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Grit Collecting and the Treatment of Flue Gases.

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Chairman: F. H. REID, B.Sc., Wh.Ex. (Member).

WHEN the subject of this lecture was first raised the author was in some doubt about the matters it should cover and whether it should be confined to the marine side only. It was suggested, however, that it should be as wide as possible and refer not only to marine plant but also to land practice. This leads to a very wide field and makes it difficult to do the whole subject the justice which its importance deserves.

The ultimate object in treating flue gases is really two-fold: *In the first place as little heat as possible should be lost to the atmosphere and, secondly, the gases discharged should be clean and free from harmful and corrosive constituents.*

The attainment of the second of these objects, clean and innocuous gases, depends largely on the previous attainment of the first, because the cooling of the gases with the consequent reduction in volume enormously simplifies their cleaning afterwards.

To obtain a clear view of the whole subject it is probably desirable to begin with the historical side and trace the developments leading up to present-day practice.

The earliest method of using flue gases was in all likelihood accidental and consisted in making them provide the draught required for the burning of the fuel on the grates. The industrialists, 100 years ago, had no further interest in the matter after the gases had created the necessary draught, and the heavy pall of smoke which hung over certain parts of the country was looked upon as an indication of the prosperity of the district rather than a proof of bad combustion conditions and inefficient engineering.

The first attempt to improve matters in these industrial plants took the line of recovering heat from the gases by means of the economiser. This, while excellent in itself, unfortunately led to reduced draught, and the already high chimneys had to be further increased, with the lamentable effect on the industrial landscapes with which we are still familiar.

Apart from these stationary plants this complacency did not exist—in fact it could not exist. On the steamship and particularly on the locomotive it was necessary to search for some artificial means of increasing the rate of combustion, because a high chimney such as could be built on land was completely out of the question. Very early in the locomotive the simple device of passing the exhaust steam from the engine cylinders through a nozzle suitably placed below the funnel base was tried. This proved to be completely satisfactory, producing such a powerful draught that the locomotive boiler at once became the most highly-rated boiler of the time in spite of the short funnel. The locomotive, of course, was and still is an engineering peculiarity. It is almost an impossibility to apply a condenser to it, and the use of this means of creating a draught was a convenient and skilful solution of the problem, which has not been improved upon in the last century.

On the marine side convenient supplies of fresh water were not available as they were for the locomotive, and the condenser was therefore early established as an essential part of the plant. Although comparatively high funnels were easily fitted to steamships, giving a reasonable natural draught, engineers began to experiment more than 100 years ago with mechanical means of increasing the draught, and it was Edwin A. Stevens who in New Jersey in 1828 first used a fan for this purpose. Along with his brother, Stevens experimented with each of the three systems which are now used either separately or in combination at sea. These were :—

(1) Blowing direct into a closed ash-pit under the fires.
(2) Drawing the gases away from the exit of the boiler by the suction of a fan.
(3) Blowing the air into an airtight stokehold surrounding the boilers.

These early experiments, however, were not successful for one reason or another and the systems were all discarded and lay in abeyance for about half a century with the brilliant exception, of course, of the locomotive.

It is not strictly within the scope of the subject of this lecture to refer to mechanical draught, but the matter must be touched upon because it is by the mechanical means of creating a draught that the engineer has become independent of the use of hot gases in a high chimney and has been able to use these gases for other purposes. In other words, with mechanical draught he is able to recover a large amount of the heat which would have been necessary to create the draught, and in recovering this heat, for reasons of economy, he cools the gases to such an extent as to allow them to be treated in various ways so that on their discharge to the atmosphere they are more or less innocuous.

Mechanical draught too permits of pressure differences which it would be impossible to obtain by the chimney's natural draught, and consequently the gas velocity through the boiler and the various auxiliaries may be increased to any desired amount, thereby increasing the heat transfer and reducing the heat exchanging surfaces with a corresponding saving in space and cost.

Before leaving this aspect of the matter it might be well to illustrate the wastefulness of relying on the high leaving temperature of the gases to provide the draught. Let us take as an example a battery of boilers burning, say, two tons of coal per hour from which the gases enter the chimney at 600 °F. This temperature in a chimney, say 100ft. high, would give a theoretical draught at the chimney base of $\frac{3}{4}$in. w.g. On the assumption that the CO_2 was about 8 per cent., the chimney loss in terms of percentage of heat in the coal would be 24·3 per cent. In other words, practically a quarter of all the coal burnt would be used to create the draught.

Now suppose the draught could be created in some other way and apparatus of some kind could be introduced to recover a proportion of the heat in the gases, and assume that by this means the final gas temperature entering the chimney was brought down to 250 °F., which is quite an ordinary figure in modern practice. If the heat represented by the difference in these temperatures were returned to the boilers by some method or combination of methods, the funnel loss, still assuming only 8 per cent. CO_2, would be brought down to about 8·6 per cent. of the heat in the coal instead of 24·3 per cent. This means a saving, compared with the previous conditions, of 15·7 per cent. or, say, 700lb. of coal per hour. We have, however, not debited anything against the means of creating the draught. If a fan were used to give a draught equal to that of the chimney before the alterations were made, the power absorbed would be about 21 b.h.p., and supposing this fan to be driven by a quite uneconomical steam engine taking say 40lb. of steam per horse power per hour, the consumption would be 840lb. of steam or, say, in round figures 100lb. of coal per hour. The nett saving would, therefore, be 600lb. of coal per hour or about 13½ per cent.

The figures used in this example are by no means coloured to show an advantage to the modernized plant. The figure of 8 per cent. CO_2 would be very poor for modern draught plant and combustion apparatus, and the steam consumption of the fan is also heavy, but in making a comparison of this kind to show only the advantages of applying mechanical draught some such figures must be taken. Actually, of course, the modernizing of such a plant would have to take into consideration a modified design of the plant to work satisfactorily with the auxiliaries which have been introduced, and in such circumstances the saving would be substantially increased.

Having now become independent of the necessity for using hot gases for creating the draught the different purposes of treating the gases can be considered. These are :—

(1) To recover what has now become waste heat.
(2) To prevent emission of grit.
(3) To prevent emission of noxious gases.

The author has not mentioned smoke because to a large extent this may be controlled by efficient combustion apparatus and proper arrangements for air admission. In passing, however, it should be noticed that entire absence of smoke does not necessarily mean the most efficient combustion. Smoke can usually be eliminated by the introduction of excessive quantities of air but this will frequently result in loss of efficiency.

The heat recovered can be used for heating feed water and heating the air for combustion. The first steps were taken in 1845 by Edward Green when he carried out the experiments with the economiser which still bears his name. He had previously shown considerable interest in the treatment of gases in another sense, and had suggested as a means of sanitary reform the connection of the sewers of a large town to a common tall ventilating shaft having a furnace at its base through which the noxious vapours (as they were called in those days) could be passed, in order to render them innocuous before being discharged to the atmosphere. This, however, was rather far-fetched and he was much more successful with the idea of the economiser.

The first of these consisted of a group of 30 cast-iron tubes 4in. dia. by 9ft. long connected at the top and bottom to hemispherical chambers. The cold feed was introduced to the lower one and passed out from the upper one to the boiler. This upper chamber was fitted with a safety valve. The first trials were highly satisfactory and the safety valve blew off regularly. The results, however, fell off with use and the draught became seriously impaired. As the apparatus had been completely bricked into the flue it was impossible to see what had gone wrong, but on taking down the brick wall it was apparent what the trouble was. The whole outfit was blocked with soot. It was carefully cleaned and the wall was built up again. The apparatus worked satisfactorily once more, but in a short time the trouble developed again. After the brickwork had again been removed and the surface cleaned access doors were fitted and the economiser was kept fairly clean by starting fires of shavings in the flue at intervals and burning off the soot. The particularly sticky bits of soots were removed from time to time by exploding small charges of gunpowder. This was all very well but it was hardly engineering, and after some time of this explosive business Green designed his famous scrapers to overcome the difficulty. The great success of the economiser was no doubt largely due to this method of removing the soot and keeping the surfaces clean.

It is interesting to compare the design of the vertical tube economiser of to-day as used with tank boilers with the original economisers as patented by Green in 1845. Except for minor details, the construction now adopted as standard remains in its essentials the same as the original design.

For modern water-tube boiler plants, however, the arrangement of the economiser has undergone considerable changes, and the vertical tubes have given place to horizontally-arranged units. In early days horizontal tubes were difficult to keep clean as no suitable type of scraper was available and early experiments with steam soot blowers were not successful, largely due to the fact that the comparatively cold surfaces of the tubes tended to make the soot build up so that it could not be satisfactorily removed.

These cold surfaces, however, have disappeared due to an increase in the temperature of the feed brought about by other changes in the modern plant and the horizontal tubes can be kept perfectly clean by efficient soot blowers. In fact, the tube surfaces themselves can be complicated by gills without in any way affecting the cleaning, but resulting in a great advantage from the point of view of heat transfer per unit length of the tube. The heat transfer per unit length in a tube with suitably-designed gills is about three times that in a plain tube under the same flow conditions.

These factors, combined with mechanical draught, have allowed the gas velocities to be so much increased that a modern economiser doing as much, it not more, work than one of the earlier designs, can be accommodated in about one-third of the space and can conveniently be carried practically in the boiler casing.

A further modern development is the steaming economiser in which the temperature of the water is raised to that corresponding to the temperature in the boiler. In the steaming economiser means have to be taken to allow the steam to be liberated freely. This economiser, however, has no advantage as far as the overall efficiency is concerned, but usually from the capital point of view it is well worth consideration as the heating surface in the economiser is less costly than that in the boiler.

The heating of the air for combustion was pioneered by James Howden, who in 1860 was granted a combination patent which included in the specification a proposal to force a supply of air to the furnace through or amongst the small tubes of the surface condenser, thus utilizing the heat of the exhaust steam for the purpose of heating the air for the combustion of the fuel generating that steam. With the exception of a small land installation, no immediate use was made of this invention, but it served as the basis for further elaboration in later years.

Early in 1880 he carried out further experiments but this time the air was heated by using a simple tubular heater in the funnel. The results were highly satisfactory and in 1884 the steamer "New York City" was fitted with a new boiler working under this system. The engine had not been altered or refitted nor had the propeller been changed, so that the difference in results was due to the boiler with hot air forced draught. Before the change the i.h.p. was 600 and the consumption 13½ tons per day. After the change, however, the i.h.p. rose to 620 and the consumption fell to 9½ tons per day.

These results quickly led to more and more installations and the tubular air heater with the gas passing through the tubes became part and parcel of the marine boiler. These tubular heaters were of the cross-flow type and had tubes about 4ft. high. Minor improvements, such as guide plates to distribute the air evenly amongst the tubes, were introduced from time to time. In its essentials, however, this heater was used for many years and is still commonly fitted where only comparatively low heat recovery is called for.

As time went on the demand for higher boiler efficiencies increased and the funnel loss was the first item to attract attention. Longer and longer tubes were used and the air was made to flow back and forth in several passes between the tubes. This was still a cross-flow heater, but as the air worked its way from the cold end back and forth towards the hot end it was approaching the ideal of the contra-flow apparatus.

Increasing the length of the tubes brought a number of difficulties into the picture. In varying degrees these were:—

(1) Difficulty in keeping the long tubes clean.
(2) A tendency towards corrosion at the cold end, particularly if the exit temperature of the gases approached the dew point.
(3) Increasing leakage at the tube plates due to expansion and contraction of the tubes.
(4) Ultimate perforation of the tubes at the cold end with consequent heavy leakage.

Quite apart from these difficulties in the operation and maintenance of these long heaters there were also drawbacks from the point of view of weight and space occupied. Even the question of capital cost entered very definitely into the consideration of the economics of the case.

The development of these large tubular heaters made most progress on the land side where the weight and space were perhaps less important disadvantages than on board ship.

To some extent the problem was eased by the introduction of plate heaters where by using envelopes fairly closely spaced and by making use of almost direct contra-flow the surface required could be accommodated in much less bulk. Here, however, spacing had to be carefully considered to prevent choking and the old trouble of corrosion at the cold end was still one of the items to be contended with.

The best-known heater of this type in this country consists of welded envelopes open at the top and bottom of one edge. These are fitted into a casing with a small space between them through which the gases rise while the air enters at the openings at the top of the side edge and passes down to the corresponding opening at the bottom.

In high efficiency heaters of this type the corrosion difficulty referred to can be overcome by recirculation. A proportion of the hot air leaving the heater is taken back to the forced-draught fan, thus raising the entering air temperature and consequently the temperature of the plates at the cold end.

All the heaters so far referred to are of the recuperative type, i.e., the gas and air remain on opposite sides of a metal wall through which the heat transfer takes place.

Shortly after the war, however, an air heater operating on an entirely different principle was introduced. This was invented by the brothers Ljungstrom as an auxiliary for a turbine locomotive on which they were working in Stockholm. This preheater is a purely contro-flow apparatus and is the only one of the regenerative type. By regenerative as opposed to recuperative previously mentioned it is to be understood that the same heating surface which picks up the heat from the gases also gives it out to the air. There is therefore no heat transfer through a metal wall as in the recuperative heaters of the plate or tubular types. As a regenerator it represents the same important step forward in preheater construction as did the Siemens regenerator compared with the old recuperator in metallurgy. This has quite a number of advantages which will be gone into presently, but an explanation of the working principle and operation of this preheater is probably desirable at this stage. The original was christened "the bicycle in the chimney" by facetious critics at the time—the justification being no doubt the bicycle chain and sprockets which figured in the arrangement. The essential features are a rotor containing heating elements revolving slowly in a casing. The air is separated from the gas by the radial plates of the rotor, two of which are always in contact with sector plates immediately above and below the rotor. The early preheaters of this type had the casing continued above the rotor to form housings for the cold air forced-draught fan and the induced-draught fan handling the cooled gases.

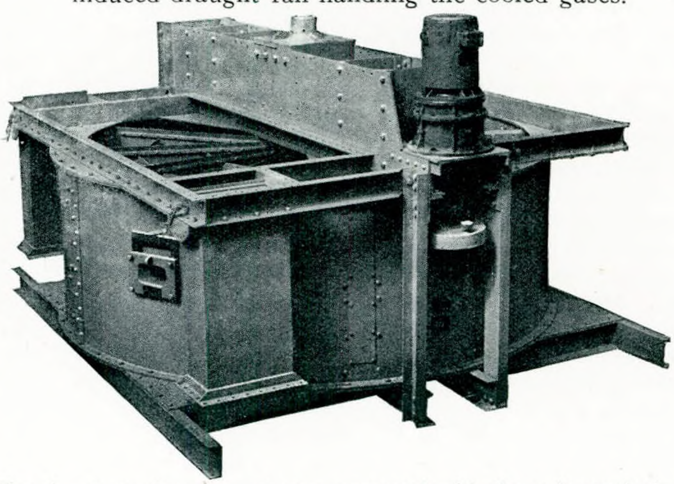


Fig. 1.—A marine air preheater arranged with the axis vertical.

Considerable numbers of preheaters of this design were installed about 15 years ago in industrial plants and astonishing results were obtained. In an installation on Lancashire boilers burning slurry containing 18 per cent. of moisture and 14 per cent. ash, the temperatures which were quite remarkable were as follows :—

Temperature of gases entering heater	...	1,000 °F.
Temperature of gases leaving heater ...	...	440 °F.
Temperature of air leaving heater ...	...	630 °F.

A modern preheater of this type is shown in Fig. 1. Here the essentials referred to in the early type are clearly seen. The casing, however, is simplified and the draught is taken care of by orthodox centrifugal fans usually arranged on a separate platform above the preheater. The drive now consists of a small separate motor driving a pinion which engages with a self-cleaning non-lubricated pin rack fixed to the rotor and the rotor is suspended from a heavy thrust bearing carried on a rigid beam independent of the casing. This view shows the sealing arrangements which prevent leakage from the air side to the gas side. The sealing strips attached to the radial plates bear against the sector plates and when properly adjusted they keep the leakage down to about 5 per cent. This may seem a high figure, but actually it is much less than that commonly found in tubular heaters which may be subject to as high leakage from the air side to the gas side as 15 per cent. This preheater may also be arranged with a horizontal axis where the layout makes this desirable.

The heating surface of the rotary heater consists of a number of mild steel sheets notched and undulated which fit into the sectors between the radial plates of the rotor. The first type of heating surface consisted of corrugated plates alternating with plain plates so that the gas passages consisted of small equilateral triangular passages, the sides of the triangles being about 8mm. This was improved later by giving the plain plates a slight undulation at right angles to these passages. The result was a turbulence in the gas and air flows which allowed the same heat recovery to be made with much less surface. This was further improved upon by the notched undulated elements which give a heat recovery per unit of surface more than double that of the original type. This means that the rotary heater now as compared with its predecessor 15 years ago is just about half the weight, and the bulk is very much less.

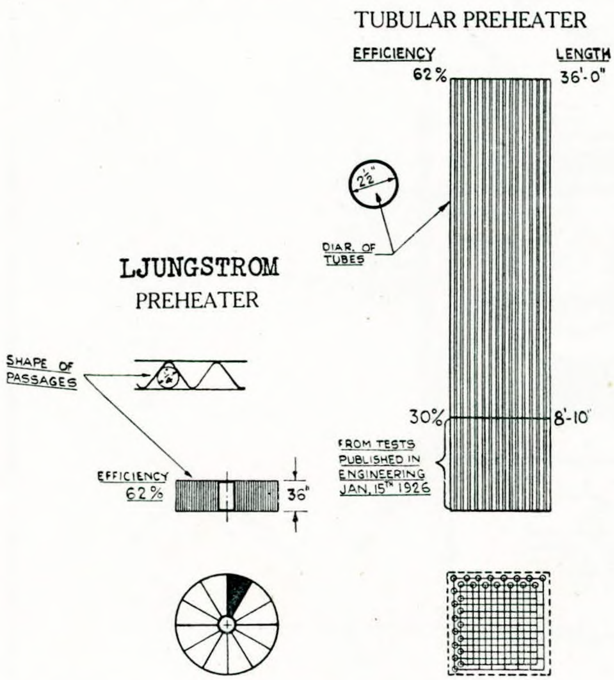


FIG. 2.—Comparison of space occupied by alternative types of air preheaters.

As compared with a tubular heater for the same performance the difference is amazing as Fig. 2 shows. Here are a rotary heater and a tubular heater of the same base area. The height of the heating elements is only 36in., while the height of the tubes in the tubular heater is 36ft. Actually of course the tubular heater would not be arranged in this way. The base would be increased in area and the tubes shortened. This, however, would mean a lower gas velocity through the tubes with a correspondingly lower heat transfer necessitating an increase in the tube surface which would result in still greater bulk.

Before leaving the subject of air heating the turbulent-flow air heater should be mentioned. This is a comparatively small air heater suitable for Scotch boilers. It occupies the space of the old 4ft. tubular heater, but the elements consist of corrugated steel plates so arranged as to provide horizontal passages for the air and tortuous passages for the gas. The turbulence set up in these gas passages increases the heat transfer so that this heater will give almost double the heat recovery of the tubular heater in the same space. This heater is extensively adopted in cases where a medium heat recovery from tank boilers is required.

The relative amounts of heating surface in the boiler, the economiser and the air heater can usually be fixed by the application of commonsense to the problem, taking into account (*a*) the working pressure, (*b*) the feed temperature entering the economiser which may be high due to bleeding the turbine, (*c*) the final funnel temperature and, (*d*) the degree of air heating permissible as well as the relative costs of the different kinds of heating surface involved in the combination.

A typical arrangement of a land boiler incorporating an economiser and an air heater is shown in Fig. 3.

On board ship the economiser is not at all a usual fitting owing to other means being available for feed heating, but the air heater is almost universally fitted.

Fig. 4 shows the arrangement of the rotary preheater on a ship with water-tube boilers.

By these means the funnel temperature may easily be reduced to about 200 °F. and the overall efficiency of the boiler plant increased correspondingly. This is perhaps about the limit to which the temperature may be reduced commercially.

So much for the recovery of heat. There still remains the question of removing the grit and rendering the gases innocuous. It is perhaps only within the last decade that this has been treated as a serious problem. It has been recognised as a problem for much longer than that, but so long as individual plants remained small it seemed to be considered too difficult to deal with. The tremendous increase in the size of industrial units and particularly power stations has had the effect of drawing public attention to the nuisance and the authorities have now taken steps to prevent the emission of grit. In plants near residential districts they are even going further than this and insisting that the sulphur must also be eliminated from the gases discharged into the atmosphere. The grit problem is one which can be fairly effectively dealt with by the use of centrifugal collectors of the cyclone or vortex types. It is probably not necessary to say very much about these as their construction is fairly well known. They consist generally of cylindrical chambers into which the gases are introduced in such a way as to set up a swirl. This swirl can be formed by a tangential inlet if the gases come from the side or fixed helical vanes if the gases enter from the end. The swirl or spiral vortex causes the particles of grit and solid matter to be thrown out by centrifugal force to the periphery of the cylindrical chamber and means are provided there either to let them fall to the bottom or be collected through holes in a suitably arranged hopper. The efficiency of this centrifugal apparatus depends on the tangential component of the gas velocity and the radius of the chamber, and varies as the resistance set up in the apparatus. On the manipulation of these factors depends the final design of this particular type of plant. This centrifugal apparatus proves very successful in removing the heavier grit and has been fitted in many industrial plants and also in power stations where the elimination of the coarser grit is all that is required.

It has also been used extensively where, in addition to the prevention of grit being discharged into the atmosphere, it is also desired to protect the induced draught fan impellers. The blades of the fan wheels suffer in two ways due to grit in the gases. In the first place if the blades are not self-cleaning, i.e., if the discharge angle is not radial, dust will accumulate on the blades and the fan will be thrown out of balance and, secondly, erosion of

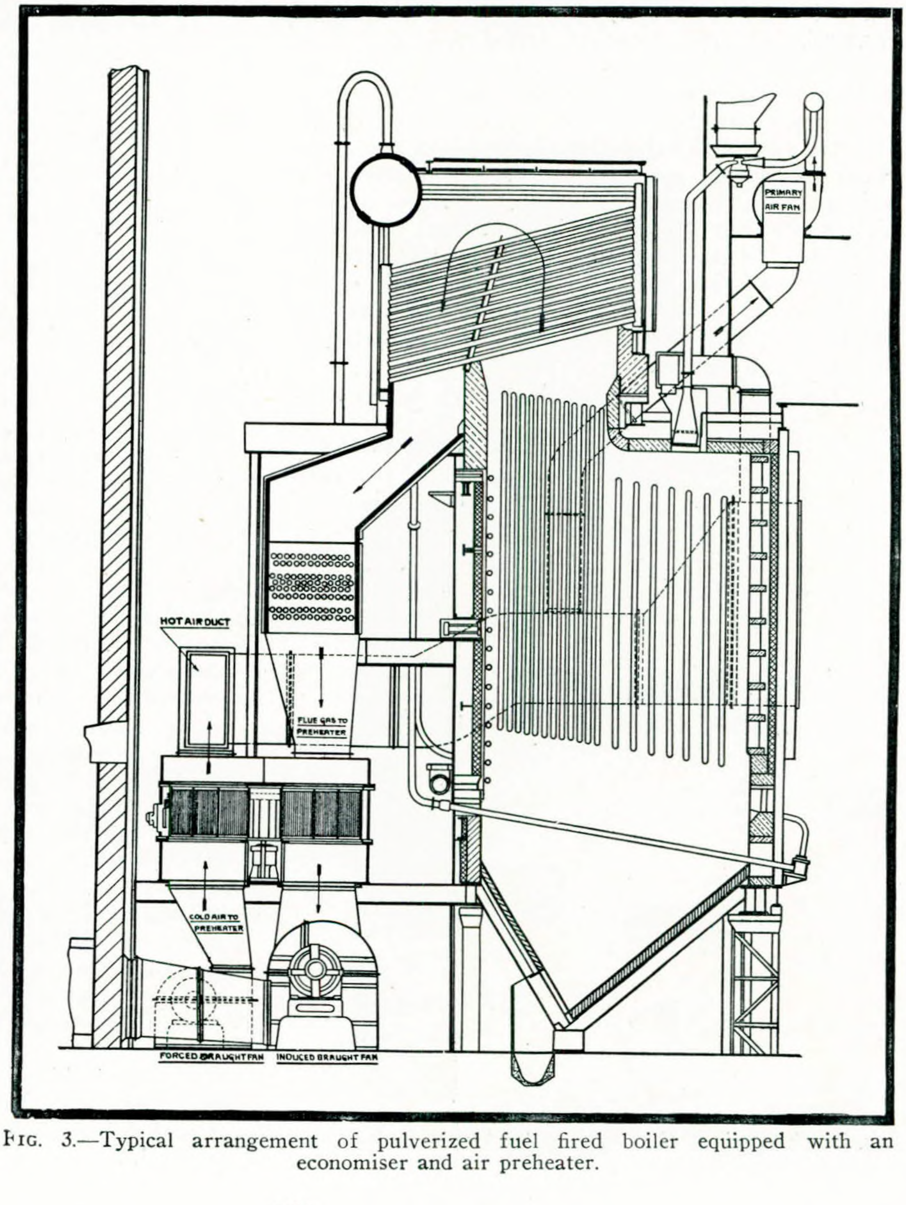


FIG. 3.—Typical arrangement of pulverized fuel fired boiler equipped with an economiser and air preheater.

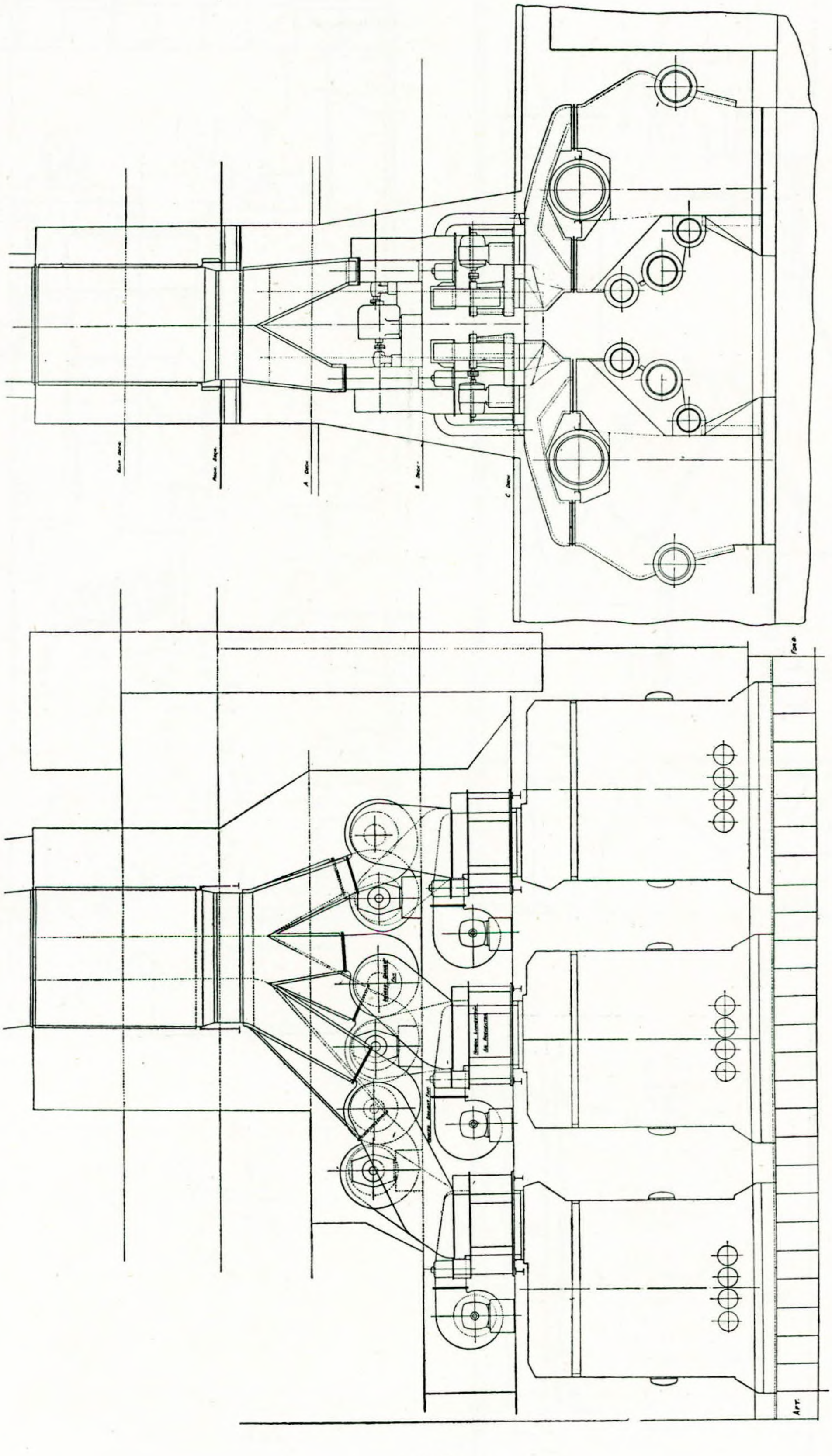


Fig. 4.—Arrangement of water-tube boilers with rotary air preheaters and forced and induced draught fans on the s.s. "Awatea".

