The
INSTITUTE of MARINE ENGINEERS
Founded 1889. Incorporated by Royal Charter, 1933.

Patron: HIS MAJESTY THE KING.

SESSION
1937.

Vol. XLIX.
Part 6.

President : STEPHEN J. PIGOTT, ESQ., D.Sc.

Different Types of War Vessels.

Report by D. Jones of a Lecture delivered by Engineer Rear-Admiral W. M. Whayman, C.B., C.B.E. (Vice-President) at the Battersea Polytechnic under the auspices of the Junior Section of The Institute of Marine Engineers on the 12th April, 1937.

WARSHIP design of the post-war era has been considerably influenced by the advent of the aeroplane; therefore one finds in the navies of the world to-day a hybrid collection of ships composed of those built during the present period and ships constructed prior to the amazing progress made by aviation, the latter being modified and reconstructed to meet modern requirements.

The type mainly affected is the capital ship, and their normal life is 21 years; of the 12 battleships and 3 battle-cruisers which make up the British line-of-battle, 12 have passed the age limit. The rôle of the capital ship was generally considered to be the seeking out and engaging of the enemy battle fleet, but to-day, owing to the increased dangers of mines, submarines, and aeroplanes, this policy against an enemy in a strong defensive position would be so hazardous, especially with so few capital ships as the Royal Navy possesses to-day, that the situation would have to be extremely critical for this policy to be adopted.

The line of action that would be more favourable in a European war is that adopted in the late war of a "fleet in being", thus acting as a shield for the smaller craft to operate under. The policy to be adopted would naturally be affected by various considerations, such as the geographical position and the forces at the Navy's disposal. As naval tactics and strategy are not dealt with in this lecture, the above is intended to be an outline of the duties of capital ships.

The "Queen Elizabeth" and her sister ships are the oldest class now in service in the Royal Navy, having been laid down in 1913-15, the first ship ("Queen Elizabeth") completing in 1915. The average displacement tonnage of these ships is 32,000 and the original armament was 8 15in., 16 6in., 6 12-pounder (anti-aircraft) guns and 4 torpedo tubes; this has since been altered to 8 15in., 12 6in., 4 (now being increased to 8) 4in. anti-aircraft guns, 2 torpedo tubes, and a large number of smaller guns. The designed h.p. of 75,000 renders these ships capable of a speed of 25 knots. One aircraft is now carried by each of the ships of this class, and the original two funnels have now been "trunked" into one. These ships were the first battleships to be oil-fired in any navy. With their relatively high speed, the "Queen Elizabeth" class is almost in the battle-cruiser category and as the 5th Battle Squadron they served as such at Jutland and were of great value to Admiral Beatty's battle-cruisers in the critical early stages of the battle. Throughout this action and the rest of the war, they stood very well the heavy strain imposed by war routine.

The "Royal Sovereign" class of 5 ships, begun in 1913-14 and completed in 1916-17, are very similar to the "Queen Elizabeth", the main difference being in the disposition of the secondary armament. This was modified in accordance with experience obtained with the first ships of the previous class. The "Royal Sovereign" class are armed with 8 15in., 12 6in., 4 4in. (anti-aircraft) and numerous smaller guns. Their tonnage is approximately 33,000. These ships were originally intended to be coal fired but while they were under construction oil was adopted. The designed h.p. of 40,000, which gives a speed of 23 knots, is considerably below that of their predecessors. In appearance the most noticeable difference from the "Queen Elizabeth" type is the one straight funnel and (in 4 of 5 ships) the tripod mainmast.

Apart from the completion of one battle-cruiser in 1920 (begun under a wartime programme), no capital ship construction was undertaken between 1918 and 1922, when the Nelson class of two ships were laid down. These ships are "cut down" models of a type begun in 1917. They were to have been armed with 12 16in. guns, and to possess a high speed, with a displacement of 48,000 tons. Construction was discontinued with the cessation of hostilities. The "Nelson" class, compared with the conventional design employed since "Conqueror" days of two turrets forward, two aft and in some classes one abaft the second funnel, is revolutionary. The main armament of 9 16in. guns is grouped forward in three triple turrets. Apart from coastal monitors, they are the first ships to carry 16in. guns. They are also the first battleships completed of post-war construction. The secondary armament of 12 6in. guns is disposed in 6 twin turrets, 3 port and 3 starboard, abaft the single funnel and forward of the tripod mainmast. The main reason for this design was economy and secondly that the maximum protection is afforded to the vital parts by the 14in. main belt. Their displacement, 33,900 tons, was limited by the Washington Naval Conference of 1921 to 35,000 tons. The designed h.p. of 45,000 gives them a speed of 25 knots. Apart from the armament mentioned above, they carry 6 4·7in. (anti-aircraft) and numerous smaller guns, and 2 24in. torpedo tubes (the largest carried in any warship). Apart from the distinctive appearance imparted by the disposition of the main armament and the position of the funnel, the foremast has been superseded by what is nicknamed in the Navy "Queen Anne's Mansions". This structure contains the navigating, signal, and captain's bridges, and the gunnery and torpedo main controls, together with the main director and other necessary "departments" who have their "offices" there. As with most new ideas the whole design has been thoroughly criticised from many angles, but it will be noticed that the French Navy has since adopted the same main design in the "Dunkerque" class of battleship. It will be of interest to note the design of the "King George V" class now under construction, in view of the experience gained with the "Nelson" class.

The next type of warship to be considered is the battle-cruiser. This type was evolved by the late Admiral Lord Fisher, the object being, as the name implies, to combine the speed of a cruiser with the hitting power of a battleship. To obtain both these qualities it was necessary to dispense with the major portion of armour carried by the latter, and to install a much higher h.p. to give the speed of the former. It was partly due to the lack of armour that the British battle-cruiser forces at Jutland suffered so heavily; but it will be remembered that in 1914 the "Indomitable" and "Inflexible" were despatched to the Falkland Islands where they successfully chased and sank Admiral Von Spee's armoured cruisers. This was undoubtedly the rôle for which they were intended. It may be said that a battle-cruiser must be capable of successfully concluding an action with any warship other than a battleship. To-day the trend is towards a battleship with a cruiser's speed, and it is highly probable that the day of the battle-cruiser has gone for ever.

The Royal Navy has to-day 3 ships of this type, two being sister ships. These are the "Renown" and "Repulse" of 32,000 tons displacement, armed with 6 15in., 12 4in., and 8 4in. (anti-aircraft) guns. The shaft h.p. of 112,000 gives them a speed of 28 knots. The armour of these ships is very light compared with that of the "Nelson" and "Dunkerque" classes, the main belt being only 9in., and this extending only for a short distance. The "Renown" was largely reconstructed between 1932 and 1936. The "Repulse" is now undergoing similar alterations. From available photographs it appears that this work has been to reconstruct both main and fore-masts, dispose of one of the triple 4in. mountings, add an aircraft hanger abaft the second funnel, a new type of fixed catapult, two aircraft cranes, 4 aircraft, re-arrange the searchlights, add new after director, increase the anti-aircraft armament from 4 to 8 4in. guns, placing two of these on sponsons each side of the first funnel, re-engine the ship completely and effect numerous smaller alterations.

The third battle-cruiser, the "Hood", is the world's largest warship, being of 48,000 tons displacement. This ship has a speed of 31 knots, armament 8 15in., 12 5·5in. (it may have been due to the weights of 5·5in. and 6in. projectiles being 82lb. and 100lb. respectively that the former unusual calibre was adopted for easier handling) and 4 4in. (anti-aircraft) guns. In many respects the design is very similar to that of the "Renown" class before the latter's latest refit. The "Hood" is an exceedingly handsome ship and has been very useful in "showing the flag".

Aircraft carriers must next receive attention, and of this type Great Britain possesses 6 built.

Nearly all these differ from each other as to a great extent they are experimental, being converted from battleships or other vessels, except in the case of the "Hermes", which was the first ship built expressly as an aircraft carrier.

The duty of these craft is to act as floating aerodromes capable of high speed (to assist the aeroplanes in taking-off and landing). For their size they are lightly armed and will in any future war be a grave responsibility to the commander of a battle fleet, owing to their high freeboard, comparatively weak anti-aircraft defence, and the large target offered by the flying deck, upon which it would be necessary to score only one direct hit (except at the bow and stern) to render the ship useless as an aircraft carrier. H.M.S. "Argus", the oldest ship of this type now in service, is now used only for training purposes. She was begun originally as an Italian liner, was bought by the Admiralty on the outbreak of war and altered into an aircraft carrier. The displacement of 14,450 tons makes the "Argus" the second smallest ship of her type in the Royal Navy. This ship has a speed of 20 knots and can carry 20 aeroplanes. She was completed in 1918 and to-day her armament is 6 4in. (anti-aircraft) guns.

The "Courageous" class of two ships were originally built as large cruisers armed with 2 18in. guns each and intended for operations in the Baltic, hence their shallow draught. They displace 22,500 tons and have a speed of 31 knots. They are armed with 16 4·7in. (anti-aircraft) and a large number of smaller guns. They carry 48 aircraft. Their one large funnel is on the starboard side with the bridge and other superstructure on a tripod mast before it. They were both completed early in 1917.

The "Furious" began in similar manner to the above class. The tonnage and speed are the same as those of the "Courageous", but the armament is 10 5·5in. and 3 4in. (anti-aircraft) and many smaller guns. The main difference is the absence of superstructure and any visible funnel. The smoke is conveyed by a horizontal funnel aft and discharged over the stern. The "Furious" was completed late in 1917.

The next aircraft carrier to be completed was the "Eagle", in 1920. Begun as a battleship for Chile in 1913, this ship still retains the lines of a battleship. The displacement is 22,600 tons, speed 24 knots. The "Eagle" has been considerably altered since 1920. To-day she has two funnels with a large superstructure built round them, on the starboard side. She carries 21 aircraft.

The latest aircraft carrier now in service is the "Hermes". This ship is smaller than any of her predecessors, being of 12,500 tons displacement, armament 6 5·5in. and 3 4in. (anti-aircraft) guns, and speed 25 knots. The "Hermes" was begun under a wartime programme and completed in 1923. This ship is in some respects similar to the "Eagle", mainly with regard to the superstructure which is in the same position. The "Hermes", although scarcely half the tonnage of the "Eagle", carries nearly as many planes (18). One crane is fitted abaft the single funnel.

The next type of warship, and one of major importance, is the cruiser. These vary in size from 4,000 to 10,000 tons. The duties of these craft are varied, but their main work is the protection of the vast trade routes of the British Empire. The continuance of overseas trade is of vital importance to this country and in war this need is accentuated, for it is beyond doubt that without it Britain would starve. Besides the question of the protection of our food supply, it is of no less importance that the oil supply for the Navy itself, the Air Force and the Army should continue; without oil Britain's defences would be paralysed. It will be seen from the above that the maintenance of a large cruiser fleet is essential. In addition to the above-mentioned defensive requirements, cruisers are also employed to engage the enemy light craft in a major action. They are also used for raiding, and to-day, even with aircraft against it, a fast cruiser might emulate the depredations of the "Emden".

There are in all 51 cruisers of all classes in the Royal Navy to-day, the oldest being the "Carlisle" class of 8 ships. These ships differ slightly in tonnage, but the average is 4,200 tons, speed 29 knots, armament (in 6 ships) 5 6in. and 2 3in. (anti-aircraft) guns, and 8 21in. torpedo tubes. In the case of the "Coventry" and "Curley", the armament consists of 10 4in. and a large number of smaller guns. These two ships were re-armed during the crisis arising from the Italo-Abyssinian war. They are intended to act solely as anti-aircraft batteries, and are at present the only ships of this type in the world. There is little doubt that, in the event of a large air attack, these ships working with the fleet would make their presence very much felt. The other six ships mentioned were to have been scrapped under the London Naval Treaty of 1930, but Britain invoked what is known as the "Escalator" clause in the agreement, thus retaining these ships, the reason given being the present unsettled state of foreign affairs, and the Spanish Civil War. Most of this class were employed during the latter part of the Great War, the majority serving with the Harwich forces. Their rakish appearance earned them the nickname of "Tyrwhitt's battlecruisers".

Built shortly after the preceding class was the "D" class of 8 ships. These are very similar but a little larger (4,800 tons). As in the "Carlisle", the 6in. guns forming the main armament are mounted in single shields, all on the centre line. With their extra tonnage the "D's" are able to carry one more 6in. gun (abaft the foremast) and 4 extra torpedo tubes, making a total of 12 tubes in all, mounted in four triple mounts. All are above water level. None of the cruisers so far mentioned carries aircraft.

About the same time as the above classes were being constructed (1917) a much larger type was in hand. This was the "Frobisher" class of 5 ships, their tonnage being 9,800, original armament 7 7·5in.

guns, speed about 28 knots. These ships were intended to act as hunters for possible German raiders, and for this reason they have a very wide cruising range. Accommodation in this class is also very good. Under the terms of the London Naval Treaty, these ships were to have their 7·5in. main armament reduced to 6in. This work is now in hand in the three ships affected. The "Vindictive", the fourth, when completed in 1918 was an aircraft carrier. She underwent attention and when work was completed she was similar to her sister ships, with the exception that she had a hangar on the forecastle. The "Vindictive" is now being reconstructed as a training ship. The fifth ship of this class, the "Raleigh", was lost off the American coast in 1922.

There is little of interest to note of the next two ships built. These were the "Emerald" and "Enterprise", tonnage 7,550, speed 32 knots, armament 7 6in. guns. This class was begun late in 1918 and completed in 1926. "E" class are really an enlarged edition of "C" and "D". One point of interest is that the "A" and "B" guns of the "Enterprise" are not in single mountings as in the other ship but are in a twin turret (the first time that this method has been employed in cruisers). These ships also carry the largest number of torpedo tubes carried by any warship, 16 21in. mounted in 4 quadruple mountings on the main deck. In 1924 the first ships of the Washington Treaty era were laid down. This was the "Kent" class of 5 ships of 10,000 tons, 8 8in. and 6 4in. (anti-aircraft) guns, speed 32 knots. All this class were completed in 1928. They will carry, as each ship is refitted, 4 aeroplanes. This and the following two classes closely resemble each other, all having an unusual appearance for a warship; they have three tall raking funnels, two pole masts, and a very high freeboard. Armour, except in the "Kent" class (which have a small belt covering the engines), has been almost omitted from these ships. In the later ships of the "County" class (this heading covers all the cruisers of the "Kent", "Dorsetshire" and "London" classes), the main difference is in the addition of 8 21in. torpedo tubes. This class has been criticised as being weak compared with contemporary foreign cruisers, and perhaps this criticism is to a certain extent justified; there can be no doubt as to the fine accommodation provided in these ships.

The year 1927 saw the first attempt to slow the pace of naval construction. Prior to this date all signatories to the Washington Treaty had built their cruisers up to the limit of 10,000 tons imposed immediately the Treaty came into operation. By 1927 navies were crowded with the overgrown "tin-clad" cruisers which were extremely expensive and whose efficiency was little better than that of cruisers half their size. In this year the British Government laid down the "York" of 8,500 tons armed with 6 8in. and 4 4in. (anti-aircraft) guns, speed 32 knots, with 1 aircraft. In the next year the "Exeter" was commissioned. These two sister ships vary slightly. In the "York" the two funnels and pole masts have a rake, whereas in the "Exeter" there is a complete absence of any rake, giving the ship an appearance not seen since the "Tiger". The "'Exeter" also has an extra aeroplane. This is the last British ship to be armed with 8in. guns. With the ratification of the London Naval Treaty, the 8in. gun cruiser went out of fashion and the 6in. gun type came in.

The first cruisers to be built with 6in. guns since the "Enterprise" were the "Leander" class of 5 ships. These have a tonnage of 7,100, armament 8 6in. and 4 4in. (anti-aircraft) guns, 8 torpedo tubes, speed 32 knots. These ships were laid down between 1930 and 1933, the last being completed in 1935. The most noticeable feature of this class is the single large "trunked" funnel. This is the only class in the Royal Navy in which this feature has been employed. These ships have pole masts and one catapult abaft the funnel, with one aircraft. The main armament has a high rate of fire and theoretically the "Leander's" 8 6in. guns should give a heavier broadside than the 9 6in. guns of the German "Nurnburg". The 6in. armament can also be elevated to 60°, thus being of great value for anti-aircraft work.

The "Arethusa" class was the next type. These cruisers are of 5,200 tons displacement, armed with 6 6in. and 4 4in. (anti-aircraft) guns and 6 21in. torpedo tubes. There are four ships of this class and they are cruisers in the real sense of the name as it is claimed (*vide* "Daily Telegraph", 31st May, 1935) that they have a cruising radius of 12,000 miles. The designed speed of this class is 32 knots. The "Arethusa", although lightly armed, should be able to protect convoys from any ordinary raider. These ships have the largest boilers ever installed in any warship. They are also comparatively cheap and were constructed in two years.

Two further cruisers, the "Amphion" and "Apollo", were completed in 1936. They are enlarged editions of the "Arethusa" class, being of approximately 7,000 tons displacement, armament 8 6in. guns, remainder of armament the same as the former class. Both these classes carry one aircraft to each ship.

The latest cruisers in the Navy are the "Southampton" and "Newcastle", commissioned for service in March, 1937. This class (14 ships) are or will be armed with 12 6in. guns in four triple turrets (the first time triple turrets have been used in the Navy), 8 4in. anti-aircraft guns, and 8 torpedo tubes. The speed of this class is 32 knots. From the one photograph available of the "Southampton", it appears that this class will not be unlike recent Japanese types. The two funnels are "staggered" and the tripod mast has returned after 15 years absence. Another new feature is the adoption of a hangar to contain 3 aircraft abreast of the first funnel. The 8 4in. anti-aircraft guns are paired, being mounted in 4 large shields. This is also new to the British Navy.

Destroyers may be termed the "handymen" of the Fleet, as their duties are so numerous and varied. Some of these are mine-sweeping, minelaying, convoy protection, torpedo attacking, and, chiefly, anti-submarine work, for which they are invaluable. There is to-day, especially in foreign navies, a tendency to merge the cruisers and destroyers under the heading of flotilla-leaders, the French and Italian navies in particular possessing a large number of these craft.

The British Navy possesses approximately 140 destroyers and genuine flotilla-leaders, the oldest now in service being the "V" class. These ships were constructed under the War programme, most of them being completed in 1917 and 1918. The armament of this class varies, but the average is 4 4in. guns and 6 21in. torpedo tubes. Their tonnage is generally 1,100 and speed 31 knots. All this class served in the Great War. The name of every ship in this class begins with the letter "V".

The "W" class followed shortly after the "V" and are, except in minor details, the same. Many of this class were used as minelayers during the War.

The Admiralty in 1924 ordered two experimental destroyers and allowed the builders more latitude in their design than is usual. These two ships are the "Amazon" and "Ambuscade", completed in 1926, armament 4 4·7in. guns and 6 torpedo tubes, tonnage 1,200 (average), speed 37 knots.

In 1928 the "A" class were commenced, being different from the "Amazon" in that they have 8 torpedo tubes in two quadruple mountings, while the gun shields are larger and afford more protection. Their speed is 35 knots. This type was standard for British destroyers except in minor points until 1936. Between these years the "B", "C", "D", "E", "F", "G" and "H" classes of 8 ships (save the "C" class of 4) followed, and it is probable that the "I" and "J" classes now under construction will be of a similar design.

Great Britain has 18 flotilla leaders, the object of these ships being to act as flagships for destroyers when operating in flotillas. They are actually enlarged destroyers, having extra accommodation. Of the Royal Navy's 18 leaders, 9 were constructed under War programmes and are of the same design. Their tonnage is 1,590, armament 5 4·7in. guns and 6 torpedo tubes, speed 36 knots.

Since 1928, one flotilla leader has been built each year, the first of this series being the "Codrington" of 1,540 tons, 5 4·7in. guns and 8 torpedo tubes, speed 36 knots. All the following ships have been of the same general design and all are named after notable British naval officers of the past.

The duties of modern submarines in a future war depend to a great extent on the observation of international law by the country to which they belong, but apart from their undoubted qualities as commerce raiders, these craft are very useful for scouting and coastal defence. Apart from this work, their offensive power against surface warships must be considered, but how submarines will fare against an organised modern battle-fleet remains to be seen.

The oldest classes now in the Navy are the "H" and "L". The former are of 410 surface and 500 submerged tons. They are armed with 4 21in. torpedo tubes. Their surface speed is 13 knots, submerged 10½. The earlier boats of this class were built in Canada and were sent from there to England under their own power.

The "L" class boats are much larger, their displacement being 845/1,150 tons and speed 17½/10½ knots. These boats were all commenced under a War programme and the last one was completed in 1924. Their armament is 6 21in. torpedo tubes and 1 4in. gun mounted on the conning tower superstructure forward of the periscope. The advantage of this method is that the gun can be used when the submarine is running awash. In all later types this method has been used.

The "L" class was followed by the "O" type, which are slightly larger and have an additional 2 torpedo tubes in the stern. Their speed is 17/9 knots and they were completed between 1926 and 1930. The "P" class which followed is slightly larger, but there is little difference between the classes.

A new, smaller type was begun about 1929. This is the "Swordfish" class of 12 boats. Their tonnage is 670/960 and speed 13½/10 knots. This class is intended mainly for coastal work but they are capable of operating in larger areas such as the North Sea. They are armed with 6 torpedo tubes and 1 3in. gun.

At the same time that the first units of the "Swordfish" class were commenced, a much larger type was laid down. This is the "Thames" class of 1,850/2,710 tons, armed with 1 4in. gun and 6 torpedo tubes. These submarine-cruisers have a speed of 22 knots and are the fastest submarines in the world.

A new type of submarine-minelayer is now entering service. They are similar in general design to the "Thames" class but have minelaying equipment in the stern. They are armed with 1 4in. gun and 6 torpedo tubes, and have a speed of 15/9 knots.

The foregoing is a brief outline of warships of the Royal Navy of to-day. Many types of smaller auxiliary craft are not included, such as sloops, which have little fighting power and are used for convoy work, fishing protection, anti-slave patrol, etc. Besides these craft there are depôt ships, oilers, tugs, trawlers and many others, each carrying out the many smaller duties necessary for the maintenance of the world's largest Navy.

Special Materials used in Marine Engine Construction.

Report by A. K. Dobbie of a Lecture delivered by Dr. S. F. Dorey (Vice-President) at the Northampton Polytechnic under the auspices of the Junior Section of The Institute of Marine Engineers on the 17th February, 1937.

The Applications and Limitations of High Tensile Steels.

In order to meet the ever-increasing demand for speedier sea transport, marine engine designers have been compelled to increase steam pressures and steam temperatures and this has necessitated the use of higher grade steels. Owing to the extensive research which has been made into the structure of steels and the effect of adding small quantities of other metals, and then applying careful heat treatment, the necessary steels have been forthcoming from the manufacturers.

At first sight it might appear that the use of high tensile steels would solve every problem that might arise, but this is not the case. In general these high tensile steels possess certain detrimental properties which only become apparent under special conditions. One such property is their low ductility, and while this is of little or no account in many engine components, it is definitely undesirable in the crankshaft and propeller shaft of a ship for the reason that torsional oscillations are set up in the shaft by the cyclic variations in the engine torque and these could lead to fracture under certain conditions if they were not damped out. If the shaft were made of mild steel, the large hysteretic loss consequent upon its high ductility would damp out the oscillations considerably; whereas if the shaft were of low ductility high tensile steel, the oscillations would be transmitted without any diminution in amplitude to the far end of the shaft where fractures are most liable to occur.

It is well known that a specimen of steel may be broken by an alternating stress of far smaller magnitude than the ultimate tensile strength of the material, and this so-called fatigue strength is a constant for a given material. The ratio of the fatigue strength to the ultimate tensile strength is not the same for all materials, it being much lower for high tensile steels than for mild steels. To take a particular example a 74 tons nickel chrome steel has only twice the fatigue strength of ·1 per cent. carbon steel of 25 tons U.T.S. Thus a three to one ratio of ultimate tensile strength gives only a two to one ratio of fatigue strength.

The surface finish of a specimen affects the endurance to a marked extent, the greatest strength being obtained when the surface is highly polished. For a given roughness of surface the endurance limit decreases with an increase in the diameter of the specimen, the effect being greater in high tensile than in mild steels, thus further reducing the advantages of the former.

When a specimen is notched, thus causing a stress concentration over a small length of the specimen, it is found that the endurance limit is reduced in a far greater proportion in the case of nickel chrome steel than in mild steel. For a given depth of notch the fatigue strength diminishes rapidly up to a diameter of specimen of $\frac{3}{8}$in., then diminishes less rapidly with diameters up to $\frac{3}{4}$in., and falls off much more gradually as the diameter is further increased. Thus when using high tensile steels, great care must be taken in proportioning any part in which there is a stress concentration. In general this means that a higher factor of safety must be employed with high tensile steels than with mild steel.

Allowance must also be made for the conditions under which the finished component will be used, as the fatigue strength of a metal varies considerably with the medium which surrounds it. In a marine engine there is the possibility of either fresh or salt water coming into contact with the machinery, and it is these two liquids which have the greatest effect on the fatigue strength of metals. A comparison between a nickel chrome steel and a ·15 per cent. carbon steel gives the following results : endurance limit of nickel chrome steel in air 30 tons sq. in. and in fresh water 6 tons sq. in., while the endurance limit of mild steel in air is 15 tons sq. in. and 7 tons sq. in. in water. This demonstrates very clearly the remarkable fact that ordinary low carbon steel will actually give better service than nickel chrome steel when working with alternating stresses under water. Experiment has further shown that as the number of stress cycles is increased beyond the recognised testing limit of 5×10^7 cycles the endurance limit of nickel chrome steel continues to fall, and on this account it should be borne in mind that this number of stress cycles is exceeded in the connecting rod of a marine engine in a few months—a very short time compared with the normal life of a ship.

A further comparison of the two above-mentioned steels reveals that in salt water the mild steel has a slightly lower endurance limit at 5×10^7 cycles than the nickel chrome steel, but both are below 6 tons sq. in., and therefore would be uneconomical to use in practice under such conditions. The most suitable metals for use under water are the stainless steels, as in either fresh or salt water these have an endurance limit which is only slightly less than their endurance limit in air, and important also is the fact that this value remains practically constant after 5×10^7 cycles. Unfortunately these steels do not find the wide application in practice which they merit, owing to their high cost.

High tensile steels find their greatest field of application in high speed engines where the inertia forces due to the reciprocating masses are of considerable magnitude. 3 to 3½ per cent. nickel steel is found to be a very satisfactory material for connecting rods, but its heat treatment is important, and the specified temperatures are very critical. The high tensile strength of the steel is obtained by oil hardening at 830°C, but as this makes it comparatively brittle, it must be subsequently tempered. The ductility of the final product is proportional to the tempering, but the more tempering it receives, the lower becomes its ultimate tensile strength, and if the temperature exceeds a certain critical value which is near the oil-hardening temperature, the tensile strength is reduced to a very low value. The tempering of this steel should be carried out at 600°C, and this gives an Izod value of 60ft. lb. and an U.T.S. of 50-55 tons/sq. in. with the satisfactory endurance limit of ±22 tons/sq. in.

