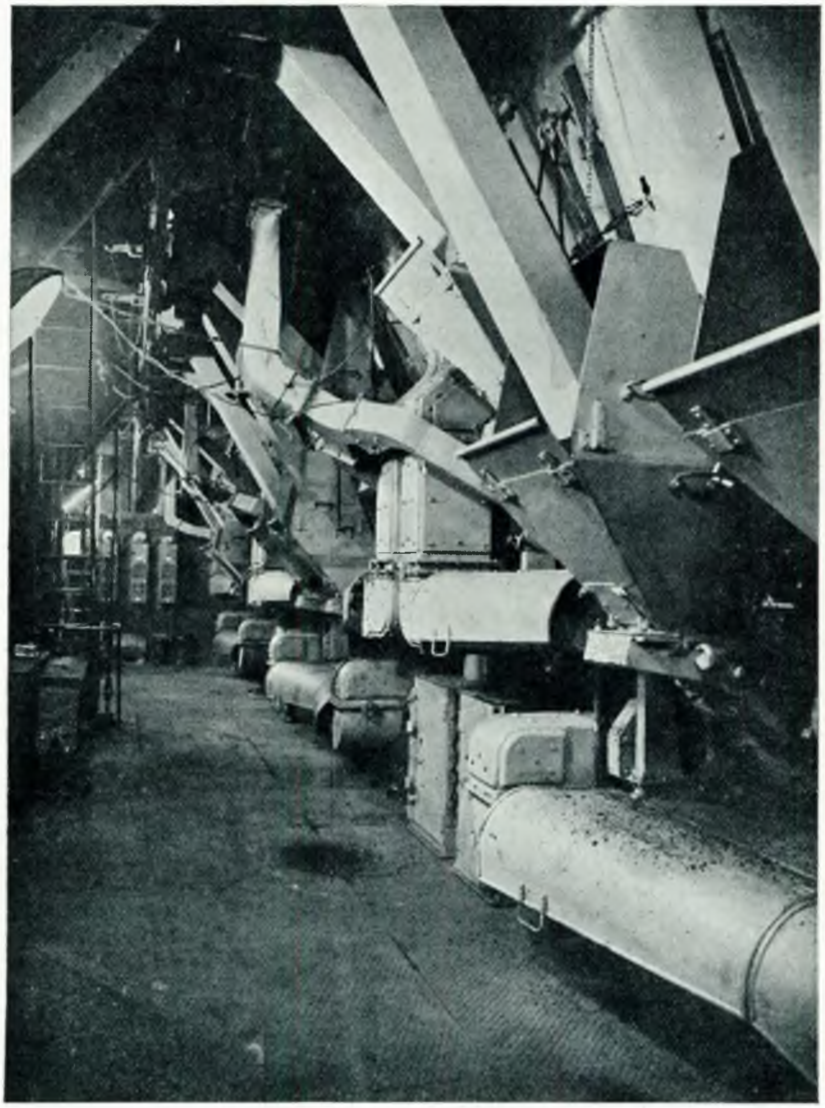
## Mechanical Stoking for Scotch Marine Boilers.

"The Engineer", February 7th, 1936.

We recently had the opportunity of voyaging on the trial trips of a vessel which is almost unique; we say almost because part of the novel equipment has already been tried out on a sister ship. She is the "Manchester Port", owned by Manchester Liners, Ltd., and is well represented in the *engraving at the head of this page. Her peculiarity lies in the fact that she is equipped with a fully automatic system of mechanical stoking in Scotch boilers. There are, of course, several vessels in service with mechanical stokers fitted under water-tube boilers, particulars of which have been given from time to time in *The Engineer,* but we believe that, with the exception just mentioned this is the first occasion when mechanical stoking has been applied to Scotch boilers afloat.

* Not reproduced.

A little more than a year ago Mr. K. Stoker, the managing director of Manchester Liners, decided to try mechanical stoking on one of the vessels under his charge, and as the "Manchester Hero" was in port discharging and loading cargo it was decided to adapt her and she was equipped with Bennis mechanical stokers. Her structural arrangements, however, precluded the use of a fully automatic system of handling and elevating the coal, and it has to be shovelled up into the stoker hoppers by hand. The results with that vessel have, however, proved so satisfactory during the past twelve months, which have included some very rough weather in the North Atlantic, that it was decided to equip the "Manchester Port", then on the stocks on the Clyde, with a rather more elaborate plant of the same kind.



Bennis mechanical stokers.

It may be well here to digress and point out that over and above the saving of the arduous labour of firing a marine boiler in a seaway, the scheme enables the ship to take bunkers in practically any port and take practically any quality of coal from run-of-mine to slack, with the assurance that a head of steam will be maintained. Anyhow the "Manchester Hero" proved, we are informed, that the steam costs could be reduced by 22 per cent. as compared with hand firing; that two boilers instead of three would carry the load; and that all kinds of coal from washed fines containing 22 per cent. moisture, through American dusty slack to dry slack with an ash content of 18 per cent. could be used satisfactorily.

So it was decided to equip the "Manchester Port" with Bennis plant. She is a vessel of 8,505 tons deadweight, 5,469 tons gross, built by the Blythswood Shipbuilding Company Ltd., of Glasgow, and is 422·2ft. long by 56·75ft. beam and 27·1 ft deep. She is intended for the North American and Canadian trade and specially arranged for carrying cattle, while there is an elaborate equipment of deck machinery, including twelve steam winches and derricks. Her masts are, of course, telescopic so that they may pass under the bridges of the Manchester Ship Canal and, for the same reason, the height of the funnel is limited.

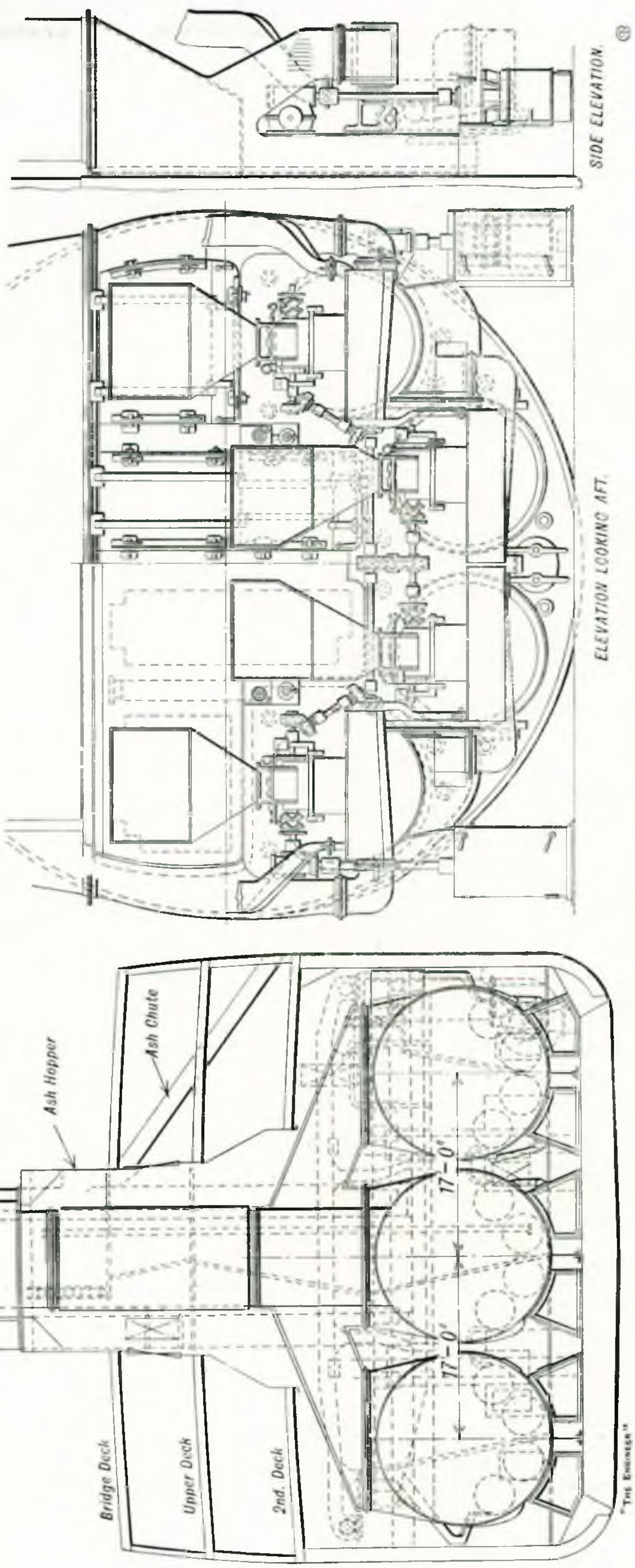
which has added to the difficulties of the combustion engineers on account of the small draught produced. She is driven by a single screw and has a normal speed of about 13½ knots.