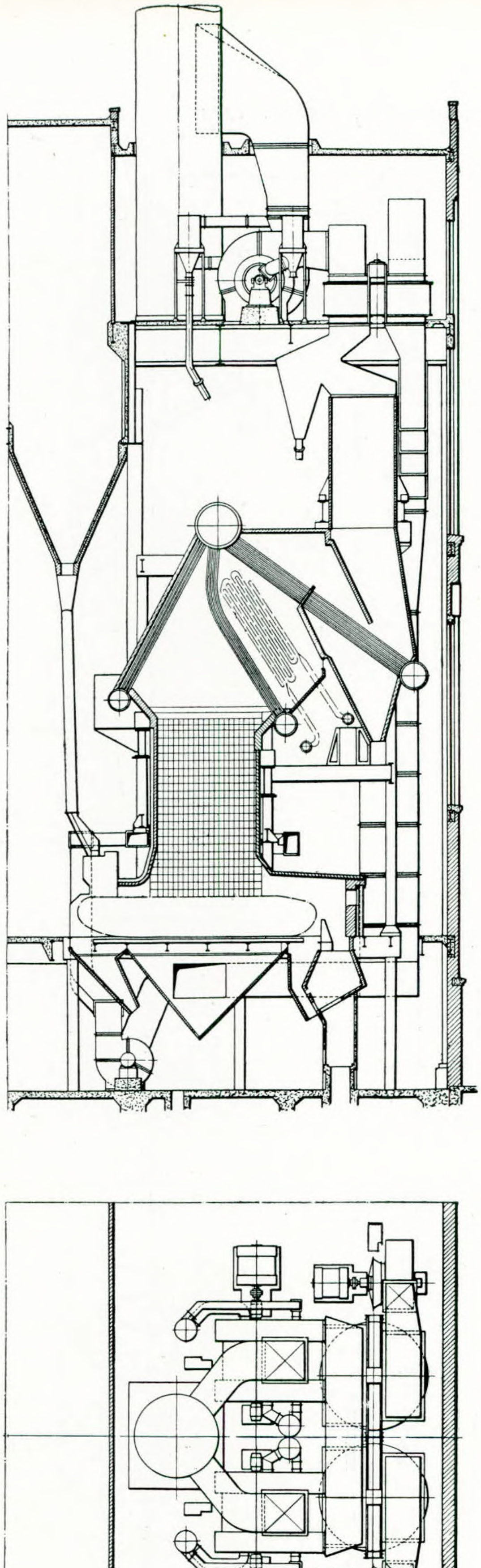


Fig. 5.—Sectional elevation of boilerhouse at Dalmarnock Power Station (Glasgow Corporation) showing air preheaters and dust-collecting induced-draught fans.

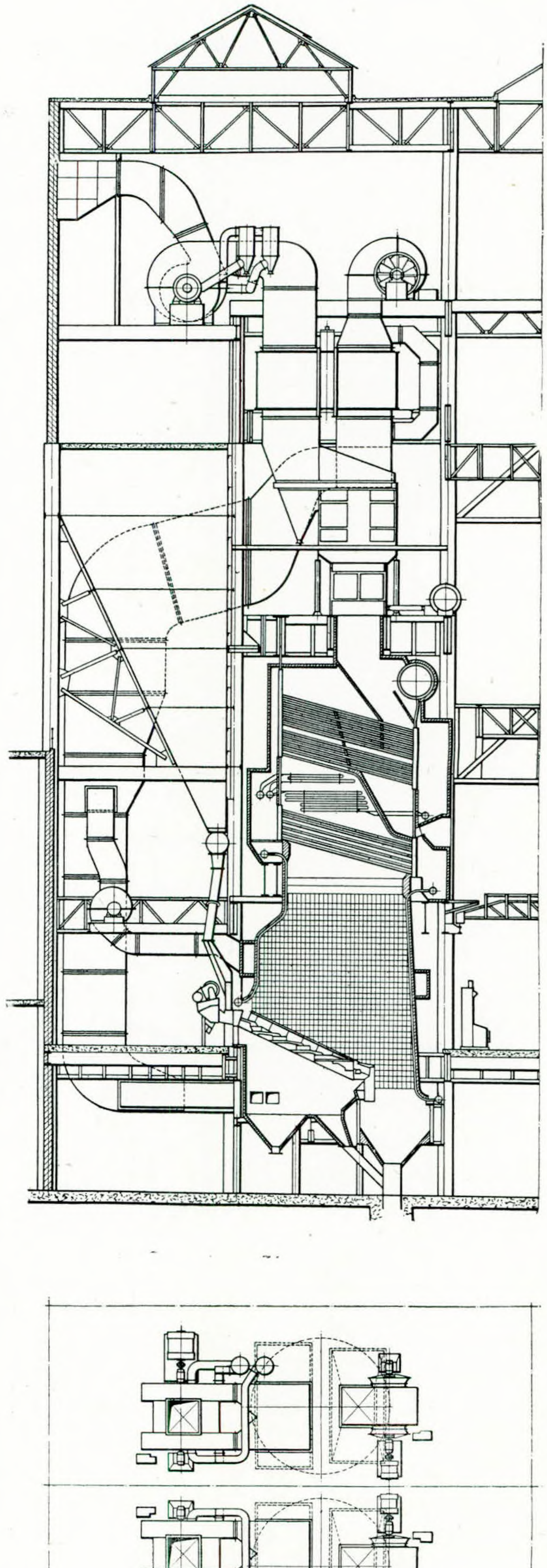


Fig. 6.—Sectional elevation of boilerhouse at Battersea Power Station (London Power Co.) showing air preheaters and dust-collecting induced-draught fans.

the blades themselves will take place. The first of these troubles is easily cured by proper design of the wheel, but the only way to cure the second completely is to remove the grit before it reaches the wheel.

In modern induced-draught fans for heavy duty it is usual to fit scroll inlets. This scroll distributes the gases evenly into the impeller and reduces inlet losses to a minimum. A slight modification to this type of inlet results in a highly efficient scroll collector which is an integral part of the fan. Part of the periphery of this inlet scroll is provided with a stepped inner skin forming slots across the width of the scroll. These communicate with a pick-up pocket situated near the end of the scroll. This pocket is connected by a small duct to a vortex collector. The outlet of this vortex collector is connected to the fan inlet inside the fixed or movable vanes in the scroll. A small portion of the gases is thus caused to flow through the shunt circuit by the difference in pressure between the periphery and centre of the scroll. The dust is thrown by centrifugal force to the periphery of the scroll where it passes through the slots and is carried by the shunted gases to the vortex cell where the dust is finally separated and the cleaned gases are returned to the eye of the fan. The increase in power consumption as a result of fitting the dust collectors with the scroll inlet is that due to the losses incurred in passing the gases through the shunt circuit and as the shunted gas volume is only about 10 per cent. of the total this increase is very small.

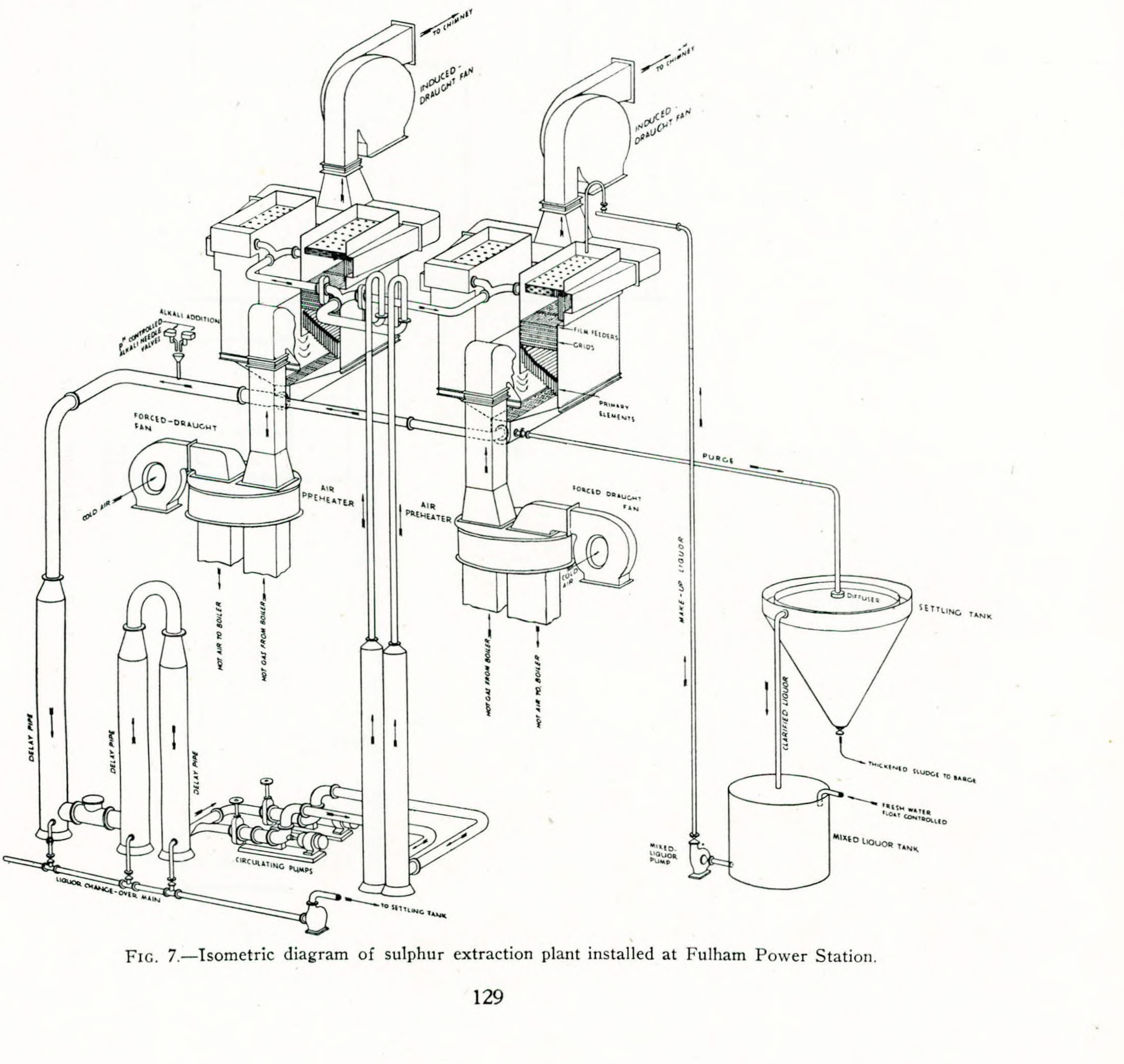


FIG. 7.—Isometric diagram of sulphur extraction plant installed at Fulham Power Station.

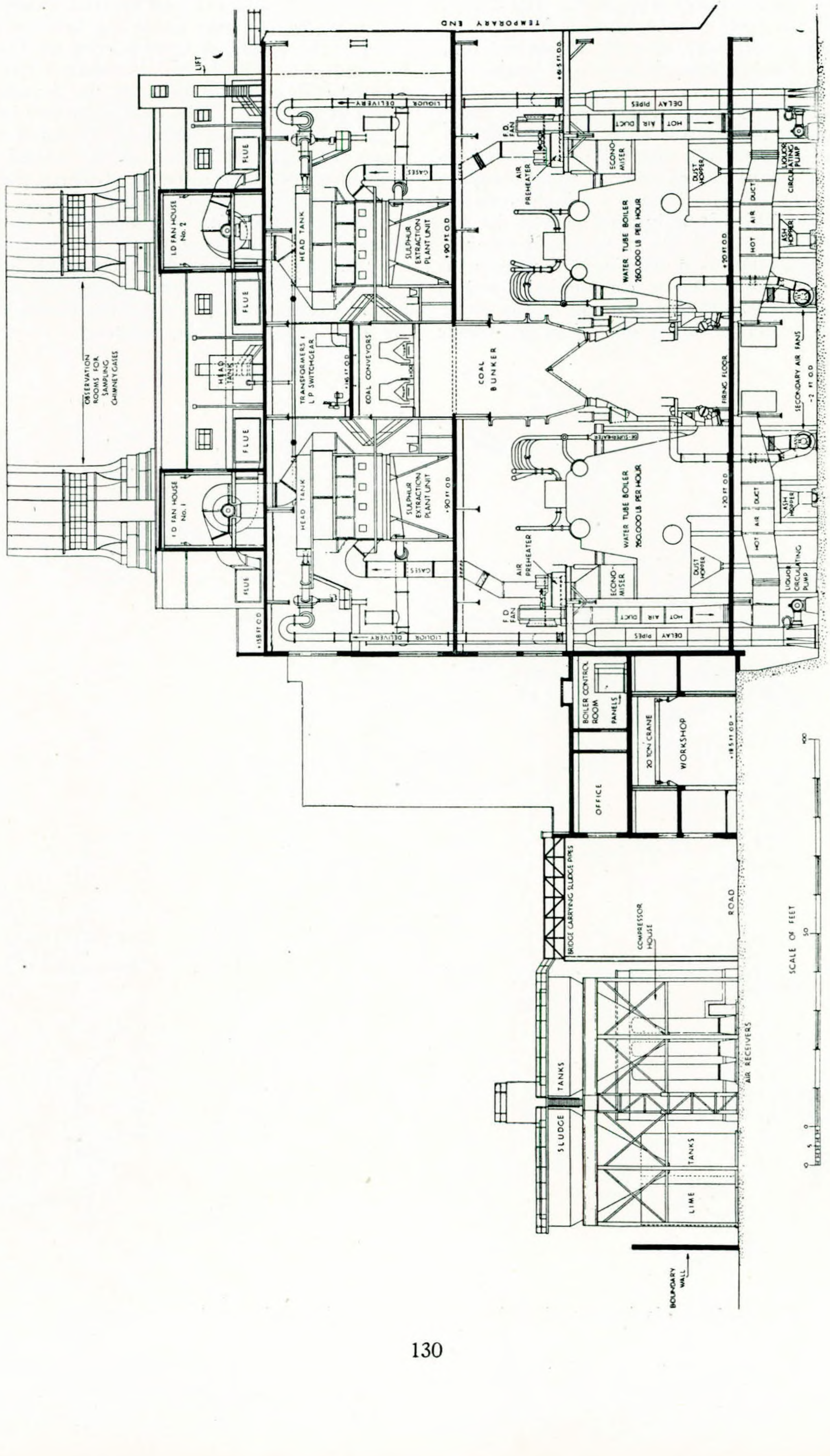


FIG. 8.—Cross-section of boilerhouse at Fulham Power Station, showing the arrangement of the flue-gas washing plant.

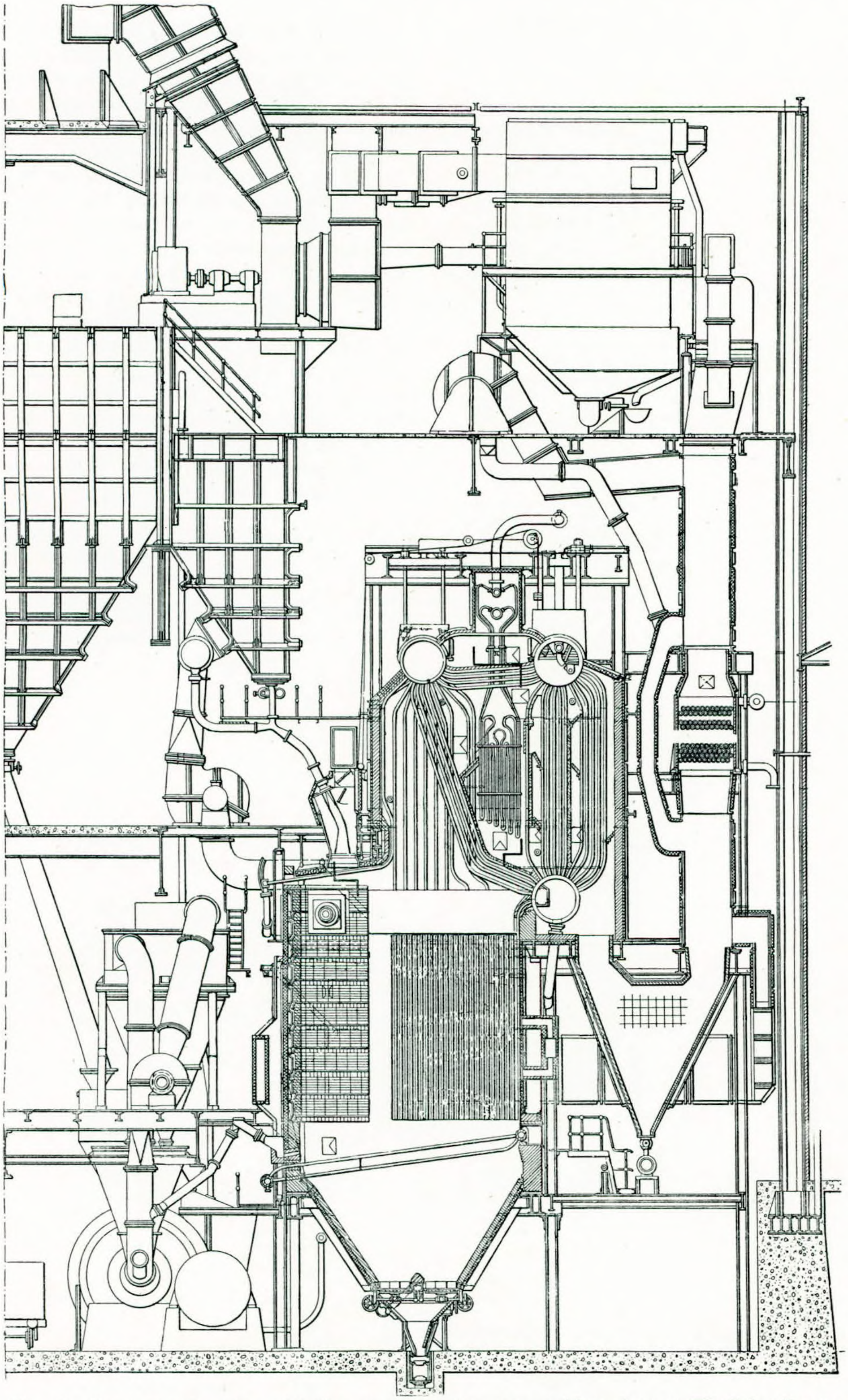


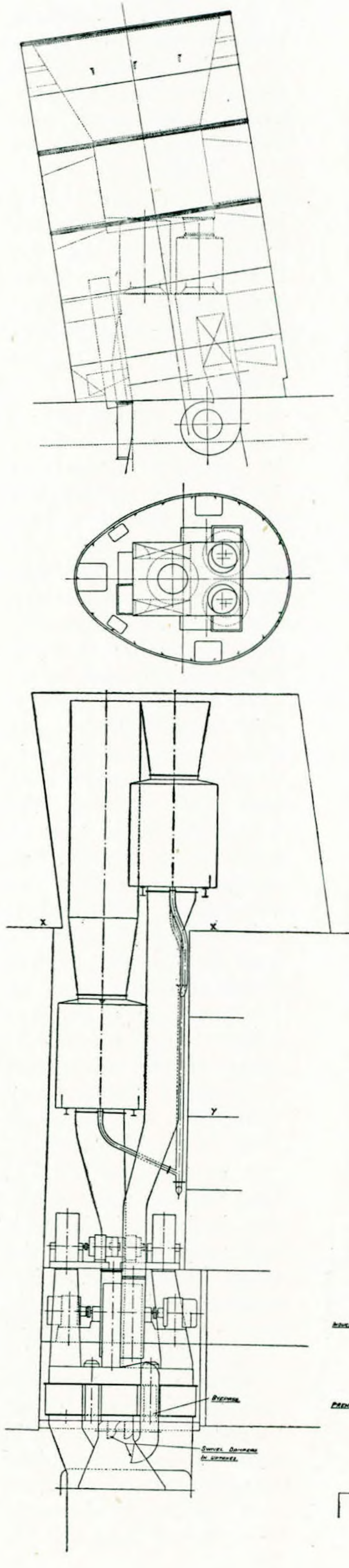
FIG. 9.—Sectional elevation of boiler plant and flue gas washing plant at Tir John Power Station, Swansea. (Four tri-drum type boilers; steam pressure 625lb. per sq. in.; steam temperature 850° F.; feed temperature 350° F.; normal evaporation 200,000lb. per hour; maximum evaporation 240,000lb. per hour; peak evaporation 280,000lb. per hour; type of firing—pulverised fuel; type of fuel—anthracite duff; c.v., 12,500 B.Th.U.'s per lb.).

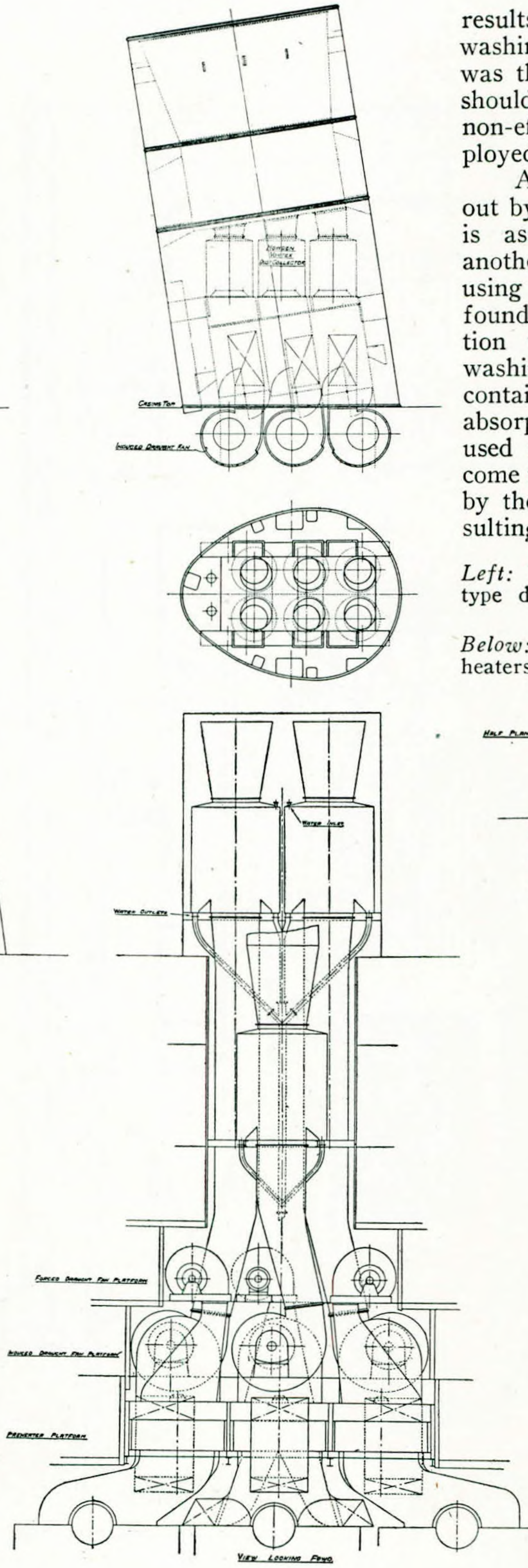
Fig. 5 is a section through the boilerhouse at Dalmarnock Power Station showing the preheater and scroll collector induced-draught fans, while Fig. 6 is a section of the boiler house at Battersea Power Station of the London Power Company with scroll collector induced-draught fans discharging to the gas washer.

That brings us to the washing of the gases. In densely populated districts the authorities now take the view that in addition to the elimination of the grit nuisance it is necessary also to prevent the discharge of sulphuric acid. From the combustion of 1,000 tons of average coal containing 1·5 per cent. of sulphur there is in addition to grit, dust and tarry matter, the formation of 45 tons of sulphuric acid as well as smaller quantities of nitric acid and hydrochloric acid. It is therefore obvious that before power stations such as Battersea and Fulham could be sanctioned means should be adopted to prevent these huge quantities of corrosive acids being liberated.

In the case of Fulham where such a quantity is burned daily, it was specified that the gases leaving the chimneys should not contain more than 50 parts of SO_2 per million by volume with coal containing 1·7 per cent. sulphur. This meant in addition to the required elimination of 96 per cent. of the solid matter also 96 per cent. of the SO_2.

To achieve these



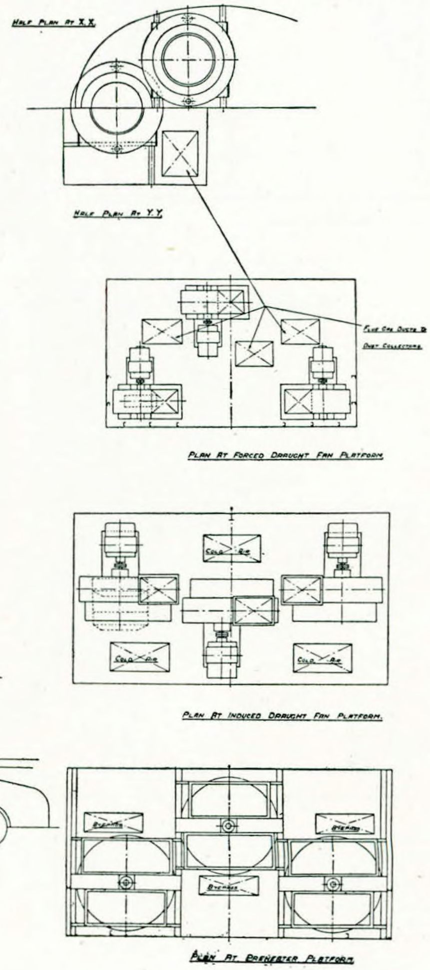


results it was necessary to resort to washing, and as another requirement was that no water from the washers should be discharged into the river a non-effluent system had to be employed.

As a result of experiments carried out by the firm with which the author is associated in co-operation with another company, a plant was evolved using a form of scrubber which was found to be really efficient in conjunction with the recirculating of the washing liquor. This liquor had to contain an alkali to obtain complete absorption of the SO_2. Lime was used for this, and in order to overcome the difficulties which would arise by the precipitation of the solids resulting from the chemical actions tak-

Left: FIG. 10.—Arrangement of vortex dry type dust collectors in s.s. "Empress of Britain".

Below: FIG. 11.—Arrangement of air preheaters, fans and wet-spray vortex dust collectors in s.s. "Asturias".



ing place in the scrubber it was necessary to employ a delay tank in the circulating system where these solids could be precipitated rather than on the elements of the scrubber and in the pipes. A diagrammatic view of an installation of this type of gas washer representing the unit for one boiler is shown in Fig. 7.

Fig. 8 is a section of Fulham Power Station showing the boilers, preheaters, gas washers, fans, and sludge tanks, while Fig. 9 shows a similar section of the Tir John Power Station, Swansea. In this the boilers and economisers, air heaters and gas washers are clearly seen.

The elimination of grit and soot on board ship is a comparatively recent development. It has no doubt been stimulated by the cult of the sun and the popularity of cruising. The sun deck is now one of the most popular parts of a ship and to have it spoiled by the continual deposit of soot is a decided nuisance and means heavy expenditure for cleaning and painting.

Soot falling on this deck also finds its way into the ventilating system and is distributed all through the public rooms and cabins necessitating costly renewals below.

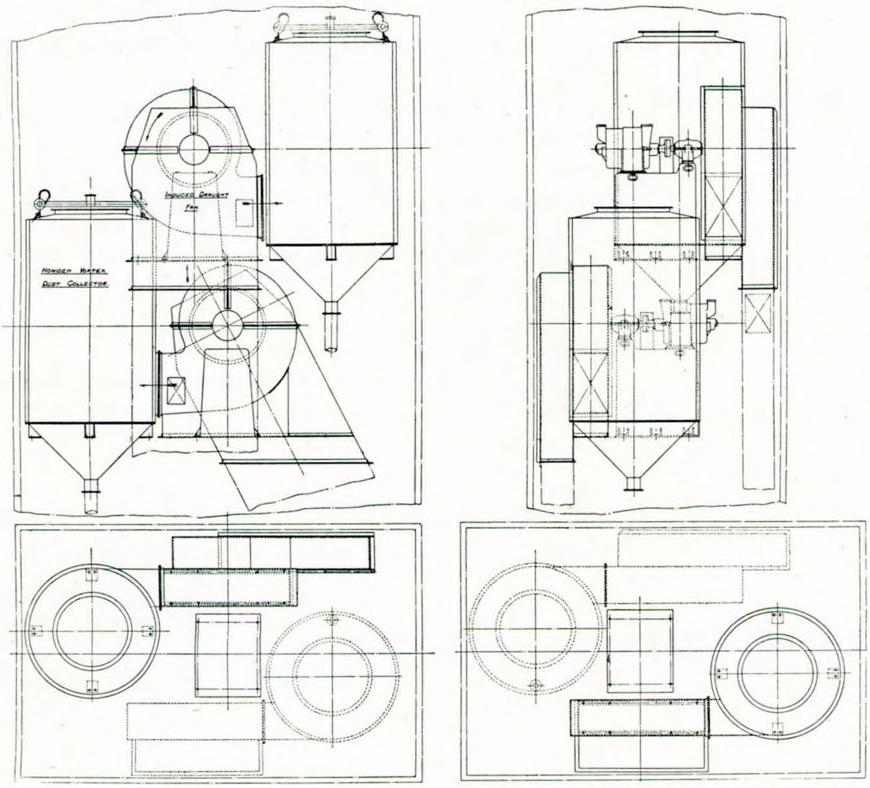


FIG. 12.—Arrangement of wet-spray vortex dust collectors and induced-draught fans.