Parts subjected to alternating stresses at high temperatures should be made of chromium steel forgings or castings containing 13 per cent. to 14 per cent. chromium, and given the following heat treatment. The final component should be annealed at 1,000°C, then reheated after rough machining to 950°C, and allowed to cool slowly (in 2 hrs.) to 900°C, from which temperature it should be cooled very quickly, preferably in oil. Finally it should be heated to 700°C, and cooled slowly to give it the necessary ductility.

Considerable care must be taken in the choice of a steel for superheater tubes, as these are subjected to high stresses at high temperatures, and in consequence the amount of creep is liable to become excessive. Alloy steels containing nickel, chromium and molybdenum are found to be the most satisfactory for such conditions, as they permit higher working stresses and temperatures for a given creep.

Thus we see that high tensile steels are almost indispensable for certain components, but they cannot be in any way regarded as the panacea for the multitudinous problems which arise in marine engine construction. The high cost of manufacture and the special heat treatment required for high tensile steels combine to make them compare very unfavourably with mild steel with its low cost, ease of production, and need of only simple heat treatment.

ASSOCIATE MEMBERSHIP EXAMINATION, MAY/JUNE, 1937.

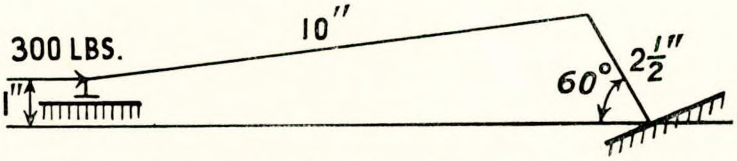
The following are the papers set for the recent Examination:—

APPLIED MECHANICS.

Monday, May 31st, 1937. 10 a.m. to 1 p.m.

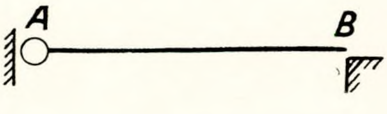
Not more than *six* questions to be attempted. All questions carry the same marks.

1.



A small engine has the cylinder line offset from the centre of the crankshaft by 1 inch. The crank arm is 2½ inches long and the connecting rod is 10 inches long. What is the crank effort for a piston force of 300 pounds when the crank is in the position shown in the diagram? Give also the piston velocity for this crank position if the engine is making 1,000 revolutions per minute?

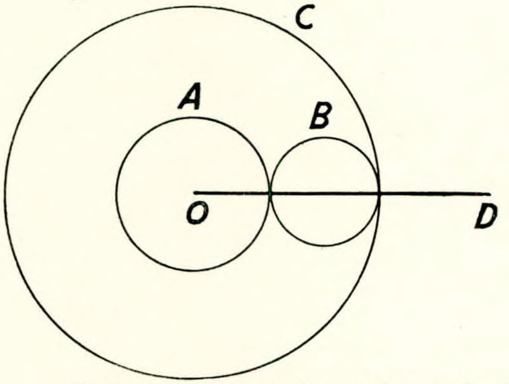
2.



A uniform rod is hinged at A allowing it to rotate in a vertical plane. A support under B is suddenly removed when AB is horizontal. Calculate the initial angular acceleration of the rod and the effect upon the supporting force at A. The rod weighs 16 pounds and it is 6 feet long. Any formulæ used in your solution must be proved from first principles.

3. A horizontal shaft 12 inches long between bearings carries at mid-span a circular disc of uniform thickness. The disc weighs 160 pounds and is 2 feet in diameter. The centre line of the shaft passes through the centre of the disc, but is inclined at 80 degrees to its plane. Calculate the forces on the bearings when the shaft is revolving at 600 revolutions per minute.

4.



With the epicyclic gear shown A has 60 teeth, B has 20 teeth and C has 100 teeth. The axis of B is carried on the revolving arm OD, which revolves about O the centre of the wheel A. If B makes 100 revolutions per minute clockwise and A makes 100 revolutions per minute anticlockwise, what is the speed and direction of the wheel C and of the arm OD?

5. A rope is passed round a bollard and a pull of 40 pounds is applied to the slack end. Calculate the number of turns necessary if the pull on the tight side is 1½ tons and the rope does not slip. The coefficient of friction is ·3.

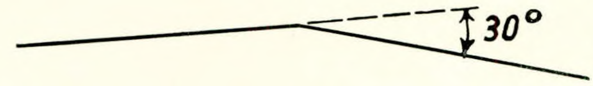
6. Water is flowing full through a horizontal pipe 8 inches in diameter. There is a gradual local reduction to 4 inches diameter. If there is a flow of 112 cubic feet per minute what is the difference in pressure due to the change of section? Prove any formula you use.

7. Define "Coefficient of Viscosity" and explain how you would proceed to estimate its value for a liquid, using any apparatus with which you are familiar.

8. Explain the Principles of Dynamic Similarity, and give a detailed account of their application to any problem you have studied.

9. The outer diameter of a centrifugal pump impeller is 5 feet, and its inner diameter is 2½ feet. At what speed should it just begin to lift against a head of 40 feet if it is full of water? Prove any formula you use.

10.



Two shafts intersect at an angle of 30 degrees. The connection is by means of a Hooke's Joint. If one shaft is revolving steadily at 500 revolutions per minute, calculate the maximum and minimum speeds of the second shaft. Prove any formula you use.

PROPERTIES AND STRENGTH OF MATERIALS.

Monday, May 31st, 1937. 2 p.m. to 5 p.m.

Five questions only are to be attempted. Each question carries the same marks and credit will be given for orderly statements showing how the numerical answers are obtained.

1. State briefly what is meant by:—(*a*) Hooke's Law; (*b*) Poisson's Ratio; (*c*) Limit of Elasticity; (*d*) Yield Point; (*e*) Annealing.

2. A solid shaft carries a flywheel weighing 3·5 tons which may be regarded as concentrated at the centre of the 8 feet span. It has also to transmit 850 horse power at 90 revolutions per minute. Find the diameter of the shaft so that the maximum principal tensile stress shall not exceed 9,000 pounds per square inch.

3. A boiler stop valve is cast 0·5 inch thicker on one side than the other, due to the core shifting. The outside diameter is 10 inches and the inside 8 inches. Compare its strength to resist bending with that of the true section.

4. Derive from first principles the torsion formula for circular shafts, $\frac{T}{J}=\frac{f_s}{r}=\frac{C\theta}{l}$ State the units employed for each symbol.

5. Describe the apparatus and detailed procedure of an experiment to find Young's Modulus of a material supplied in the form of a long wire.

6. What are the general properties of cast iron in relation to its uses in marine engineering? Give an account of the recent advances made in the manufacture of castings.

7. Derive an expression for the maximum deflection in the case of a beam of span L units securely fixed at each end on level supports and carrying a load W units at the centre. State precisely the terms of the other units adopted.

8. A compound thick cylinder consists of one tube shrunk on to another. The external diameter is 10 inches, the junction diameter is 8 inches, and the internal diameter 6 inches. The

shrinkage produces a radial stress of 1 ton per square inch at the junction. If there is an internal fluid pressure of 5 tons per square inch, find the hoop stresses in each tube at each diameter.

9. A weight of 20 tons is supported by three comparatively short pillars each one square inch in cross-sectional area. The centre pillar is of steel and the two outer pillars of copper. The pillars are so adjusted that at a temperature of 15 degrees Centigrade each takes the same load. If the temperature is now raised to 115 degrees Centigrade find the stress in each column. You may assume the columns adjust themselves to equal lengths after heating.

Take E for steel 30×10^6 pounds per square inch
E for copper 12×10^6 pounds per square inch
Coefficient of expansion (steel) 12×10^{-6} per degree Centigrade
Coefficient of expansion (copper) $18{\cdot}5 \times 10^{-6}$ per degree Centigrade

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HEAT ENGINES.

Tuesday, June 1st, 1937. 10 a.m. to 1 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. One pound of air at 20 pounds per square inch absolute and 10 degrees Centigrade is compressed adiabatically until its pressure is 200 pounds per square inch absolute. It is then expanded isothermally until its pressure is again 20 pounds per square inch absolute. What is the ratio of the work done by the air during expansion to that done on the air during compression? Also calculate the temperature at the end of compression and the change of entropy during expansion. Take $\gamma = 1{\cdot}4$ and R, the gas constant = 96·3 foot pounds per pound per degree Centigrade.

2. Steam at 300 pounds per square inch absolute and 0·97 dryness fraction expands through a nozzle to 15 pounds per square inch absolute and the nozzle efficiency is 90 per cent. If the outlet area of the nozzle is 1·5 square inch determine the discharge in pounds per minute.

If the steam supply had been throttled to 200 pounds per square inch before entering the nozzle what would be the condition of the steam at entry? Would such throttling be likely to increase or diminish the discharge through the nozzle? Give reasons for your answer.

3. An eight cylinder marine oil engine, cylinder bore 600 millimetres, stroke 1040 millimetres, working on the four stroke cycle, develops an indicated mean effective pressure of 96·2 pounds per square inch when on full load and running at 160 revolutions per minute. The fuel consumption rate is 0·36 pound per I.H.P. hour with fuel oil of calorific value 19,000 B.Th.U. per pound. If the allowable rise in temperature of the jacket cooling water is 90 degrees Fahrenheit calculate the quantity of cooling water required in tons per hour. Assume that 20 per cent. of the heat supplied in the fuel is carried away by the cooling water.

Describe, with sketches, the arrangements you would make for metering the quantities of fuel oil and water on a shore test of an engine of the above size.

4. A slide valve has a travel of 7 inches; outside steam lap, 2 inches; lead, ¼ inch; inside lap, ⅜ inch. Neglecting the effect of the obliquity of the connecting rod determine at what percentages of the stroke the following occur:—admission, cut-off, release, and compression. The steam pressure at admission is 180 pounds per square inch absolute and owing to wiredrawing the pressure at cut-off is 5 pounds per square inch less than the admission pressure. Assuming a constant exhaust pressure of 3 pounds per square inch absolute set out to scale the probable indicator diagram. What is the value of the pressure at release. You may assume that expansion and compression are hyperbolic. The clearance is 8 per cent. of the piston displacement volume.

5. At a stage of a pressure compounded impulse steam turbine the mean diameter of the blade ring is 40 inches and the ratio of the blade speed to the jet speed is 0·4. The nozzle angle is 20 degrees and the speed is 3,000 revolutions per minute. The blade outlet angle is 30 degrees. If the blading velocity coefficient (ratio of outlet relative velocity to inlet relative velocity) is 0·82 find (*a*) the horse power developed by the blades for a steam flow of 720 pounds per minute, (*b*) the diagram efficiency (efficiency of the blading), and (*c*) the dynamical axial thrust.

6. An ammonia refrigerating plant works between temperatures of 8 degrees Centigrade and 20 degrees Centigrade, and the liquid refrigerant is cooled in the condenser to 12 degrees Centigrade before passing through the expansion valve. If the ammonia vapour is dry-saturated at the end of the adiabatic compression find the theoretical coefficient of performance of the plant. Also estimate the compressor horse power for a production of 0·875 ton of ice per hour, from and at 0 degrees Centigrade. The actual coefficient of performance is 0·6 of the theoretical.

Latent heat of ice, 80 C.H.U. per pound.
Latent heat of ammonia at -8 degrees Centigrade 318 C.H.U. per pound.
Latent heat of ammonia at 20 degrees Centigrade 284 C.H.U. per pound.

Specific heat of liquid ammonia 1·1.

Entropy of the liquid at 20 degrees Centigrade 0·0775.

Entropy of the liquid at -8 degrees Centigrade $-0{\cdot}031$.

7. A Diesel engine has a compression ratio of 13 and the pressure at the beginning of compression is 14·2 pounds per square inch absolute. Assuming the theoretical cycle to be followed and that the fuel valve is open for one-fifteenth of the stroke find the mean effective pressure. Take γ equal to 1·4 for compression and expansion.

8. The volumetric composition of the dry flue gases obtained on a boiler trial was as follows :—CO_2, 10·7 per cent.; O_2, 9 per cent.; N_2 (by difference) 80·3 per cent. The percentage composition of the fuel by weight was C, 80; H_2, 5·5; O_2, 6·5, remainder ash. Determine (*a*) the percentage composition of the dry flue gases by weight, (*b*) the weight of the flue gases per pound of fuel, and (*c*) the air supplied per pound of fuel. The air supplied is preheated and its temperature at inlet to the heater is 80 degrees Fahrenheit. The drop in temperature of the flue gases through the heater is 450 degrees Fahrenheit. Estimate the temperature of the air leaving the heater.

Specific heats: air 0·24; dry flue gas 0·25; superheated steam 0·5.

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

9. In a marine installation the turbines develop 18,500 S.H.P. and the steam consumption is 9·3 pounds per S.H.P. hour. The vacuum at the condenser is 28·57 inches of mercury on the standard barometer. The steam at inlet to the condenser has an estimated dryness fraction of 0·96 and the condensate leaves at a temperature of 83·5 degrees Fahrenheit. The inlet and outlet temperatures of the circulating water are 65 and 78 degrees Fahrenheit respectively. Determine the diameter of the circulating water inlet for a water velocity of 8·5 feet per second. If the velocity of the water in the condenser tubes is not to exceed 6 feet per second and the tubes are 0·875 inch external diameter and 0·056 inch thick, determine the number of tubes required per pass. Sea water weighs 64 pounds per cubic foot.

10. In a single stage double acting air compressor the pressure ratio of compression is 5 and the diagram volumetric efficiency is 80 per cent. The compressor has to deal with 750 cubic feet of free air per minute at 14·7 pounds per square inch absolute and 60 degrees Fahrenheit. If the revolutions per minute are 500 and the allowable piston speed is 1,250 feet per minute find the bore and stroke. Also find the clearance volume in cubic inches. Take $n = 1{\cdot}3$ for the expansion and the compression curves.

ELECTROTECHNOLOGY.

Tuesday, June 1st, 1937. 2 p.m. to 5 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. 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. Two resistances of 12 and 25 ohms respectively are connected in parallel. The combination is then connected in series with a coil of 30 ohms resistance.

What voltage will be required to send a current of 6 amperes through the whole circuit?

What will be the voltage at the terminals of each resistance under these conditions?

What current will flow through each of the resistances?

2. Give a description of the construction and action of the nickel-alkaline type of accumulator.

What are the particular advantages of this type of cell compared with the lead-acid accumulator?

What rules should be observed in order to maintain a battery of such cells in good condition and how would you satisfy yourself as to the readiness of the battery for an emergency?

3. What do you understand by *Reactance* and *Impedance?*

A non-inductive resistance of 20 ohms is connected in series with a coil having a resistance of 30 ohms and an inductance of 0·25 henry across a 220-volt, 50-cycle supply. Find the value of the current flowing through the circuit, and the voltage drop down the resistance and down the coil.

4 What do you understand by the terms *Star* and *Mesh* connections as applied to the stator windings of an induction motor?

A 3-phase motor connected across a 230-volt supply has its windings mesh connected. It gives out 16 brake horse power and at this load has an efficiency of 85 per cent and a power factor of 90 per cent. Determine:

(*a*) The kVA input of the motor;

(*b*) The line current;

(*c*) The current flowing through each of the motor windings.

5. Why does the PD at the terminals of a shunt dynamo drop with increased load?

When supplying a current of 200 amperes a separately excited dynamo has a terminal pressure of 437·2 volts. The load on being increased to 550 amperes causes a fall in the terminal pressure to 432·3 volts. Calculate the E.M.F. generated by the dynamo and the value of its armature resistance.

6. In a particular case where three compound dynamos were run in parallel it was found that repeated reversal of one particular generator took place on shutting down. Explain:

(*a*) The probable cause of this;

(*b*) How its occurrence would be indicated;

(*c*) How you would rectify it, and if possible prevent its recurrence.

Illustrate your answers by means of diagrams wherever possible.

7. Discuss the particular atmospheric and other conditions which affect the design and construction of the electrical machinery installed on a ship as compared with normal land equipment for similar purposes.

What special precautions are taken in the construction of such machines to protect them against the conditions you specify?

8. The load on the positive half of a 3-wire d.c. distribution system consists of 150, 100-watt, 220-volt lamps connected in parallel and on the negative half consists of 250, 100-watt, 220-volt lamps connected in parallel. Owing to a break in the middle wire, the balancer is unable to maintain the voltages equal and the two loads are thus connected in series between the outers. Assuming the resistance of the lamps to be the same as when burning normally, what would be the resulting voltage at the terminals of each lamp on the positive and negative halves of the system?

9. What is a *synchronous* motor?

When motors of this type are used on board ship for propulsion explain how the following may be accomplished:

(*a*) Starting;

(*b*) Speed control;

(*c*) Reversal.

10. Give a general description of the operation of the Ward Leonard method of speed control of a main windlass or capstan motor. Illustrate your answer by diagrams of connections and state the principal disadvantages of this type of control.

11. What is meant by the *Temperature Coefficient* of an electrical conductor?

The resistance of a generator armature at 16 degrees Centigrade is 0·27 ohm. The machine is run for 6 hours under full load conditions and on shutting down the resistance has increased to 0·31 ohm. What is the final temperature of the windings?

(Temperature coefficient of copper = 0·0043 per degree Centigrade, per ohm, at 0 degrees Centigrade.)

NAVAL ARCHITECTURE.

Tuesday, June 1st, 1937. 2 p.m. to 5 p.m.

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

1. Sketch a typical bracket connection between a deck beam and the ship's-side frame below. Show how to estimate the safe bending moment which can be carried by such a connection.

2. Describe the arrangement, operation and maintenance of a double bottom water ballast tank on a normal cargo vessel of about 400 feet L.B.P., indicating the normal positions of suctions, air pipes and sounding pipes.

3. A steel cantilever beam is to be fitted in a ship's engine room to carry a concentrated load near its outer end. For a safe load of 2 tons a welded beam of I type is proposed with top and bottom plates 9 inches × 0·5 inch and web 6 inches × 0·5 inch. What alterations would you make in these dimensions in order to provide for:

(*a*) double the load keeping the depth of web unchanged.

(*b*) double the load altering only the depth of web, assuming the web is thick enough for the increased shear.

4. Make freehand sketches showing:

(*a*) in outline, an arrangement of steering gear.

(*b*) a bottom rudder pintle about 8 inches diameter, with gudgeon, arranged to carry the whole weight of the rudder.

5. The following information is to be despatched to a ship abroad:

(*a*) the difference in draft on moving from river water of specified density to sea water; and (*b*) the fore and aft shift of a specified weight, required to bring the ship to level keel, the drafts forward and aft being given.

Explain how to obtain this information from the lines plan of the ship.

6. Show with the aid of diagrams how the transverse stability of a ship at small angles of heel is governed by the relative vertical positions of the centre of gravity, the centre of buoyancy and the metacentre.

7. Explain the difference between skin friction and wave resistance. In the case of a proposed new vessel, show how to estimate the value of these two resistances at a given speed.

8. Two sister ships make the same voyage under almost identical conditions. Ship A has an average speed of 9·6 knots on a coal consumption of 22·0 tons per day with an average displacement of 11,500 tons. Ship B has an average speed of 10·1 knots on a coal consumption of 24.2 tons per day with an average displacement of 11,200 tons.

Determine which ship has made the more efficient voyage.

9. On the measured mile trials of a new ship the following times were found for four consecutive runs between the posts, which are 6,080 feet apart:

North	5 minutes 45 2/5 seconds.
South	4 minutes 58 seconds.
North	5 minutes 30 4/5 seconds.
South	5 minutes 8 2/5 seconds.

Calculate the "true mean speed" in knots and state the error if the simple arithmetic mean is taken.

10. It is necessary to order a new propeller for a certain vessel which is to be the same as the existing *uniform* pitch propeller, the plans of which are not available. Explain with diagrams how to obtain sufficient information to enable the makers to cast the new propeller.

MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, June 2nd, 1937. 10 a.m. to 2 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 the with the drawings.

Either.

1. The accompanying pictorial sketch (Figure I) shows a connecting road for a reciprocating marine steam engine in skeleton form, concerning which certain essential dimensions are given. The maximum load which the connecting rod is required to sustain is 41,500 pounds.

Determine :—(1) From the information given in the appended table of British Standard Fine Bolts, the diameter of the top end bolts assuming an even distribution of the load at the top end, and a stress intensity not exceeding 5,500 pounds per square inch.

(2) From the same table, the diameter of the bottom end bolts assuming an even distribution of the load at the bottom end and a stress intensity not exceeding 6,500 pounds per square inch.

(3) The diameter and length of the top end bearings assuming an even distribution of the load and a load intensity not exceeding 925 pounds per square inch of projected area, the ratio of diameter to length being 0·9.

(4) The length of the bottom end bearing assuming a load intensity not exceeding 425 pounds per square inch.

(5) The stress intensity due to bending in the top end keeps assuming an even distribution of the load and freely supported ends.

(6) The maximum direct stress in the body of the connecting rod neglecting any buckling effect.

(7) The maximum *resultant* stress across the sections of the forked end arising from the proportions adopted in the design.

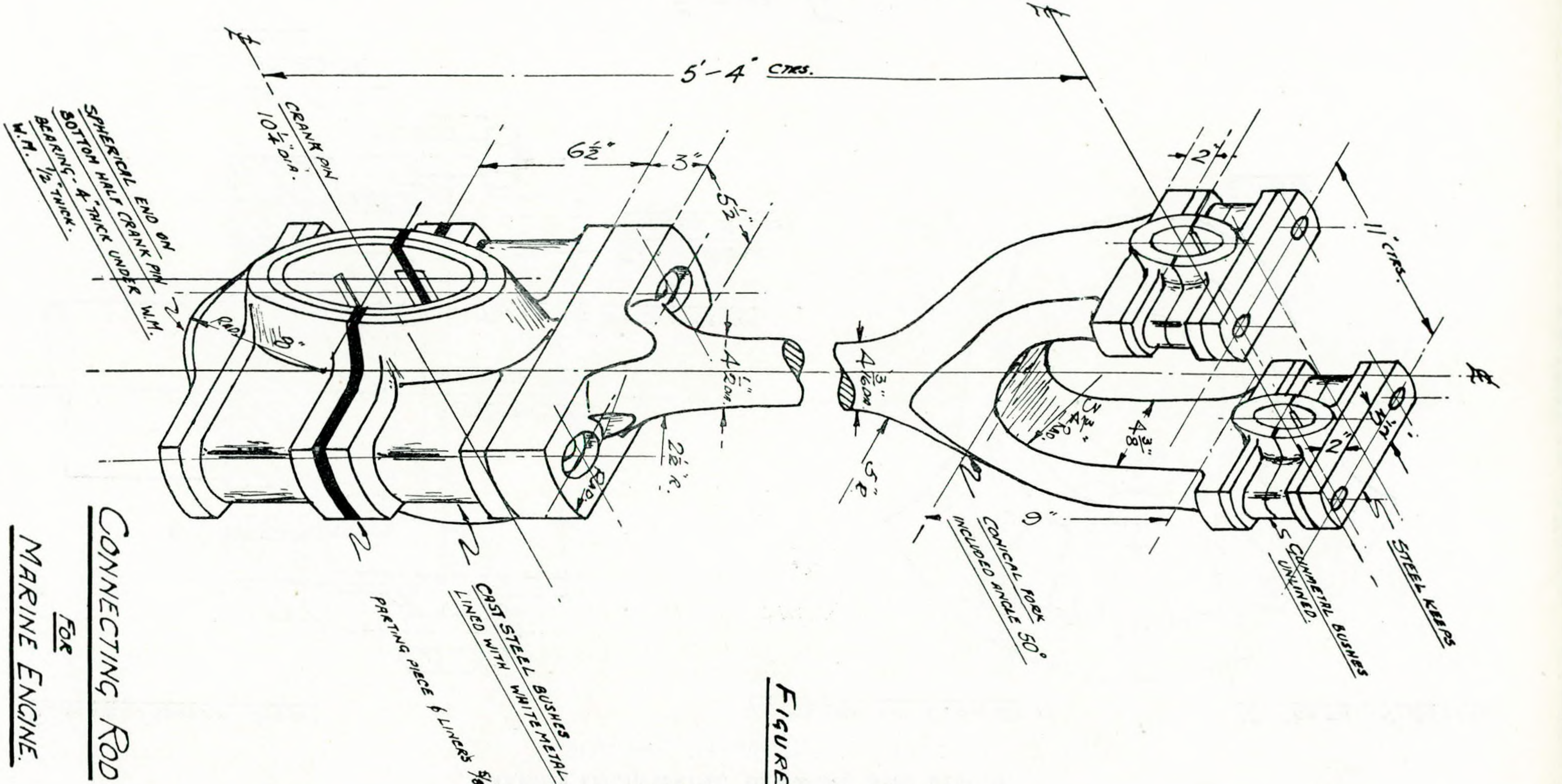
Make a working drawing of the connecting rod which should consist of the necessary co-related views. Show clearly—

(*a*) The method of securing the white metal filling at the bottom end.

(*b*) The methods of securing the top and bottom end bolts.

MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, June 2nd, 1937, 10 a.m. to 2 p.m.



CONNECTING ROD FOR MARINE ENGINE.

FIGURE I.

MARINE ENGINEERING DRAWING AND DESIGN.

Wednesday, June 2nd, 1937, 10 a.m. to 2 p.m.

