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

Patron: HIS MAJESTY THE KING.

SESSION 1937

Vol. XLIX. Part 12.

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

The Transatlantic Liner of the Future.

Some Notes on the Probable Future Trend of Transatlantic Passenger Shipping to and from New York with reference to potential Air Competition and in particular relation to Progress made with High-powered Machinery and the "Fuel Valve" type of Boiler.

READ

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On Tuesday, December 14th, 1937, at 6 p.m.

CHAIRMAN: The PRESIDENT.

Synopsis.

IT is assumed that in the future mammoth transatlantic liners will play an even more important part than they have in the past. It is further suggested that the vessel to come must be able to some extent to deal with competition from the air and must therefore have a speed which approximates as nearly as conditions can permit to aircraft speed. This requires various alterations in terminal facilities, which are discussed. Above all it needs a vessel capable of a speed about 4 or 5 knots in excess of anything at present possible. To accomplish this a power plant must be employed more powerful than anything yet conceived in marine electric propulsion, and six screws with turbo alternators and special fuel valve type boilers are suggested.

The layout of machinery is illustrated and technical details as to size, weights, etc., are given. It is emphasised that enormous in power though this machine is—some 400,000 h.p. on six screws—there is nothing in any portion of the power plant which does not represent normal well tried power plant practice ashore.

The Authors advance their ideas not in the sense of a detailed specification of the ship of the future, but as an indication based upon rational lines of what shape the transatlantic mammoth will take if developments follow their present trend.

General Considerations.

It appears that the Northern Atlantic routes will in the future remain among the key lines of world transportation and that they are likely to continue to cater for the carriage of the large number of luxury, business, and tourist passengers which they have handled in the past. Any study of transatlantic services indicates, however, that conditions of the future will not necessarily be governed by the past either as regards the type of ship employed or the terminal facilities for handling it. Just at the present time in fact, the subject is one which demands study on two counts.

(1) The possible effect of rivalry by air transport, and
(2) Developments in marine machinery and hull forms.

These lead to the conclusion that the transatlantic liner of the future—we are not necessarily considering the immediate future—will have to embody many characteristics which from the present-day outlook are unorthodox in the extreme. The authors submit therefore that with the unique facilities which they have had on the one hand of operating existing craft of transatlantic type and on the other hand of studying their performance from a practical as well as from a theoretical point of view, they are able to offer some observations on the question which may be of general value. It should be emphasised at the outset that this paper in no sense of the word is intended to be a complete builders' specification for a ship of the future. Before, however, any shipbuilding project actually reaches the drawing board stage, certain definite thoughts and ideas must be agreed upon which will eventually take their place in the final design. This study is along those lines.

The authors believe that the influence of aircraft design will make itself felt upon ship design, that streamlining, originally adopted for æsthetic reasons, has now proven itself as an integral part of the modern *ship, that modern ship design is influenced by aircraft form, and that steam propulsion in association with high velocity steam generators which the authors call loosely and non-technically but for want of a better term †"fuel valve" boilers, must be the governing factor in all transatlantic mammoths designed in the future. The authors believe too, that the potential flexibility of electric drive in association with these fuel valve type steam generators must be employed if the highest powers are to be arranged in a hull, the principal limiting factor to the dimensions of which is the size of quay and dry-dock accommodation at either terminal. The authors are not regarding the ship from a point of view of first cost, since even to-day mammoth liners are paid for by nations rather than by individual concerns. (It may be mentioned here that the cost of the machinery alone, as presently outlined, works out at about £1,758,000 or about £4·8 per shaft horse-power). On the contrary the picture is painted with broad vigorous strokes and with the feeling that the suggestions offered are technically sound and that the designer of the future may take them into consideration for reasons which are developed below. Speed and power of such a ship have been anticipated and confirmed by a high authority and the authors are glad to see that Dr. Baker in a recent Andrew Laing lecture forecast a ship agreeing closely with their own.

In any case, whether in the main the conclusions are acceptable or otherwise, it is inescapable that when the problem of the transatlantic liner of the future is approached, cognisance must be taken of the most advanced improvements in marine engineering. These are mainly concerned with the steam producing plant as the complementary electrical plant suggested is perfectly standard power station practice. Much progress has been made in this even in the last decade and there are now enough special types of steam-raising plant in operation in power stations ashore as well as at sea to justify the statement that in the near future such boilers as the Velox, the Sulzer monotube, the Benson, La Mont, Loeffler or others, will be available with a sufficient degree of reliability to be used for very high powered ships. The overall gain achieved is such that roughly speaking some 50 per cent. of the space of the boiler room and weight compared with many conventional high pressure water-tube boilers can be saved.

Admitting this, it must be agreed that the designer of the transatlantic liner of to-morrow will be confronted by two avenues of approach. Either he can take advantage of the saving in machinery weight and build a somewhat smaller "Queen Mary" or "Normandie", or he can employ the extra space and weight available for fitting much higher power in hulls of somewhat increased dimensions to get the even higher speed which may be necessary in future mammoths.

Competition from the Air.

To date, the transatlantic liner has only needed to compete against other units of its kind and to cross the Western Ocean to an exacting schedule which is the same practically for all express ships. But in designing the ship of the future, we must not forget possible competition—even menace—from the air, competition which has not been faced by ships built or now building but which has become very marked within a relatively short space of time. In order to meet this change, the forward-looking designer must provide a ship having the highest possible speed consistent with good seaworthiness and reliability, cost being probably in part at any rate a matter of national finance. It is suggested that among the most serious future competitors of these ships are the fast flying boats and catapulted

* See Appendix, "Evolution of the Modern Ship Profile".

† The term is indefensible technically, but practically it is felt to be the only expression capable of describing in an explanatory manner the devices which are making external combustion resemble internal combustion and which possess extreme rapidity of steam output, compactness and quick steam raising ability. (See articles by A. C. Hardy in the "Journal of Commerce" dated March 18/37, August 26/37, July 2/36).

seaplanes which have made many trial flights this year and which may be in regular service next year. Though they are temporarily under a cloud we cannot discount for the future the dirigibles of the "Zeppelin" type which can carry a relatively large number of passengers and cross in about 48 hours. It must be remembered, however, that aircraft, heavy or light, take passengers and land them at air ports which are not necessarily those centres in which passengers wish to attend to business. Indeed when lighter-than-air craft operate, periods of time varying up to nearly twenty hours maximum are required to get from Lakehurst, N.J. at the American end to New York, or from London, or Paris to Frankfurt at the European end. It may, therefore, be assumed that the "door to door" voyage by airship from New York to London or Paris is roughly in the neighbourhood of three days or a little over. The seaplane or flying boat services will be rather less. As regards volume of traffic, no North Atlantic seaplane figures are available, but the French South American Lines across the South Atlantic made 212 trips in 1936. The German figures speak eloquently of the real demand existing for this kind of transport. Dirigibles carried in the summer season of 1936 on the North and South Atlantic routes some 3,530 passengers and proved popular. Their service is experimentally superseded by fast mail carrying seaplanes with catapult ships as bases. Within the next few years they will be in regular service with, in all probability, Zeppelins too. In order to meet this or similar competition from lighter-than-air craft, the liner should be able to give a $3\frac{1}{2}$ days or 84 hours quay-to-quay service. This demands a service speed of 35 to 37 knots. To maintain rigidly this speed in all kinds of weather, the ship should be large enough to withstand the impact of the waves without undue strain on the hull structure and without discomfort to her passengers. The trip would still be 24 hours longer than by air, but owing to the more comfortable conditions of travel especially in bad weather and the smaller expense of the passage, the authors feel that conditions would be in favour of such a ship. This is considered a reasonable fundamental assumption upon which the design of future transatlantic liners should be based. It is suggested also that the "big ship" theory has been proved sound, being both practical and popular, and that companies in the future will concentrate their transport in few fast mammoth units rather than scatter their efforts over a large fleet of slow small units. This, as a fact, is a tendency manifesting itself in all branches of shipping, especially in modern cargo liner and tanker fleets where a small number of ships of upwards of 18 knots speed are performing efficiently the work of a larger fleet of 14 knotters.

The experience gained from the winter seasons operations of the "Queen Mary" and "Normandie" shows us that the ship of about 1,000 feet in length can cross in such weather conditions at a speed of a little less than 30 knots. As for the extra 5 to 7 knots demanded by the authors' ship of the future to maintain an 84 hour schedule an increased length of hull will be needed, it may be concluded that this ship will have to be of the largest possible type. Any thoughts of the smaller kind of perhaps 800 to 900 ft. in length must be eliminated. Owing to the very high speed—much in excess of that of the "Queen Mary" and "Normandie"—it is likely that to get good hull efficiency a sea speed of about 37 knots will be needed. The draft must be as small as possible in order that the ship can use the Ambrose Channel or Southampton Harbour, although other terminals may be contemplated. The performance of the big transatlantic mammoths in rough seas shows that with their length, speed can be maintained in any kind of weather. A ship with an extra 100ft. should be *even more* efficient. Rolling has caused bother on both the "Normandie" and "Queen Mary" and the effect is increased by their great height. For the new mammoth the fitting of anti-rolling tanks or of gyro stabilisers would be considered, and possibly special turreted superstructure. In short the ever increasing threat of quicker trans-ocean travel via the air may make it necessary to tackle shipbuilding from a new angle. The up-to-date shipbuilder recognises this and also the fact that he cannot and never will be able to compete in speed with this new form of transportation. It behoves him, therefore, to take cognisance of his position and see what inducements he has to offer the travelling public in association with the highest speeds which the medium in which his products operate permits. He has much to offer in place of high aircraft speeds. He can give comfort, safety, freedom, cuisine, amusement and rest in the order that appeals most to individual tastes. These no other form of transportation can offer, and if ships can be speeded up to reasonably comparable schedules a large proportion of passenger ocean travel can still be commanded, but those wants must be anticipated to the limit of his ability and knowledge.

Terminal Considerations

Note that this schedule calls for 84 hours from terminal to terminal and not from pilot to pilot. The existing differences between these two periods of time are among the most amazing anomalies of modern transport. The shipowner is blameless in this respect, for the fault lies at the door of officialdom. The location of terminals, too, has a marked effect on the terminal-to-terminal time. So far, it has been the general custom, arising from the idea that goods should be landed from ships as near as possible to the consumption-point, that harbours should be inland as far as possible, Manchester in this country being a good case in point. This practice can be amply justified when it is only a question of handling cargo, but for super-fast liners the problem is entirely another one and should be regarded in a different manner. The difficulty of

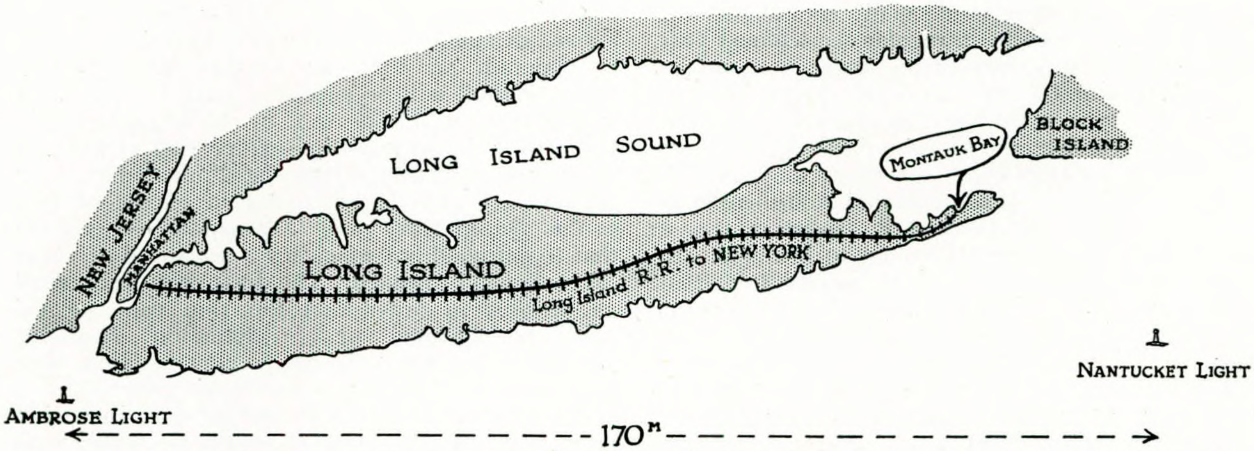


FIG. 1.—Long Island, showing location of proposed Montauk terminal in relation to Ambrose Lightship and New York.

correlating the real terminal with the point of arrival and departure is something which affects all forms of ultra-rapid transport—particularly aerial. This is an important aspect of the transatlantic situation in the question of aircraft versus water craft.

It is an undisputed fact that ships will never be able to travel at speeds approaching those realised on land or in the air. It may be assumed in this connection that in the not far distant future trains will be able to travel in the neighbourhood of 120 miles per hour, and aeroplanes three times as fast. For this reason, an express service should be limited to the shortest sea route and be able to give its passengers facilities to connect with the fastest methods of travel possible. All "inland" terminals should be discarded and facilities provided in convenient places, of easy access in every condition of tide and weather, with fast connections by air or by rail. On this side, it may be necessary to make Plymouth into a port with some pretence of catering for passengers or to provide these connections in a suitable place in Cornwall or on the coast of Brittany for the Continent. The use of such landing places would save 12 hours journey or more by steamer for the passenger going to London or Paris and avoid the difficult and dangerous Channel navigation, with its hazards caused by fog and crowded shipping.

On the American side some enthusiasts put forward, many years ago, a scheme for providing adequate docking facilities for ships on the north east end of Long Island, in the Bay of Montauk—shown in Fig. 1. So far, this scheme has not been adopted, owing to the opposition of many interests, but it may be that in the end it will have to be revived if the crossing time of the Atlantic is to be seriously reduced. Actually an express liner like the "Queen Mary" or "Normandie" takes nearly 10 hours from a position near Montauk Bay to her New York Pier, that time being accounted for by the extra length of the trip, as well as by conditions of tide and weather. Many of these delays could be avoided and the time of the journey curtailed by an express service from Montauk to Pennsylvania Station in the heart of New York—a saving of about ten hours being achieved. As a step in the right direction formalities of quarantine at New York have now been dispensed with, being carried out as the ship proceeds up the Lower Bay.

Coupled with these improvements, special care should be taken to curtail and expedite the various formalities attending the landing of passengers. At the present time, it is an incongruous thing to see ships being pushed to their utmost speed, at very great expense to their owners, just to save a few hours on the crossing and these same precious hours being lost by wearying and drawn out passport or Customs examinations, or by slow train connections. The journey from the departure in New York to the arrival in London or Paris should be treated as a whole, breaks and intermediate stops being reduced to the bare minimum and all formalities concluded during the crossing or at the journey's end. In that way, even without increasing the speed of the ship, nearly a full day could be cut from the actual schedules. Baggage handling presents a problem the importance of which increases with the size of ship. It can be expedited as far as the ship is concerned by carrying on board a portion of the crew devoted to this and similar duties, or by the use of special containers actually lifted on board. Thus heavy baggage loaded at the London terminal is unloaded in the ship's baggage room. One mammoth transatlantic liner for example has 40 men especially for this work. The ship of the future may have a clear central alleyway with mechanical baggage apparatus. Even then, however efficient the ship's arrangements, they are ultimately governed by the shore in so far as the comfort of the passenger goes. Many of these improvements are obvious, but it is often the most obvious which for one reason or another remains undone.

The Passenger Factor.

Lest it be felt that some of the authors' con-

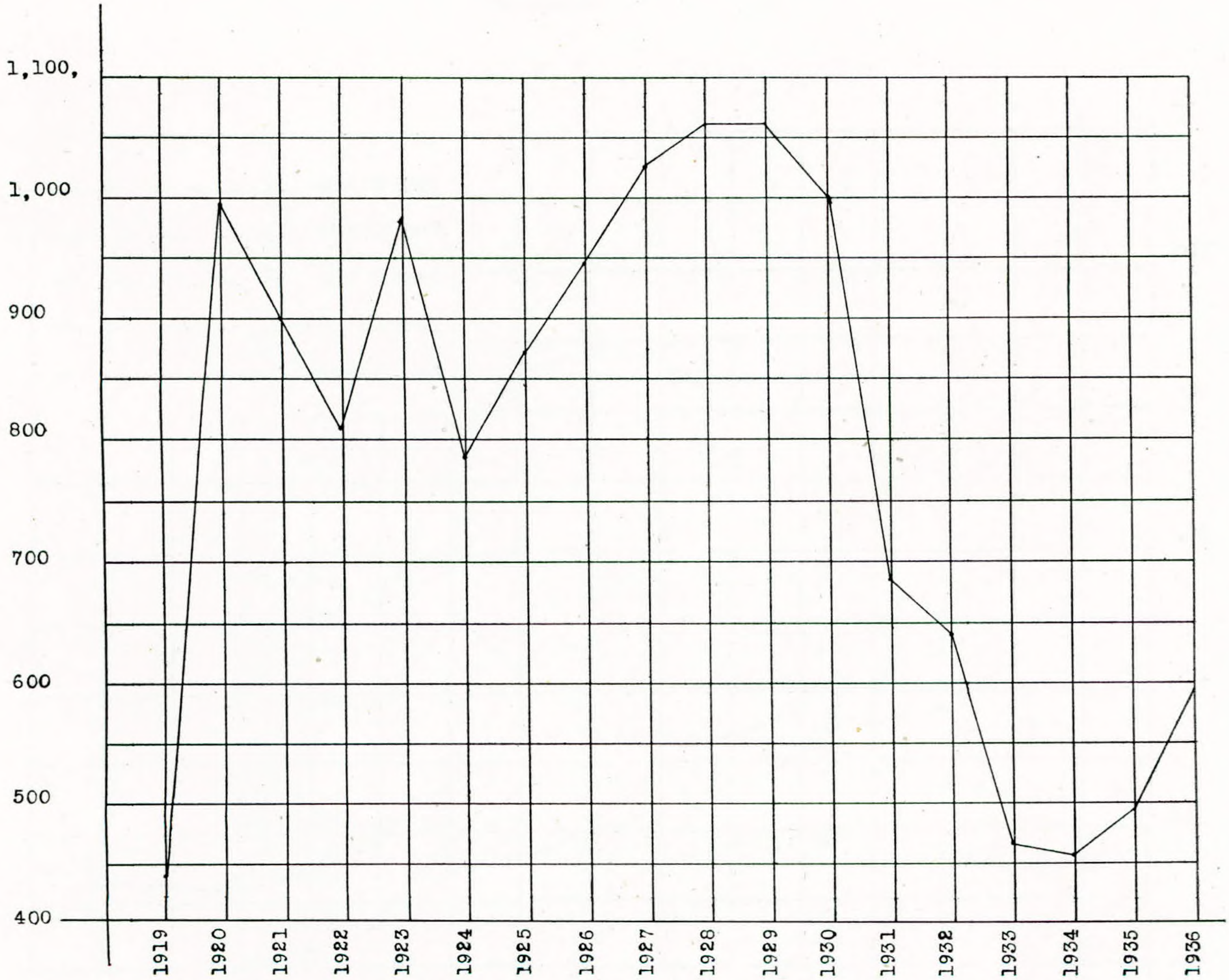


FIG. 2.—Curve showing total passengers (in thousands) carried on North Atlantic international lines.

clusions with regard to the size of ship required postulate a vessel or vessels too large for the number of passengers offering at a given time and do not really represent the potential human requirements of the future, let us enquire into the relative importance of each category of passengers to be carried, giving attention at the same time to what can be expected in the future. In any case the size is governed by the speed.

Fig. 2 shows very clearly the total importance of transatlantic traffic carried by the international lines from 1921 to 1936. After the peak year of 1920 came a slow depression till 1924. The falling figures for 1921, 1922 and 1924 were caused by the more and more stringent restrictions imposed upon immigration by the U.S.A. For the six following years there was a constant upward trend, culminating in 1928-29, when the slump began, with a tremendous fall for 1930 and 1931 and another sharp setback in 1932-33, 1934 being the turning point and showing a slight increase over the preceding year. 1936 gave another increase, but the total figure may be misleading, and it is more useful to study the variations of traffic in relation to the classes carried. In Fig. 3 the various diagrams pertaining to this traffic as split between classes are drawn. Their most noteworthy feature is the steady decline of the third-class traffic from 1921 to 1933, a decline which had its source in the limitation of immigration and the steady impoverishment of the small wage-earner, who mostly favoured that type of travel. Even omitting the carryings before 1928, it can be seen when referring to that year that the third-class traffic had lost nearly 50 per cent. of its previous importance. The second-class had nearly disappeared, the cause being the creation of the tourist class, originating in 1926. It can be seen that in 1927, 1928, 1929 and 1930, the increase in tourist class had been roughly equal to the decrease in the second-class, showing that the first-named was growing out of the extinction of the other classes. After a peak year in 1930,

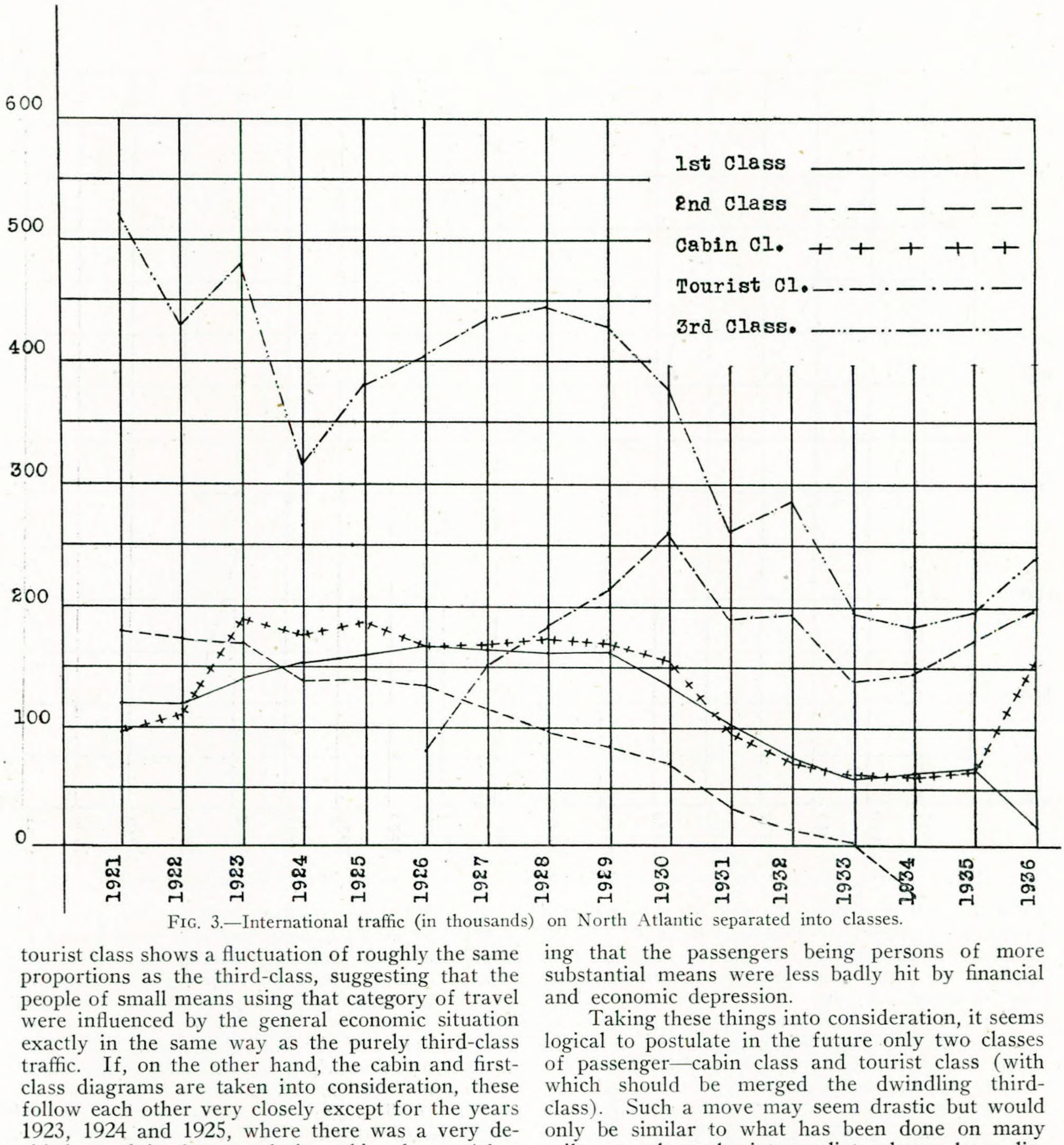


FIG. 3.—International traffic (in thousands) on North Atlantic separated into classes.

tourist class shows a fluctuation of roughly the same proportions as the third-class, suggesting that the people of small means using that category of travel were influenced by the general economic situation exactly in the same way as the purely third-class traffic. If, on the other hand, the cabin and first-class diagrams are taken into consideration, these follow each other very closely except for the years 1923, 1924 and 1925, where there was a very decided trend in favour of the cabin class. After that year, the two curves are nearly identical and show very conclusively that the same type of passenger was carried by these two categories and that the decision of the North Atlantic Conference to merge these classes into one was certainly a wise one. It may be noticed, too, that the variation of traffic in these two categories has been much less abrupt than in other classes and the curves show very much less sharp maxima and minima indicating that the passengers being persons of more substantial means were less badly hit by financial and economic depression.

Taking these things into consideration, it seems logical to postulate in the future only two classes of passenger—cabin class and tourist class (with which should be merged the dwindling third-class). Such a move may seem drastic but would only be similar to what has been done on many railways, where the intermediate classes have disappeared and where passengers are carried only in first and third class, with a few de luxe carriages of Pullman type for people willing to pay a supplement. On American railroads the simplification has been pushed one step farther, as there is one class for all travellers and Pullman class for people wishing to enjoy superior accommodation.

It would be quite justifiable to say that in the future, two classes on ships would be amply sufficient to cater for the majority of potential travellers. A certain amount of de luxe accommodation would have to be provided for persons having means of paying the extra charge for these accommodations, the proportion of the total capacity of the ship being 15 per cent. de luxe, 30 per cent. cabin and 55 per cent. tourist-third amalgamated.

Arrangement of the Hull.

Thus the mammoth of the future would not be the floating luxury palace, cold, sophisticated and unfriendly its present-day detractors would have us think it. Indeed, the trend is towards large public rooms of high standard for all classes with but small de luxe accommodation. The trend of railway development, where third-class to-day is superior to the first-class of ten years ago, is a pointer in this direction. Transport is changing overnight. The mammoth of the future will take full cognisance of these facts, but above all it is obvious that an arrangement such as will now be sketched for machinery must have its effect upon the hull layout. Attention is directed to Figs. 4 (aerial view) and 5 (profile) in this connection. Many of the features successfully incorporated in existing transatlantic liners, such as the completely clear and interior dining saloon, the curved structure forward and the clear top decks would be retained, because it is contended that these nicely combine practical needs with æsthetic considerations. Clear top decks which are the natural concomitant of logically disposed boiler uptakes and internally arranged ventilation are not, however, such an advantage on transatlantic liners as might at first be supposed, owing to weather conditions and to the incidence of flue gases beating down on the top deck under certain wind conditions. This latter disadvantage could be eliminated by disposing of the flue gases over the stern, out of the sides, or under water. This is a problem presenting great difficulties and the authors feel that for some time to come it may be necessary to employ orthodox funnels the area of which can be reduced in proportion to compactness of the steam producing plant. Gas washing and cleaning devices will be proposed for the funnels and the disposition of the gases is suggested as horizontal at sea and vertical in port as will be seen. Since, however, glass is being used to an increasing extent on shipboard and because it is now manufactured strong enough to withstand the blows of the heaviest of transatlantic waves, the authors suggest its employment to a great extent on the clear superstructure (Fig. 5). This will give the passenger all the advantages of the open deck spaces which the disposition of machinery provides for, but at the same time will protect him from the rigours of the weather. It has enabled also a profile to be introduced which, whilst apparently unusual, will at the same time be entirely practical. In any case, to-day the advantage of a modern profile is paramount from the point of view of attracting passengers who are apt to feel, often with justification, that because a ship looks old-fashioned or orthodox outside, she is the same inside.