In very small ships quite a large proportion of the soot may be suspended for a sufficient time to allow the ship to get clear before the soot falls to the level of the deck, but on larger ships the distance from the funnel to the stern is too great for this and the after ends of the decks become smothered in soot unless means are taken to prevent the soot being discharged from the funnels.

The first marine installations of soot collectors consisted of dry vortex collectors and were made on small cross-Channel steamers burning coal. These collectors were fitted in the uptake and consisted of cylindrical chambers such as have been described, but owing to the arrangement on board ship the gases must enter at the bottom and the vortex is formed by guide vanes or a tangential inlet.

In the smaller installations the grit and soot collected are kept in a hopper until a suitable opportunity occurs for its discharge, or it may fall down from the hopper through a pipe to the stokehold floor where it can be put into the ash ejector and discharged overboard.

On the larger ships, such as the "Queen Mary" and the "Empress of Britain", the dry vortex collectors normally discharge the soot from the dry hopper fitted on the side of the collector to a flushing hopper where water is introduced to carry the soot and grit continuously through pipes overboard. Fig. 10 illustrates the arrangement of these dry vortex collectors on the "Empress of Britain". The arrangement on the "Queen Mary" is very similar, but she has a total of 12 collectors.

These dry collectors are capable of collecting about 65 per cent. of all the solids in the gases from oil-fired boilers, and about 90 per cent. from coal-fired boilers. For efficiencies higher than these, however, the wet system has to be employed.

On board ship space does not permit of such an elaborate gas washing system as that described for Fulham Power Station. In any case this is unnecessary because the discharge of sulphuric acid does not matter at sea.

As far as soot and grit are concerned highly satisfactory results can be obtained with a modification of the vortex system.

Fig. 11 shows the arrangement on the "Asturias" and "Alcantara". Here are three vortex chambers in the uptakes—one from each boiler. In principle these vortex chambers are the same as the dry type, but round the periphery of the chamber there is a descending water film which traps the soot and grit thrown outwards by centrifugal force. This soot and grit is carried down inside the chamber and carried away through the discharge pipes. Under oil-fired conditions this apparatus will remove about 95 to 97 per cent. of all the solids so that the ship is kept perfectly clean under all conditions of the weather. This illustration, incidentally, also shows the three preheaters and the three forced-draught and three induced-draught fans.

Fig. 12 shows a similar arrangement on the "Arundel Castle" and the "Windsor Castle". In this case, however, the gas inlet to the collectors is tangential.

As stated at the beginning, it has not been possible to treat this wide subject in great detail, but the author hopes that his remarks have been of some interest.

INSTITUTE NOTES.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Monday, 13th June, 1938.

Members.

John Charles Baker, c/o Shanghai Power Co., 181, Nanking Road, Shanghai.
Leofric Henry Benson, 81, Bede Street, Roker, Sunderland.
Robert Birnie, Skaw Road, Workington.
James Flynn, 45, Sandycoombe Road, Twickenham.
Harold Major, 185, Abbey Road, Barrow-in-Furness.
William Brandon Morritt, 2, Western Beach, Gibraltar.
Harold Orchard, 135, Hillmorton Road, Rugby.
James Edward Pratt, Naldera, 124, Cannock Road, Stafford.
Frederick George Reason, 12, Marine Terrace, New Brighton, Wallasey, Cheshire.
Charles William Lawrence Slater, Eng. Com'r., R.D., R.N.R.(ret.), 203, Malden Way, New Malden, Surrey.
John William Taylor, 4, Aldborough Grove, Hull.

Associates.

Bernard Acworth, Capt., D.S.O., R.N., 40, Bedford Street, W.C.2.
John David Clarke, 209, Staines Road, Sunbury-on-Thames.
Sidney James Fish, 50, Plymouth Road, Penarth, S. Wales.
Edward Charles Flood, 101, The Crescent, Eastleigh, Hants.
Robert Newall, 156, Hill Street, Garnethill, Glasgow.
Harold John Doel, Wyndsbere, 109, Weelsby Road, Grimsby, Lincs.

Transfer from Associate to Member.

Harold Mackegg, 15, Repton Road, Orpington.
Bryan James Piner, Eng. Lieut., R.I.N., c/o Lloyd's Bank, Ltd., The Broadway, Muswell Hill, N.10.

Transfer from Student to Associate.

Lionel James Humphrys, 114, Springbank Road, Hither Green, S.E.13.
Ralph Davison Potts, 34, Glenhouse Road, Eltham, S.E.9.
Albert Benjamin Richard Sexstone, 45, Hazelbank Road, Catford, S.E.6.
Braham Swarup Sood, s.s. "Varsova", Mackinnon Mackenzie & Co., Bombay.

ADDITIONS TO THE LIBRARY.

Purchased.

The Directory of Directors, 1938. Thomas Skinner & Co., 25s. net.

Pitman's Handbook of Commercial and Technical Education. Edited by Harold Downs and containing sections on organization, administration, examinations syllabuses, qualifications and careers. Sir Isaac Pitman & Sons, Ltd., 586 pp., 15s. net.

Presented by the Publishers.

Copper Pipe-Line Service in Building. Copper Development Association.

Shipbuilding Practice Abroad. Paper read by Dr. J. Montgomerie before the North East Coast Institution of Engineers and Shipbuilders.

A General Review of the Development of the Diesel Engine during 1937. Diesel Engine Users Association.

Practical Mathematics for Marine Engineers, Second Class. By P. Youngson, B.Sc. and T. A. Bennett, B.Sc. James Munro & Co., Ltd., 13th edn., 553 pp., illus., 12s. 6d. net.

The publishers state that a book which has reached thirteen editions needs no preface, and for similar reasons one feels that it hardly requires to be reviewed. While, however, this book must be widely known amongst marine engineers, it must be remembered that each year there is an influx of junior engineers to the Merchant Navy to whom it may not be familiar. A useful purpose may therefore be served in summarizing the contents, which comprise arithmetic, mensuration, mechanics, heat and practical engineering problems. The five chapters on mathematics cover elementary algebra; simple equations, quadratic equations, variation; logarithms and trigonometry; mensuration of areas; and mensuration of solids. There are eight chapters on mechanics, materials and hydrostatics; these deal with graphic statics, the laws of motion, the simple machines, strength of materials, bending, torsion, boiler formulæ and hydrostatics. The third section of the book deals with heat and heat engines, the six chapters of which it is formed dealing respectively with heat and steam, expansion of steam, power and consumption, ship propulsion, mechanism and electricity. Examples with answers are appended to each chapter.

Maintenance of High Speed Diesel Engines. By A. W. Judge, A.R.C.Sc., D.I.C., Wh.Sc. Chapman & Hall, Ltd., 2nd edn., 254 pp., 211 illus., 13s. 6d. net.

The favourable reception accorded to the first edition of this book, which was published less than two years ago, has necessitated not only a subsequent reprinting of the first edition, but also the present new edition which brings the book up to date. A number of new features and illustrations have been included, together with appendices dealing with the maintenance of typical high-speed oil engines. The new matter relates to more recent servicing methods and equipment; the lubrication system, care and maintenance of the cooling system, new patterns of fuel feed and injection pumps and nozzles; the pneumatic type of fuel pump governor; reconditioning of worn parts by the nickel and chromium electrodeposition method; valve insert methods and tools; timing chain maintenance; fuel filters and air cleaners. In addition, a number of practical hints on the tuning, speed regulation, starting and stopping of oil engines and their fuel injection equipment are given.

The additional information and new illustrations should extend the field of usefulness of this valuable work.

The Welding Engineer's Pocket Book. Edited by J. V. Brittain. George Newnes, Ltd., 208 pp., illus., 3s. 6d. net.

This pocket book certainly fulfils the intention of the editor expressed in the foreword, namely, to include as much information as possible on various phases of welding. In fact it covers in a general way all the more usual types of electric and gas welding. The information has been carefully and accurately collected and debatable points presented in an impartial manner, and there is little to object to in the conclusions where expressed. The editor asks that any errors be pointed out. In the illustration on page 20 the single vee and U butt welds are shown without a sealing run on the reverse side. This is no doubt accidental, but it is of considerable importance.

The Way of Ships. By Edmund Vale. Country Life, Ltd., 129 pp., illus., 5s. net.

There are books innumerable about the sea and ships—some good, some bad, some indifferent. One half of this book is good, the other half indifferent. It is well printed, well illustrated, and written by one who loves the sea and ships and enjoys writing about them. This is seen unmistakably in the first twenty pages devoted to waves, tides and weather. This part is a fascinating little study. The second section of thirty pages devoted to sail is also good and the author is thoroughly at home when describing the evolution of hulls and rigging. This part might be described as a concise guide to rigging.

So far so good, but when we come to the sixty pages comprising the third section headed "Power", one feels the author is out of his depth. Is there any reason why a writer on ships should be less accurate when dealing with engineers and engineering than when treating of seamen and sails? In the first six pages of this section Thomas Savery is referred to as Martin Thomas Savery, Robert Fulton as Henry Fulton and Henry Bell as William Bell. Contrary to what the author says, it may be remarked that the boats of Rumsey and Fitch did *not* sail on the Hudson, Symington did *not* die nine years after the "Comet" was built, Dr. Lardner (rest his soul!) was *not* asked for his expert advice on transatlantic steamships, the "Great Eastern" was *not* laid down in 1858, and Dr. Kirk did *not* invent the triple-expansion engine. A water-tube boiler is *not* a principle, and engineers do not speak of the internal combustion Diesel engine. It may amuse marine engineers perhaps to learn of the thrust block that "its function when the ship is going ahead is to keep the propeller shaft from knocking the engines bodily into the forehold, and when she is going astern to keep the same shaft from leaving the ship and cutting a dash into the sea". The author does not write about sailing ships in this way; why then write nonsense about machinery?

Combustion, Flames and Explosions of Gases. By B. Lewis, Ph.D., and G. von Elbe, Ph.D. Cambridge University Press, 415 pp., 79 illus., 21s. net.

The authors of this book are well known for their work on combustion, and more particularly for their application of physical-chemical methods to the problem. It is only natural therefore that three-quarters of their book should deal with the subject from the standpoint of physical chemistry, and, as such, should be of minor interest to the engineer. Moreover, physical chemical theory is for the most part only an attempt to provide a speculative explanation for facts which have been discovered by experiment.

In the present volume the presentation of these facts is poor; many important experimental results appear only as half a sentence and a reference to the literature. On the other hand, the explanations provided by the authors are the main theme of the book, and they are based very largely on the conception of the mechanism of combustion with which the authors' work has been chiefly associated, namely, the chain reaction theory. There is much evidence in favour of this theory: there is also a striking amount of loose thinking and unproven hypothesis associated with its application to particular cases. It is certain that engineers will find that a knowledge of the physical chemistry of combustion will be a necessity in the future, and it is well therefore that anyone going to this book with the object of acquiring such knowledge should realize beforehand that he will find in it more theory than fact; theory with which not all experts on the subject will agree.

The first three parts of the book deal with the chemistry of combustion; the propagation of flames, including flame photography and flame speeds and detonation; and the state of the burnt gas, dealing largely with dissociation, and temperature and radiation of the burnt gas.

The fourth section, consisting of two chapters only, is entitled "Problems in Technical Combustion Processes". The first chapter entitled "Industrial Heating" consists of two pages which are in fact nothing more than an apology for not dealing with the subject. The final chapter is on internal combustion engines, and in twenty-five pages deals with the thermodynamics of combustion in the Otto and Diesel cycle, the combustion processes in these two engines, and fuel ratings. This chapter is indeed nothing more than a rapid glance at the literature of the subject.

There are in addition three useful appendices giving thermodynamical data, limits of inflammability, and flame temperatures for combustible gases.

The Efficient Boiler House. By J. J. Simmons. The Technical Press Ltd., 2nd edn., 135 pp., 15 illus., 3s. 6d. net.

The author of this "practical manual for the guidance of boiler-house operators" is evidently an experienced practical engineer who is eager to assist others by recording his achievements in promoting efficiency in boiler-house operation. He believes wholeheartedly in his cause and earnestly puts his case for careful and continuous supervision, urging the regular use of appropriate instruments for checking coal and water consumption, temperature and composition of flue gases and steam produced. A number of hints are given on the maintenance of boilers, brickwork, furnaces and auxiliaries and some space is devoted to a discussion of the benefits to be derived from the use of treated feed water, economisers and superheated steam.

Possibly because of the variety of subjects with which the author has tried to deal within the covers of a small book, the result is disappointing: one finds that apart from a passing reference to the susceptibility of wet-bottom multitubular boilers to furnace crown collapse, only Babcock & Wilcox chain-grate boilers are mentioned; similarly only Green's medium pressure economiser is described, whilst no mention is made of air heaters, induced- and forced-draught fans, steam jets, soot blowers, closed feed systems, steam accumulators, boiler lagging, mountings, or heat exchangers for blow-down recovery or waste-heat boilers, all of which are either sources of economy or waste.

Coal is the only fuel mentioned and although two chapters are devoted to combustion and coal analysis, it is remarkable that the only guidance offered as to the choice of this fuel is that one should avoid coal having an excess of 35 per cent. volatile matter. Surely a book on boiler-house efficiency should give at least one typical proximate analysis and make some reference to the economic aspect of ash contents and fusibility. Referring to the chapter on combustion, the matter on pages 15 to 22 appears to have been extracted in detail from A. D. Pratt's "Principles of Combustion in the Steam Boiler Furnace", although the customary acknowledgment is not published.

A number of the author's statements make curious reading; for example, on the subject of air leakage through defective brickwork (page 8) he suggests that the condition of the brickwork between the boiler shell and the surrounding bricks can be ascertained by "placing the hand upon it when it can be found out whether too much heat is being wasted by radiation"; again, on page 11, on the forcing of boilers, he states that "it is justifiable to force boilers over a short peak if it saves placing another boiler in service, but the amount of overload to be taken should be governed by the quantity of feed water available (in this connection, an economiser helps as it is full of water)".

Fully to justify its title the book needs considerable extension. Suggested means of improving efficiency should be illustrated by figured examples of proved results and space now given to quoting at length from manufacturers' instruction sheets would be more usefully employed in dealing with shell boilers, hand firing, mechanical stokers and liquid fuels, whilst the correction of several errors in punctuation and English would improve the book.

A.B.C. of Marine Diesels. By Victor W. Pagé. The Penton Publishing Co., 194 pp., 71 illus., 8s. 6d. net.

This interesting little book deals principally with the elementary principles of the small Diesel or compression-ignition engine as applied to small vessels, lorries and passenger vehicles. It is somewhat misleading in that the title mentions marine Diesels only.

To those familiar with the ordinary petrol engine and having only a perfunctory knowledge of the modern oil engine, it explains very lucidly the essential differences in the two types of internal-combustion engine.

The remarks on page 15 about the hot bulb or surface ignition engines are hardly correct so far as marine propulsion is concerned; there are many British and Continental engines of this type which have been in service from 10 to 15 years, giving reliable and economical results and at varying speeds of revolution. Although this type has now been practically superseded the statements on page 15 are a little misleading. On page 22 it is mentioned that "the connecting rods are pulled up and down". In a four-cycle single-acting engine this is incorrect; they are obviously pushed down by the piston and up by the crank. Rather too much space in the earlier chapters is devoted to emphasising the elementary principle of the petrol engine, sometimes a repetition of previous remarks. Chapter III is a very good exposition of the problems which face designers of a high-speed oil engine and discusses clearly the difficulties encountered of combustion and ignition lag. Practical and explanatory information on fuel nozzles of nearly all modern types used in small engines is given in detail in Chapter V. Page 51 gives a very lucid explanation of the fundamental fuel difficulties to be overcome in a high-speed Diesel engine as compared with the orthodox slow running type. On page 130 where viscosities and gravity of fuel and lubricating oil are given in Saybolt and Beaumé scales, it would be advantageous in addition to give these in ordinary Redwood No. 1 and specific gravity which is more usual in British countries. On page 139 it is recommended to change lubricating oil in the sump every 50 hours. This would not always be practicable and would depend on the amount in circulation. In a fishing vessel which may be away for 120/130 hours, the engines running continuously, some relation should be given as to quantity of oil in circulation. On page 151 there is a timely warning about running engines for a few minutes to warm through after starting from cold (especially in frosty weather) before putting on full load. Many troubles and undue cylinder liner wear are due to this cause, frequently engendered by engine salesmen stressing the can-at-once-take-full-load-from-cold slogan.

This is a book which can be profitably read by engineers having auxiliary Diesel engines of the high-speed type under their charge.

The Works Engineer. By W. R. J. Griffiths and W. O. Skeat, B.Sc. Sir Isaac Pitman & Sons, Ltd., 351pp., 202 illus., 21s. net.

In the preface to an engineering textbook published a few years ago, there appeared the following sentence: "What I have written, I know to be true, and I have tried to be so definite and clear that there is no ambiguity anywhere". Such a slogan must have guided the authors in their authorship of this remarkable book for rarely can there have been written such a vast amount of information within the limits of a moderately-sized textbook all without the slightest ambiguity and all so obviously proved by the authors' experience. The book is divided into twelve chapters covering—office organisation and routine; steam; water, gas, compressed air and vacuum; electrical equipment; millwrights, pattern makers and joiners' work; fans; safety; fire brigades and fire equipment; heating; buildings; miscellaneous and timber damage due to dry rot and insect attack. These chapters are again divided under sub-headings, each of which introduces a wealth of information augmented as necessary by formulæ, tables and illustrations. Space will not permit of a detailed description of the various chapters, but as an illustration of the ground covered, the sub-headings of those on fans and factory buildings are quoted: fans and their application; air; relative humidity; velocity and volume; water gauges; Pitot tubes; fans (types and characteristics); fan laws; anemometers; propeller fans; air ducts and trunking; ventilation systems; dust exhaust systems; mechanical draught and grit arresting: boiler draught; cyclones; bag filters; factory buildings; single-storey construction; foundations; roofing; glazing; opening lights; down pipes; gutters; floors; lavatories; multi-storey construction; steel frame; reinforced concrete; floor construction; combined single- and multi-storey type; light wells; services, etc.; battery rooms; overcrowding of workshops, painting.

Written for a special group of engineers who must not only be also well versed in the arts of physicists and chemists and the crafts of plumbers, painters, carpenters, electricians and bricklayers, but in some way acquire a knowledge of office routine and fire-brigade management, it is inevitable that some subjects appear to need extending, but as the authors remark "any one chapter would form a book in itself" and the reader who seeks further information on a particular subject will find the excellent bibliography of great assistance.

The authors have earned the congratulations of all works engineers for this most attractive and informative book and it should easily prove to be a "best seller" among technical books for engineers.

ABSTRACTS OF THE TECHNICAL PRESS.

Method of Estimating Weights of Machinery Installations.

When preparing a proposed arrangement of machinery for a vessel, one of the principal problems is that of estimating the weight of the proposed installation. It is considered necessary to determine the weight of each separate section of the installation in detail. The author has therefore divided the total weight into nine different sections, *i.e.* (1) main turbines, (2) boilers, (3) auxiliary machinery (each machine separate) including heating and cooling apparatus, (4) machines for service purposes, (5) piping arrangement, (6) propellers, (7) shafting, (8) thrust blocks, and (9) water and oil. In all, 36 curves of weights are given for the following items of the installation: geared turbines, with condensers, gearing, mountings and insulation; boilers (oil-fired water-tube of the triangular type), without water; tubular air heaters (thickness of tubes 2mm.); piping arrangement; turbo-ventilating fans; turbo-feed pumps; turbo-circulating pumps; turbo-condenser pumps; circulating condenser pumps; turbo-centrifugal oil pumps; geared turbine oil pumps; turbo-oil-fuel pumps; turbo-fire pumps; centrifugal service pumps; direct-acting pumps; water ejectors; double-acting steam air ejectors; heating apparatus; condensers; electric motors (direct and three-phase current); petrol motors; steam reciprocating auxiliary engines; helical transmission gearing with cast metal casing; turbo-dynamos; Diesel dynamos; propellers; propeller shafting (solid and hollow); Michell thrust blocks. The weights of the boilers and heating apparatus are given on the basis of heating surface and the various machinery items in relation to power or output. The weight of water in boilers, hot wells, condensers, and circulating water and lubricating oil are given in accordance with heating surface and horse-power; spare parts, platforms, ladders and seatings are in percentages of the total weight.—*"Soudostroienie", No. 12, 1937.*

Review of Shipbuilding and Engineering Progress in the U.S.S.R., 1917/37.

The progress achieved in shipbuilding and engineering in the U.S.S.R. during the past twenty years is described in a series of articles in No. 11, 1937, issue of the journal "Soudostroienie". The first article deals principally with various types of vessels built at shipyards on the river Volga for river and canal service, and includes cargo vessels and tankers for trading in the Caspian Sea; illustrations are given of the different types. Detailed particulars and a description of a large icebreaker are contained in another article; this icebreaker has been built for working in the Arctic Ocean and her dimensions are 106·6m. × 28·1m. × 12·61m. with a draught of 9·15m. and a displacement of 11,000 tons; the propelling machinery consists of three triple-expansion engines with a total i.h.p. of 10,000 at 125 r.p.m., supplied with steam from nine boilers of the Scotch type with a total heating surface of 2,250 sq. m. and 15·5 atm. pressure. The third article deals with theoretical and experimental work in laboratories and experimental tanks of the U.S.S.R. in connection with the resistance and speed of vessels. The general progress made in marine turbine construction is described in a further article and special attention is drawn to the increase of circumferential speed of rotors and the great improvement made in the material used for the blades; a comparison is made of the various elements of turbines built in 1916 and 1936. Next a short history is given of the advancement made in the construction of cylindrical and water-tube marine boilers and recommendations for their future development, such as the adoption of water-tube boilers in place of those of the Scotch type, modernizing existing water-tube boiler installations by fitting supplementary water screens with natural and forced circulation, and the de-aeration of the feed water. The progress made in electric welding in ship construction from 1926 to 1937 is then described and several graphs are given showing this progress; one graph indicates the percentage of steel work electrically-welded in different years. Thus, in 1926 the amount was only about 2 per cent., in 1930 13 per cent., and thence it rose rapidly to approximately 73 per cent. in 1937. A number of all-welded vessels have been constructed and an all-welded floating dock was built in South Russia and towed to the Far East. Several views are shown of an electrically-welded cargo steamer during construction. An article relating to ferro-concrete shipbuilding states that this system of construction was commenced in the U.S.S.R. in 1919 and the majority of the craft were constructed on the river Volga; about 40 craft of various types and size have been built, including a large self-propelled horse-and-cart ferry for the river Volga, a landing stage 85 metres in length, and three floating docks of 4,000 and 6,000 tons lifting capacity. Outline plans are shown of a 65-metre floating landing stage and a 6,000-ton floating dock, as well as detailed plans of a proposed vessel 52 metres in length for service in northern waters. The construction in the latter case is of a composite nature, *i.e.,* ferro-concrete framing, with shell and deck of wood. Small craft construction is the subject of an article describing the various types of small craft for passenger, fishing, sport and general service; plans are shown of a proposed building yard arranged specially for the construction of small craft. There is also a separate article dealing with wooden vessels engaged in the coasting trade of the U.S.S.R. Articles are also included on motor launch construction in connection with the reconstruction of the river Volga, and the building of a proposed fleet of vessels fitted with gas engines and gas-producing installations. The final article relates to the anode-polarization of aluminium and its alloys for protection against corrosion by the atmosphere and sea-water; this is described as one of the most effective and cheap methods employed for this purpose.—*"Soudostroienie", No. 11, 1937.*

Southern Railway Motor Car Ferry "Lymington".

The new ferry for passengers, goods and vehicles across the Solent, is built to B.O.T. Certificate S.T.4, with the following characteristics:—

Length overall	148ft.
Length on car deck	133ft.
Breadth moulded	26ft.
Breadth extreme	36ft. 8in.
Depth moulded amidships	9ft.
Maximum loaded draught	5ft. 6in.
Designed service speed	11 knots

Twin-screw, four-stroke, six-cylinder airless-injection Diesel engines, each of 200 s.h.p., running at 530-700 r.p.m., with bore 230mm. and stroke 300mm. (9in. and 11·8in.) are connected through toothed bevel wheels to two Voith-Schneider propellers, port forward and starboard aft. Each has six blades turning in a 1,200mm. (47·2in.) circle at 230 r.p.m. During trials the speed was 11·09 knots; the ship turned on its own axis in a circle of 150ft., and stopped in 22 sec. At full speed ahead the ship turned through 360° in 82 sec.—*"The Engineer", 6th May, 1938, p. 516.*

Lubricating Film Theories and Bearing Design.

Classical theory is valid only for an infinitely long bearing and continuously rotating shaft, *e.g.,* in turbines, dynamos and motors. In reciprocating machinery the mean film pressure rises parabolically and falls to zero. Recent work by Denison, Gümbel, Kingsbury, Howarth, Barber, Davenport and others, is discussed critically. Theoretical investigation leads to the following equation:

$$f=f_v+f_p=\eta v/h+(h/2r)\ (dp/d\phi)$$

where $\eta v/h$ is toughness friction independent of the axial length and $(h/2r)\ (dp/d\phi)$ is pressure friction; from this a dimensionless value can be calculated for the frictional moment

$$M^1=[1\eta nr^2]\ [R-r)/r]\ [M_v+kM_p])$$

where R and r are the radii of bearing and shaft, and k is a factor between 0·3 and unity. For ease of calculation results are given in the form of curves and it is found that bearings with great play and well run-in give results agreeing best with theory. Limits of film thickness for metallic contact are 0·00035 - 0·0025mm. (0·014 - 0·1 thous.). Axial oil transfer is function of loading and oil pressure in the unloaded zone, and a dimensionless value may be deduced for Q, $\pi/6\ (1+3x^2/_2)$. If the value Q (which may be calculated from the frictional loading and permissible rise in oil temperature, usually 50 - 60° C.) is known, the oil pressure required in the bearing can be deduced.—*E. vom Ende, "V.D.I., Zeitschrift des Vereines deutscher Ingenieure", 23rd April, 1938, pp. 505-507.*

Sprung Seating for Machines.

Springing is suitable only when the machine is so stable that the forces resulting can cause it no serious deformation, and are small in comparison with its mass; with large machines these conditions are often not fulfilled. Such a machine must be securely mounted on a heavy foundation, which itself may need to be sprung. Ground plates which are flexible, *e.g.,* a concrete-filled angle-iron frame such as is frequently used for small Diesel motors, are not suitable, since they do not stabilise the machine, and nett total vibration may even be increased. Mathematically there is no difference between a sprung machine and a sprung foundation. The author discusses the principles on which springing can be calculated from characteristic frequency of the machine, the probable effect of shock or harmonic forces on the springing, and difficulties likely to arise. He illustrates the method in the case of an idealised mass of 20 tons subject to a vertical harmonic force of ± 1 ton with frequency of 5, supported by 9 springs at each of eight points.—*E. Rausch, "V.D.I., Zeitschrift des Vereines deutscher Ingenieure", 23rd April, 1938, pp. 495-501.*

Exhaust Systems of Two-stroke Engines.