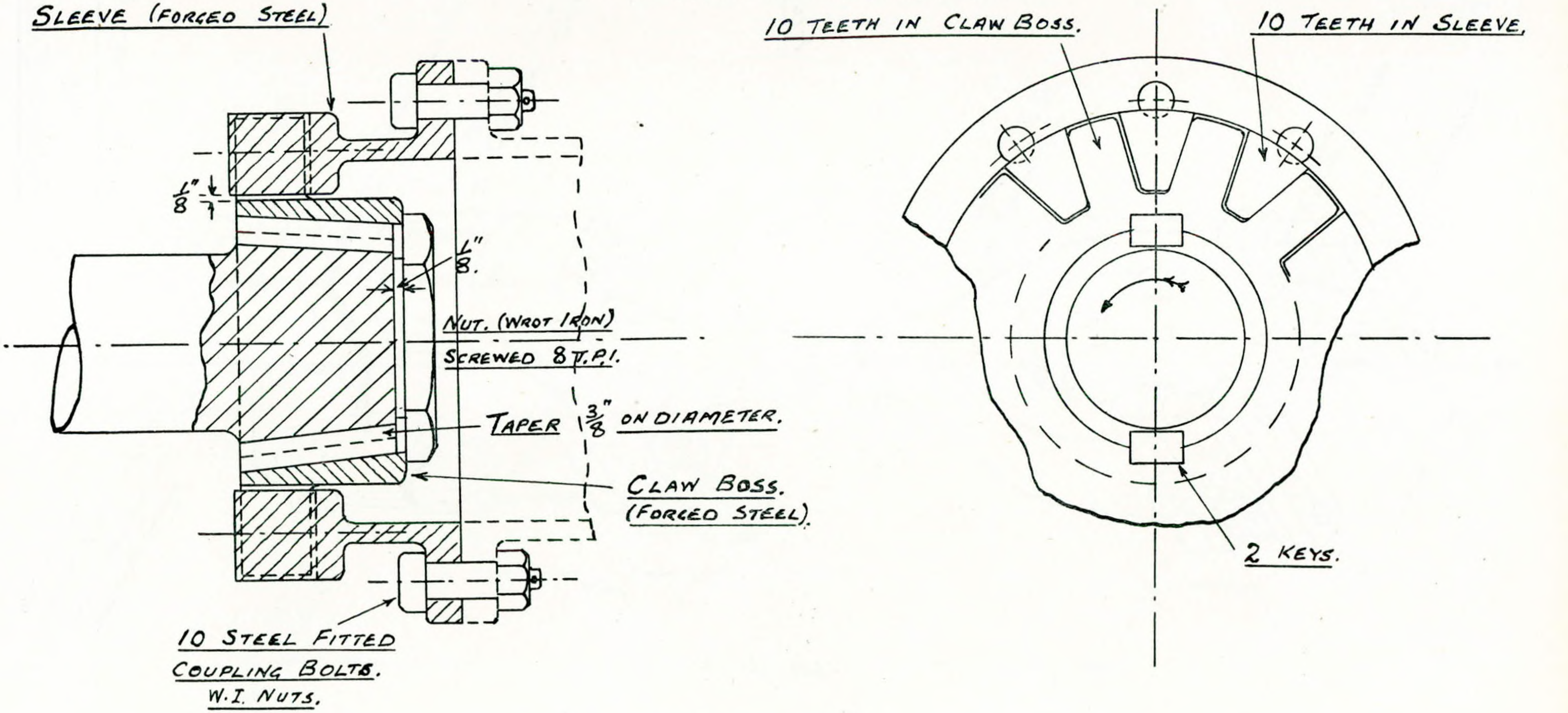


FIGURE II.

Data.

Table of British Standard Fine Bolts and Nuts.

Full diameter, inches.	*Threads per inch.*	*Area at bottom of thread in square inches.*
1¼	9	0·9637
1½	8	1·4100
1¾	7	1·9285
2	7	2·5930
2¼	6	3·2576
2½	6	4·1065

Or

2. In a marine geared turbine set, the drive from the turbine to the pinion shaft is effected by means of a "claw tooth" flexible coupling consisting of two claw bosses, mounted one on the end of each shaft, and a sleeve through which the drive is transmitted. The sleeve is built up of two similar pieces secured together by ten parallel fitted bolts (Figure II). Each portion of the sleeve contains ten teeth which engage with the same number in each claw boss. The driving surfaces are flat and both faces of the teeth are bedded to suit either ahead or astern running with a clearance of 1/64 inch on one face when the other face is bearing hard. The shafts are enlarged locally at their ends to take the bosses. The drive from shaft to boss and from boss to shaft is by means of two keys, located at a mean diameter of 1·2 times the normal shaft diameter.

Design the coupling to transmit 2,000 horse power at a speed of 2,400 revolutions per minute.

Make a working drawing of the complete coupling showing as many co-related views as are necessary to make the design clear.

Data.

The following stresses and pressures are not to be exceeded:—

Shear stress for shafts	2,200	pounds per square inch
Bearing pressure on claw teeth	350	,, ,, ,, ,,
Bending stress on claw teeth	1,500	,, ,, ,, ,,
Shear stress in sleeve coupling bolts...	1,300	,, ,, ,, ,,
Shear stress in keys	1,750	,, ,, ,, ,,
Shear stress in sleeve	720	,, ,, ,, ,,
Crushing pressure for keys	5,000	,, ,, ,, ,,

Assume width of key equal to (0·2 × diameter of shaft + ⅛inch), length of claw teeth equal to (1·2 × depth of teeth), and diameter of claw boss equal to 1·6 × normal diameter of shaft.

MARINE ENGINEERING KNOWLEDGE—Morning Paper.

Thursday, June 3rd, 1937. 10 a.m. to 1 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. Sketch a longitudinal section through a manhole in the cylindrical shell of a multitubular marine boiler showing the door in position. Show clearly how the strength of the shell is compensated at this point, the details of the method of securing the door into position, and the joint between the door and the shell; the clearance between the door and the shell should be carefully dimensioned.

2. Sketch two views of the method of making the longitudinal joint of a cylindrical multitubular marine boiler suitable for a boiler of 15 feet diameter carrying a working pressure of 200 pounds per square inch. Show the pitch of the rivets and the thickness of all the plates employed, and from the figures assumed show the full calculations from which the strength of the joint can be determined. The ultimate tensile strength of the steel may be taken as 30 tons per square inch and the shear strength of the rivets as 24 tons per square inch.

3. What are the objections to the presence of salt water in modern high pressure cylindrical multitubular marine boilers? How is the presence of salt water detected? How is the progressive accumulation of salt prevented in the event of salt water feed? Under these conditions, state what is considered a safe density at which to maintain the water in the boiler and give full reasons for this figure.

4. Describe in detail an hydraulic test on a cylindrical multitubular marine boiler that is in commission. State how the boiler is prepared for the test, giving the normal working pressure and the pressure employed for the test, the parts examined during the test, and the measurements considered desirable to take before, during and after the test.

5. Describe with suitable sketches an automatic feed water regulator as fitted to a marine water tube boiler. Give the reason for the necessity of such a fitting.

6. Draw an outline of a Yarrow water tube boiler and indicate all the fittings necessary in their correct positions. Sketch also as a separate detail the main steam stop valve in section.

SECTION B.—RECIPROCATING ENGINES.

1. Describe a means of governing the speed of a large marine reciprocating steam engine used for propelling a ship. How does the governor act in the event of a fractured shaft?

2. Sketch a cylinder cover for a large low presure marine reciprocating steam engine. Give two views and show the insulation and all the fittings required.

3. Describe a steam hydraulic reversing engine suitable for a main marine reciprocating steam engine. Explain how the main engine may be linked up while running, and how the main engine links may be operated from the ahead position to the astern position in port, when no steam is available for the reversing engine.

4. Sketch and describe a main engine eccentric strap and sheave. What governs the diameter of the sheave and the travel of the valve? How is the sheave secured to the shaft? State the materials employed and the method of lubricating and cooling the strap while running. Indicate by a line on your sketch the relative position of the crank.

MARINE ENGINEERING KNOWLEDGE—Afternoon Paper.

Thursday, June 3rd, 1937. 2 p.m. to 5 p.m.

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

SECTION C.—INTERNAL COMBUSTION ENGINES.

1. What parts of a main marine internal combustion engine require cooling? Enumerate the choice of media employed giving the relative merits of each. State also the pressures and temperatures maintained and the approximate percentage of the total heat supplied thus lost to the cooling medium.

2. Upon what type of internal combustion engine is a blow lamp employed for starting purposes? Give the cycle of events in this engine and draw an indicator card. What is the reason for the blow lamp, and what test is made to ensure that the engine is ready for starting?

3. For what part and for what period of the stroke is fuel injected into the cylinder of a Diesel engine? How can this period be reduced, delayed or increased? Sketch the fuel cam to illustrate the answer.

4. To what extent is compressed air used in marine Diesel engines? Give the pressures employed and describe in detail the means for storage, making special mention of any safety devices provided in the case of fire.

5. To what extent is compression carried in internal combustion engines working on the " constant pressure " cycle, and the " constant volume " cycle, and what considerations limit the compression ratio in the latter case? Draw an indicator diagram of each cycle giving the approximate pressures and temperatures attained at each point in each cycle.

SECTION D.—TURBINES.

1. Sketch a longitudinal section through the rotor of a reaction steam turbine indicating one row of blades only. Show the attachment of the shaft at each end, the fixing of the dummy pistons, and the arrangements provided to allow the shaft to warm up at the same rate as the outside of the rotor. What are the functions of the dummy pistons?

2. Explain the principle of an exhaust steam turbine fitted to augment the power of a main reciprocating engine. Describe the coupling between the two and the gearing employed, and state what provision is made for the turbine when the reciprocating engine is running in the reverse direction.

3. Make a line diagram of the steam pipes installed in a twin screw ship propelled by turbines showing the arrangement from the forward engine room bulkhead to the condensers. Enumerate all the valves including the steam pipe drains and indicate their correct positions on the sketch. Show also an arrangement of connections that can be used in the event of a complete breakdown of one unit.

4. Sketch an arrangement for turning a double reduction geared turbine when in port.

5. Describe a stuffing box and gland for an impulse steam turbine. What pressure is maintained in the gland and how is this pressure regulated to suit the varying speeds of the engine? What periodic attention is required?

SECTION E.—AUXILIARIES.

1. What is understood by the term "spontaneous combustion"? Explain how this can take place in bunkers designed for carrying coal fuel. How can the danger of this be increased or reduced? What methods are available for its detection and what remedies are used to extinguish a fire started in this way in a steamship?

2. What emergency pump is available in the case of the flooding of the main propelling engine room spaces? Give the approximate capacity of the pump and describe the emergency suction valve and suction pipe, showing the provision against choking. Describe the operation of the valve and state any necessary periodic attention.

3. Explain what is meant by the term "water hammer" and enumerate the evils resulting from it. Sketch an arrangement fitted to a "live" steam range which may prevent this danger. What would be the most effective position of the arrangement?

4. Sketch two views of a hand-operated door existing between the engine room and tunnel of a steamship fitted with a water tight bulkhead at this point. Show how the door may be operated from the deck level and also at the tunnel entrance. What periodic attention is essential?

5. In an installation of triple expansion steam engines in a modern steamship trace the passage of steam from the boiler stop valve back to the feed check valve. Explain fully the functions of the various fittings supplied between these two points. What tests may be applied to the feed water and what results should these tests show? What danger results from neglect of any point of the system?

INSTITUTE NOTES.

SEVENTH ANNUAL GOLF COMPETITION.

It must be gratifying to Mr. John Weir, whose gift of The Institute of Marine Engineers' Cup in 1931 initiated The Institute's Annual Golf Competition, to note the steady increase of interest in this direction of The Institute's social activities. On the occason of the Seventh Annual Competition for The Institute Cup and other valuable prizes, held at Hadley Wood, Herts., on Monday, June 14th, 1937, thirty-four Members participated in the day's events. Weather conditions were again perfect and the course at its best.

Messrs. J. N. Henderson (left) and A. N. Harnett.

The Cup Competition in the morning resulted in a tie between A. N. Harnett and J. N. Henderson with net scores of 73, the former being declared the winner on his better score for the last nine holes.

J. A. Goddard was the third prize-winner with a net score of 75.

MR. A. N. HARNETT,
Winner of the Cup.

The afternoon event was a two-ball foursome bogey competition, which resulted in a very close finish, three couples tieing with net scores of four down. The final order, as decided on the scores for

Some of the Competitors.

the last 9, 12 and 15 holes respectively, gave the first prize-winners as H. S. Humphreys and L. J. Le Mesurier; second, Eng. Capt. R. D. Cox and R. M. Gillies; third, A. N. Harnett and J. N. Henderson.

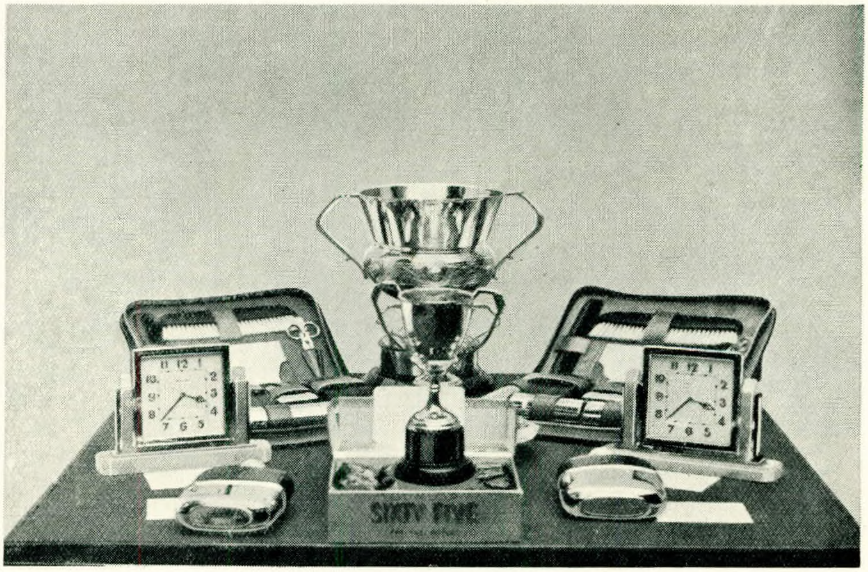
The prizes were presented by Mr. J. Hamilton Gibson (Vice-President), who voiced the opinion of all present that the meeting had been an unqualified success, for which they were grateful to Mr. Robertson (Convener) and his colleagues of the Social Events Committee, including the Secretary, for their excellent organisation of the day's programme, also to Mr. C. L. Gamble (Secretary), Major Leslie (Assistant Secretary) and the Committee of the Hadley Wood Golf Club for their hospitality.

It was unanimously decided to hold an Autumn meeting at Hadley Wood, particulars of which will be announced shortly.

The following is a list of the prizes and the names of the donors, to whom a special vote of thanks was accorded at the conclusion of the prize distribution.

Cup Competition: second prize—silver card tray, presented by Mr. H. S. Humphreys; third prize—silver cup, presented by Mr. A. W. Richardson.

Afternoon Competition: first prizes—two chrome and onyx clocks, presented by Messrs. D. M. Denholm and R. S. Kennedy; second prizes—two silver and crocodile flasks, presented by Mr. L. J. Le Mesurier; third prizes—two morocco "zipp" dressing cases, presented by Messrs. J. Hamilton Gibson and J. A. Goddard.



The Prizes.

Mr. A. N. Harnett received a small replica of the Cup, suitably engraved.

The Members who participated in or were present during the day's events included Messrs. E. F. J. Baugh, F. P. Bell, F. M. Boyes, F. M. Burgis, R. D. Cox, R. K. Craig, A. E. Crighton, B. C. Curling, D. M. Denholm, J. Hamilton Gibson, R. M. Gillies, J. A. Goddard, S. G. Gordon, H. Gordon-Luhrs, A. N. Harnett, D. J. Harris, E. C. Hatcher, J. R. Henderson, S. Hogg, G. A. Hughes, L. G. Hughes, H. S. Humphreys, E. B. Irwin, W. C. Jones, L. J. Le Mesurier, F. R. Lindley, O. H. Moseley, W. R. Parnall, R. B. Pinkney, R. Rainie, W. Ridley, A. Robertson, H. J. Savage, W. Tennant, W. G. Thomson, A. Walker, and J. H. Williams.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, July 5th, 1937.

Members.

Hugh Woodhams Brady, 127, Bridport Road, Dorchester, Dorset.

George Panos Callinicos, 45, Northumberland Place, W.2.

Charles Cuff Gambles, 95, Manor Lane, Sunbury-on-Thames, Middlesex.

James Graham, Hillswood House, Hillswood Avenue, Leek, Staffs.

William Bell Harrison, 104, Holywell Avenue, Monkseaton.

Andrew McBride, Moreton Freezing Works, Brisbane, Queensland.

Andrew Malcolm, 31, Therapia Road, E. Dulwich, S.E.22.

Robert Hamilton Reid, 54, Pollard Road, Whetstone, N.20.

Bertie Walford, 30, Ferncourt Avenue, Roseville, Sydney.

William Henry Reginald Watts, 73, Gantshill Crescent, Ilford, Essex.

Associate Member.

James Robert Watson, Assist. Supt. Engr. to Straits S.S. Co. and Ocean S.S. Co., c/o Messrs. Mansfield & Co., Ltd., Singapore.

Associates.

Stanley Walter Edwards, Sherford, Cornelia Crescent, Bournemouth, W.

Charles Albert Rischmiller, 6, Staunton Street, Deptford, S.E.8.

Robert Cecil Wilson, Jesmond Cottage, West Meadows Road, Cleadon, Sunderland.

Transfer from Student to Associate.

George Reginald Hawkins, 27, Westborough Road, Westcliff-on-Sea, Essex.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

Rules for the Construction and Classification of Steel Ships and their Machinery, 1937. The British Corporation Register of Shipping and Aircraft.

The Nickel Bulletin, Vol. 9, 1936. The Mond Nickel Co., Ltd.

"Experiment Results for a Series of Three-bladed Model Propellers in Open Water". Paper read by G. Hughes, B.Sc., Ph.D., before the Liverpool Engineering Society.

British Standard Specification No. 739-1937. Machine Tool Elements.

Transactions of the Institution of Engineers-in-Charge, Vol. 41, containing the following papers :—

"Milk and Mechanisation", by Barton.

"Power Plant Pipework and Fittings", by Bugden.

"Fractional H.P. Motors in Relation to Modern Domestic and Industrial Development", by Eley.

"Central Heating and Hot Water Supply", by Jones, Klausner, and Philliston.

"Boiler House Efficiency", by Chadwick.

"The Cause and Prevention of Industrial Accidents", by Ranger.

"Modern Developments in Welding", by Bainbridge.

Transactions of the Institution of Engineers and Shipbuilders in Scotland, Vol. 80, containing the following papers :—

"River Work for the 'Queen Mary' ", by Gardner.

"Timber and Shipbuilding", by Robertson.

"The Propulsion of Single-Screw Vessels : the Effect of Varying the Speed and Diameter of the Propeller", by Baker.

"The Electrically Welded Ships 'Bruce Hudson' and 'Transiter' ", by Macmillan.

"Television", by Howe.

"Training and Control of Welders", by Heigh and Orr.

"Cast Iron and Its Applications in Engineering", by Campion.

"An Analysis of the Performances of Some Diesel Propelling Engines", by Robb.

"Road Planning with Special Reference to Safety", by Budgett.

"Some Aspects of Metallic Corrosion", by Evans.

"Developments in Screw Fans", by Third.

"The Influence of Film and Time on Force and Shrink Fits", by Russell.

"Torsional Oscillation Analysis", by Davis.

"A.S.T.M. Standards on Petroleum Products and Lubricants" (prepared by Committee D-2 on Petroleum Products and Lubricants). American Society for Testing Materials, Philadelphia, 372pp., illus., $2.00 net.

The A.S.T.M. Standards on Petroleum Products and Lubricants is a compilation of the annual work by Committee D.2 on Petroleum Products and Lubricants. This committee and its sub-committees and technical committees is responsible for the development and preparation of technical standard methods of tests, for the drafting of specifications, for the nomenclature of terms and definitions, and finally for the issue of any charts and tables connected with petroleum products and lubricants.

The American Society for Testing Materials (A.S.T.M.) is a national technical society engaged primarily on the standardisation of methods. All standards are also approved by the A.S.A. and by the A.P.I. In this respect the co-operation is on similar close lines as that between the British Standards Institution as the main body and the I.P.T. Committee for the standard methods of testing petroleum and its products. The A.S.T.M. has 60 standing and research committees for the purpose of studying the properties of all important materials used in engineering, and the I.P.T. committee collaborates to a very high degree in connection with petroleum products.

The 1936 report deals with a number of revisions and tentative new standards for all major petroleum products, and the practical scope of these investigations is indicated by such headings as, for instance:—

Suggested Uniform Automotive Engine Lubrication Recommendations.

Diesel-Fuel-Oil Classification.

This year's report has extended the test methods, and amongst them are: Carbon residue of petroleum products; dilution of crankcase oils; analysis of knock characteristics of motor fuels; thermal value of fuel oil; and water and sediment in petroleum products. The specifications include one for fuel oils and amongst the new definitions relating to petroleum terms we find tentative suggestions for crude petroleum oil, gas oil and petroleum spirits.

All these subjects are, perhaps, more in the interests of the oil industry, but it is well for the marine engineer to remember this source of information, in case evidence in support of or against statements is called for relative to supply, quality or suitability of a particular fuel or lubricant.

A publication of this character, and of such high technological standard, calls for no comment except that the engineering world should be grateful for this valuable voluntary service from those many experts who annually assist in crystallising their wide and useful experience for the benefit of the engineering industry and its members.

"Examples in Practical Mathematics—Third Year (Senior) Course", by L. Turner. Edward Arnold & Co., 112pp., illus., 2s. net.

As its title implies this book contains examples of questions in practical mathematics, the answers being given at the end of the book .

It is grouped into chapters comparable with a general course of study of practical mathematics for the year quoted, but as each chapter is simply a number of questions of each division of the course, the book is perhaps of little value unless the student is working from what may be termed the "key" book of the course.

The book's principal value would be to students attending the author's course where the instruction would correspond with the chapters in the book.

"Patents for Inventions", by Reginald Haddan, Fellow of the Chartered Institute of Patent Agents. Sir Isaac Pitman & Sons, Ltd., 99pp., 3s. 6d. net.

The best recommendation for a book of this description was given quite spontaneously to the present reviewer by one to whom it was shown, viz., "I wish I had seen it before: it would have saved me a lot of time and needless expense".

This little handbook will be found extremely useful by inventors who have hitherto had no experience of Patent procedure to say nothing of those who think they know all about it. Fifteen short chapters deal with all the essentials, provisional protection, search of past records, value of further experiment during probationary period, the complete specification and claims, foreign and colonial patents, stamp duties, fees and agency charges, negotiations with licencees, etc.

There is a final page of advice in brief from which the following are selected: Do not delay application; the patent belongs to the first applicant, and priority is secured in forty-six countries. Do not disclose an invention before making application for protection or patent. Do not offer an unprotected invention for sale. Do not commence with a complete specification before the invention is tried. A search is advisable before filing the application.

"The Vertical Steam Engine" (Instructions in Engineering Design, Volume I), by H. P. Philpot, Wh.Sch., B.Sc., etc. Longmans, Green & Co., 100pp., illus., 5s. net.

The author of this interesting book is Principal and Professor of Technology at the Benares Hindu University and the whole scheme of work set out is designed for the enquiring student. It is not intended as a guide to engineering design in general but as a collection of notes on a specific case, to which, it is suggested, the student should design a parallel example. Hence we find interpolated in the text careful explanations of the theoretical and the practical problems involved. For example, the reasons for using a "diagram factor", the various aspects and possibilities of "compounding", the basic principles of valve diagrams, etc., are all carefully set out, while an appendix contains a statement of the three theorems of elastic failure. At the same time, due weight is given to a point often neglected in text books on design, namely that of the manufacturing aspect. The importance of complete and correct dimensioning of drawings is stressed, and the fact that a good theoretical design may have to be modified to suit the workshops or the general layout, is dwelt on.

Within the limits of its intended scope, the book is a valuable addition to an engineering library. The fact that in some cases illustrations are several pages distant from the relevant text is probably unavoidable, since such a fault occurs in almost every book of this nature.

"Elasticity, Plasticity and Structure of Matter", by R. Houwink. Cambridge University Press, 376pp., 214 illus., 21st. net.

One of the purposes of this book is to bring the physicists, the chemists and the scientific technologists into closer contact with each other, so that they may understand one another more easily, and, by the aid of an insight into the structure of matter, may seek to improve existing materials and to discover new ones.

This is not a book for the practical engineer who is looking for more information about the strength of materials; nevertheless, his knowledge of the properties and the structure of metals will be enriched by an acquaintance with this new line of approach.

The first chapter introduces the terms elasticity, relaxation, hysteresis, plasticity, trixotropy and yield value, and goes on to discuss methods of measuring. There appear to be certain analogies between behaviour of metals under test and other materials, which appear surprising to the mechanically-minded. This remark is borne out in the very first diagram which graphs together on the same stress/strain axes such materials as steel and rayon.

The next chapter is devoted to general remarks about the internal structure of matter. The cohesive and repulsive forces between atoms is discussed and the importance of Van der Waal's forces is emphasised. The reader is shown how the arrangement of the oxygen and silicon atoms in chains explains the formation of asbestos, while their grouping in lattice planes accounts for the thin plates that characterise the structure of mica.

Gels and fluids are investigated on the same lines as for solids and their properties are discussed in terms of their molecular arrangements.

The conditions for the elastic and plastic behaviour of matter are next examined. We read in this chapter that the technical tensile strength of a solid substance is usually from 1/500 to 1/1,000 of the theoretical strength as calculated with the aid of the forces acting between the constituent atoms, and this piece of information alone should give sufficient incentive to pursue this enquiry into the possibility of improving the strength of materials.

Chapter V, "The Plasticity of Crystals" is contributed by Dr. W. G. Burgers, and a study of this most interesting subject gives the engineer considerable enlightenment regarding certain phenomena observable when metals are exposed to stress.

The chapter covering amorphous substances deals with glass, resins and asphalt, special consideration being given to their elastic and plastic properties, under the influence of various temperatures. The effect of fillers in asphalt is discussed and the curves bear out the results in an interesting way.

Rubber, gutta-percha and balata are dealt with in fifty-eight pages, and a very full description is given of the chemical structure and behaviour of rubber during various stages of vulcanization. The enquiry into the elastic, plastic and molecular structure of rubber paves the way to an investigation into the composition of artificial "rubbers" such as chloroprene (or duprene) and similar synthetic materials which are coming more and more into the service of the engineer every day.

Cellulose products (cotton, rayon and cellophane) are given attention along the same lines, and a table is set out comparing strengths with those of wool, rubber and metals, and in another chapter proteins, which embrace animal products such as gelatine and glue, wool, and silk, are under review.

Bakers' dough, being a composition of cellulose and proteins is treated in a chapter by itself, as its characteristics are not altogether a combination of its constituents.

Paints and lacquers, clay and sulphur are the subject matters in the three concluding chapters, and while each class has special characteristics the investigations are all carried out along parallel lines.

The book is very fully supplied with references to the different authorities cited in the text, and readers interested in any particular aspect of the theories and discussions will find no difficulty in tracing the various sources of information.

This branch of science is still in a state of growth, and opinions of authorities are by no means alike. Nevertheless, the author has made a very plausible effort to trace unity of thought as far as it is possible at present. He fully believes that the subject matter discussed provides the key to the deliberate synthesis of materials, with definite desired elastic and plastic properties, which will be carried out in the coming decades.

The book is well printed and the diagrams, together with the several half-tone illustrations, are of special interest. The list giving the notation of the most frequently-used symbols just preceding the first chapter assists the reader to keep in touch with the various definitions and formulæ, while the index (authors and subjects) provides a very handy reference to the text, and it would be an injustice to the work if no reference were made to the excellent "Contents" from which the page of each section and sub-section can be obtained with the least amount of trouble.