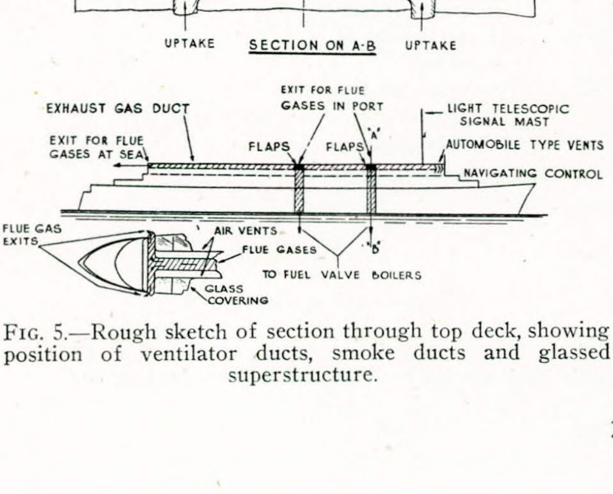


FIG. 5.—Rough sketch of section through top deck, showing position of ventilator ducts, smoke ducts and glassed superstructure.

Ship of the Future.

The following points are noteworthy as showing the departures which have been made from existing practice in passenger layout due to the fact that the turbo-electric machinery with fuel valve boilers occupies relatively so little space in the hull. These will be appreciated also on reference to the sketches of the transatlantic liner of the future which are produced herewith. Larger though the proposed ship is, she should present no greater problems of manœuvring than the two existing mammoths. For handling in port, very close co-operation would be necessary with tug companies in the design stage. The transatlantic liner of the future is a speciality ship catering primarily to one class of people and for one specific purpose, with ports defined before construction, these ports of call being specially built to receive and despatch in the most efficient manner possible. The idea of a general utility ship adaptable to varying trades went with the advent of the "Queen Mary" and "Normandie", though even the latter is to cruise to South America next year. The largest ships of the future must be built for the North Atlantic trade only with wharves or piers specially constructed to expedite arrivals and departures and every known form of equipment on the docks to aid in getting passengers and baggage to their destination in the shortest possible time. There is little use in speeding up the ship if the time gained in this way is lost at the terminals, as the authors have suggested.

No new form has been evolved in the design of any ship near the size of the one the authors have under consideration, nor is something radically different from anything ever attempted in shipbuilding contemplated. The length of the mammoth is about 1,350ft. b.p. If the hull could be duplicated in lighter form and placed upside down on the main deck, this would give as clean a form moving through the air as the water and also ideal streamlining. As this is impracticable, compromise must be effected and wind resistance cut down to a minimum by eliminating all deck obstructions. The most decided changes for a completely streamlined ship must necessarily take place in the superstructure. As this consists largely of passenger accommodation, the utmost care will have to be taken to impair in no way creature comforts.

With the greatly accelerated speed and greatly increased dimensions, it might be considered advantageous to step back the hull at each deck height from the main deck up, which would form a stronger structure, and if the same idea was carried into the superstructure, we would get a species of turret formation thereby concentrating the weights closer to the centre of the ship. Gyro stabilisation would be considered. Only one precedent exists for this at the moment. This again would affect state room and public accommodation, but it could be overcome as there is considerably more beam to work on. One serious drawback to this turret formation would be the lowering of lifeboats, but as ships grow in height this problem will have to be tackled and perhaps solved by stowing them on a lower deck under cover, as indeed was done in some of the early transatlantic mammoths.

It is contended that no benefits are obtained from streamlining unless a body is passing through the air at the rate of 60 miles per hour, but if the speed of this new liner is about 40 miles per hour it only takes a light breeze to give conditions favourable to streamlining. With this in mind, the authors feel that this transatlantic mammoth of the future will be streamlined to the greatest possible extent and all deck obstructions or projections will be eliminated. Lifeboats always have been a problem to handle and the necessity for quick accessibility and the irregularity of their shape and lowering gear make them an added problem to try to cover or streamline. Future generations may decide that they are as redundant to a properly designed and protected mammoth as parachutes are to an air liner.

In these thoughts the authors see the dawn of a new era in ocean transport, with the possible in-

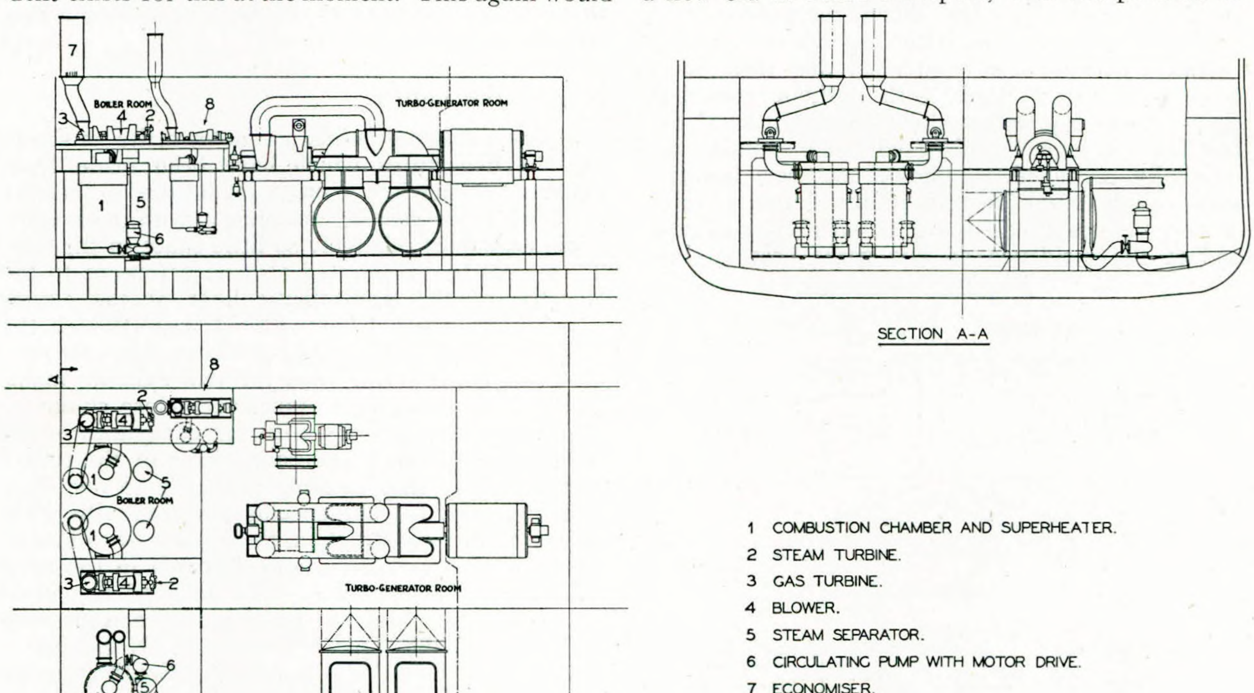


FIG. 6.—Plan of portion of engine room, showing main and auxiliary Velox boilers, condensers, etc.

FIG. 4.—An impression of the transatlantic liner of the future showing clear glassed-in upper decks and horizontal smoke ducts.

cidence of completely enclosed and air-conditioned speed boats of mammoth size and 45 knots speed.

In any event smoke stacks, external ventilator gear and other deck wind catchers will all be eliminated in the transatlantic liner of the future by carrying the top hamper in a straight line from the navigating bridge aft to the break down. The funnels are horizontal on the recreation rooms and extend over them almost the entire length of the ship as Fig. 5 shows, at least from the bridge aft. This fore and aft tunnel is divided into three compartments properly insulated and open at both ends, natural draught and/or fans being used to drive the smoke aft. The two outer compartments are used for ventilating machinery, holds and passenger accommodation. Funnels are the greatest offenders in the prevention of streamlining and as the new structure very easily lends itself to running the uptakes into a horizontal tunnel, this is combined with parallel or adjoining tunnels to ventilate the entire ship. Furthermore, this structure is directly over the sports or boat deck with a dome formation forming a glass enclosure for sports. This will give a very pleasing effect and in no sense of the word look forced. A grid similar to a motor radiator may form the forward end and openings will be made at various distances along the side and top for access to adjust wind scoops and fans when at sea. The possibility of also making a sheltered run-way for the crew was considered but not thought necessary.

Only conditioned air will be used in public rooms and inside staterooms where passengers have no control over the ventilation. Elsewhere the right of the individual to regulate the atmospheric conditions of his own compartment and get a breath of sea air cannot yet be denied him.

The navigating bridge will work into the general contour, and docking bridges both amidships and aft will also form part of the streamlined structure while at sea and be operated mechanically to slide out to the desired position when docking or on other occasions. As the entire superstructure is enclosed, all stairs and elevators which will be greatly increased in number, should extend up to the boat deck for quick egress. Consideration also will be given to some form of escalators. As the distances increase these devices will find a new application.

Machinery Arrangement.

Having thus put forward an argument showing the lines upon which the transatlantic liner of the future must be conceived with regard to length of voyage and therefore of speed, size and arrangement, the authors can now conveniently develop the theme with regard to the machinery. It may be estimated that about 400,000 s.h.p. continuous service rating will be needed. This the authors propose to distribute over six screws, three on either side of the centre line. Because of this

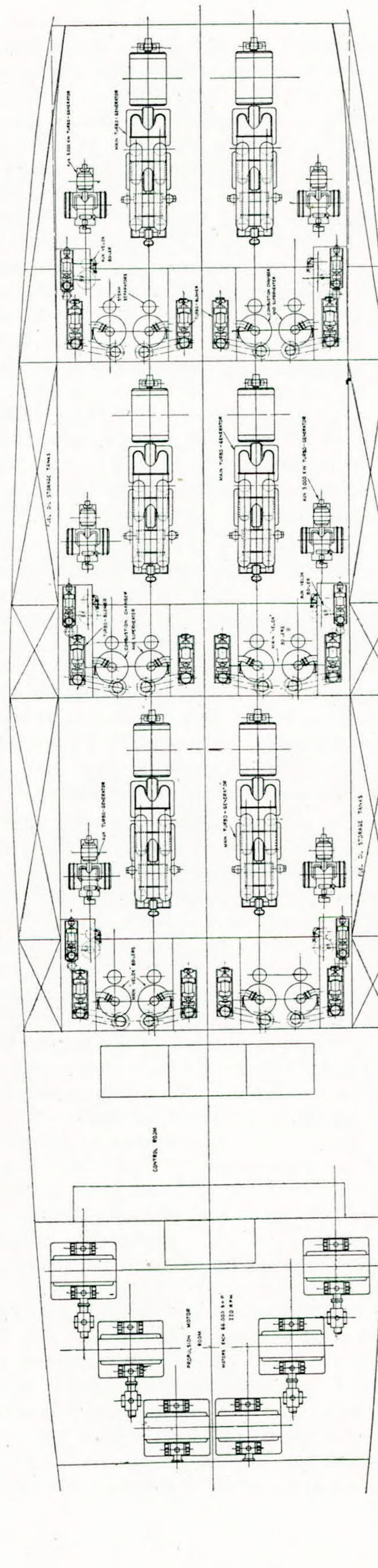


Fig. 7.—General arrangement plan of engine room, showing layout of propelling motors, control cubicle and turbo-alternator rooms.

power, greater than anything that has yet been conceived for marine propulsion, it is necessary that the utmost economy be used in the space taken for the layout. Investigation shows that there is only one method in which a ship such as is proposed can be propelled, because of the six screws and the distribution of the shafting in the power room. This is by turbo-electric drive and the general scheme is to have six turbo-alternators each complete with its own fuel valve type boiler, *see* Figs. 6 and 7. For purposes of this investigation the authors have selected the Velox boiler, but the remarks would apply equally to any of the fuel valve types which will shortly form the subject of a review at The Institute. The authors arrange the six turbo sets, each of which is self-contained, in three power rooms separated by a transverse water-tight bulkhead. Abaft No. 3 power room as will be seen from the diagrammatic layout in Fig. 7 is a control station in which the whole of the manœuvring will be carried out and near to which the exciter sets are arranged.

Abaft this are the two main propelling rooms, the forward one of which contains four single-armature motors, each of 66,600 h.p. output and approximately 220 r.p.m., and the aft one two. The sketch shows the arrangement by which the centre screw in each trio is operated by the motor which is furthest aft. This is merely a matter of convenience. Should it be desirable or necessary a fore and aft watertight bulkhead can divide the two motor rooms into four separate compartments.

One of the greatest difficulties with which the designer of such a ship is faced, is that of fuel consumption. Therefore, forward of the No. 1 power room two tanks have been arranged, since the side bunkers will certainly not be sufficient to carry all the fuel required. If a big transatlantic mammoth is taken as a basis of comparison, she uses roughly 500 tons a day; the consumption of the transatlantic liner of the future for a crossing would therefore be about 2,150 tons per day. This requires space for at least 11,000 tons of fuel per voyage in addition to say 3,000 tons of feed water. Arrangements must therefore be made, in order to preserve the correct trim of the ship, for the substitution of ballast water for the fuel as this is used. Assuming then that the authors' layout is roughly as shown in Fig. 7, the following are the more intimate details of the machinery which will be employed. Based on electric drive it uses six main turbo-alternators, each with a capacity of 51,000 kW. (68,300 h.p., 2,640 r.p.m.) at the terminals, giving a total output of 399,600 h.p. at the propeller shafts. Each main unit would have two Velox steam generators, each with a capacity of 200,000 lb. per hour at 825lb. pressure (gauge) and 925° Fahr. total temperature; there would therefore be twelve main boiler units. In each of the six engine rooms there would be installed an auxiliary turbo-generator of 3,500 kW. capacity with its auxiliary Velox steam generator with an evaporation of 50,000 lb./hr. at 365lb. pressure (gauge) and 700° Fahr. total temperature. The steam generator would supply steam at a lower pressure and temperature not only to the turbo-generator but also to the auxiliary turbines of the main boiler units in addition to its own auxiliary turbine. Two small heavy-oil engines would supply energy for starting up the auxiliary boilers when no steam is available. Weights and other conditions are as follows and the space required is shown in Figs. 6 and 7. This makes the equipment virtually self-explanatory and establishes it is hoped that there is nothing extraordinary in such a power plant from the marine engineering point of view. Indeed, if anything the rating and output is conservative. Everything is normal power station practice.

Finally, the authors would like to express their appreciation to Mr. W. J. Belsey of the British Thomson-Houston Co., Ltd., to Mr. E. S. Dean of Messrs. Richardson, Westgarth-Brown Boveri, Ltd., to Mr. A. Thomson of Messrs. Pilkington Bros., and to Mr. A. W. Ballardie for their help and criticism in the many conferences which have been necessary in the evolution of the authors' Ship of the Future, which it is hoped will stimulate interest as well as a fruitful discussion.

MAIN TECHNICAL DATA OF PROPULSION EQUIPMENT.

Main Turbo-alternators; 6 units:		
Type	...	two-cylinder
Output, max. continuous rating ...	kW. ...	51,000
Speed, max.	r.p.m. ...	2,640
Steam pressure	lb./sq. in. g.	800
Steam temperature	°F. ...	900
Vacuum (Bar. 30" Hg.)	"Hg. ...	29
Condensing Plant:		
Cooling surface	sq. ft. ...	55,000
Circulating pumps	4 units motor driven	
Extraction pumps	2 units, motor driven, each for full capacity	
Feed heating	...	single stage
Propeller Motors:		
6 syn. ind., 66,600 h.p., 220 r.p.m.		
Main Steam Generators; 12 units:		
Type	...	Velox oil-fired
Capacity of each unit; max. continuous evaporation	lb./hr. ...	200,000
Steam pressure	lb./sq. in. g.	825
Steam temperature	°F. ...	925
Feed water temperature to auxiliary preheater condenser...	°F. ...	200
Auxiliaries:		
Power consumption of pumps—		
circulator pump 122		
regulating oil pump ... 6		
fuel oil pump 25		
kW. 153	kW. ...	153
Charging unit, steam auxiliary—steam consumption for aux. boilers at 350 lb./sq. in. g. and 700° F.—exhausting at 30lb./sq. in. abs. into heater-condenser...	lb./hr. ...	5,000
Fuel oil consumption—oil consumption at max. continuous evaporation	lb./hr. ... tons/hr.	15,400 6·87

Auxiliary Turbo-alternators: 6 units:

Output; max. continuous rating...	kW. ...	3,500
Speed	r.p.m. ...	3,000
Steam pressure	lb./sq. in. g.	350
Steam temperature	°F. ...	700
Vacuum (Bar. 30″ Hg.)	″Hg. ...	29

Auxiliary Boilers; 6 units:

Type	...	Velox oil-fired
Capacity at max. continuous evaporation...	lb./hr. ...	50,000
Working steam pressure	lb./sq. in. g.	365
Steam temperature...	°F. ...	720
Feed water temperature	°F. ...	200
Auxiliaries:		
Power consumption of pumps...	kW. ...	40
Charging unit—steam auxiliary exhausting into heater-condenser steam consumption ...	lb./hr. ...	1,500
Fuel oil consumption — oil consumption at max. continuous evaporation	lb./hr. ...	3,680
	tons/hr. ...	1·64

Auxiliary Load:

Requirements of each main propulsion unit with its auxiliary turbo-generator and Velox boiler:

Main condenser:		
C.W. pumps (against 30′) ...	kW. ...	500
Condensate pumps (against 100′)	kW. ...	35
Boiler feed pump (against 1,000 lb./sq. in.)	kW. ...	650
Main Velox boilers...	kW. ...	305
Auxiliary condenser, total... ...	kW. ...	50
Auxiliary Velox boiler	kW. ...	50
Exciter unit for main generator and propulsion motor	kW. ...	600
Approx. total for one main power unit with auxiliaries	kW. ...	2,190
Hotel load and deck auxiliaries—Estimated total	kW. ...	6,000
Total kW. load per auxiliary turbo-generator = (2,200+1,000)	kW. ...	3,200
Equivalent steam consumption at 9·75 lb./kW./hr.	lb./hr. ...	31,200
Steam consumption of main Velox auxiliaries	lb./hr. ...	10,000
Steam consumption of auxiliary Velox auxiliaries	lb./hr. ...	1,500
Total auxiliary steam demand ...	lb./hr. ...	42,700
Equivalent oil consumption (net calorific value 18,000 B.Th.U./lb.)	tons/hr. ...	1·44

Approximate Fuel Consumption:

Main units:		
Heat consumption at normal rating...	B.Th.U./s.h.p./hr.	7,380
Fuel oil consumption: (based on oil with net calorific value of 18,000 B.Th.U./lb.) ...	lb./s.h.p./hr.	0·45
Total fuel oil consumption of main units when operating at 400,000 s.h.p.	tons/hr. ...	80·3
Auxiliary units:		
Fuel consumption for the 6 units	tons/hr. ...	8·7
Total fuel consumption including all auxiliaries	tons/hr. ...	89
Ditto	lb./s.h.p./hr.	0·5

Oil 19,000 B.Th.U.'s 0·474 lb./s.h.p./hr.

Summary of Total Weights:

Turbo-alternators 6 units	1,970
Main condensers and auxiliaries...	1,560
Main boilers, 12 units	1,630
Auxiliary turbo-alternators, 6 units (including condensing plant)	270
Auxiliary boilers, 6 units	222
Main propulsion motors	1,740
Exciter units	90
Propellers and shafting thrust and line bearings	1,200
Cables	400
Control...	60
Auxiliary Diesel sets	Make and arrangement not decided
Ladders and gratings	300
Bilge, ballast, sanitary and other pumps... ...	300

APPENDIX.

EVOLUTION OF THE MODERN GLASSED-IN SHIP SUPERSTRUCTURE.

It is thought that the following notes on the evolution of the modern ship profile are apropos as showing the development which has led up to the existing transatlantic mammoth, and which will be taken further in any new ships.

To all intents and purposes the Scandinavian nations introduced the glassed-in front to the promenade deck, doing so even on cargo liners and North Sea packets. From this simple glassing in, the present day profile and curved superstructure may be said directly to have sprung. The Scandinavian nations are naturally sea-faring but being good seamen they are not unmindful of comfort on board their ships. Being hospitable, they like to have guests even on their cargo vessels and the "guest" at one time was more often than not the owner. What more natural then than to take the forward end of the promenade deck, short or long though it might be, fit wooden frames with glass to keep the wind from blowing down the deck? What more natural at a later date, than to remove the wooden frames and substitute steel partitions? During this period of time improvement had naturally taken place in the manufacture of glass. The increased demand of the automobile industry throughout the world upon the glass manufacturers, directed the attention of the latter to making products which would be stronger than the ordinary non-safety type of glass. Hence in turn they found that they had something to offer to the shipowner which would tempt him to use more of their product, namely a strong well-tempered splinter-proof article. The greater the extent to which the shipowner felt he could rely upon this glass, the more, naturally, he was willing to employ it and we find that these panels gradually began to creep round the sides of the promenade deck. Glass enclosed, there was a natural tendency to regard the promenade deck more in the light of part of the structure. The fact too, that it was shut away from wind and waves encouraged the placing of small tables outside the main superstructure and of the taking of meals on these tables during the fine weather. Thus what was originally a walkway, now became a kind of verandah cafe and it was not long before certain of the more bold designers decided to do away with what was originally their superstructure wall and to extend their interior public rooms to the glassed-in sides of the ship. This has culminated in arrangements such as we find on the transatlantic liners "Queen Mary" and "Normandie" and on the Belgian State Railways' cross-Channel packets "Prince Baudouin" and "Prins Albert". On these three ships, though different in their *raison d'être,* there is more glass than on practically any other vessel afloat. It is carried to a further extent forward and has become virtually part of the hull of the vessel.

Discussion.

Mr. W. J. Belsey (Visitor), opening the discussion, said that he was only concerned with the machinery from the turbine stop valve to the motor coupling at the propeller shaft, and he could say that if the required quantity of steam was delivered at the turbine stop valve from any type of boiler at the pressure and superheat mentioned in the paper, then the problem of delivering 66,000 s.h.p. to each of the six propeller shafts presented no difficulty whatsoever.

He pointed out that within a radius of ten miles of The Institute there were at work continuously three 75,000 kW. sets at Barking "B" Power Station, and a fourth 75,000 kW. set would presently be installed there. At Battersea Power Station there were two 66,000 kW. sets and a further set of 100,000 kW. was being erected, so that the turbo-alternators put forward were machines of designs which had been well tried out in service.

The motors and control gear presented no difficulty whatsoever, being of standard design.

It was of interest to note that the whole of the 400,000 s.h.p. machinery would go into rather less space than that occupied by the machinery of the "Normandie", which was normally rated at 160,000 s.h.p.

Eng. Rear-Admiral W. R. Parnall (Member) considered that the authors had made a case for a ship of great size and of high speed for the Atlantic service. The commercial and economic aspects of the proposal did not come within his sphere, but he would comment on the authors' proposals for propelling machinery.

He had no reason to suppose that the scheme was impracticable—certainly the turbo-alternators appeared to be everyday practice, and the arrangement by which the funnels were replaced by a horizontal duct had already been adopted in at least one of the aircraft carriers. One feature which was remarkable was the extraordinarily small floor space allotted to the boilers. They were accommodated in an area approximately 80ft. by 90ft. and they occupied rather less than 20 per cent. of the total length of the machinery space as compared with some 60 per cent. in the "Queen Mary". It was no wonder that the authors felt they had to find some such expressive term as "fuel valve" to describe them. The speaker confessed that he did not quite understand the incidence of that particular term. If Rudolph Diesel had preceded James Watt he might in due course have been led to temper the blast of the flaming oil to the unsheltered pistons by interposing between them the mollifying medium steam and doubtless the name would have followed the fuel. Whether the term "fuel valve boiler" was good or not, it certainly indicated a departure from a modified kettle with its accumulation of heated water and suggested that steam was there to transmit the heat energy of the fuel to the engine just as fast as that energy was developed, and that in a subsequent development the engine might be controlled by supply of fuel—though they had not quite got to that yet.

On page 274 the authors stated that there was only one method by which a ship such as was proposed could be propelled. In this he disagreed with them. When the proposal first came to his attention he considered it a matter of interest to ascertain if similar power might be produced with geared turbines. Inspection of the problem indicated that if there were any difficulties in the design they would arise in respect of planning a reasonable propeller, the arrangement of the turbines about the shafts, and the provision of sufficient steam generation in the available weight and space.

Now taking these in order, the conclusions from a brief inspection of the propeller problem were that it should be quite practicable to design efficient propellers to transmit 400,000 or even 500,000 s.h.p. on *four* shafts. Such a propeller for 400,000 s.h.p. might be some 23 or 24ft. in diameter and would run at some 140 r.p.m., the pitch ratio being perhaps 1·35, and it was thought that this would be quite a good propeller.

As regards the arrangement of turbines, by the use of two gear wheels on each shaft the power ranged about each gear wheel became comparable with that in use to-day and would thus present no difficulties.

The authors had shown how to provide for the generation of steam in very little space, but should the prospective shipowner feel more conservative, the speaker had no doubt that ample boiler capacity with the natural circulation type of boiler could be accommodated in the space saved by elimination of the alternators. In this connection he would refer to a paper read by Engineer Admiral S. R. Dight before The Institution of Naval Architects in April, 1936.

Dr. G. S. Baker (Visitor) said that his own paper, to which Mr. Hardy had referred, was read about a month ago, and an anonymous writer had suggested that his remarks in regard to future liners were made without consideration of the problems involved. He thought that the proposals now put forward by Messrs. de Malglaive and Hardy were an effective answer to that writer.

He (the speaker) had as a matter of fact taken the trouble to check the possibilities of such a ship by getting out the weights. He had based his engine and fuel data on the American mercury boiler which was more economical than some of those mentioned in the paper, and working on this the two schemes mentioned in his own paper were quite feasible. He had found that a power of 500,000 s.h.p. was possible, and it was evident that such vessels were feasible from the point of view of making them work, assuming that they could be built. He had listened with interest to the remarks of Mr. Belsey and Admiral Parnall on the engineering side of the question.

Mr. de Malglaive knew most about the commercial aspects of the proposition, but there were several points in the design which called for comment. First of all, no account had been taken of the possibility, instead of spending enormous sums of money on new ports, of taking off by helicopter the few people who were in such a hurry. These were being considered as adjuncts to ships. They could rise and settle almost vertically, they required no catapults, and he thought they would be found to be much less expensive than the terminals which the authors had suggested.