The greater sensitivity of the two-stroke engine to exhaust variations than the four-stroke engine is well-known; the author reports the results of works investigations on three small crankcase-scavenged engines with bore 3½ to 4¾in., stroke 4½ to 6½in., speed 650-1,000 r.p.m., output 3 b.h.p. to 10 h.p. With straight pipe fitted in place of the silencer box, a "good" length of 7ft. gave a clean exhaust and enabled the engine to carry an overload without difficulty; a "bad" length of 13ft. would not permit the engine to carry even its rated load for a prolonged period, and there were symptoms of lack of air, *e.g.,* a dirty exhaust. Curves are given for exhaust temperature and fuel consumption against equivalent length of pipe; these show marked peaks at about 11ft., 54ft., 147ft. A mean value of v=1,260ft./sec. for the velocity of travel of a "puff" impulse in the exhaust system is obtained. From experimental values of the "bad" lengths for these three motors at speeds of 650 - 900 r.p.m. (39·7 - 54·1ft.), the time in crank degrees is calculated for a puff to travel twice this length, *i.e.*, to the open end and back. Despite that no corrections for temperature variation were applied, values of 335° - 379° are obtained—approximately a complete cycle of 360°. By oscillograph measurements it is shown that for a "good" length of pipe the whole system is at or below atmospheric pressure, for a "bad" length a positive pressure exists throughout. A twin-cylinder engine exhausting into a common manifold behaved like the above single-cylinder engines, but on fitting an expansion box and secondary pipe, behaviour was not affected by the length of the latter, *i.e.*, any wave motion from the first cylinder is destroyed by that of the second. Similarly a two-stroke ported engine with blown scavenger air is little affected by exhaust variation. With short pipe-lengths "bad" points come at frequent intervals; as length increases they are spread out; a very long pipe is sufficiently cold at the exit to condense the water vapour. Pressure distribution in the system is discussed, with special reference to the self-induction engine (see *"Engineering", 1936, p. 667*) where pressure variations are used for scavenging and pumping, without any auxiliary air pump.—*H. O. Farmer, "Engineering", 1st April, 1938, pp. 367-369.*

Tensile Tests of Light Alloys.

Load-extension diagrams are reported for three magnesium alloys, cast, heat-treated, and extended, a cast copper-aluminium, two light aluminium alloys, and a mild steel. The latter would need to show an ultimate stress of 75 tons/in.^{2} to compare with aluminimum alloy on a weight basis; this is not unattainable by quenching but only in association with very low extension; even better properties can be had in austenitic steels. The author deprecates the common idea that these light alloys are relatively three times as strong as steel, nevertheless their combination of high strength, ease in machining, malleability and ductility, is attractive. Castings may be made thin, and the alloys are useful for lowly-stressed structures or where bulk (rather than strength) is necessary and weight must be kept down. In the interests of stiffness, present-day internal-combustion engines have the cylinder-block, gear-box and crank-case cast in one, aluminium being used only in the pistons. Slow loading (0·007in. per hr.) of an extended alloy gave lower breaking stress and elongation than did rapid loading (0·125in. per min.), 16·27 tons against 17, and 8·35 per cent. against 10 per cent.; a further increased rate (1in. per min.) had no further effect. Under sustained load hysteresis and hardening occurs.—*H. Quinney, "Engineering", 13th May, 1938, pp. 530-531.*

Pressure Loss in Pipelines.

In connection with performance measurements on turbines at the Bannalp hydro-electric power station, the effect of welding on the resistance of a 4,800ft. pipeline, about one third being 22in. and the remainder 19in. in diameter, was determined by two sensitive manometers. A value of $\lambda = 0{\cdot}01484$ was obtained, in poor agreement with the old formulæ of Weissbach, Darcy, Kutter, Beil and Lang, which, however, do not fulfil the principle of similarity (*e.g.*, Weissbach gives 0·02205). Nikuradse (*V.D.I. Forschungsheft, 361, 1933*) suggests $\lambda = (1{\cdot}74 + 2 \log [r/k])^{-2}$, but gives no values for k for the material of the pipeline. To correlate observed results with actual values found, a value of $k = 0{\cdot}30$mm. must be chosen. In this connection one must remember that Nikuradse's tubes were roughened artificially.—*A. L. Calfisch, "Schweizerische Bauzeitung", No. 4, 1938, p. 35;* reproduced in *"V.D.I. Zeitschrift des Vereines deutscher Ingenieure", 7th May, 1938, No. 19, p. 558.*

Gearing for Diesel-electric Vehicular Ferry.

Main propulsion gears are of straight-tooth type to permit slight axial movement, the vessel being double-ended. Profile grinding of the teeth has given as even a load distribution as is obtainable normally with larger double-helical gears. Smooth running was promoted by cutting the final wheel while mounted on its shaft, the whole being balanced as a complete rotating element. Speed reduction is from the 600 r.p.m. of the main engine to 140 r.p.m. of the propellers. Lubrication is first by dip, later by pressure; connection between engines and gears is by cone-ring couplings. Owing to tidal effect combined with restricted waterway, Clyde vehicular ferries are fitted with a lifting deck, worked by a worm reducer of 20in. centres, transmitting 100 h.p. with 500 r.p.m. to 102 r.p.m. The worm is of case-hardened steel with profile-ground teeth, the wheel rim being of centrifugally cast bronze.—*"Engineering", 13th May, 1938, p. 543.*

Firelimiting Wooden Linings for Iron Cabin Walls in Ships.

Recent investigations in "Nantasket" in U.S.A. are reported. 24·4kg. of combustible material per m.^{2} of floor space (50lb./ft.^{2}) was placed in cabins of different sizes, this representing the average amount brought on board by passengers. When damaged the walls ignited much more easily, and many normally satisfactory woods cease to be so when the temperature of the steel wall behind them rises; this is attributed to the use of a more inflammable veneer. Recommendations are that only highly fireproof woods should be used, and these fitted very closely in contact with the wall. Under these conditions, the fire will burn itself out without spreading, even though the veneer is burnt.

In contrast to this, cabins fitted with ordinary wood ignited while half of the combustibles were unconsumed. Rising demand for proofed wood should reduce its price to such an extent that the extra cost and time required for installation should not press too heavily on the shipbuilder.—*"Mechanical Engineering", 1938, No. 1, p. 61;* reproduced in *"V.D.I. Zeitschrift des Vereines deutscher Ingenieure", 7th May, 1938, No. 19, p. 559.*

Fundamental Factors Influencing the Determination of Loads on Electric Supply Plants at Welding Stations.

The fundamental factors governing the ascertainment of loads at welding stations when calculating the required power and the electric network of a proposed welding plant are (1) the number of welding arcs, (2) the coefficient of utilization of the welding station, by time, and (3) the coefficient of simultaneous work. Before proceeding to analyse the choice of a particular plant for supplying the current for welding purposes, it is first necessary to ascertain in full detail the factors which influence the correct solving of the problem of the load which has a subsequent bearing on the basic calculations. The initial data for calculating the network and fixing the power of the electric supply plant should be the maximum value of the current acting on the parts under consideration, which determines the heating of the wiring and overload of the machines and apparatus. This maximum value connected with the coefficient of simultaneous work has a place in the separate parts as well as in the system as a whole. The term coefficient of simultaneous work in the energy system is generally understood to mean the ratio of the maximum load to the possible load by the working of all switched-on apparatus. As in the examination of the productive work of separate welding arcs it is found they differ very little one from the other, by the term coefficient of simultaneousness for arc welding, it is hereinafter understood to mean the ratio of the number of burning arcs to the total number of established welding posts. The coefficient of simultaneousness depends, on the one hand, on the total number of established posts and, on the other, on the coefficient of utilization of the welded arcs, by time. Up to the present, when designing a proposed welding station the coefficient of simultaneousness has been generally chosen in a very approximate form and has not been connected with either theoretical or practical investigations. The value of this coefficient quoted in various literature varies considerably and is not connected with the factors which influence it. In a large number of literary sources the coefficient of simultaneousness is given as a quality of some conditional value for this or that branch of productiveness, without any sort of basis or indication of its relation to the above-mentioned factors. In the absence of any statistical and experimental material for ascertaining the value of the coefficient of simultaneousness, naturally a large number of approximations and to some degree provisory solutions were brought forward for determining the load. For ascertaining the coefficient of simultaneousness, also the calculated current and load connected thereto, a method of mathematical analysis will hereinafter be adopted, which is usually used when examining general cases of recurring short-duration work of receivers. This method in the given cases is considerably simplified in view of the fact that by mass working of welding arcs in shipbuilding (for ascertaining the type of production) the load will be of one order. The definitions and their significance which will be used in subsequent calculations are as follows:—

(1) Coefficient of work of the welding station E is the ratio of the duration of productive welding process (machine plus auxiliary time) to the duration of the working shift;

(2) Coefficient of the arc content ϵ is the ratio of the continuous burning of the arc (machine time) to the productive process of welding (machine and auxiliary time).

(3) Coefficient of utilization of the burning arc, by time, η_A, is the ratio of the continuous burning of the arc (machine time) to the duration of the working shift.

(4) Coefficient of simultaneous working of the welding post η_g, as already accepted, is the ratio of the simultaneous burning of the arc to the total number of installed welding posts.

For determining the numerical values of these coefficients it is necessary to analyse the work of a welding station in concrete cases. For this purpose chronometrical readings have been taken during a continuous working shift at two shipyards at Leningrad. The first reading relates to the work of the hull section at a yard where the work was of a non-continuous character with long intervals of a non-productive nature; the second and third readings were taken where the work was of a mass productive and continuous character (the third case was examined when the "Stakanov" method was applied). *Photostats are shown of the above three chronometric readings in Figs. 1, 2a and 2b, and coefficients, E, ϵ and η_A are worked out from information obtained from the readings, particulars of which are given in three tables. The following six graphs are also furnished: Fig. 3 showing the probable duration of simultaneous working of welding arc with a coefficient of $\eta_A = 0{\cdot}502$; Fig. 4 showing the dependence of the coefficient of simultaneousness on the number of installed arcs with a coefficient of $\eta_A = 0{\cdot}433$; Fig. 6 showing a similar graph with a coefficient of $0{\cdot}776$; Fig. 7 showing the dependence of the coefficient of simultaneousness on the number of installed arcs with various coefficients of utilization, by time; and Fig. 8 showing the dependence of the coefficient of simultaneous-

* These and the other illustrations and formulæ to which reference is made are not reproduced.

ness η_g on the coefficient η_A for different numbers of installed arcs. Tables of particulars from which these graphs have been derived are given for 10, 25, 50, 75 and 100 welding posts, and the formulæ adopted for obtaining the particulars are furnished. The conclusions arrived at by the author are that the theoretical investigations of the coefficient of simultaneousness indicate that the value of this coefficient is not only connected with the coefficient of utilization of welding arcs but also with the number of welders in the welding shops. With a very small number of installed welding posts the coefficient of simultaneous work equals unity; by increasing the number of posts it decreases and approaches the coefficient of utilization. From this it follows that with a small value of the coefficient of utilization an installation with a varying number of welding posts may have coefficients of simultaneousness greatly differing one from the other. Calculations for the welding network and generating plant based only on the one coefficient of utilization of the station, as is usually carried out and as recommended in most literature, may give very incorrect results. It is not possible to confirm the value of the coefficients of simultaneousness by experimental data as up to the present time such investigations have not been carried out. The possible practical deviation of the given values from those obtained by calculations should, in any case, not affect their relative changes depending on the investigated factors.—*"Soudostroienie", No. 12, 1937.*

Catalytic Combustion of Gases on Metals.

A cheap efficient catalyst, promoting combustion at moderate temperatures would obviously be advantageous in boiler construction. Bone has found that in general the efficiencies of different substances in promoting surface combustion become more nearly equal at high temperatures, but this does not apply to metals where catalytic activity is marked only in the platinum group. Wires 0·001 in. in diam. were stretched within a cast-iron cylinder one cubic foot in capacity, connected to vacuum pump, gas cylinders and gauge, the voltages across an ammeter shunt and rheostat being measured. Temperature was calculated from resistance, and rate of combustion by plotting temperature against power input. Results are given for air containing (1) 0%, 1%, 2%, 3% H_2, (2) 0%, 2%, 4%, 6% CO, (3) 0%, 1%, 2%, 3%, 4%, 5% CH_4, (4) 0%, 1% H_2, 2% CH_4, (1% H_2+2% CH_4) for Pt wires; and (5) 0%, 1% H_2, 2% CH_4, (1% H_2+ 2% CH_4) for Ni wires. With 1% H_2 reaction began very sharply at 200° C.; the sharp rise due to catalytic combustion might cause serious errors in fine wire thermometry. With CO, combustion does not begin till about 400° C. despite the higher heat of combustion per molecule; possibly the rate of combustion is governed also by density and this may be of interest in combustion of oil and pulverised fuel. For CO and H_2, rates of combustion at first increase and then decrease, the curves being parabolic about 1,200° C. The possibility of heating fine wires in an explosive mixture to above its ignition point is probably due to the intense thermal gradient—100° C. or more in a distance equal to the mean free path. In small amounts, methane does not react below a wire temperature of 800° C., activity then increasing uniformly up to the melting point of Pt; so that between 200° and 900° C. the last trace of hydrogen can be removed by the highly selective combustion occurring. A small percentage of acetylene suppresses combustion of hydrogen, *e.g.* 1% of added acetylene raised the explosion temperature of a 30 : 70 H_2 : air mixture from 280° to 600° C. Gold, silver, copper and iron wires were wholly ineffective as catalysts even when heated to the melting point, but nickel promotes the combustion of acetylene only. The results agree well with recent theories of catalysis.—*W. Davies, "Engineering", 27th May, 1938, pp. 587-589.*

Quick-acting Safety Valve for Air-starting Systems.

Normally the Diesel starter is protected from excessive pressure by an automatic valve, with either a spring-loaded safety valve or a diaphram as second line of defence. The new valve obviates the sluggishness of the sprung valve on the one hand, and the need for renewal of the ruptured diaphram on the other. A plain cylindrical casing is attached by flange to the end of the starting air manifold or other convenient point, the enclosed piston being packed with a flexible L-ring, with a mitered flange closing down on a seating of ordinary type; the air supply is taken in at a point not likely to be affected by the explosion. Normally the valve is held down by a steady positive pressure, the mitered area being about 50% greater than that of the piston, but these dimensions may be varied in accordance with the closing pressure desired. When air pressure in the manifold rises slightly above the value chosen, the valve opens at once, relief is given and the air supply is cut off; reseating is also very rapid. After operation the engine can be restarted immediately and it is claimed that the valve cannot be overloaded, does not jam even after long disuse, is not liable to weakening from corrosion and does not rapidly deteriorate.—*"Engineering", 27th May, 1938, pp. 604-605.*

Refining Plant for Used Lubricating Oil.

When impurities (*e.g.* petrol, water, carbon, metallic particles, acids) are removed from used oil, the stable hydrocarbons remain unaffected, and its lubricating properties may even be improved to the extent that gumming constituents have been eliminated. The plant described is essentially a miniature refinery. About 4lb. of fuller's earth is stirred into a charge of 6½ gall. and the whole preheated by volatile substances passing off from a subsequent stage, *viz.* petrol, water and oil vapour. After 40 min. the mixture is forced by compressed air or nitrogen into a chamber containing eleven

1,150kW. heaters and raised to 500° F. (260° C.). Steam at 20lb./in.^{2} is then admitted for 30 sec. and heating continued to 575° F. (300° C.), current is then cut off and steam readmitted. The temperature gradually falls and at 550° F. (245° C.) the oil is run off into the pressure chamber below, from which it is forced by compressed air at 15-25lb./in.^{2} through an asbestos cloth disc into an open steaming tank. The refining powder and impurities collect in a layer 1in. high and the whole is removed with the filter disc and thrown away. Steam at 10-15lb./in.^{2} is then passed for 5-15 min. as required to remove odour, but no naked light can be brought near as the oil is above its flash point. A one-man plant can handle about 80 gall./day at a cost of 2¾d. per gall., excluding labour; the volume lost is 5-25%. In general, closed flash point and viscosity are increased and acidity is reduced. By omitting the final steaming and keeping the temperature below 400° F. (205° C.) transformer oil can also be treated. Two photographs and a scale drawing of the apparatus are given.—*"Engineering", 13th May, 1938, pp. 528-529 with plate.*

Condensation in Ships.

A paper on "Condensation on Board Ship" was read before the Royal Society of Arts on the 26th ult. by Mr. S. J. Duly, M.A. At the conclusion of the paper, which dealt chiefly with grain cargo, the author said:—

"The aim of the shipbuilder should be to build the ship with no warm surfaces forming part of the confining walls of the cargo spaces. The devices for insulating and cleading and the use of coffer dams should be used as freely as may be. Steam should preferably not be taken through the tunnel at all. In this way a common cause of damage to cargo, its sweating, its deterioration through warm stowage, or its drying out and its presence as the origin of moisture-laden air which may condense elsewhere would be avoided. Hardly any boon more welcome to the ship operator and the merchant alike could be provided by the builder than a completely cool ship.

"Artificially cold surfaces within the ship are the second sources of danger. Some refrigerated space is now found on most ships, and in some trades an appreciable percentage of the available cargo space is insulated and refrigerated. In these circumstances it is even more difficult to avoid cold surfaces confining ordinary cargo spaces than it is to avoid the effect of ship's heat. The precise position of such cold surfaces in new ships should be carefully thought out in regard to their action as condensing surfaces in general cargo spaces, and the ship designed so that they are restricted in their distribution and do not present too difficult a problem to the chief officer in dunnaging them thoroughly and protecting cargo from their double effect. For they not only condense moisture which may drip on cargo, but they may also hold cargo stowed too near them below the dewpoint".—*"Ice and Cold Storage, April, 1938.*

Progress of Marine Electricity—Developments in Propulsion and Auxiliary Machinery.

The past year has been one of considerable activity in the marine electrical world, not only on account of increased shipbuilding activity but from other causes.

Electric propulsion in British yards has been on an almost negligible scale, but this is not the case on the Continent and in Germany in particular. The latter has broken fresh ground by the use of alternating current for Diesel-electric applications, and several large and important vessels equipped with this system have been completed and further vessels are still building. The pioneer of these, the "Wuppertal", has now been in commission for over twelve months, and, it is understood, continues to give satisfaction.

Some indication of the activity in Germany is given by the following list of vessels recently completed or under construction. All of these are on the A.C. system with the exception of the motorship "Vogtland".

Name.	No. of screws.	engines.	Description.	S.h.p.	Tons gross.	Remarks.
"Wuppertal"	1	3	Diesel-elec. 2 SCSA	9,800	6,137	—
"Vogtland"	2	5	Diesel-elec. 4 SCSA	—	6,932	Conversion
"Patria"	2	6	Diesel-elec. 2 SCSA	—	—	—
—	2	—	Diesel-elec. 2 SCSA	12,300	15,000	Launched
—	1	3	Diesel-elec. 2 SCSA	6,800	6,750	Under Construct.
—	1	—	Turbo-elec.	5,800	4,400	Under Construct.
—	1	—	Turbo-elec.	5,800	4,400	Under Construct.
"Helgoland"	2	—	Turbo-elec.	—	—	Voith Schneider Propellers
—	2	—	Diesel-elec. 4 SCSA	16,500	9,400	—
—	2	—	Diesel-elec. 4 SCSA	16,500	9,400	—

In this country electric propulsion in new vessels constructed during the past year has been confined to small craft such as the Trinity House vessels "Vigia" and "Patricia", the tug "Robertsbridge" and the Clyde ferry still under construction. The "Patricia" is, perhaps, the most important of these, consisting of two engines of 4 stroke cycle single acting type, and twin screws giving a total of 1,330 s.h.p., employing D.C. transmission on the controlled current principle.

The returns of Lloyd's Register of Shipping show the following position with reference to world tonnage of electrically propelled vessels of 300 tons and over:—

	No. of vessels.	Tons gross.
Turbo-electric	42	483,150
Diesel-electric	62	129,237
Total	104	612,387

This list takes no account of small craft such as tugs and other vessels under 300 tons, of which there are many scores in operation, mainly with Diesel-electric equipment.

The foregoing account of recent building also omits reference to progress in the U.S.A., but in passing mention must be made of an 18,500 ton tanker, the "J. W. Van Dyke", built for the Atlantic Refining Co. In addition to being the world's largest all-welded ship this vessel has turbo-electric propulsion, 625lb. steam pressure at 825° F., 5,000 s.h.p. Auxiliary power is also taken from the propulsion generator, being transformed from 2,300 volts to 440 volts for this purpose.

Advent of the Electric Slip Coupling.

The advent of the electric slip coupling is perhaps the most notable of recent advances in methods of transmission for propulsion purposes. It is in some respects a compromise between direct drive and electric drive, possessing many of the advantages of the latter. For instance, it enables the prime mover to be split up into a number of units of relatively higher speed having lighter moving parts, requiring less head-room, and enabling one or more units to be shut down when required for adjustment or overhaul or repair, or to effect economies when full output is not wanted. They have still to prove themselves in service over long periods, but, as will be seen from the table below, a number of them have been in commission for several months and are proving satisfactory.

Name of vessel.	Total B.h.p.	Number of screws.	Number of engines.
"Anita"	1,740	1	2
"Astri"	1,740	1	2
"Astri Thorden"	2,100	1	2
"Dagmar Salen"	4,400	1	4
"Norviken"	4,400	1	4
"Werna"	1,400	1	2
"Wiros"	1,400	1	2
"Goteborg"	580	1	1
Oresundsvarvet Yard No. 32 ...	1,820	1	2
„ Yard No. 51 ...	4,400	1	4
„ Yard No. 52 ...	1,820	1	2
„ Yard No. 53 ...	1,400	1	2
A/B Finnboda Yard No. 322 ...	1,820	1	2
"Formosa"	5,120	2	4

Auxiliary Electrical Equipment.

In regard to the progress of auxiliary electrical equipment, an indication of the extent of this may be obtained from an analysis of the equipment of some 391 new vessels for which electrical plans were dealt with by Lloyd's Register during 1937.

Total generator capacity.	Number of vessels.	Percentage of total number.	Aggregate kiloWatts.
15kW. and under ...	142	36	799
16kW. to 100kW. ...	128	33	4,788
100kW. to 200kW. ...	46	12	6,666
200kW. to 500kW. ...	50	13	15,420
Over 500kW.	25	6	32,108
	391		59,781

When we take into account the fact that the total lighting, ventilating, heating and power capacity installed may be anything from twice to four times the generator capacity, we have some idea of the magnitude and importance of the marine field to the electrical industry.

The ten largest equipments included in this summary were as follows:—

Shipbuilder or name of vessel.	Total kiloWatts.
"Capetown Castle"	4,000
"Stratheden"	1,760
"Strathallan"	1,760
"Zaandam	1,645
"Canton"	1,410
P. Smit, Yard No. 651	1,050
P. Smit, Yard No. 652	1,050
"Beacon Grange"	1,040
"Lochavon"	1,000
"Dunera"	915

It is important to note that this list refers only to those vessels for which plans were passed during the year, and does not include all vessels completed during that time.

The work which is being done in connection with rules and regulations is of considerable importance. The Ship Electrical Equipment Committee of the Institution of Electrical Engineers is now actively engaged on the third edition of the I.E.E. Regulations. This Committee of over thirty members, representative of numerous interests in marine electricity, has appointed various sub-committees, some of which are meeting almost weekly, to deal with the present revision. The second edition was issued in June, 1926, and a number of amendments were approved and published in July, 1929. Subsequent to these dates considerable advances have been made in electrical science, and innovations have taken place which were not then visualised. Consequently, the Regulations are due for overhaul, and it is anticipated that a section dealing with electric propulsion will be added.

The International Electrotechnical Commission is also moving in the matter and has set up a Committee with a view to evolving a set of international standards for electrical installations in ships. Members of the I.E.E. Committee previously referred to are actively participating through the British Standards Institution in this work, and a considerable measure of agreement has already been achieved. The geographical distribution of the delegates and language problems naturally slow up the proceedings, but nevertheless considerable ground has been covered and it is hoped that during the next few months the first draft will be ready to circulate to the various National Committees for comment. This draft will cover practically the same field as the existing I.E.E. Regulations.

It is, perhaps, well to remember that although it is now just 50 years since the first electrical installations in ships, it was after the Great War that rapid strides were made and the application of motor power began to forge ahead and permeate every department. Although motors had been used for fans and pumps and in other directions on a comparatively small scale, applications of electricity on a large scale to steering gear, winches, capstans, galleys, etc., were still in their infancy. Consequently, in 1926, when the second edition of the

I.E.E. Regulations made its appearance, many of these applications were comparatively new and many fresh departments have been encroached upon since that date, quite apart from the normal progress of the electrical industry and continuous extensive research into the behaviour of materials.

"Neon" Lighting for Ships.

An instance of more recent development is to be found in an innovation in the interior lighting of ships which, though at present in its infancy, may make rapid strides in the near future, namely, the use of luminous gas discharge tubes or, as it is more commonly called, neon lighting. The use of this system of lighting involves alternating current and adjacent to the tubes this has to be transformed to voltages of 2,000 and upwards, depending on the length of tube. If properly installed these voltages can be quite safe, and, recognising this, Lloyd's Register of Shipping has already issued tentative rules.

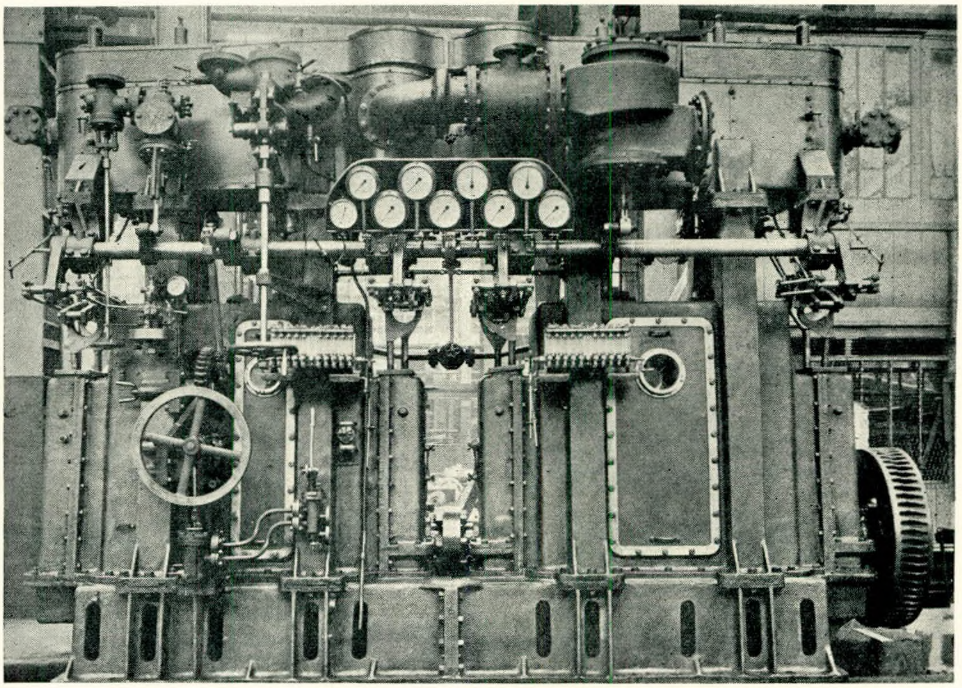
The term "neon" is actually a misnomer in this connection, as neon gas produces the red coloured light with which we are only too familiar, but by using other gases such as argon, helium, etc., other colours are produced, and by coating the inside of the tube with fluorescent material a creamy white light can be obtained. The main advantages are economy in current consumption, even distribution of light, and reduction of heat generated. The tubes are quite cold to the touch and consequently the problem of dissipating and disposing of the heat from the lighting of cornices and fittings in public rooms is solved. This absence of heat may also be advantageous in preserving decorative finishes which so often become discoloured, due to the carbonisation of paint and dust where heat is present.—*G. O. Watson, "Shipping World", 6th April, 1938, p. 467-9.*

Marine Steam Engine Design—Progress of Reciprocating and Combination Machinery.

It is an interesting fact that during about 40 of the past 50 years, very little change was made in the design of the then universal reciprocating marine steam engine. In the last decade, however, considerable changes have taken place, largely as a result of the intensive competition of the Diesel engine. This period has seen a revolution in the performance and the design of the machinery fitted in the ordinary tramp steamship.

Perhaps the most noteworthy development in this connection was the introduction in 1926 of the Bauer Wach exhaust steam turbine, which is now fitted in more than 530 vessels with an aggregate horse power of considerably over $1\frac{1}{2}$ million. The general design and performance of the Bauer Wach exhaust turbine are too well known to call for recapitulation. It is sufficient to say that a device which, other things being equal, would give a 20 to 25 per cent. improvement in steam consumption, and which was applicable to existing engines without extensive modification of the engine or ship, was a step forward of the first magnitude and was bound to take a prominent place in marine engineering economics. Indeed, it was of such importance that many observers thought that scope for further progress in this field was almost non-existent.

The concurrent progress made with marine oil engines was, however, so remarkable that marine steam engineers had perforce to take up the challenge of the motor ship with renewed vigour. As a result of this, further interesting developments have taken place in marine steam engine design and it would be a bold prophet who would say that finality has been reached, or even approached.



Double compound reciprocating unit for a set of White combination machinery; the enclosed crankcase will be observed.

The Turbo-Compound Engine.