"Diesel Engines", by P. E. Biggar. Macmillan & Co., Ltd. 165pp., illus., 10s. 6d. net.

The field covered by this book is chiefly that of the small high-speed heavy-oil engine as now used in the U.S.A. for road transport and for small stationary and marine installations. In addition, brief mention is made of larger stationary and marine engines as well as developments in heavy-oil engines for aircraft.

The first three chapters describe how the modern heavy-oil engine was developed from the Akroyd Stuart and the first blast air injection Diesel engines, its characteristics and applications and give a comparison of its construction and method of working with those of a petrol engine. This part of the subject, although very clearly set out is brief, dealing only with high-speed road vehicle engines and ignoring the larger stationary and marine engines.

Two important features of the engine, the full injection system and the engine speed governor, are next dealt with. In a later chapter maintenance of the injection system is also treated.

Chapters 6 and 7 discuss the properties of fuel oil suitable for high-speed Diesel engines and the process of combustion in the engine. Of these chapters perhaps the most interesting section is that dealing with the ignition quality of fuel oils, which quality has only recently been appreciated and compared.

Further chapters describe modern types of combustion chambers, types of road vehicle, marine and stationary engines and discuss the trend of Diesel engine design and the probable future development. Whilst of these latter chapters those dealing with road vehicle engines are well written and contain accurate information, this unfortunately cannot be said for those dealing with marine and stationary engines. Several statements are made which can be taken to apply to engines of all sizes and outputs whereas they should only apply to engines of the small high-speed type.

To those who wish to acquire a general knowledge of the high-speed heavy-oil engine as fitted in road vehicles without going into a mass of technical detail, this book will be of interest. The value of the book could be greatly increased by referring only to this type of engine and dropping all reference to the larger marine and stationary engines and also by adding further chapters dealing with subjects such as the design of the main parts of the engine and pressure charging.

"Standard Seamanship for the Merchant Service". By Felix Riesenberg, C.E. Chapman & Hall, Ltd. 2nd edn., 942 pp., 627 illus., 36s. net.

Riesenberg's excellent book "Standard Seamanship for the Merchant Service" appears to deal fully with all the problems likely to arise in the modern cargo steamers of the Mercantile Marine. The diagrams and sketches are very good, and of these the sketches in Chapter III, in conjunction with the text, should be of interest to the younger seamen who wish to become thoroughly conversant with the correct way to manipulate ropes, wires, etc. The chapter on ship maintenance should prove very useful to young chief officers as it contains a lot of valuable information on this subject. Chapter XIX on the handling of sailing ships should be read by all officers trained in steam, as it will give them a very clear account of how the various manœuvres, such as tacking, wearing, etc. are carried out in sail.

Finally, practical seamanship is treated throughout the book in a modern sense, that is, the methods and mechanical appliances described are those used in ships of the present day.

"Electricity and Magnetism for Degree Students", by S. G. Starling, B.Sc., A.R.C.Sc. Longmans, Green & Co., 630 pp., 446 illus., 12s. 6d. net.

This is the sixth edition of a book first published in 1912 which has earned a well-deserved popularity among students of electricity preparing for degree examinations. In this new edition the original framework of the book is unchanged, but several parts of lesser importance have been omitted. Amongst the latter is the subject of ship's magnetism which has been omitted entirely. In the new additions to the book may be noted brief accounts of developments such as cosmic rays, the neutron, positron and induced radioactivity, together with some mention of spectra. The book has now been reset in larger and clearer type, and in this respect is a considerable improvement on the previous issues.

The contents include a detailed study of the theory of magnetism, instruments and measurements, the electric current, resistance, electrolysis, Kirchoff's laws, electrostatics, thermo-electricity, application of thermodynamics, electro-magnetism, magnetic properties of substances, varying and alternating current circuits, effects of resistance, inductance and capacitance in such circuits, vector diagrams, units, electromagnetic radiation, propagation of waves, high frequency currents, conduction in gases, ionisation, mass spectra, radioactivity, atoms, and Zeeman, Stark and Faraday effects.

The subject matter in the fundamentals of magnetism and electricity is particularly complete and detailed, and consideration of the newer developments is as complete as space and their bearing on the importance of the subject will allow in a book which is already of considerable size.

At the end of the book is a collection of examples derived from the London University B.Sc. degree examination papers which will be a guide and help to the student preparing for this and similar examinations.

We have no hesitation in recommending the book, if such recommendation is needed for so successful an issue, to students who are preparing for the various university examinations in this subject, as well as to the general reader who wishes to obtain a concise yet general account of the latest developments.

ABSTRACTS OF THE TECHNICAL PRESS.

Air Preheaters for Marine Boilers.

The author discusses the general principles of air preheaters, their advantages and the troubles which have been experienced with them, and describes various types. The efficiency of a boiler depends largely on the temperature of the gases in the uptake, and without preheaters it is impracticable to reduce the temperature below about 200 to 250° C., even when the gases are used to heat the feed water. The corresponding loss in boiler efficiency is of the order of 10 per cent., but when preheaters are used the temperature can be reduced to 100 to 120° C., giving a chimney loss of less than 5 per cent. The gain with preheaters is due principally to the transfer of additional heat to the water *via* the air, the combustion temperature being raised, but there is also a slight improvement in the combustion itself at the higher temperature. The author gives figures to show that in the particular case of a water-tube boiler installation working at 400lb. per sq. in. and 400° superheat, the gain is sufficient to save a quantity of fuel equal to the weight of the preheaters in about three days. He emphasises the importance of designing the furnaces for preheaters in the first instance. The troubles encountered with the preheaters themselves he sums up as : deterioration of the heating surfaces, corrosion due to sulphuric acid, and choking with solid matter. To prevent corrosion, due to the formation of acid from gaseous sulphur-trioxide and water vapour, it is sufficient to prevent the mixture from reaching its dew point. Sooting-up requires periodic cleaning, which may be effected by blowing through with superheated steam or compressed air. As regards types of preheater, these fall into two main divisions, the plate or tube type in which the heat passes by conduction from the gases to the air, and the regenerative type, where the air and gases are admitted alternately to the same chamber, a typical instance being the Ljungstrom. In the case of the plate type, the plates may be corrugated to produce eddying and increase heat transmission. The Ljungstrom type has been adopted on a number of ships, and the author states that it does not easily become choked, and is readily cleaned. The tendency to recover heat by means of air preheaters rather than by feed water heaters will increase as working pressures rise.—*M. Liebaut. "Bulletin Technique du Bureau Veritas", Vol. 19, p. 127-135.*

Welded Pressure Vessels.

Under the title "Requirements for Welded Pressure Vessels intended for Land Purposes", Lloyds Register of Shipping have now issued a more detailed set of regulations replacing the tentative rules published three years ago. The new regulations relate to vessels of a thickness of not less than $\frac{3}{16}$in. and operating at temperatures not exceeding 650° F., but they may be applied to vessels designed for higher temperatures subject to special consideration of the scantlings and routine tests required. The fastenings covered are divided into "fusion welds" and "forge welds". The former include all welded joints made by the oxy-acetylene, oxy-hydrogen, metal-arc and electric-arc processes in which the arc and the deposited metal are shielded from atmospheric contamination. Forge welds are defined as welds made by hammering or rolling in which no added metal is included. In addition to the tests, the booklet contains illustrations of typical acceptable methods of attaching dished and flat ends to cylindrical shells; branches, compensating rings, and boxes to shell plates; and flanges to branches. Directions are also given for the inspection of materials, work in progress and plant.—*"Engineering", 11th June, 1937, p. 664.*

Heat Insulation.

Commenting, in an editorial, on the problems of heat insulation with special reference to high efficiency thermal plants in which very high temperatures are a prime consideration, the writer states that where there are definite restrictions of weight and space, as on board ships, the limitations of existing materials represent a serious obstacle to further thermodynamic development. A long list of exacting requirements has to be met. A low heat transfer coefficient is, naturally, of great importance, but the material must also be non-corrosive and non-hygroscopic to avoid all risk of chemical or electrolytic action at the surface of contact. It must be light and, preferably, capable of convenient removal and replacement; in addition it should be incombustible to obviate the fire risk in general and the possibility of deterioration as a covering by charring in particular. It should further be proof against spalling or splitting as a result of high temperature and mechanically strong enough to resist vibration. Finally the question of cost has to be considered. The writer states that within the range now associated with superheated steam the choice of materials is virtually limited to asbestos, spun glass, kieselguhr, aluminium foil and various combinations of the three first named materials. He states that the limiting temperature for felted asbestos is in the region of 800° to 850° F., while spun glass can be used to an upper limit about 100° higher. Beyond this level dual coverings comprising an inner layer of highly resistant material and an outer layer which will serve to withstand the lower grade heat escaping through the inner layer must be employed. By this means the temperature limit can be raised to the region of 1650° F. With regard to aluminium foil, for which extensive claims have been made, the writer states that its limiting temperature is much lower than the last named figure, even when it is new and bright, and he quotes recent publications to the effect that its efficiency falls when it becomes dirty, while its low mechanical strength calls for somewhat elaborate supporting arrangements. Pending the introduction of more effective media, the writer considers that much might be done to minimise heat losses in existing plants by accurate calculation of the insulation required, by skilful application and by careful inspection and maintenance, i.e. by remedies within the reach of every plant engineer.—*"Engineering", 4th June, 1937, p. 639.*

Progress in Smoke Abatement.

Commenting on the 22nd report on "The Investigation of Atmospheric Pollution", which covers the year ended March 31st, 1936, the Superintendent of Observations considers that on the whole there has been a definite reduction of pollution in the past twenty years. Thus, taking as a basis the total solids deposited together with the sulphates and the tar estimated therefrom, London from 1922 to 1936 showed little change in the total solids, but this was accompanied by an increase in the deposits of both sulphate and tar. If, however, the comparison is based on the amount of winter sunshine recorded respectively at Kew and in Central London, the observations indicate a noticeable improvement, the percentage of such sunshine in Central London having increased from 20 per cent. to 52 per cent. since 1881. Fluctuations in pollution have, however, occurred, e.g. at St. Helens. Here the total solids deposited fell from 612 tons per sq. mile in 1917-18 to 447 tons in 1935-36, but this figure had been as low as 371 in 1921 and as high as 759 in 1925-26. In the case of suspended impurities conditions and tendencies are similar. The figures for tar show an increase, one of the worst stations in this respect being Golden Lane, London, where an increase of 243 per cent. on the general average of the last five years was recorded. London shows the highest average pollution with a marked seasonal effect, which indicates the domestic fire as the principal culprit. The sulphur pollution at Greenwich seems to be one-third that in Central London, a result which suggests that in the latter area there are sources of sulphur pollution which are not serious sources of smoke pollution and points to industrial furnaces having no provision for the absorption of sulphur as being the cause of the higher sulphur pollution in London.—*"Engineering", 25th June, 1937, p. 735.*

New Fruit Research Laboratory at Covent Garden.

The article describes the enlarged laboratory of the Department of Scientific and Industrial Research established to examine fruit from the market, particularly fruit which has deteriorated and experimental consignments. A refrigerator and stores in which fruit can be preserved or ripened by adjusting the temperature are provided. Tests applied to fruit include the determination of sugar, acid and alcohol content, and the rate of respiration, the latter being an index of the rate of breakdown of sugar to carbon-dioxide. There will be a museum consisting of coloured photographs of specimens of deteriorated fruit.—*"Engineering", 2nd July, 1937, p. 17.*

New Propellers for the "Normandie".

The article gives some particulars, taken from the "Génie Civil", of the three sets of propellers

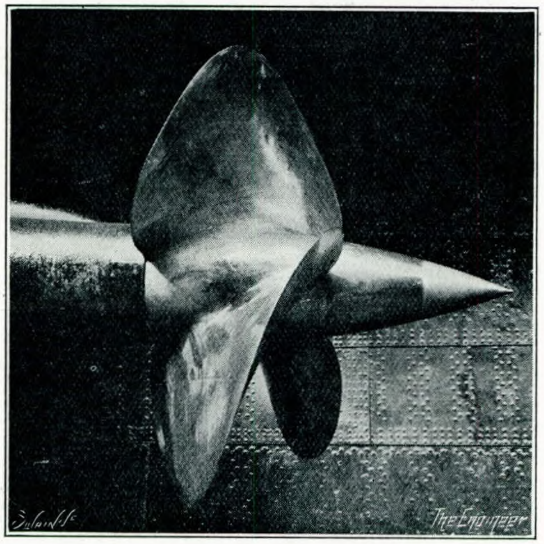


FIG. 1.—Three-bladed propeller—1935.

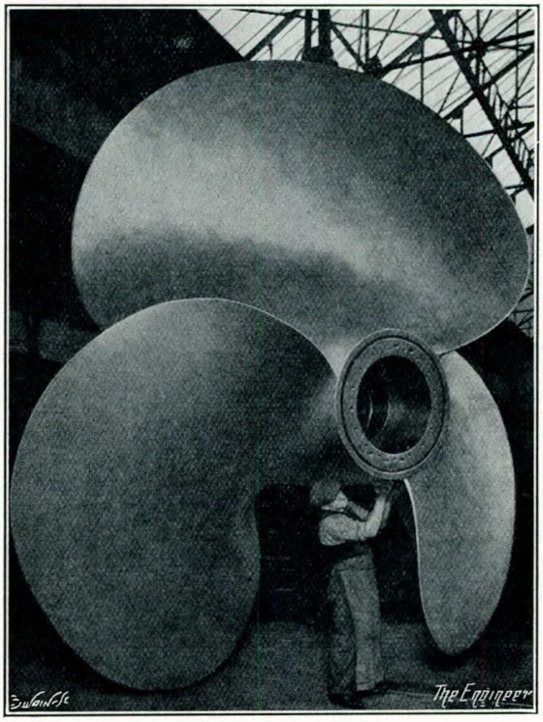


FIG. 2.—Three-bladed propeller.

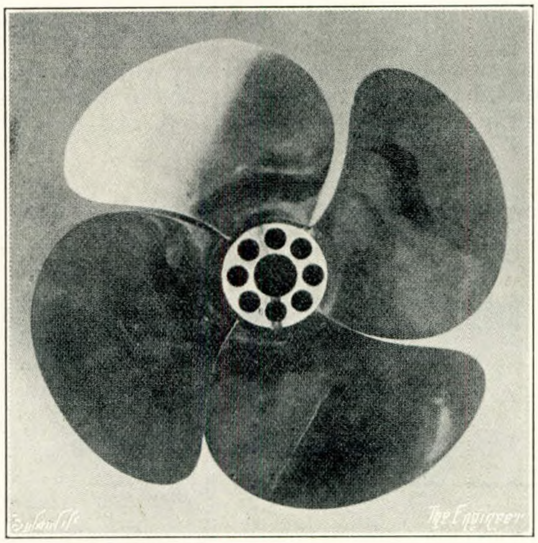


FIG. 3.—Four-bladed propeller—1937.

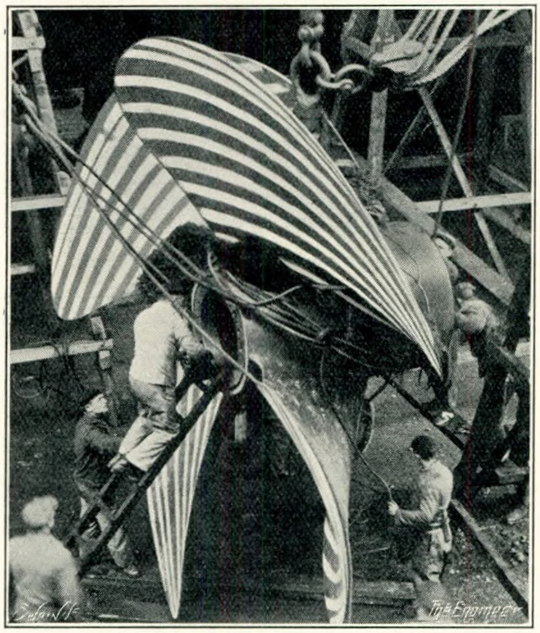


FIG. 4.—Four-bladed propeller.

with which the French liner has been fitted at different times. The first set, three-bladed and 15·7ft. dia. and 17·5ft. pitch, weighing 23 tons each, had no rake or sweepback. They were thought to be partly responsible for the vibration at first experienced and were replaced by four-bladed propellers of 16·55ft. dia. and 19ft. pitch, with 15° rake in order to increase the clearance from the shaft bossing, and with the blades swept back. This set gave about 28 knots at 190-200 r.p.m., a lower speed than the first set. To regain the lost speed a third set was fitted at the beginning of this year, similar as regards general design to the second, but having practically the same pitch and diameter as the original propellers. At the same time the power of the turbines was increased, and during the record run 180,000 s.h.p. was developed at 231 r.p.m., giving a maximum speed of about 32 knots. Vibration had been reduced with the second set, although this may have been partly due to hull modifications, and was still further reduced with the third. It is possible that still higher speeds may yet be achieved with the increased power of which the machinery may be capable.—*"The Engineer", 11th June, 1937, p. 674.*

Compositions for Deck Sheathing.

The article summarises a Board of Trade Circular giving the general conditions of approval for deck compositions of various types and a list of approved brands. Approval is subject to the results of tests of samples, and tests may also be made during laying. The general requirements are that a composition must be non-absorbent and sanitary, provide good foothold, be a bad conductor of heat, and incombustible. The Board specifies the position in which a composition may be used and the procedure to be followed in laying it. Thus magnesium chloride compositions must be laid on a deck which has been coated with non-corrosive. A certificate of heat conductivity is required in the case of compositions to be laid on weather decks, over boiler rooms, galleys and refrigerated spaces. There are also special requirements for decks over oil tanks. The circular covers sheet as well as plastic compositions, and also cements.—*"Engineering", 4th June, 1937, p. 635.*

EXTRACTS.

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

North Eastern Reheater Triple.

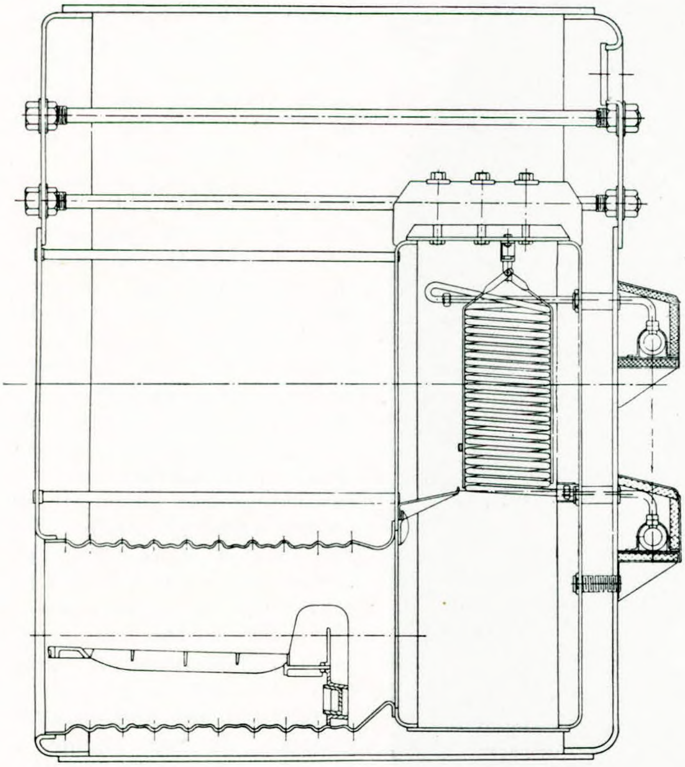
High economy with mechanical simplicity.

"The Marine Engineer", April, 1937.

As long ago as July, 1933, we made brief reference to an engine in which the steam was reheated in between the expansion stages with a view to improving economy by obtaining better conditions after the steam leaves the high-pressure cylinder. The idea of reheating the steam is, of course, not new, but so far as marine work is concerned very little has been done with the project despite its theoretical attractions. By means of reheating a high degree of overall economy should be obtainable, the additional complication and cost are not great, and the general reliability of the engine need not be impaired.

A North Eastern triple-expansion engine in an existing vessel was converted to this system in 1933 and the idea has since been given a very thorough testing in ordinary sea service. The economy to be expected by reheating has been realised in practice, the reheater has given no trouble, and as a result the Wallsend firm have felt encouraged to proceed further with the idea in a machinery installation calculated to give just about as high a degree of economy as might reasonably be expected with a triple-expansion not employing an exhaust steam turbine. In the original installation rather less severe steam conditions than those employed in the later installations about to be described were adopted. The results obtained with this original plant were, however, so satisfactory that the builders felt thoroughly justified in employing a higher degree of superheat in the later sets.

In the original triple-expansion installation as we know it to-day, the upper limits as regards steam conditions are usually a pressure of about 220lb. per sq. in. and a final temperature for the superheated steam of about 600° F.; such temperature is normally obtained with superheaters of the smoke-tube type. Compared with similar saturated steam installations, these conditions give a heat consumption economy of approximately 15 per cent. With this degree of superheat for the pressure mentioned no condensation occurs during the expansion of the steam in the high-pressure cylinder. During its passage through the intermediate-pressure cylinder, however, it becomes wet, while the degree of wetness encountered in the l.p. cylinder is greater still. It will be appreciated, therefore, that the greater part of the economy due to superheating the steam arises from the reduction of condensation. Additional superheating, it will further be appreciated, will improve these conditions to some extent, particularly in the l.p. cylinder, but there is a limit beyond which it is hardly worth while to go, apart altogether from any question of the mechanical difficulties arising due to very high steam temperatures. If, however, the steam is reheated after it leaves the high-pressure cylinder and before it enters the m.p. cylinder it is possible to be certain of dry steam right through the engine, that is, until it leaves the l.p. cylinder for the condenser. The amount of reheat required for this purpose varies, of course, but usually lies between 140° and 200° F.



Section through one of the main boilers for the reheater installation, showing the new form of combustion chamber superheater.

Steam conditions with different engine types.

At this stage, it may be of interest to examine the approximate steam dryness conditions at inlet and exhaust to and from the high-pressure, intermediate-pressure, and low-pressure cylinders of the three basic types of triple-expansion engine discussed, namely, saturated steam, superheated steam, and superheated and reheated steam.

As mentioned above, the superheated engine shows an economy in heat consumption of about 15 per cent. over the saturated steam installation, while experience to date has shown that with reheating an economy of at least 10 per cent. over the superheated engine is obtained. In fact, the experience so

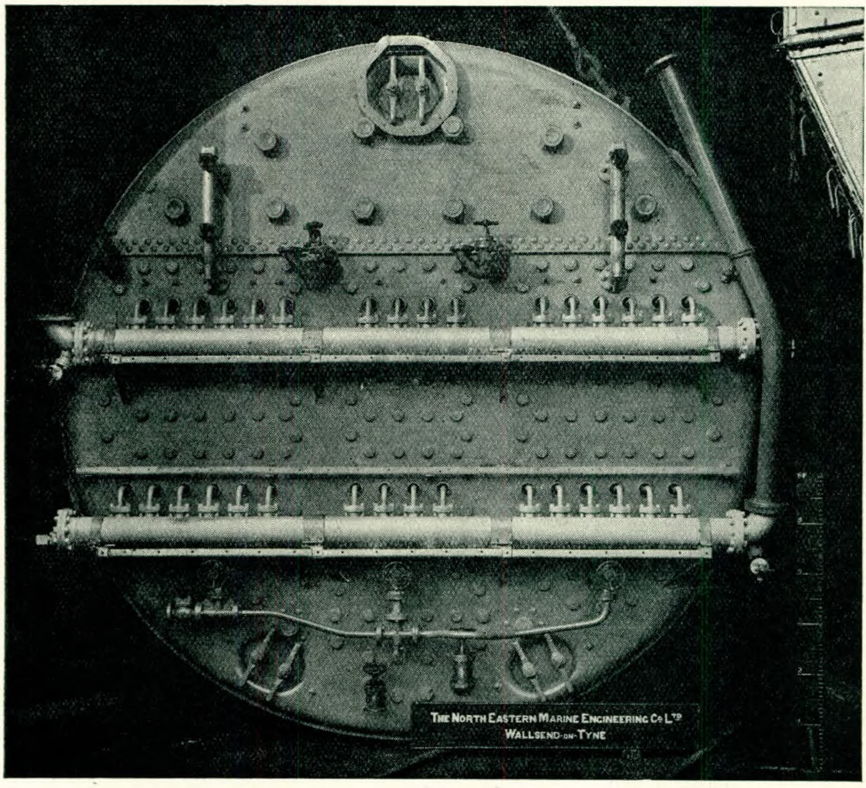
		Saturated steam, per cent. wet.	Superheated steam, °F. superheat.	Superheated and reheated, °F. superheat.
H.P.	Admission	2	200	200
„	Exhaust	6	85	85
M.P.	Admission	6	85	240
„	Exhaust	9	2 per cent. wet	125
L.P.	Admission	9	2 per cent. wet	125
„	Exhaust	12	5 per cent. wet	0° superheat

far gained seems to show that this last-mentioned figure is very conservative and is actually nearer 15 per cent. than 10 per cent. Having regard to the fact that the reheater installation is relatively simple—and by no means costly—the economic importance of this development will at once be appreciated. Furthermore, it is interesting to recall that the ideal of the complete elimination of cylinder condensation completes the line of development initiated by the great James Watt about 150 years ago, when, by his important invention of the separate condenser, he greatly reduced cylinder condensation losses.

It may be pointed out that in the case of the superheated installation the actual economy in heat consumption obtained in practice is greater than the theoretical figure and the same circumstance holds in the relation between the reheater engine and the normal superheated steam installation. This discrepancy between theory and practice is due to the deleterious effect of wetness on the efficiency of the cycle not being taken into account where the superheated steam installation is concerned.

Two reheater triple-expansion engines have recently been completed in the Wallsend works of the North Eastern Marine Engineering Co., Ltd., in which are embodied the improvements suggested by the experience obtained with the original installation referred to at the beginning of this article. These engines have been installed in the two new cargo vessels "Lowther Castle" and "Lancaster Castle" which James Chambers & Co., Ltd., the Liverpool owners, have recently placed in service. The main engines for one of these ships is shown in an accompanying illustration and it may be mentioned that it is rated at 1,800 i.h.p. at 68 r.p.m.; the cylinders have the following dimensions: 23in., 38in. and 66in., by 45in. stroke.