On page 156 we give a line *drawing of the machinery space of the ship showing the general disposition of the various units of the plant, and we also reproduce on page 159 a *photograph of the main propelling machinery, taken in the shops. It is of the Parsons single reduction turbine type and was manufactured by David Rowan & Co., Ltd., of 231, Elliot Street, Glasgow. The working pressure is 225lb. per square inch and there are three turbines, each driving one main gear wheel on the propeller shaft through separate pinions. The gear teeth are, of course, cut helically. For going astern there is an h.p. turbine consisting of an impulse wheel, in the same casing as the l.p. ahead turbine, which works in series with an l.p. astern turbine incorporated in the same casing as the l.p. ahead turbine. The turbines and gearings are designed for about 3,800 s.h.p. at 90 r.p.m. and for a maximum power of about 4,200 s.h.p.

There are three cylindrical return tube boilers, 16ft. diameter by 12ft. long, by Rowans, each boiler having four furnaces with 8,568 square feet of total heating surface each. The mechanical stoking gear was supplied by Bennis Combustion, Ltd., of Little Hulton, Bolton.

For supplying coal to the stokers there are two elevators, but only one is needed at a time. These elevators reach from recesses at the bottom of the bunker up to a transverse conveyor. Above the boot of each elevator there is a coal crusher of the Jeffrey single-roll type, made by British Jeffrey Diamond, Ltd., of Wakefield, of which we give a line drawing. It is a simple machine and needs little explanation, the coal being dragged round against a breaker plate by a toothed roll. This machine breaks the coal down to ½in. size. The transverse conveyor and the elevators can be seen at the top of one of our engravings, with the shoots leading down to the hoppers in front of the furnaces on the right. Each of these hoppers holds about 2 cwt. of coal and the conveyor will handle 25 tons an hour.

The stokers are very similar to the land type of Bennis air draught stoker, which we have described before, but have been modified somewhat for marine service. The driving shaft cannot, for instance, go straight across the front of the boiler, as




Cross-section of ship and arrangement of boiler front.

* Not reproduced.

VOYAGE NO. 1.—MANCHESTER, QUEBEC, MONTREAL, HALIFAX, N.S., AND RETURN TO MANCHESTER.

| | Steaming at sea only. | Steaming at sea and under pilot and in port, banking and raising steam. |
|---|---|---|
| Date of test | October 11th to November 29th, 1935. | |
| Duration of test, hours | 439·87 | 1,160 |
| *Particulars of Boilers.* | | |
| Number of boilers in ship | Three | Three |
| Type of boiler | Single-ended Scotch marine, four-flued | |
| Size of boiler | 16ft. by 12ft. | |
| Heating surface each boiler, square feet | 2856 | |
| Grate surface each boiler, square feet | 58·5 | |
| Ratio of heating to grate surface | 48·8 : 1 | |
| Nature of draught | Balanced | |
| Type of firing apparatus | Bennis system of marine stoking | |
| Heating surface superheater, square feet | 1,140 approx. | |
| *Conditions of Combustion (Averages).* | | |
| Temperature of flue gases, deg. Fah. | 510 | — |
| Temperature of air to furnaces, deg. Fah. | 224 | — |
| $CO_2$ in flue gases in uptakes, per cent. | 13·7 | — |
| *Conditions of Evaporation.* | | |
| Temperature of feed water entering boiler, deg. Fah. | 250 | 230 |
| Steam pressure by gauge, lb. per square inch | 215 | 200 |
| Corresponding saturation temperature, deg. Fah. | 393·8 | 388 |
| Temperature of steam leaving superheater, deg. Fah. | 630 | 600 |
| Number of degrees of superheat, deg. Fah. | 236·2 | 212 |
| Heat supplied to each pound water: In boiler, B.Th.U. | 990·1 | 1,001 |
| In superheater, B.Th.U. | 132·2 | 120 |
| Total B.Th.U. | 1,122·3 | 1,121 |
| Factor of equivalent evaporation as from and at 212 deg. Fah. (boiler and superheater) | 1·157 | 1·155 |
| *Nature of Fuel Used.* | | |
| Origin of fuels | Lanarkshire washed pearls, Nottingham washed singles, Nottingham washed peas, Nottingham washed slack, Canadian large coal, Sydney, Cape Breton. | |
| Calorific value of fuel per pound, as fired, B.Th.U. | 11,320 | |
| Approximate analysis of fuel: | | |
| Volatile matter, per cent. | 31·15 | |
| Fixed carbon, per cent. | 51·00 | |
| Ash, per cent. | 5·85 | |
| Moisture, per cent. | 12·00 | |
| *Quantity of Fuel Used.* | | |
| Total weight of fuel burnt, lb. | 2,262,400 | 3,084,480 |
| Fuel burnt per boiler per hour, lb. | 1,715 | 930 |
| Fuel burnt per square foot grate surface per hour, lb. | 29·35 | 15·87 |
| Tons per day of coal at 11,320 B.Th.U. per lb. as fired | 55·2 all purposes | |
| Tons per day if best Welsh at 14,500 B.Th.U. per lb. as fired | 43·2 all purposes | |
| Coal coefficient with coal at 11,320 B.Th.U. per lb. as fired | 18,432 outward, 21,546 homeward, all purposes | |
| Coal coefficient if best Welsh at 14,500 B.Th.U. per lb. as fired | 23,600 outward, 27,600 homeward, all purposes | |
| Admiralty coefficient $\frac{D^{\frac{2}{3}} V^3}{\text{i.h.p.}}$ | =262 | — |
| *Quantity of Water Evaporated, Actual.* | | |
| Total quantity of water evaporated, lb. | 19,238,000 | 23,100,000 |
| Water per boiler per hour, lb. | 14,600 | 6,950 |
| Water per square foot boiler heating surface per hour, lb. | 5·11 | 2·44 |
| Water per pound of fuel, lb. | 8·50 | 7·50 |
| Total heat supplied to water per pound of fuel, B.Th.U. | 9,540 | 8,410 |
| *Efficiency.* | | |
| Total thermal efficiency boiler, superheater, and air heater, per cent. | 84·1 | 74·5* |
| *Steaming Conditions.* | | |
| Average displacement | 10,570 tons | |
| Total distance steamed | 5,794 miles | |
| Speed | 13·17 knots (heavy weather experienced at times, necessitating reduced speed) | |
| Average s.h.p. | 3,600 | — |
| Equivalent average i.h.p. | 4,200 | — |

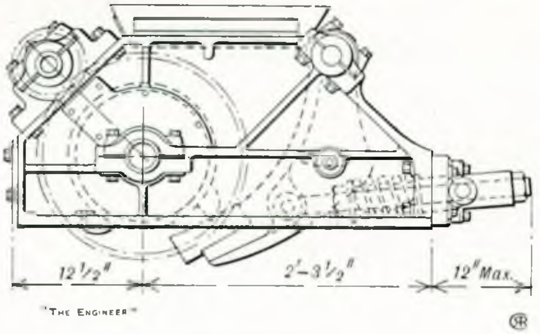
*Approximate Heat Balance.*

| | Per cent. |
|---|---|
| Heat usefully employed in superheater | 9·9 |
| Heat usefully employed in boiler | 74·2 |
| Heat lost in funnel gases | 11·75 |
| Heat lost in radiation, ash, and unaccounted for | 4·15 |
| | 100·00 |

* Out of a total of 1,160 hours for the round voyage the boilers were more or less banked for about 700 hours and were relighted more times than usual.

in a Lancashire boiler, on account of the different levels of the furnaces in the Scotch boiler, and has to be divided into three sections connected together by skew gearing. This gearing is plainly shown in the elevation of the boiler front. The grates also are much shorter, being only 4ft. 6in. long. It is unnecessary here to give a description of the Bennis sprinkler stoker, which distributes the coal over the grate by means of a spring-driven V-shaped shovel; but it may be as well to point out that the fire-bars are cooled by means of a draught of fairly high pressure air passing down their hollow interiors. This air, which, having become heated in its passage, is used to help combustion, is supplied by either one of two small fans arranged in the fiddley. The forced draught fan is in the main engine-room.

The stoker mechanism is driven by totally enclosed variable-speed motors, with a reduction between the motor spindle and the input shaft of a totally enclosed worm and wheel-reducing gear-box. The gear-box is provided with machine cut gearing, with a hardened steel worm in gear with a wheel cast from Admiralty mixture bronze. The driving unit is coupled to the general transmission shaft of the coal throwing mechanism, and the throwing mechanism shafts are coupled to each other through machine-cut totally enclosed bevel gear-boxes with completely flexible couplings. The furnaces are separately driven by the same size motors and a powerful chain drive between the shafts. All the shafts are of high tensile steel. Each motor is of the totally enclosed dust and deluge-proof variable-speed compound wound interpole type, with a variation in speed of from 750 to 1500 r.p.m. by shunt field control. All the




Coal crusher.

motors were specially constructed to comply with the Board of Trade specification for sea-going and tropical conditions.