He could not help thinking that the authors had treated speed a little lightheartedly. They spoke of 35, then 40 and ultimately of 45 knots, as though 5 knots amounted to nothing very much. This rather put one off that side of the paper. He doubted very seriously whether 400,000 s.h.p. would give a trial speed of 45 knots. He had reckoned that 500,000 s.h.p. would be required to give 40 knots with a suitable hull design.

With regard to streamlining, most of those present would remember that a few years ago there existed in the motor industry a great fancy for streamlining. The windscreen was made so small that it was difficult to see through it and the back of the car was made so that one could hardly get in. No-one wanted that and the manufacturers had gone back to more normal shapes. With high ship speeds it was necessary to cover up the passengers, but that there was a great deal to be gained by extreme streamlining was entirely wrong. The wind resistance coefficient of the "Lusitania" hull and superstructure was ·17 and the utmost that could be done by every kind of streamlining was to bring it down to ·12. Now ·17 meant that the air resistance in still air was about 2 per cent. of the whole power of propulsion and with a 30-knot head wind only 8 per cent. This was with moderate streamlining as at present, and the gain from further streamlining would only reduce these percentages in the ratio ·17 to ·12.

He would cross swords with Mr. Hardy on the subject of the clear foredeck. Most of those who had been on a cruise had seen "the bright young things" perching themselves on a winch at the fore end and sitting quite comfortably in a head wind. Why did they do it? Because there was no wind on the forecastle deck of a modern ship. It was all thrown up and there was no need to move winches, etc., from the forecastle deck. All the transverse curvature given to the superstructure had practically no effect at all. This was borne out by experiments. The passengers must be covered up but there was no necessity to waste weight and money in unnecessary curvature of structure.

Another difficulty with these great sweeping curved fronts of the deck erections was that with a 30-knot wind playing against the front, the velocity on the sides was about 45 knots. The result was that it would be quite dangerous to attempt to go round these curved surfaces. He had seen one of his staff try to get round a large funnel in a high wind and he was unable to do it. The deck near these would be untenable.

Why had so much attention been given to getting the funnels down and the exhaust gases through to the stern? What was gained by it? All the passengers were covered up so soot could not reach them, and as the resistance of the funnels was small he doubted whether there would be an advantage of even one half per cent. Why spend all that money to discharge the gases at the after end of the ship which, incidentally, was the only part where the passengers could possibly get out in the open. Also, what happened when there was an astern wind?

Mr. T. C. Tobin (Visitor) said that it must be more than 70 years ago that a very distinguished countryman of Mr. de Malglaive's published a story which was read avidly by schoolboys for several generations. He was referring to a work called, he believed, "The Clipper of the Clouds" by Jules Verne. Even before that, Tennyson the Poet Laureate had visualised "the nations' airy navies grappling in the central blue". He did not believe that these dreamers really contemplated such an early materialisation of their ideas as the present generation had lived to see, and it would therefore ill-become those present to discourage the co-dreamers who had presented the paper that evening.

He could not help recalling that about nine years ago a Committee was set up in America to investigate the question of the super liner. This Committee put forward proposals for a ship of 35 knots maximum speed to maintain what they called a four-day service with an average speed of $32\frac{3}{4}$ knots. But these proposals only visualized a ship of 900ft. in length. Two or three years later there was a paper read before the American Society of Naval Architects and Marine Engineers dealing with a similar scheme for a ship of 930ft. with a maximum of 200,000 s.h.p. These dimensions and powers had now become actual facts. One paragraph in the American report stayed in his memory and laid emphasis on one of the real difficulties of the problem. This stated that unless the terminal facilities were specially designed and the personnel specially trained, it would be impossible to keep the schedules. More than half the problem was associated with this question. The report also suggested that it should be understood that the American terminal should be somewhere within 200 miles of New York. That he assumed was expressed in the authors' suggestion to make the terminal at the eastern end of Long Island, which would save about three hours steaming at the rate of speed contemplated in addition to the time saved by avoiding the slow passage up channel from Ambrose Light to New York. In regard to the shore facilities and personnel, it was important to note that at the average speed mentioned, every hour lost in port meant an increase of 3/7th of a knot to maintain the schedule.

So far as the actual building of the ship proposed by the authors was concerned, the dimensions indicated were such that there might be two or at most three building slips in the United Kingdom of Great Britain and Northern Ireland which could by any possible alterations be made to accommodate a ship of these dimensions. The length difficulty would be the first and that would give rise to some awkward launching problems, especially on such rivers as the Tyne and Clyde. The beam would probably necessitate a special slip being built, and he did not know if there was in existence a dry-dock or even a floating dock which would take a vessel of such dimensions. These were vital problems associated with the whole scheme.

He had been extremely interested in Dr. Baker's remarks on streamlining, and his version of the "dream" ship.

Mr. E. S. Dean (Visitor) said that in view of the fact that he was connected with the manufacturers of the Velox steam generator, his contribution to the discussion must essentially take the form of a statement supporting the practicability of the scheme as put forward by the authors insofar as the boiler plant was concerned.

The specific rating, weights, dimensions and scantlings of the boilers as shown in the paper were based on units already built and in service; a specific example of such boilers, which had already proved themselves in service, was those at the Rosenkrantzgate Power Station in Oslo. These boilers were each for an evaporation of 165,000 lb./hr. at 400 lb./sq. in. and 800° F. They had been in service for over a year and a third unit had recently been ordered. The floor space occupied by these units was approximately 9 sq. ft. per ton of steam. In the transatlantic liner project this was approximately 7·7 sq. ft. per ton of steam and the difference was explained by the fact that the layout in the ship permitted the charging units and economisers to be placed at a higher level, with a corresponding saving in floor space. The following tabulation would give details of the heat surfaces and specific ratings, the latter corresponding substantially with those of the Oslo and other units :—

Heating surfaces:	
generating surface	1,490 sq. ft.
superheater surface	1,610 sq. ft.
economiser	4,400 sq. ft.
total surface	7,500 sq. ft.
Combustion chamber:	
volume	436 cu. ft.
Specific evaporation:	
per unit area of generating surface	134lb./sq. ft./hr.
per unit area of total surface ...	26·7lb./sq. ft./hr.
Specific heat release:	
B.Th.U./cu. ft./hr.	625,000.

The foregoing remarks would suffice to indicate that the boiler project in question had been based on equipment which had already been proved in service, and it might be mentioned, furthermore, that there were now approximately 60 such boilers either in service or under construction conforming to the design and ratings which had formed the basis of this particular project.

Mr. W. W. Marriner (Visitor) said that he had had the pleasure of crossing the Atlantic on the "Queen Mary" on two occasions. He had gone all over that wonderful ship which he thought then, and still thought, was the finest thing man had ever done. He had inspected the ship from the stern at the end of the shaft tunnel right to the anchor locker forward.

They had all heard about the vibration, but in no part of that ship was there more vibration than there was in the Lecture Hall in which they were now congregated. He could speak in the shaft tunnel just as easily as he spoke now. He mentioned this to show the perfection which had been reached by shipbuilders who had had the co-operation of the superintendent engineers in giving their practical experience.

One of the great drawbacks of these big ships was the abnormal distances which one was compelled to walk. This was a real objection. The promenade deck of the "Queen Mary" was a formidable walk.

It seemed to him that no consideration was given to weight in these big liners. In destroyers they tried to save every ounce of weight, and it was said that 10 per cent. saved in the weight meant one knot increase in speed. It meant at any rate 10 per cent. less power. The demands of passengers on these big liners were so great that even swimming baths were required. He thought that these could be eliminated and that a great deal more attention might be given to the saving of weight.

Mr. C. Sharp (Visitor) said that he spoke as a tug and tender operator, and many of his remarks applied to some existing ships.

The length of the vessel proposed by the authors was such that it would be an awkward ship to manœuvre in anything like a breeze. It was considered, however, that only one more tug would be required than was at present needed for the "Queen Mary". Incidentally, it was found that new ships were very much easier to handle than old ones.

It would be preferable if tugs could get hold of the ship when pushing her into a berth, which the midship tugs had to do. The midship tugs were not tied up, and therefore were unable to check the liner if she was going into the berth too fast. Mr. Sharp suggested that they should have a hook at the fore end of the tug so that this could be done, and when the ship's propellers were suddenly put astern without warning, they could slip the wire and get out without damaging themselves or the ship.

With regard to tenders, he stated that from the owners' point of view, speed seemed to be of maximum importance, and to enable them to be quicker it would be better if easier arrangements for making the tenders fast to the vessel were made, i.e., doors on the level or about level with where the tenders required to pass their ropes out. At any rate, it took a long time for ropes to go 60 or 70 feet up fore and aft, and when they were there they were of little security to the tender. Again, lower doors about the level of the tenders where light gangways could be used—gangways which a couple of men could handle instead of as at present ones weighing over a ton—would make for speed.

The speaker did not think that tenders would grow in proportion to the liners. Tenders had to pay dock dues, and these expenses were kept to the minimum by occupying out-of-the-way spaces in the dock.

Mr. A. Thomson (Visitor) said that the authors had referred to the use of glass for covering the decks of the ship they had proposed, and he assumed that the glass selected would be of the toughened variety. He then described the difference between normal plate glass and the toughened quality, the process by which it was made, and its characteristics.

A previous speaker had raised the question of weight, and it was interesting to note in this connection that whereas one square foot of polished glass of the necessary thickness weighed approximately 13lb. the weight of one square foot of toughened glass of the reduced thickness permitted by the Board of Trade was only 8lb. This was quite a consideration in a modern vessel for which much glass was used.

He stressed that the method of fitting the glass was of considerable importance.

From the point of view of the glass manufacturer the scheme outlined in the paper presented no difficulties whatever.

Captain E. C. Goldsworthy (Visitor) said that Mr. Tobin had already mentioned two very important points, namely terminal operation and the special staff which such big ships demanded. Mr. Sharp had given some very practical thoughts from the tug and tender operators' points of view and these must necessarily go under the general heading of terminal operation and as part of the special staff mentioned above.

The present big ships of 1,000ft. long were extremely difficult to handle when moving at a very slow speed approaching a pier or anchorage, particularly when there was tidal influence and still more so when the wind was strong. The ship visualized in this paper, having a length of 1,350ft. and a continuous structure rising perhaps to 140ft. above the waterline, gave a tremendous area for wind influence at low speeds. It was not uncommon for the ships of to-day, when anchored in the Solent under a strong wind and a tide, particularly if the former was athwart the tide, to yaw up to 50°, making the process of disembarkation of passengers and baggage by tenders alongside, a matter of difficulty and delay.

Again, when such ships were going alongside or getting away from a pier with a heavy broadside wind, the tugs attempting to control her were often powerless to prevent heavy blows, with their attendant possibilities of damage to the ship and to the pier.

It therefore appeared that very careful consideration would have to be given not only to the choice of the terminal port and the position of the anchorage or piers with relation to the current or tide and prevailing wind, but that serious consideration must be given to some form of additional control for the ship itself when at low speeds. Dr. Foerster, in his paper before the International Meeting of Naval Architects and Marine Engineers in New York last year, suggested a central Voith-Schneider propeller for the propulsion and control of such big ships at low speeds. This should be seriously considered if and when vessels of the size of the one suggested in this paper were contemplated.

Mr. E. G. Warne (Member) said that when he read the paper he found himself wondering whether it was to be seriously considered. Even if it were considered as an engineering proposition, it could not be considered as a commercial proposition. He based that remark on the known inability of the two largest liners to pay their way, and the impossibility of one of them earning enough to pay its depreciation. He believed its laying-up costs were somewhere about £750,000 per year. Some way out of that difficulty had to be found.

At the present time the only way to build such a ship as the authors suggested was by taxing the country for which that ship was built, and the people who were taxed would, for the most part, never be able to make a trip in the ship for which they had paid. Although in this Institute they considered the scheme chiefly as engineers, it was no good introducing a proposal which was going to be a commercial catastrophe.

There was a case for the building of such ships as the "Queen Mary" and the "Normandie" owing to the great use they would be in time of war, and for their usefulness in carrying mails. The ship proposed by the authors, however, would be of no use in wartime. He thought the authors should give some idea of how the ship was going to be built and who was going to provide the money for it.

Mr. C. J. Hampshire (Member) said that it appeared the mammoth fast liner did get her full complement of passengers whose aim was to be rushed across the sea in the shortest possible time. Therefore a passenger ship designer of the future might have to put speed before anything else.

He was very interested in Fig. 4. He remembered being shown a small model a year ago very similar to the illustration, and it was the subject of some strong argument.

It was his firm opinion that streamlining as applied to the superstructure of a ship could be carried too far. It was the *underwater* part that was most important and should be streamlined. One saw funnels pear-shaped, and the same even with the masts of racing yachts. This he thought was merely a fad. In the air where speed was much greater he agreed that streamlining was valuable, but not on a ship. By all means round off bridges and step back the superstructure fore and aft, but a clean sweep should not be made of all the deck fittings, etc. He could not see that whatever speed a ship had, it warranted excessive streamlining.

He was delighted to see that the authors had allowed two pole masts, but with the improvements in wireless communication they might even do without these in the future.

Regarding the huge weight of fuel which was

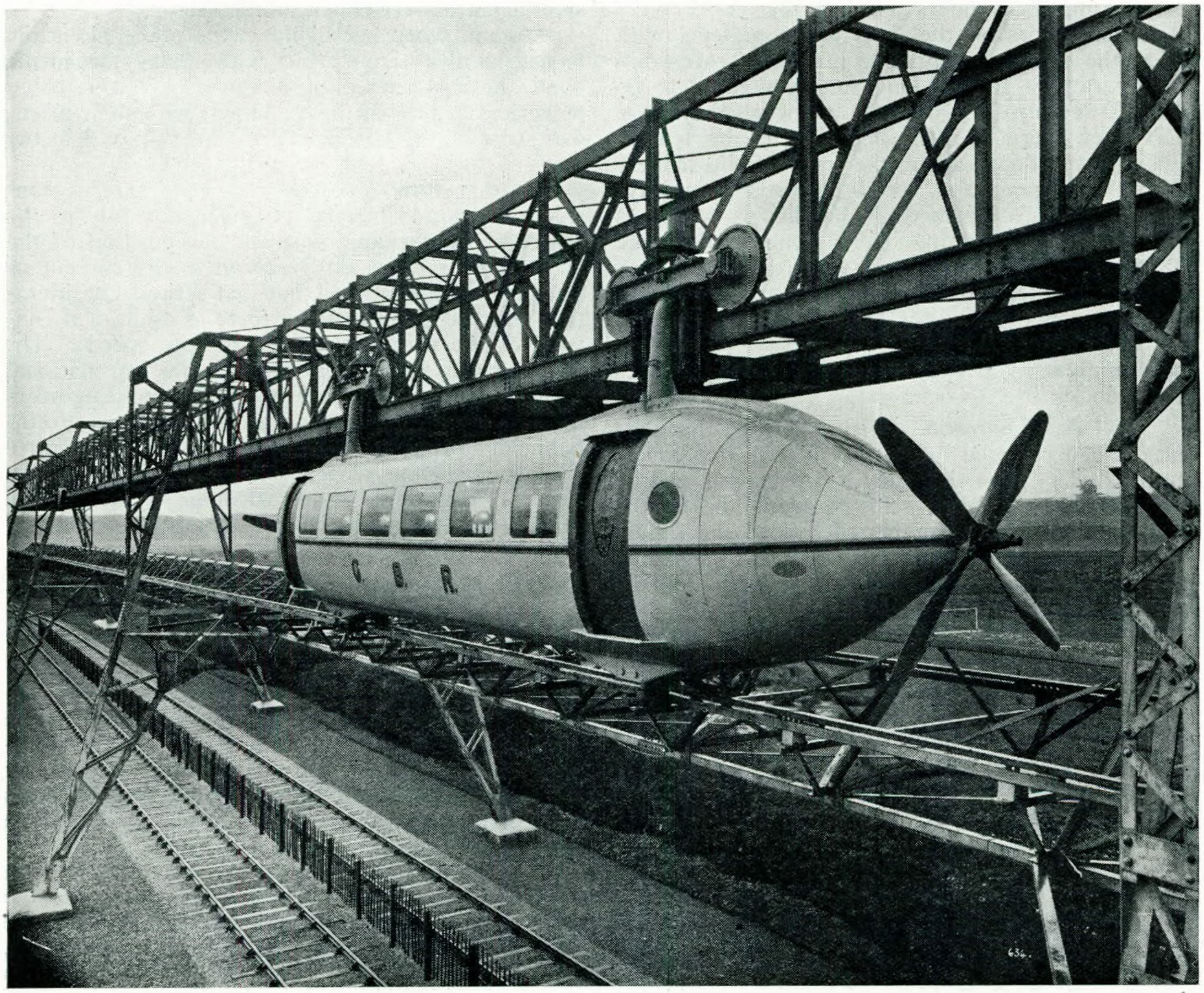


Fig. 8.

mentioned, he suggested that perhaps in a few years scientists might produce a compact type of very high-powered fuel, taking up very little space. Boiler feed would be taken direct from the sea, distilled aboard and fed direct to the boilers which would be of a very high-pressure flash type. The space thus gained could be used with greater advantage to the shipowner. The loss of the weight of fuel would be taken up by cargo.

He liked the idea of the arrangement of the six screws with turbo-electric drive, which certainly took up less space and was very flexible. Air conditioning was now being adopted on many modern liners, and he suggested that an extra dose of brine be added as the enclosed passengers would not smell the real thing.

Washing devices for the funnel gases were ideal to keep a glass ship clean, and the draught the vessel drew would have to be very carefully watched. In conclusion might he ask the authors to allow them to keep the funnels for a few more years.

On the proposal of **Mr. R. Rainie, M.C.** (Chairman of Council) a cordial vote of thanks to the authors was heartily accorded.

By Correspondence.

Mr. G. Bennie wrote that he noted in reference to Fig. 1 that fast communication was suggested between Montauk Bay and Manhattan and that train speeds of 120 m.p.h. might be assumed in the not far distant future.

It was rather a coincidence that a speed of 120 m.p.h. should be mentioned. The railplane system of transport with which his name was associated, a film of which he had been permitted to exhibit following the discussion at the meeting, gave a cruising speed of 120 m.p.h. He had invented this system with a view to shortening the journey between airports and cities. By installing the system, the time of travel between airports and cities, which now averaged about one hour, could be reduced to six minutes. The distance of 170 miles between Montauk Bay and Manhattan could be accomplished in $1\frac{1}{4}$ hours as the top speed of this railplane was 200 m.p.h. for distances of 170

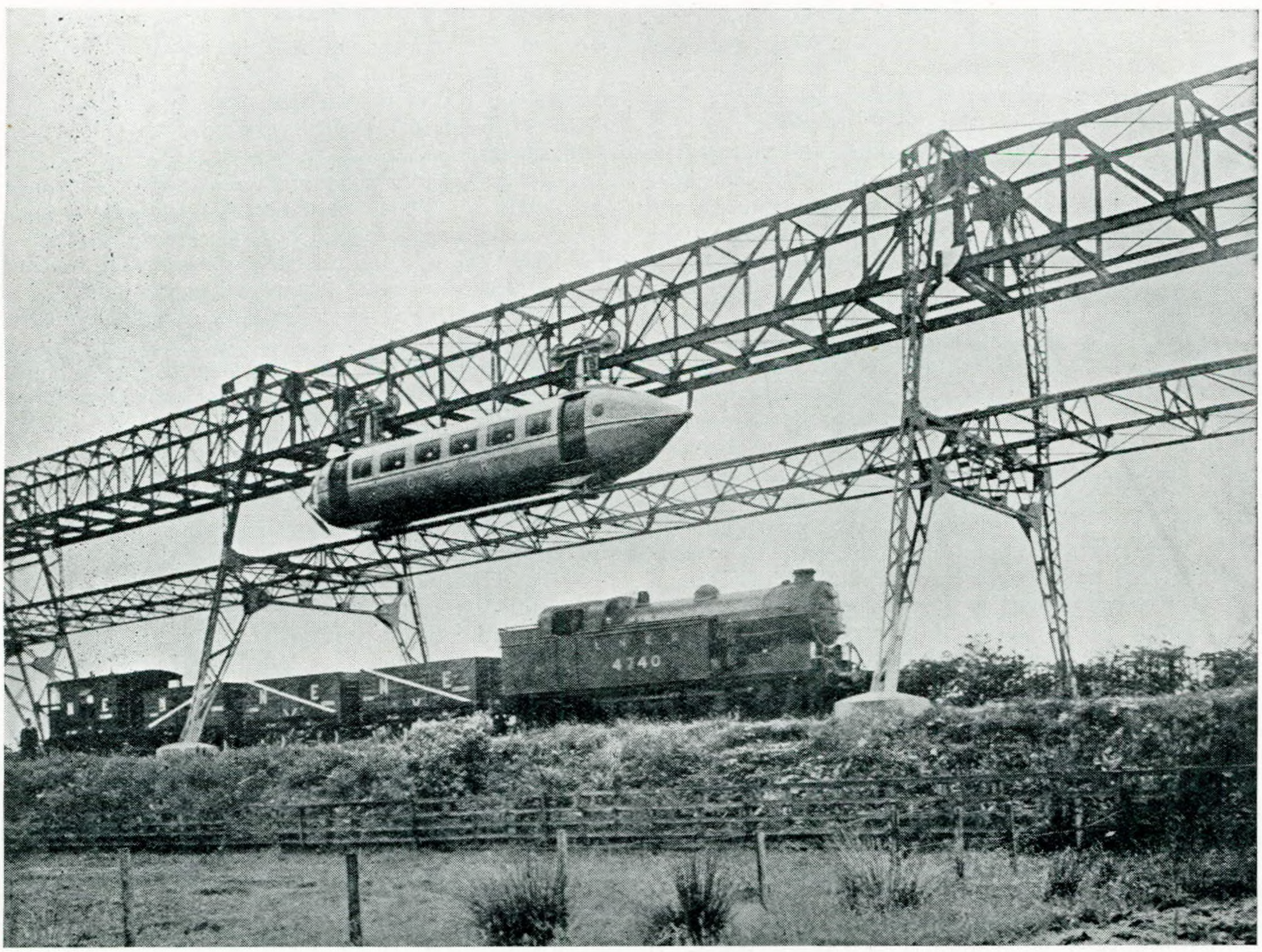


Fig. 9.

miles and over. The solution to the problem in Fig. 1 could therefore be easily found.

The time taken at present between Paris and London by air was $4\frac{1}{4}$ hours. The actual flying time was only one hour, the balance being taken up by ground transport. By adopting the railplane system the time taken between Paris and London could be reduced to $1\frac{1}{2}$ hours, i.e., from London to airport six minutes, flying time from the British to the French airport one hour, and time taken from the French airport to Paris six minutes, making a total of one hour 12 minutes. (This was allowing a distance between airports and cities of 13 miles at each end). The balance of 18 minutes could be allowed for loading and unloading the aeroplane, thereby making the exact time taken between Paris and London one hour and 30 minutes.

The use of such a system between Montauk Bay and Manhattan would save 12 to 14 hours journey by steamer for passengers going by London or Paris. A line on the railplane principle could be built between London and Southampton and the time taken for the journey would be half an hour, thereby saving another six hours of the journey between London and New York. The total saving of time between London and New York would be 18 hours, i.e., six hours between London and Southampton and twelve hours between Montauk Bay and New York.

Figs. 8 and 9 were photographs taken from a test line built at Milngavie, near Glasgow, over the London & North Eastern Railway. As these photographs showed, the speeding up by overhead transport which he proposed need not interfere with existing ground transport and did not involve the purchase of the land but simply the acquiring of the right of way. The writer was at present preparing plans and drawings for a speed test line to be erected near London. He was of the opinion that at least 18 to 24 hours could be saved between the landing of ships' passengers at the pier head and the arrival at the destination, i.e., between pier heads and cities.

The Authors' Reply to the Discussion.

The authors noted Mr. Belsey's remarks, which called for no comment.

In reply to Admiral Parnall it should be said that notwithstanding the fact that the authors knew very well the good points of the geared drive, they thought it would be impossible to have a satisfactory lay-out with that type of transmission when considering six propellers, and the use of the gear would entail a great length of high-pressure steam piping, which was not a very desirable feature.

Dr. Baker suggested the use of helicopters as adjuncts to ships, to cater for passengers in a special hurry. What the authors contemplated was not a service for a special category of passengers but a standard service available to everybody. Besides, the question of housing the helicopters, landing and taking-off from the ship in mid-ocean, seemed to be very difficult to solve in a satisfactory way. The tests made with seaplanes catapulted from the "Ile de France" and from German liners, had not proved very successful.

The expense of building new docks, as suggested, would not be prohibitive, as they would certainly not be as expensive as those which would have to be built in Manhattan, should that port have to be maintained as port of call.

With regard to streamlining, the authors could not accept the figures of Dr. Baker without strong reservations. When the "Lusitania" was designed, the science of aero-dynamics did not exist and the experimenters of that time had certainly not the technique developed since that day. The figures given by Dr. Baker did not tally at all with those found in modern wind tunnels. Owing to the enormous power generated, a saving of only 2 or 3 per cent. in the power required amounted to a very large figure, and it must not be forgotten that for about 40 per cent. of each crossing the ship would travel through a hurricane having a velocity of 60 to 80 miles an hour.

As far as the question of discharging exhaust gases over the stern was concerned, one might take for granted that it would be practically impossible to keep absolutely tight all the glass-plating on the ship, and some of the discharged gases would find their way into the passenger quarters. In the case of a following wind having a slightly higher speed than the ship herself, the discharge over the stern would be impossible. It would always be possible, in that case, to divert the exhaust to the vertical openings amidships.

Mr. Dean's remarks were noted and required no comment.

In reply to Mr. Marriner, the question of weight had always been uppermost in the minds of those who had been designing big liners. However, contrary to the case of warships, the question of cost had a very great bearing on the planning of commercial vessels. It had been found that the use of extra-light alloys was so expensive that a large part of the gain ensured by using them was offset by the extra cost; it was for that reason that the use of these alloys had been limited to a minimum. But there was no doubt that in the ship of the future great care should be taken to reduce, as far as possible, the size of the scantlings and to make a very extensive use of welding, high-tension steel and light alloys.

The handling of big ships mentioned by Captain Goldsworthy obviously involved a very delicate problem which required careful consideration, and any special terminal to be built should be laid with due consideration to the prevailing winds and tides. Alternatively, with good tug-power and perhaps by adding the Voith-Schneider propeller as suggested by Captain Goldsworthy, the problem could be solved in a satisfactory way.

The authors took very strong objection to the statement of Mr. Warne regarding the inability of the two largest liners to pay their way, and the impossibility of one of them to earn enough to pay its depreciation. That contention was entirely wrong. It was a well-known fact that those two large liners were quite a financial success and that they were earning not only their depreciation but very handsome surpluses for their owners. On the other hand, they agreed with Mr. Warne that, in case of war, the ship proposed would perhaps be of no use. But it must not be forgotten that, happily, war was only an accident in the life of the world and not a permanent feature, and that it was better to build ships for peaceful purposes than for war. Incidentally, one might wonder if such vessels endowed with high speed—which could be maintained in any kind of weather—would not be of some use, as they would be able to steam at full speed when all cruisers or destroyers would be hove-to.