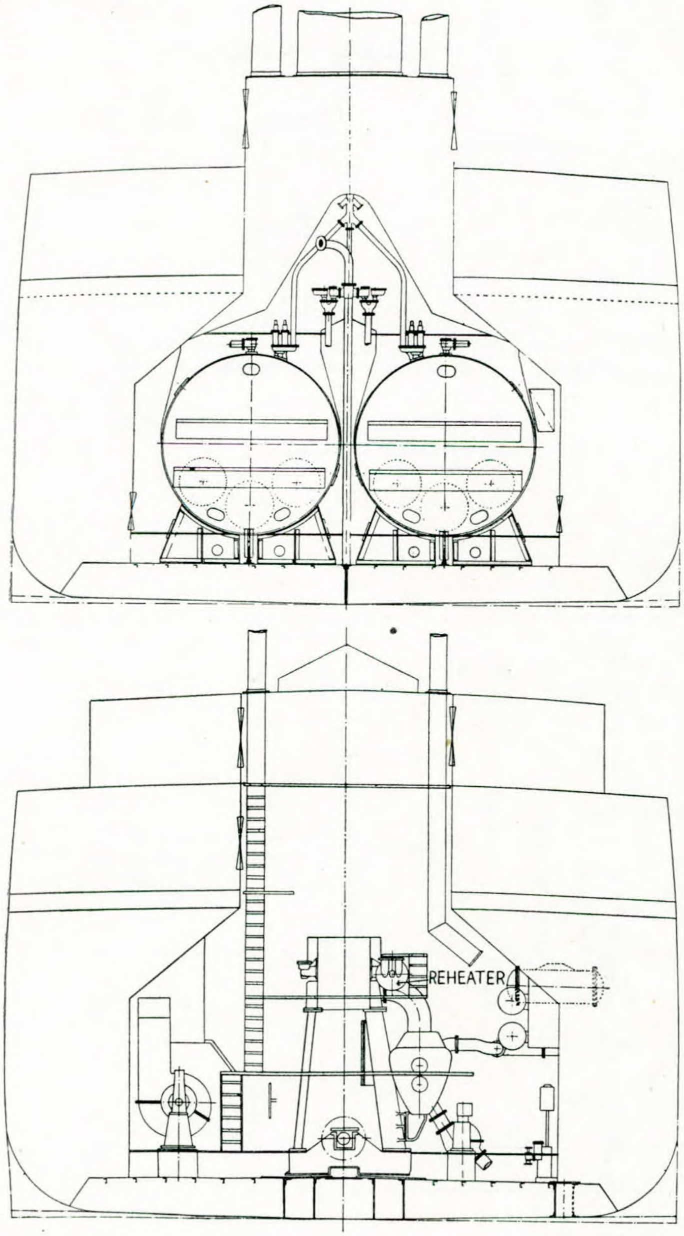
Whereas in the earlier reheater engine only the high-pressure cylinder was provided with North Eastern double-beat poppet-type inlet and exhaust valves, it has been found desirable in these new engines to utilise these valves in the middle-pressure cylinder as well. The low-pressure cylinder has a Martin & Andrews balanced slide valve. The valve gear throughout is of the Stephenson link motion type. The l.p. cylinder is at the centre of the engine, with the h.p. forward, and the m.p. cylinder aft, an arrangement which renders the valve gear particularly accessible and places the heaviest line of moving parts between the lighter parts, thus tending towards good running balance.



This view of the back of one of the boilers shows the accessible location of the superheater headers, which project into the engine-room when the boiler is installed.

The reheater is mounted directly on the side of the cylinders of the engine and when we had the opportunity of examining one of these engines in the shops at Wallsend we were favourably impressed by its accessible location and moderate size. An illustration showing the reheater mounted on the engine and another view of the component parts are included with this article. The superheated steam from the boilers enters the tubes of the reheater at a temperature of about 750° F. and leaves them at a temperature of about 600° F., after which it is admitted to the high-pressure cylinder of the engine at approximately the latter temperature. The exhaust from the high-pressure cylinder passes around the outside of the tubes of the reheater, thereby being reheated before going to the intermediate-pressure cylinder.

Notwithstanding the different steam conditions, the materials of the cylinder liners, the valve gear design and materials, and the cylinder lubrication arrangements of this triple follow standard North Eastern practice such as has been thoroughly tried out in a large number of superheat installations; cylinder lubrication, incidentally, is attended to by Kirkham T. & K. mechanical lubricators. Campbell & Banks piston rings are used throughout.



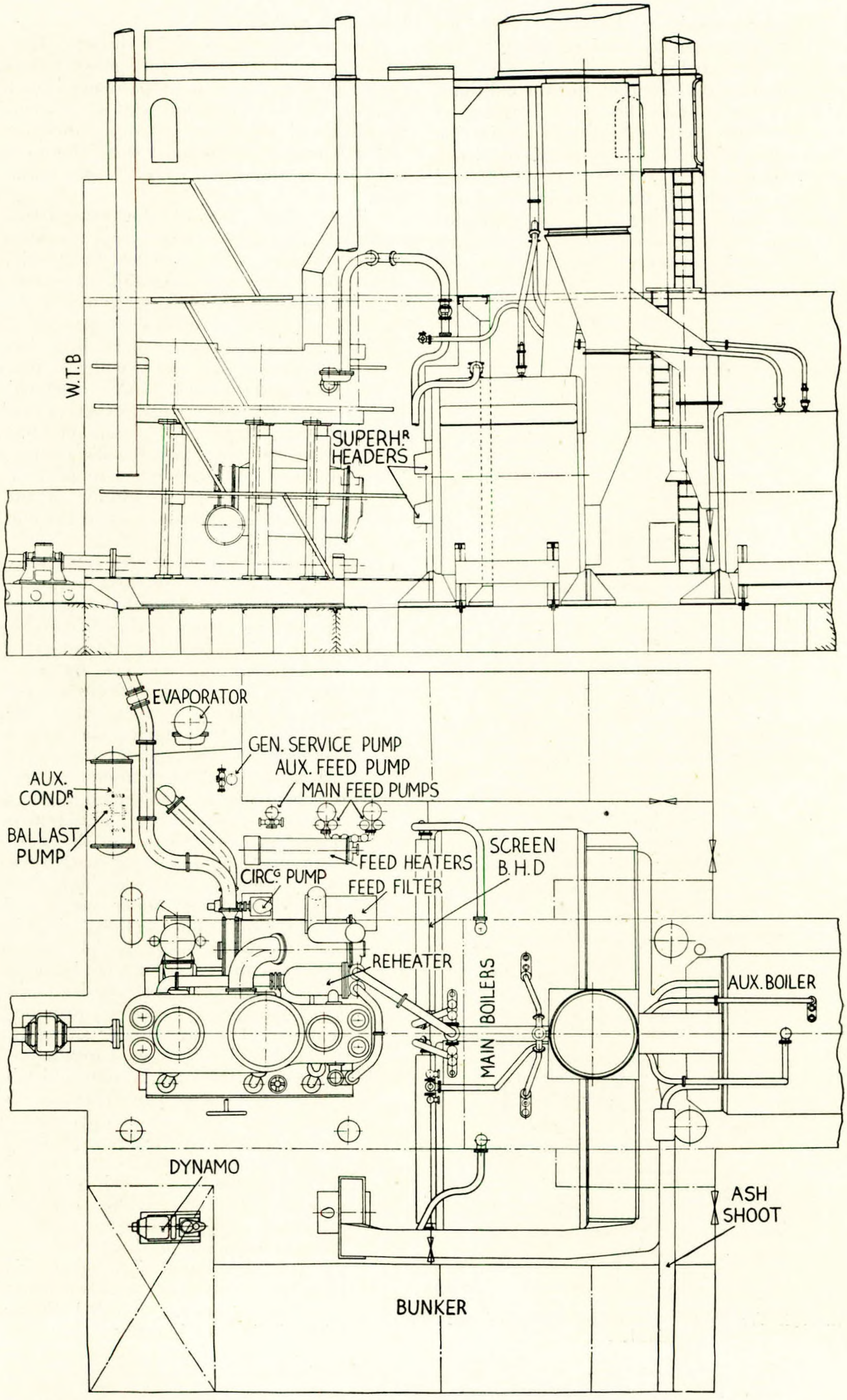
Sections through the boiler- and engine-rooms of the "Lowther Castle".

Latest type superheaters.

Each vessel has three boilers 15ft. 6in. in diameter by 12ft. long, the general design being shown in one of the accompanying drawings. The working pressure is 220lb. per sq. in. (gauge) and the designed final steam temperature is 775° F., which is one of the highest steam temperatures we can recall in connection with a Scotch boiler installation.

The boilers are of the three-furnace type, arranged, as the accompanying machinery space drawing shows, abreast with long side bunkers passing well back into the engine-room to port and starboard. In addition, immediately forward of the two main boilers and on the centre line of the vessel, there is a two-furnace auxiliary boiler. This boiler is not provided with superheaters, but is designed for the same working pressure as are the main boilers. It is 12ft. 6in. in diameter by 11ft. 6in. long and, besides being used for auxiliary purposes when in port, it can also be employed for circulating steam through the main superheaters when raising steam in the main boilers.

Turning now to the superheaters, these are of particular interest because they are of a new type. A sectional drawing through one of the boilers accompanies this article and it will be seen that the superheater is of the high-temperature type, but of somewhat different form from the combustion chamber type superheaters which the Wallsend firm have constructed during the past ten years. Virtually the superheater consists of a steel coil about half the diameter of the furnace, this being freely suspended vertically in the combustion chamber. The boilers are of special proportions to suit this new development, it being necessary with this form of superheater, and for the high temperatures adopted, to design boiler and superheater in combination. The sectional drawing shows that the two headers are placed outside the boiler on the back plate and are actually in the engine-room; suitable insulation in the form shown is, of course, provided for the headers. The superheater elements are self-draining and it is an easy matter to uncouple any element top and bottom and withdraw it downwards through the furnace. Naturally, in view of the high temperature, the construction and materials used for this new superheater had to be of rather special character, the steel used being of a heat-resisting character. The two main boilers are fitted with the Howden system of forced draught with air pre-heaters in the uptakes, the forced draught fan being driven by a Howden Thermall totally-enclosed high-speed steam engine. Both boilers are fitted with Clyde soot blowers.



Elevation and plan of the engine- and boiler-rooms of the new reheater- engined steamships.

Machinery layout.

The layout of the engine and boiler spaces is, it will be noticed, particularly compact and yet thoughtfully arranged from the standpoint of accessibility. The plan view shows the pipework to and from the reheater and gives an excellent conception of the layout of this equipment. The engine drives its air, bilge, and hotwell pumps through levers off the m.p. cylinder crosshead in the usual manner, while the circulating pump is a 12in. independent centrifugal unit of Drysdale manufacture. It is driven by a totally-enclosed Drysdale Thermall steam engine.

Two stages of feed heating are provided, the first stage being by exhaust steam and the second by live steam; feed heaters as well as the feed water filter are of North Eastern manufacture. The various independent engine-room pumps, which are disposed in the manner shown on the accompanying drawing, have been supplied by J. P. Hall & Sons, Ltd., of Peterborough, with the exception of a small semi-rotary fresh water pump. All the Hall pumps are of the vertical direct-acting type and are as follow: Main feed pumps, 7in. by 9½in. by 18in.; ballast pump, 10½in. by 12½in. by 21in.; general service pump, 7½in. by 5½in. by 15in.; and auxiliary feed pump, 7½in. by 5½in. by 15in. There is a 25-ton North Eastern evaporator in the engine-room, while the auxiliary condenser, which has a cooling surface of 650 sq. ft. has also been supplied by the engine builders. A Crompton ash hoist is installed in the boiler-room.

The ships.

In conclusion, a few descriptive notes on the vessels themselves might not be out of place. The first of the pair is the "Lowther Castle", and the following description specifically applies to her, although we believe that the "Lancaster Castle" is identical. Both ships have been built by Sir James Laing & Sons, Ltd., Deptford yard, Sunderland, the leading particulars being as follow:—

Length overall	454ft. 3in.
Breadth extreme...	57ft. 3in.
Draught	24ft. 8¾in.
Deadweight capacity	9,250 tons
Service speed	10¾ knots

The vessel is constructed on the open shelter deck principle with topgallant forecastle, five large hatches, and clear holds. The crew are housed in the poop, the accommodation being in accordance with the latest Board of Trade recommendations. Framed on the Isherwood combination framing system to plans approved by Sir Joseph W. Isherwood & Co., Ltd., the hull is the builders' special design. This design is now becoming well known to shipowners as the result of the performances of vessels built by Joseph L. Thompson & Sons, Ltd., since 1935. Sir James Laing & Sons, Ltd., collaborated in the research work which led up to the production of this successful model, but the "Lowther Castle" is the first vessel to be built at Deptford since 1930. It is fitting that in re-opening the yard, the first vessel should mark an important step forward in efficiency and economy of operation.

The combination of the already successful hull with the latest development in marine engine practice is expected to show results which will mark a further important stage in the development of the steam tramp, the economic efficiency of which has improved so much in recent years. The "Lowther Castle" has just completed her maiden voyage to the Plate. She was in ballast trim and averaged 10·7 knots on an average daily consumption of 14 tons of North Country coal, which can be regarded as a good performance. At a later date we hope to publish service performance data extending over a reasonably lengthy period, because we hold the view that the combination of the efficient hull form used and the North Eastern reheater engine offers something of great attraction to the shipowner. The reheater engine promises high economy with a simple installation and a moderate first cost. Clearly, therefore, its potentialities are great.

All-diesel Installations for Small Craft.

By Captain C. E. A. L. Rumbold.

"Shipbuilding and Shipping Record", June 3rd, 1937.

An obvious ideal for a diesel-propelled motor yacht of medium tonnage, and similar small craft, is an all-diesel engine installation; that is to say, the auxiliary motor for driving the air compressor, dynamo or water pump and suchlike purposes should also be a diesel.

This ideal, which is inspired by a desire for enhanced safety, economy and reliability, was until recently unobtainable, because a diesel small enough for auxiliary work in vessels of the kind indicated above simply did not exist. Indeed, none is made to-day in Great Britain and the only one I have been able to discover on the Continent is the 4-B.H.P. diesel at 1,200 r.p.m., which has been developed under the designation, "type 202", by the Compagnie Lilloise de Moteurs of Lille, whose head office is in the immediate vicinity of Paris at 85, Rue Marius-Aufan, Levallois-Perret (Seine).

I first saw a specimen of this engine some eighteen months ago at the Paris Motor Show (Salon de l'Automobile). It was then obviously a new introduction and in such a case it is always wise to let "the other fellow" experiment with the newcomer until the latter has surmounted its teething troubles, so I bided my time.

My acquaintance with this engine was renewed while homeward bound from the Riviera last April, when we had arrived in my yacht "Lily Maid IV", 37 tons T.M., at Lyons after we had successfully mounted the turbulent Rhône against a flood under our own power, i.e., 102 B.H.P. at 800 r.p.m. (Gardner diesel). The reports I received at Lyons about the new engine were very favourable and I ascertained that an agent there for the Lille company, viz., Monsieur R. Pellarin, 275, Rue Vendôme, Lyon (Rhône), could supply from stock a "type 202" motor, which I promptly ordered. Moreover, he showed me a specimen of such engine in half-section. This skeleton machine was very instructive, for at a glance it was easy to observe the action of the engine which is a two-stroke single-cylinder vertical motor with opposed pistons.

Crank case compression is not employed (thank goodness!), and the necessary scavenging air is obtained by means of the upper piston which pumps air into a chamber at the top of the cylinder. The connecting rod of the lower piston follows the usual practice, while there is a connecting rod on each side of the upper piston, and consequently three big end bearings in all operate on the crankshaft. Ordinary gas oil is used as fuel.

Starting.

In "Lily Maid IV" the new diesel with its satellites is lined up on two steel girders, bolted to a stout oak bench, and is placed between the auxiliary dynamo and the auxiliary air compressor, where it is started via the crankshaft of the latter by means of a connecting clutch and ordinary starting handle. This follows the same practice as employed with its predecessor, a four-stroke single-cylinder 1¼-B.H.P. at 770 r.p.m. paraffin motor, which made more noise and much more vibration than its unostentatious successor, and this latter may be said to function with "that reserve which stamps the caste of Vere de Vere," indicating that it comes from a house of refinement.

We do not run our latest acquisition at more than 1,000 r.p.m., as this speed suits the dynamo, while our two-stage Hamworthy air compressor must not be operated at a greater number of revolutions than those just enumerated. I may add that we found the newcomer exceedingly easy to instal in the available space, and that the exhaust pipe, which is flanged together (i.e., not screwed) for ease of cleaning, is carried upwards through the yacht's funnel.

The height of the engine is 28¾in., and its length, as installed, is 22in., while its weight is about 2cwt. It is made under a Junker's licence, but that firm do not themselves manufacture a diesel engine less than 8 b.h.p. "Type 202" is also obtainable as a propulsive unit, combined with a reversible propeller for driving launches and similar boats.

Readers of my previous articles in this journal must be well aware that I am no respecter of persons, or firms, when I encounter inefficiency and react on such occasions with a "Toledo pen", to use a French term, but in the instance under review I have really no adverse criticism to make as the little diesel has run without giving any trouble from the day when it was first installed.

Improving Boiler Efficiency.

"Shipbuilding and Shipping Record", 10th June, 1937.

The desire for improving the performance of cargo steamships has led to the adoption of many new types of equipment as, for example, exhaust turbines and dual air pumps. In the majority of cases, however, it will be found that these are connected in some way or another with either the main engine itself or the condenser and its auxiliaries, thereby giving rise to the impression that the usual Scotch type of boiler has already reached the stage when little or no improvement in performance can be expected. It will be recalled, perhaps, that a short while ago Mr. T. G. Potts read a paper before the North-East Coast Institution entitled "Some Recorded Water Consumptions and Powers of Merchant Vessels", an abstract of which appeared in our issue of January 21st last (see page 69). In this paper the author was principally concerned with the performance of the main engines, but he did happen to make a brief reference to the effect of reducing the excess of air used for combustion in the furnaces, and it is of interest to note that this part of his paper received perhaps more attention in the subsequent discussion than any other single item. The figures given were, of course, sufficient to justify this, since the author first of all showed that when a vessel is burning 55 tons of oil per day, the weight of flue gases leaving the boilers is no less than about 1,000 tons per day, assuming a CO_2 content of 12·3 per cent. If, therefore, the excess of air is eliminated or at least substantially reduced, a considerable measure of economy can be effected. In this particular case the boiler efficiency was increased from 80·4 to 83·0 per cent., with a reduction in oil consumption of 1·9 tons per day, which with fuel oil at, say, £2 per ton, represents a saving of approximately £136 on a voyage of 36 days' duration.

Some very valuable data regarding the problem of the heat loss in the uptakes were given in the discussion, from which it is apparent that attention to this phase of the problem, which is too often neglected, may yield very encouraging results. Paradoxically enough, the use of mechanical means for supplying the air to the furnaces in the form of either forced- or induced-draught fans, instead of relying upon natural draught, leads to a considerable reduction in the amount of excess air supplied and if, in addition, some form of combustion air heater is installed, a further improvement in efficiency is obtained. Thus, it was suggested that under these circumstances, using oil as fuel, the dry gas funnel losses can be reduced to about 5·7 per cent., which represents a flue gas leaving temperature of about 300°F. with a CO_2 content of 12 per cent., while for hand-fired coal, the corresponding figures are 9 per cent. funnel loss with an average CO_2 content of 9 per cent. In the vessel referred to by Mr. Potts, the funnel temperature was reduced to 425°F. and it was stated that had a modern type of air heater been fitted to bring the funnel temperature down to 300°F. a further saving of about 1·5 tons of oil per day, i.e., 54 tons per voyage, or an additional saving of £108 per voyage would have been effected.

The presence of excess air in the flue gases is shown either by a low CO_2 content or by the funnel temperature, and it is apparent that if a check is to be kept on these during the course of a voyage not only must accurate CO_2 measuring instruments and flue-gas thermometers be available, but it is desirous that these should be of the automatic recording type, so that a continuous record of the conditions throughout the voyage is available. In this connection, the story was related of the recording instruments installed during the trials of a particular ship (the mention of the fact that a cinematograph film was taken of the instrument panel enables one to identify the ship without difficulty) so that the reaction between the conditions in the boilers and those in the turbines could be investigated. It was found that the boiler irregularities had a very definite repercussion on the work of the turbines and *vice versa.* More especially is it to be noted that a sudden variation in the load on the turbines gave what was called "a violent jolt" to the boilers—or at least to the water surfaces therein—with the result that there was a flood of hot water through the main turbine and its governor gear. Fortunately this did not have any serious effects, but it is easy to imagine that the consequences might well have been disastrous. The same speaker referred to certain 9,000-ton cargo steamers turned out on the Tyne having a complete battery of recording instruments checking the operations of the engines and the boilers, and as a result of which the owners and the engineers have in a few months' running obtained from these automatic records a line of information as to operating results of the highest value.

Steam Turbine Research.

"Shipbuilding and Shipping Record", June 17th, 1937.

An investigation into the performance of any well-designed modern steam turbine reveals the fact that the efficiency actually obtained on test approaches very closely the theoretical maximum. It would seem, therefore, as though any further noticeable improvement is hardly to be expected, unless it be by an accumulation of small gains made at different parts of the machine. There is, of course, still plenty of scope for improvement in the direction of obtaining longer life for those parts which are subjected to excessive wear, particularly in view of the desire to utilise steam of higher initial pressure and temperature; while the increase in the size of individual units coupled with the use of higher speeds of rotation is for ever demanding greater care in the choice of suitable materials used in the construction of the various parts, if greater reliability and longer working life are to be obtained. There is thus still plenty of scope for the activities of the research engineer and in an article in the house journal of one of our leading turbine manufacturers, an interesting account is given of some of the investigations which have been and are being carried out on the test bed and in the research laboratory.

On the test bed itself work of a more or less routine nature is carried out in order to determine the performance of each turbine before it leaves the works and, prior to this, the materials used in the construction of the blading, the forgings for the rotors, the castings for the casings, and so on, have all been subjected to most careful testing in order to determine their suitability for the work they are called upon to perform. It is, however, when the decision has been made to use, for example, a new blade form, a new type of blade fixing or a blade of exceptional length that special tests have to be carried out on specimens of the new design in order to investigate such problems as the efficiency of the steam flow, the mechanical strength under reproduced conditions of centrifugal force, natural period of vibration, and strength under combined centrifugal force and bending loads. For this purpose an experimental turbine is available of sufficient size to deal with a steam flow of 30,000 to 40,000lb. per hour, and in this completely bladed wheels or nozzle diaphragms can be employed, so that the effect of even small changes can be accurately deduced. Among the problems which have been investigated in this way are the influence of nozzle chamfer on steam efflux angle, the effect of blade width, questions affecting blade lap and clearances, and water erosion of blading. In particular, it is to be noted that with the use of higher steam pressures with a corresponding increase in the density of the steam, the smaller cross-section of the steam path renders the efficiency of flow very sensitive to small inaccuracies and irregularities in the passages through nozzles and blades.

The importance of these apparently small items can be gauged from the results of an investigation into the influence of nozzle edge chamfer. Various degrees of chamfer were tried and it was found that not until an appreciable chamfer was used was there any reasonable approach to uniformity in the jet angle. The best results obtained on the experimental turbine were then used on comparative tests on two 1,000-kw., 3,000 r.p.m. turbines and repeated on a 5,000-kw. set of similar speed. These machines were first run with unchamfered nozzle plates and later tested after the edges had been chamfered. These tests established conclusively that an appreciable improvement followed the use of chamfered discharge edges and gave, in addition, a considerable amount of information on the degree of chamfering necessary, together with the correct efflux angle to produce the best results. Important results also followed an investigation into the effects of the wetness of the steam at the low-pressure end of a turbine. A considerable amount of data was obtained using steam at various inlet temperatures and, incidentally, data were also secured as to the value of inter-stage reheating. The degree of wetness at the l.p. stages was found to be of prime importance and led to the adoption of an improved design of blade, and the incorporation of various types of water-catching grooves and baffles which enable an appreciable amount of water to be withdrawn.

Heat Insulation.

"Shipbuilding and Shipping Record", July 1st, 1937.

Recent developments in steam turbine practice have created an entirely new problem in heat insulation. Such, at least, is the opinion of Captain Ormund L. Cox, of the United States Navy, who, in a paper read at the recent meetings of the American Society of Naval Architects and Marine Engineers, suggested that with the present-day high-pressure steam plants with superheat temperatures in excess of 500°F., the familiar insulating material containing 85 per cent. hydrated magnesia carbonate, calcined and decomposed so that it could no longer be employed. Apparently the U.S. Navy had found it a rather difficult matter to find a suitable substitute, and in view of the large number of different materials which were submitted for this purpose, a specially designed testing plant had been installed at the Naval Engineering Experiment Station, Annapolis. This had been designed to simulate service conditions, the conductivity being measured by the heat loss through the covering on a 3-in. diameter wrought iron pipe containing electric heating coils which could be raised to any desired temperature, while the heat transmission through a flat plate of the material was also measured by means of thermocouples.

As far as naval work is concerned, Captain Cox suggests that the order of importance of the various characteristics of an insulating material are (i) conductivity; (ii) durability; (iii) ease of application; and (iv) density, and it might be urged that this is also a suitable order as regards merchant ship work. Mention has already been made of the methods adopted for measuring the conductivity. To test the durability, a section of the material in pipe covering form was mounted in a vibration machine giving 700 vibrations per minute through an arc of 15 minutes at a radius of 30in. for a period of at least 96 hours. Loss of weight exceeding 5 per cent., sagging, looseness or crumbling would lead to rejection of the material. The hardness, the structural strength and the strength to resist abrasion were also measured. The adhesive properties of any proposed material were tested on a cement adhesion apparatus which measured the load required to rupture the bond per square inch of a steel plate adhering to the sample. In addition, the water absorption was measured, as also was the moisture absorption, while the physical changes of the material under the influence of heat were investigated, and a complete chemical analysis was made in each case. The test procedure was altered as necessary, and, if any doubt existed, approval was made subject to the behaviour of the material in actual service for a limited period.

Following these extensive investigations, it is of interest to note that no single type of insulation was discovered which was suitable in every respect for temperatures above 500°F. A group of materials has therefore been adopted which comprises sectional and segmental moulded insulation, fabricated felted rock wool, aluminium foil, insulating cement, asbestos pad and blanket, and asbestos tape. The moulded materials are usually composed of diatomaceous earth and magnesium or calcium carbonate bonded with small amounts of asbestos fibre. These are suitable for pipes and combustion surfaces where the temperature range is from 500°F. to 1,300°F. The rock wool is made from natural stone consisting of calcium, magnesium and aluminium oxides and silica blown with a steam jet while in a molten state. The fibres are felted without the use of added binders and secured to inner and outer metal supporting members of screen wire. The insulating properties of this material are high and the first cost is less than that of most other types, but it is not suitable for temperatures above 1,000°F. The only advantage of aluminium foil appears to be its light weight, but its cost is high and its use is restricted to temperatures not exceeding 850°F. The insulating cements are divided into three groups, viz., those made of diatomaceous earth, rock wool cements and exfoliated mica cements. The first were found to be efficient heat insulators, but they were difficult to apply and were possessed of poor adhesive properties. The rock wool cements were unique in their adherence to hot surfaces; they also became tough and strong when dried, while the exfoliated mica cements, owing to the abundance of air voids, had high coverage capacity and light weight. Asbestos pads and blankets are used where the application of other forms of insulation is difficult, such as in the case of flange pipe joints and corrugated bends, and asbestos tape is used for pipes ½in. diameter or less, special types being suitable for temperatures up to 750°F.