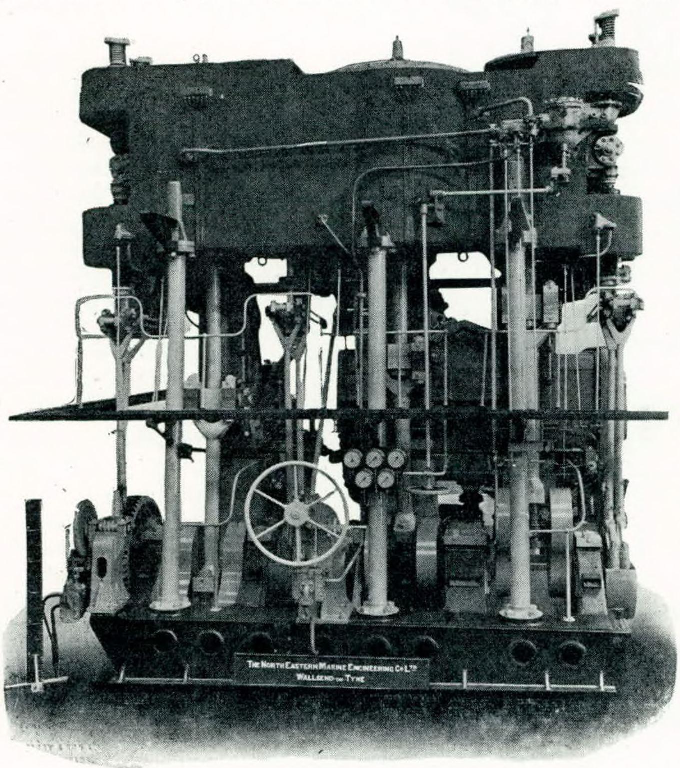
The period following the introduction of the Bauer Wach exhaust turbine was one of intensive marine steam engine development. The manner in which the Lentz poppet valve engine was adopted in a number of cases; the appearance of alternative exhaust turbines to the Bauer Wach-type; the trying-out of such novelties as the Lindholmen electric superheating arrangements; the use of the Maier-Mattern hydraulic valve gear, and so on, could all be discussed in the light of their technical significance were space available, but attention will have to be confined on this occasion to more recent developments.

Reverting to the Bauer Wach exhaust turbine. Originally this invention was developed as an efficiency increasing device for use with engines of standard design, both new and existing, and the great majority of installations so far made have been of this type. At the same time, it was recognised at an early date that a logical line of development was to design reciprocator and exhaust turbine as an harmonious whole. By employing such a principle, a simple compound reciprocator with but two cylinders can give excellent results in association with an inbuilt exhaust turbine. Such an arrangement, which has the additional advantages, in comparison with a three-cylinder triple-expansion engine and exhaust turbine, of greater simplicity, smaller overall dimensions, and lower weight, was produced a few years ago in the form of Dr. Bauer's turbo-compound machinery. As would be expected, this has proved popular for vessels of moderate size. In my opinion, this type of machinery could very well be extended in scope for use in cargo steamers of appreciably more than 1,000/1,100 total i.h.p.

Success of the White Engine.

Another logical line of development, and one, incidentally, which I suggested as being desirable in a paper read before the Institute of Marine Engineers nearly 10 years ago, is to employ a simple form of compound or double-compound fairly high-speed reciprocating engine in association with an exhaust turbine. Proposals of this kind were put forward by Dr. Bauer several years ago but it has been left to a British marine engineer, Mr. W. A. White, of White's Marine Engineering Co., Ltd., to produce a marine engine along these lines, and it is a matter for congratulation that Mr. White's bold policy of showing his faith in his design by associating himself with the placing in service of the first White engine met with conspicuous success.

It is now a matter of history that the original White-engined ship, the converted "Adderstone", proved highly economical and reliable from the outset. She has been followed by a number of orders for White engines, all of which have shown consistently good results in service and have established the engine as one of the best solutions of the problem of the high-efficiency cargo steamship of moderate first cost. In numerous White installations the illusive ideal performance of one pound of coal per i.h.p. per hour for all purposes has been realised, a result which few alternative types of improved steam machinery of moderate power can show.



North Eastern reheater triple-expansion engine with separate steam and exhaust poppet type valves for two cylinders.

Superheat and Reheat.

The most important recent development in the reciprocator field is, I consider, the reheater principle, which will be discussed by Mr. Harry Hunter before the Institution of Naval Architects on Thursday. Mr. Hunter's firm, the North Eastern Marine Engineering Co., Ltd., are responsible for the development of the reheater engine, which has been watched with keen interest since it was tried out experimentally a few years ago. As a solution of the problem of providing a high-efficiency marine steam engine without undue complication or increase of first cost, the reheater engine is a really notable development. Moreover, it is logical that it should be sponsored by the firm who have done more in furthering the cause of superheat than any other British marine engine builder.

The reheater engine, most readers will appreciate, is but a logical development of superheat, for it seeks to make use of comparatively high temperature superheated steam in the ordinary commercial reciprocating steam engine. Expressed in simple language the reheater, which is nothing more than a multitubular heat exchanger, is a static addition to the engine in which the incoming highly-superheated steam (at a temperature, perhaps, of 750° F.) is partially cooled before entering the high-pressure cylinder by giving up some of its heat to the exhaust steam from that cylinder. In this way the temperature of the steam entering the engine is about 600° F., and at the same time the temperature of the steam entering the intermediate pressure stage of the engine is correspondingly increased, to the benefit of the thermal economy of the engine.

A Commercial Proposition.

The reheater is arranged alongside the cylinders of the engine, and so improves the conditions throughout the engine that a gain in economy over the ordinary superheated steam installation of nearly 10 per cent. is obtained. Having regard to the moderate cost of the reheater—which, in the case of the North Eastern engine, is associated with the firm's well-tried cam-operated poppet valve gear for two of the three cylinders of the engine—the commercial benefits of the development will be appreciated.

As a matter of technical interest the accompanying figures showing the steam dryness conditions at inlet and exhaust for each of the three cylinders of a North Eastern reheated triple engine are worth noting and serve to show, incidentally, that the engine is admirably suited for operation with an exhaust steam turbine. The steam conditions are as follows:—

	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

A number of these North Eastern reheater engines have now been fitted into ships and thoroughly tried out at sea. The first two vessels to be so equipped were the Liverpool steamships "Lowther Castle" and "Lancaster Castle", both general cargo carriers of about 9,300 tons deadweight. It is interesting to find from the published figures relating to a 12,000 mile round voyage of the "Lancaster Castle", that this ship can steam rather more than 10 knots on an all-purposes daily coal consumption of 13·3 tons; this gives the highly meritorious specific fuel consumption of 1·01lb. per i.h.p. per hour.

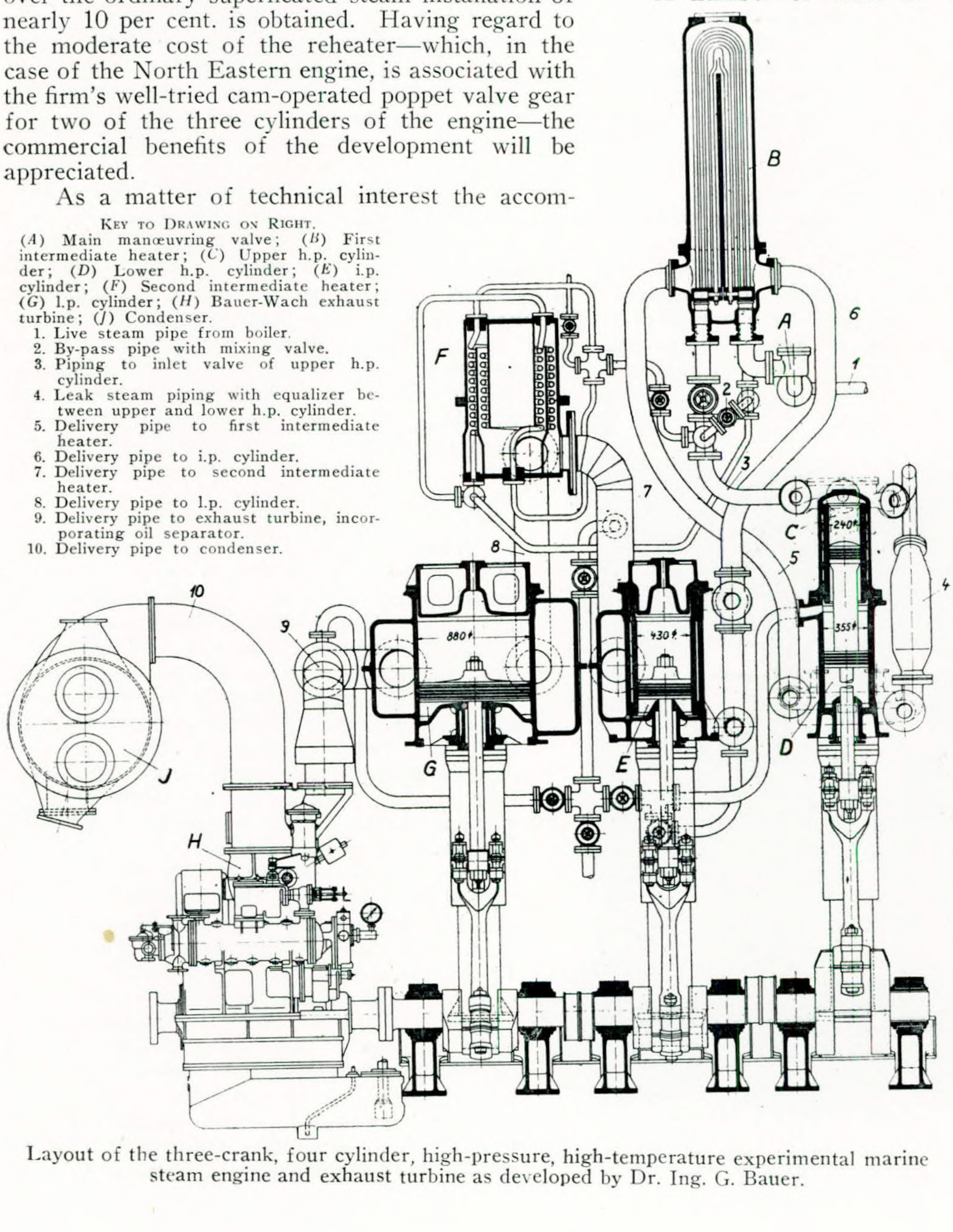
The Ultimate Economy.

If the performance figures already quoted in this article strike the comparatively uninformed reader (using the term strictly in the technical sense) as being almost revolutionary alongside the best results of even a few years ago, the

KEY TO DRAWING ON RIGHT.

(*A*) Main manœuvring valve; (*B*) First intermediate heater; (*C*) Upper h.p. cylinder; (*D*) Lower h.p. cylinder; (*E*) i.p. cylinder; (*F*) Second intermediate heater; (*G*) l.p. cylinder; (*H*) Bauer-Wach exhaust turbine; (*J*) Condenser.

1. Live steam pipe from boiler.
2. By-pass pipe with mixing valve.
3. Piping to inlet valve of upper h.p. cylinder.
4. Leak steam piping with equalizer between upper and lower h.p. cylinder.
5. Delivery pipe to first intermediate heater.
6. Delivery pipe to i.p. cylinder.
7. Delivery pipe to second intermediate heater.
8. Delivery pipe to l.p. cylinder.
9. Delivery pipe to exhaust turbine, incorporating oil separator.
10. Delivery pipe to condenser.



Layout of the three-crank, four cylinder, high-pressure, high-temperature experimental marine steam engine and exhaust turbine as developed by Dr. Ing. G. Bauer.

results which are cited below may at first sight appear unbelievable. Recently, with a view to showing what could be achieved with marine steam machinery of straightforward but advanced design, Dr. Ing. G. Bauer designed and constructed in the Deschimag works at Bremen an experimental set of combination machinery of about 1,000 i.h.p. at 130 r.p.m. of the reciprocator shaft. With this engine, using steam at a pressure of about 800lb. per sq. in. absolute and superheated to the very high temperature of about 1,000° F., a specific steam consumption of about 5·1lb. per i.h.p. per hour was returned, including allowance for the losses in the Vulcan fluid coupling and reduction gearing of the Bauer Wach exhaust turbine forming part of the installation. This is easily the lowest steam consumption ever obtained with a reciprocating engine, turbine, or combination of both.

While it may rightly be argued that the steam conditions used in this experimental engine are not likely to attract even the most enterprising shipowner, the experimental work in question is highly important as giving an indication of what could be achieved in a commercial installation of the most modern type. Actually, at the present time, Dr. Bauer's firm are building some high efficiency installations based upon this experimental plant and it is interesting to note that the water-tube boilers are to be provided with mechanical stokers.

Before concluding this short survey it will be of interest to technical readers to give a brief description of this remarkable marine steam engine. The accompanying diagram and photograph show that the reciprocating element is a four-cylinder three-crank unit, the cranks being equally disposed at intervals of 120°. The l.p. and m.p. cylinders are normal and do not call for comment but the two high-pressure expansion stages are arranged in tandem and, it will be noticed, are both single-acting.

Two Stages of Reheating.

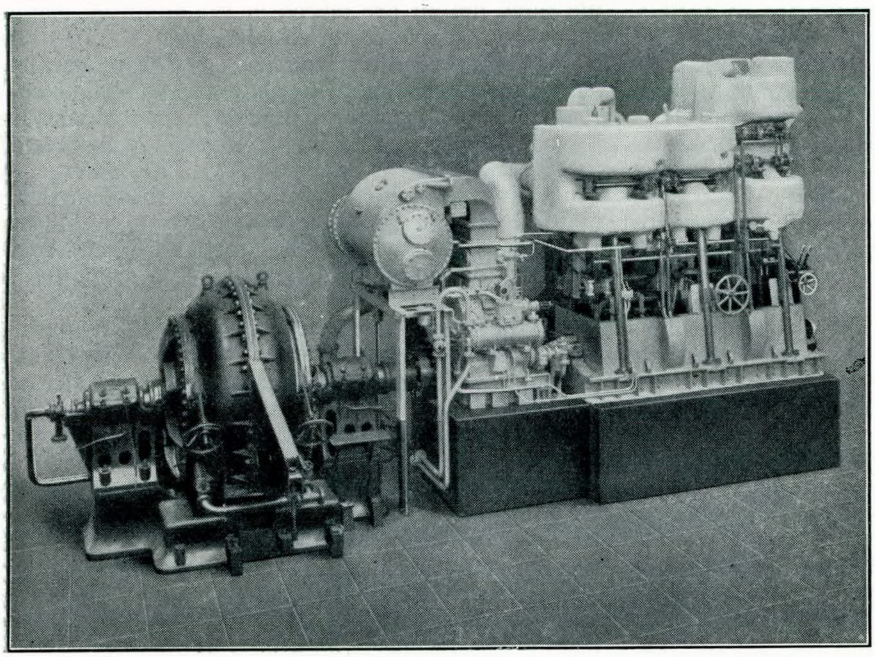
The interesting construction adopted for the high-pressure engine is designed to avoid possible trouble with the high-pressure piston rod gland in view of the very severe steam conditions. The steam enters the engine on the top side of the first high-pressure piston and then operates on the lower side of the second high-pressure piston, which, incidentally, is rigidly attached to the upper piston by means of a distance piece; any steam leakage from the first- or second-high-pressure pistons passes into the common annulus shown and is led away to the later stages of the engine, preferably the low-pressure cylinder.

An important feature of the engine is that two stages of reheating are provided, the two forms of intermediate heater being shown as B and F in the accompanying diagram. Space does not allow of our giving a full description of these heaters or of tracing the path of steam through the engine but if the accompanying drawing is studied in conjunction with the key provided the general design of the engine will be appreciated.

The exhaust turbine is of normal design and is located at the after end of the engine; the principal modification in this turbine is that the six rows of reaction blading with which it is provided are arranged for a smaller heat drop than would be used with engines of more normal type.

A great deal more could be written on this fascinating subject and if space allowed descriptions and performance figures could be given for a number of noteworthy high-efficiency marine steam engines such as the Elsinore turbo-compound type, the Christiansen & Meyer double-compound semi-uniflow engine, the Fredriksstad "steam motor", the Rankin & Blackmore triple with Andrews & Cameron separate cam-operated slide valves, and others.

Sufficient has been said, however, to show that marine steam engineers have not neglected their opportunities in recent years. In association with modern boilers and mechanical stokers the results possible can bear comparison in the economic sense with the best results obtainable from



Dr. Bauer's combination machinery ready for test.

Diesel machinery and the view is held by many marine engineers that these modern steam installations, utilising indigenous fuel, are likely to play an increasingly important role in shipping in the future. —*G. R. Hutchinson, "Shipping World", 6th April, 1938, pp. 471-5.*

The Latest Developments in the Electrical Installations of German Merchant Ships.

The author considers that the most noteworthy features of the marine electrical installations lately built in accordance with the standards laid down by the German Mercantile Marine Standards Committee are the single-pole layout, in which the hull is used as the return line, and the adoption of 220 volts as the standard tension for light and power installations for both direct and alternating current, except in tankers for which special rules are in force. He states that in German merchant ships preference has hitherto been given to direct current, although in several vessels of the Hamburg-America Line alternating current is now employed. The layout of modern single-pole 220-volt d.c. installations is appreciably simplified by the arrangement in parallel of the generators, with a common busbar and a single distribution net for the whole of the vessel. To illustrate the differences between past and present practice, the author reproduces the distribution diagrams of the pre-war Atlantic liner "Vaterland" and of the "Europa". The former shows a lay-out of five turbo-generators in series supplying current to independent circuits by means of separate busbars and selective switches, so that a breakdown in any of the circuits will not affect the rest. In the "Europa", four Diesel generators supply a common busbar which is subdivided by means of a separation piece in such a manner as to enable part of the installation to be cut out for overhaul. This arrangement permits the transfer of the load from one generator to another without any interruption of the current, which is essential in the case of such plants as the steering gear and the gyroscopic compass, as well as the equal distribution of the load over the generators in operation, and offers considerable advantages from the point of view of convenience and economy of operation. In the case of the breakdown of one of the generators, the possible over-loading of the remaining sets is obviated by safety switches which automatically cut out current consumers of secondary importance such as fans and heaters. The greater simplicity of the layout in parallel has acquired increased importance owing to the greater size of the installations, brought about by the extended use of electrical auxiliaries in steamers, and the adoption of the all-electric auxiliary drive in motor vessels, while in electrically-propelled vessels the requirements of the main installation in respect of excitation, ventilation, etc. also lead to increased dimensions of the auxiliary generating plant. In large present-day turbo-generators, fast-running turbines drive the generators through reducing gears and sea-water cooling in built-in ribbed coolers has recently been adopted. In such cases the generators take the cooling air from the surrounding space into which it is pressed back after the heat absorbed from the generator has been abstracted in the cooler. In Diesel generators airless-injection four-stroke engines and for large outputs, single-acting two-stroke engines of the trunk-piston type are well established in German vessels. Storage batteries are not employed for lighting and power purposes to any great extent, but they are generally used for emergency wireless transmitting sets and for supplying current to telephone installations, the tension adopted being either 12 volt or 24 volt according to size. In order to obtain improved economy generators driven off the main shafting by means of chains or gear transmission have recently been fitted, as for instance in the four vessels of the "Hansa" class of the Hamburg-America Line where pairs of 150-kW. generators of this type supply the current for the auxiliaries required in connection with the operation of the main engine, and these are at the same time capable of feeding into the general auxiliary system. In the case of motor vessels such as the "Caribia" and "Cordillera", on the other hand, steam of 86·5lb. pressure and 480° F. temperature generated in exhaust gas boilers is utilized in a 250-kW. turbo-generator, with the consequent improvement of several per cent. in the overall thermal efficiency of the installation. The author reproduces the main distribution diagram of the cruising liner "Wilhelm Gustloff" of the "Strength through Joy" organisaton. This vessel is equipped with two "generating stations" of which one consisting of three 380 kW. Diesel generators is situated in the main engine room, while two Diesel generators of the same output are placed in the auxiliary engine room, a cross-over connection enabling the two sets to be operated either independently or in parallel. The supply connections of the most important current consumers are distributed over the two stations in such a manner as to ensure a reserve in case of the breakdown of either set. The emergency generating set, which is situated on the boat deck, is fitted with an appliance which permits automatic starting in the case of the stoppage of the main supply. On the switchboards all live parts are in accordance with German practice arranged at the back, the front being reserved for the actuating handles and the instruments, so as to ensure safe operation. The cable material employed in German installations is of the lead-covered rubber type, the use of lead-covered paper cables being avoided on account of the difficulty of forming branches. In cabins and public rooms rubber-insulated conductors are fitted in wooden casings, covered with two coats of silica paint for fire protection, and conductors serving different purposes are distinguished by differences in colouring. Endeavours are also being made to introduce cables without lead coverings, such as the "Buna" (rubber substitute) cables used in the "Wilhelm Gustloff", and the author considers that these types are likely to gain ground owing to their reduced weight. In view of the great number of cables to be dealt with, these can no longer be made to pierce watertight and fire-resisting bulkheads singly. Special bulkhead passages are therefore arranged to take large bundles of cables and in view of the fire risk various non-inflammable brands of putty are taking the place of Chatterton's compound to secure water-tightness. To eliminate interference with the wireless installations the more recent German regulations prescribe the adoption of symmetrical reversing pole windings. Apart from this, the author considers that it is sufficient to give special attention to motors placed close to the wireless installations and to earth the coverings of cables leading into the spaces where these are situated so as to suppress the interference waves emanating from the ship circuits. Reviewing constructional details associated with the various applications of electricity to marine uses, the author states that for lamps of up to 60 Watts, holders of the Swan bayonet type are in general use, as in comparison with the Edison type these offer the advantage of not being loosened by vibration. For lamps of larger sizes, however, Edison holders with spring bottom contact are adopted. For staterooms reversible switches are preferred. These are housed under common covering plates with the bell pushes in sheet metal cases and fitted with rubber sound dampers. The type of switch is not standardized, but for the sockets the use of ceramic materials is strictly adhered to in German merchant ships. The motors are made moisture proof throughout and if necessary provided with heat-resisting windings. The magnet frames are of the welded-plate type and the bearings are either ball or roller bearings with vibration damping beddings where motors affected by hull vibration stand still for prolonged periods. To save space multiple automatic starting appliances have been developed as in the case of the liners "Caribia" and "Cordillera" where two starters of this type each serving nine motors are fitted close to the main switchboard, with starting and stopping pushes at the motors, the connections being arranged in such a manner as to enable each starter to act as a stand-by for the other. For groups of small motors, special starting boards are provided from which one or several motors can simultaneously be started by means of a change-over switch and a common automatic starter. A brief review is given of the development of electric deck auxiliaries, kitchen equipment, and heating installations in German ships and it is stated that with the introduction of alternating current, increasing use is now made of electrode boilers. *(To be continued).—C. Meyer. "Schiffbau", Vol. 39, Nos. 10 and 11, p. 161 and 188, 15th May and 1st June, 1938.*

The Mobilisation of Knowledge.

Sir Josiah Stamp, in the Liverpool University Rankin Lecture, discussed the classification of technical papers and articles and the question of rendering available to engineers the research results and other new matter contained in the enormous number of articles published throughout the world. He stated that existing abstracts do not cover the field for engineers in the same thorough way as for physicists, chemists or metallurgists, and even if they did adequately cover engineering itself, there would remain the problem of supplying information about advances in kindred branches of science which might be of importance to engineers. He advocated the Universal Decimal Classification System as a method of indexing articles, but the high degree of subdivision to which this system lends itself may actually be the reverse of helpful. Most of the articles published contain little that is new or valuable, and only the minimum number should be abstracted, or the results will be indigestible. The production of abstracts or indexes of all scientific matter by organized highly technical and highly critical staffs is still a long way off. This probably does not result in important novelties being overlooked, but it may cause time lag in their dissemination.—*"Engineering", 3rd June, 1938.*

The Joint Committee on Materials and Their Testing.

The first annual report has been published. The Committee represents 25 British institutions and has also taken over the duties of the British Committee of the International Association for Testing Materials. The first General Discussion, at which foreign as well as British papers were read, was held in October, 1937, the subject being "Notched Bar Impact Testing". A discussion on "Non-Destructive Testing" is to be held in November. These discussions are associated with particular Institutions, the first with the Manchester Association of Engineers, and the second with the Institution of Electrical Engineers.—*"Engineering", 3rd June, 1938.*

Disorderly Molecules and Refrigerating Engineering.

The molecular mechanism of refrigeration is discussed in non-technical terms. Sizes, velocities, collision frequencies and phenomena are described in detail. Under normal conditions the molecules of a substance in the gaseous state are about ten times as far apart as in the liquid or solid, and not, therefore, so widely separated as is commonly supposed; latent heat of evaporation is a measure of the intra-molecular attraction. In general, expansion of a compressed gas causes cooling (Joule-Thomson effect) *e.g.* air at 0° C. cools 0·29° C. for a pressure drop of 1 atm., and some gases may even be liquefied in this way. In practice, expansion to atmospheric temperature is very rare, since the work done in compression is approximately proportional to the logarithm of the ratio of initial and final pressures. To obtain liquefaction the gas must originally be below its critical point—for air 132° K.—this being secured by a cold exchanger developed by Linde and Hampson. Claude cooled the compressed air by allowing it to expand in a cylinder producing external work, the cold expanded air being used for cooling purposes, as before. Lubrication troubles were experienced owing to the low temperature and to avoid these Kapitza used an undersize piston, working his liquefier very fast, to minimize leakage. With an efficient rectification column almost complete fractionation of liquid air is possible; of the rare gases argon is used in filling electric light bulbs and neon in advertising signs. Carbon dioxide can be liquefied by mere pressure since its critical temperature of 31° C. is above room temperature; on releasing the pressure, solid CO_2 (snow) is obtained which passes directly into gas and is therefore easy to handle. If ferric alum in a magnetic field has the field suddenly removed, cooling occurs by starting from a temperature near the absolute zero, a point as low as 0·003° K. has been attained. Present-day refrigerator practice with ammonia and carbon dioxide, and its applications in artificial weather, skating rinks, boring in wet sands, and food transport, are described. 1¼ million tons of ice are produced annually in Great Britain, over a half for the fishing industry. In the twenty years to 1935 the number of refrigerated certificated ships rose from 174 to 546; total refrigerated food imports in that year were £110 millions, of which £39 millions comprised 19 million cwts. of meat.—*F. Smith, "James Forrest" Lecture to the Institution of Civil Engineers; reproduced in "Engineering", 6th May and 13th May, 1938, pp. 501-502 and 576-577.*

Engine Bearing Temperatures.

Experiments were carried out on a reconditioned used six-cylinder car engine, with bore 65mm. (2·6in.), stroke 101·6mm. (4in.) and swept volume 2022 cc., with crankshaft running normally in four white-metalled bearings of length 1·75in. and 2in. diam., with maximum continuous speed 3,000 r.p.m. The technique of the measurements by copper-constantan thermocouples is described. An appreciable proportion of the temperature-rise in the lubricant is due to heat picked up during its passage through hot oilways. A given change in inlet temperature persists without substantial alteration through the whole system, and temperature rise in the bearings is roughly proportional to the inverse of the circulation rate; these facts suggests that a large proportion of the heat generated in the bearings is removed as sensible heat in the oil. Plots of the temperatures of crank pin and main bearings against engine speed were found to be approximately linear. Experiments with three oils indicated that the thinner lubricants showed considerably less increase in temperature and less decrease in actual operating viscosity, as speed increased; it would appear therefore that, in certain conditions, bearing life might be extended by use of a light oil. The reduced frictional loss is indicated on torque-speed curves. In general there is comparatively little change in bearing temperatures over a fairly wide range of engine load. The paper is illustrated with 13 graphs, 4 figures and a photograph of the measuring apparatus; further work on six-cylinder engines —a 4 litre at maximum speed 3,400 r.p.m. and a 1½ litre at 4,400 r.p.m.—is contemplated.—*C. G. Williams and J. Spiers, "The Engineer", 6th May and 13th May, 1938, pp. 505-506 and 548-549.*

Ship Design for Rough Weather.

In general, ship design is based on smooth water performance, with allowances to take account of the varying and apparently indeterminable conditions of actual service. The seaworthiness of the merchant fleet amply confirms the soundness of this, but a new technique is developing. While the m.s. "San Francisco" was hove-to during exceptionally heavy weather in the North Atlantic, wave profiles were investigated by electric contacts outside the hull, pitching by a gyro, and water pressure by diaphrams at various parts of the body; from these data the accelerations and forces acting on the vessel in turbulent seas were determined. The stresses deduced from these showed close agreement with those measured directly by the deflection of the ship. Model experiments have done much to advance design for rough-water conditions, the cruiser stern having become general. Its effect is to move aft the pitching point so that the propeller remains submerged and racing is avoided. Reduced resistance is also obtained by reversion to the heavily raked stern, which is being fitted increasingly in full-form ships these being very susceptible to the speed-reducing effect of rough weather. To improve the reduced course-keeping qualities the adoption of mainmasts trysails has been advocated, as used to improve the steering of trawlers. Marine machinery is at a disadvantage in rough weather, because of the lack of variable speed-reduction gearing suited to the large powers transmitted; with a constant pitch propeller, increased resistance involves lowered speed and consequent reduced efficiency. Propellers with rotation-torque characteristics correlated to reduce this degeneration are contemplated, but at present the theory of propeller operation is not too well understood. Attempts are now in progress in Britain and Germany to improve speed indicators; a Pitot tube transmits pressure via a mercury column to a speedometer; very accurate results quite unaffected by rough weather have been obtained.—*"Times Trade and Engineering", June, 1938, p. 32.*

Blowers and Compressors.