The authors did not mention the underwater part of the ship, as it was so obvious that this was a crucial point of the design. They therefore thought it would be absolutely futile to dwell upon the point. Besides, the modern form of underwater lines was so well advanced that the problem could be considered as solved by the studies of such well-known naval architects as Yourkevitch, Maier and others.

INSTITUTE NOTES.

ELECTION OF MEMBERS

List of those elected at Council Meeting held on Monday, 10th January, 1938.

Members.

James Alexander Bell, 59, Winstanley Road, Waterloo, Liverpool.

Frank Boothroyde, Rectory Cottage, Bassett Avenue, Southampton.

David Bruce, 50, Burlington Avenue, Kelvinside, Glasgow, W.2.

Frank Wallace Cass, 26, Lee Terrace, Blackheath, S.E.3.

Allan Davidson, 8, Hill Street, Saltcoats.

Philip Salmon English, 6, Canford Gardens, New Malden, Surrey.

Samuel William Calderwood Fleming, Annandale, 41, Letham Road, Strathaven, Lanarkshire.

James Hendry Galloway, 19, Morland Avenue, Bromborough, Ches.

Charles Alastair Macgregor Gray, 16, Vanburgh Park, Blackheath, S.E.3.

Frank Richard Harvey, 9, St. Mary's Ave., Shortlands, Kent.

William John Henton Jones, Barrymore, 291, Stand Lane, Radcliffe, Manchester.

Thomas John King, 7, Manor Road, Glasgow, W.4.

George Edmund Kirkbright, St. Heliers, Caledonian Road, W. Hartlepool.

Philip Michael Lennon, 85, Balliol Road, Liverpool, 20.

Duncan MacKenzie, 49, Burnt Oak Lane, Sidcup, Kent.

William Wright Marriner, 36, Parkside, Knightsbridge, S.W.1.

Frank John Palmer, 112, Well Hall Road, Eltham, S.E.9.

Companion.

Alexander Macintosh, Three Oaks, Broad Walk, Winchmore Hill, N.21.

Associates.

William Kenneth Gwynne Allen, The Old Manor, Aspley Guise, Bedfordshire.

Stephen Griffin Gilmore, 25, Paget Avenue, Birstall, Leicester.

Francis Anthony Aloysius Whitehead, 7, Chord Road, Drogheda, I.F.S.

Probationer Student.

Victor George Happy, Kelvin, Leopold Road, Ramsgate, Kent.

Transfer from Associate Member to Member.

Howard Vincent Campbell, 52, Randolph Road, Glasgow, W.1.

Transfer from Student to Associate.

Leslie Charles Bingham, 56, Stanhope Road, Dover, Kent.

John George Sanderson, c/o Royal Bank of Scotland, Princes Street, Port Glasgow.

ADDITIONS TO THE LIBRARY.

Purchased.

Report of the Fuel Research Board for the Year ended 31st March, 1937. H.M. Stationery Office, 3s. 6d. net.

Presented by the Publisher.

"One Hundred Years in Steel". Brochure issued by Messrs. Thos. Firth & John Brown, Ltd., in celebration of their Centenary.

The following publications of the Combustion Appliance Makers' Association (Solid Fuel) :—

- "Modern Trends in Coal-Burning Appliance Design", by Bennett.
- "Practical Research in the Use of Coal", by Lindars.
- "Mechanics of Coal Pulverisers", by Heywood.
- "The Testing of Pulverised Fuel Installations for Commercial and Scientific Purposes", by Rosin and Rammler.
- First Annual Conference.

The following publications of The British Oxygen Co., Ltd. :—

- "Chemical Plumbing, Leadburning and Oxy-Acetylene

Welding for Plumbers and Heating Engineers", by Partington.
"Copper in Cast Steel and Iron".
"The Rightward Method of Oxy-Acetylene Welding".
"Aluminium Welding".
"Lindewelding".
"Cast Iron Welding Rods".
"Aluminising".
"The Metal Spraying Process".

"Instructions as to the Tonnage Measurement of Ships". H.M. Stationery Office, 1s. 3d. net.

"Some Notes on the Performance of Piston Rings in relation to Medium Speed Diesel Engines", by F. C. Caistor.

The following British Standard Specification:
No. 759-1937.—Valves, Gauges and Similar Fittings for Land Boiler Installations.

"Munro's Engineer's Annual, 1938". James Munro & Co., Ltd., 16, Carrick Street, Glasgow, C.2, 191 pp. illus., 2s. 6d. net.

In addition to the usual mathematical, tide and other tables the new issue of this well-known publication contains a number of interesting articles and several abstracts of papers read before the technical institutions during the past year. The young engineer at sea will be particularly interested in the specimen Board of Trade examination papers submitted by two of the colleges which specialise in tuition for these examinations.

"Marine Diesel Oil Engines", by J. W. M. Sothern. The Technical Press, Ltd., 5th edition 1134 pp., 816 illus., 50s. net (two vols.).

Like the author's other works, this manual of marine oil engine practice has become so well-known to marine engineers that it will suffice to say that it contains exhaustive notes and sketches descriptive of the principle, construction and running of large marine sets, the faults usually experienced and their cause and remedy. The main features of this new edition are that it has been carefully revised, corrected and entirely re-classified, thus making for the more convenient and rapid location of any particular subject required by the reader, and is now issued as two volumes. With the same object in view the index has been considerably amplified and more fully detailed. The volumes contain illustrated descriptions of the latest developments in marine Diesel engine construction, in addition to much new and useful general matter. Of special interest is the author's claim that the answers to all Board of Trade new "Engineering Knowledge" questions for the motor examinations are contained in this new edition.

"An Introduction to Workshop Practice", by P. E. Ellis. Blackie & Son, Ltd., 164 pp., 216 illus., 4s. net.

Of all branches of engineering that of workshop practice is possibly the most difficult to explain in print; many of the processes demand diligent practice on the part of the student rather than long courses of instruction by a tutor. Some may readily be demonstrated practically, but defy simple, yet lucid description in writing, and almost all have that aggravating quality of tempting the author to overwrite his subject. Notwithstanding such discouragements writers do produce books on this subject, and the volume under review is of interest not only as the work of a well qualified instructor, but for its attempt to break new ground in the pictorial representation of difficult movements. This is effected by "films" operated in the manner of primitive moving pictures. Pages of the book are rapidly flicked over so that the progressively varied sketches of the particular movement illustrated give the illusion of a moving picture. Four of these "films" are presented: (*a*) The operation of filing; (*b*) the movement of a self-centring chuck; (*c*) tumbler gearing; and (*d*) the mechanism of a shaping machine. The pictures are certainly novel and may make a passing appeal to young students, but having regard to the author's admirably clear written descriptions of these movements, it seems a pity to have sacrificed rather more than one-third of the total available space in the book to a device that is of no lasting value, especially as the subjects appear to have been chosen to fit the novelty rather than because they were thus more clearly explained.

The author has very successfully fulfilled his aim of introducing the apprentice or junior engineering student to the engineering workshop and if he is inclined occasionally to make the introduction perfunctory it must be remembered that as the student mainly requires guidance along practical channels where he will acquire both practical skill and technical knowledge, this possibly is actually beneficial. None the less, one remarks a number of unexpected omissions in a book of this type, the most notable of these being any reference to Whitworth gas threads, the scraping of any other than flat surfaces, reversibly driven and geared head lathes, and in the section devoted to materials, mention of the physical properties of metals other than cast and wrought iron.

The book is clearly printed within stiff cloth covers and should prove attractive to beginners who desire an introduction to the engineering workshop at an economical price.

"Technical Drawing, Part II", by James D. Chalmers. Robert Gibson & Sons (Glasgow) Ltd., 55 pp., copiously illus., 2s. net.

This is the second of a series of three books, of which the first was reviewed on page 409 of our issue for January, 1937. It follows the same lines and merely develops the various subjects already introduced. The emphasis is still on the geometrical principle rather than the specialised example, in accordance with the avowed object of the course. Examples are well chosen and the production of the book leaves nothing to be desired.

"Handbook of British Refrigeration Material and Refrigeration Catalogue—1938". Cold Storage and Produce Review, 200 pp., illus., 5s. net.

This volume is unique in refrigeration literature inasmuch as it covers every range of equipment that British manufacturers can supply. As a trade reference it should prove valuable to those already familiar with the industry and also to those who are contemplating entering any of the various fields of refrigeration. For the buyer, the first part of the book is well indexed having reference to the manufacturers from whom the various materials can be obtained, afterwards passing to machinery and prime movers. A wide selection of chambers and cabinets are contained in the latter part of this section, which should cover the requirements of any intending purchaser. The list of standard works and the directory of cold stores and ice factories of Great Britain and Ireland supply the needs of both the technical and commercial side of the industry. To the marine engineer, the latter part of the book will be found particularly interesting, containing as it does a large amount of data, in concise form, relating to technical questions which arise in modern insulated vessels. Refrigeration occupies a growing part of the duties of the contemporary marine engineer, and a volume such as the one under review should prove of great assistance.

"Hydraulics for Engineers", by R. W. Angus, B.A.Sc., M.E. (Professor of Mechanical Engineering, University of Toronto). Sir Isaac Pitman & Sons, Ltd., 332 pp., 185 illus., 12s. 6d. net.

The author of this book so clearly states its salient feature that the appropriate extracts from his preface deserve publication in full. "It is a matter of regret to most instructors of engineering students that the latter do not take more kindly to advanced mathematics as the student's outlook is decidedly limited through lack of it. However, the condition does exist, and further than this, the practising engineer has usually forgotten his purely mathematical work. An attempt has been made to deal with the subject without the introduction of difficult mathematics, and there is scarcely a section in the book involving more than a knowledge of quadratic equations. The part dealing with non-uniform flow is a good example of how exceedingly complicated problems may be dealt with by arithmetic and the application of elementary principles of hydraulics".

The author has achieved his aim with remarkable success and has produced a book of exceptional appeal to those for whom it is written. As the title indicates, it is a book for engineers and discussions of an academic nature are therefore omitted. Among the subjects treated, particular mention may be made of friction loss in pipes and fittings, calculations on the flow in pipes of all kinds, hydraulic turbines and centrifugal pumps, water-hammer in pipe lines and unsteady motion in closed pipes. The work is copiously illustrated by photographs and diagrams and is attractively produced. "Hydraulics for Engineers" is an excellent book and may be confidently recommended.

"Alternating Current Electrical Engineering", by P. Kemp, M.Sc. Macmillan & Co., Ltd., 611 pp., 421 illus., 15s. net.

This is the fifth edition of a work first published in 1918. Even in a book of 600 pages it is impossible to include a detailed survey of alternating current electrical engineering. The author therefore has exercised his judgment, excellent by reason of his wide experience and knowledge, to omit irrelevant matter, condense as far as possible all that must necessarily be included, and at the same time to keep the volume up to date. In this he has succeeded particularly well. The book covers all the fundamental principles of alternating current engineering. It explains practical applications of these principles insofar as space will permit, and at the same time appears to cover the whole ground embraced by the title.

The reviewer would suggest that the book is particularly suited to those who wish to study the first principles of alternating currents. It is produced especially for students preparing for both the Ordinary and Higher National Certificates in the subject dealt with, as well as for those preparing for degree examinations. The reviewer is not aware of any more suitable book for the purpose.

Briefly stated the ground covered includes fundamental principles of alternating e.m.f. and current, vectors, power and power factor, instruments, transformers, alternators, motors, converters, rectifiers, protection of a.c. systems, and transients.

At the end of each chapter are given a few useful examples with solutions. The printing and paper are good, the figures carefully drawn and selected, the general production excellent and the price exceptionally low for the material provided. The book can be recommended without hesitation to all who are interested in the theory and application of the fundamental principles of alternating currents.

"Steam Turbine Operation", by W. J. Kearton, D.Eng. Sir Isaac Pitman & Sons, Ltd., 3rd edn., 356 pp., illus., 12s. 6d. net.

This is the third edition of a deservedly popular book, the second edition being published about eighteen months ago. The new edition contains additional matter on regenerative feed heating and make up feed evaporators.

This essentially practical work commences with installation which includes various types of expansion bends and high-pressure steam joints. Working procedure and the necessary care during warming-up, stage drainage, expansion, and the measurement of clearances are fully dealt with. Various types of shaft and diaphragm glands are described and illustrated with clear sketches. Lubrication of the numerous parts and different methods of governing are fully covered. The chapter on turbine troubles is very practical, numerous failures are quoted and probable causes given, the effects of corrosion and erosion of blades and diaphragms are well explained, there being a special chapter on the erosion of l.p. blading. Several systems of regenerative feed heating are described and although the author states that the theory of feed heating is outside the scope of the book, the reviewer feels that the inclusion of a few numerical examples, giving the quantities of steam bled from the different stages, and the feed temperatures in stage heaters with the effect on efficiency, could come within the purview of a practical work. While the inspection, overhauling and testing of turbines is well described, the inclusion of the adjustment and maintenance of the various types of turbine thrust would improve this excellent book. The majority of the illustrations are very good and serve to help the text, but a few such as Fig. 120, page 205, could easily be omitted. The book is well printed and easy to read, and although a considerable portion deals with land practice this serves to amplify the sections given to marine work.

The purchase of this book is recommended with confidence.

"Boiler House Practice", by E. Pull. The Technical Press Ltd., 181 pp., 10 illus., 6s. net.

As a technical author Mr. Pull needs no introduction to engineers, his books on workshop practice having been long regarded as standard works. He is also the author of an excellent treatise on "Modern Steam Boilers" so that he approaches this new work "Boiler House Practice" as a writer of considerable experience. Having achieved a reputation for highly informative books, it is disappointing to find that the necessity for limiting the extent of this book has compelled Mr. Pull to write a précis of his subject rather than a text book about it. This book is announced as a textbook for engineers-in-charge of small industrial plants, steam users, boiler attendants and engineering students, and is intended to assist candidates for the City and Guilds Examination in boiler practice.

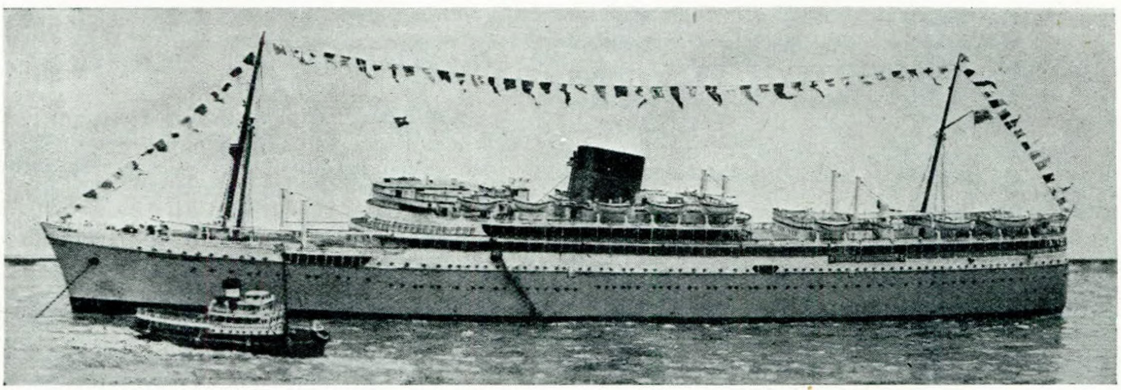
Within approximately 170 pages the author has compressed a wealth of information on the evaporative power of steam generators, production of heat and steam, types of industrial boilers, combustion and draught, coal, mechanical stokers, water, economisers, superheaters and air heaters, mountings, pumps and steam pipes, instruments and records, heat losses, steam economy, heat recovery, inspection, operation and maintenance, condensate and steam traps, and workshop and factory heating, concluding the book with fifty examination questions and an extract from Callender's steam tables. Compression of such an extensive subject as boiler-house practice into so small a space is commendable only if it involves no sacrifice of fundamental information and permits adequate description of all the topics introduced. In the case of this book, which is claimed to be a textbook for those "of limited technical knowledge", it may be asked if the author has not achieved brevity by statements of facts accompanied by a scarcity of detailed description, based on a too generous estimate of the degree of knowledge possessed by many engineers-in-charge and students and particularly by attendants and steam users.

To quote three examples. The composition of flue gases is mentioned, but methods of analysis are not given although a question on the Orsat apparatus appears in the examination questions. Fuels, other than coal, are passed over in the bare statement that "fuels such as oil, coke and coke breeze can be efficiently consumed in all types of boilers—sawdust, wood, vegetable matter and other unusual fuels require furnaces and combustion chambers of suitable design, and special attention must be given to the type of boiler selected", yet in the test questions, the student is invited to "describe, giving diagrams, a simple oil burning installation", and to say "what practical significance attaches to the flash point and viscosity of the fuel oil". Again, it is stated that "pumps will lift water at temperatures up to 175° F.; above that temperature, the water must flow by gravity to the pump suction. At 212° F. it is necessary to provide a head of not less than 15lb. on the suction valve". None familiar with the subject will dispute this as a true general statement but if the book is intended to instruct the uninformed, one feels that this bald pronouncement is insufficient to satisfy such readers.

As a digest of boiler house practice, however, the book is excellent and may be recommended to those who already possess a good foundation of technical and practical experience. To be an ideal textbook for the less well-instructed it requires considerable extension and much more generous illustration.

Presentation of Collection of Ship Models by Mr. C J. Hampshire.

Members and others who have visited The Institute and have seen the various ship models which have hitherto been displayed in the Reading Room, on loan from Mr. Charles J. Hampshire (Member), the well-known expert in this art, will be glad to learn that he has presented the whole collection to The Institute.



Mr. Hampshire's generous gift was gratefully accepted by the Council at their December meeting, and a formal resolution was passed unanimously, recording the Council's appreciation of his having made it possible to retain for permanent exhibition at The Institute such an interesting and valuable collection of models.

The models are all to the scale of 1/64 inch to a foot, and some idea of their perfection may be obtained from the adjoining illustration of one of them—the Union Castle liner "Athlone Castle". The collection includes the following: Cunard White Star s.s. "Queen Mary", H.M.S. "Hood", H.M.S. "London", Cunard White Star m.v. "Britannic", P. & O. s.s. "Viceroy of India", H.M.S. "Victory", H.M.S. "Prince", Canadian Pacific s.s. "Empress of Japan", and the Union Castle m.v. "Athlone Castle".

ABSTRACTS OF THE TECHNICAL PRESS.

Modern Non-Ferrous Castings and their Engineering Interest.

The author gives examples of the most important developments in non-ferrous casting technique, covering bronze, high tensile brass, and copper base bearing metals with special reference to recent investigations on the effect of additions to these alloys of other metals such as nickel and silicon. He states that the addition of small percentages of nickel to bronze has been found to promote solidity and density, homogeneity, grain refinement, wear and corrosion resistance, and to result in superior mechanical properties. In castings that have subsequently to be nickel-plated, the use of nickel bronze also ensures better adhesion of the deposit, and the presence of nickel in copper-tin alloys enables the ordinary range of cast bronzes to be heat treated, when high strength and hardness values can be obtained. Nickel further stabilizes the properties of bronzes at abnormal temperatures, particularly in the presence of silicon, and the author observes that the reliability of modern methods of steam control depends to no little extent on this matter. Discussing high duty brasses, he refers to the modern tendency, particularly in connection with large manganese brass propellers for modern high speed ships, of increasing the tensile strength by an increase in zinc or the zinc equivalent, and he considers that by such an increase the structure of the material is seriously impaired with resultant liability to failure by fatigue or corrosion fatigue. In regard to the further problem of grain growth in the heavy sections adjacent to the propeller boss due to slow cooling, the author points out that if an alloy could be developed that would harden on slow cooling, the maximum strength would be obtained in the heaviest sections where it is most needed, and he suggests that the necessary results would be obtained by the addition of small percentages of nickel and aluminium to manganese bronze with or without a small percentage of tin. Reviewing copper base bearing metals, the author states that the addition of nickel to phosphor bronze bearing metals results in a very finely dispersed hardening constituent consisting of nickel phosphide which has great value in enhancing wearing properties and freedom from pitting effects. Cadmium additions to babbit metals for high speed bearings are helpful in increasing resistance to fatigue failures, and such material is only slightly inferior to the new and latest cadmium nickel alloys, but in many instances troubles can only be positively overcome by the use of copper-lead bearings in view of their higher mechanical properties. Taking into consideration, however, the difficulties in founding and casting the copper-lead alloys, the author considers that with the continued increase in bearing loads, the bearing of the future should be a steel shell bearing lined with a leaded bronze as distinct from a copper-lead such as the alloy containing 75 per cent. copper, 21 per cent. lead, and 4 per cent. tin already used by American aero engine manufacturers.—*F. Hudson, Trans. Inst. of Engineers and Shipbuilders in Scotland, Dec., 1937.*

New Krupp Two-stroke Diesel Engines with Archaouloff Injection.

Continuing his *description of the Archaouloff system of injection the author gives particulars of the latest type of this fuel pump, which was fitted in the 3,500 h.p. seven-cylinder Krupp-engined cargo vessel "Cairo" of the Levante Line. Here the gas cylinders, which communicate with the working cylinders of the engine, are arranged above the fuel pump cylinders so as to preclude the possibility of any fuel oil reaching the circumference of the gas piston or its stuffing box. The connection between the lower end of the gas piston and the upper end of the fuel piston is established by a saddle bearing in such a manner as to permit independent alignment of the two pistons and to avoid any lateral thrust which would impair their tightness. A spring, which at the same time actuates the suction stroke of the fuel pump piston, enforces the contact in the bearing, the tension being such as to exceed the pressure on the gas piston during the low pressure phase in the working cylinder of the engine. The suction valve of the fuel pump is also used to regulate the quantity of fuel supplied at the end of the pressure stroke. This is effected by means of a lever of which one end is fitted to a rotating pin attached to the upper end of the fuel piston, while the other end is eccentrically mounted on a small shaft and presses on the projecting end of the suction valve spindle, the eccentricity, and thereby the quantity of fuel admitted, being capable of adjustment from the control platform by means of a system of pull rods and levers mounted on a common thin shaft situated at the level of the tops of the working cylinders. A further connection of this shaft with the safety governor automatically keeps the revolutions within the safety limit. For some time before the pressure stroke commences the suction valve of the fuel pump is kept open by the lever described, but this does not imply any variation in the commencement of injection as in a cam-operated pump. In the Archaouloff system this depends on the fuel pressure and takes place after the closing of the suction valve, as soon as the pressure driving the gas piston downward is sufficient to open the fuel injection valve. In an engine which runs at a varying rate of revolution, such as a marine engine, the crank angle at which injection commences is not maintained with accuracy, as the compression varies with the rate of revolution, so that injection is retarded at reduced revolutions. This, however, does not alter the crank angle corresponding with ignition, as the

* *See* December, 1937, Trans., p. *260*.

rate of travel of the gas piston is reduced in correspondence with the reduction of the advance of the crank angle. The fuel is drawn from a high level tank through an Auto-Klean filter and the safety governor directly regulates the pumps by the Krupp method, in which the scavenge air pressure is utilised for this purpose. The injection valves, i.e. the pressure valves of the Archaouloff pump, are similar in design to those employed in cam-operated pumps, from which they differ only in appearance owing to the addition of air cylinders fitted for the adjustment of the tension in the valve springs in starting and at reduced speed. Owing to the elimination of the camshaft the space and the power required for the starting and manœuvring arrangements, which the author describes in detail, are appreciably reduced. Particulars taken from engine reports of the tanker "Calgarolite", in which air injection was replaced by Archaouloff injection in 1933, indicate a saving of 11·5 per cent. of fuel cost owing to the elimination of the compressors, and the author states that an appreciable improvement of the engine torque was also recorded. He further emphasizes the rapidity and ease with which the Archaouloff system can be installed in existing vessels, such installations having in a number of cases been carried out in service at sea.—*S. Bock, "Schiffbau", 1st Dec., 1937, p. 397.*

Electric Welding of Light Material as Employed in the Construction of Motor Launches.

This article describes the method of electric welding as practiced in a small yard for building motor launches. The method described relates to a "Chine" type of launch 30 metres in length. It is mentioned that for the welding of light material, 1in. to 1¼in. in thickness, welders generally require a special training of about two to three months. Single welding machines are preferred to a number connected to a common welding station, as the latter does not give a steady flow of current. In organizing the work the following points should be observed:—

(1) Great care should be taken in the erection of suitable staging so as to enable the welders to accomplish their work in comfort.

(2) The work should be carried out under cover, so that the material is kept as dry as possible, thus saving valuable time by avoiding the necessity of drying the material prior to commencing welding operations.

(3) The whole of the material should be kept thoroughly clean and free of all rust. The interior of the boat should always be kept clear of dirt to prevent burning when welding thin material.

(4) Special attention should be paid to the space left between the plates when erected and the standard space fixed by practice should be adhered to with precision. The framing and plating should be erected complete, and the space left between adjoining plates, by one-side welding, is recommended to be 2mm. for plates 3mm. thick. The framing should fit close to the plating.

Fifteen sketches are given illustrating the method of procedure adopted in welding together the various parts and sections of the hull, showing also the direction the welding should take. The procedure is explained in detail for framing, bulkheads, shell and deck. It is stated that by the method now adopted in the yard in question, the welding time has been reduced from 900/1,200 man-hours to about 250 man-hours for a 30ft. launch, with a tendency to a further reduction.—*"Soudostroienie", No. 8, 1937.*

Vessels for Service on the Moscow-Volga Canal.

This article gives a description and plans of three different types of vessels under construction for service on the above canal, viz. (1) motor passenger/cargo vessel of 700 h.p., (2) motor boat for 300 passengers, (3) motor boat for 150 passengers, and (4) a motor tug of 300 h.p.—*"Soudostroienie", No. 8, 1937.*

High-speed Motor Craft.

In a paper read before the North-East Coast Institution of Engineers and Shipbuilders on "High Speed Motor Craft", Captain David Nicolson said that in discussing small motorboats of this type they should be divided into six different classes: (a) Fast displacement or round-bilge hulls; (b) Vee-bottom hulls; (c) Inverted-vee bottom or sea-sled hulls; (d) Hydro-gliders; (e) Multi-step hydroplanes; and (f) Single or mono-step hydroplanes. Model experiments had demonstrated and actual experience proved that, given the same equivalent displacement and the same equivalent horsepower, the easiest boat to drive was the mono-step hydroplane. Some designers considered that there was no advantage in fitting more than one step, as when at full speed such a boat would be running on one step and the stern in precisely the same manner as a mono-step hull.

The sea-sled type is not so successful for speed as the step boats, and the vee-bottom stepless hull falls below the sea-sled, the ordinary round-bilge boat then being considerably below the vee-bottom, although this round-bilge type is better to handle in a seaway at slow speeds.

The evolution and development of the exceptionally fast motor-boat must necessarily be a somewhat slow process, as they had to search for the ideal combination of hull, motor and propeller from the reports of actual trials and tests of boats previously constructed, and so build up step by step better results on every attempt made.

In the author's opinion many fast motor-boats, or hydroplanes, had a considerable range of utility. In war time they would form a most efficient mosquito fleet, cheaper and more mobile than destroyers or cruisers, darting in and out, dodging rocks or big ships, running over shallows, in a manner which would be impossible to a larger vessel. These little motorships, owing to their rapid manœuvring qualities, were exceedingly difficult to hit by aircraft, and equally hard to hit by direct gunfire.—*"The Shipping World", 29th December, 1937.*

Rivets of High Tensile Steel.