The whole of the operation of the boilers is controlled from the engine room by means of the instrument board, of which we give an *illustration.

The men in the stokehold have little more to do than rake out ashes, trim coal when the bunkers get low, and oil some of the moving parts.

The boiler-room control panel is placed in the engine-room, conveniently at hand for the engineer on watch to be able to see what he is doing as he controls the stokehold with the main engines or turbines. At the top of the control board is a line of draught gauges, which give him the readings of the draughts at the various points, such as over the fires and in the uptake of each boiler.

* Not reproduced.

Below the draught gauges there is the electrical control. The combustion air-fan, by Howden, is engine driven, is situated in the engine room and its speed can be controlled from the turbine control platform alongside the stoker control board. Each set of four stokers on each boiler has two motors, one controlling the speed of the stokers and the other the speed of bar travel. These motors are themselves controlled by drum starting and regulating totally enclosed panels on the control board, and are each fitted with a 6in. dial ammeter marked "Port", "Centre" and "Starboard" boilers. The top three starters are labelled "Stokers" and the bottom three "Furnaces". The main damper is also controlled from the engine room. Thus the best balanced draught conditions are easily maintained, and when manœuvring the ship the stoker may be slowed down or stopped or speeded up and the draught altered accordingly by the engineer on watch, while a sub-control is provided in the stokers themselves, except when they are entirely stopped.

The trials to which we referred at the beginning of this article took place over the Skelmorlie measured mile on the Clyde. The ship had only been out of the builder's dock a day when she went down to Tail of the Bank to adjust compasses. At half-past nine the visitors and officials went on board at Craigandoran and she immediately got under way. The run down to Skelmorlie was uneventful and then four double runs were made at progressive speeds. The first two gave speeds of 12·85 and 12·72 knots at about 80 r.p.m. The speed was then increased to 90 r.p.m. and the knots were 14·06 and 14·17. One other trip was made at 14·00 and 14·75 knots. It is noteworthy that when the ship was steaming steadily on the mile there was little more than a haze coming from the funnel, although there was some smoke when the engines were suddenly throttled down to make turns.

The coal used on these trials was slack having a calorific value of 11,312 B.Th.U. per pound as fired. Its analysis was:—

| | Per cent. |
|---|---|
| Volatile matter ... ... ... | 32·22 |
| Fixed carbon ... ... ... | 50·02 |
| Ash ... ... ... ... ... | 6·76 |
| Moisture ... ... ... ... | 11·00 |

The performance of the boilers may be gauged by the following comparative statements, which have been supplied to us:—

| | Estimated operating conditions. | | Actual conditions operating on voyage No. 1, Oct./Nov., 1935. |
|---|---|---|---|
| Temperature of water entering boilers | 280° F. | ... | 239° F., rising to 250° F. |
| Total hourly evaporation in lb. per hour | 41,000 | ... | 43,800 |
| Thermal efficiency, boilers and superheaters, while steaming at sea | 84 p.c. | ... | 84·1 p.c. |

The ship then started on her first voyage, round to Manchester, and nothing happened except that we ran into a storm off the Isle of Man, which entailed a slight reduction of speed, as the ship was light. The machinery in all parts behaved admirably and gave no trouble.

We have to thank the owners, Manchester Liners, Ltd., Mr. K. Stoker, Mr. Moore, the superintendent engineer, the Blythswood Shipbuilding Company, and many others, in helping in the preparation of this article and for their hospitality.

Since we made the trip on the "Manchester Port" she has made a round voyage to Canada and back, and we give on page 40 the results of the observations on the performance of the stokers which were made during that voyage as being more complete than those taken during the trial trip.

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### Mechanical Stoking for Scotch Marine Boilers.

"The Engineer", February 21st, 1936.

Sir,—In your article on the above in the issue for the 7th inst., it is stated that the installation of mechanical stokers on the "Manchester Port" is, you believe, the first on Scotch marine boilers afloat.

Your correspondent is in error with regard to this. As far back as 1884 my firm fitted up the Scotch marine boilers on the s.s. "State of Nevada" with sprinkling stokers, and hand-rocked fire-bars. This ship was one of 1,200 tons, trading between Glasgow and New York, and made several voyages so equipped.

At that distant date stokeholds were a very different proposition to what they are to-day, being very cramped, the boilers having very small furnaces, no electric current being available, and, further, the matter of making up water for the boilers was a great difficulty.

The stokers themselves functioned perfectly, but the use of steam for the auxiliary engine for driving the stokers was prohibitive, so further use of the stokers was abandoned.

Ten years later we fitted up the s.s. "City of Chicago", a passenger liner trading between Liverpool and New York. All the thirty furnaces on the Scotch-type boilers were equipped with our coking stokers, which ran successfully for six months during the winter season. When the Shipping Company wished to place an order for us to equip their two largest passenger boats the opposition of the trade union was strong enough to prevent anything being done. This firm carried the mails, and had a subsidy from the Government for this work, so they could not risk any labour troubles; consequently, further stokers on the Atlantic service could not be applied.

In 1906 we fitted up a Scotch boiler on the s.s. "Britannia", trading between Glasgow and Bombay, which made several successful voyages.

In 1908 we fitted up a large tug, H.M.T. "Prudent", for the British Admiralty, to which we also applied our coking type stoker on a three-furnace Scotch marine boiler, and added an induced draught fan. These worked very successfully, with the result that stokers were applied to the Belleville boilers on H.M.S. "Sharpshooter", which were also successful; but when it came to the question of fitting mechanical stokers to a large battleship, the extra weight entailed was so considerable in view of the fact that everything was being lightened to allow of increased armour plating and armament, that they could not consider stokers on account of the reduced cruising area that would have been entailed.

In 1909, the celebrated American yacht, s.y. "Corsair", was equipped on her twelve Scotch boiler furnaces, giving most excellent results.

We also fitted stokers to the s.s. "Alexandra", 7,000-ton cargo boat, and one or two smaller steamers; but in each case the labour opposition amounting to sabotage in some cases prevented our going any further, since which time we have devoted ourselves entirely to stokers for land installations.

As the pioneers of this class of boiler firing, we experienced the force of conservatism and opposition to the fullest extent.

Now that the stokeholds have ample room, the boilers having larger furnaces with plenty of electric current available, and labour troubles not likely to arise, there is no reason why installations on Scotch marine boilers should present any greater difficulty than many land installations.

James Hodgkinson (Salford), Ltd.,
Arnold Hodgkinson,
Pendleton, February 17th. Director.

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### The Latest A.E.G.-Hesselman Engine.

Modifications in the Design in the Latest Models for Tanker Propulsion.