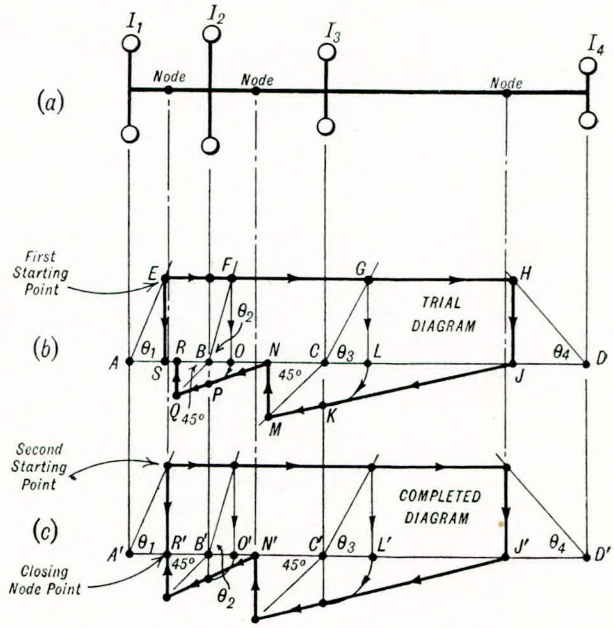
The special detachable supplement of 36 pages opens with an historical survey by W. J. Kearton, under the heads—Blast-Furnace Blowers. Positive Rotary Blowers and Compressors, Reciprocating Air Compressors, Turbo-Compressors, Regulating Gears for Turbo-Compressors, Turbo-Compressors for Moderately High Pressure, Compressors in the Chemical Industry. Manufacturing practice in various countries is then described in detail, special attention being given to scale-drawings and photographs, of which there are over seventy of each. This wealth of illustration has naturally entailed some limitation of letterpress, despite the 36 pages, and the compilers have concentrated their attention on special or unusual features or new developments. The section on British practice is classified under vertical machines, multi-stage machines, gas compressors, vacuum pumps, horizontal machines, turbo-blowers and compressors, and rotary machines. In the American section subdivision under the companies' names is adopted. Under the section on Continental Practice, machines produced in France, Switzerland and Germany, are discussed.—*Suppt. to "The Engineer", 27th May, 1938, 36 pp.*

Measurement of Circulating Water.

Little attention is usually paid to measurement of circulating water, even in the up-to-date power-house, and although the work involved is only a small fraction of the total turbine output, it is obvious that the pumping of 10,000 tons or more of cooling water per hour cannot be had for nothing. Since flow and pumping head are substantially predetermined by the original design of the plant; scope for economy is usually limited, but from an efficiency standpoint the value of such measurements is high. Further, only about one third of the energy input is converted into electricity, while over 60 per cent. may be carried away in the circulating water, and one degree rise in temperature may mean an increase of several per cent. in overall heat consumption. The problem is that of metering at 100 cu. ft./sec., and for the results to have any real value, each condenser must be treated separately; fortunately the range of flow is small. Since it would interfere with siphoning, the V-notch is precluded, so that in effect measurement is restricted to Venturi or sharp edge inserts in the inlet pipe. Alternatively Pitot-tubes or loss-of-head measurements may be used after previous calibration. On principle an addition to the already formidable array of instruments is to be deprecated; nevertheless a single loss of more than half of the energy of the fuel should not escape attention entirely. Inlet and outlet temperatures are already known, and this supplementary information would be of use in estimating the performance of the condenser itself. The engineer should account for every B.Th.U. liberated in his furnace; he cannot do this while in any degree uncertain of the amount rejected by his turbines.—*Leader, "The Engineer", 27th May, 1938, pp. 595-596.*

Highest Frequency of Torsional Vibration.

In certain very high-speed systems destructive stresses may be set up through coincidence of one of the lower impulse harmonics and the *highest* frequency of natural vibration. The author has devised a simple graphical method for locating nodes in an idealised system comprising a number of rigid mass moments of inertia spaced in any manner along an inertialess shaft of uniform torsional elasticity. A system with m masses gives $(m-1)$ nodes if "free-free", m—if "fixed-free", and $(m+1)$ if "fixed-fixed". Once the nodes have been found, frequency can be calculated by substituting the value of any mass together with the length of its "equivalent single shaft" in the equation $(2\pi f)^2 = (2\pi/T)^2 = NJ/l_1 I_1$ in which f is the frequency, N the shear modulus for the shaft material, J the polar moment of inertia, l_1 the length of shaft controlling the mass and I_1 the moment of inertia of the mass



about the shaft axis, all quantities being expressed in consistent units. The conception is developed from a geometrical standpoint for single mass fixed-free, single mass fixed-fixed, four mass free-free, three mass fixed-free, and six mass free-free systems, and it is explained how it can be applied to the case of axial vibrations of masses on a rod; N is replaced by Y.M., I and J are replaced by the masses M and cross sectional area of the shaft A, respectively. In a further contribution (*"The Engineer", 27th May, 1938, p. 592*) the author discusses an analogous optical construction suggested by Dick (*"The Engineer", 11th March, 1938, pp. 267-268*).—*G. G. McDonald, "The Engineer", 13th May, 1938, pp. 542-544.*

Development and Performance of the Maier Form.

During the last ten years the Maier form of hull has been used in 480 seagoing ships ranging up to 22,000 tons. The advantages claimed include a reduction in horse-power of 8 to 10 per cent. in smooth water, and 15 to 25 per cent. in heavy weather due to reduced pitching and less racing of the propellers in consequence. There is a gain of 2 to 3 per cent. in cubic capacity, and an increase in deck area, greater stability, and less damage to both vessels in a collision, on account of the overhanging bow. High propulsive efficiency has been achieved as a result of many tank model tests, and from the analysis of service performance data, for a variety of classes of ships. The ships built on the Maier principle include 140 fishing vessels and 43 coasters. For these seaworthiness and heavy-weather performances are particularly important. A gain in speed on trial of 1/4 knot as compared with a ship of normal design was recorded for one coaster. The Maier design was successfully applied to some ships intended partly for river work and partly for sea service, trading between London and Cologne. 120 large cargo vessels have been built and a number of 8-9,000 ton tramps with steam reciprocating engines showed a fuel coefficient in service of 35,000. Among faster cargo vessels, a 14-knot motorship gave a fuel coefficient of 100,000. The system has proved suitable for fruit carriers requiring large tween-deck spaces; the flared bow lines protect the deck cargoes carried on these ships from seas and spray. 12 fruit ships and 23 tankers have been built with Maier bows and some notable gains in average speed in very heavy weather are reported. For passenger ships the lessened pitching makes for greater comfort, and several have been rebuilt and converted, improvements in machinery being made at the same time, resulting in a total gain in speed of 2 knots. One 300ft. passenger ship of 21 knots has been built, and others are projected. Rather more than half the total number of ships has been constructed in Germany, and 55 in England.—*H. Kloess, "Werft, Reederei, Hafen", Vol. 19, pp. 164-170.*

Materials of Aircraft Construction.

The article is based on the Wilbur Wright Memorial Lecture, in which the author compares the properties of different structural materials and describes recent developments. Specific lightness is advantageous even though the strength and modulus of elasticity are reduced in a similar ratio to the specific gravity, since the lighter material, with the corresponding increase in thickness, is less liable to buckling in shear or compression. High tensile steel strip as used in biplane wing structures requires spar sections which are of complex type to withstand the tendency to buckle; wood and light alloy members can be of simpler form. Light alloy is suitable for monocoque fuselages, where the skin takes shear loads and also part of the bending loads, and for thick monoplane wings, in which the metal skin usually takes shear only, the bending loads being carried by spar flanges and stringers. Extruded duralumin sections are widely used, and "clad" duralumin skin to resist corrosion, although further treatment in the form of anodising and varnishing is general for additional protection. Riveted connections are usual at present, but welding is likely to be developed. A recent development in wooden construction is the use of plywood in two layers separated by a layer of balsa wood, the plywood being thus rendered stable in compression. Reinforced timber, consisting of impregnated laminations, cemented together under pressure, has been produced, and is very much stronger than ordinary timber, although somewhat heavier. The use of plastic materials has been proposed, and whilst those at present available have a lower strength-weight ratio than competitive materials, they may be moulded into panels, facilitating assembly.—*H. J. Gough, "The Engineer", 3rd June, 1938, pp. 626-628.*

The Motor Liner "Black Prince".

The "Black Prince" is one of two sister ships built in Norway for the Oslo-Newcastle service. Her principal dimensions are length 386ft., beam 53ft., depth to main deck 30ft., draft 18ft. 6in., gross tonnage 5,200. She carries 200 first-class passengers and 50 second-class, and has a service speed of 18·5 knots. The main machinery consists of two sets of nine-cylinder two-stroke single-acting Diesel engines giving a total of 7,000 i.h.p. at 145 r.p.m. in service, the bore and stroke being 500 and 900mm. respectively. The electric generating plant comprises three 165 kW. oil-engine driven dynamos. The steering gear and cargo winches are electrically driven. The main engines are of the airless-injection type, and are fitted with poppet exhaust valves. The exhaust gases are passed to two composite oil-fired boilers; at sea there is a surplus of exhaust heat. Most of the first-class accommodation consists of single-berth cabins. Special provision is made for the carriage of motor-cars on the fore deck and in the tween-decks.—*"The Engineer" 27th May, 1938, p. 602.*

Vibration in Ships.

The principal unavoidable cause of vibration is due to wake variation over the propeller disc. All propellers create a disturbance caused by the irregularity in the propeller resistance.

The empirical formulæ and the mathematical calculations for the determination of the frequency of flexural vibration in ships are usually derived from the ideal case of the free-free beam of uniform section vibrating in air, but the difference between the assumptions made in the theoretical case and the conditions actually obtaining on a ship at sea is in certain respects so great that it is impossible to obtain agreement between theory and practice without introducing in some form or other empirical coefficients or more or less scientifically determined correction factors.

These factors are:—

(1) The virtual mass, or mass of water entrained by the hull during vibration.

(2) The distribution of moment of inertia and mass over the length.

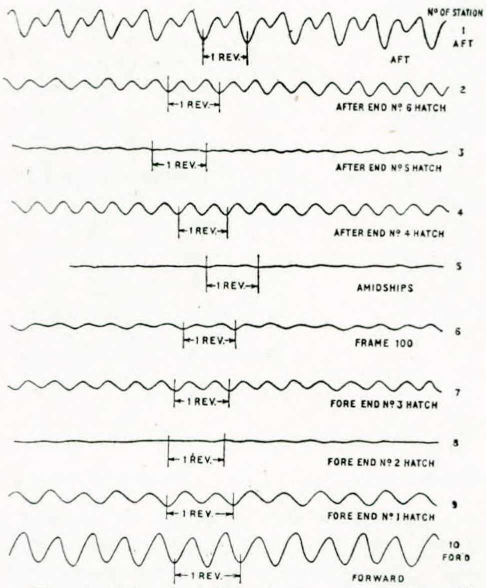


FIG. 1.—Diesel-engined shelter deck cargo ship. Displacement 8,740 tons. Vertical flexural vibration, three-node type.

(3) The ratio between the nominal and the effective value of the product E × I.
(4) The influence of the shear deflection.
(5) The damping factor.
(6) The rotational K.E.

As in all strength calculations, including the mathematical determination of the frequency of vibration of a ship's hull, which is also essentially a strength problem, the modulus of elasticity "E" and the moment of inertia "I" occur as a product, and the determination of which of the two factors is responsible for the discrepancy is largely a question of opinion.

Since the test-piece value of the modulus of elasticity cannot reasonably be expected to change simply because the steel is worked into a ship's structure, the explanation must logically be found

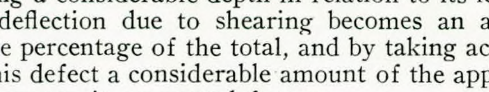


FIG. 2.—Amplitude curve.

in certain inconsistencies in the standard strength calculation. In all beams the deflection consists of two components; the deflection due to bending, and that due to shearing. In a girder, such as a ship, having a considerable depth in relation to its length, the deflection due to shearing becomes an appreciable percentage of the total, and by taking account of this defect a considerable amount of the apparent discrepancy is accounted for.

The remainder of the difference may be attributed to the partial failure of the longitudinal members under compression to take up their full share of load, to the progressive reduction of stresses towards the centre of the deck and bottom, to imperfections of workmanship, to differences of temperature, and to several other causes.

When faced with the impossibility of obtaining by pure mathematics the exact quantitative solution of a problem, and this seems to be the general rule in naval architecture, one is compelled to adopt empirical coefficients or systems of calculation in order to reconcile theory with practice. The so-called "standard" inertia calculation, neglecting all semi-continuous and intercostal members and all the sections between openings, is a typical example of all empirical calculation.

Reliable information for checking the accuracy of the "standard" moment of inertia is very scant. The observations made by Dr. Lockwood Taylor

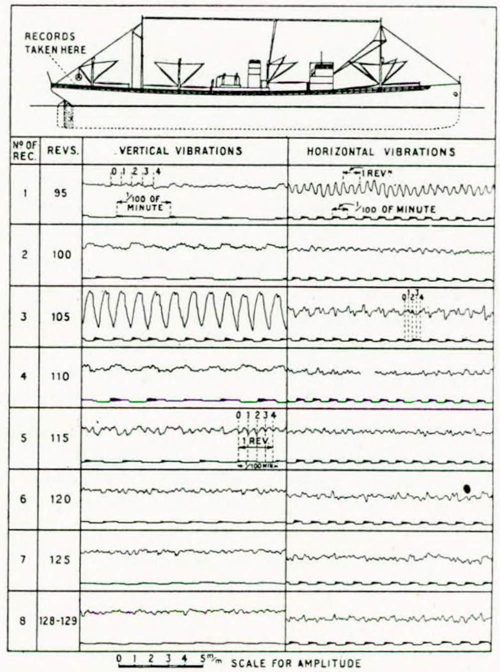


FIG. 4.—Vessel with propeller half submerged. Draught 12ft. 7in. aft. Displacement 5,050 tons.

seem to confirm that for transversely framed merchant ships, assuming an "E" value of 13,000 tons per sq. in., and after correction for shear deflection, the "standard" and the "effective" "I" values are approximately equal.

For longitudinally framed tankers, the inclusion of about 50 per cent. of the area of the longitudinals also brings agreement between observed and calculated deflections. The reduction in thickness of plating in passing from merchant to Naval vessels increases the effect of buckling and reduces the "effective" "I" to values considerably lower than the "standard".

Records of Vibration.

Vessel A.—Fig. 1 shows a series of records taken at ten different stations along the deck. The frequency of vibration is exactly two per rev. (second order), while there are three points along the vessel's length, corresponding approximately to stations 3, 5, and 8, which do not move (nodes), which characterize the "mode" of vibration. A "three-node", "secondary" or "second-degree" mode of vibration of the second order is therefore called into play.

The vibration in this case was caused by the second order unbalanced forces or moments of the main motor. By plotting to a suitable scale the recorded amplitudes at each station, and joining the points thus obtained by a fair curve, the characteristic "amplitude" curve given in Fig. 2 is obtained.

Vessel B.—In Fig. 4 vertical vibration records 1 and 2 show the fourth order vibration due to the four-bladed propeller together with an eighth order vibration quite pronounced in this case (double shock of blades leaving and re-entering the water with propeller only half-submerged, draught 12ft. 7in.). The increase of revolutions from 100 to 105 causes the whole vessel to vibrate violently with frequency 105. "Resonance" has been reached between the first order unbalanced forces of the main motor (105) and the lower critical frequency of the hull (105). By increasing the revolutions to 110 the vibration disappears.

Vessel C.—Referring to Fig. 7 for vertical vibration, the records having been taken forward, there is no trace of propeller vibration. The undulations in the first three records are due to pitching. Resonance occurs here at 114 revs. It is interesting to note that a second degree vibration is superimposed on the primary.

Fig. 8 gives an interesting example of "local" vibration caused in this case by the second order unbalanced forces of the four-cylinder auxiliary generator. The numbers on the sections on the left indicate the position in which the corresponding records, given on the right, were taken.

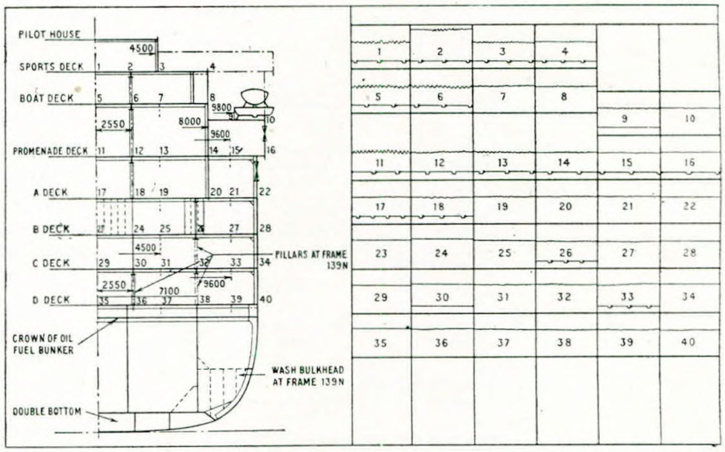


FIG. 8.—Quadruple-screw ship. Local vibration (vertical).

Vessel D.—Fig. 9 gives a good example of the recurring type of vibration set up by two engines running at different speeds. As the vibration in this case is due to the second order forces (two vibrations per rev.), the period during which the amplitude goes through a semi-cycle from maximum to minimum is precisely the time taken by one of the engines to make an extra one-quarter rev. ($\frac{1}{2}$ cycle second order force, $\frac{1}{2} \times 180^\circ = 90^\circ$). The time taken to perform the extra one-quarter rev. (from 1 to 2) $= 13/100$ minute; therefore at that particular moment one engine was running $\frac{4 \times 13}{100} = 1{\cdot}93$ revs. per min. faster than the other. When record "A", Fig. 9, was taken the engines were apparently running at almost synchronous speed.

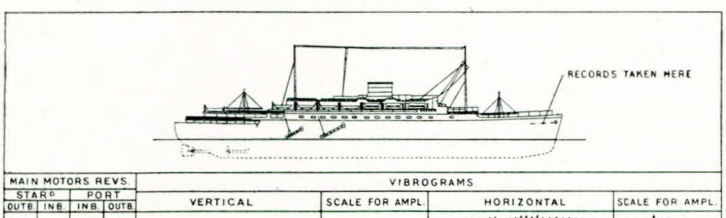


FIG. 7.—Quadruple-screw motor passenger ship. Displacement 19,530 tons.

Cure of Vibration.

Granted that some kind of vibration must unavoidably be present, what are the means at the disposal of the designer for minimizing its unpleasant effects?

(1) Special attention should be given to the balancing not only of the primary, but also of the secondary and higher order forces and moments of all reciprocating machinery.

(2) The most accurate balancing is useless to prevent vibration unless combined with a rigid engine. In an engine with flexible framing each cylinder will act on its own and set up vibration. Although motors have been generally improved in this respect in recent years (thanks also to the action taken by shipbuilders who refused to supply under the name of "seatings" something which, by rights, should have formed part of the engine bedplate), a few more tons

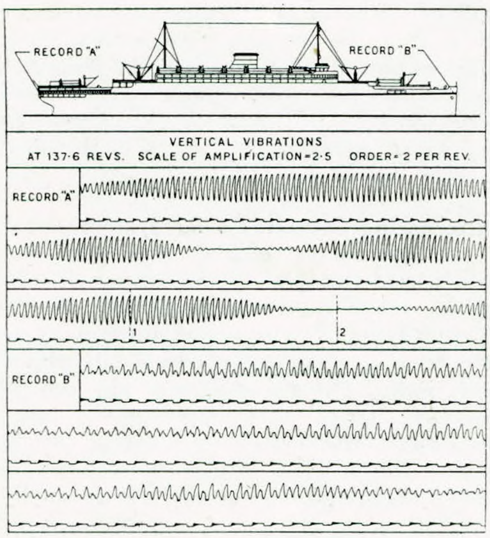


FIG. 9.—Twin-screw motor passenger ship. Displacement 26,000 tons.

of cast iron judiciously distributed over the engine framing would be well worth the little extra money.

(3) Motorcar designers, who are apparently more keenly concerned to keep down vibration than their marine confrères, have realized long ago that the point of support of reciprocating machinery should be situated, to minimize vibration, at the point where the least motion due to internal forces takes place, *i.e.*, at about mid-depth of the engine, and that the satisfactory results thus obtained could be further improved by placing the engines on elastic supports.

(4) So far as the average passenger is concerned, half the discomfort caused by vibration is due to rattling. Here again the motorcar designer could teach something to the shipbuilder. The cheapest car, at least when new, is rattleproof; why some of the simple devices, so successfully used on cars to eliminate noises, could not be used on luxury liners, where doors, beds, glasses, etc., continue undisturbed their noisy protests, is a mystery which still remains to be solved.

(5) Local vibration, when confined to isolated portions of decks between pillars, can be easily

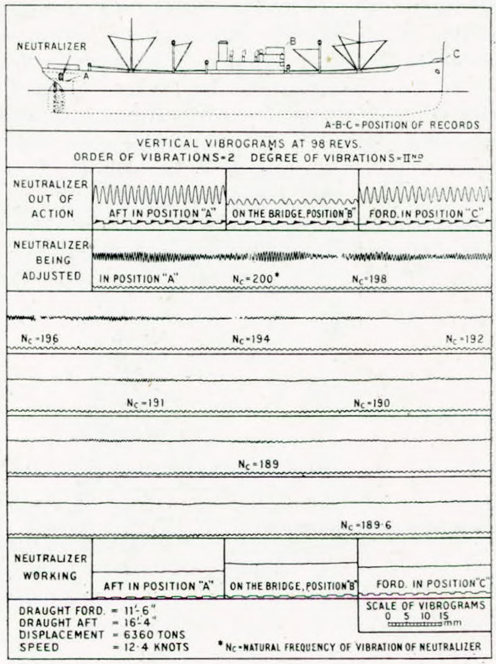
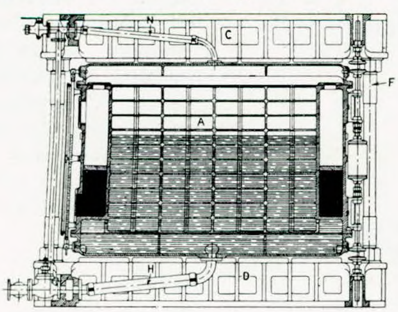


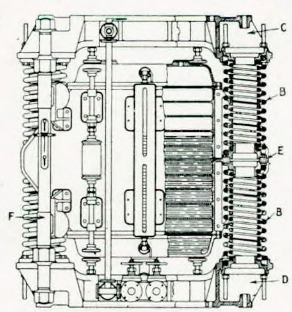
FIG. 14.—Vessel to which Figs 1 and 2 refer. Effect of neutralizer.

eliminated by extra pillaring or local stiffening, or even ballasting.

(6) A form of local vibration, against which one is practically helpless, is that set up by the propellers.

The practical difficulties encountered in the elimination of vibration have led to the study of the third and last possibility of avoiding vibrations, viz., the neutralization of the disturbing forces. An attempt of this kind was made by Dr. Frahm as far back as 1907, but apparently without much success. A practical solution of the problem is that devised by Dr. Loser, of Messrs. Cantieri Riuniti dell' Adriatico.





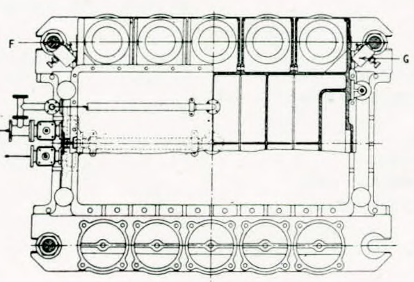


FIG. 12.—Neutralizer for vertical vibration.

The apparatus designed by Dr. Loser (Fig. 12) consists of a cast-iron tank A, supported through the projecting lugs E, by a series of double springs B, inserted between E and two rigid frames C and D. C and D are inter-connected by four strong tie rods F, which also act as guides for the vertical motion of A. Guide rollers G render the system practically frictionless. Internally, the tank A is sub-divided into a number of intercommunicating small cells, which, through the pipes E and H, can be filled at different levels with water, thus altering the mass of A, and hence the natural frequency of the system.

When a practically frictionless elastic system is acted upon by a periodic impulse, the phase of the resulting vibration is only slightly retarded to that of the impulse so long as the frequency of the disturbing force is smaller than the natural frequency of the elastic system; when synchronism is reached a sudden phase change takes place, impulse and vibration becoming outphased through practically 180°. In this case the exciting force is supplied by the vibrating ship and by adjusting the quantity of water in the tank "A" the natural frequency of the neutralizer can be brought to be slightly less than that of the ship, then, in accordance with the principle just enunciated, impulse (ship) and vibration (neutralizer) will be outphased through 180°.

Fig. 14 shows graphically the effect of the neutralizer. The original vibrations have been reduced by about 94 per cent. The neutralizing force transmitted was about 8 tons, and the weights of the neutralizer and fully loaded ships 12 tons and 11,700 tons, respectively.—*M. Constantini, Trans. Institution of Naval Architects, 1938; "The Motor Ship", May, 1938, pp. 70-1.*

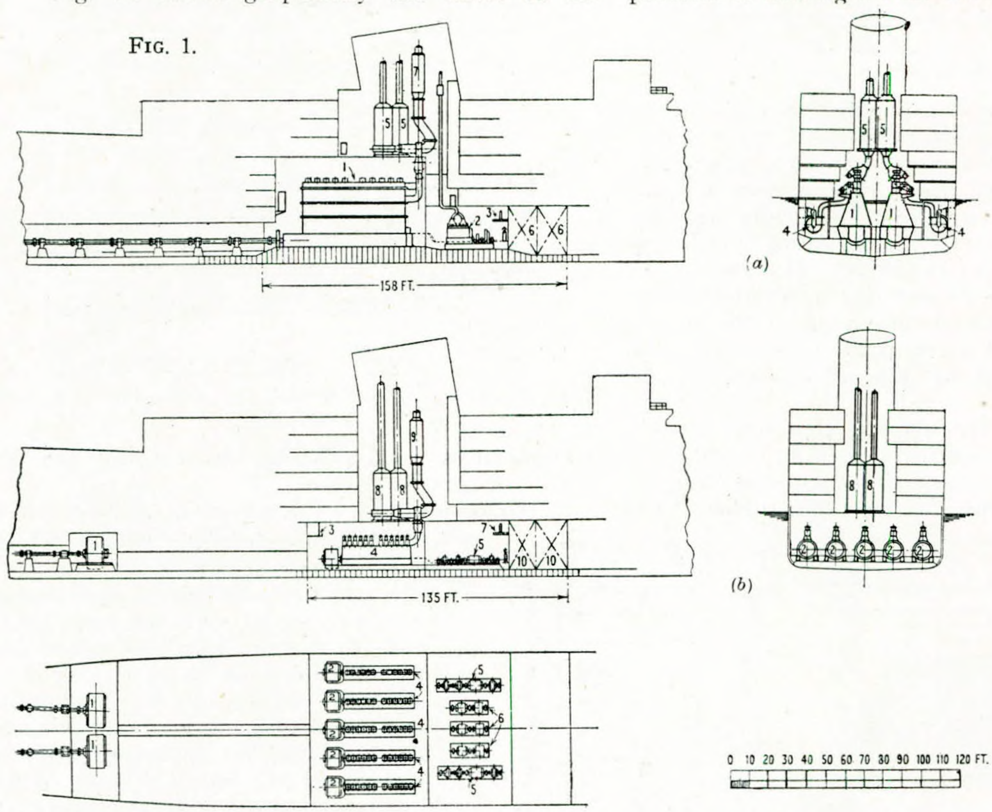
An Alternating Current Power System.

The most robust, reliable, highly efficient, and lightest for its output of all types of electrical machinery is the synchronous salient pole alternating-current type. In the vessels fitted with turbine-electric drive synchronous machines are almost universally used. The advantages of the synchronous motor have been fully appreciated, and many schemes have been considered whereby this type of machinery can be used with Diesel engines, but the problem of holding the alternators in parallel during manoeuvring periods has, up to recently, been limited in application in a practical manner to equipments comprising only one or two engines *per* propeller.

With the turbine-electric drive only one prime mover per propeller, or propellers, is in service, so that the question of parallel operation does not arise. The difficulty of holding any number of Diesel engines in parallel during manœuvring periods has been overcome by the method described in Appendix I.

The author proposes to take as an example a twin-screw passenger liner of, say, approximately 23,000 gross tonnage, having a total power of, say, 24,000 h.p. Fig. 1 shows the outline of the machinery spaces of a vessel fitted with :—

FIG. 1.