In the application of high tensile steel to shipbuilding the great problem is to find a steel suitable for rivets with a high tensile strength and a good welding quality. Trials are therefore being made with various alloy steels such as chromium, manganese, silicon, copper and nickel. Material employed in the construction of a vessel often consists of high tensile steel with a tensile strength of 60 to 70 kg./mm.^{2}, and at the same time the rivets used are of ordinary carbon steel of 38 to 45 kg./mm.^{2} or 41 to 47 kg./mm.^{2} which necessitates an extra row of rivets; the rivets also quickly deteriorate by becoming electro-positive relative to the mass of electro-negative plating. Arising from the above the Russian Institute of Shipbuilders decided to endeavour to manufacture a high tensile steel suitable for rivets, this steel to have a tensile strength of not less than 55 kg./mm.^{2} with good mechanical qualities and to have the maximum resistance to corrosion under service conditions of sea-going vessels; the rivets it was intended should also be electro-negative by minimum difference of potential between the plates and the rivets. For this purpose several charges were prepared of various chemical analysis (see table), and also of ordinary rivet steel for comparison.

Number of charges.	*C.*	*Si.*	*Mn.*	*Cr.*	*Cu.*	*P.*	*S.*	*Ni.*
1	0·15	0·94	0·99	—	0·24	0·05	0·039	0·24
2	0·15	0·60	0·76	0·55	0·06	0·038	0·05	a trace
3	0·19	0·61	0·65	0·53	0·61/0·69	0·049	0·035	,,
7	0·19	0·059	0·64	0·62	0·75	0·051	0·032	,,
9 (ordinary rivet steel)	0·07	a trace	0·42	a trace	0·10	0·021	0·032	0·24
Steel plates (medium manganese)	0·27	0·16	1·02	—	0·056	0·062	0·025	—

Bars were rolled from the different charges and samples 10mm. in diameter were used for carrying out tensile, bending and hammering tests. The results of the mechanical tests on Nos. 1, 2, 3 and 7 exceeded those for ordinary rivet steel (No. 9) as regards tensile strength, limit of proportionality and Charpy values. All the steels in the test of double shear greatly exceeded the standard test required by the Register of Shipping, U.S.S.R. The whole of the tests carried out showed that steels Nos. 1, 2, 3 and 7 fully satisfied the requirements for rivets for high tensile steel. For the corrosion tests, samples 25mm. in diameter by 300mm. in height were cut from bars rolled from the various charges. These were heated and then crushed under a power hammer to a height of 10mm.; from these crushed pieces specimens were prepared 25mm. diameter by 10mm. high. For contact tests the specimens were connected together by screws forming pairs, in each case one half being a specimen from the steel plate. The specimens intended for the potential measurement tests were connected to a screwed iron bar. The experiments were carried out by alternating and continuous immersion in synthetic seawater. The corrosion stages were determined by noting the external alteration of the surface, loss of specific weight and variation of the potential. Examination of the results of the experiments makes it possible to arrive at the following conclusions:—

(1) That No. 2 appears to be 1·5 to 3 times corrosion-resisting as compared with carbon rivet steel in conditions of marine service; this ratio may be designated the corrosion-resistance factor. This steel proved to be electro-negative relative to a medium manganese steel, and the increase of the potential was within the limits of 0·008 to 0·036 volts. Steel No. 2 may therefore be used for riveting high tensile carbon steel plates 50-60 kg./mm.^{2}; also for riveting manganese steel plates.

(2) Steel No. 3 was 1·5 to 2 times corrosion-resisting during the whole period of the tests. It was electro-negative in relation to manganese steel plates, and the increase of the potential was from 0·005 to 0·027. This steel, with a tensile strength of 57·7 kg./mm.^{2} and an elongation of 26·4 per cent., is suitable for the riveting of medium manganese plates 60-70 kg./mm.^{2}; No. 3 steel has a copper content of 0·61-0·64 per cent.

(3) Steel No. 7 has a corrosion-resisting factor 3·5 to 5·2 times greater than ordinary carbon rivet steel in conditions of continuous immersion in seawater. For the duration of a 1,200-hour test this steel was electro-negative with an increase of potential 0·007 to 0·036. Its mechanical properties fully satisfied the conditions for riveting plates of medium manganese steel. It has a copper content of 0·75 per cent.

(4) The factor of resistance to corrosion of steel No. 1 approached very closely to that of ordinary rivet steel No. 9. In most cases this steel appeared to be electro-positive relative to medium manganese steel plates. The low resistance to corrosion of steel No. 1 is explained by impuri-

ties contained in the charge.

In conclusion it should be observed that from the results of the mechanical and electro-chemical corrosion tests it would appear that the steel most suitable for rivets is steel No. 2. It is recommended that when ordering rivet steel a Baumann test should be included in the conditions of tests, and in the examination of rivet bars particular care should be given to the cleanliness of the surface as regards hair cracks and other flaws. — *"Soudostroienie", No. 8, 1937.*

The Streamlining of Ship Superstructures.

The author suggests that the top of a funnel having a streamlined casing should also be streamlined, in side elevation, and that this might improve the flow of hot gas. Space is not usually available for a complete streamlining of deck erections, but the number of projections and discontinuities could be reduced. Some trawlers, and certain other ships have been built with rounded bridge fronts. The scope for improvement by such modifications, leaving the eddy-producing aft end of the erection unchanged, is however limited. Prolongation of an erection aft, though it may give less resistance ahead, is not so advantageous in a beam wind. So far as the minor projections of a ship's upperworks are concerned, the possible gain depends largely on the degree of screening by adjacent structures. Streamlining of a mast may be hardly practicable, but the diameter may be reduced by designing it as a pin-ended strut, and not, as is usual, allowing it to carry bending moments in addition. The loads on the stays are, of course, increased. The stowing of a derrick vertically behind a mast gives a partial streamlining, and the crow's nest also lends itself to reduction of air drag by suitable shaping. Where it is essential to connect the tops of two derrick-posts by an athwartship member, this should be tubular, rather than of built-up type. A smooth rod has less drag than a wire rope, but the question of relative strength and of flexibility enters. A supply ventilator necessarily causes drag, but probably the drag can be made less without impairing the supply. Some improvement of exhaust ventilators, from the point of view of amount of air sucked out for a given amount of drag, is probably also possible. The form of davit which is most efficient structurally, as a beam, is, as it happens, a very poor one from the drag point of view. Some degree of enclosure for the boats and davits may, however, be possible to arrange. Beams and brackets of exposed decks are a possible cause of air drag, as are awning supports and stanchions. The latter may take the form of a collapsible structure, but there remains the question of the drag when the awning is actually in use. Draught diverters above the bridge bulwark are a frequent source of drag, and in this and in other connections wind tunnel tests are desirable.—*F. Schleufe, "Schiffbau", 15th December, 1937, pp. 419-422.*

New Types of Tanker on the Caspian.

The author gives particulars of ships designed for service on the Caspian Sea, but of sufficiently shallow draft to enable them to reach Astrakhan on the Volga. The vessels range from 460 to 590ft. in length and 11·5 to 14·75ft. in draft, and for these extreme proportions the provision of adequate longitudinal strength is a difficult matter. Two special designs have been developed. One has the hull proper of minimum depth, with longitudinal stiffening in the form of a framed arch built up on deck, extending over about 60 per cent. of the length and reaching a height of about twice the depth of hull. The other has a special strength erection amidships, the deck of which slopes down and merges into the hull at about a quarter of the ship's length from the ends. The total depth amidships is thus brought up to about $^1/_{14}$th of the length. The main deck amidships, forming the tank top, is relatively light, with close-spaced longitudinals. Both types are of welded construction, and show a saving in steel weight over a ship of normal design of about 12 per cent. The ratio of deadweight to displacement ranges from 0·62 to 0·70 according to size, and is about 5 per cent. better than for a normal design. The ratio of length to beam is about 8, so that the beam/draft ratio and the metacentric height are abnormally large, the latter ranging from 19 to 26ft. In service the type having the special strength erection has proved more satisfactory than that having the framed arch. —*K. A. Pohl, "Werft, Reederei, Hafen", 1st December, 1937, p. 351-6. (Abstractor's note: The information is stated to be derived from Russian journals).*

Apparatus for Ascertaining the Coefficient of Utilization of Power of Welding Stations.

This article describes an apparatus designed and used by the Laboratory of the Leningrad Shipbuilding Institute for the purpose of determining the useful work carried out by welders using the electric-arc system At the outset it states that it is possible to determine the time necessary for executing welding work of a given construction, also to calculate the quantity of metal used in welding seams and the productivity of the welder by the melting of the metal. This problem is met by the determination of a standard of welding work and by concrete calculation. For either case the following formula may be taken :—

$$T=\frac{G \cdot M}{g \cdot I \cdot K}$$

where G = the amount of metal in grammes melted per metre of weld;

M = the length in metres of weld of a given section, carried out by current I;

I = the current in amperes;

g = the coefficient of melting, in grammes per ampere for one hour's nett burning of the arc;

K = the coefficient of utilization of the welding station, i.e. the ratio of the nett time of burning of the arc to the total working time of the welder;

T = the total time in hours.

The coefficient K in the above formula varies within very wide limits due to the influence of a number of factors. The difference I − K gives the ratio of the total sum of all lost time, i.e. unavoidable, accidental and loss due to unsatisfactory organization. The sum of the unavoidable time lost in the process of welding may be designated "auxiliary time" which includes the time taken for changing the electrodes, cleaning the seams, alteration in the direction of the weld, etc.; the time occupied in effecting these functions is not continuous and may be measured in seconds. The amount and number of these interruptions varies within very great limits, depending on a variety of causes; the tempo of movement in carrying out these functions varies also according to the temperament and experience of the welder, also the condition of the equipment. There still remain other losses of time in connection with executing the work as a whole; the sum of these losses might be called "surplus or extra time" in which is included the time necessary for regulating the machine, laying cables, preparing the edges, etc.; these stoppages of work are considered as necessary, usual and not regular but protracted, each of them being of more importance than those designated above as "auxiliary time".

In 1936 tests were carried out in order to obtain comparisons between the ordinary and the more experienced welders by means of chronometric readings. Characteristic graphs are given in the article showing the difference between the two classes of welders over a working period of two hours. Approximately the sum of the narrow spaces between the dark markings indicates the "auxiliary time" and the wide gaps, the intervals between the working periods, the "surplus or extra time".

If Σa = the sum of the whole period of burning of the volt arc;

Σb = the sum of the periods of the "auxiliary time";

and Σc = the sum of the intervals of the "surplus or extra time";

then $T = \Sigma a + \Sigma b + \Sigma c$

and $K = \dfrac{\Sigma a}{\Sigma a + \Sigma b + \Sigma c}$

If the coefficient for utilizing the current from the power station is ascertained only for the working periods, excluding the lost time of "surplus or extra time", then a coefficient will be obtained which might be designated the "coefficient of contact" characteristic of the process of carrying out the work of welding. It will be seen that this coefficient is:—

$$Ka = \frac{\Sigma a}{\Sigma a + \Sigma b}$$

Another interesting coefficient may be obtained from the chronometric data and that is the "coefficient of work". This shows the ratio of the total time to the continuous period expended in welding the seam, etc., i.e.:—

$$Kb = \frac{\Sigma a + \Sigma b}{\Sigma a + \Sigma b + \Sigma c}$$

and $K = Ka \cdot Kb$

These coefficients obtained by chronometric graphs at a Leningrad shipbuilding yard were as follows:—

Contact coefficient $Ka = 0{\cdot}73$.

Coefficient of work $Kb = 0{\cdot}63$.

Coefficient of utilizing the welding station $K = 0{\cdot}50$.

A great difference noticed in these coefficients is between the work executed by an experienced welder as compared with that of an ordinary welder, for the coefficients for the former were:—

$Ka = 0{\cdot}84$, $Kb = 0{\cdot}92$ and $K = 0{\cdot}78$;

and for the latter:—

$Ka = 0{\cdot}54$, $Kb = 0{\cdot}80$ and $K = 0{\cdot}43$.

As the method of obtaining the necessary data by the chronometric device was very intricate and tedious, a special portable apparatus of the automatic integrator type was designed and constructed, the data obtained by this apparatus enabling the author of this article to construct some very interesting graphs showing the useful work carried out by the welders not only for the whole of the working period but also for each hour. A full description of the apparatus is given in the article with views and scheme of the construction. Coefficients are also furnished showing the percentage of use made of the welding power station by five different welders, with characteristic graphs showing the percentages hour by hour. With one exception they showed a gradual decrease of efficiency from the commencement of work up to the dinner hour and again from the recommencement of work to the end of same. The author also includes in the article various coefficients of the utilization of the welding station for different classes of work during the 1½ months the apparatus was installed at a shipbuilding and engineering works. In conclusion he states that he is not yet in a position to furnish a standard coefficient for the various kinds of welding work. Further investigations are at present being carried out with the assistance of the abovementioned apparatus by the Laboratory connected with the Leningrad Shipbuilding Institute.—*"Soudostroienie", No. 8, 1937.*

The Application of the Diesel Motor to the Propulsion of Large Express Liners.

The writer reproduces the results of an investigation made by Mr. F. Mayr of the M.A.N. on the comparative advantages resulting from the application to a 26-knot 30,000 h.p. liner of the following systems of propulsion: (1) Direct coupled Diesel drive by two double-acting two-stroke motors of 15,000 b.h.p. each; (2) Diesel drive by two similar but fast-running motors, each geared and coupled by a Vulcan clutch to a line of shafting; (3) Diesel electric drive by six groups of Diesel generators supplying current to two propulsion motors on each shaft; (4) Steam turbo-electric drive consisting of two turbo-generators and two propulsion sets. A comparison of the fuel consumed per b.h.p. per hour indicates the superiority of the direct Diesel drive when more than one-third of full power is developed. Below this power the geared and Diesel electric systems are more favourable, and the advantages of the latter become marked at outputs below one quarter of the full power, as part of the generating installation can then be shut down. In the steam turbo-electric drive the fuel consumed per s.h.p. per hour rises rapidly below one half of full power, but the writer considers better results could be obtained if a quadruple layout was accepted. A comparison of the radius of action corresponding with a common bunker capacity of 2,000 tons indicates that at 20 knots, i.e., at one half of full power, there is no appreciable difference between the three types of Diesel installations; between 20 knots and 26 knots the direct drive appears preferable; below 20 knots electric or gear transmission is more advantageous. At 26 knots the Diesel drive permits a radius of action of 10,000 nautical miles as compared with 6,500 nautical miles for a turbo-electric drive using steam of high temperature and pressure; for Diesel and steam drive at 20 knots and 12 knots the corresponding figures are respectively 17,000 against 9,000 nautical miles and 35,000 against 14,000 nautical miles. Taking account of the prices of Diesel and boiler oil, the fuel cost per mile of the motorship would—for 24 knots—be two-thirds that of the steamer if the ratio of the price of diesel oil ÷ price of boiler oil was 1·1, and it would rise to 84 per cent. at a price ratio of 1·4. Equal fuel costs would only be established at the top speed of 26 knots if the price ratio rose to 1·6. On the basis of prices ruling early in 1937, Diesel propulsion therefore appears superior for vessels trading between Europe and the Far East, and it may become a practical proposition for high-powered express liners running between Europe and the Atlantic coasts of North and South America.—*"Journal de la Marine Marchande", 23rd December, 1937, p. 1819.*

Alterations Made to Obtain Increased Power in the Liner "Athos II".

The original machinery of this vessel consisted of seven oil-fired cylindrical boilers of 3,500 sq. ft. total heating surface, which supplied steam of 200lb. pressure to two sets of h.p. and l.p. double-reduction geared turbines developing a total of 10,000 s.h.p. at 96 r.p.m. on two shafts. Each set of turbines exhausted into a condenser of 6,725 sq. ft. cooling surface. In order to increase the vessel's power and speed a set of high pressure steam turbines has been added to each of the existing sets. The additional sets are supplied with steam at 683lb. pressure and 840° F. temperature by a Velox boiler generating steam at the rate of 15·4 tons per hour, and to make room for this boiler one of the cylindrical boilers was removed. The steam generated in the Velox boiler leaves the two new h.p. turbines at 200lb. w.p.; of this total, 40 to 45 per cent. is then expanded to the condenser pressure in the new l.p. turbines; the remainder is utilised to supplement the steam supply of the old turbine sets. Both the old and the new l.p. turbines now exhaust to a common condenser of 7,427 sq. ft. of cooling surface. As reconstructed the propelling machinery develops a total of 16,000 s.h.p. at 137 r.p.m., which is made up as follows: 2 new h.p. turbines of 1,030 s.h.p. each, and 2 new l.p. turbines of 1,370 s.h.p. each running at 5,500 r.p.m.; 2 old h.p. turbines of 2,485 s.h.p., each running at 3,120 r.p.m., and 2 old l.p. turbines of 3,115 s.h.p. each running at 2,800 r.p.m. When going astern the new turbine sets, which do not include astern turbines, are disconnected by emptying the hydraulic coupling. In the reduction gear the speed of the new turbines is reduced from 5,500 r.p.m. to 880 r.p.m. in the first stage. This speed is brought down to 834 r.p.m. by the slip in the intervening hydraulic coupling and finally reduced to 137 r.p.m. in the second stage. The condensers, which are of the Uniflux type, have been enlarged, as indicated above, and the air and condensate pumps and ejectors have been suitably modified. The higher thrust of the new propellers has further necessitated the fitting of two new single-collar pressure-lubricated thrust blocks.—*"Journal de la Marine Marchande", 30th December, 1937, p. 1853.*

Ventilation and Sound Proofing of the Engine Rooms of Sea-going Motor Vessels.

The author points out that in Diesel installations the heat communicated to the surrounding air by the machinery is not sufficient to create the up-draught which in steam installations largely ensures the adequate ventilation of the engine and boiler rooms, its place being taken in most cases by the pressure gradient set up by the suction of the scavenge air fan. This will produce about 20 to 25 changes of air per hour which the author considers sufficient, given adequate cooling of the motor, together with good insulation of the exhaust piping and ventilation arrangements which will preclude the formation of air pockets. In the special cases in which the scavenge air is not drawn from the engine room but from the outside atmosphere, these arrangements should be similar to those adopted in steamships. Where, however, the scavenge air is drawn from the motor room the air flow conditions will be considerably modified, as the suction thus set up at a short distance above the engine room floor may balance or even reverse the upward movement of the air in the engine casing and in the funnel, so that with funnels having open crowns the exhaust gases may, in extreme cases, be drawn back into the motor room.

This danger is met by closing the funnel at the top and by fitting hood protected openings in its lower part for the admission of the scavenge air; alternatively, special air shafts ending near the scavenge air intake may be fitted. The author states that such special shafts, which are provided with rain hoods and with drainage fittings at their lower ends, are frequently employed in tankers to maintain the ventilation in bad weather, when all other openings leading to the engine rooms have to be closed and the pressure ventilators have to be turned out of the wind. In addition, such air shafts, the openings of which point forward, are intended to utilise the relative air flow resulting from the forward motion of the vessel, and the author discusses the more general application of this principle by fitting ventilators with watertight spherical pressure heads, which he describes and illustrates. The efficiency of such ventilators can be further increased and the pressure defect in the engine room diminished by designing the lower end of the ventilator as a nozzle in such a manner as to permit the partial or total deflection of the air flow in the horizontal direction. Referring more briefly to the problems of sound proofing, the author stresses the difficulty of preventing the propagation of the ordinary running noises emanating from the engine, as these are largely "structure-borne", so that bulkheads and sound insulation will be of no avail. The noise produced by the combustion and scavenge air suction can, on the other hand, be reduced by fitting padded air chambers or silencers of various types. The noise of the exhaust is already reduced by the coverings providing the heat insulation of the exhaust pipes and by the heating boilers silencers and spark traps inserted in the exhaust lines, and the author suggests that further damping of this noise can be obtained by designing the upper part of the funnel as an additional silencer and spark trap. As regards the "air-borne" part of the engine room noises, the author considers that these will be more effectively combated by means of heavy bulkheads and casings than by a combination of hard and soft insulating materials. —*Dipl. Ing. Freudenthal, "Werft, Reederei, Hafen", 15th December, 1937, p. 366.*

The Unification of Calculations for Natural Ventilation.

The article commences by stating that the low efficiency of natural ventilation is due to certain causes such as the difference in temperature of the exterior air and the air in the interior of the compartment to be ventilated, also the velocity of the exterior air relative to its deflection by the direction and velocity of the wind or/and by the speed of the vessel, the worst case being when the vessel is at anchor in calm warm weather.

Before deciding on a system of artificial ventilation which is costly, it is advisable to consider what could be effected by natural ventilation. Each of the above two causes, velocity and difference in temperature which in the case of natural ventilation affects the movement of air in the ventilating trunks, is investigated separately, and a number of formulæ, coefficients and nomograms are given for each case. In conclusion the author of the article points out that the height of the ventilating shaft is one of the most important factors in natural ventilation; when designing by the temperature method it is of great importance, but when using the velocity method it has a negative effect; it is therefore impossible to decide the question without making a concrete examination of each separate case. Velocity ventilation is more effective than temperature except in special cases, such as exceedingly cold exterior air or hot air in the interior of the compartment. In view of the greater efficiency of velocity ventilation as compared with that of temperature, in cases of approximate calculations for natural ventilation the velocity method only need be considered. More accurate calculations could be made by taking into account both factors in fixing the diameter of ventilating shafts. In consequence of the greater efficiency of velocity as compared with temperature ventilation, in most cases $H=l$ (where H=height of ventilating trunk and l=total length of same) and should be kept low; in all cases, wherever possible, a horizontal position of ventilating trunks should be avoided, as it does not increase the general pressure head but increases the resistance. It is also desirable to examine thoroughly the question of efficiency of different types of deflectors in conditions as experienced in a vessel. As natural ventilation is considerably cheaper than artificial, preliminary calculations by means of the given formulæ and nomograms might, whenever possible, be investigated before deciding which system of ventilation is to be adopted.—*"Soudostroienie", No. 8, 1937.*

Diesel-electric Propulsion.

The writer contends that the Diesel-electric drive is the most effective and flexible propulsion system up to 600 s.h.p., which he considers the present-day limit without too many generating sets, and he suggests that high-speed Diesel generating sets of the type now adopted in American Diesel electric locomotives, which range from 300 b.h.p. to 1,500 b.h.p. at revolutions between 600 and 1,500 r.p.m., should be adopted for marine purposes. He claims that the adoption of such units would allow Diesel-electric propulsive power to be purchased more cheaply than any equivalent power and stresses the following advantages: Generating sets could be placed forward or aft of the usual location, in waste spaces if necessary, and the propulsion motor could be placed aft. The generators could be operated in multiples of 2, 4, 6 or more independent units and used as desired for $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ or full speed and 10 per cent. above; fuel economy would remain constant, regardless of the number of units used; remote control from the bridge or pilot house could be arranged. The weight and the cubic space required for the entire plant would be less than for any equivalent installation. With duplicate sets a minimum of spare parts would be necessary. With a closed circulating system no sea-water would enter the ship, and with small units capable of being installed on or below the main or strength deck it would be unnecessary to cut these strength members. For a 2,000 s.h.p. cargo vessel such a layout would comprise six identical 300 kW. generating sets and a double-armature propelling motor occupying a length of 38ft. 9in. of the after end, all below the main deck. Any two of the generating units would propel the ship, should it be necessary to shut down as many as four, and any one may be used for port load. The overall weight of the plant would be 134 tons. There would be no feed water, and fresh water for circulation for all units would only be 200 gallons. To illustrate his points the author reproduces a simplified diagrammatic layout of a Diesel-electric installation furnished by the General Electric Company together with a table showing the per cent. of speed possible with two to six generating units when one or more are in operation and the others idle.—*Eads Johnson, "Marine Engineering & Shipping Review", November, 1937, p. 591.*

Geared Turbines for Lake Freighters.

The writer gives detailed particulars of the geared turbine installations adopted for four new bulk freighters of the Pittsburgh Steamship Company, which he states represent one of the most outstanding engineering developments in Great Lakes practice of the past year, reciprocating steam engines using low pressures and temperatures with steam driven auxiliaries of low efficiency having been universally employed during the past 30 or 40 years. The principal dimensions of the new vessels are: 593ft. 9¾in. length b.p. × 60·0 beam × 32ft. 6in. depth, the displacement being 16,980 tons on 20ft. draught. Two of the vessels are being fitted with De Laval geared turbines and Foster Wheeler boilers of the two-drum "D" type, while General Electric turbines and Babcock & Wilcox boilers of the cross-drum sectional header type are being installed in the remaining two. In general the design of the turbines, which only vary in detail for the two makes, is similar to that of those fitted in the Standard Oil Company of New Jersey tanker "R.P. Ensor". Each propulsion unit will consist of a compound turbine, connected by flexible couplings to a double-reduction gear assembled complete in one casing. The turbine is rated at 2,000 normal 2,300 maximum s.h.p. and will receive steam at 375lb. pressure and 725° F. total temperature, exhausting into a vacuum of 28½in. of mercury with 70° F. cooling water. At 2,000 s.h.p. the propeller revolutions are 90 r.p.m., at which speed the h.p. turbines revolve at 5,965 r.p.m. and the l.p. turbines at 5,005 r.p.m., the speed of the intermediate reduction gear being 805 r.p.m. The engine room auxiliaries for regular use will be electrically driven, while the stand-by auxiliaries will be steam driven, and to utilize the high efficiency of the main units for the generation of power to operate auxiliaries a 125kW.-240 volt generator is connected by means of a flexible coupling to the l.p. second reduction pinion. In addition two independent generating units are installed, which are supplied with steam at 375lb. pressure and 725° F. temperature. Automatic controls are provided by which the load will be transferred from the main unit generator to an independent generator, whenever the speed of the pinion to which the main generator is coupled exceeds 902 r.p.m. or falls below 545 r.p.m. The boilers, which the writer describes in detail, are fitted with mechanical stokers and economisers in addition to the air heaters and super-heaters. The estimated speed performance for normal service conditions is 12·2 miles per hour, and it is anticipated that when using coal of 14,000 B.Th.U. per lb. heat content a fuel consumption of ·86lb. per s.h.p. for all purposes will be realized, corresponding with a heat consumption of 12,050 B.Th.U. per s.h.p. and 21·5 per cent. thermal efficiency. As the fuel consumption for all purposes of the steam machinery employed in existing Great Lakes vessels must be taken as 1·50lb. per i.h.p. equal to 1.67lb. per s.h.p., a reduction of nearly one half will thus be obtained with the new turbine machinery.—*"Marine Engineering & Shipping Review", November, 1937, p. 586.*

EXTRACTS.

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

Marine Diesels in 1937.

By A. C. Hardy, B.Sc., A.M.I.Mar.E.

Annual Review Design and Equipment Number of "Shipbuilding and Shipping Record", 31st December, 1937.