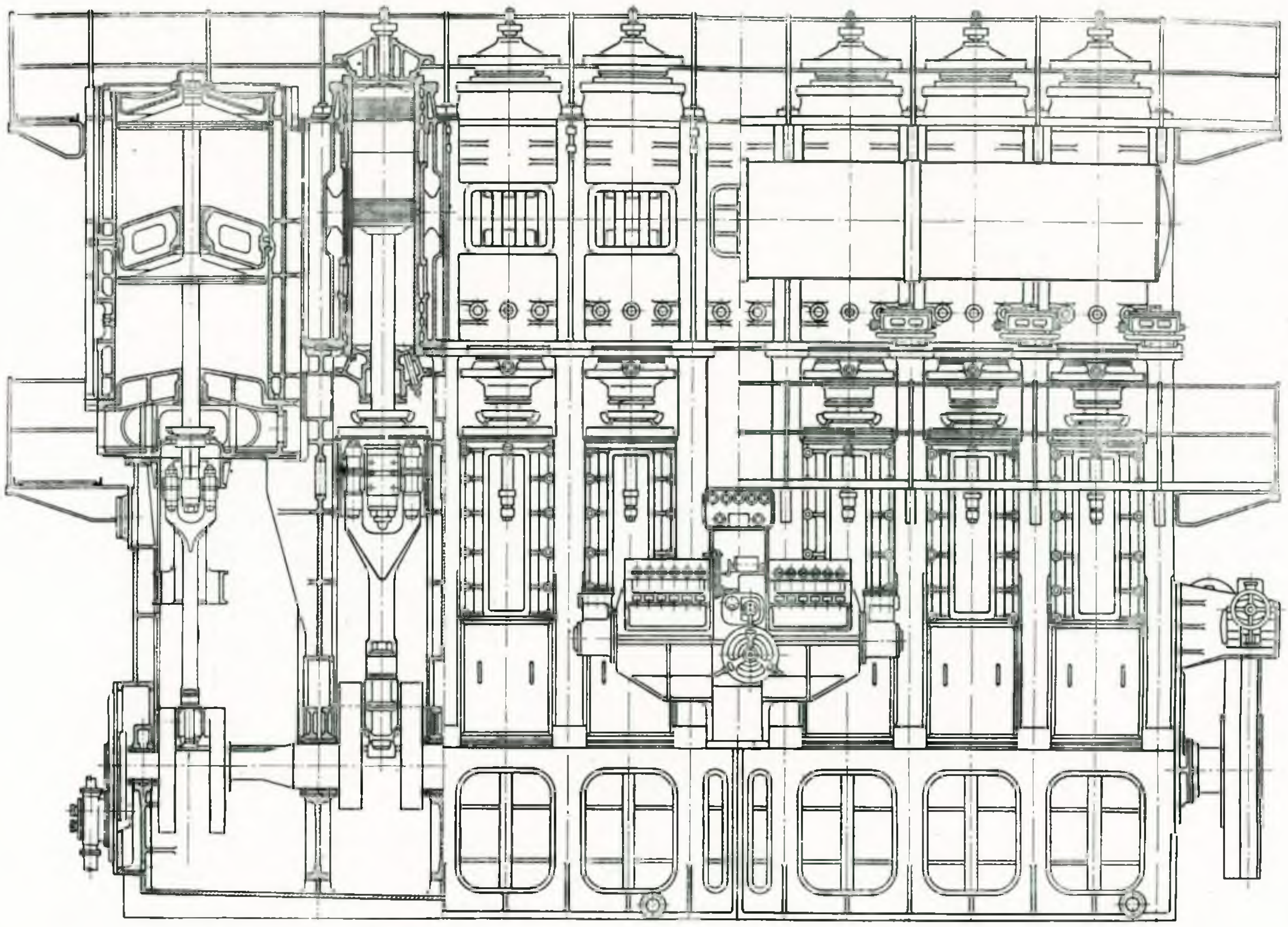
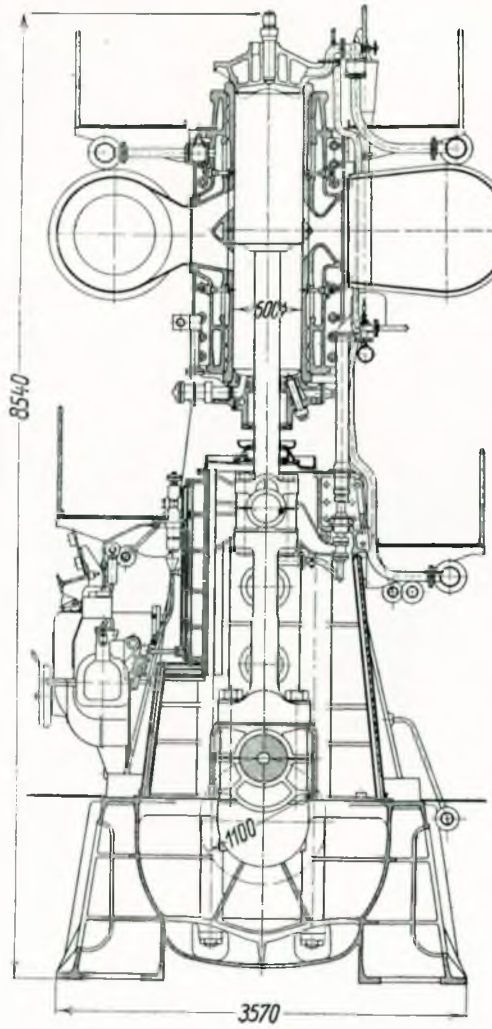
"The Motor Ship", March, 1936.

Steel Cylinder Heads.

The engine has an output of 4,100 b.h.p. at 118 r.p.m. and has six cylinders with a diameter of 600 mm., the piston stroke being 1,100 mm. Its special features are the employment of the Hesselman system of fuel injection and the so-called soldered construction of cylinder cover and piston body. The lower portion of the cylinder cover is of mild steel and the upper part of cast steel, the two being brazed together by a special method developed by the engine manufacturers in which the whole operation takes place in nitrogen.

In the new engine the bedplates are no longer provided with a bolted-on oil sump, but the sump is part of the bedplate casting; this adds stiffness to the bedplate and eliminates any possibility of oil leakage.

The piston rods are not provided with a protecting cast-iron tube as formerly. They are of chrome nickel molybdenum steel and the delivery of the piston-cooling water takes place in the


Sectional front and end elevations of the latest A.E.G.-Hesselman double-acting engine.

ordinary way through the hollow piston rods. It is anticipated that no trouble will be experienced with corrosion fatigue. The discharge is through a single vertical pipe. Some improvement has been effected in the design of the cylinder covers by the elimination from the combustion chamber of any portions which have been brazed, whilst the construction has been strengthened and rendered more secure.

Fuel System.

The fuel-injection system, including the pumps, valves and nozzles, are mostly unaltered. A modification has been made in the position of the seat of the fuel valve, which is of the Hesselman membrane type. This alteration has been carried out with a view to the utilization of heavy oil, and the seat has been arranged so as to be as close as possible to the holes in the nozzles. For the same reason, at the lower cylinder cover four needle valves are employed instead of the open nozzles which have hitherto been utilized.

Cylinder Jacket and Piston Cooling Water Systems.

The cylinder cooling is carried out by sea water, whilst fresh water is employed for the pistons. In the earlier engines fresh water was also adopted for cooling the cylinders. The delivery of the piston cooling water within the crankcase is so arranged that at no point can any deposit form; this might be possible with the utilization of sea water for cooling when the ship is at the mouth of a river or in other muddy waters.

The engine is provided with a tandem piston-type scavenging pump at the forward end driven from the crankshaft. In addition to this pump, there is a pump for forced lubrication, this being driven direct by the engine.

The fuel consumption, based on test-bed figures of both engines, showed that in normal circumstances about 133 gr. of oil are required per i.h.p.-hour, or about 0·29lb. per i.h.p.-hour with the engine on full load.

Allowing for a mechanical efficiency of approximately 85 per cent. to 86 per cent. this is equivalent to a fuel expenditure of 0·34 lb. per b.h.p.-hour.

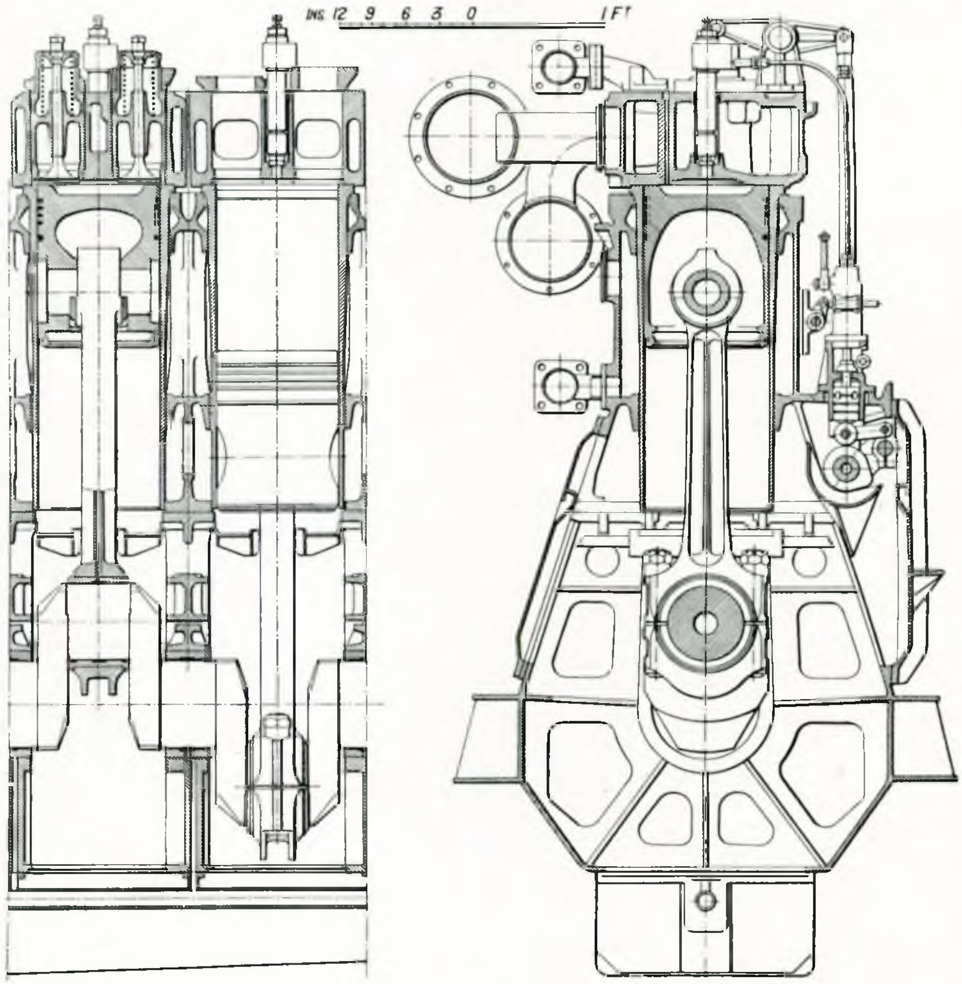
We are informed that up to the present time the engines in service have operated very satisfactorily and have fulfilled expectations, both in the matter of fuel consumption and in general reliability of operation.