(*a*) *Direct-Coupled Diesel Engines.*

1. Two 12,000 S.H.P., 100 R.P.M. direct-coupled engines.
2. Five 700-K.W. auxiliary engine-driven generators.
3. Gallery for direct-current switchgear.
4. Four motor-driven scavenge blowers.
5. Waste-heat boilers.
6. Fuel tanks.
7. Silencer.

(*b*) *Diesel Engines with Alternating-Current Transmission.*

1. Two 12,000 S.H.P., 100 R.P.M. propelling motors.
2. Five 4,185 K.W. 225 alternators.
3. Gallery for alternating-current switchgear and control station.
4. Five 5,700 B.H.P. engines.
5. Two motor-driven exciter sets.
6. Three 500 K.W. motor generator sets.
7. Gallery for direct-current switchgear.
8. Waste-heat boilers.
9. Silencer.
10. Fuel tanks.

COST AND WEIGHT TABLES.

Direct Coupled Engine.		*Diesel Engine with Electric Transmission.*	
Two 12,000-h.p. per engine, 100 r.p.m., complete with accessories ...	£195,000	Five 5,700-h.p., 225 r.p.m. engines complete with accessories	£154,000
Five 700-kW., 300 r.p.m., 220-volts auxiliary generating sets	£38,700	Five alternators, 4,185 kW. Two 12,000-h.p. propeller motors at 100 r.p.m. Control gear, switchgear cables, exciters, air cooler, etc. Three 500-kW. motor generators	£85,500
	£233,700		£239,500

Direct Coupled Engine.	Tons.	*Diesel Engine with Electric Transmission.*	Tons.
Two 12,000-s.h.p., 100 r.p.m. engines with accessories	1,720	Five 5,700-B.h.p. engines, 225 r.p.m., with accessories	940
Five 700-kW. Diesel engine-driven auxiliary generators ...	265	Two 12,000 h.p., 100 r.p.m. motors ...	172
168ft. of 20-in. shafting, plummer-blocks, and seatings not required by electric transmission	100	Five alternators ...	155
		Control gear, switch gear, exciters, cables, ventilating fans, etc.	67
		Three 500-kW. motor generator sets ...	60
	2,085		1,394

Saving in favour of electric transmission ... 691 tons.

(*a*) Direct-coupled Diesel engines, 24,000 s.h.p., propeller revolutions, 100.

(*b*) Diesel engines with alternating current transmission, 24,000 s.h.p., propeller revolutions, 100.

The information on the Diesel engines has been supplied by Messrs. Sulzer Bros.

With the arrangement shown in Fig. 1, the electrical gear is entirely self-contained, and all auxiliary power is obtained from the main propelling engines; such auxiliaries as scavenge blowers (if fitted), lubricating and circulating pumps, etc., the duty of which varies with the speed of the propeller, would be driven electrically from the main alternators. The ship's ventilating fans, steering-gear, cooking, lighting, and refrigerating plant up to 1,500 kW., the requirements of which are independent of the speed of the propeller, would be driven from the main alternators through motor-generator sets, and therefore no auxiliary generator need be fitted beyond the supply of 40 kW. direct current, to provide excitation for the initial start of one of the alternators. This could be supplied from the emergency generator. After the initial start the electrical machines would be self-excited.

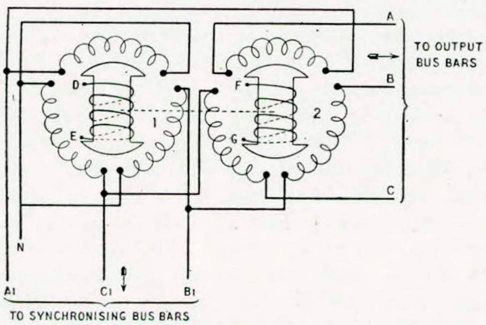


FIG. 2.—Showing field excitation circuits and connections between the two half-unit alternator phase circuits.

The electrical equipment would comprise two 12,000 s.h.p. main propelling motors of the synchronous type, running at 100 r.p.m.; five alternators of sufficient capacity to supply power to the propellers and to the auxiliaries, each rated at 4,185 kW. at 225 r.p.m.; two motor-driven exciters for supplying excitation to the alternators and motors; and three 500 kW. motor generator sets, 220 volts, for auxiliary purposes, other than those supplied by the main alternators.

The relative cost of the medium-speed Diesel engine and electric transmission, compared with a direct-coupled engine and auxiliary generators, is given above, the engine accessories being the same in each case.

To offset the saving of £5,800 shown in favour of the direct-coupled engines, there will be a saving in the air compressors, for the direct-coupled engines would require three compressors, each capable of delivering about 300 cubic ft. per min. at 450lb., whereas with the electric transmission only a small compressor would be required, and therefore the saving in favour of the electric transmission, due to the smaller compressor, would be about £1,500; the motors being placed aft would save about 81 tons of shafting, which, at £49 per ton, plus seatings and plummer-blocks, would be about £4,500—total £6,000.

The comparative weights of the two schemes are shown in the bottom right-hand table.

The overall efficiency of the electrical machinery from the engine coupling to the propeller

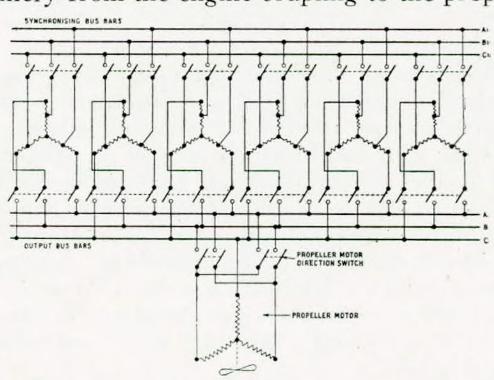


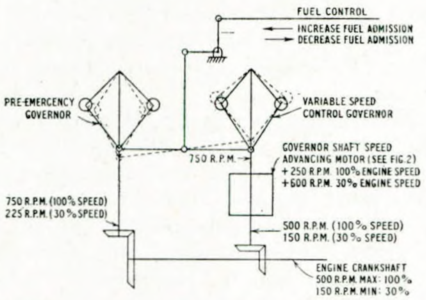
FIG. 3.—Group of six double-unit alternators arranged for supplying power to a propeller motor. A.C. power circuits only. Field excitation circuits not shown.

motor coupling, including all losses in the motors, alternators, cables, control gear and excitation, and fan power for ventilating the motor and alternator, would be :—

Engines in service ...	5	4	3	2
Load in s.h.p.	24,000	17,300	11,300	5,750
Propeller r.p.m.	100	90	78	64
Overall efficiency	91·7%	92·0%	90·6%	88·9%

The small variation in efficiency between full load of 24,000 s.h.p. and 5,750 s.h.p. is remarkable. Due to the lighter machinery, there should be a saving of about 1·8 per cent. in power at the various speeds, which would, of course, offset some of the electrical losses. In Appendix II detailed particulars of the losses are given, showing how the overall efficiencies are obtained.

It appears to the author that this type of propelling machinery would be particularly suitable for single-screw vessels of the higher power type, and it is outside his province to suggest what determines whether a vessel of, say, 8,000 s.h.p. shall have single or twin screws, but he has been informed by various responsible marine engineers that given two



Full lines show governor positions and linkage for engine speed 500 R.P.M.
Dotted lines show governor positions and linkage for engine speed 150 R.P.M.
At full engine speed (500 R.P.M.) both governors rotate at 750 R.P.M.
At 30 per cent. engine speed (150 R.P.M.) the pre-emergency governor rotates at 225 R.P.M., but the variable-speed control governor always rotates at 750 R.P.M.

FIG. 4.—Governor control.

vessels of exactly the same form, dimensions and displacement, the one being fitted with a single screw and the other with twin screws, the single-screw vessel will have a propulsive efficiency at least 10 per cent. better than the twin-screw vessel.

APPENDIX I.

Diesel Electric A.C. Ship-Propulsion System.

This system has been developed as a result of experience at sea since 1921 with alternating-current propeller motors of the salient pole synchronous type, used with turbo-electric propelling equipments.

For the benefit of those unfamiliar with the method of control adopted in the case of a normal turbo-electric equipment, it should be explained that each motor is normally supplied by a separate alternator, and the latter are not operated in parallel, though two or more motors are frequently connected in parallel with one alternator when operating at reduced power.

This arrangement enables the reversing switches between each motor and alternator to be opened on a "dead" circuit by previously interrupt-

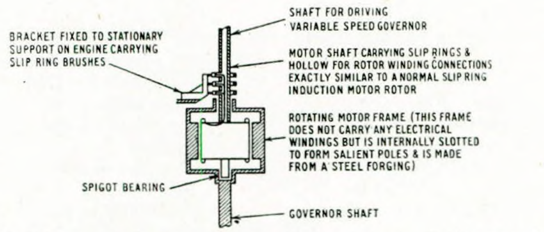


FIG. 5.—Internal arrangement of governor shaft speed-advancing motor.

ing the alternator excitation. The motors are provided with squirrel-cage windings in the pole faces, so that they start and reverse as induction motors, and are finally pulled into step by applying excitation to the salient-pole windings.

Speed control is obtained by varying the frequency by changing the turbine speed, and the frequency is usually reduced to about one-third of the full value while manœuvring, in order to give better torque characteristics.

Turning now to Diesel electric drive, the same system can obviously be used, provided that the number of engines is not greater than the number of motors, but this is rarely the case, since the electric drive is usually introduced as a means of coupling a number of high-speed engines to a single propeller shaft.

It becomes necessary, therefore, to operate two or more alternators in parallel, but if the fields of the alternators are de-energized to permit "dead" circuit switching, they will fall out of step, and time will be lost before the alternators can be re-synchronized so that their combined effect can bring about a reversal of the propeller motor. The difficulty becomes progressively greater as the number of generating units increases. The system described overcomes the difficulty entirely by maintaining the alternators in synchronism at all times, while still enabling "dead" circuit switching to be carried out when reversing the synchronous propeller motor. The solution is shown diagrammatically in Figs. 2 and 3.

Each engine alternator set comprises two half-size alternators, each having a distinct stator and rotor winding, but with the stator windings connected as shown in Fig. 2.

It will be seen that the corresponding phase on

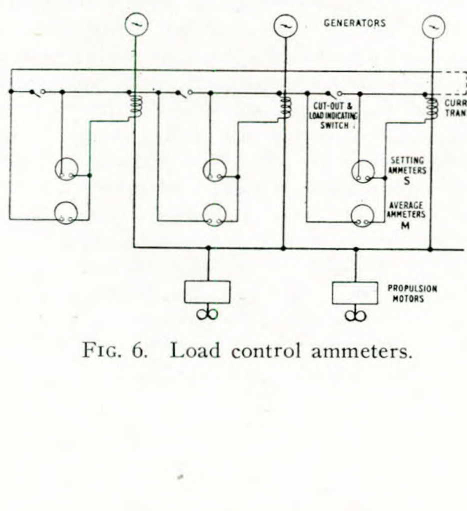


FIG. 6. Load control ammeters.

each half-size alternator is connected in series with the outer terminals marked A, B and C, and the "mid" point terminals A1, B1 and C1.

The rotating field systems are mounted on a common shaft in correct electrical alignment, so that when each half-field winding is excited equally, both in value and polarity, the phase voltage across A, B and C will be twice that across A1, B1 and C1.

If the field windings are equally excited, but opposite in polarity, it will be seen that the phase voltage across A, B and C will be zero, but the voltage across A1, B1 and C1 will remain unchanged.

Fig. 3 shows the stator phase connections for six complete engine alternator sets (the field connections are not shown), all connected to give a power supply to the output busbars A, B and C, and with the terminals A1, B1 and C1 connected to what are termed synchronizing busbars.

It will now be seen that by reversing one half-field circuit against the other half-field circuit of all the six alternators, the voltage at the output busbars A, B and C can be reduced to zero, while the voltage at the synchronizing busbars, A1, B1 and C1 remains unchanged.

It is essential to vary the speed of all the engines simultaneously, and the system (*see* Figs. 4 and 5) described employs a method which is applicable to an unlimited number of engines, and only requires an electrical connection between each engine and the control station. The engine governors always rotate at a constant speed, irrespective of the engine speed, so that the sharing of load between the engines is accurately maintained over a wide range of operating speeds. This is brought about by the use of a small synchronous motor which is best described as being inserted in "series" with the mechanical drive from the engine crankshaft to the governor shaft. A variable frequency supply is obtained from a small D.C.-driven alternator set and applied to all these synchronous governor motors, with the result that when the speed of the D.C. motor driving the small alternator is varied by means of a rheostat at the control station, the speed of all the engines is varied simultaneously, and this varies the speed of the propeller motor.

The engine attendant must have some ready means of knowing what load any engine should be carrying, assuming that the load is to be shared equally. It is obviously impracticable during a manœuvring period for the engineer at the control station to keep the engine attendant informed of the load each engine should be carrying, and for this reason an electrical indicator has been developed. Fig. 6 shows the electrical connections.

APPENDIX II.

It may be of interest to know how the efficiencies given are arrived at, and in the following table the losses are segregated :—

Engines in Service	5	4	3	2
% Power	100	72	47	26
% R.p.m.	100	90	78	64
	kW.	kW.	kW.	kW.
Two Propeller Motors, Output	17,900	14,150	8,420	4,650
Propeller motor losses :—				
Excitation, motors	134	121	107	94
Exciter losses	52	47	43	39
Fan power	72	56	33	19
Fan power motor exciter losses	28	23	14	9
Friction and Windage	24	20	14	10
Core losses	162	138	112	84
Copper losses	266	170	96	43
Five Alternators.				
Total losses :—				
Copper losses	270	216	163	108
Core losses	170	104	56	24
Friction and Windage	100	67	29	11
Excitation	180	144	108	72
Exciter losses	38	30	24	17
Fan power	72	56	43	29
Fan power motor exciter losses	14	11	9	6
Cable losses, motor	23	15	9	4
Cable losses, alternators	25	20	15	10
Total kW. for Propulsion	19,530	15,388	9,295	5,229
Overall efficiency from Engine Coupling to Propeller Shaft Coupling	91·7%	92·0%	90·6%	88·9%

W. J. Belsey, Trans. Institution of Naval Architects, 1938; "The Motor Ship", May, 1938, pp. 74-5.

Structural Stress in an Oil Tanker.

The determination of stress in a ship at sea during heavy weather is investigated in this paper in the case of an oil tanker in ballast and load conditions.

The vessel, an 8,000-ton tanker, is of the single-screw Diesel-propelled type. She was built in 1936, and is of combined longitudinal and transverse construction, having two complete fore-and-aft bulkheads broken only in way of the cofferdams. The principal dimensions are tabulated below.

Motor Tanker "San Conrado".

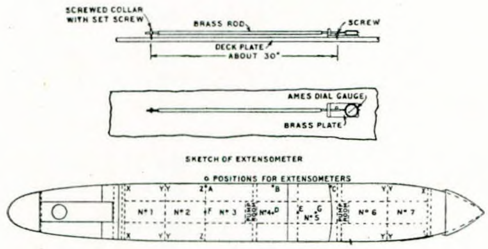
Length O.A. = 483ft.
Length B.P. = 460ft.
Beam Mld. = 59ft.
Depth Mld. = 34ft.
Draught (winter) = 26ft. 10in.
Corresponding displacement = 16,280 tons S.W.
Light weight = 4,595 tons.
Average sea speed = about 10 knots.

Observations were mainly confined to the upper side of the deck plating, where readings were taken in load and ballast conditions.

Most of the readings (at least their higher values) were obtained at position "E", Fig. 2 (*b*), *i.e.*, on the middle line between Nos. 4 and 5 holds.

Instruments.—The exposure to sea and air calls for the simplest and most robust instruments, and with this in mind the extensometers shown in Fig. 2 (*a*) were used. As shown, they were screwed into the deck at two points approximately 30in. apart, and as only two complete instruments had been constructed they had to be fitted in position as required. A 3in. portable strainmeter, which had been adapted for use at sea, was also available, and so at times three sets of readings could be taken practically simultaneously. Several dial gauges reading in $^1/_{1000}$in. and $^1/_{10000}$in. were used, and these were changeable.

When used in the same position, the small 3in. strainmeter gave good agreement with the extensometers. It would appear, though, that the only



FIGS. 2, 2A and 2B.

satisfactory method of measuring strain in really bad weather is by self-recording instruments, completely enclosed and electrically synchronized. Such were the type used by German investigators on the M.V. "San Francisco" when a range of stress as high as 8·8 tons per sq. in. was measured.

Rolling and pitching were occasionally observed and recorded. The maximum angle of roll was about 18°, while the maximum pitch was about 9°.

In this vessel, in a sea two or three points off either bow, there was noticeable at times a tendency

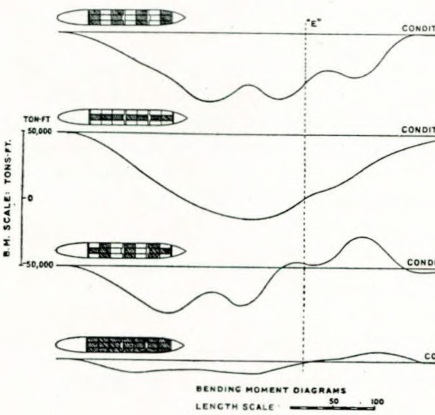


FIG. 4.

to "waggle" in a horizontal plane. The term "waggle", if not very scientific, describes exactly the nature of this movement. It was supposed that such flexing might be due to a low transverse moment of inertia about the centre-line.

Loading and Resulting Stress.—At the commencement of the voyage, tanks Nos. 1, 3, 5 and 7 were partially filled, right across, with water ballast.

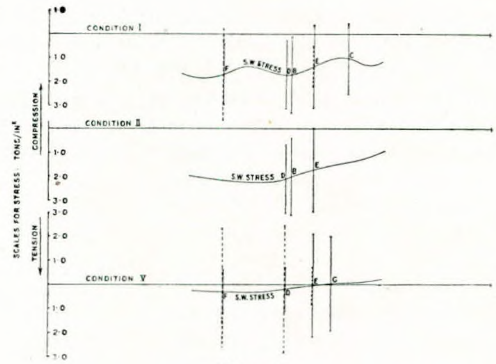


FIG. 6.

This is Condition I. as shown in Fig. 4. When the other tanks were cleaned, after about ten days at sea, the scheme of ballasting was reversed. The pumping, however, was stopped at an intermediate stage—Condition II.—in which the centre tanks only were filled, right fore and aft. This is an interesting condition, because while it would appear at first sight to give a good weight distribution for longitudinal stress, it turns out to be one of the worst conditions at sea, due, possibly, in some measure, to the loss of displacement. The motion in a sea-way was much more pronounced.

A long wire stretched diagonally across No. 2 tank (port) at the level of the upper shelf was the only means by which any movement could be detected. This shelf is about 3ft. above the neutral axis, and in Condition I. little or no movement was evident. In Condition II. a maximum movement of 0·02in. was observed on the pointer. The movement was jerky and irregular, and the period as ascertained from several attempts about $\frac{3}{4}$ secs. As it is impossible to estimate the effects of longitudinal bending this result can only be comparative. It is interesting to note that a calculation of the natural frequency of vibration of the vessel in Condition II. gives this figure as 81 per min., *i.e.*, a period of $\frac{3}{4}$ sec.

The bending moment (and hence stress) diagrams were also obtained by integration for each condition of loading. The homogeneous nature of both cargo and ballast enables this to be done with a considerable degree of accuracy. These diagrams are shown together with the appropriate loading in Fig. 4.

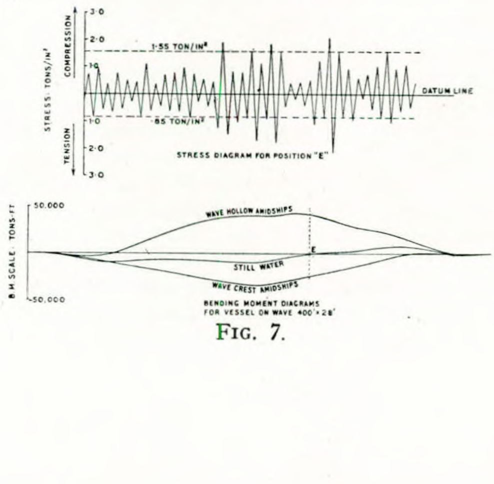


FIG. 7.

To assess, as completely as possible, the total stress in the deck at any time, the still-water stresses due to loading (Conditions I., II., and V.) are shown in Fig. 6. Actual ranges of stress measured in Conditions I. and V. are shown in their respective positions on the diagrams. As it was found that readings taken in positions "E" and "D" in Conditions I. and II. were almost identical, the maximum values for "E", "B" and "D" are also plotted on the still-water stress diagram for Condition II. This gives a slightly greater total stress than is obtained in either Conditions I. or V.

Wave-length and Range of Stress.—The largest waves measured were encountered on the homeward voyage in April. These were somewhat irregular, varying from about 380ft. × 25ft. to over 400ft. × 30ft. The average size was judged to be about 400ft. × 28ft.

The load curves were drawn for the fully-loaded vessel on such a wave, and from them the bending-moment curves shown in Fig. 7 obtained. These curves are for the wave crest amidships, and for the wave hollow amidships respectively. The wave was assumed trochoidal.

The result is rather contradictory. At position "E", measuring from the still-water line as datum, the effect is as follows :—

Compressive stress due to sagging = 1·55 tons/in.^{2}
Tensile stress due to hogging ... = 0·85 ton/in.^{2}

Range of stress = 2·40 tons/in.^{2}

i.e., the compressive stress is almost double the tensile stress, while over a length of stress diagram they have been shown to be approximately equal. It is, of course, possible that the assumed positions of the wave do not give the limiting values of stress of "E".

A diagram taken by an extensometer in position "E" under the above conditions is also shown in Fig. 7. On it are plotted the above calculated values.

In certain instances the measured range of stress agrees well with the calculated values, which might be taken as showing that such waves were actually encountered. It also suggests that the ratio of $\frac{\text{compressive stress}}{\text{tensile stress}} = 1{\cdot}85$ at "E" may be a peculiarity of this particular size of wave.

The main points arising from the observations may be summarized as follows :—

(1) The combined longitudinal and transverse form of construction employed affords ample strength in respect of normal hogging and sagging stress.

(2) Consequently stress values are low throughout—probably less than for cargo vessels of similar size and normal transverse construction.

(3) The method of construction and stiffening employed is not of sufficient strength to resist vibration and bending in a horizontal longitudinal plane. Some scheme of diagonal bracing would help materially to reduce straining of the wing bulkhead brackets.

(4) The ballast should not be distributed in the centre tanks right fore and aft, as this condition is not conducive to easy motion in a sea-way.—*I. C. Bridge, Trans. of Institution of Naval Architects, 1938; "The Motor Ship", May, 1938, p. 78.*

Hardening Gear Teeth by Oxy-acetylene Flame.

The author describes the workshop process of torch-hardening by means of mechanically-controlled apparatus as distinct from the occasional use of the blow-lamp in hardening small components. This consists of local heating by means of an oxy-acetylene burner followed by immediate quenching by a water jet, both the burner and the jet being mounted on a moveable head which is traversed mechanically along the line of a tooth. On completion of one tooth the gear is rotated in its bearings to bring the next tooth into position and the operation is repeated as often as it may be necessary. The gear wheel to be hardened is mounted on an arbor, or on its own shaft supported on rollers. Each of two torch heads has two oxy-acetylene jets, but only one jet impinges on each side of the tooth, when working on straight spur or helical gears. When double helical or herringbone gears are being hardened all four jets are used, one pair operating on the right hand helix of one tooth and the other pair on the left hand helix of the adjacent tooth. The quenching nozzles are mounted behind the flame nozzles in each case, the water being contained in a tank and supplied to the nozzles by a motor-driven pump. Experience with the machine has shown that it is suitable for gears ranging from 4 d.p. to 1 d.p., but gears as fine as 6 d.p. have been hardened, and to cover the complete range from 6 to 1 d.p. seven sizes of torch nozzles are provided. It has been found practicable to obtain any desired hardness between 60 and 80 Seleroscope, or 400 to 550 Brinell, but experience indicates that a Seleroscope hardness of between 70 and 75 is the highest that should be sought for the best service performance. The linear speed of operation ranges from 6in. to 10in. per min., according to the size of tooth and the dimensions of the gears that can be treated from a minimum of 2in. diameter and 2in. face width to 84in. diameter and 24in. face width. For the best results the steel used for the gears should be selected with due regard to the hardening process. For most purposes a carbon content of 0·35 per cent. to 0·50 per cent. can be employed, but for heavy-duty gears alloy steels such as chrome-vanadium, chrome or medium manganese have been used with good results.—*"Engineering", 27th May, 1938, p. 590/1.*

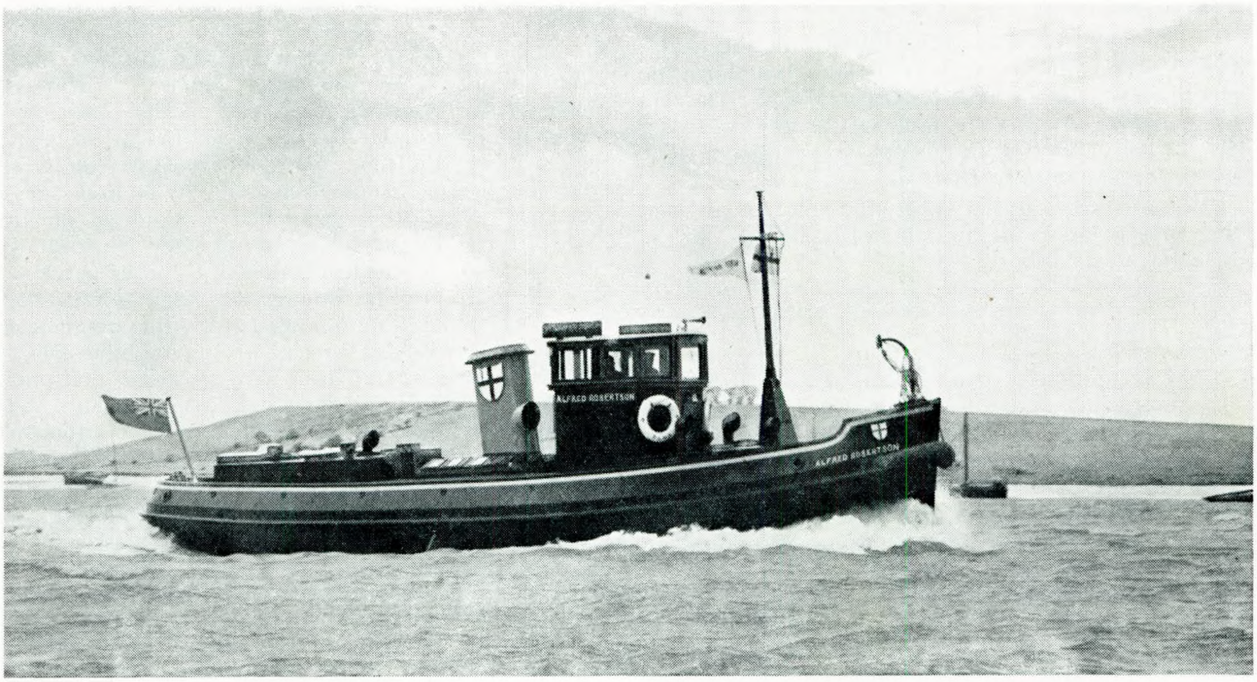
EXTRACTS.

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

The Launch of the "Alfred Robertson".

A particularly interesting launching ceremony took place on the 16th May at Messrs. James Pollock, Sons & Co.'s shipyard at Faversham. In the presence of a large number of people a boarding launch, built by the firm for the Port of London Health Committee, and named the "Alfred Robertson", was successfully placed in the water.

The christening was performed by Mrs. Alfred Robertson, wife of Mr. Alfred Robertson, Honorary Treasurer of The Institute of Marine Engineers and late Chairman of the Port of London Health Committee, who, during his year of office, directed attention to the inadequacy of the existing craft and was virtually responsible for the introduction of the new ship. Prior to the launching ceremony, Mrs. A. Robertson was presented with a bouquet of roses, and Mrs. R. R. S. Hewett, Mrs. F. Whittingham and Mrs. Firmin were each presented with bouquets of carnations, the presentations being made by four of the shipyard's rivet boys.



The hull of the vessel is of steel. The dimensions are: length overall, 54ft. 9in.; breadth, 12ft.; depth, moulded, 6ft. 6in.; draught, about 4ft. 6in. A 136-b.h.p. Gardner Diesel engine fitted with Gleniffer reversible reducing gear will give her a speed of about 9¾ knots. The cost of the launch will be about £4,550. She has a raised wheelhouse, crew's quarters forward and officers' quarters aft, and will be used for the transport of Medical Officers and Sanitary Inspectors at Gravesend to and from vessels coming into the River Thames. The vessel was complete and ready for sea when launched and sea trials were held during the following few days.