A total of 6,763 motorships, having an aggregate gross tonnage of 13,748,713, is listed in the current issue of Lloyd's Register Book. This marks an increase over some 6,128 units and 12,290,599 gross tons in the previous issue. Of the total now recorded, 992 are of 6,000 tons and upwards, 497 have tonnages between 6,000 and 8,000 tons, 324 between 8,000 and 10,000 tons, 131 between 10,000 and 15,000 tons, and the remainder being of 15,000 tons and upwards. These figures are quoted to show that the motorship movement is still growing. The year which has just passed has from some points of view been one of the most outstanding since the publication of the 1914-15 edition of Lloyd's Register Book, which showed only 297 units with 234,287 gross tons. At that time, the "Selandia" was, relatively speaking, a new ship. Many of the vessels listed were auxiliary sailing vessels and small craft of one kind or another. The motor vessel was regarded frankly as an experiment, and, by the more conservative of marine engineers, as an experiment not likely to come to fruition. How incorrect those conservative pessimists were and how equally wrong in their assumption that the diesel engine could never stand up to hard marine work, is proved by the fact that on 17th February, 1937, was marked the passing of a quarter of a century since the East Asiatic Company took over the motorship "Selandia" from Burmeister & Wain. This ship, which can claim in all fairness to be the first ocean-going oil-engined vessel in the world, is still afloat under another name. From these small beginnings have grown up the large motorship fleet of to-day, and history will certainly approve the remark of one who was present at the "Selandia's" trial to the effect that "One day we shall tell our children that we were among the first to sail in such a vessel". The year 1937, too, has marked 40 years since Dr. Diesel himself invented the internal-combustion engine which now generally bears his name, although different in many aspects from his original idea. This fact was appropriately celebrated at the works of the Maschinenfabrik Augsburg, Nuremberg, or "M.A.N.", as it is more familiarly called, in Germany and elsewhere. It could be wished that such an important year, therefore, might have been marked by some further outstanding developments in marine diesel engines themselves. Such, frankly, has not been the case.

Steady progress can be reported, but this is a progress of Application rather than of Evolution. It is a year, for example, which has seen the advent of the fastest cross-channel boat, the 25¼-knot "Prins Albert" on the Ostend-Dover service of the Belgian State Railways. It is a year which has seen the launch of the "Capetown Castle", the biggest British ship to be put into the water since the "Queen Mary" was launched. She is propelled by double-acting two-cycle Harland-B. & W. diesels of upwards of 30,000 h.p. It is a year which has seen the arrival of the first triple-screw ocean-going motor vessel, one of a trio for her owners and one of five similar ships ordered during the period under review. It is a period which has seen the application of the diesel engine in association with electric propulsion to a large number of special type ships, including the first ocean-going vessel—a German cargo ship—in which diesel engines have been coupled to alternators in turn supplying current to a.c. motors on the shaft. Some 76,000 s.h.p. aggregate of similar ships have been ordered, only in Germany unfortunately, in the period under consideration. The year which has just passed has seen also the practical introduction of a method of indirect drive of diesel engines, whereby electricity is employed as an alternative to hydraulic couplings which have formerly proved and still are so successful. This was the Asea electro-magnetic slip coupling, which has been used on a single screw with a single engine in a pilot cutter, on single-screws with twin engines for fruit ships, cargo vessels and special coasting ships running in Sweden and in association with a single screw and four engines for a special type of cargo liner. From some points of view this electro-magnetic slip coupling was one of the outstanding developments of the marine engineering year. It is likely to go much further, particularly if it is contemplated fitting internal-combustion engines to ships of upwards of 50,000 h.p. in the course of the next few years. Many people consider that it may ultimately have a profound effect upon the future of large heavy double-acting two-cycle airless injection engines for these very high powers. The use of welding has continued on a number of makes of diesel engines the designers of which have specialised in such construction for them. As a method of building up engine frames, however, it cannot be said to have spread, although proving eminently satisfactory in those designs to which it has already been applied.

Airless injection of fuel has long established itself, with the result that the injection air compressor driven from a forward extension of the crankshaft, once the bugbear of operating marine engineers, has now entirely disappeared. The year has not been remarkable, however, for any tendency to do away with a similar "excrescence" at the forward end of single- and double-acting two-cycle airless injection engines. The crank-driven scavenge pump remains. It is excusable and even desirable in units up to, say, 1,000 or 1,500 h.p., but it does appear in big double-acting or single-acting engines of upwards of 4,000 h.p. to take up space, as well as to prove a clumsy if certain method of delivering the necessary air at slightly above atmospheric pressure for cleaning out the cylinders. In this respect, therefore, it has been interesting to note on the two 12-cylinder 7,500-b.h.p. diesels of the new cross-channel ship "Prins Albert" the arrangement of special beam-driven scavenge pumps, one for each pair of cylinders. This does not add to the total length of the engine, does away with the necessity for noisy electrically-driven scavenge blowers and makes for a desirable fore and aft compactness.

One might mention here in parenthesis that the above remarks should not be taken as a general criticism of electrically-driven blowers, for these are perfectly satisfactory and even necessary on large ships and many small ships, but in a long narrow box-like structure, such as a cross-channel vessel, where they are running at relatively high speed in confined spaces, they are apt to be noisy as well as adding considerably to the auxiliary load. This in turn means more diesel engines, more moving parts, and hence a greater chance of vibration and, what is allied thereto, noise also.

The Four-cycle Engine.

As regards development of engine types, the two-cycle engine in powers of above about 1,500 h.p. is having almost entirely its own way. Except in special cases, where owner's practice demands them, such as, for example, Anglo-Saxon tankers, the four-cycle engine has to all intents and purposes disappeared. Where, however, it is retained, continuous supercharge is an integral part of the design. This can be obtained either by some method of under-piston pressure generating, such as is used by Werkspoor, as well as by Harland & Wolff, or by the highly successful Buchi exhaust turbine system, also favoured in Belfast, or even by electrical blower. From the point of view of four-cycle engine progress, one of the outstanding events of 1937 was the ordering by the Royal Packet Navigation Company of Amsterdam of two fast cargo liners from the Van der Giessen Yard near Rotterdam for an entirely new round-the-world service. These ships have approximately 8,000 h.p. apiece on two screws and each screw is driven by a Werkspoor four-cycle single-acting diesel of 4,000 h.p. The two vessels when completed will be the highest powered units in existence with four-cycle machinery. Many people consider that this engine has been condemned to a too early grave, and that by its inherent simplicity, which is not spoiled by multiplicity of working parts, it still offers a great deal to the shipowner. Weight for weight and dimension for dimension, however, it has not, even with continuous supercharge, the same power output as its two-cycle opposite number.

Two-cycle advantages.

The year 1937 has shown that for a concentration of power on a single-screw there are few if any designs to equal a double-acting or opposed piston two-cycle airless injection unit, unless low headroom is a vital consideration. Fore and aft compactness is accomplished at the expense of height, but this, it is submitted, is a matter of little or no importance in the average cargo vessel. Notable examples of ships with the majority of well-known makes of double-acting two-cycle engines have been finished. Among these, the Burmeister & Wain and Harland-Burmeister & Wain engines, with those made by the licensees of these two firms, have been well to the fore. Considerable success has likewise attended M.A.N. units, where the tendency has been towards higher speeds of rotation. German naval architects have always favoured indirect drive for their motor vessels gearing two engines to one shaft, or employing them in association with alternating current drive as mentioned above. Sulzer's with their licensees, have been actively engaged in fitting ships with both single-acting and double-acting two-cycle engines. The Sulzer predilection, however, has been rather towards single-action wherever possible, and it is not surprising to find that the five ships with triple screws built or building all have Sulzer engines constructed either in Winterthur or under licence. The first of these the "Boisswain" for the Royal Packet Navigation Company's China, Java, Mauritius South Africa trade, was completed towards the end of the year. Each of the three engines delivers its rated power at different revolutions.

Three- and four-screw motor liners.

This represents a very attractive method of distributing a total power of up to about 24,000 with low headroom, an essential in passenger ship construction on many routes. The Sulzer and Burmeister & Wain types still continue to be used internationally, but during the last year the M.A.N. unit, due no doubt to politico-economical rather than to technical reasons, has tended to be concentrated in German tonnage, very few licence-built units having been completed. No review of this kind would be complete without adequate reference to the Doxford engine, one of the latest successes of which has been scored by the ordering on the part of Shaw, Savill & Albion Co., Ltd., of a quadruple-screw ship for an entirely new service between U.K. ports and Capetown, Australia and New Zealand. No reliable official figures have yet been issued concerning the total power output on the four shafts, but it seems probable that five-cylinder opposed-piston engines will be employed with a diameter of 28·56in. and a combined stroke of 88·56in., the total power developed on four screws being some 26,500 at 120 r.p.m.

The new Shaw, Savill ship will be the first quadruple-screw motor liner to be finished since the "Reina del Pacifico" in 1931, and the second quadruple-screw motor liner in the world to be fitted with Doxford engines, the first being the ill-fated "Bermuda", herself completed in 1928, and having a total power output of her four screws of 11,250 h.p. and 110 r.p.m. Two of the original engines of this latter ship are at present in existence in a ship owned by Andrew Weir & Co., trading between Capetown and Rangoon thus again proving in this year 1937 that the diesel engine is capable of long and faithful service. The progress in the big engine field, then, will be seen from the above few brief remarks to have been steady and unspectacular.

Improvement in detail.

The main advances in design have been concerned with improvement of detail. Controls now are extremely simple, and it is only necessary to spend a short time watching the large double-acting two-cycle engine of upwards of 15,000 h.p. being manœuvred to realise that there is but little to choose in quickness on the telegraph between steam reciprocating engines, turbines and diesels; in fact, for actual rapidity of start there is very little doubt that the internal combustion engine has it. The question which those who study the future are now asking themselves as a result of progress in 1937 and previous years is "Where is the limiting power of the internal-combustion engine?" Will it be a physical one as to size, just as it was with the old steam reciprocating engine before the rotary prime mover, the turbine, came to take its place? Many people think that we are now rapidly approaching this limit on physical grounds. If this is the case, then, the devices mentioned above for indirect drive, namely, alternating-current propulsion, electro-magnetic slip or hydraulic couplings will be readily available. Many prophets foretell, for the higher powered internal-combustion engined ship, twin engine rooms in tandem with a staggered engine arrangement, two or four being grouped round one shaft. Each propulsion engine group will be in its own engine room with its complementary auxiliaries. This would appear to be an eminently satisfactory arrangement, particularly in long narrow ships. So much for high powered ocean-going craft; what of the smaller vessel?

The coaster movement.

The coaster movement has contributed during 1937 to the success of the diesel engine on a numerical if not on a technical basis. So great has been the demand for these little motorships that practically any engine capable of delivering upwards of 500 h.p. on a single screw and suitable propeller revolutions could be sold, provided the price was right. The owner's choice in small craft to-day is almost entirely governed by price and in this field the four-cycle engine is not only a powerful, but a dangerous rival to the two-cycle. Of coasters built and delivered to British and Dutch owners during 1937, it would be a safe guess that between four-cycle and two-cycle the numbers must be about "fifty-fifty". Indeed, there is a great deal to be said for the four-cycle engine of upwards of 500 h.p. It is simple to operate, compact in construction, and although there are many more moving parts, these are of easy access and easy to understand. The two-cycle engine, on the other hand, makes for a slightly superior fuel consumption, may claim a better exhaust, and other selling points. In any case, whatever the technical points governing choice, it is the price which is the final governing consideration.

Reduction-reverse gears.

The majority of small craft fitted with diesel engines during 1937 have had direct-coupled prime movers. Almost the only country still building motorships with the prime mover indirectly coupled, i.e., driving through some reduction reverse gear, is Great Britain. This is partly because some manufacturers in this country do not make direct reversing standard units, but also because the standard diesel engine turns for given rated power at rather too high a number of revolutions for best theoretical propeller conditions. The architect of the coaster demands, as his ideal, diesel drive with steam propeller conditions. This argument suits the manufacturer of the non-reversing engine well and it must be admitted for those units fitted with an hydraulically-operated reduction reverse gear between the prime mover and the propeller have given but little trouble in service. There seems to be, however, a rooted, although perhaps old-fashioned, prejudice in the minds of many marine engineers against fitting any type of prime mover which is not direct coupled to the propeller shaft. In spite of the many obvious advantages this is a prejudice which will take a great deal of overcoming. The year 1937 closes with the coaster situation as interesting and pregnant with development as it ever has been.

Diesel-electric drive.

As far as other small craft are concerned, the question of the tug, and particularly of the Thames tug, is one of considerable interest. Attempts have been made, and are still being made, successfully to introduce diesel-electric drive, but the majority of owners seem to find that the first cost is too high, although the operating results, judged from those ships at present in service on the Thames, more than justify this extra cost. There are so many excellent standard diesel engines, which are very attractive to the owners of tugs at "off-the-shelf" prices, under which conditions they can be sold also to coaster owners, that it is a little difficult for them to see at first the wisdom of paying fairly high prices for non-standardised electrical gear. If electric propelling motors, generators, exciters, switchgear, etc., could be sold as standard units for tug work, there is no doubt that electric propulsion would achieve a much greater popularity than in the past. In spite of this, some noteworthy examples have been contributed to the mercantile marines of the world during 1937, particularly so from our own shipyards; to mention only one example, the Trinity yacht "Patricia". She is the second electric ship for Trinity House, the first having been the pilot cutter "Vigia", originally built as a standard steam drifter and afterwards converted to electric propulsion.

High-speed engines.

The "Vigia" is particularly noteworthy as being the first electrically-driven vessel in which really high-speed four-cycle diesel engines of automotive type were fitted, each coupled to an electric generator. The rating of these bus engines, if the term may be used, was 100 to 125 b.h.p. at 1,000 to 1,650 r.p.m.—that is really high speed—for the average marine man still looks on high speed as anything over 400 r.p.m. In spite of the uniform success of this little ship, apart, it is understood, from one rather unfortunate accident which could not be foreseen, there is still a prejudice against high speed for internal-combustion engines. Marine men consider that they require a great deal more attention, that they may be more expensive in lubricating oil, and that their life may be shorter.

More important than that, however, is the psychological question, for the idea of high speed is entirely remote from, and foreign to, marine thought. It is not always easy, in the face of potential operational difficulties, to persuade marine engineers that there are considerable advantages to be gained by small, standard, high-speed units. To tell such men that if anything goes wrong with the engine it is only necessary to communicate with the makers, who will arrange to remove the offending unit *in toto* and substitute immediately another standard engine, is but poor consolation for the trouble caused at sea by, say, a broken crankshaft. To explain the advantages gained in space and weight is to offer something applicable perhaps only to certain types of ships, for what—it may be asked—is the value of such gifts, if the engine manufacturer presents them on the one hand and the measurer of tonnage takes them away on the other? Nevertheless, in spite of all these apparent disadvantages, the day of the really high-speed internal-combustion engine for shipping work will come. Never, for ordinary cargo-carrying ships, and perhaps never for the ordinary type cargo liner and tankers, in which if the examples completed during the year 1937 are to be taken as in any way typical, direct-coupled prime movers, with 400 to 500 r.p.m. auxiliaries will always provide the best solution to the problem, but in special craft, such as fast excursion ships or cross-channel vessels. Here high-speed units, geared round a single propeller shaft in pairs, will prove something of a very great value from a space and weight point of view, as well as for speed of overhaul.

Special devices.

Another aspect of marine propulsion with diesel engines has presented itself during 1937 and that is the equipment of certain special type ships with a device, the Voith-Schneider propeller, whereby a non-reversing constant-speed prime mover can be coupled up to the propeller itself, on which latter all manœuvring is done. This device eliminates the ordinary screw and does away with the necessity for a rudder, since it combines both functions in one structure. One ship has been completed and three ordered with this device in 1937. By this means, we have seen reintroduced to marine circles the horizontal engine.

The *vis-a-vis* or straight line unit is now fitted for propulsion work, as inquiries during the year have proved. Hitherto, it has been employed in association with electric propulsion for ferries. The year 1937 saw its proposed application to ferries, but in association with the device mentioned above. The horizontal engine is coming into its own again in cases where headroom is severely restricted and overhaul of the engine is impossible. There are three types of horizontal diesel engines available in this country to-day, the Crossley-Premier, the Brush, and the Robey. Of these, the first-named only has had actual marine-propulsion experience, although two have been used for the operation of refrigeration compressors in 'tween decks. These, then, are some of the "high spots" of marine engine development during 1937.

The late Spring of 1938 will see a 20¼-knot North Sea "mammoth"—the Bergen Steamship Company's "Vega", sister to the 7-year-old "Venus".

Steam Propulsion in 1937.

Published results of performances—Improved turbine machinery—Economical reciprocating engines.

Annual Review Design and Equipment Number of "Shipbuilding and Shipping Record", 31st December, 1937.

The past year has proved interesting from the point of view of steam propulsion, not because of any particularly outstanding or revolutionary developments, but owing to the performance results of a number of vessels now being available. That the steam engine of the present day is an economical and efficient machine can hardly be questioned, as weights and consumptions have been cut down to figures regarded as impossible not many years ago. Competition from the diesel engine has, of course, resulted in steam-engine builders carrying out extensive experiments towards greater economy in cargo vessels, and should the necessity arise, a considerable weight saving may yet be effected by the use of aluminium alloys.

Published results of the "Queen Mary", the largest geared turbine-driven vessel, showed that on actual service, fuel consumptions ranging between

0·586 and 0·614lb. per s.h.p. hour were obtained. These consumptions which are based on oil fuel with a calorific value of 18,250 B.Th.U. per lb. are of particular interest, as in the "Queen Mary" the hotel services are entirely separate from the propulsion boilers and feed systems. This permits a reliable fuel consumption for propelling machinery only to be ascertained. The fuel consumption for hotel services is approximately 2 tons per hour.

One of the most interesting performances published during the year was that of the "Scharnhorst" and "Gneisenau", the Norddeutscher Lloyd East-Asiatic express liners. The vessels are sister ships in every respect except that the "Scharnhorst" is fitted with turbo-electric drive, while the "Gneisenau" is provided with geared turbines. High-pressure steam boilers are fitted on both vessels, the installation consisting of four Wagner-Deschimag water-tube boilers operating at 50 atmospheres (710lb. per sq. in.). Over a period of three voyages, the fuel consumption of the "Scharnhorst" worked out at 0·668lb. of oil per shaft horse-power per hour while that of the "Gneisenau" was 0·623lb.

Development of the steam turbine is also demonstrated by the decision of the Union-Castle Line to install machinery of this type in their liners "Arundel Castle" and "Windsor Castle" in order that the vessels may take their place in the company's accelerated mail service to South Africa. Both vessels, which were built in 1921, had as the original machinery a twin-screw installation of h.p. and l.p. turbines geared to the propeller shafts, the turbines being supplied by steam from 11 cylindrical boilers working on natural draught.

Under the reconstruction scheme the original machinery is being replaced by Parsons triple-expansion, single-reduction gear, turbines supplied with steam from four Babcock-Johnson water-tube boilers with a working pressure of 425lb. per sq. in. The two single-ended boilers, however, have been retained for auxiliary purposes and converted to oil burning under forced draught. In the case of the "Arundel Castle", these alterations have been completed and the vessel is now in service, the "Windsor Castle" being in the hands of Harland & Wolff, Limited, Belfast, for similar reconstruction and will shortly resume her place in the fleet at a considerable increase in speed. An illustration of one of the new sets of turbines for the "Arundel Castle" appears on page 290.

Of the larger turbine-driven passenger vessels completed during the year, the Orient liner "Orcades" and the P. & O. liner "Stratheden" take a prominent place. Both vessels, which have a gross tonnage of about 24,000 tons were built by Vickers-Armstrongs, Limited, Barrow-in-Furness and have similar machinery installations.

The propelling machinery consists of two sets of Parsons turbines, each comprising an h.p., i.p. and l.p. turbine working in series and driving separate pinions engaging with the main gearwheel. The h.p. turbine is of the impulse reaction type, the first stage consisting of an impulse wheel with two rows of blades followed by six stages of reaction blading. The i.p. turbine is of the reaction type with seven stages of blades, while the l.p. turbine has 16 rows of reaction blading mounted on forged-steel disc wheels.

All the turbines are designed to run at 1,715 r.p.m., which is reduced by gearing to 112 r.p.m. at the propeller, the total s.h.p. developed by the two sets of turbines being 24,000. Steam is supplied by six Babcock & Wilcox high-pressure marine type boilers with a working pressure of 450lb.

Although many improvements have been carried out in the steam propelling machinery for large passenger vessels during the past few years, it is to the cargo vessels and coasters to which one must turn for the greatest developments effecting economical performance. A recent example is the "Lancaster Castle" which, with her sister the "Lowther Castle", was built by Sir James Laing & Sons, Ltd., Sunderland, both vessels being propelled by North-Eastern reheater engines.

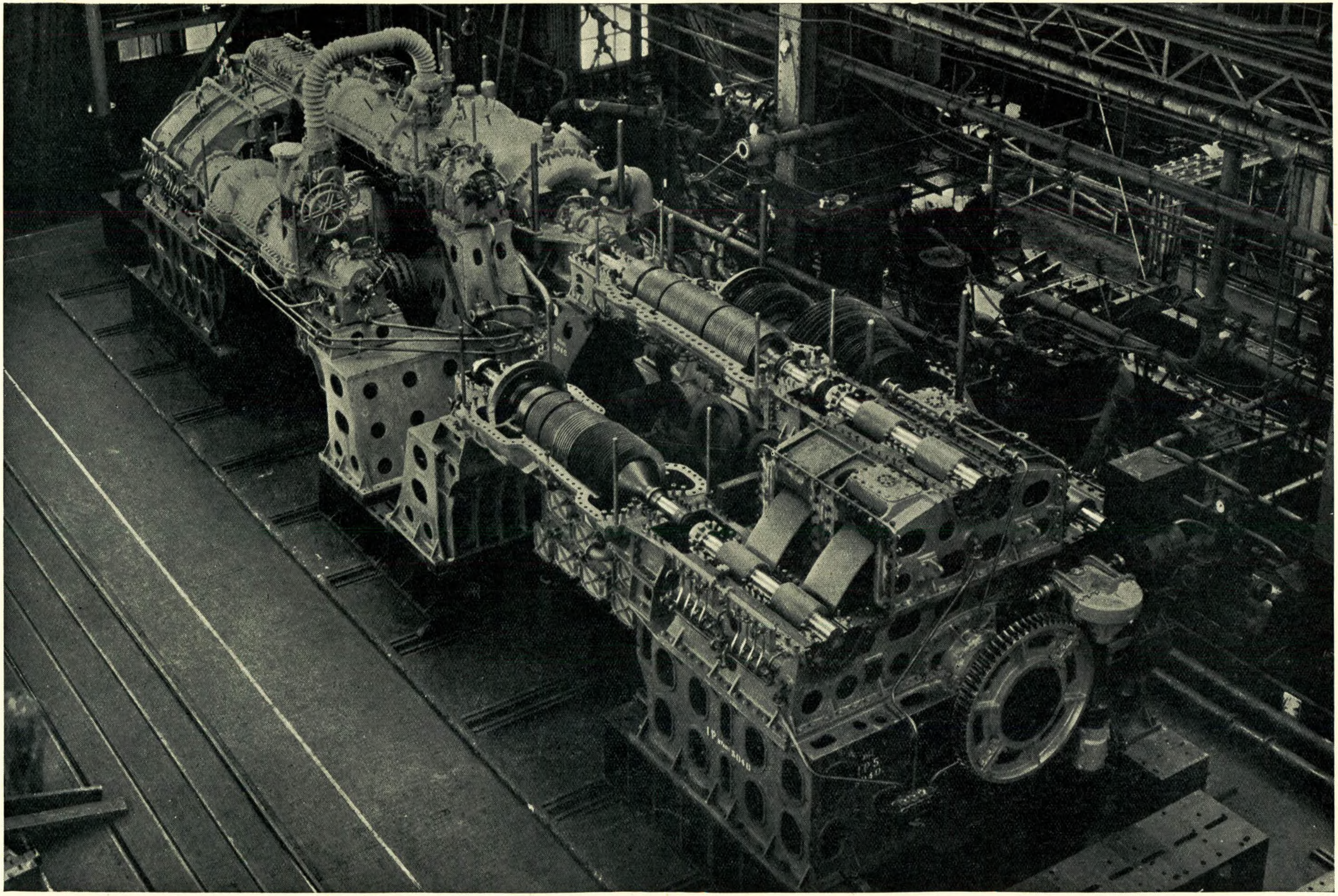
Until recently the usual initial steam conditions in marine reciprocating triple-expansion steam engines were a pressure of about 220lb. per square inch and a temperature of about 600° F. These conditions, as compared to saturated steam, give a heat consumption economy which varies with the type of engine, but may be taken as about 15 per cent. With this degree of superheat no condensation occurs during expansion in the h.p. cylinder; the steam becomes wet, however, during expansion in the m.p. cylinder and wetter still in the l.p. cylinder.

In the North-Eastern reheater engine, the steam conditions at high pressure are about the same as above, but before admission to the m.p. cylinder the steam is reheated by an amount which insures its remaining dry throughout expansion in the m.p. and l.p. cylinders. The amount of reheat for this purpose varies, and usually lies between 140° and 200° F.

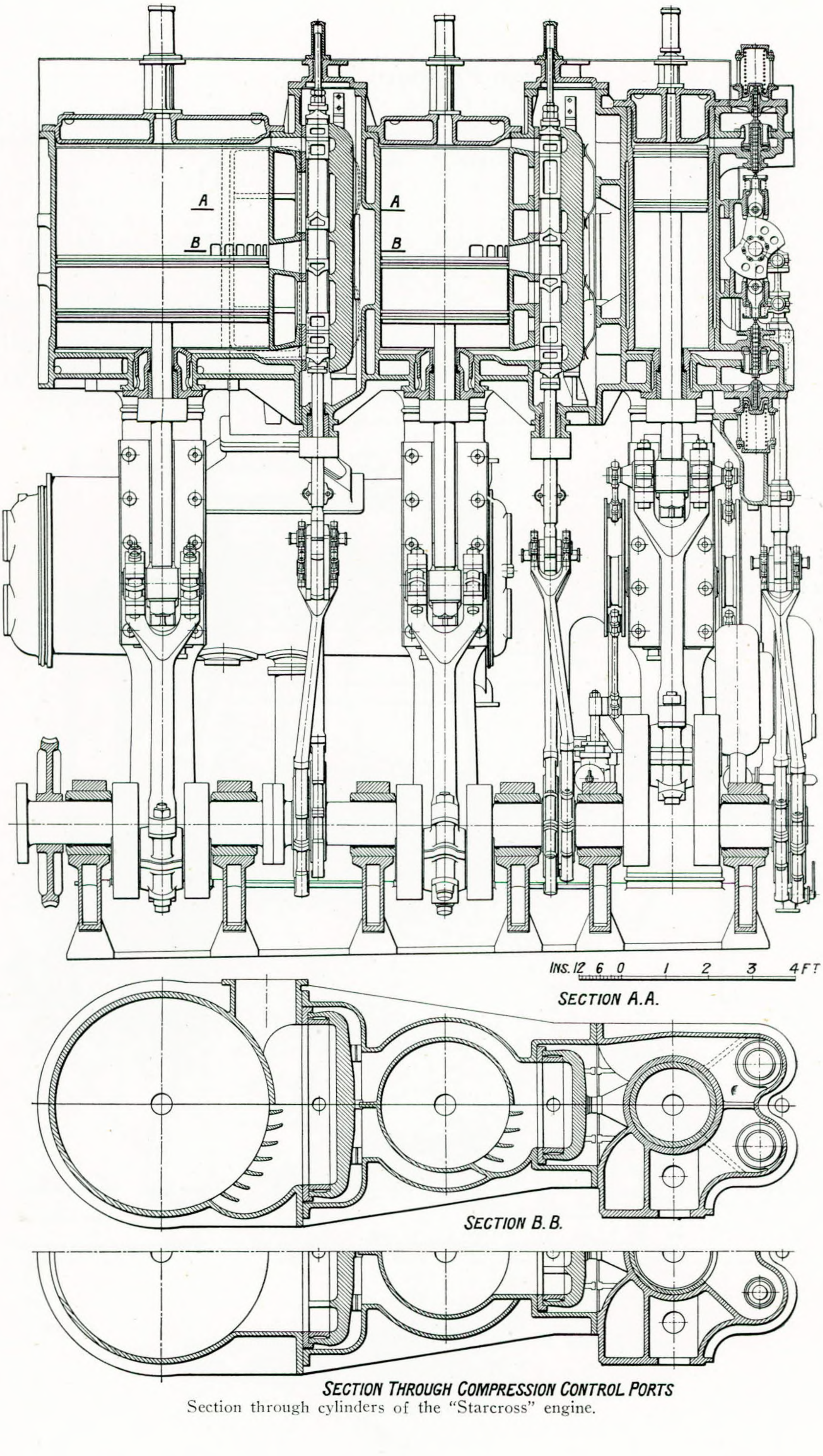
The engine is of the three-cylinder triple-expansion type, with cylinders 23, 38 and 66in. diameter, with a stroke of 45in. Both h.p. and m.p. cylinders are fitted with North-Eastern poppet valves and the l.p. cylinder is fitted with a special type of balanced slide valve. The reheater is mounted direct on the side of the cylinders.