Making Use of Exhaust Gas.

An examination of the possibilities with Four-stroke and Two-stroke-cycle Marine Engines.

"The Motor Ship", June, 1937.

Exhaust-gas boilers are now fitted to almost every new motor ship, those employing two-stroke engines being no exception. Such engines require a constant source of energy for the compression of scavenge air, yet this energy is not usually derived even partly from the heat in the exhaust gases.

Steam generated in exhaust-gas boilers is, indeed, used for many purposes, such as the actuation of steam steering gear, bilge pumps, etc., rather than for air compression. In none of these alternative applications is the load so constant as that offered by the scavenge air compressor. Driving the latter, therefore, would seem to be the natural and proper vocation of exhaust-generated steam or of exhaust-gas turbines in ships engaged in the transport of general cargo and passengers. Motor tankers are in a class by themselves, as such ships require a supply of steam for oil heating, tank cleaning and other purposes connected with their cargoes. It is not intended, therefore, that the following should apply to tankers or similar vessels, or to vessels engaged on voyages of short duration.

On full load, a Diesel engine rejects to the exhaust perhaps 40 per cent. of the heat in the fuel, without regard to its cycle of operation. In the case of a four-stroke-cycle engine, the temperature of the exhaust gases is usually in the neighbourhood of 650-800°F. Assuming a water temperature in the boiler of 215°F., plus a temperature difference of 150°F. as the limit of useful interchange, we can cool the exhaust gases from their initial port temperature down to 365°F., generating a considerable amount of steam in doing so.

Regarding two-stroke-cycle engines, although the actual heat rejected per b.h.p. is little affected, the temperature of the exhaust gases is usually from 480°F. to 550°F., so that, if we retain the temperature of 365°F. as the lowest to which we can cool the gases profitably in steam generation, our range of cooling is much reduced and, with a given interchanger, the quantity of steam raised is correspondingly reduced. It is the temperature rather than the mass which governs the energy we can obtain from the gases.

Two-cycle Engine Exhaust Temperatures.

It may be interesting to recall the reasons for the low exhaust temperatures in two-stroke engines. One is that, since large marine engines do not employ high speeds of revolution, the scavenge air is in contact with the hot gaseous combustion products for an appreciable time, during which it absorbs heat rapidly. The shape of the scavenge and exhaust ports has a considerable influence in this connection by controlling the intermixture of the inlet and exhaust charges. It is obvious that the penetration of the exhaust gases by the scavenge air should be a minimum to obtain least heat transference. The effect of intermixture is that the unburned air must be swept out with the exhaust gases to obtain a pure charge. Heat transference decreases the volumetric efficiency so that unburned, but heated, air must be rejected through the exhaust ports to obtain a heavy inlet charge. The net result is a greater energy expenditure in providing the excess scavenge air and a lowering of the exhaust temperature.

Taking a broad view of the whole situation, it seems that great efforts, perhaps too great, have been taken in the direction of obtaining the maximum economy of fuel for work done inside the cylinders, and any apparatus making use of the exhaust energy has not been regarded as an actual part of the engine. Usually the engine's brake thermal efficiency is forced as high as is practicable without regard for the exhaust temperature and, rather as an afterthought, an exhaust-gas boiler is expected to make the best of what remains.

It is quite usual for the scavenge pumps to deliver 50 per cent. in excess of the swept volume, the excess being required to maintain the best scavenge effect and the highest volumetric efficiency practicable despite the intermixing effect of swirl. It should be possible to obtain the desired results, or almost so, with less rejection of unburned air to the exhaust, and in so doing to maintain the exhaust temperature. Efficient use might then be made of the gases in generating steam or in driving an exhaust turbine so that compression of the scavenge air could be obtained.

The Question of Fuel Consumption.

An apparent small increase in fuel consumption to obtain these results might really mean an increased efficiency, as will be understood by the following examples. In these we have assumed the power required to drive the scavenge pump to be 10 per cent. of the engine b.h.p. This is, in many cases, a good deal higher than the actual figure, but since each engine differs from others in this respect, the value of 10 per cent. has been chosen to facilitate reasoning.

A marine engine of 3,000 b.h.p. may have a fuel consumption of 0·35lb. per b.h.p.-hour. Its scavenge pump is independently driven and absorbs 10 per cent., i.e., 300 b.h.p. Assuming similar consumptions, the main engine requires 1,050lb. and the scavenge pump engine 105lb. of fuel per hour, i.e., a total of 1,155lb. The net useful work obtained is, however, only 3,000 b.h.p.; therefore the actual fuel consumption is 0·385lb. per b.h.p.-hour. It would pay to employ exhaust energy for the scavenge pump even if, because of this, the combustion efficiency were so adversely affected that the engine required, say, 0·375lb. per b.h.p.-hour.

Another case is that of an engine driving its scavenge pump mechanically. Suppose it also is of 3,000 b.h.p. and that it has a fuel consumption of 0·375lb. per b.h.p.-hour. Its scavenge pump requires 300 h.p., therefore the true b.h.p. developed is 3,300 for a fuel consumption of $3{,}000 \times 0{\cdot}375 = 1{,}125$lb. per hour. Thus the real fuel consumption is 0·341lb. per b.h.p.-hour. If the engine be relieved of the air compression load by the utilisation of exhaust energy, we can effect economies so long as the fuel consumption is less than 0·375lb. per b.h.p.-hour, and we can also obtain 3,300 b.h.p. without overloading.

It is realized, however, that the steam generated by the exhaust gases, even when the engine and exhaust gas installation have been designed in combination with the view of attaining the highest overall efficiency, might be insufficient to carry the whole of the scavenge air load. This modifies but does not nullify the results of the above applications. In addition, there is the necessity for some form of positive drive, giving immediate operation of the scavenge pump to enable the engine to be started.

There are many possible solutions, of which two will be instanced. First, with regard to an engine having its scavenge blower independently driven, the steam raised could be utilised in generating electricity (in conjunction with further Diesel generators), and the scavenge pump would be electrically driven.

Secondly, an engine with a direct-coupled scavenge pump could have the other end of the pump shaft connected through a free-wheel device and step-up gearing to a steam turbine. On starting, the engine would carry the compressor load; as steam was generated, the turbine would come into operation and, through the gearing and clutch, would carry the compressor load to the best of its ability, the remaining proportion being supplied by the engine. An exhaust-gas turbine could be utilised in place of the steam installation in the same manner.

Whatever the method adopted, it is most important that a proper balance should be obtained between the actual engine and the exhaust energy converter in order that the overall efficiency of both, considered as one machine, should be a maximum.

Shipyard Apprentices.

"Shipbuilding and Shipping Record", June 17th, 1937.

The problem of training skilled artisans for the shipyard and the marine engineering shop has recently been the subject of considerable thought, and in particular, Mr. A. P. M. Fleming's paper, read before the Institution of Mechanical Engineers, to which attention was drawn in our issue of March 25th, has served to show the necessity for framing a scheme of apprenticeship which will be sufficiently attractive to draw young people just leaving school from the many more-remunerative, but blind-alley occupations which are available. This phase of the problem is stressed in the annual report of The Skilled Employment and Apprenticeship Association, which has recently been published. The Association stands for the adoption of a system of indentured apprenticeship, and the report states that of the total of 503 boys, 193 were placed in the engineering and heavy-metal industries. In comparison with the requirements of the various branches of the engineering industry in this country, the figures are almost pathetically small, but they indicate what can be done. Incidentally, the report shows that as a consequence of the greater industrial prosperity, an increasing number of children after leaving the elementary schools, are going to the central schools, where they remain until the age of 16, and since this represents the ideal age for the commencement of an indentured apprenticeship, an effort should now be made to attract them to the ranks of skilled artisans.

The Diesel-electric m.s. "Wuppertal".

First Large Motor Ship with Alternating Current Transmission. Why the Hamburg-American Line Adopted Electric Drive.

"The Motor Ship", May, 1937.

The "Wuppertal" was built by the Deutsche Werft, and is the first motor ship to have Diesel-electric drive on the alternating current system, a voltage of 2,000 being used, whilst all the engine-room motors, also the lighting circuit, are supplied with alternating current. For the first time in a large sea-going vessel roller bearings are used for the propeller shafting, also for the propeller motor, and the electrical system is such that at sea all the auxiliary power is supplied from the main Diesel generators, so that auxiliary generating sets are not in operation.

The "Wuppertal" is a modern cargo ship intended for the Hamburg-American Line's service to Australia. The general details are as under:—

Length overall	151·80 metres, or 497ft.
Length between perpendiculars	142 metres, or 465·9ft.
Beam	18·7 metres, or 61·4ft.
Depth to main deck	9·12 metres, or 29·9ft.
Draught on summer freeboard	7·95 metres, or 26ft.
Maximum speed	16 knots.
Service speed	15 knots.
Machinery output	7,800 b.h.p.

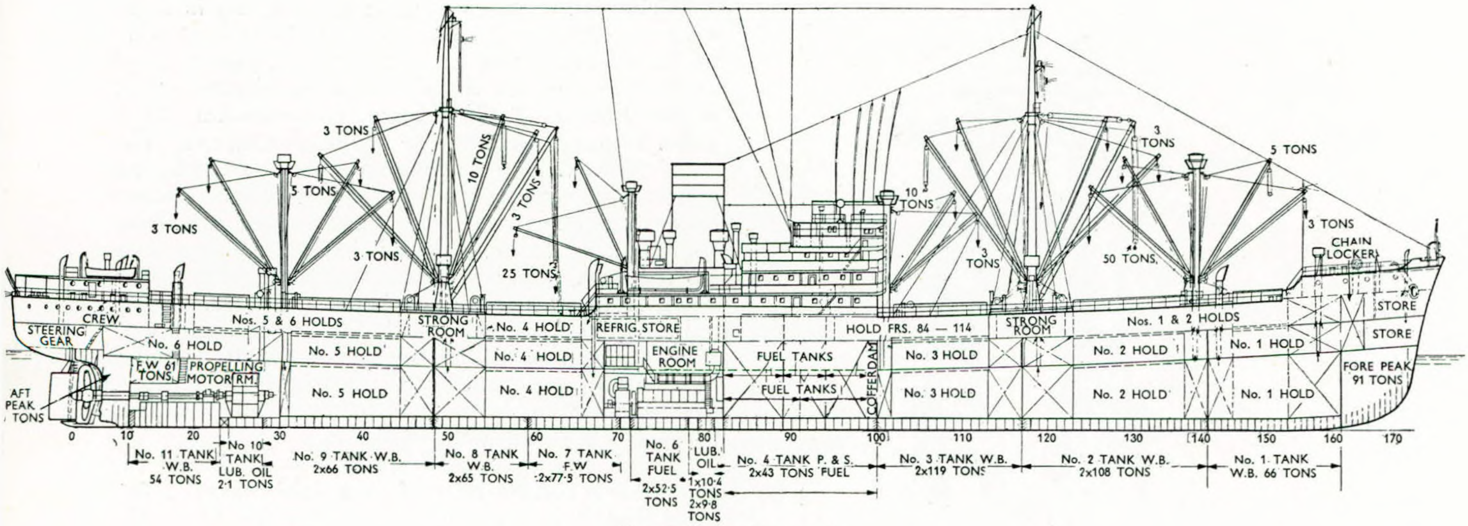
In normal trade on this route the ship proceeds to Australia with the holds only partly filled, and returns fully loaded. For the outward journey a speed of 12 knots to 13 knots is sufficient, whilst on the homeward voyage an average of 15 knots is required, which means that the ship must be able to maintain 16 knots continuously in calm weather when needed.

The Reason for the Diesel-electric Drive.

On such a route it was considered that the Diesel-electric drive has special advantages. By employing three generating sets it was found possible to design the installation so that two only need be in service on the outward run. Hence they can operate at maximum efficiency and lowest fuel consumption, for although the Diesel engine has a comparatively small drop in efficiency over a considerable range of power, with two-stroke engines, having direct coupled scavenge pumps, the scavenge pump efficiency falls at reduced load.

Secondly, the lubricating oil consumption is, with the Diesel-electric installation, in direct relation to the output if one unit is shut down. The employment of three high-speed (250 r.p.m.) engines means a reduction in weight of Diesel machinery, also in the space occupied, so that the generating engine-room amidships is only 47ft. in length, and of low height; the absence of shafting and tunnels enables a No. 4 hold to be designed so that large cargoes can conveniently be carried there. By the adoption of three-phase synchronous motor drive the electrical losses are stated to be only 6 per cent. If it be assumed that the losses in the shafting with direct transmission are 4 per cent. to 5 per cent., the overall propulsive efficiency should be the same as in a direct driven installation, since by the use of roller bearings for the propeller shaft it is believed 2 per cent. of the power is saved. We were informed by the engineer that it is possible to turn the shaft by hand and that no trouble had been experienced with the bearings.

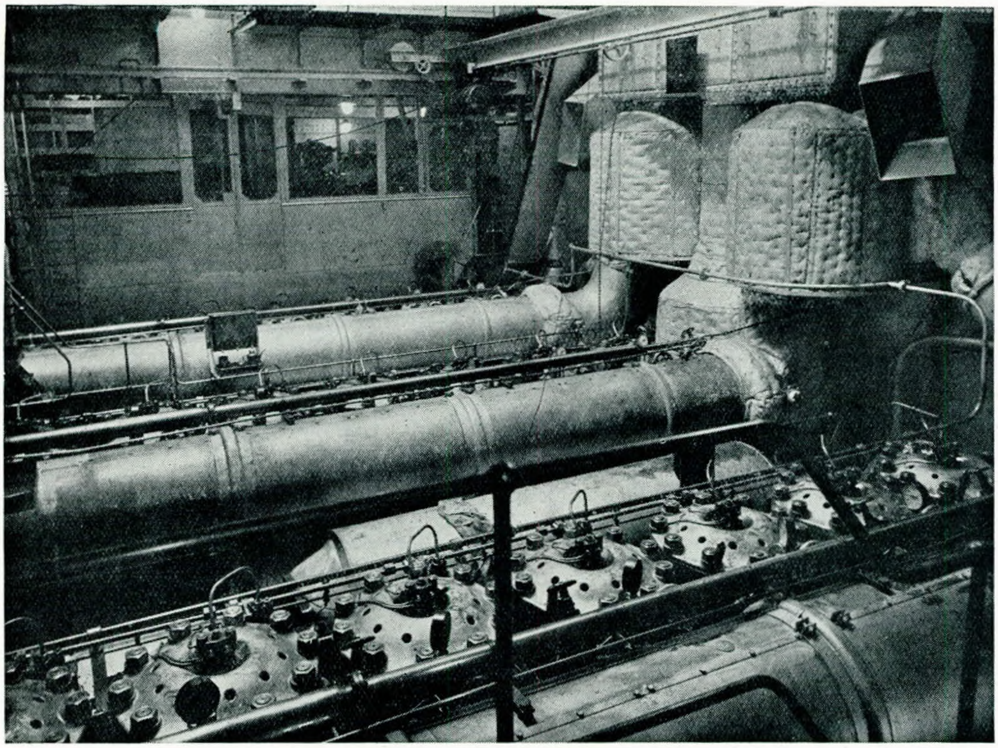
Briefly, therefore, the claim is made that the efficiency of this system of Diesel-electric transmission is equal to that of the direct drive, and that,



General Arrangement.

if anything, the advantage lies with electric transmission in the matter of weight and space. Overhaul is easier, due to the lighter weight of the plant, and, finally, it is stated, surprisingly enough, that the total cost of the machinery is rather less than that of the direct coupled single- or twin-screw installation.

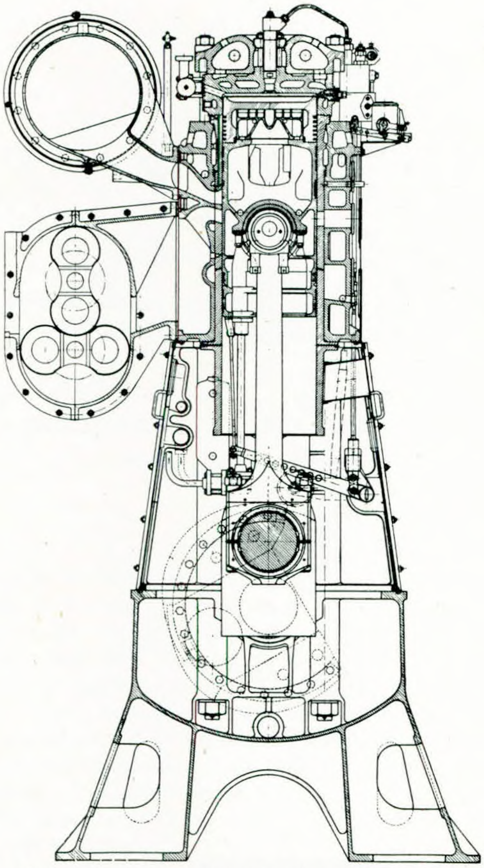
It was these considerations, bearing in mind the particular service in which two-thirds of the power is sufficient for the outward voyage, that caused the Hamburg-American Line to adopt the electrical system. We do not suppose it is suggested that electric transmission in all cases is superior to the direct drive, nor that the new and undoubtedly advanced design produced by the advisers to the Hamburg-American Line would necessarily be advantageous in every instance. But there is no question that this represents a new phase in the development of Diesel-electric propulsion, which will have to be the subject of careful consideration by shipowners and their engineering staffs.



The tops of the three engines showing two of the silencers.

2,000-volt Generating Plant.

Installed in the main generating room are three two-stroke single-acting trunk-piston M.A.N. engines of 2,600 b.h.p. each, coupled to a 1,900-k.v.a. three-phase alternator generating current at 2,000 volts. The current is supplied at this pressure to the propeller motor, which runs at a speed of one-half of that of the generators. At full output the latter turn at 250 r.p.m., the corresponding speed of the propeller motor being thus 125 r.p.m. In



Sectional elevation through a cylinder of one of the engines in the "Wuppertal".

normal circumstances it is found that engine revolutions of about 230 r.p.m. are suitable for the desired ship's speed.

The engines have seven cylinders 520 mm. in diameter, the piston stroke being 700 mm. Naturally, with such small dimensions, the replacement of parts is comparatively simple, and we were informed by the engineer on board that a piston can be taken out and replaced in about two hours. The fuel consumption of the engines (gas oil being employed) is 170gr., or 0·37lb. per b.h.p.-hour. The pistons are oil cooled, and the temperature rise of the oil is limited to 10° C.

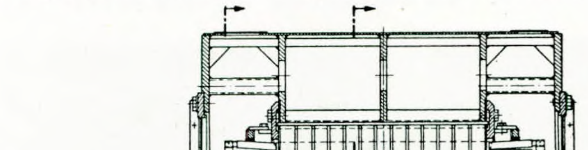
For the cylinder jackets and covers sea water is employed, and by by-passing some of the discharge water the inlet temperature is maintained as nearly as possible constant at 30° C., which is approximately the temperature of sea water in the tropics. It is found that corrosion does not result if the cooling spaces are occasionally cleaned out with fresh water containing 1·5 per cent. of special oil. This oil is not sufficient to affect the heat transmission, but it coats the surfaces with a very slight film which prevents corrosion. Vibration dampers are fitted to the engines, and the sets are directly carried on the double bottom. The bearings are electrically insulated.

The continuous rating of the engines is 2,300 b.h.p. at 230 r.p.m., with a mean indicated pressure of 5·2 kilogs. per sq. cm. and a mean piston speed of 5·38 metres per second. The maximum power is 2,600 b.h.p. at 250 r.p.m., corresponding to a mean indicated pressure of 5·5 kg. per sq. cm. The usual M.A.N. loop scavenging system is employed, and the scavenging air is supplied from a rotary blower on the exhaust side of the engine, driven by spur gearing from the crankshaft. The engine is started with compressed air, the range of pressure being from 30 to 10 atmospheres. The starting air valves in the cylinder heads are so designed that they can open only when the pressure in the cylinder is below the pressure in the starting air pipe lines. The starting air valves are pneumatically actuated through a starting air distributor.

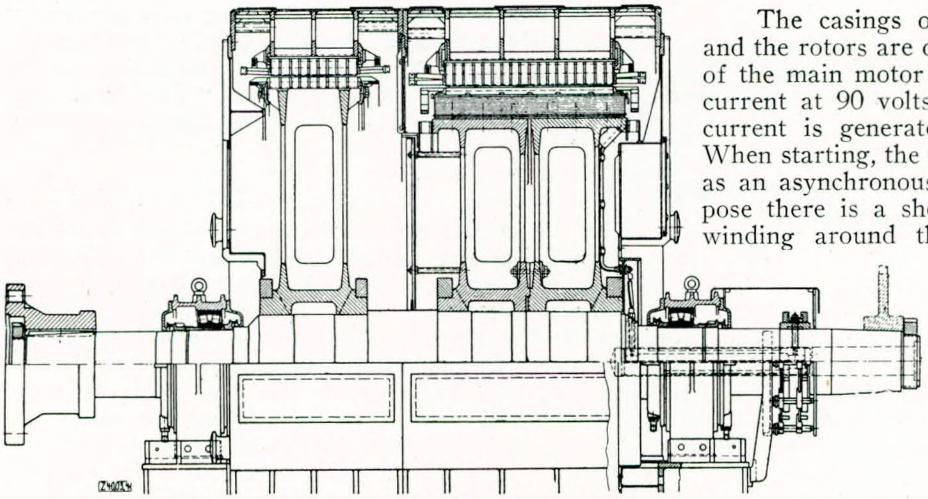
Each stator (of cast steel) is welded, and the generator is totally enclosed, removable covers being fitted, but it is watertight up to the height of the shaft to prevent access of bilge water.

The Main and "Fog" Propeller Motors.

There are actually two propeller motors on the same shaft. The main unit is a synchronous motor absorbing the full power, and the second is an asynchronous motor, termed the "Nebel", or "fog" motor, with a maximum capacity of 900 h.p., and used only when very low speeds are required. It has a short circuited rotor, and the speed ratio, compared with the main engines, is 1 to 3. The low



Section through one of the main generators.



Section through the propeller motor. On the left is the "fog" motor, used only at low speeds, and to the right is the main motor.

propeller revolutions when using this engine in harbour manœuvres are very convenient. It can be employed when the speed does not exceed 9 knots and when the main propeller motor is driving the propeller no current is passing through the fog motor.

The main propeller motor receives current from the generators at 2,000 volts, as already stated, and speed variation is effected by regulating the speed of the generating sets or varying the number in operation. The speed can be brought down to 80 r.p.m., with a corresponding main propeller motor speed of 40 r.p.m.

The stators of the two propeller motors are bolted together, and at each end are two roller bearings (used for the first time in a ship for this purpose), external to the forward bearing being the slip rings for the synchronous or main propeller motor.

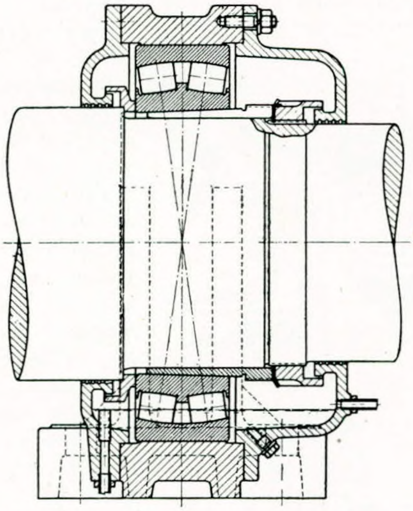
The casings of the motors are welded, and the rotors are of cast steel, the rotor poles of the main motor being supplied with direct current at 90 volts from the slip rings; this current is generated in a rotary converter. When starting, the main motor may be utilized as an asynchronous motor, and for this purpose there is a short circuited asynchronous winding around the pole shoes. The fog motor is, as already stated, a pure asynchronous motor with a short circuited rotor. The bearings of the motors are electrically insulated from the hull.

The propeller motors are cooled by a circulation of air, two fans being employed for the purpose. The air is in a closed circuit and is cooled by pipes of aluminium bronze having cooling ribs of copper. A closed circuit is used to avoid variation in temperature, also the presence of moisture in the air.

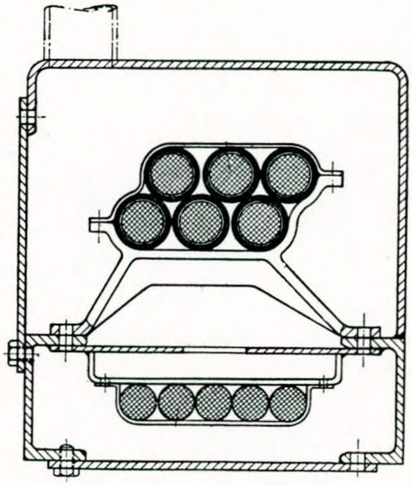
It is probable in future ships that the fog motor will be dispensed with, since the general operation of the main propeller motor and its flexibility have proved very satisfactory on the maiden voyage. This will represent a simplification and a reduction in initial cost.

Auxiliary Generators and A.C. Auxiliary Motors.

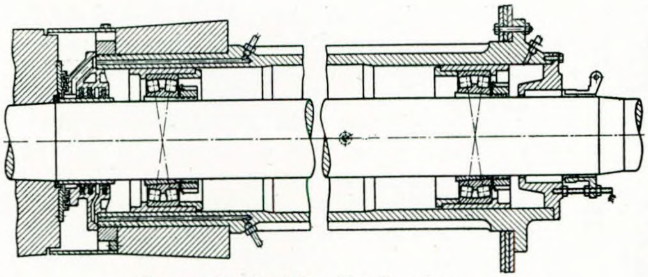
It has been stated that at sea the current for the auxiliaries is obtained from the main generators, hence the auxiliary generating plant is comparatively small. There are two five-cylinder Deutz four-stoke engines running at 500 r.p.m. They are of 220 b.h.p. and are coupled to 120-kw. three-phase 380-volt alternators. All the motors driving the auxiliary machinery in the engine-room and else-



A roller bearing for the shaft of the propeller motor in the "Wuppertal".



Section through cable box. The upper cables are for the h.t. circuit and the lower for the excitation current.