## The Main Engines of the "Vigilant".

Four-stroke-cycle, direct-injection type Sulzer engines built by Sir W. G. Armstrong, Whitworth (Engineers) Limited, Scotswood.

"Shipbuilding and Shipping Record", February 13th, 1936.

The propelling engines of the "Vigilant", a new fishery cruiser for the Scottish Fishery Board, built by William Denny & Bros., Ltd., Dumbarton, are of particular interest as they probably develop higher power to displacement ratio than any vessel afloat with the exception of certain naval vessels




Part sectional elevation and cross section of one of the Sulzer engines for the fishery cruiser "Vigilant".

such as destroyers. In the "Vigilant", not only was weight important but it was necessary to have small machinery space in order to allow good accommodation for the crew, as the ship may at times spend long periods at sea. The maximum engine output is, of course, only used occasionally, but it is of the greatest importance that consumption figures should be guaranteed down to 1/12 power.

The engines are of the Sulzer four-stroke cycle direct-injection type, and were built by Sir W. G. Armstrong, Whitworth & Co. (Engineers) Ltd., at Scotswood, under their manufacturing agreement with Sulzer Bros. (London) Ltd. The engines are not reversible but are coupled to the propeller through Sulzer oil-operated reversing gears.

Each main engine has eight cylinders, 280 mm. bore by 380 mm. stroke, and gives an output of 750 b.h.p. at 700 r.p.m., corresponding to a brake mean pressure of 74lb. per sq. in. and a piston speed of 1,740ft. per min. The weight of the engine complete with flywheel, gearbox, thrust block, oil cooler and all piping on the engine, is about 13 tons, a low figure for an engine of this size designed for severe marine conditions and complying with Board of Trade requirements.

The general design of the engine will be seen from the drawing on page 44. The crank-chamber and frame are of all-welded construction and of very stiff design. A heavy fore and aft girder on each side of the crank-chamber has coupled to it an extension which carries the gear-box. This girder is bolted down to deep seatings in the ship, the combination of stiff engine framing and seatings providing the necessary rigidity to

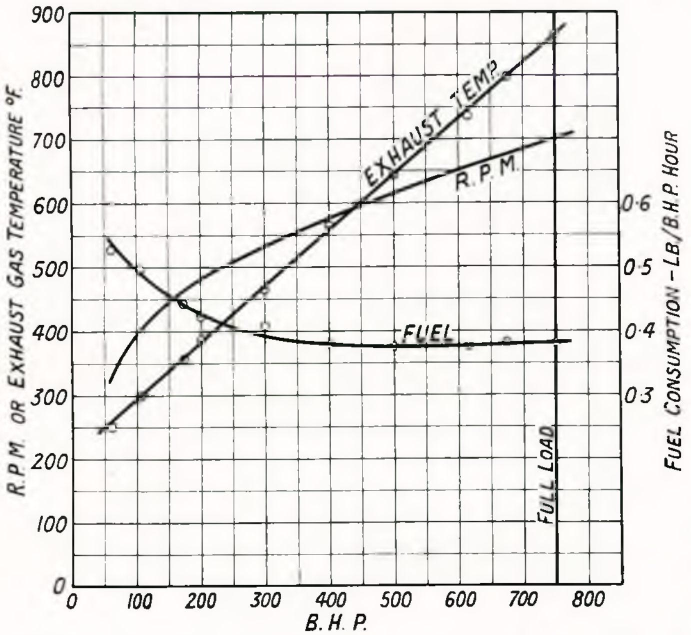



Diagram showing test results of starboard engine of the "Vigilant".

ensure freedom from vibration. The cylinders are arranged in a block and are of cast steel with cast-steel cylinder covers. Each cylinder has a loose interchangable liner of cast iron. Pistons are of forged aluminium alloy with cast-iron piston rings and are coupled to the crankshaft by steel connecting rods of I section. Top end bearings are of bronze, while main and bottom end bearings are white-metal lined. The camshaft is driven through spur gearing from the crankshaft and is arranged in a closed casing at the bottom of the cylinders. Inlet and exhaust valves are operated through push rods and rockers and the cam-driven Bosch fuel pumps are arranged above the camshaft separately for each cylinder. Starting air control valves are arranged at the forward end of the camshaft and operate automatic starting valves on the four forward cylinders. Instead of the usual direct control of engine speed by hand control of the quantity of oil delivered, the speed control on these engines is through a governor with hand control of the load on the governor spring. This has been usual Sulzer practice on engines with reversing gear boxes, but for this particular vessel it has the added advantage that racing of the engines in heavy weather will be avoided even with the engine running at slow speeds. The governor speed control and the controls to the reversing gear are interlocked so that the gear can only be engaged or moved from "ahead" to "astern" when the engine is running below half speed, thus avoiding danger of damage that might arise through sudden engagement of the gear with the engine running at full speed.

To reduce engine noise to a minimum, the fuel pump timing is variable, the shaft which controls this being coupled up to the governor control so that the timing of injection is automatically adjusted to suit engine speeds.

The gearbox is of particular interest as it is probably transmitting a higher power than any reversing gear that has previously been installed on board ship. In design, the gearbox is of the standard Sulzer type, of which large numbers have been installed in tugs, river and coasting vessels, and is oil-operated.

A double clutch cone connected to the propeller shaft through a thrust ring is free to move with the shaft in a fore and aft direction. This clutch cone carries three pairs of pinions, the larger wheel of each pair engaging with an internal toothed gear wheel connected to the engine shaft, while the smaller pinions engage a spur wheel mounted at the forward end of a shaft which is coupled to the propeller shaft. On the outside of the large internal toothed wheel there is a clutch cone, while a further cone is arranged in the gear casing. The shaft which is connected to the propeller shaft can be moved in a fore and aft direction by means of the oil servo motor piston connected to it by a ball thrust race, and in moving fore and aft it carries with it the main double cone clutch. When this double cone clutch is moved forward, it engages with the cone on the outside of the internal toothed wheel, thus giving a direct drive between the engine and the propeller shaft. If the double cone is moved aft it engages the cone in the casing and is thus held stationary so that the propeller shaft turns in the astern direction driven through the epicyclic gear train.

Test Results.

Both engines were subjected to thorough shop tests coupled through the gearbox to a water brake. A four hours' run at full power was followed by a series of $\frac{1}{2}$-hour runs at various fractional powers and a one-hour run at 170 b.h.p., and again at 60 b.h.p. Fuel consumptions were measured over the whole range of powers. Immediately following the last of the low power runs, the engine was again run up to full power for half an hour, fuel consumption again being measured. The results of the tests for the starboard engine are shown in the illustration on page 45.

It will be seen that a remarkably flat fuel consumption curve has been obtained. From full to half load, the consumption is between 0·375 and 0·38lb. per b.h.p. hr., and at 1/12 load it rises only to 0·53lb. per b.h.p.-hr. The full load consumption taken after the low power runs agreed exactly with the figures taken before these runs. The results obtained on the port engine confirmed exactly those from the starboard. The running of the engine was reasonably quiet at all speeds, though it is, of course, not possible in a high-speed engine to obtain the same quiet running that is possible with an engine running at 100 or 120 r.p.m.

## Exhaust Steam Turbines.

"Shipbuilding and Shipping Record", February 6, 1936.

The general arrangement of the turbo-compressor, engine, and condenser in the Rowan-Götaverken designs was shown by Dr. Sneeden in the diagrams illustrated on this and next page. The triple-expansion engine, he stated, is of standard type, with the exception of the intermediate pressure steam chest which embodies certain special features. This chest is divided into two compartments A and B; A forms a receiver for the high-pressure exhaust steam, and B forms the supply chest to the intermediate-pressure cylinder. The dividing wall being fitted with a number of automatic valves opening into the intermediate-pressure steam chest. When the exhaust turbine is out of action, the automatic valves are kept open by the flow of steam, as shown in the diagram (Fig. 1). The pressure drop from one side of the valves to the other rarely exceeds 2lb. per sq. in.

The compartment A is connected through separator S and valve E to the suction or low-pressure side of the compressor, while compartment B is connected through a valve F to the delivery or high-pressure side. These valves are both closed when the compressor is idle, and both valves are open when it is working. After doing its work in the intermediate and low-pressure cylinders, the steam exhausts into the pipe C, and it can then either flow direct to the condensers as shown in the diagram (Fig. 1), or enter the turbine as shown in the diagram (Fig. 2). The change-over is brought about by valve D, through a small hand-operated oil pump, as will be explained later.

When the turbine is brought into action, valves E and F are open, and the change-over valve D is in the position shown in the diagram (Fig. 2). The compressor produces a drop in pressure in compartment A and a rise in pressure in compartment B. This pressure difference ensures the closing of the automatic valves. The control of the change-over valve will be understood from the diagram (Fig. 3), while the construction of the valve is shown in Fig. 5.