Steam from the boilers enters the tubes of the reheater at a temperature of about 750° F. and passes through the tubes leaving at a temperature of about 600° F. and being admitted to the h.p. cylinder at this temperature. The h.p. exhaust passes round the outside of the tubes and receives its reheat from the h.p. steam inside the tubes.

The "Lancaster Castle" recently completed a round voyage of 12,000 miles fully loaded in both directions, and during the outward passage tests



Starboard set of Parsons turbines and gearing for the Union-Castle liner "Arundel Castle", which has been re-engined at Belfast for the accelerated mail service between this country and South Africa.



Section through cylinders of the "Starcross" engine.

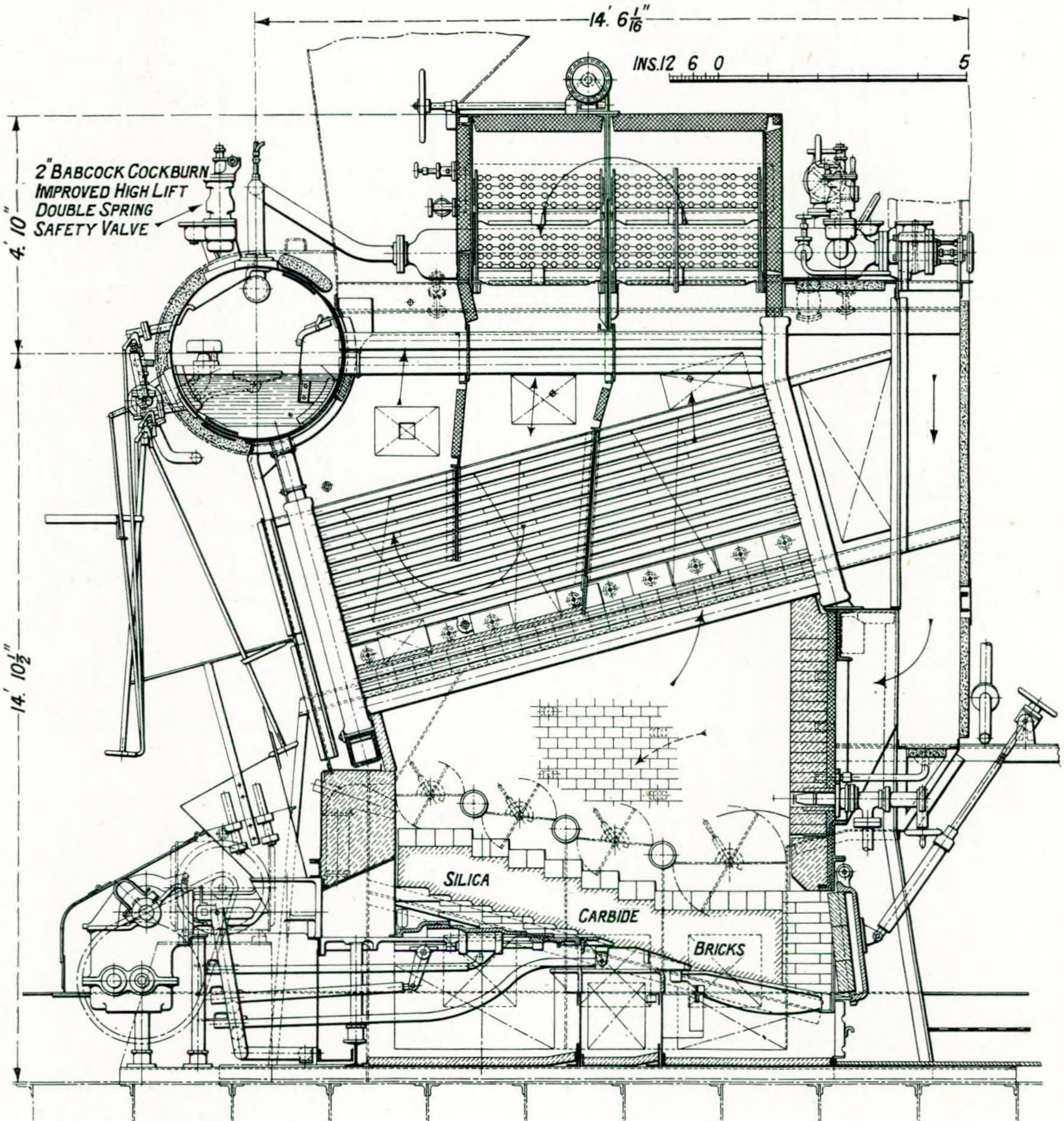
were carried out with the machinery developing various powers from half to full-power. Data at each setting was obtained over a 24-hour period, coal consumption and speed being carefully ascertained. The results obtained were:—

Ship's speed, in knots ...	8·7	10·12	10·76	11·39
R.p.m.	52	58	62·5	66·5
Slip, per cent.	5·5	2	6·6	3·6
I.h.p.	903	1,220	1,510	1,790
Coal per day in tons (all purposes)	9·4	13·3	17·5	19·6
Coal per i.h.p. lbs. (all purposes)	0·97	1·01	1·08	1·02

In the round voyage the coal consumption per day for all purposes was 16·14 tons, equivalent to 1·025lb. per i.h.p. per hour, a figure which ably reflects the economy effecting the triple expansion engine of to-day.

Other interesting installations of triple-expansion engines are those of the "Starcross", a 9,000-ton d.w. cargo steamer built by Joseph L. Thompson & Sons, Ltd., of Sunderland, and the "Torr Head" of 5,000 tons gross, built by Harland & Wolff Limited, Belfast.

The "Starcross" is fitted with triple-expansion engines of 1,250 i.h.p., built by Richardsons, Westgarth & Co., Ltd., Hartlepool, using superheated steam at 600° F. The cylinders are 21in., 35½in. and 60in. diameter, with a stroke of 39in. The h.p.



Side elevation of one of the Babcock and Wilcox boilers installed in the "Mulubinba" for Australian coastal service, which has Babcock-Erith-Roe mechanical stokers.

cylinder is fitted with separate steam and exhaust double-beat poppet valves at each end, while the m.p. and l.p. valves are of the flat balanced slide valve type and are arranged to provide double-port opening to steam and quadruple opening to the central exhaust.

The machinery of the "Torr Head" is rather interesting, as it consists of a triple-expansion engine working in conjunction with an Elsinore exhaust turbine and is the first British application of such machinery.

The main engine has cylinders 22in., 37in. and 61in. diameter, with a stroke of 45in. Steam admission and exhaust valves are of the cam-operated balanced type; separate valves and ports being provided for admission and exhaust. The exhaust turbine is mounted on a special seat incorporated in the main condenser top. Power from the turbine is transmitted through a single-reduction gear of the double-helical type and finally through a chain drive to the main shaft. A disconnecting clutch is interposed between the reduction gear and the chain-drive pinion, the chain wheel on the engine shaft being of a special elastic spring type.

The spring mounting of the chain wheel smooths out the uneven turning of the engine, while the turbine tends to prevent the engine from racing.

Among the smaller steamships completed during the year the "Mulubinba", a coaster built by Henry Robb, Limited, Leith, for Australian owners, is an interesting example of what can be done with triple-expansion engines taking steam from water-tube boilers, using coal as a fuel. The propelling machinery, which is of North Eastern Marine manufacture takes superheated steam at 215lb. per sq. in. pressure and 550° F. temperature from two Babcock & Wilcox marine water-tube boilers having a total heating surface of 4,200 sq. ft. The boilers are arranged for burning coal which is fed to the furnaces by Babcock-Erith-Roe 4-retort rear-ashing type stokers. On trials the "Mulubinba" exceeded her designed speed of 11¼ knots by more than 1 knot.

Alternating Current Drive for Propulsion and Auxiliary Machinery.

The Use of Three-phase Current Based on the Experience Gained with the M.S. "Wuppertal".

By B. Bleichen, Engineering Director of the Hamburg American Line.*

"The Motor Ship", January, 1938.

The Diesel electric installation in the motor ship "Wuppertal"† consists of three Diesel generators which, separately or together, can be switched on to a single propeller motor. In this paper I shall confine myself to what is new in the transmission system, the experience we have had and the new knowledge which we have gained.

The main objections to the electric drive which have been put forward in technical circles are:—

(1) The high price of the installation.
(2) The higher weight.
(3) The transmission loss.
(4) The danger of cutting out.
(5) Difficulties of the engineering staff in running the machinery.

So far as price is concerned, it must be remembered that it is the total cost which has to be considered. In nine more ships which we have ordered we have adopted the electric drive. We obtained quotations for three 6,500-ton d.w.c. ships with 6,000 b.h.p. machinery, with different systems of propulsion: direct Diesel; geared Diesel with two engines; Diesel electric; geared turbine and turbo-electric propulsion. In view of higher fuel costs, amounting to 85 per cent., the steam drive was ruled out. The increased price of the Diesel electric drive over geared turbine was 100,000 marks, or about 3 per cent. of the total cost. We have found that this increased cost is more than warranted, but it is necessary that observance should be taken of all the possible advantages of the electric drive. It is not enough to consider it only in relation to the propelling machinery.

According to our experience, the higher weight of the Diesel electric installation is of no importance. It is questionable if it is actually greater. The engines run at higher speed and weight is thereby saved. This advantage is also gained with geared Diesel machinery, but the weight of the gearing has to be included, whilst the increased auxiliary plant and the tunnel shafting have to be considered.

There is a substantial saving in auxiliary weight by the use of alternating current. The total weight of the Diesel electric plant was 570 tons, against 540 tons with a geared Diesel drive (with two engines and one shaft), so that, allowing for tunnel and shafting, there is no appreciable difference in weight.

The transmission losses can be exactly calculated. The measurements on board have demonstrated the accuracy of the calculations, and have provided some information which, whilst not new, is usually forgotten, I will refer to this later.

The danger of stoppage through cutting out can be provided for in the design. In bad weather the power variation may be as much as from 500 kW. to 3,000 kW. in the "Wuppertal", but in this ship there has been no involuntary stop.

The question of staff has been solved by us without any difficulty. The engines are the M.A.N. two-stroke single-acting trunk-piston type, compressorless and non-reversible. I do not think there can be a much simpler engine for marine work. When the "Wuppertal" returned from her second voyage, it was noticeable that the engineers went on watch wearing stiff white collars—a small matter, but informative. There is very little electrical work

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* Translation of extracts from a paper read before the Schiffbautechnische Gesellschaft, Berlin.

† For a full description of the "Wuppertal", see "The Motor Ship", May, 1937.

TABLE I.—ENGINE-ROOM STAFFS.

Ship	"Wuppertal"	"Ruhr"	"Duisburg"	"Kurmark"	"Bitterfeld"	"Bochum"
Type of machinery.	Diesel electric.	Two oil engines with Vulcan drive to one shaft.	Double-acting two-stroke oil engines.	Geared turbine, oil-firing.	Geared turbine, coal-firing.	Reciprocating engine and exhaust turbine, coal-firing.
I.h.p.	9,800	4,100	5,100	6,300	6,300	5,000
Engineers	5	5	5	4	4	4
Electrician	1	1	1	1	1	—
Assistants	4	4	4	2	3	2
Greasers, etc. ...	2	2	1	2	2	2
Firemen or cleaners	6	5	6	6	15	12
Trimmers	—	—	—	4	12	6
Boys	1	1	1	1	2	1
	19	18	18	20	39	27

to do, and at the end of the first voyage the chief engineer informed me he could dispense with two of the three electrical engineers. The table shows the small engine-room staff compared with that in ships with other means of propulsion.

The main advantages of the electric drive may be summarized :—

(1) Division of the propelling plant into several units.
(2) Provision for reversal by electrical means.
(3) Greater flexibility of the propelling machinery according to the power requirements.
(4) A better use of available space.
(5) Freedom for the most satisfactory arrangement of engine and boiler-room.
(6) Absence of tunnel.
(7) Provision of electric current for auxiliaries from main generators.
(8) Possibility of exact power measurement.

The main generators in the "Wuppertal" can be switched in or out as desired. When switching in, it is necessary to bring the engines to the same revolutions so that the periodicities are equal at the moment of switching. This manœuvre involves no difficulty and can be carried out at any time during a normal watch if required. Switching out a generating set is also quite simple.

Equal loading of the generators is, of course, highly desirable, and good governors and absolutely reliable revolution indicators are essential. Synchronous operation is necessary and when speed is varied, simultaneous regulation of the Diesel engines has to be carried out. Individual speed control has to be effected after synchronization to equalize the load. To obtain reliable regulation it is not only necessary to adjust each governor exactly, but to test them against each other. If this be not done the engine with the governor which reacts most quickly will be overloaded, since it will tend to drive the other Diesel generators. Moreover, at sea, the governor tends to hold the speed constant whilst the load varies within wide limits. Further, it is required that the Diesel generators should have no criticals, in order that the engines may run at various speeds. We have had good experience with the Pielstick spring coupling in this connection.

The revolutions of the engines should be capable of regulation at as low speeds as possible, since this is particularly important when reversing. The maximum speed is 250 r.p.m., and, on reversing, this is brought down to 100 r.p.m. when the full turning moment is available. We have examined the reversing mechanism cinematographically and found, what had previously never been observed, that the speed fell back to 65 r.p.m. Unless the governing be exceptionally good there is the danger that the engines will stop. The slip stream tends to turn the propeller in the old direction and there is a powerful contrary turning moment when reversing. With turbo-generators the considerable kinetic energy of the fast-running sets comes into service, which is not usually the case with Diesel engines. Hence the revolutions must be reduced and from this results a substantial

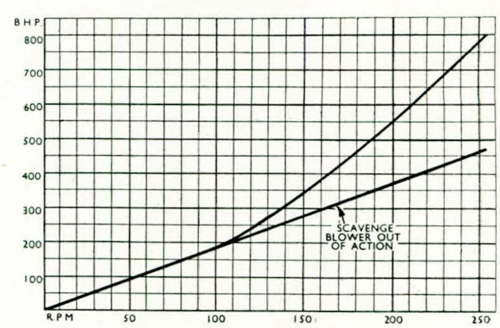


FIG. 1.—Mechanical losses in a Diesel engine.

diminution of the ship's speed. This is, however, the same in other systems of propulsion. Reversal at full speed is not to be expected with merchant ships, and with motor ships is probably not to be desired. I think in the near future means will be found to render electrical reversal easier, quicker and safer than at present.

The efficiency of the machinery depends on the losses in the complete plant. An advantage of the electric drive is that the main engines can always operate at maximum efficiency. The figure for the "Wuppertal" engines was given as 80 per cent., the scavenging blower and lubricating oil pump being direct driven. The i.h.p. measurements of the Diesel engines and the electrical records for the generators and propeller motor obtained on board

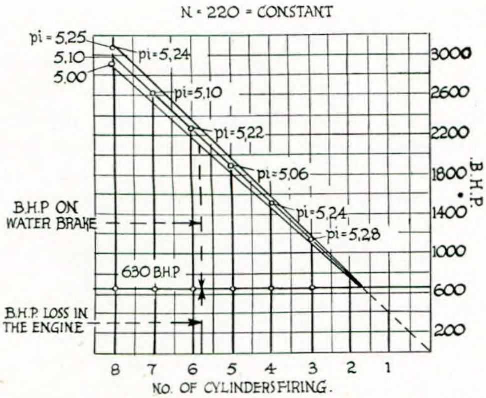


FIG. 2.—Graphs showing results of tests to ascertain the losses in a Diesel engine.

differed by a considerable margin. In order to determine the losses in the Diesel engines, electrical measurements were now made. Two of the main generators were run up and switched, in synchronism, on to the propeller motor. Fuel was then cut off one engine, and as the generators were electrically coupled the first carried the second with it. The power absorbed by the driven generator represented the light-load loss of the generator and engine. The generator losses (electrical and bearings) are known exactly. The total losses are shown in Fig. 1, and as tests were made at various speeds a curve was obtained. We have also ascertained the part played by the scavenging blowers in the losses. The driven generator had the blower cut out of action, so that only friction losses, etc., remained. It was found that at 220 r.p.m. the blower required 100 b.h.p. to drive it, and this was equivalent to 4 per cent.

I think this method of measurement is quite reliable. Blohm and Voss later determined the losses by other means. They made accurate i.h.p. measurements at constant speed and, equally accurately, measured the b.h.p. on a water brake. In an eight-cylinder engine of the same type, five cylinders have been cut out, one after the other, the speed being maintained constant. It was found that the loss in the eight-cylinder engine was 630 b.h.p.; the losses in the working cylinder were equal to those in the cylinders cut out, as shown by the straightness of the line of losses (Fig. 2).

Accuracy of the measurements was confirmed through fuel-consumption tests, the result being 136-137 grammes per i.h.p.-hr. The seven-cylinder engines of the "Wuppertal" showed practically the same losses as the eight-cylinder Blohm and Voss motor, but the scavenging-air pressure of the latter was 1,450 mm. against 2,000 mm. in the "Wuppertal". This is due partly to higher back pressure, but mainly to the large quantity of scavenging air used, and to an improved arrangement of scavenging ports in newer engines. The influence of the scavenging pump is evident. Too much scavenging air or too high a pressure is unfavourable and the effect is more strongly marked the lower the mean effective pressure. On the other hand, an ample supply of scavenging air is

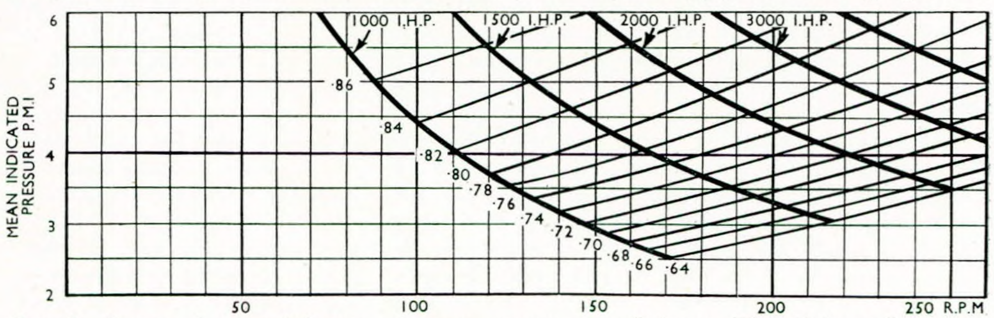


FIG. 3.—Curves showing influence of mean pressure on efficiency. The efficiency lines are seen from ·64 to ·86

good for combustion and for longevity of the engine. It is a question of finding the best compromise.

We have ascertained that the i.h.p. measurements of fast-running Diesel engines, by indicators, are notably inaccurate. The diagrams seemed remarkably good and the combustion was excellent, but the diagrams were too large. They showed a power that does not exist. This led to too low a fuel consumption per i.h.p.-hr. being recorded, also a too small apparent electrical power. The latter

TABLE II.

Test No. ...	1	2	3	4	5	6	7
Speed, knots ...	15·8	14·4	14·6	15·8	16·46	14·3	14·4
Propeller, r.p.m. ...	117·6	105·1	112·6	120·4	125·2	106·2	114
Generator output, kW. ...	3,740	2,810	3,430	4.120	4,640	4,940	3,710
Generator loss, kW. ...	105	84	99	114	126	80	105
Diesel effective power, kW. ...	3,845	2,894	3,529	4,234	4,766	3,020	3,815
Cable loss up to generator, kW. ...	330	290	310	350	340	270	350
Cable loss up to Diesel coupling, kW. ...	340	300	320	360	350	280	360
Propeller motor power, kW. ...	3,310	2,440	3,000	3,650	4,160	2,640	3,270
Propeller motor loss, kW. ...	90	71	83	98	110	76	88
Shaft power, kW. ...	3,220	2,369	2,917	3,552	4,050	2,564	3,182
Effective Diesel power, excluding cable loss, kW.	3,505	2,594	3,209	3,874	4,416	2,740	3,465
Electrical efficiency, motor and generator ...	92	91·4	91·2	91·8	91·8	93·8	92

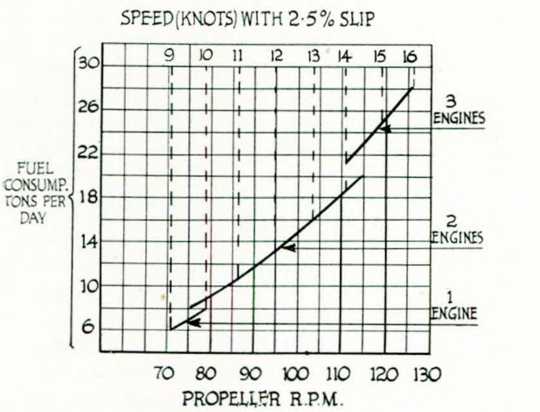


FIG. 4.—Fuel consumption curves, using one, two, or three generating sets, according to the speed required.

might certainly be due to poor efficiency of generators and propeller motor, but the losses can be very accurately determined. The electrical losses are shown in Table II based on very careful measurements over two voyages, instruments being checked before and after.

The influence of mean pressure on efficiency is seen in Fig. 3. On the outward voyage to Australia the speed is usually 13 knots and homeward it is at least 15 knots. This is a big difference and with a direct drive, would involve a low mean pressure for the reduced speed. With electric transmission, by varying the number of Diesel engines in use the mean pressure for maximum efficiency—5·2 to 5·3 kg./cm.^{2}—can always be used. Part of the voyage can be made with a speed slightly higher than the average and part somewhat below. From Fig. 3 it may be noted how rapidly the efficiency falls with the mean pressure, and Fig. 4 indicates the gain effected by the use of a high mean pressure. By cutting out one Diesel engine, moreover, the lubricating oil consumption is reduced by one-third. The ship's engineer very willingly runs his engines with low mean pressures, as heat stresses are diminished and work of overhaul diminished. That is, however, at the cost of efficiency.

A further advance in the "Wuppertal" is the employment of three-phase current for driving the auxiliaries, which has the advantages of cheapness and simplicity. The motors run with a voltage of 220-380. The speed of rotation of the motors is dependent on the periodicity, which varies with the speed of the generators. This involves no difficulty with most of the auxiliary machinery. The output of the cooling-water pumps may be lower at reduced speeds than at full speed. Scavenging and lubricating oil pumps are engine driven. The bilge pumps, sanitary pumps and fans can be designed to give sufficient output at the lowest speed, and can be throttled down at higher speed. The electric drive has led to the general employment of the rotary pump. It is my opinion that greater attention should be given to the question of glands for these pumps.

For lighting, a special circuit is provided in order to prevent flickering when the generator speed varies, and similar provision is made for the galley. In harbour the auxiliary generator is employed, which, naturally, maintains constant periodicity. With large installations it will usually be arranged that one of the six main generators will be wholly employed for the supply of current for the auxiliaries.

In the "Wuppertal" direct current for the excitation of the generators and propeller motor is delivered from different motor generators. It has been found, however, that the voltages are so similar that one motor generator is sufficient. Direct current is also used for the winches, as we did not yet feel justified in having a.c. winches. The question of the employment of alternating-current winches is uncertain, but I think that when a.c. is used in a ship for other purposes we shall ultimately employ it also for the winches.

Formerly it has been considered that the most important characteristic of a winch was lifting speed, but there are limits. For the elucidation of this matter we have carried out some time trials under working conditions at Hamburg, Antwerp and New York over a period of eight hours with modern steam and electric winches. As an example, results with the m.s. "Caribia" are given (Fig. 5). Coffee in sacks was being handled in hold No. 3, the depth of the hold being 15 metres, so that full advantage could be taken of high lifting and lowering speeds. An electric crane, very flexible in operation, was used. The weight of a lift averaged 1,120 kg. One man worked the winch, three were on deck and eight in the hold. The load was lifted on deck and from there landed by a shore crane. The total time for a complete lift was 107 seconds, and of this only 24 per cent. was taken for lifting and lowering. An increase of hoisting speed of 20 per cent. would thus save only 4·5 per cent. of the total time. It should also be noted that the full hoisting speed cannot be used, as it is seldom that the load was raised the complete height without stopping. An increase of the lifting speed of

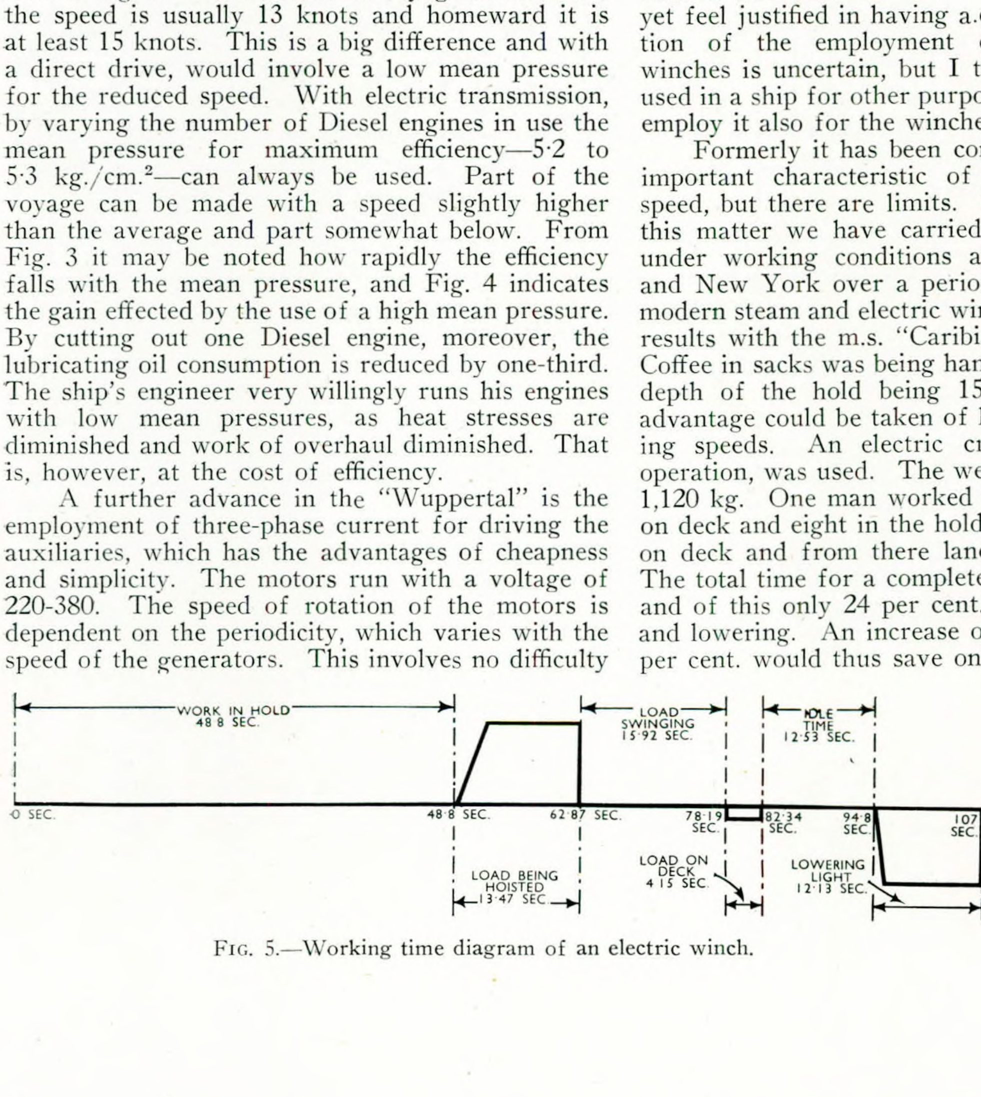


FIG. 5.—Working time diagram of an electric winch.

this winch with a 75 h.p. motor, in my opinion, is of no value. The capacity is 2 tons at a lifting speed of 0·7 metre per sec. and 0·5 metre per sec. with a 3-ton lift, and this satisfies all requirements.