Stern gland with roller bearings.

where (excluding the winches and windlass) are short circuited three-phase synchronous machines. The advantage is that commutators are rendered necessary, and they are started with simple three-pole switches without resistances. Speed regulation is, however, not so easy, depending as it does directly on the speed of the main generators. But this is suitable for the pumps, etc., which serve the main engines, including the cooling sea water pumps, whilst the scavenge and fuel pumps are directly driven from the engines. The general service, ballast and drinking water pumps have to be driven by motors which are conservatively rated, so that a speed reduction still allows sufficient capacity. Alternating current is also employed for lighting, but in order to prevent flickering two 20-kw. regulating transformers are installed.

When at sea the 2,000-volt current from the main generators is transformed to the working pressure of 380-220 volts (this being the range according to the speed) by oil-cooled transformers of 175-kva. capacity; their adoption is an innovation on board ship. They are located in a special transformer room adjacent to the machinery control position, and the room is air cooled, whilst if it is inadvertently entered, the fact of opening the door automatically switches off the current.

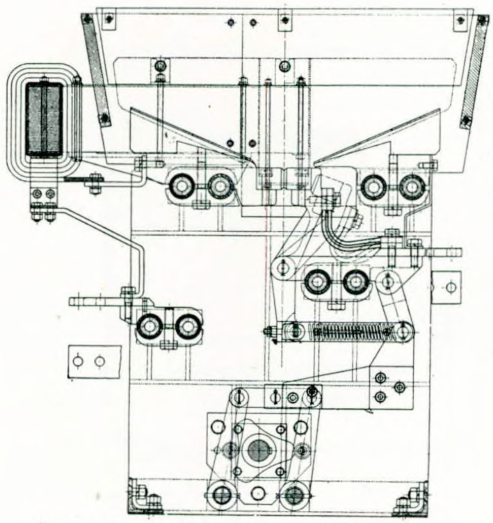
Direct current supply is needed in the ship for the operation of the cargo winches and anchor windlass, and for the excitation of the main generators and the synchronous propeller motor. Incidentally, it is possible in future ships that alternating current will be used for all deck motors. The direct current supply is obtained from three rotary converters.

The Electrical Circuits.

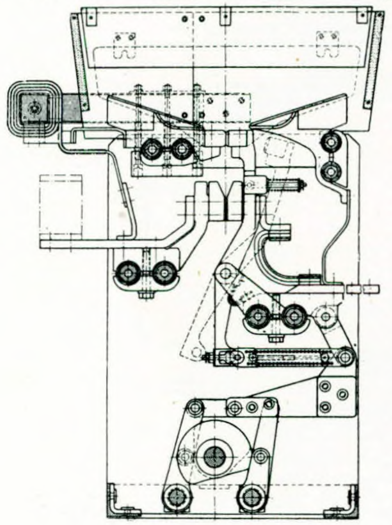
There are two electrical circuits. The first is for the propeller motor drive and the second for the ship's supply for lighting and power. For each main generator there is a hand-operated circuit breaker. The auxiliary circuit is connected to the main network through two 175-kva. transformers, which, as already mentioned, are arranged in the transformer room. The switches for the excitation circuit of the main generators and the propeller motor are mechanically coupled with the high-tension switches, and are operated with the same gear. For the protection of the rotary converters which transform alternating current to direct current there are three field switches for the excitation circuit, which serve to switch off the excitation current at stopping and starting, also to cut out excitation when the safety switches come into operation.

One of the rotary converters supplies the current for the excitation of the generators, one for the synchronous propeller motor, and the third is a spare, also feeding the winches and windlasses through suitable switches. There are voltage equalization relays which protect the high-tension circuit from a short circuit or earthing. These relays have three trip switches, and if the voltage difference in the three phases is greater than 10 per cent. one of the trip switches is cut out automatically, and the excitation current is broken.

The switch gear is such that either one, two or three of the main alternators may supply current to the propeller motor, and at the same time one of them may provide the necessary current for auxiliaries via the transformers. Alternatively, as, for instance, when approaching harbour, the auxiliary generators may be brought into operation to supply the necessary auxiliary current, and as many main alternators as necessary kept in use for the provision of current to the propeller motor. In fog, or or when it is necessary to proceed at low speed for considerable periods, it may be desirable to run one main generator for the propeller motor and utilize



One of the generator circuit breakers.



Reversing switch.

the two auxiliary Diesel-engined generating sets for the ship's electrical supply.

How Manœuvring is Carried Out.

In the ordinary way, when it is desired to get under way, the three main Diesel engines are all started up by means of starting levers arranged at a control panel for each individual engine, on a level with the main switchboard. This incidentally, is at the after end of the engine-room, on a platform with a view over the machinery. The engines are all brought to a speed of 200 r.p.m.

The whole control is now vested in the main switch control table. The speed of each engine is regulated by the three small levers seen to the left of the large wheel. This allows individual electrical control of the amount of fuel delivered to each engine. When all the engines are operated together at normal speed and in phase the one lever seen to the right may be utilized for the complete control.

To proceed ahead from stop, the engine speed is brought down to about 90 r.p.m. to 110 r.p.m., and the current switched on to the propeller motor, when synchronous running follows. Any required slight variation of speed of engine necessary to obtain perfect synchronism is effected through the switches already mentioned.

When manœuvring is being carried out only two of the generators are switched on to the main 2,000-volt circuit to the propeller motor; the third supplies the current for auxiliary purposes, at the same speed as the other two. When it is required to go astern, the speed of the engines supplying the propeller motor is brought down to about 100 r.p.m., and the excitation of the propeller motor and the generators switched off. The reversing switch is brought to the stop position and then reversed, the propeller motor being supplied with current and operating asynchronously. When, however, the speed of the propeller reaches about 40 r.p.m. the propeller motor excitation current is switched on and the motor and generators operate synchronously. The engines are next speeded up to the necessary degree, according to bridge requirements.

The whole of this control is carried out by means of the large hand wheel in front of the switch control table, the operation being effected automatically and continuously by a rotation to the right or left. In front of the engineer are meters and gauges showing the speed of the generators and motor respectively, astern or ahead; also ammeters and indicator lights to show whether the generators are supplying current to the propeller motor or to the auxiliary circuit. It is stated that the length of time required for reversing is less than that needed with a direct drive.

The motors driving the auxiliary pumps, etc., in the engine-room can only operate between a frequency of 50 and 36. Hence the necessity for having one of the main generators exclusively devoted to the supply of power for these motors when the

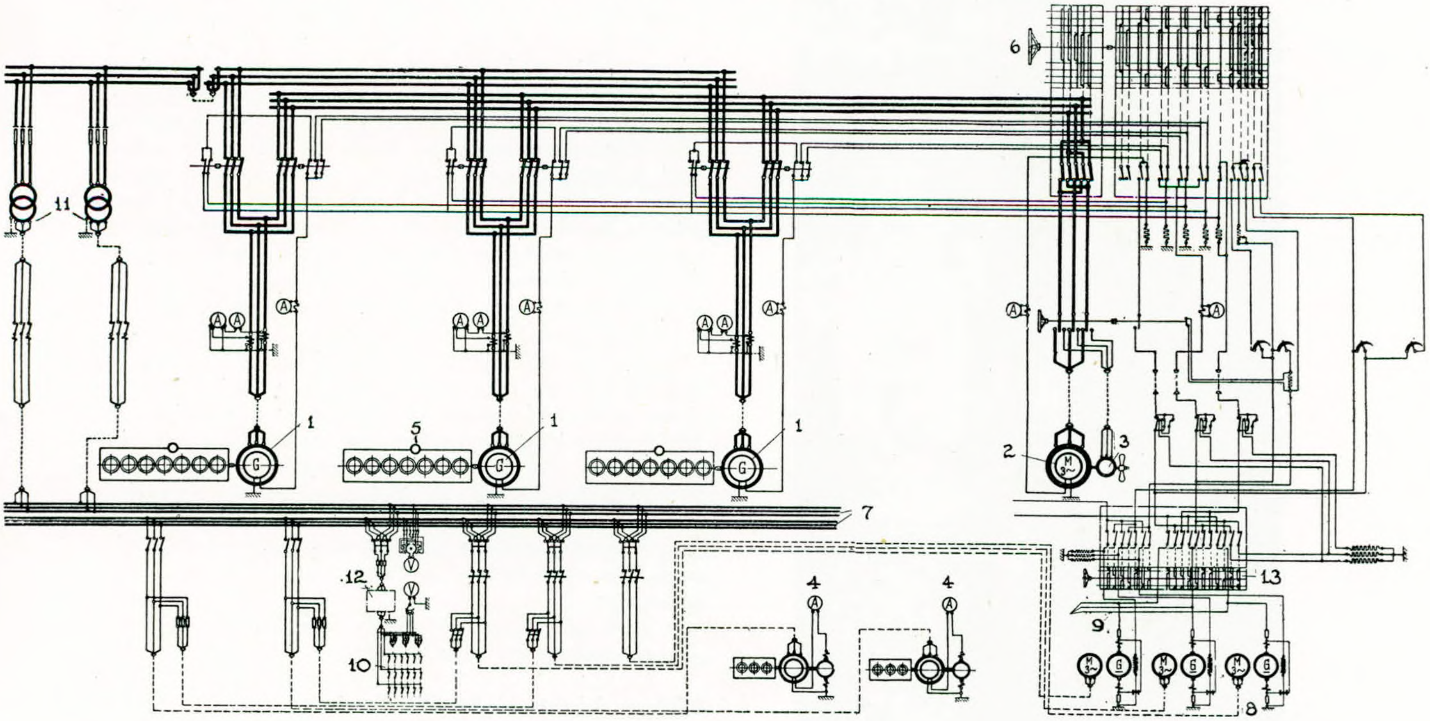


Diagram of electrical connections.

1.—Main generators (1,900 kva. 2,000 volts). 2.—Main propeller motor (synchronous). 3.—Fog propeller motor (asynchronous) for low speeds. 4.—Auxiliary generators (380/220 volts 150 kva.). 5.—Electric motor for engine speed control. 6.—Reversing switch. 7.—Low pressure a.c. circuit, three phase 380/220 volts. 8.—Rotary converters for excitation current. 9.—Cables to deck motors. 10.—Lighting distribution wiring. 11.—Transformers from 2,000 volts to 380/220 volts. 12.—Regulating transformer for lighting. 13.—Motor generator switchgear.

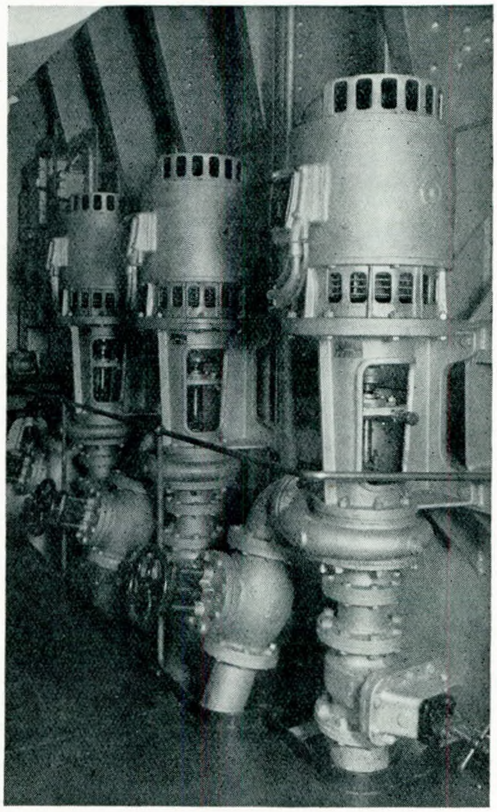
ship is manœuvring. There is, therefore, a locking device which prevents the main hand reversing wheel being operated until one of the generating sets is switched out of the main circuit.

The Switch Gear.

Turning now to the arrangement of the switch gear as a whole to the right of the main switch control table, facing the engine are the main high-tension circuit breakers with the high-tension transformer room behind. These circuit breakers, two for each panel, permit any of the three main alternators to supply current either (*a*) to the high-tension network (and thence to the propeller motor) or (*b*) to the auxiliary circuits, through the transformers in the high-tension transformer room.

To the left of the control table is the switch gear for the rotary converters supplying d.c. current for excitation and other purposes, whilst beyond is the three-phase low-tension switchboard. It is all very neatly arranged with ready access, and supervision should be simple.

The arrangement for carrying the cables between the generating-room and the propeller motor-room is illustrated. They are totally enclosed and are laid in the holds, a current of air being forced through the cable trunks so that they are kept cool. The upper cables are for the main high-tension circuit and the lower for the D.C. excitation wiring. The former are carried in troughs made of silumin. In the event of fire in the holds these trunks could be flooded with water, and the cables would not be affected, since they are watertight.



The three sea-water circulating pumps driven by A.C. synchronous motors.

In the main generator room, apart from the machinery which has already been mentioned (the two auxiliary generating sets and three rotary converters), are three salt-water cooling pumps, a Turbulo oily bilge separator, the vertical bilge and ballast pumps which operate in conjunction with a vacuum tank for priming, one fuel oil transfer pump, two daily service pumps, a sanitary pump, a drinking-water pump (stopped and started automatically when required), and a lubricating oil pump. A Westfalia centrifugal separator is installed for purification of the lubricating oil, which is heated before being passed through the separator. The silencers for the engines are arranged in the engine-room and are well lagged, but no exhaust-gas boiler is installed. There is no steam whatever in the ship.

Forward of the engine-room is a series of deep tanks, those in the wings being used wholly for carrying fuel oil, and amidships some of them are employed either for fuel oil or for edible oil. The total amount of fuel oil may be 2,000 tons. Warm air is delivered to heating trunks around and below the deep tanks mentioned. This air is at a temperature of about 45° C., and the oil is easily maintained at a temperature of 35° C. The circulation is simple. A few feet below the top of the funnel it is entirely plated over, apart from the exhaust outlets. The exhaust pipes pass up this enclosed funnel, and from the space around the pipes the heated air is drawn down through ducts by electric fans around and below the oil tanks.

In the construction of the ship and equipment very considerable use is made of electric welding, and in particular in connection with the engine foundations and the oil bunkers, which are completely welded. It is stated that so advantageous has this proved that whereas the ship was designed for a deadweight capacity of 9,500 tons, it is actually 9,950 tons, due to the saving in weight.

Fuel Consumption.

During the course of the homeward voyage at full speed the propeller speed was maintained at about 110 to 114 r.p.m., representing approximately 15 knots, whilst on some days 16 knots was maintained, the average fuel consumption being in the neighbourhood of 26 to 28 tons per day. On trials a mean speed of 17·2 knots was reached.

The ship carries five engineers and three assistants, in addition to a chief electrician and two assistants.

The performance on the maiden voyage has proved eminently satisfactory.

Vickers Lightweight Oil Engine.

A new type designed for small submarines and other special craft.

"Shipbuilding and Shipping Record", 1st July, 1937.

A new lightweight oil engine, designed primarily for special naval service where maximum output on minimum weight is an important consideration, has just been placed on the market by Vickers-Armstrongs Limited, Barrow-in-Furness.

Two types are manufactured, a six-cylinder engine developing 600 b.h.p. at 500 r.p.m., and an eight-cylinder, which develops 800 b.h.p. at the same speed. The small space occupied by the engine is an important consideration in small submarines, and as the overall length of the six-cylinder type is only 11ft., while that of the eight-cylinder unit is 13ft. 11in., this feature has received particular attention in the design. The weight of the engine is about 30lb. per b.h.p. at submarine rating, showing that it is definitely in the lightweight class.

The engine is of the solid-injection type, is single acting, works on the four-stroke cycle, and has cylinders of 12¾-in bore, with a stroke of 13½in. A bed-plate of composite construction, incorporating cast-steel cross girders which carry the main bearings, and which are welded into a steel plate trough to which the holding-down flanges are welded carries a crankshaft of oil-toughened mild steel. Of extremely large diameter, the crankshaft is hollowed out for lightness and affords unusual stiffness and bearing efficiency. The crankshaft is in two lengths, joined by a coupling on which is mounted the slightly helical spur wheel for driving the camshaft. Bottom main bearing shells are of forged steel, while the caps comprise two steel stampings welded together. Both shells and caps are white metal lined, the cap being secured to the bedplate cross girders by four large bolts. Connecting rods are steel stampings of approximately H section, machined on the profile and drilled for the passage of lubricating oil.

The trunk piston is manufactured of special cast iron of plain design, and in one piece, five narrow impulse rings and two scraper rings being arranged. Each cylinder cover, which carries two inlet and two uncooled exhaust valves in removable valve boxes, consists of a steel casting into the bottom of which is welded a forged-steel combustion plate. The covers are bolted together, forming a continuous girder, which rests on the top of the columns, being held down by massive studs.

Single conical springs, designed to avoid "flutter", are fitted to the valve boxes, the valves being operated by light stamped levers and hollow push rods fitted with large rollers at their lower ends.

Cylinder liners.

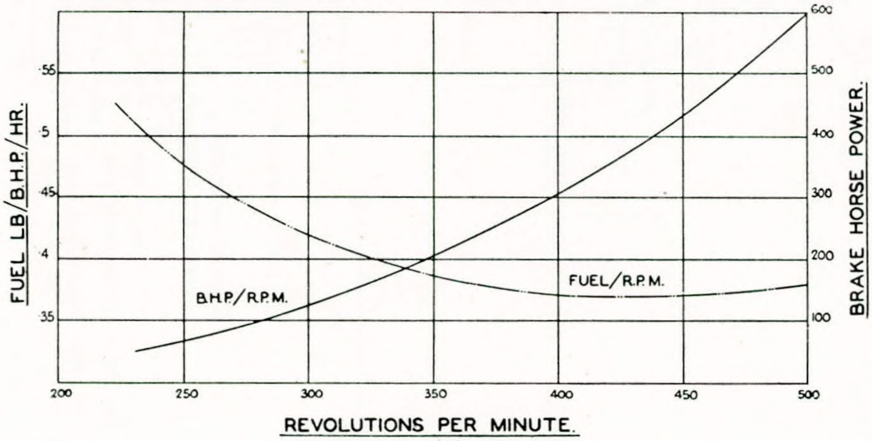
Cylinder liners are of special steel, and are held up to the under face of the cylinder cover by a forged-steel ring to the lower side of which is attached the sheet-steel water jacket. The water joint is independent of the gas joint, so that water cannot leak into the cylinder.

The camshaft is driven by means of helical spur wheels which are force-lubricated, and the fuel pump, driven off the end of the camshaft, has six pump units housed in a forged steel block. The fuel pump discharges to a common fuel rail from which leads are taken to the mechanically-operated fuel spray valves. These valves are carried in stamped steel bodies, and work in ground guides, no soft packing being necessary.

Control gear is fitted at the end of the engine. The output of the fuel pump is controlled by the hand lever on the left, while the adjacent lever regulates the duration of opening of the spray valves, the timing being automatically adjusted to suit. The small handwheel below these levers permits of further retardation or advance of the fuel injection, and the right-hand lever admits starting air to the engine.

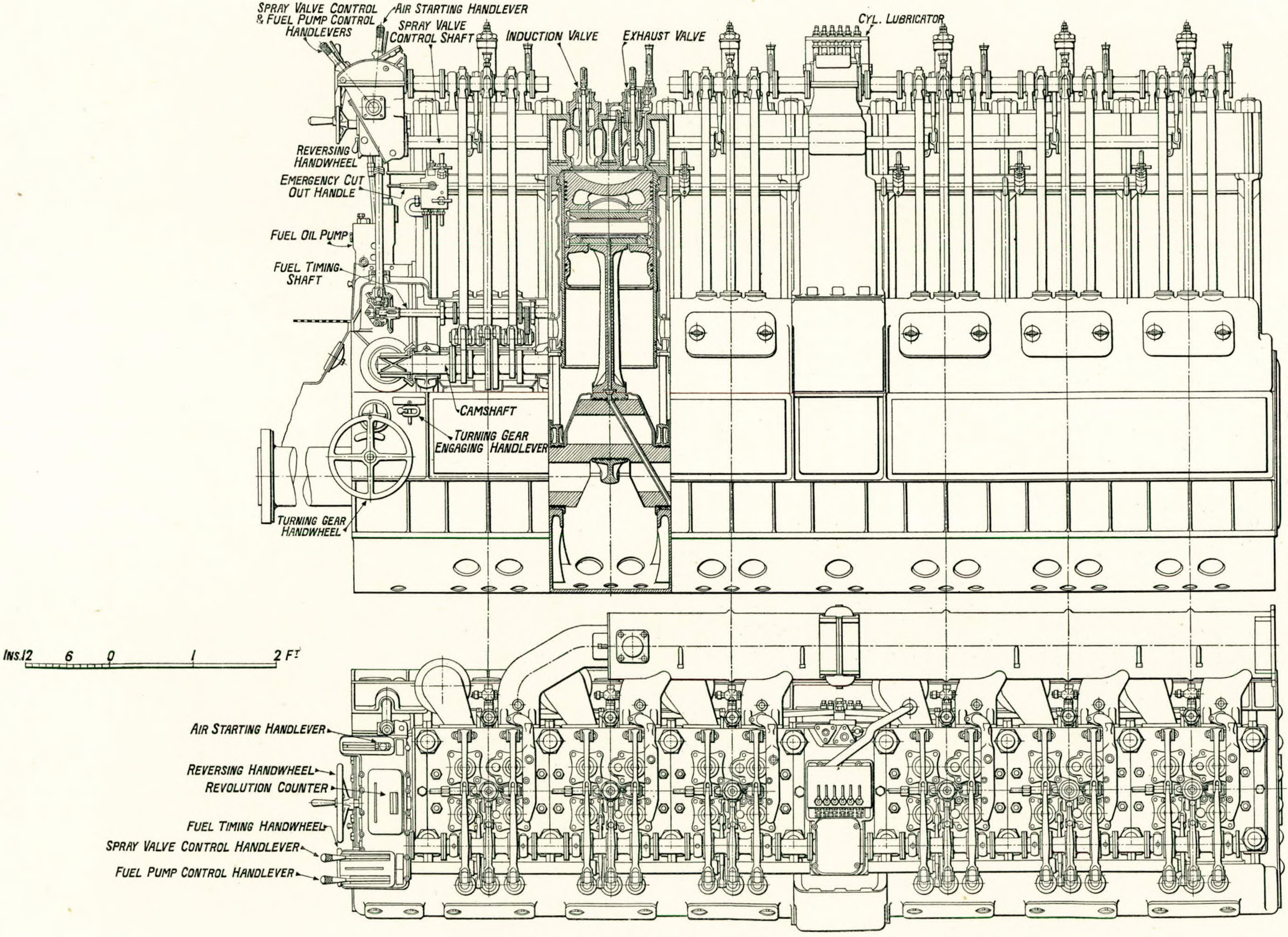
Starting air passes to a distribution box at the back of the engine, in which a cam-operated valve for each cylinder is arranged.

These valves admit air in correct sequence to a non-return valve on each cylinder cover. The large handwheel, which is interlocked with the control levers, reverses the engine by raising the push rods, sliding the camshaft to bring the second set of cams under the push rods and then lowering the latter. This reversal is carried out very rapidly by hand power alone.



Fuel consumption curve.

Cooling water for the engine enters at the bottom of the cylinder jacket, passes up outside the liner to the hollow ring securing the latter, and thence to the cylinder cover, through four accessible connections. The water next passes over the face of the combustion plate to the centre of the cover, then rising and passing through the exhaust valve boxes to the exhaust manifold. All the water passages are large, and the system ensures an efficient self-



Arrangement of the new Vickers lightweight oil engine.

venting arrangement with a minimum of piping on the engine.

Extreme simplicity, combined with rigidity, are the principal features of the design, the underlying intention being to present an engine free from avoidable wear and risk of derangement. A low fuel consumption over a wide range of duty is obtained, as may be seen from the fuel curve above. This low fuel consumption is accompanied by a small lubricating oil expenditure.

Although primarily designed for naval work the engine is also available for yacht propulsion and the driving of generators.

Twin-screw Tug with Kort Nozzles.

The "Ness Point", built by Richard Dunston Limited, Thorne, for L.N.E.R. towing services in Lowestoft Harbour.

"Shipbuilding and Shipping Record", 1st July, 1937.

The first twin-screw tug fitted with Kort nozzles to be built in Britain was recently completed by Richard Dunston Limited, Thorne, near Doncaster, to the order of the London & North Eastern Railway Company for service in Lowestoft Harbour.

Built to the requirements of Lloyd's Register for towing services, the vessel is sub-divided by four watertight bulkheads into five compartments, comprising the fore peak, crew accommodation and feed tank, machinery spaces, store and after peak.

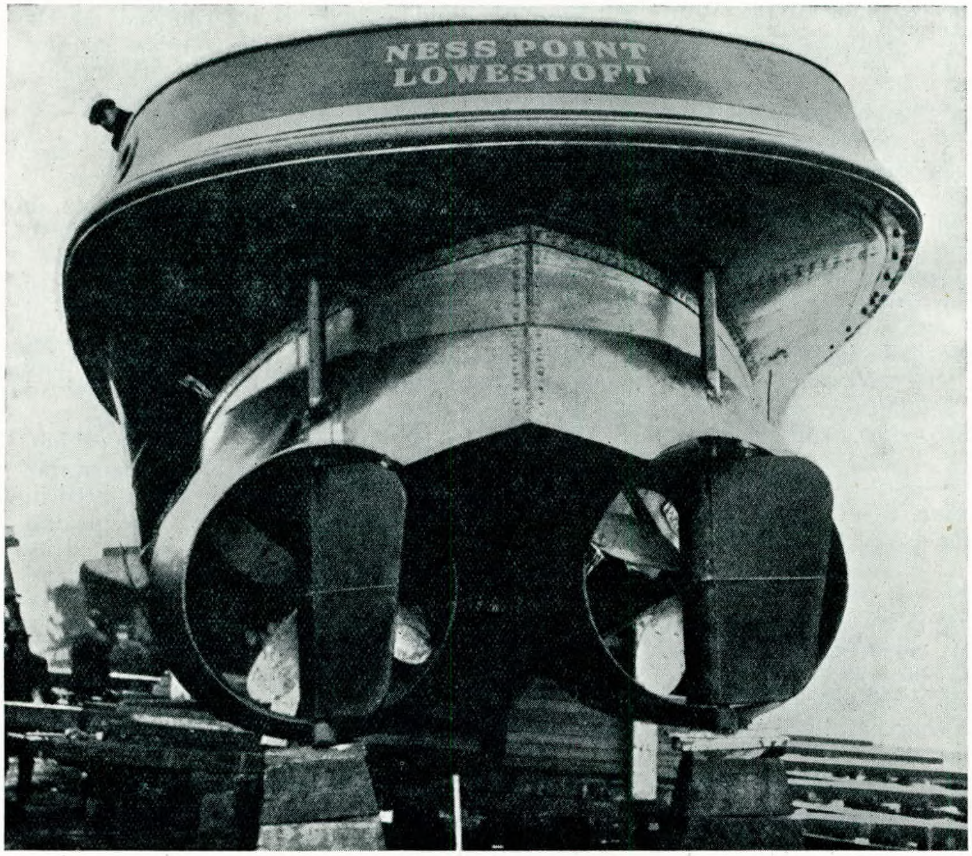
The principal particulars are :—

Length, b.p.	71ft.
Breadth, moulded	18ft.
Depth, moulded	9ft.
Draught, mean	7ft. 4in.