With the turbine at rest, and no oil pressure in the turbine lubricating system, Dr. Sneeden continued, the changeover valve is kept open to the condenser by means of the spring-loaded piston in the control cylinder C (see Fig. 3). If the shut-off valve B is now opened, and the hand-pump P operated, a few strokes will build up a pressure in the oil-line from B to C. When the oil pressure is sufficient to overcome the load caused by the spring in C, the piston moves to the right and swings the change-over valve to the turbine inlet. The turbine will then start and the main oil pump M, driven by gearing from the turbine shaft, will maintain the necessary pressure in the control cylinder C. The shut-off valve is closed as soon as the pressure of the lubricating oil has reached the normal working value, about 20lb. per sq. in.

The turbo-compressor is thus entirely independent of the engines and can only be maintained in action by the pressure of the oil in the control cylinder C. Should this

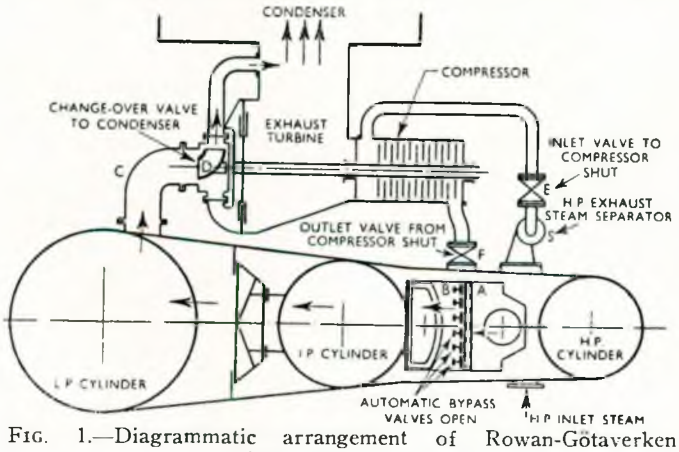



Fig. 1.—Diagrammatic arrangement of Rowan-Götaverken system: compressor out.

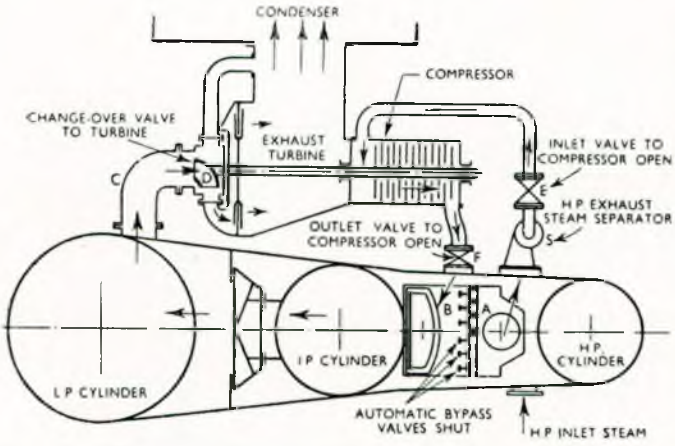



FIG. 2.—Diagrammatic arrangement of Rowan-Götarverken system: compressor in

pressure fail to overcome the pressure of the spring, either through the failure of the lubricating system, or through the action of the governor and oil escape valve when the turbine speed becomes excessive, the turbo-compressor is cut out and the engine functions normally.

The absence of gears and mechanical connections is possibly one of the most outstanding features of this system. It renders manœuvring and reversing extremely simple, as the turbo-compressor adjusts itself to the requirements of the occasion. The turbo-compressor is a single self-contained unit, with the exhaust turbine mounted on the same shaft as the steam compressor. The rotors are statically and dynamically balanced and run at 6,500 r.p.m. The construction was clearly illustrated on page 132 of last week's issue.

The unit is very compact and can be easily accommodated in the ordinary engine room. It is usually mounted on top of the main condenser, either on a separate platform supported from the engine frame or on the top of the condenser itself. It is usual in Rowan-Götaverken designs for a rotary feed-water pump to be incorporated with the turbo-compressor unit. The feed pump is directly driven by the turbine, and is mounted at one end of the compressor shaft.

The addition of the centrifugal pump at this point introduces a slight complexity into the layout of the piping system. On account of the inability of such pumps to produce a suction effect or to lift the feed from the filter tanks without danger of cavitation, it is necessary to provide the feed to the pump with a head of 3 to 4ft. With this object, the ordinary feed pump is kept working when the turbine is in operation, but instead of delivering the feed through all the heaters into the boiler under high pressure, the reciprocating pump delivers the feed through the low-pressure heater into an overhead tank placed at a height of about 6ft. above the centrifugal pump. The latter discharges through the auxiliary exhaust heater and the high-pressure heater (if any) into the boilers. The complete feed circuit is shown in Fig. 4.

When a centrifugal pump is used the work required to feed the boilers is considerably reduced, on account of the higher efficiency of the turbine-driven rotary pump. On the other hand, a small reduction in feed heating accompanies the decrease in the steam discharged, compared with that from the reciprocating pump. When the feed amounts to 20,124lb. per hour at 220lb. per sq. in. the pump brake horse-power is about 5·3; if the consumption is taken as 50lb. per brake horse-power-hour, the steam consumption for the reciprocating pump is approximately 1·5 per cent. of the total steam. It will thus be seen, declared Dr. Sneeden, that the saving in heat consumption of 17·3 previously calculated may be in some cases increased to 18 per cent. or slightly more.

The author mentioned, however, that the steam required to seal the glands of the turbo-compressor will probably be responsible for a slight loss of economy; but since this applies equally to other systems, no correction for this loss has been applied in these comparisons. The centrifugal pump has three stages, the rotor shaft is mounted on ball bearings and is directly driven by the turbo-compressor shaft.

The first combination machinery installed by David Rowan & Co., Ltd., was for the "Harlingen", belonging to the Harrison Line, in 1933; but due to lack of time, it was not then possible to carry out a complete trial to ascertain the saving due to the compressor unit. However, at the beginning of 1934, a loaded trial was conducted from Newcastle into the North Sea. The machinery had been in use about a year. The ship sailed with the tur-

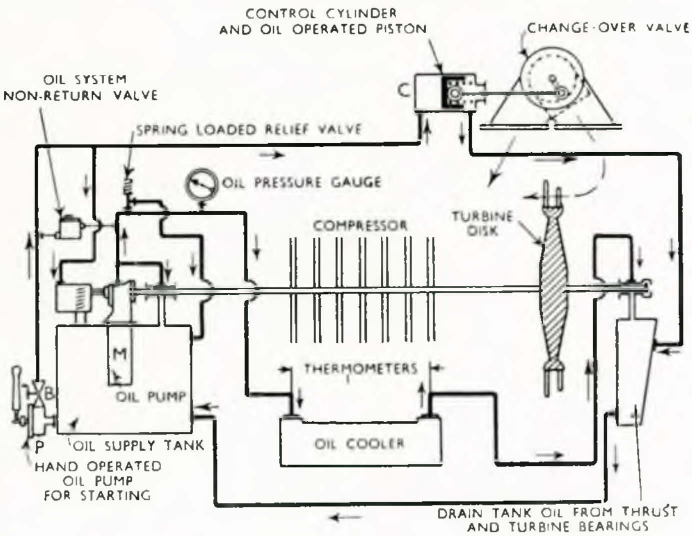



FIG. 3.—Diagrammatic arrangement of oil relay, lubrication, and control of change-over valve.