At the reception held after the launching ceremony, Mr. Walter Pollock toasted Mrs. Alfred Robertson, wished good luck to the new launch, and as a memento of the occasion, Mrs. Robertson was presented with a silver salver by Mr. Walter Pollock, the Chairman of the Company.

In the evening a dinner was given by the City of London Corporation, to celebrate the occasion, presided over by the Chairman of the Port of London Health Committee, Capt. R. R. S. Hewett, the principal guest of the evening being The Institute President, Sir E. Julian Foley, C.B.

Heat Insulating Materials.

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

With the gradual tendency towards the adoption of extreme temperatures, both at the higher limit in propelling machinery and at the lower limit in refrigerating machinery, the problem of finding a suitable heat insulating material is one of considerable importance. For steam-pipe lines, exhaust manifolds, etc., asbestos in some form or other has for a long time been regarded as the most suitable material available, just as cork is regarded as the best material for refrigerated chambers. Other substances are, however, continually being made the subject of investigation in an endeavour to obtain improved insulating properties, greater mechanical strength, and so on. Among these, particular interest attaches to those materials in which a cellular structure can be obtained, thereby making use of the insulating properties of air when it is in a stationary condition. These materials include various forms of concrete in which pumice, foamed slag, expanded slate and other cellular materials are used. It may be mentioned that the thermal conductivities of a series of these concretes has recently been measured at the National Physical Laboratory, while a concrete in which the cellular structure was produced by adding a foam-producing liquid to the mix has been used in the construction of a cold store in the Dominions. These materials merit further investigation.

Training of Artisans.

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

We have previously drawn attention in these notes to the fundamental difference between the training of engineers and the training of artisans. The former as carried on in our technical colleges and universities seeks to train young men for the higher executive posts in the engineering industry, whereas the latter, if it is consciously practised at all, endeavours to produce young men who will take their place in the engineering industry as fitters, turners, and so on. Unfortunately, however, there is a tendency to neglect this very important task of training workers for industry, with the result that the fear is often expressed that sufficient skilled artisans are not coming along to meet present and future demand. It is with interest, therefore, that we call attention to the action of the Association of Chambers of Commerce, which has circulated a memorandum on the training of artisans in Great Britain and the Continent and has asked its constituent chambers of commerce to secure the views of large employers of labour on the question as to whether they are satisfied that the present methods are producing the right grade of craftsman, and if not, whether they would be in favour of setting up special schools for the training of boys of 14 to 16 as artisans in the various crafts before they enter industry. It is suggested that on the Continent such special schools are already in existence and that, as a consequence, there is a standard of craftsmanship which is "considerably superior to that obtained by the apprenticeship system in Great Britain".

Painting Rusty Surfaces.

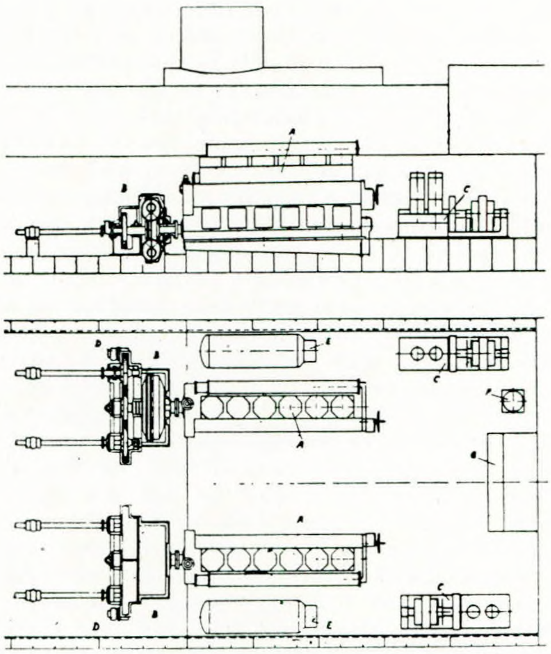
"Shipbuilding and Shipping Record", March 24th, 1938.

It is generally understood that as a preliminary to painting the plating of a ship all patches of rust should be carefully removed, otherwise the paint will quickly flake off at these places and further rapid corrosion will ensue. It is this preliminary cleaning which adds substantially to the cost of the job. With a view to eliminating this costly preliminary process and at the same time to kill the effect of the patches of rust on iron and steel a well-known British firm of paint manufacturers has recently placed on the market a paint which can be directly applied to rusty surfaces in the same way as paint is normally applied to a perfectly clean surface. This special paint contains a combination of chemical solutions and chlorinated rubber which immediately react with the rust changing it into a corrosion proof coating, a film being formed of a dark blue colour which subsequently changes to black. Moreover, the coating thus formed not only inhibits the further formation of rust, but also resists the effects of the weather as well as those of acids and alkalis. Some idea of the protective power of this paint can be gathered from the statement that during the course of investigations single coats were applied to rusty surfaces under unfavourable circumstances and that after four years' exposure they were still undamaged and no trace of corrosion could be detected. There would appear to be considerable possibilities in a paint of this nature, particularly if it can be shown to resist the corrosive effect of sea water and sea air.

Quadruple Screw Propulsion with Two Engines.

"The Shipping World", May 4th, 1938.

The subject of geared Diesel machinery has previously been dealt with in "The Shipping World"; the usual arrangement discussed has involved the employment of two or more engines for driving each propeller shaft. It is a distinct novelty to find, therefore, that an engine room layout involving what might be regarded as a reversal of this arrangement is at present being put into practice. In other words, two engines are being used to drive four screws. This installation is being made for a tug to operate on the River Danube, the employment of the quadruple screw arrangement being necessary for draft considerations. Propulsion is by means of two six-cylinder, directly-reversible Diesel engines, each rated at 640 b.h.p. at 325 r.p.m. These are shown at A in the accompanying diagram. The power of each engine is then passed through a Vulcan hydraulic coupling (B) and helical gearing is then employed to divide the power over two propeller shafts; incidentally, no speed reduction is effected in the gearing, which has a 1 to 1 ratio. Each Vulcan gearing set drives the lubricating oil pump for the system, this being shown as D at the after end of the gearcase. Starting air receivers for the directly-reversible main engines are located in the engine room wings (E), the necessary compressed air being furnished by the compressor (F) which is a motor-driven unit. The main switchboard is shown at G and the two Diesel-



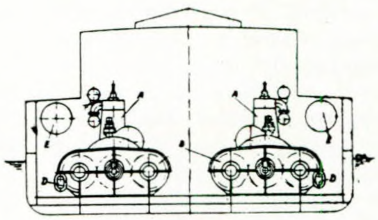
Driving quadruple screws by means of two Diesel engines through Vulcan gearing.

dynamo sets for supplying power for various auxiliaries, lighting, etc., are placed forward in each engine room wing (C). This is believed to be the first machinery arrangement of the type, but there is no doubt that it has sufficient practical attractions to justify its employment in other installations where comparatively high power is required on a moderate draft without the utilisation of a multiplicity of high-speed Diesels.

How Many Piston Rings?

"The Shipping World", May 4th, 1938.

If the general arrangement drawings of Diesel engines of a few years ago are studied it will be noticed that the working piston is generally provided with five, six, or more piston rings, usually of the ordinary Ramsbottom type. In recent years there has been a marked tendency to reduce the number of rings in oil engines of all types and sizes. This is a step in the right direction provided that gas-tightness can be maintained, for there is no doubt that piston ring friction is the most important single item in the mechanical losses of the Diesel engine. Many makers have carried out interesting experiments in this direction and one case is known where a large marine Diesel engine was run quite successfully on the testbed with but one ring per piston, this being of the ordinary Ramsbottom type. Obviously, of course, this practice could not be employed commercially because of the dangers of the top (and therefore only) ring sticking in service, a by no means unusual happening. Even more interesting than this experimental demonstration, however, is the fact that another equally well-known builder of Diesel engines has standardised the em-



ployment of two rings per piston where a few years ago seven were used. These rings are of the special double-seal type and despite the opinions of many experts that rings of this type tend to aggravate cylinder wear this has not been the experience of the firm in question. Moreover, piston blow-past is stated to be less than was ever experienced when more rings were used, and it is believed that the lubricating oil consumption of these engines is also good. Attention has been drawn to this interesting side light on Diesel engine construction because there seems little doubt that further research on the whole subject of piston ring position, design, material, etc., is needed. The subject is an important one, especially in its relation to cylinder liner wear and engine maintenance in general.

Streamline Flow Stop Valves.

"Shipbuilding and Shipping Record", April 7th, 1938.

It is one of the recognised axioms of mechanics that any change either in the magnitude or direction (or both) of the velocity of a fluid is accompanied by a loss of energy. In particular, when dealing with fluids at high temperature, such as steam, this loss of energy is accompanied by considerable wear, due to erosion at the seating faces of the valve. Hence, numerous attempts have been made to produce stop valves in which the fluid shall have streamline motion in order to reduce both the loss of energy and the effects of erosion to a minimum. Attention may, therefore, be drawn to a new type of streamline flow valve which has recently been placed on the market by a well-known British firm, in which in addition to the streamline form of the passage through the body of the valve, the piston principle is adopted for controlling the flow. The valve is of the straight through type, the lower part of the passage being formed with a ridge in which is machined a seating to take the liner, this, in turn, being held in position by two packing rings and a cover. The pipe wall on either side of the ridge is designed with an easy approach curve, and, to conform approximately to the streamlines set up by the fluid in passing over the ridge, the underside of the piston is made concave so that a reasonably uniform cross-section of flow is maintained throughout the valve. When the valve is closed, the lower portion of the piston projects into the passage on one side of the ridge, while the parallel portion of the piston advances into and is sealed by the lower packing ring.

Heat Generation by Electricity.

"The Engineer", 18th March, 1938.

In the course of a paper before the Royal

Society of Arts, Mr. E. V. Evans referred to the use of electrical energy for heat. He pointed out that the user of electricity for such purposes was apt to regard it as a convenient and highly refined form of fuel, and not as it truly is, a means of transmitting mechanical power. It is recognised, said Mr. Evans, that in converting heat to mechanical energy, between two-thirds and three-quarters of the heat energy of the coal is lost. The loss arose, not from lack of technical skill, but owing to the operation of thermodynamic limitations. He considered that the last purpose to which such energy should be put was the reconversion to the low-grade heat energy from which at such cost in fuel and money it was obtained.

Action of Hydrogen Upon Coal.

"The Engineer", 15th April, 1938.

The Department of Scientific and Industrial Research has issued a third report in the series dealing with the hydrogenation of coal, which gives an account of the development of a small-scale plant for the continuous hydrogenation of coal in the liquid phase. The plant described was evolved as a natural consequence of work previously carried out in other types of apparatus. Briefly, the essential part of the plant (which treats 28lb. of coal per day) is the reaction chamber, or converter, consisting of a vertical cylindrical vessel of 3¼in. bore and 35½in. internal height. The ground coal, made into a paste with heavy oil derived from the process, is injected into the base of the converter and fills it to a level determined by an overflow pipe. Compressed hydrogen at a pressure of 200-250 atmospheres enters by the same pipe as the paste, and after passing through the paste is removed from the top of the converter, taking with it a part of the oil produced. The remainder of the product is recovered from the material (the sludge) passing down the overflow pipe. The temperature maintained in the converter is of the order of 450° C.

Tin-base Bearing Metals.

"The Engineer", 15th April, 1938.

Mr. D. J. Macnaughtan, Director of the International Tin Research and Development Council, in a recent paper to the Institution of Mechanical Engineers, discussed typical failures in tin-base bearing metals and the factors underlying them. Tests revealed the degree of stress in white-metal linings on thin steel shells due to thermal expansion and contraction, and showed to what extent the stress could be relieved by creep. Other probable causes of tensile stresses were discussed, and the author considered at what temperature the fatigue properties should be compared in view of results obtained at room temperature and 150° C. with bearing metals containing additions of cadmium and lead. These experiments suggest that less than 2 per cent. of cadmium and no lead should be permitted in white bearing metals. This paper has now been issued by the International Tin Research and Development Council, and copies may be obtained free of charge from Manfield House, 378, Strand, London, W.C.2.

An Unusual Method of Riveting.

"The Engineer", 8th April, 1938.

For riveting closed work where it is difficult or impossible to get at the shank to form a head, a German firm has introduced a new form of rivet. It is similar to an ordinary rivet, but the lower part of the shank is drilled out and filled with a small amount of explosive material. The rivet is placed in position and the charge is then fired by means of an electrically heated dolly held to the rivet head. The explosion expands the end of the shank and the joint is made.

Steam Pipe Repairs.

"Shipbuilding and Shipping Record", April 21st, 1938.

It is generally realised that steam pipe failures occur more frequently than do boiler failures on board ship owing to the vibration and other stresses which are placed upon the piping when the vessel is working in a seaway. It follows, therefore, that extreme caution should be exercised when steam pipe repairs have to be carried out and careful inspection should be made to see that brazed and welded joints have been properly made. These are the conclusions reached by American Bureau of Marine Inspection after it had investigated the failure of a steam pipe repair which resulted in the death of two men. It appears that a main steam pipe, 5½in. diameter, had been lengthened by about 13in. by swaging a new piece into the old and expanding the other end into the flange, the expanded joint being finished off by brazing. The explosion occurred as a result of the pipe drawing away from the flange, and subsequent inspection showed that not only had the expanding process been done by a peening hammer, yielding very imperfect contact between the pipe and the flange, but the subsequent brazing had been such that in places, the brazing solder had only penetrated a distance of one-sixteenth of an inch. It is suggested that the only way in which a pipe can be secured to a flange is that it should not only pass right through the flange, but the end should itself be flanged into a recess turned on the face of the flange to prevent the possibility of withdrawal in the event of a failure of the brazing metal. Further, the brazing should be effected from the back of the flange only, but in such a way that the braze metal runs for the entire length of the bore of the flange being visible on the front face.

Testing Steam Turbines.

"Shipbuilding and Shipping Record", March 31st, 1938.

The fact that no simple equivalent for the indicator has been devised for estimating the power developed by a steam turbine renders the testing of this type of engine a problem of considerable difficulty. Various kinds of acceptance tests have been introduced and for many years there has been in existence a British Standard Specification covering the rating and performance of steam turbines which provided certain general standards for design, materials, as well as methods for calculating steam or heat consumption. This specification was last revised in 1930, and in view of the developments which have been made since that time, it has been considered advisable to bring it up to date. This has now been done and a new specification supplementing the former one has been published* under the title "British Standard Test Code for Acceptance Tests for Steam Turbines". The new code is designed to cover the verification of guarantees of capacity, consumption, etc., in respect of condensing turbines operating on complete expansion, reheating or regenerative cycles or combinations of these and is divided into six sections. It contains much information governing the conduct of the test, instruments and methods of measuring output, steam consumption, etc., as well as the procedure for computing and the method of presenting the results. Perhaps for marine turbines so complete a system of testing may not be considered necessary, but the specification certainly indicates the lines upon which the essential tests should be made.

Auxiliary Diesel Engine Progress.

"The Shipping World", March 23rd, 1938.

In view of the present position, the conservative-minded shipping man or marine engineer may feel that the immediate future is not likely to see any spectacular technical advances in the motorship field. There is no doubt, however, that considerable scope still exists for progress in directions other than the main machinery. For example, if recent progress with the small high-speed engine in the stationary, road vehicle, and railway traction fields is reviewed it will be seen that the experience gained in these spheres is not entirely useless to the marine engineer. The view is held by many marine engineers that auxiliary marine Diesels are still for the most part unnecessarily large and heavy. While few practical engineers would recommend the employment of modified vehicle Diesel engines in ordinary passenger and cargo liner type motorships, the suggestion is worth examining that the modern medium high-speed, heavy-duty multi-cylinder "Vee" type Diesel engine is an attractive unit for auxiliary service in large motor-ships. Engines of this type have proved their worth in railway service under very exacting conditions and the same may be said of certain multi-cylinder twin-crankshaft engines of high output which are used in some foreign locomotives. These engines are not excessively rated but, notwithstanding, their weight per horse power is distinctly good. Units of these types, if used in a large motorship having considerable auxiliary load, would undoubtedly show a useful saving in weight, even if they were run at a somewhat lower speed than is the case in railway service; and the results, it is believed, would be good from the standpoints of fuel consumption and maintenance costs. Another interesting line of progress in the railway traction and, to a lesser degree, stationary Diesel engine fields is the application of supercharging to engines of about the size and power of those employed for auxiliary service on shipboard. Credit for most of this development work goes to the Buchi syndicate, who have, in association with the Brown Boveri interests, designed and produced some remarkably compact, simple, and highly-efficient exhaust gas-driven turbo-charging sets which can be neatly incorporated into the engine with a minimum of external pipework. Engines of as low a nominal output as 100/150 b.h.p. have been provided with such supercharging equipment with good results. The application of this form of pressure charging to marine auxiliary engines is as yet in its infancy.

Two-Stroke Cycle Engines.

Another possible direction in which progress might be made with auxiliary marine Diesels is an extension of the employment of the two-stroke cycle engine. In its modern form this is a highly efficient engine, easy to maintain, very reliable, and has moderate overall dimensions and a good specific weight figure. Here again the experience of railway Diesel engineers is interesting. The highly-developed Winton two-stroke uniflow-scavenging engine in both vertical and "Vee" cylinder forms has proved very successful in many of the large high-powered trains in America. To a lesser degree the fairly high-speed Burmeister & Wain two-stroke engine has proved itself a sound prime mover for railway traction purposes, while a somewhat similar engine is, of course, available for marine work. Quite recently, a much smaller two-stroke uniflow-scavenging engine of attractive design was introduced by the General Motors organisation in America. This engine has a continuous rating of 15 b.h.p. per cylinder at 1,200 r.p.m. with a brake mean effective pressure of 70lb. per sq. in. and a piston speed of 1,000ft. per minute. This rating is admittedly moderate but the weight per b.h.p. is no more than 22lb. or thereabouts; the construction is in cast iron and is really robust. Such an engine should prove most attractive for emergency lighting sets, as well as for driving generators on smaller craft, including yachts and naval vessels. At the present time a somewhat larger engine (having a minimum output of 200 b.h.p. in four cylinders and being built in its largest size with eight cylinders, developing 400 b.h.p.) is in process of being added to the General Motors range, and this engine, with its moderate overall dimensions, easy rating, and light weight, promises to approach the ideal of many engineers in the matter of marine auxiliary Diesels. Another attractive, moderately-high-speed two-stroke engine which seems to have a great future for marine auxiliary purposes is the new horizontal,

*British Standards Institution Publications Department, 28, Victoria Street, London, S.W.1, price 2s. 2d. post free.

opposed-piston Sulzer engine which was recently described in these notes.

Compact Machinery Arrangement.

"The Shipping World", March 23rd, 1938.

Mention was made in these columns last week of the compact arrangement of two boilers and a double reduction cross compound turbine developing about 6,000 h.p. in the new America C-2 proposed design of standard cargo vessel. Layouts such as these cannot be neglected when any study is made of the future of steam propulsion. America, whose designers have never favoured the large marine Diesel, has recently contributed much to the efficiency and general layout of steam plant. United States oil companies were among the first to use high pressure water-tube boilers and geared turbines for single screw oil tanker propulsion, and they made great movement in the direction of economy of space, at any rate in the way in which they arranged their boiler, or boilers, abaft and above the main turbine shaft. In Germany, also, progress has been made. An interesting layout was proposed recently in a paper read before a leading German technical society. It is true that this arrangement is associated with electric propulsion, but the author of the paper in question feels that properly laid out electric propulsion gives a more compact power plant per output than any other. His proposal is to arrange a single turbo-generator fore and aft on the centre line of the ship, sitting above its own condenser. This is the main power room and is flanked on either side by a fore and aft bulkhead, less than a third of the total width of the ship from the centre line. This bulkhead, with the two tanks, forms two boiler rooms, one on either side of the ship, in each of which are to be found two Benson fuel valve type boilers. This is the whole power plant for some 8,000 h.p., and it only remains for a single or double armature motor to be tucked away at the end of the shaft tunnel in a small compartment to complete the layout. Though the equipment has not the flexibility given by two turbo generators, it is notable from the point of view of athwartship compactness.

Cell-faced Piston Rings.

Interesting development intended to reduce liner and ring wear during the running-in period.

"The Marine Engineer", May, 1938.

Research carried out for a considerable period has resulted in the development of a process which is likely to do much to solve the problem of cylinder wear.

In the early stages of bedding-in a piston ring there is sometimes a certain amount of wear set up by high spots either on the liner or ring or both, due to temporary lack of lubrication or blow-by, and this is liable to cause "scuffing" (*i.e.*, roughening of the surface of the ring or bore). To combat this, what is known as a cell-faced ring has been produced, by which certain of the softer elements such as the iron itself together with the graphite is dissolved out of the surface, leaving the phosphide network standing out from the main body of the material.

When examined under the microscope the face of the ring gives the appearance of a honey-combed surface, and in each of the small pockets oil is carried which, it is stated, blow-by cannot displace, thus resulting in constant effective lubrication of the ring and cylinder wall during the early stages of running-in, and entirely eliminating scuffing.

While these rings are suitable for all types of engines, including Diesels, they are of particular interest to the aircraft industry where the bedding-in of rings in steel or chromium-plated cylinders is a lengthy business. Attempts to shorten the period of bedding-in in aircraft engines have been made by using rings of reduced bearing area with a one degree bevel, but this it is stated, results in pushing up the unit loading, and is liable to aggravate scuffing. The cell-faced ring has a reduced area on the cylinder wall and consequently beds in very quickly. As the whole surface of the ring is composed of these pockets carrying oil there is no scuffing either of the ring or cylinder barrel, and longer life of the ring itself is assured.

Unusual Arrangements of Propellers.

"Shipbuilding and Shipping Record", May 12th, 1938.

Some years ago the suggestion was put forward by General Rota that a decided gain in propulsive efficiency would result if it were found to be possible to use two screws on one axis, that is one working on an inner shaft and one on a shaft outside of this, with screws rotating in opposite directions. The general impracticability of this proposal was at once apparent and not until twenty years had elapsed was the suggestion put into actual practice. In 1934, Col. Rotundi recorded the trials of the "Cristoforo Columbo" (fitted with two co-axial contrary turning screws) in his interesting paper, read before the Institution of Naval Architects in that year. The astonishing statement was made by Col. Rotundi that the first application of co-axial contrary turning screws went back to 1839, when Ericsson fitted them to the "Robert F. Stockton". Since then, they have been resorted to in isolated instances for small craft and their use has become general for torpedoes.

The preliminary investigations carried out by General Rota and subsequent experiments carried out by the late Mr. Luke suggested that this unusual arrangement of propellers would afford a gain in propulsive efficiency of well over 10 per cent. This gain was well worth striving after, but the mechanical difficulties appeared to be insuperable. It was found possible, however, to have such an arrangement in the vessel named above, which was a 218ft. sailing training ship for the Italian Navy, with an auxiliary drive. The speed trials revealed that the gain in propulsive efficiency with contrary turning screws, compared with the one screw, is about 18 per cent.; a speed of 10·02 knots being obtained with a total expenditure of 925 s.h.p. in the one case and 10·13 knots with a total power of 1,199 s.h.p. in the other.

From the foregoing figures, it may be observed that the power being transmitted by each shaft is in the region of 600 only, which is some explanation of how it was possible to adopt such an unusual arrangement. This interesting case points to the possibility of testing unusual suggestions in vessels of moderate power which might be impossible of actual application in large ships for general service.

Attention was called by two authors of papers recently delivered to experiments which had been carried out, relating to screws being carried in front of shaft brackets and not behind them, as is usual practice. In his paper, read before the North-East Coast Institution in March, Mr. Gawn, of the Haslar tank, had as his subject "Effect of Shaft Brackets on Propeller Performance". In this contribution, he dealt with some experiments which had been carried out with shaft brackets before the propeller and shaft brackets abaft the propeller. The results obtained showed a fair advantage for the arrangement with the screw forward of the shaft brackets, although Mr. Gawn's conclusions in this point were that in the cases tried "no propulsive advantage was obtained sufficient to offset the practical objections to arranging the shaft brackets abaft the propeller, such as resistance and weight of the larger and heavier brackets, possible greater diameter of the shaft and the probable increase of vibration". Apart from these objections, the experimental results were in favour of this unusual arrangement.

It was rather strange that the paper given by Messrs. Kent and Cutland at the recent meetings of the Institution of Naval Architects, entitled "Further Experiments in Smooth and Rough Water with a Model of a High-speed Ship", should have a section dealing with this particular problem. Part 3 of this paper relates to increase in efficiency of propulsion obtained by placing propeller brackets behind the propellers. The experiments carried out in the National Tank in this connection showed gains in propulsive efficiency and decrease in power from 13 per cent. to 21 per cent. with one series of screws and from 5 per cent. to 11 per cent. with another series. It is possible that these increases in efficiency were gained through the "guide blade" action of the brackets abaft the screws.

Experimental research has, therefore, shown that some gain may be secured by this arrangement, but it is also clear that the application of such an arrangement presents some practical difficulties. It is possible that, as was the case with contrary turning screws on a common axis, the placing of screws before the shaft brackets would be quite possible with smaller twin-screw vessels of low power and quite impractical with warships developing great power. There is nothing to hinder this arrangement being used for twin-screw launches and vessels similar in type, and builders of small craft would be well advised to investigate the practical means of securing the increased efficiency disclosed by these experiments.

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 21st April, 1938 :—		
Gilchrist, Robert	1.C.M.E.	Glasgow
Govan, John	1.C.M.E.	London
Howie, John	1.C.S.E.	"
Hutton, Philip A.	1.C.M.E.	Glasgow
McKay, James M.	1.C.M.E.	"
Nicholls, Stanley W. ...	1.C.M.E.	Cardiff
Robinson, Lawrence J. ...	1.C.S.E.	Newcastle
Whitfield, Albert	1.C.M.E.	London
Kelly, Edward G. J. ...	1.C.	Cardiff
Thomas, Arthur H.	1.C.	"
Doel, Harold J.	1.C.	Hull
Pearson, John M.	1.C.	"
Raddings, John L.	1.C.	"
Witty, Richard E.	1.C.M.	"
Gemmell, John	1.C.	Glasgow
Phillips, David G. R. ...	1.C.	"
Venn, Cecil A.	1.C.	London
Robertson, Arthur J. ...	1.C.M.	"
Rowell, Henry W.	1.C.	Newcastle
Willey, George P.	1.C.	"
Grice, James W.	1.C.M.	"
Ash, William	1.C.	Liverpool
Manson, George	1.C.	"
Piper, Rocco R.	1.C.	"
Fosler, Reginald P. ...	1.C.M.	"
For week ended 28th April, 1938 :—		
Kaye, James	2.C.	Leith
Bolt, Robert O.	2.C.	London
Reid, David M.	2.C.	"
Campbell, Hugh E. ...	2.C.	Liverpool
Charlton, William G. ...	2.C.	"
Pinches, Harold E.	2.C.	"
Gray, James S.	2.C.	Glasgow
Lounie, Andrew	2.C.	"
Brown, Robert	2.C.M.	"
Smith, Matthew	2.C.	Newcastle
Durrant, Harry E.	2.C.M.	"
Heddle, Robert	2.C.M.	"
Jeffery, John	2.C.M.	"
Dixon, Sydney S.	2.C.M.E.	"
For week ended 5th May, 1938 :—		
Chantler, Evan A. H. ...	1.C.	Belfast
Simpson, Ernest K.	1.C.M.	Newcastle
Riddle, Ellison H.	1.C.	"
Tallack, Arthur	1.C.	"
Thomson, Joseph E. ...	1.C.M.	"
Rankine, Thomas N. ...	1.C.	Liverpool
Smith, David	1.C.	"
Arthur, William L. ...	1.C.M.E.	Belfast
Tucker, Ronald L. ...	1.C.M.E.	"
Cameron, Ian	1.C.M.E.	Newcastle
Forster, George J.	1.C.M.E.	"
Seymour, William W. ...	1.C.M.E.	"
Dickinson, Ronald H. ...	1.C.M.E.	Liverpool
Mallett, Alfred J.	1.C.	London
Mann, Charles J.	1.C.	"
Polack, Ivor J. E.	1.C.	"
Nelson, Charles T.	1.C.M.	"
Summers, Benjamin G. ...	1.C.	Leith
Berlie, William C.	1.C.	Glasgow
Cherrie, John	1.C.	"
Davie, James	1.C.	"
Gamble, Alexander	1.C.	"
Gilfillan, Robert G.	1.C.	"
Gladstone, Sydney	1.C.	"
MacLellan, Donald W. ...	1.C.	"
Marshall, William J. C. ...	1.C.	"
Roberts, George S.	2.C.	Belfast
Ferguson, John D.	2.C.M.	"
Henderson, James	1.C.M.E.	Glasgow
Dewar, Leonard S.	1.C.M.E.	"
Hoare, Alfred	1.C.M.E.	London