The stern, designed to suit the Kort nozzles, departs from a normal design in that no stern frame is required and the keel runs up from the after peak bulkhead in a straight line to just below the load water line at the extreme after end. The Kort nozzles are fitted with watertight diaphragms which isolate them from the main hull. Twin rudders are fitted, foot-step bearings being embodied at the bottom of the exit of the nozzles, the rudders being connected on deck by link gear and operate together, controlled by Donkin's hand and steam steering gear from the bridge. Twin rudders have the advantage that steering way is obtained as soon as the engines are started ahead irrespective of whether the vessel has any way on her or not, since rudders lie entirely in the accelerated propeller slip area.

In the orginal specification, for a tug of normal design, the owners called for 300 i.h.p., a 3 tons pull, and a free running speed of 9 knots. The Kort Propulsion Co. Ltd., London, were asked to submit their assessment of power for a 3 tons pull, and in view of the reduction in horse-power which could be anticipated for the bollard pull by fitting Kort nozzles, they put forward a collective i.h.p. of 180, but assessed a free running speed of only 8 knots.

In view of the reduced horse-power the Kort Propulsion Company suggested to the builders that they could take advantage of a smaller hull, but the owners decided to build the tug of the same dimensions as for the 300 i.h.p. originally suggested, with a reduction in the machinery space and bunker capacity. The nozzles were supplied by R. H. Green & Silley Weir Limited, in their capacity of licensees of the Kort Propulsion Co. Ltd., and were dispatched



Stern of the "Ness Point" showing Kort nozzles.

to the builder's yard complete and ready for fitting to the hull.

Propelling machinery consists of two sets of vertical compound surface-condensing engines built by Plenty & Son, Newbury, which at full power turn 160 r.p.m. Pumps are driven from eccentrics at the after end of the engine and an independent circulating pump and donkey pump are installed. The donkey pump has suctions from the sea, bilges, and fore and after peaks. An ejector is also fitted for removing water from the bilges. Steam is supplied by a single coal-fired cylindrical boiler with a working pressure of 160lb. per sq. in.

Trials of the "Ness Point" were carried out early in June on the Humber and in the Hull Docks. A standing pull of 4·1 tons was obtained at the designed revolutions of 160 per minute, the horsepower being in the region of 180. The free running speed was 8·3 knots.

With regard to manœuvring ability, with both engines running at full ahead and the rudder to starboard, the vessel turned a complete circle in 1 min. 56 sec., and with the rudder to port in 1 min. 53 sec., the steering circle being about 150ft. in diameter. With the starboard engine full ahead and the port full astern, helm hard to port, the vessel turned a complete circle in 1 min. 50 sec., the diameter of the circle being little more than the length of the tug and was less than 100ft. With the tug running full speed ahead and the engine brought to full astern, way was taken off the vessel in 37 sec.

After trials the tug was manœuvred between two large vessels in dock, the space between them being less than 5ft. in excess of the overall length of the tug. The "Ness Point" was laid alongside the quay in this space without a fender which showed her fine manœuvring qualities.

These trials are interesting and will undoubtedly be of great importance to tug owners and builders and it is certain that the future performance of this vessel will be closely watched.

The specification for the "Ness Point" was prepared by the Engineer, Southern Area, L.N.E.R., on whose behalf the Docks Engineer supervised the building of the vessel.

Ellerman Liner "Malvernian".

Built by William Gray & Co. Ltd., West Hartlepool, for the Mediterranean cargo trade of the Ellerman Lines.

"Shipbuilding and Shipping Record", 24th June, 1937.

In accordance with the policy of the Ellerman Lines to build and maintain an up-to-date fleet of fast passenger and cargo steamships for their Mediterranean and Eastern services, the firm has recently taken delivery of the "Malvernian", the first of four cargo liners ordered from Wm. Gray & Co., Ltd., West Hartlepool.

Mr. H. S. Holden, managing director of the Ellerman Lines, gave some details of the company's new building programme when he spoke at a luncheon on board the "City of Benares" during the trials of that vessel, last October. The "City of Manchester", Mr. Holden stated, was the first of the new vessels, then followed the "City of Benares" (described in "Shipbuilding and Shipping Record" of October 15, 1936), and the "City of Agra".

At that time a further six high-speed cargo vessels were on order—two on the Clyde, two at Birkenhead, and two at West Hartlepool. Since Mr. Holden's speech, however, further orders have been placed and no fewer than fourteen vessels are on order for the Ellerman Lines in British yards.

The "Malvernian" is of the one deck and shelter deck type with forecastle, long midship bridge house, and small poop house aft. Built for the general cargo trade of the Ellerman & Papayanni Lines Limited, and the Westcott & Laurance Line Limited, with special provision for the conveyance of perishable cargoes, the vessel has been constructed under the supervision of Mr. Wm. Hinchcliffe, chief superintendent of the Ellerman Lines Limited.

Model tests.

In view of the speed requirements of the owners, a series of model tests was carried out at the William Froude Tank at the load displacement and at speeds equivalent to a range of 10-15 knots. The resultant form has a very long and fine entrance, the middle body being confined merely to one or two frame spaces. The design has also a good beam, such as to ensure satisfactory stability under usual working conditions of load and ballast.

The vessel has a smart appearance with a characteristic well-raked plate-type stem and elliptical stern, two masts and a single funnel amidships. A well-rounded bridge front embodied in the construction has been designed to reduce head resistance.

The hull was built under special survey to Lloyd's Register highest class with freeboard corresponding to a complete superstructure type with a tonnage opening aft, so that the ship may be readily convertible to qualify for the deeper load draught awarded to a full scantling type.

The structural design is, generally speaking, of conventional form with the usual transverse system of framing and wide spaced pillars fitted in association with fore and aft girders. The general and local strength have been further improved by a number of owners' extras in the scantlings and riveting beyond the highest classification requirements. Particular mention may be made of the stern frame which is a massive two-piece steel casting with scantlings in excess of rule requirements and designed to give the maximum streamlining effect.

The main watertight sub-division is effected by seven watertight and one non-watertight transverse bulkheads extending to the shelter deck, but fitted with openings in way of the 'tween deck space to comply with tonnage exemption requirements. The scheme of sub-division gives three cargo holds and a separate cross bunker forward, and two cargo holds aft with the machinery space amidships and the usual peak tanks at the ends of the ship.

A cellular double bottom is arranged all fore and aft between the peak bulkheads and is divided by watertight floors into seven tanks, of which two, in way of the machinery space, are intended for reserve feed-water, the remainder being for water ballast. The centre girder is maintained watertight throughout the double bottom length, except in way of the end tanks.

Capacity is provided in the double bottom for about 280 tons of reserve feed-water and for about 500 tons water ballast in the double bottom and peak tanks.

Permanent space for bunkers is arranged in wing compartments in the engine room and in the 'tween decks abreast the casing, the total space including feeder shoots being sufficient for about 500 tons of coal at the normal storage figure. Substantial reserve capacity is provided in the cross-bunker and in the corresponding bunker 'tween decks above.

Cargo capacity.

Provision is made for the carriage of general cargo in the five holds and cross bunker, corresponding shelter 'tween deck spaces and forecastle. The gross capacity of these spaces is about 300,000 cu. ft., giving a relatively high storage rate for cargo.

With the exception of the forecastle and reserve bunker spaces, all cargo compartments are fitted with vertical cargo battens, and the tank top in way of hatches is sheathed with 3-in. spruce. Particular attention has been paid to securing clear hold space suitable for the shipment of large pieces of machinery and the hatchways to cargo spaces are of a good size. Hatch closing is effected by the usual hatch beam and wood cover system, the hatch beams at the weather decks being of the T. & B. patent rolling type. Nos. 1, 2, 3, 4 and 5 shelter 'tween decks are specially arranged for the carriage of fruit cargoes, and in those spaces air circulation is maintained by means of mechanical ventilation, fans being fitted in the ventilators.

Monarch air extractor ventilators, manufactured by the Monarch Controller Co. Ltd., London, are fitted at the top of each of the two amidship derrick posts, which are also arranged as ventilators to the cross bunkers.

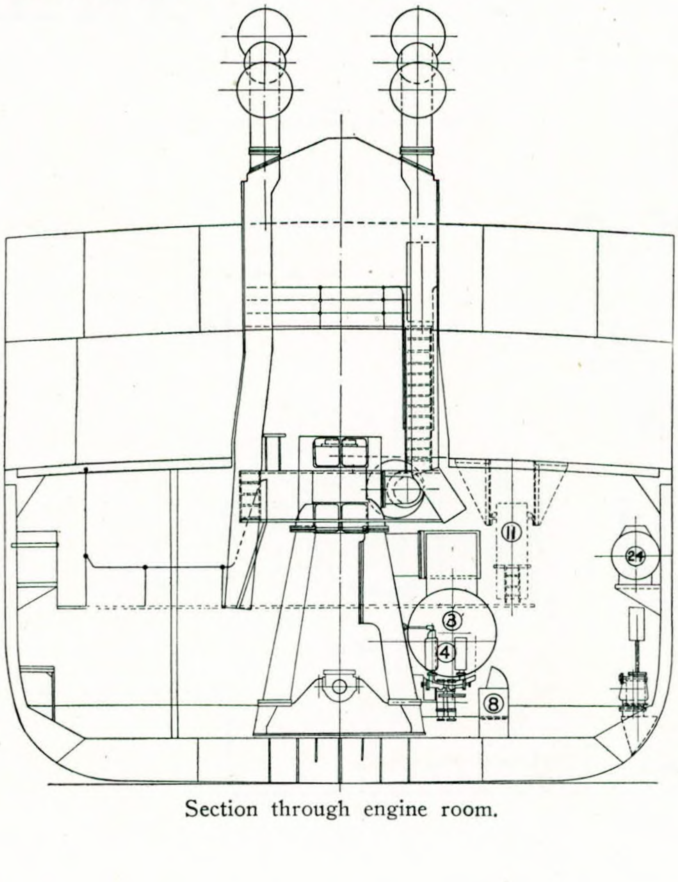
Refrigerating plant.

A further insulated compartment for refrigerated cargo is fitted in the shelter 'tween decks, with a net capacity of about 3,000 cu. ft. The insulation work for this space was carried out by the Cork Insulation Co. Ltd., London, and consists of slab cork faced with cement for the walls, and granulated cork, retained by t. & g. boards for the roof. Fixed brine grids are fitted to the walls and roof and the refrigeration is on the CO_2 brine system. The refrigerating plant was provided by the Liverpool Refrigeration Co. Ltd., and includes a steam-driven vertical single-acting twin compressor machine, and associated auxiliaries.

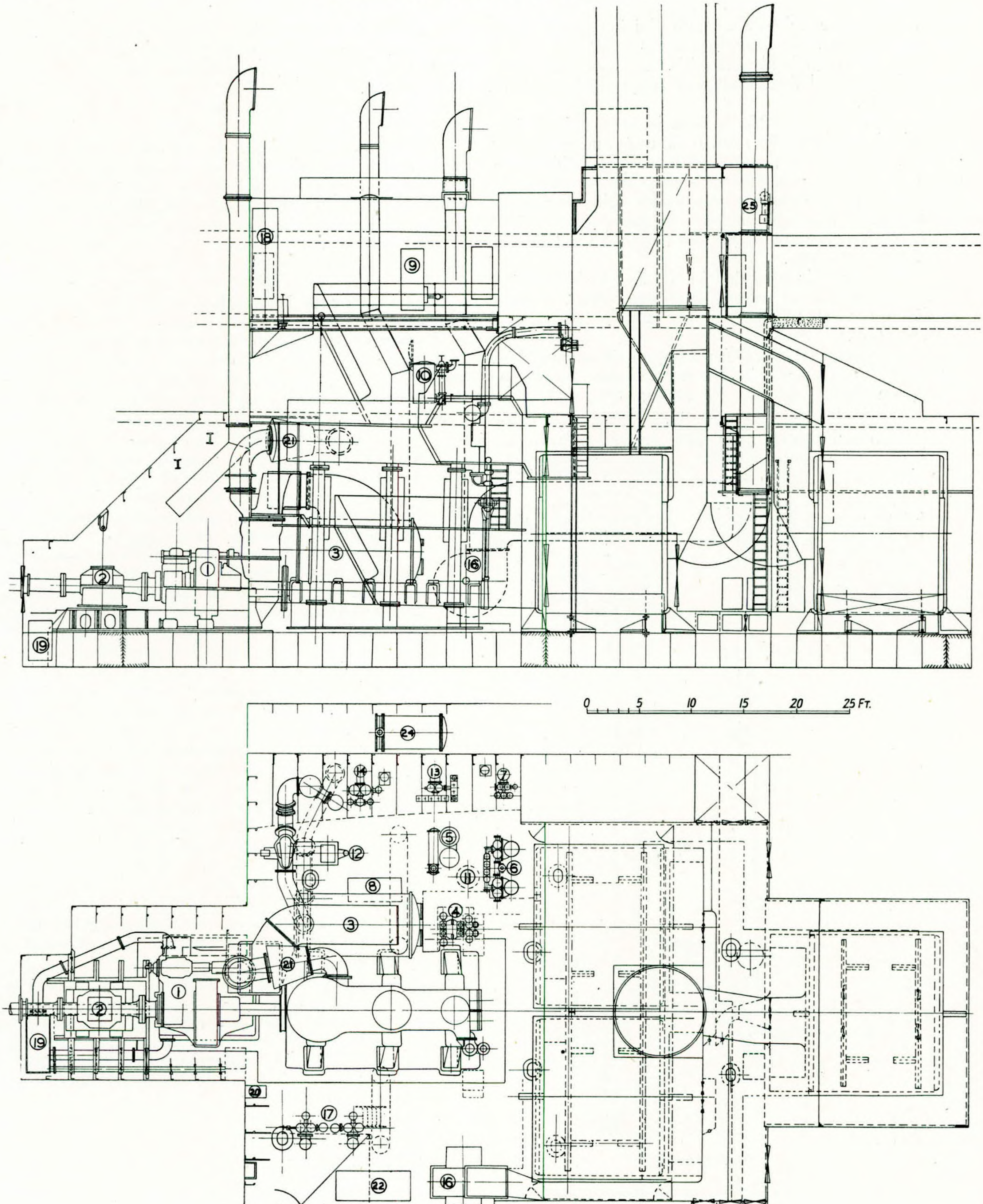
A very full equipment of derricks has been supplied for cargo handling which includes five 7-ton derricks at the foremast serving Nos. 1 and 2 hatches, two 5-ton derricks, stepped on derrick posts amidships serving No. 3 hatch, and six 7-ton derricks at the main mast serving Nos. 4 and 5 hatches. In addition, there is a 25-ton heavy derrick fitted at the after side of the foremast and serving No. 2 hatch. All derrick booms are made of steel and operate in conjunction with ten steam cargo winches, supplied by Clarke Chapman & Co. Ltd., Gateshead-on-Tyne.

KEY TO MACHINERY ARRANGEMENT BELOW AND OVERLEAF.

1. Bauer-Wach combination exhaust turbine.
2. Michell type thrust block.
3. Main condenser—Weir regenerative type: C.S. 4.400 sq. ft.
4. Engine-driven hotwell, bilge and sanitary pumps.
5. Independent air pumps.
6. Main feed pumps.
7. Auxiliary feed pumps.
8. Hotwell and scum tank.
9. Direct-contact feed heater.
10. Gravitation filter.
11. Secondary surface feed heater.
12. Main circulating pump.
13. General service pump.
14. Ballast pump.
15. Evaporator.
16. Forced-draught fan and engine.
17. Forced-lubrication oil pumps.
18. Lubricating-oil gravity tanks.
19. ,, ,, drain tank.
20. ,, ,, centrifugal purifier.
21. Vortex oil and water separator.
22. Electric generator.
23. Switchboard.
24. Auxiliary condenser.
25. Ash hoist.



Section through engine room.



Machinery arrangement of the "Malvernian".

An additional steam winch by the same makers is fitted aft for mooring and warping purposes, this winch having extended shafts with warping ends. For handling the bower anchors and for warping duties forward, a steam-driven windlass manufactured by Emerson Walker & Co. Ltd., Dunston-on-Tyne, is provided.

The steering gear, housed in the poop house on the shelter deck, is of the Wilson-Pirrie type with the usual Ellerman requirements incorporated. The gear was manufactured by John Hastie & Co. Ltd., Greenock, and is capable of putting the rudder hard over to port or starboard through an angle of 42° with the vessel steaming full speed ahead in loaded condition. The gear, which is controlled from the bridge by a MacTaggart Scott telemotor, operates a non-balanced rudder of double plate streamline design built up on a cast-steel frame and attached to a forged-steel stock through a horizontal flanged coupling. The weight of the rudder is taken by a carrier through the medium of a heavy collar forged on the stock above the upper deck level.

The outfit of boats carried under davits on the boat deck consists of two 23ft. and two 22ft. wood lifeboats. These boats were supplied by Rutherford & Co., Birkenhead, are clincher-built of larch and equipped to Board of Trade requirements.

The equipment of navigating instruments is of high-class standard and includes a Kelvite 10-in. dry-card standard compass with coach spring suspension and mattress bowl complete with azimuth mirror and all necessary correctors, supplied by Kelvin, Bottomley & Baird Limited, Glasgow, a dry-card steering compass in the wheelhouse and a 10-in. spirit compass for the auxiliary steering position aft. A Marconi Echometer sounding device, type 421/429 MF, a Marconi direction finder, type 579, an electric rudder indicator, and a Kelvite Mark IV hand sounding machine are also installed.

The wheelhouse and chart-room on the navigating bridge are of teak construction and fitted with Beclawat sliding windows manufactured by Beckett, Laycock & Watkinson Limited, London. The wireless telegraphy station, fitted with a Marconi 1½-kW. CW/ICW transmitter, a receiver, type 352A, and also an emergency set, is arranged adjacent to the operators' room on the port side of the bridge house and is in telephonic communication with the wheel-house.

Propelling machinery.

Propelling machinery, built at the Central Marine Engine Works of the builders, consists of a set of triple-expansion engines arranged to work in conjunction with a Bauer-Wach exhaust steam turbine unit of improved type. The combination is designed to give 3,500 equivalent i.h.p. at 90 r.p.m. of the propeller shafting.

Between the main engine and the exhaust turbine there is fitted a 25-in. direct flow Supreme Vortex exhaust steam separator supplied by William Alexander, Glasgow.

Steam is supplied by three single-ended boilers of the cylindrical multi-tubular type, constructed for a working pressure of 225lb. per sq. in. The boilers are fitted with Howden's system of forced draught and latest system of tubular air heaters. Air is supplied to the furnaces by a Howden high-efficiency fan, driven by an enclosed forced lubrication Thermall engine. Superheaters of the latest CMEW smoke-tube type having headers of mild ingot steel and designed to give a final temperature of about 600° F. are fitted to all boilers. The boilers are fitted with Clyde soot blowers and the three further vessels on order are to be similarly equipped.

The triple-exansion engine has cylinders 23in., 38in., and 65in. diameter, with a stroke of 48in. Independent steam and exhaust valves of Andrews & Cameron quadruple opening, balanced cam-operated type, are fitted to the h.p. cylinder, the m.p. and l.p. cylinders being fitted with balanced slide valves of the triple-opening type supplied by the same firm.

The turbine is of the impulse type and is supplied with steam from the l.p. cylinder exhaust of the reciprocating engine through a steam separator, working in conjunction with a by-pass which serves to connect the engine exhaust either to the turbine or to the condenser. The turbine is connected to the main shafting through single-helical type double-reduction gearing, incorporating a hydraulic clutch of the Vulcan type. The main condenser is a two-flow regenerative type, the cooling water being supplied by a centrifugal pump driven by an enclosed lubrication Thermall engine. The air and condensate are dealt with by a Weir's Paragon twin barrel air-pump working in conjunction with a vacuum augmentor, comprising steam-jet, air ejector and ejector condenser.

Other Weir auxiliaries include two main feed pumps of the direct-acting type, each having a capacity of 37,000lb. per hour at 8½ double strokes per minute; a direct-contact feed heater with float control gear; and a secondary surface feed heater, capable of raising the temperature of the boiler feed from 210° to 300°, supplied with steam at 90lb. per sq. in. bled from the m.p. receiver.

Feed-water purification is dealt with by means of a CMEW combined drain, scumming and float tank in conjunction with a CMEW gravitation filter. The lubricating oil system includes Clensol strainers. For use in the forced-lubrication system in connection with the Bauer-Wach unit, two simplex-type pumps are supplied, each being capable of supplying the requisite quantity of oil at full power, so that one pump is always available as a standby. For lubrication of the main engines, T. & K. lubricators are provided. An audible alarm is provided in the system, designed to give the engineer on watch adequate warning of failure of the oil supply.

Auxiliaries.

Included also in the oil system are suction and discharge strainers, magnetic filters and oil coolers, and, for continuous purification, an electrically-driven oil purifier of the centrifugal type, working in conjuction with a special heat, is fitted. An ample service of auxiliary machinery is provided including ballast, general service and harbour feed pumps, evaporator, auxiliary condenser, steam and hand ash hoists, and so on. The thrust block and also the tunnel-shaft bearings are of the Michell type. The "Malvernian" is provided with a propeller having a cast-iron boss, with four detachable manganese-bronze blades, the design being the result of extensive tests at Teddington.

The "Malvernian" ran trials on June 3, when a mean speed of 14½ knots was reached, and proceeded to Liverpool via Bristol Channel and Glasgow to load for Mediterranean ports.

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 27th May, 1937 :—		
Alcock, Daniel G.	2.C.	Liverpool
Burke, Edmund	2.C.	"
Drury, George	2.C.	"
Walker, Arthur E.	2.C.	"
Howie, Robert	2.C.M.	"
Gilhooley, James	2.C.	Glasgow
Henry, David	2.C.	"
McLean, Allan McD.	2.C.	"
Ralston, John B.	2.C.	"
Stephenson, Tom P.	2.C.	"
Allan, James H.	2.C.M.	"
Johnston, Robert B.	2.C.M.	"
Brittle, Francis J.	2.C.	Newcaste
Dawson, Robert	2.C.	"
Lawson, Gilbert Y.	2.C.	"
Donnelly, Francis V.	2.C.	"
Heede, George B.	2.C.	"
Hines, John A.	2.C.	"
Kirk, Thomas	2.C.	"
Fife, George F.	2.C.M.	"
Hall, John L.	2.C.M.	"
For week ended 3rd June, 1937 :—		
Scott, James	1.C.M.	Liverpool
Sutcliffe, Frederic N.	1.C.	London
Hope, James	1.C.	Glasgow
Moore, Quintin	1.C.	"
Pain, Edward F.	1.C.	"
Bell, Thomas	1.C.	Newcastle
Hughes, William L.	1.C.	"
Spence, Alexander	1.C.	"
Strachan, Richard R.	1.C.S.E.	London
Metcalf, Arthur T.	1.C.M.E.	Newcastle
Watson, Joseph	1.C.M.E.	"
Mackay, William	1.C.M.E.	Glasgow
Walker, David L.	1.C.M.E.	"
Porteous, Thomas A.	1.C.M.E.	London
Mitchell, Edmund N. M.	1.C.M.E.	"
Watson, Mark L.	1.C.M.E.	Liverpool
Duffy, John O. C.	1.C.M.E.	Liverpool
Mosley, George	1.C.M.E.	Newcastle
For week ended 17th June, 1937 :—		
Doye, John	2.C.	Cardiff
Lewis, Richard M.	2.C.	"
Ford, Douglas F.	2.C.	London
Howell, Edward D.	2.C.	"
Sills, Fred S.	2.C.	"
Collard, Herbert R.	2.C.	Liverpool
Fisk, Harry	2.C.	"
Postlethwaite, William E.	2.C.	"
Wainwright, Kenneth J.	2.C.	"
Williams, John	2.C.	"
Drakard, Ronald	2.C.	Newcastle
Hermeston, Andrew	2.C.	"
Iles, Thomas J. R.	2.C.	"
Rhodes, Christopher G.	2.C.	"
Watson, William P.	2.C.	"
Buckingham, Allan D.	2.C.M.	"
Carr, John	2.C.M.	"
Lally, Patrick	2.C.M.	"
Pledger, Rowland	2.C.M.	"
Tate, Edward M.	2.C.M.	"
Forsyth, Alexander T. M.	2.C.	Glasgow
McLean, William J.	2.C.	"
Peddie, George	2.C.	"
Richardson, John	2.C.	"
McCaffery, William	2.C.M.	"
Mitchell, John C.	2.C.M.	"
Pearson, James E.	2.C.M.	"
Templeton, William W.	2.C.M.	"
For week ended 24th June, 1937 :—		
James, Norman C.	1.C.	Cardiff
Reed, Robert C. H.	1.C.	"
Roberts, Edward H.	1.C.	"
Morris, William A.	1.C.M.	"
Hogg, Thomas A. I.	1.C.	Glasgow
Leiper, Alexander	1.C.	"
Matthewson, James	1.C.	"
Allan, John	1.C.	Newcastle
Culpitt, Charles	1.C.	"
Hepton, Maurice F.	1.C.	"
Peters, Christopher W.	1.C.	"
Murphy, Francis	1.C.M.	"
Thomas, Vivien C.	1.C.M.	"
Thompson, Wilfred	1.C.M.	"
Burrows, John K.	1.C.	Liverpool
Mason, Philip W.	1.C.	"
Falconer, William T.	1.C.	"
Hunt, Arthur	1.C.	London
King Robert H.	1.C.	"
Priestley, David P.	1.C.	"
Rischmiller, Charles A.	1.C.	"
Vann, Clarence R.	1.C.M.	"
Carter, George L.	1.C.S.E.	Glasgow
Sutherland, James L.	1.C.S.E.	"
Shaw, Thomas	1.C.S.E.	Newcastle
Brand, Robert M.	1.C.M.E.	Glasgow
Aird, Peter U.	1.C.M.E.	"
Girdwood, John R.	1.C.M.E.	"
Somerville, John L.	1.C.M.E.	"
Davidson, James	1.C.M.E.	"
Morrison, Walter A.	1.C.M.E.	"
Warnaby, Harry	1.C.M.E.	Newcastle
Marshall, Hugh	1.C.M.E.	"
Shepherd, Robert J.	1.C.M.E.	"
Fairbairn, Cyril D.	1.C.M.E.	"
Brown, Cyril K. L.	1.C.M.E.	London
Sage, Arthur L.	1.C.M.E.	"