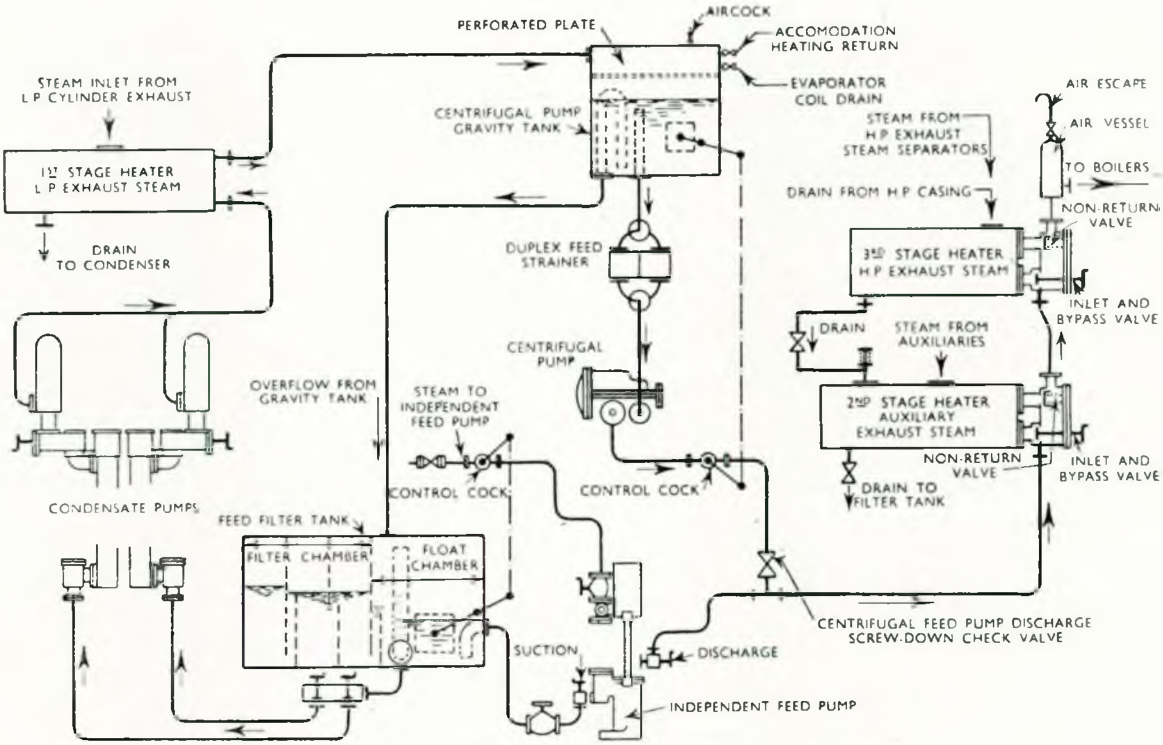



FIG. 4.—Diagrammatic arrangement of feed circuit.

bine out of action, and readings were not taken until she was fairly well out of the estuary. The valves were then set and conditions adjusted so that the indicated horse-power was about 1,600. The first half of the trials lasted for four hours. All conditions were normal and remained fairly steady during the test. On the return journey to the river mouth, the turbo-compressor was put in action and the revolutions per minute immediately rose. Increased speed or power was not, however, the aim of the shipowners in selecting this type of machinery, but decreased steam consumption at equal power. So the high-pressure cut-off was made earlier, and other conditions were adjusted until the number of revolutions per minute was as nearly as possible equal to that in the first half of the trial. After a reasonable time had been allowed for steady conditions to be attained, observations were made, and continued over another period of four hours. Again the smoothness of running and the constancy of the readings were a feature of the second half of the trial.

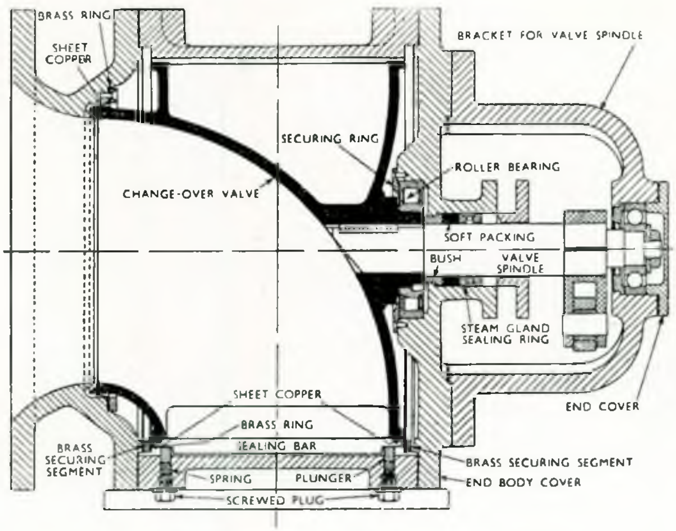



FIG. 5.—Construction of change-over valve.

After the experience gained with their first three installations, David Rowan & Co., Ltd., made several alterations to the relative sizes of the cylinders of the reciprocating machinery and to the location and adjustments of the automatic byepass valves. Two sister ships which soon followed, the "Harpasa" and the "Hartlebury", were fitted with triple-expansion engines, cylinder diameters 22½, 36 and 65in., stroke 48in., and piston rods 6¼in. in diameter, designed for supply conditions of 230lb. per sq. in. abs. and 550° F. These vessels were both tried in the Firth of Clyde and showed savings in heat consumption per indicated horse-power-hour of 18·6 and 18·3 per cent., respectively. Independent readings were taken on the trials of the "Harpasa" at intervals of 10 minutes by Prof. A. L. Mellanby, D.Sc., M.I.Mech.E., Dr. J. F. Shannon, A.M.I.Mech.E., and the author. The average result for the trials of the

"Harpasa" are given in the first part of the table on this page, and the deductions in the second part of the same table. The points to which the observations refer may be easily found by reference to the feed circuit diagram opposite.

Dr. Sneeden stated that it was always difficult during trials of machinery in actual use to obtain all the items necessary for a satisfactory and absolute analysis of the performance. Although in the trials many observations were taken which are usually absent from published results of trial trips, yet, in one respect, and always from the point of view of possible analysis, it was unfortu-

Average Results for the Trial of s.s. "Harpasa"
Firth of Clyde, January 26th, 1934.

Cylinders: diameters, 22½, 36 and 65in.; stroke, 48in.
Diameter of piston rods, 6½in.

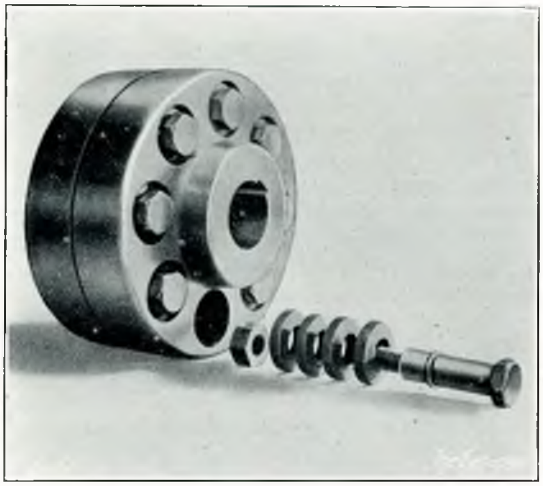
| | Without compressor. | With compressor. |
|---|---|---|
| *Part I. Observations—* | | |
| Pressures: | | |
| h.p. inlet, lb. per sq. in. abs. | 231·0 | 230·0 |
| h.p. exhaust " " | 63·0 | 52·0 |
| i.p. receiver " " | 62·0 | 78·0 |
| l.p. receiver " " | 20·3 | 20·5 |
| l.p. exhaust " " | 2·85 | 4·24 |
| Condenser (vacuum, in. of mercury) ... ... ... | 27·82 | 29·64 |
| Temperatures (deg. F.): | | |
| h.p. inlet ... ... ... | 540·5 | 537·5 |
| h.p. exhaust ... ... ... | 307·3 | 311·0 |
| i.p. receiver ... ... ... | 304·5 | 359·0 |
| l.p. receiver ... ... ... | 224·0 | 224·5 |
| l.p. exhaust ... ... ... | 145·0 | 158·0 |
| Top of condenser ... ... | 102·5 | 74·7 |
| Condensate ... ... ... | 77·6 | 79·2 |
| Hotwell ... ... ... | 94·6 | 95·2 |
| Inlet to l.p. heater ... ... | — | 92·3 |
| Outlet from l.p. heater ... | — | 150·5 |
| Outlet from overhead tank ... | — | 153·8 |
| Inlet to exhaust heater ... | 97·3 | 152·0 |
| Inlet to boiler ... ... ... | 184·2 | 229·9 |
| Inlet circulating water ... | 48·0 | 48·4 |
| Outlet circulating water ... | 84·6 | 63·5 |
| Feed water, lb. per hour ... | 19,599 | 16,730 |
| Speed, r.p.m. ... ... ... | 66·55 | 67·60 |
| *Part II. Deductions from Observations—* | | |
| I.H.P. (average, allowing for area of piston rods): | | |
| h.p. cylinder ... ... ... | 618 | 601 |
| i.p. cylinder ... ... ... | 485 | 588 |
| l.p. cylinder ... ... ... | 503 | 425 |
| Total ... ... ... | 1,606 | 1,614 |
| Total heat per lb., B.Th.U.): | | |
| Steam at engine stop valve ... | 1,291·8 | 1,289·7 |
| Feed at boiler check valve ... | 152·2 | 198·0 |
| Heat in steam ... ... ... | 1,139·6 | 1,091·7 |
| Heat supplied per hour ... | 22,335,020 | 18,264,141 |
| Heat supplied per I.H.P.-hr. | 13,907 | 11,316 |
| Net saving with turbo-compressor, per cent. ... ... | — | 18·6 |

nately impossible to measure separately (1) the feed to the main engines; (2) the steam to the auxiliaries, excluding the reciprocating feed pump; (3) the steam to the reciprocating feed pump; (4) the sealing steam to the turbine glands; (5) the sealing steam to the low-pressure gland; and (6) the steam for the ejector at the vacuum augmenter. It will, of course, be readily admitted that such detailed measurements could not very well be carried out on trial trips, hence it is inevitable that certain assumptions should be made in order to arrive at a detailed account of the performance of the plant: a most desirable aim if improvements are to follow in the wake of costly experiments.

## The "Cone-Ring" Flexible Coupling.

"The Engineer", 29th May, 1936.

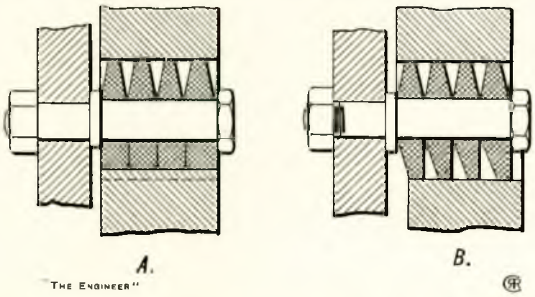
If proof is required of the value of a flexible coupling to the engineer, it is only necessary to observe how many such devices are already in use, and how frequently new designs are brought out. As the coupling described in this article has been developed by David Brown and Sons, Ltd., it may safely be concluded that any defects that may have been apparent in original experimental designs have been eliminated, and that the device is, in fact, thoroughly practical. Indeed, the reasons given by the firm for adopting the particular design are such as to appeal directly to the intelligence, while observation of the drawings and engraving will confirm the impression that the design ought to be



Component parts of "Cone Ring" coupling.

successful. A completely flexible coupling should not only compensate for errors of eccentricity and alignment, but should also allow axial freedom At the same time it should provide torsional elasticity to absorb the shock of suddenly applied loads, and have a damping effect upon the transmission of vibrations. If all these conditions are to be complied with, a resilient material is clearly required, and David Browns, after considering the relative advantages of steel and rubber, chose the latter for the following reasons:—The use of strip steel involves rubbing between highly stressed surfaces when axial motion occurs, leading inevitably, despite lubrication, to wear of the parts and also to the transmission of quite considerable axial loads. Moreover when used to provide torsional flexibility, the amount of energy steel can absorb is limited by the allowable stress (equal to about 5·3 foot-pounds per pound), while, except when stressed beyond the elastic limit, which is obviously not feasible, steel shows practically no hysteresis loss and cannot, therefore, damp out vibration. Rubber, however, has much more advantageous properties if properly used. It needs to be remembered that when compressed along one axis, it suffers practically no change of volume. If then, its resilient properties are to be utilised to the full, it must not be too much confined.

The design of coupling brought out by the firm has been based upon the conventional pin and bush




Action of rings under tangential and axial loads.

type. In considering this type of coupling, it will be observed that the longitudinal expansion of the bush is seriously constricted by friction between the parts. The firm's designers have therefore substituted for the plain bush a number of rubber rings of conical section. As will be observed from the line engravings, which indicate somewhat exaggerated conditions, these rings can freely deform under load, and it is claimed give over four times the torsional flexibility obtainable with the ordinary sleeve type bush. Axial freedom is provided by a "rolling" or "dishing" action of the rings. The coupling also has the characteristic that torsional flexibility is greatest at light loads, diminishing as the load increases. There is, of course, no hysteresis loss available for damping when the load is constant, but with a varying load, although the loss is in itself small, it is, so the firm claims, sufficient to restrain the building up of vibration.

These "Cone-Ring" couplings are made in a range of eighteen sizes, and are as easily assembled or dismantled as the conventional bush type.

## 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.

| Name. | Grade. | Port of Examination. |
|---|---|---|
| **For week ended 7th May, 1936 :—** | | |
| Rees, David G. ... ... | 1.C.M. | Liverpool |
| Williamson, Robert J. ... | 1.C.M. | " |
| Adams, Henry A. ... ... | 1.C. | London |
| Howe, Leslie H. ... ... | 1.C. | " |
| Jones, Thomas P. ... ... | 1.C. | " |
| Mitchell, Edmund N. M. ... | 1.C. | " |
| Dawes, William V. ... ... | 1.C. | Newcastle |
| Douthwaite, James W. ... | 1.C. | Newcastle |
| Wilkie, John S. ... ... | 1.C. | " |
| Wilkinson, John O. ... | 1.C. | " |
| Crawford, William ... ... | 1.C. | Glasgow |
| Humphreys, Thomas V. ... | 1.C.M.E. | Liverpool |
| Orr, John E. ... ... ... | 2.C.M.E. | Newcastle |
| Heaney, Alexander M. ... | 1.C.M.E. | London |
| Souter, George William ... | 1.C.M.E. | Newcastle |
| Ferguson, James ... ... | 1.C.M.E. | Liverpool |
| **For week ended 14th May, 1936 :—** | | |
| Warwick, Campbell R. J. ... | 2.C.M. | Cardiff |
| Williams, David G. ... ... | 2.C.M. | " |
| Knowles, Richard E. ... | 2.C. | " |
| Martin, Alfred ... ... | 2.C. | " |
| Huddart, Thomas H. ... | 2.C. | Newcastle |
| Wykman, Carl M. J. ... | 2.C. | " |
| Holtum, Richard R. ... | 2.C. | London |
| Allen, Philip B. ... ... | 2.C. | Liverpool |
| Barron, Norman G. ... | 2.C. | " |
| Hyde, Harold R. ... ... | 2.C. | " |
| Johnston, Angus McA. ... | 2.C. | " |
| Lamb, Richard W. ... ... | 2.C. | " |
| Rutherford, Eric M. ... | 2.C. | " |
| Wainwright, Kenneth M. ... | 2.C.M. | " |
| Watkinson, Roy C. ... | 2.C.M. | " |
| McGarrity, George K. ... | 2.C. | Glasgow |
| Monaghan, Charles ... ... | 2.C. | " |
| Russell, James B. ... ... | 2.C. | " |
| Wilson, John ... ... | 2.C. | " |
| Urquhart, Robert K. ... | 2.C. | " |
| Dun, George A. C. ... ... | 2.C.M. | " |
| Pryde, James S. ... ... | 2.C.M. | " |
| Wootton, Eric A. ... ... | 2.C.M.E. | Liverpool |
| **For week ended 21st May, 1936 :—** | | |
| Harrison, Cyril ... ... | 1.C. | Newcastle |
| Hassan, Robert V. ... ... | 1.C. | " |
| Scaife, Allen A. ... ... | 1.C.M. | " |
| Huxtable, Frederick J. ... | 1.C. | Cardiff |
| Roberts, Samuel H. ... | 1.C. | " |
| Davidson, David L. ... ... | 1.C. | Glasgow |
| Falconer, William R. D. ... | 1.C. | " |
| Kerr, William ... ... | 1.C. | " |
| McLean, Daniel ... ... | 1.C. | " |
| Kittow, Geoffrey C. ... ... | 1.C. | London |
| Stone, Hugh M. ... ... | 1.C. | " |
| Walsham, Thomas H. D. ... | 1.C. | " |
| Wilson, Richard ... ... | 1.C. | " |
| Mavin, Stanley ... ... | 1.C.M. | " |
| Winhall, Edwin K. ... ... | 1.C.M. | " |
| Evans, John N. ... ... | 1.C. | Liverpool |
| Jones, Percy W. ... ... | 1.C. | " |
| Finlinson, Harold M. ... | 1.C.M. | " |
| MacDonald, John A. McL. | 1.C.M.E. | " |
| Sara, Arnold H. ... ... | 1.C.M.E. | Glasgow |
| Pawson, Laurence J. ... | 1.C.S.E. | Liverpool |
| Smart, John A. ... ... | 1.C.M.E. | " |
| Johnson, Leslie ... ... | 1.C.M.E. | " |
| Boothroyd, Alexander ... | 1.C.M.E. | " |
| Jenkins, Ivor D. ... ... | 1.C.M.E. | London |
| Howe, Leslie H. ... ... | 1.C.M.E. | " |
| Wyld, John ... ... ... | 1.C.M.E. | Glasgow |
| Rutherford, John ... ... | 1.C.M.E. | Newcastle |
| Raeburn, George R. ... | 1.C.M.E. | " |
| Orr, John E. ... ... ... | 1.C.M.E. | " |
| Chambers, Robert H. ... | 1.C.M.E. | " |
| **For week ended 28th May, 1936 :—** | | |
| Chalmers, Albert E. ... | 2.C. | Newcastle |
| Kent, Frank ... ... ... | 2.C. | London |
| Walley, Leslie G. ... ... | 2.C. | " |
| Mills, John A. ... ... | 2.C.M. | " |
| Parrott, William L. A. C. ... | 2.C. | Liverpool |
| Ratcliffe, Frederick ... ... | 2.C. | " |
| Leslie, Paton L. ... ... | 2.C. | Glasgow |
| Thomson, Alexander ... | 2.C. | " |
| Cain, William L. ... ... | 2.C.M.E. | Liverpool |