Based on a conference instigated by the Germanische Lloyd and attended by the three leading German electrical firms, S.S.W., A.E.G. and B.B.C., the Germanische Lloyd has expressed its agreement with an extension of the use of alternating current on board ship. It is not merely a question of supervising and testing the installation and the cables and wiring, but of the choice of suitable manufacturers for carrying out the work. We are of the opinion that, just as on land, a.c. transmission will soon find a wide field of application at sea.

For the first time, we have used roller bearings for the stern gland in the "Wuppertal". There was much criticism and it was held by many that the employment of lignum vitæ was right and necessary on account of the softness of the bearing which it provided. I have come to quite a different conclusion. A few months ago we had to renew four propeller shafts in one week. At the same works were two shafts of another company suffering the same fate. I am in agreement with many of the experts of the Germanische Lloyd in expressing the opinion that the lignum vitæ bearing and bronze bush are a danger. Some 240 shafts in the world's shipping fleet are broken each year and at least 10 times the number are renewed because inspection has shown that their further service at sea is questionable. After the lignum vitæ wears 5 mm. or 6 mm. corresponding bending results in the shaft. The bronze bush becomes loose and sea water penetrates on to the shaft. That is the experience that is becoming more and more general, and that is why I am abandoning such bearings and have used a roller bearing. From the lowest to the highest revolutions, even in a nearly light ship, there is no vibration, and this applies aft, above the propeller.

Hitherto the system of propulsion employed has set limits to the machinery arrangement to be adopted. With electric propulsion some of these limits are set aside. In the "Wuppertal" the three Diesel generators are located side by side and a short engine-room results. I see no reason why, when it may prove desirable, the engine-room should not be above the shelter deck, with which layout no special problem of stability need arise.

We are now only at the beginning of the development of the Diesel-electric drive for ships. The system is admittedly not suitable for all vessels, but once used it will be found that its field will widen rapidly.

Diesel-electric and Direct Drive Compared.

An Analysis of the Cost, Weight and Fuel Consumptions of 10,000 s h.p. Machinery.

By a Correspondent.

"The Motor Ship", January, 1938.

In this article an attempt is made to afford a comparison between a passenger liner requiring machinery of 10,000 s.h.p., (1) equipped with two 5,000 b.h.p. two-stroke single-acting engines running at 115 r.p.m. and driving the propellers direct, and (2) four alternators driven at 250 r.p.m. by 2,650 b.h.p. two-stroke trunk-piston single-acting engines supplying power to two 5,000 s.h.p. 100 r.p.m. propeller motors.

Synchronous electrical machines are employed, which, it is claimed, will enable manœuvring to be carried out equally as well as in turbo-electric or geared turbine ships. The arrangement of the machinery in the Diesel electric ship is given in the accompanying illustration.

The main engines are of normal design having eight cylinders with a diameter of 480 mm. and a piston stroke of 700 mm. Rotary electrically driven scavenging blowers are employed and each is fitted direct on to its engine. As the motors driving the blowers are supplied from the alternators, the speed will vary with the speed of the engine; a small blower is fitted for starting, driven from the d.c. supply and having a capacity of about 6,200 cubic ft. of air per minute at 1·2lb. per sq. in. pressure. Once the engines are under way the individual blowers would start up automatically. Three 320 kW. auxiliary generating sets are installed, generating at 220 volts when running at 290 r.p.m.

For propulsion there are two 5,000 s.h.p. propeller motors of the synchronous type running at 100 r.p.m.

The total costs for the complete plant for direct drive and for the Diesel electric transmission are given below, these figures being those quoted a few months ago.

Diesel Electric.		Direct Coupled Diesels.	
4 2,650 h.p. 250 r.p.m. engines, complete with accessories as noted	£64,200		
4 1,880 kW. alternators, 2 5,000 h.p. motors, 2 balancer boosters, fans, coolers, control gear and switchgear ...	£36,300	2 5,000 h.p. 115 r.p.m. direct coupled engines, complete with same accessories as noted	£91,800
	£100,500		
3 325 kW. engines, each engine coupled to one 325 kW. 220 volt, 340 r.p.m. generator ...	£11,400	3 325 kW. engines, each engine coupled to one 325 kW., 220 volt, 340 r.p.m. generator ...	£11,400

The saving with the propelling plant for the direct-coupled system is £8,700, or 8·7 per cent. However, with the direct drive, two compressors, each capable of delivering 200 cubic ft. of air at 450lb. per sq. in. are required, whereas with the electric drive, only two small units are needed, capable of delivering 50 cubic ft. of air per minute at 450lb. per sq. in. The total costs of these respectively are £1,450 and £450, which represents a saving of £1,000 in favour of the indirect drive with electric transmission.

Comparative Weights.

The Diesel-electric drive is considerably lighter and probably would enable a saving of 250-300 tons to be effected in the steel work of the hull, representing an economy of, say, £5,500. The final difference between the two propelling systems would therefore amount to only £2,200.

The weights of the Diesel-electric drive are as follows:—

Four engines	350 tons
Four alternators	63 „
Two propeller motors	120 „
Control gear, balancer, boosters	20 „
Ventilating fans and cables	12 „
Total	565 tons

For the direct drive the weights are as under:

Direct coupled engine	820 tons
Three air receivers	14 „
Total	834 tons

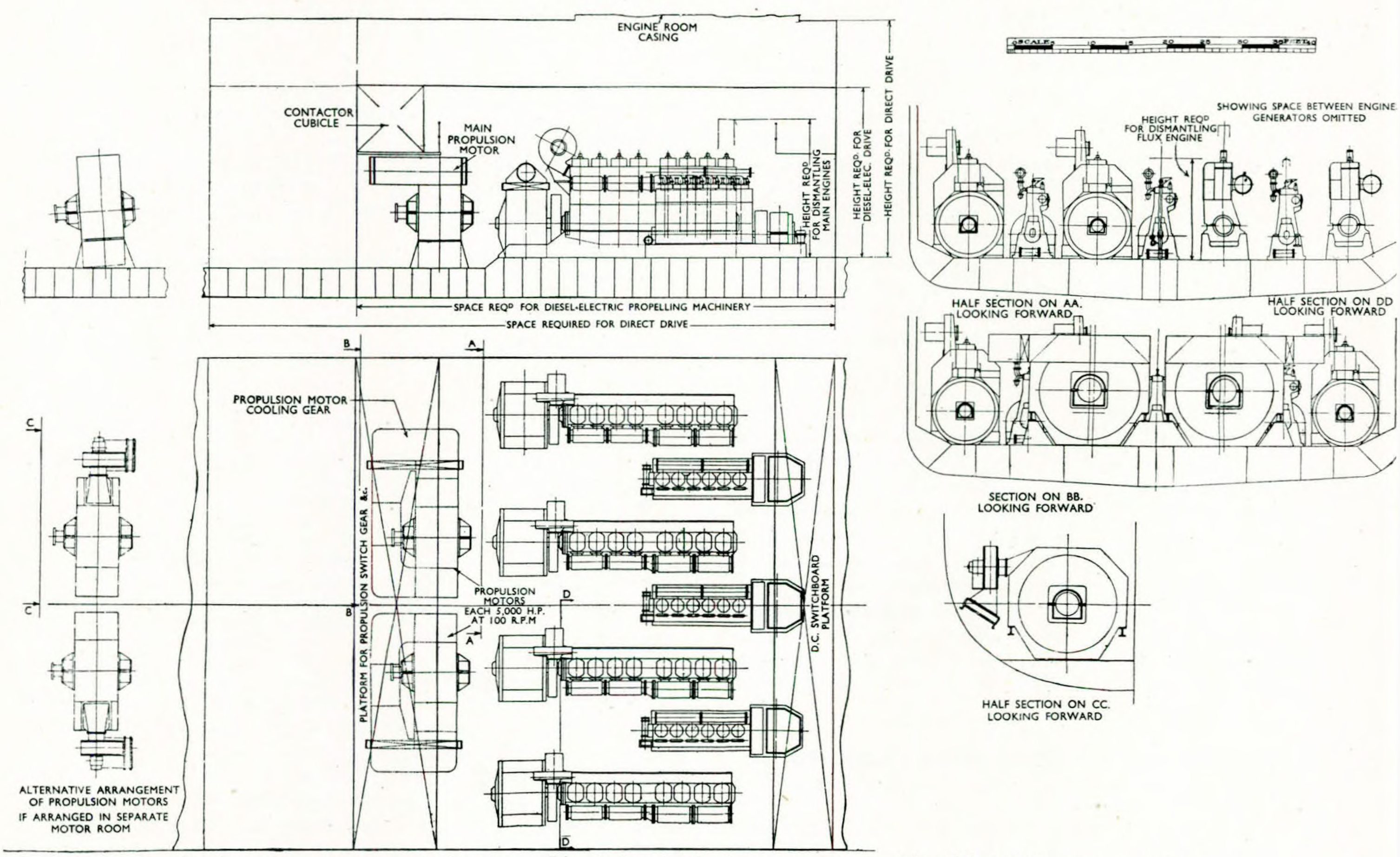
The net saving in favour of the Diesel-electric drive is thus 269 tons. The low headroom will allow of a further saving in the weight of the hull structure and an extra deck space may be gained over the engine-room, so that for the same total amount of passenger accommodation the amount of superstructure on a deck could be reduced, with a saving in the cost of the steel work.

Roughly, it may be estimated that for the same dead-weight and accommodation there would be a saving on the hull of about 250 tons of steel work. On the other hand, the better arrangement and greater available deadweight could be made use of to improve the passenger accommodation, if this were so desired.

Fuel Consumptions.

The following table gives details of the operating conditions with four, three and two engines working and the fuel consumptions per shaft horse-power-hour. The quantity of scavenging air is for one engine in cubic ft. per minute, and the pressure in lb. per sq. in.

The electrical losses would be about 6 per cent., excluding excitation, but there would be a gain of 3 per cent. in propeller efficiency by running the shaft at 100 r.p.m. instead of 115 r.p.m.



Engine-room arrangement plan for a Diesel-electrically driven passenger ship with 10,000 s.h.p. machinery.

The saving of 269 tons in machinery and 250 tons in steel work would result in a saving of power due to the lesser displacement, and it is estimated that there would be a reduction of 2·5 per cent. of the power to drive the vessel at the same speed, making a total saving of 5·5 per cent. There would

Engines running.	Prop. speed.	S.h.p.	B.h.p. per engine.	Engine r.p.m.	Blower r.p.m.
4	100	10,000	2,650	250	3,000
3	87	6,400	2,280	218	2,620
2	72	3,500	1,870	180	2,160

Quan. of air.	Press. of air.	Lb. of fuel per s.h.p.-hr.
11,800	3·5	·386
10,300	2·8	·39
8,500	2·0	·401

be a certain amount of economy in lubricating oil if any of the engines were shut down.

The cubic capacity of the engine-room with direct-coupled engines is 180,000 cubic ft. With the Diesel-electric drive the figure is approximately 99,000 cubic ft., representing a saving of 81,000 cubic ft.

If desirable, it would be possible to have a single-screw vessel of 10,000 s.h.p., which would give higher propulsive efficiency. The shaft tunnel space might be saved if the propeller motors were placed right aft and a clear hold would be available. The length of the engine-room of the Diesel-electric ship would be 65ft. and the height 23ft.

Two Japanese Geared Diesel-engined Ships.

"The Motor Ship", December, 1937.

This autumn the O.S.K. Line placed in service two notable passenger and cargo motor ships, named "Bangkok Maru" and "Saigon Maru", specially designed for the Japan-Siam route. Hitherto two steamships have been operated on this run, but now, with the reinforcement of these up-to-date motor ships, the service is considerably improved, the time required between Nagoya and Bangkok being shortened by five days and the number of voyages increased to five in two months.

The "Bangkok Maru" and "Saigon Maru" were built and engined at the Kobe shipyard of the Mitsubishi Heavy Industries Co., Ltd., Tokyo. While the two ships are similar, the following description refers particularly to the "Bangkok Maru". The principal dimensions and other characteristics are as follow :—

Length overall	121·5 metres.
Length between perpendiculars ...	113·0 metres.
Breadth moulded	17·0 metres.
Depth moulded	10·0 metres.
Fully loaded draught	7 metres.
Gross register	About 5,400 tons.
Net register	About 4,000 tons.
Deadweight capacity	6,500 tons.
Cargo capacity, bales, approx. ...	100,000 cubic metres.
Trial speed, approx.	15·9 knots.
Service speed, fully loaded ...	13·5 knots.
No. of passengers :—	
First-class	20.
Third-class	50.
Machinery	3,140 b.h.p.
Engine speed	300 r.p.m.
Propeller speed	110 r.p.m.

General Arrangement and Hull Construction.

The "Bangkok Maru" is a complete superstructure vessel with two continuous structural steel decks, extending over the whole length of the ship, viz., the upper and second decks, the third deck being partially incorporated over Nos. 1 and 3 cargo holds and the engine-room at the sides and front.

The stem is considerably raked and slightly curved at its upper part with a fashion plate, whilst the stern is of the elliptic type, and a double-plated streamlined rudder is fitted. Model tests of the hull and propeller were carried out in the experimental tank of the Nagasaki Mitsubishi shipyard in order to ensure minimum resistance for propulsion, particularly with respect to the stern form, including the propeller and bossing.

The hull is subdivided by six water-tight transverse bulkheads, extending to the upper deck, into seven compartments, viz., the forward peak, Nos. 1 and 2 cargo holds, the engine-room, Nos. 3 and 4 cargo holds and the aft-peak tank, the positions of the bulkheads having been decided in compliance with the Japanese Law of the Safety of Ships at Sea (which is similar to the International Convention).

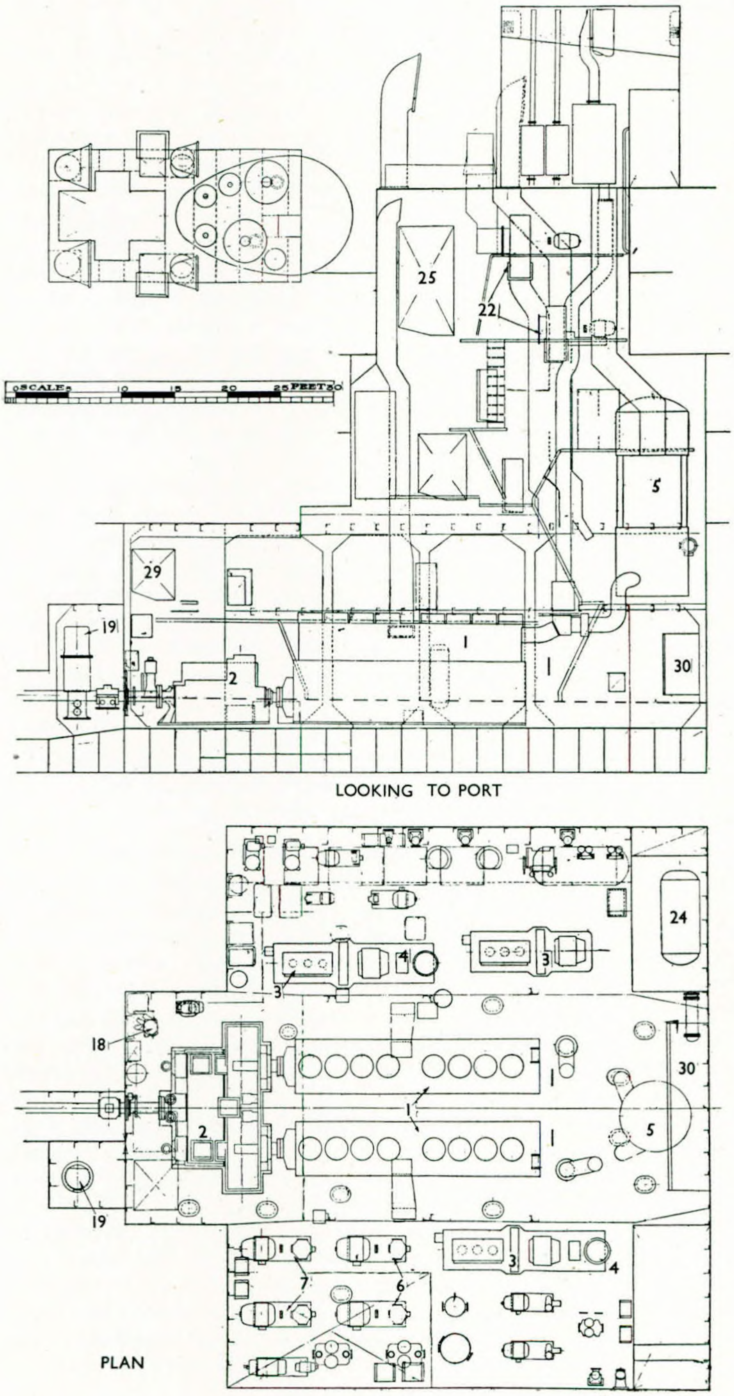
A cellular double bottom extends throughout the length of the ship between the peak bulkheads, and comprises seven compartments, for fuel, water ballast, fresh water and lubricating oil.

Geared Propelling Machinery and Vulcan Clutches.

The "Bangkok Maru" is propelled by a single screw through Vulcan gearing driven by two Mitsubishi four-cycle airless-injection reversible Diesel engines, each having eight cylinders, 450 mm. bore and 630 mm. stroke, with an output of 1,570 b.h.p. at 300 r.p.m. These engines have been developed by the Mitsubishi Kobe works and represent a considerable difference from the Mitsubishi two-cycle single-acting and double-acting airless-injection engines constructed at the Nagasaki shops, the Kobe engines being for the smaller or medium outputs, whilst the Nagasaki engines are for higher powers.

The camshaft, which is at the top of the engine, is driven from the crankshaft through an inclined shaft and skew gearing at the after end, whilst the engine controls are located forward. Four plunger-type fuel pumps are driven by eccentrics fitted at the forward end of the crankshaft and the fuel maintains a constant pressure in the pipeline, the amount required being injected to the cylinders by means of the valve mechanism, which is suitably timed. With this system the injection oil pressure can conveniently be adjusted, independent of the revolutions and the load, by varying the opening time of the injection valves and the effective stroke of the pumps.

Manœuvring of the engines is carried out by turning a hand-wheel. When the wheel is moved to the right from the stop position, ahead, stand-by, starting, slow and full speed are effected in succession. By turning the wheel to the left, a similar sequence of operations is carried out for astern running. Interlocking devices are provided. The speed of 300 r.p.m. of the two engines is reduced to 110 r.p.m. at the propeller shaft. The Vulcan coupling is of the normal design, utilizing lubricating oil. It is not reversible, as the main engines are of the reversible design. Connection to or disconnection from the propeller shaft is carried out by filling, or draining the oil in, the coupling.



(1) Main Diesel engines. (2) Vulcan clutches and gearing. (3) Diesel-engined dynamos. (4) Air compressors. (5) Exhaust gas and oil-fired boiler. (6) Circulating pumps. (7) Circulating pumps. (18) Oil separator. (19) Emergency bilge pump. (22) Fans (24) Air receiver. (25) Service tank. (29) Oil tank. (30) Switchboard.

Auxiliary Machinery.

Current is supplied throughout the ship from three Mitsubishi four-cycle airless-injection engines of 150 b.h.p. each coupled to a 100-kW. 225-volt dynamo; two of them also drive air compressors of the Mitsubishi-Weir type through magnetic clutches. Further, an emergency dynamo of 20 kW., together with an air compressor, is provided. The electrically driven auxiliary plant includes two cooling-water pumps for the main engines (one being a stand-by pump), each with a capacity of 130 tons per hour; two piston-cooling oil pumps for the main engines (one also a stand-by pump), each of 85 tons per hour capacity; two oil pumps for the Vulcan coupling, each of 85 tons per hour capacity; a fire and general service pump of 100 tons per hour capacity, a bilge and ballast pump of the same output, a bilge and fresh-water pump, a fuel-transfer pump, a lubricating-oil-transfer pump, a 30-ton sanitary pump, and an emergency bilge and fire pump of 40-80 tons capacity per hour. There are also a lubricating-oil purifier of 1,350 litres capacity per hour, two fuel purifiers with the same output, and a fuel service pump. Further, there are two lubricating-oil coolers and an exhaust-gas and oil-burning boiler.

Trial Results.

A summary of the results of

the progressive trials, which were carried out off Awaji Island, in the Inland Sea, is given below :—

Load.	No. of run.	Time. min.	Time. secs.	Speed. knots.		R.p.m.		B.h.p.
¼	1	6	4⅗	9·99	9·91	75·6	73·95	788
	2	6	10	9·84		72·3		
½	3	4	44⅕	12·81	12·6	94·5	94·65	1,610
	4	4	54	12·38		94·8		
¾	5	4	10⅘	14·52	13·97	106·1	106·05	2,347
	6	4	31⅖	13·42		106·0		
4/4	7	3	45⅕	16·17	15·36	117·0	117·1	3,125
	8	4	10⅖	14·54		117·2		
Overload	9	3	37⅘	16·72	15·95	122·5	122·55	3,500
	10	4	0	15·17		122·6		
4/4, one engine	11	5	2⅕	12·05	11·29	85·2	84·8	1,125
	12	5	46	10·52		84·4		

Draught :—	
Forward	1·97 metres (before trials).
Aft	4·97 metres (before trials).
Mean	3·47 metres (before trials).
Trim, by stern	3 metres.
Displacement	4,550 tons.
Block coefficient (mld.)	0·656.
Course	One mile.

Fuel Particle Size.

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

It would appear to be almost a truism to state that the efficiency of combustion depends upon the size of the fuel particle. This is obviously the case with oil fuel, whether it is sprayed into the furnace of a steam generator or injected into the combustion space of a diesel engine, and it is equally obvious in the case of coal if it is burned after having been previously pulverised. Actually, however, the size of the particle affects the problem of the combustion of every type of fuel, from graded coal down to gaseous combustibles, since the size of the particle influences not only the surface which is exposed to the effects of the oxygen in the atmosphere, but also the penetration of the current of air between the particles as well as a vast number of other factors directly and indirectly connected with the problem of fuel combustion. Some idea of the intricacy of the question was given in the paper by Dr.-Ing. P. R. Rosin, which was read a short time ago at Newcastle at a joint meeting of the various chemical and engineering societies in the district. Dr. Rosin not only gave a very valuable survey of the problem of particle size—in which must be included such factors as shape and weight—in so far as it affects some of the more important questions of fuel technology, but he gave a bibliography of the various papers dealing with the subject, which have been written in recent years. Here is a field which presents considerable opportunities for research, the results of which might have almost fundamental effects upon the development of the various forms of heat engine.

Furnace Repairs by Welding.

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

A very interesting repair job has just been brought to light in which by the use of welding the cost of two new corrugated furnaces was saved. The two furnaces, which were 3ft. 9in. in diameter, collapsed badly while the vessel was on a voyage from Calcutta to the West Indies, and she put into Durban, where the repairs were carried out. Some idea of the extent of the damage can be gathered from the fact that the portion cut out from the top of each furnace measured 5ft. 6in. in circumference and 2ft. 6in. wide, and to get the damaged plates through the furnace mouths they had to be cut in two pieces. It was also found that the furnaces were out of round to the extent of approximately 1½in., and they were jacked up and faired before templates were prepared and the corrugated plates built to shape, the edges being bevelled for welding. These plates had also to be made in two pieces, and they were first fitted into position by tack welding. Having made certain that they formed a true circle with the furnace, welding then proceeded, most of the welding being done in the water space of the boiler with a view to having most of the job done by down-hand welding. On the completion of the job, which took 13 working days, the boiler was tested to 250lb. per sq. in. under hydraulic pressure and proved satisfactory in every way. In addition to the saving of money, in having the work carried out at the South African port there was also a considerable saving of time, as new furnaces would have had to be obtained from Europe.

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 11th November, 1937 :—		
Urquhart, Francis	Ex.1.C.	Glasgow
Evanson, Austin E.	Ex.1.C.	Liverpool
Bolton, Ronald R.	Ex.1.C.	Newcastle
Bell, Hugh I. T.	2.C.	Glasgow
Blakely, George	2.C.	,,
Hamilton, James G.	2.C.	,,
Fletcher, Alfred O.	2.C.M.	,,
Murdoch, Terence MacK. ...	2.C.M.	,,
Buddle, Henry N.	2.C.	Liverpool
McLean, Leslie A. F. ...	2.C.	,,
Neilson, Thomas E. ...	2.C.	,,
Clews, Ernest S.	2.C.	London
Woodward, Robert	2.C.	,,
Scholefield, John M. ...	2.C.	Newcastle
Clements, Harry	2.C.M.	,,
For week ended 18th November, 1937 :—		
Fish, Sidney J.	1.C.	Cardiff
Radcliffe, Harold D. ...	1.C.	,,
Thomas, Noah G.	1.C.	,,

Name.	Grade.	Port of Examination.
Thomas, Norman W. ...	1.C.	Cardiff
Henderson, James	1.C.	Glasgow
Howie, James O.	1.C.	"
McMeckan, Hugh	1.C.	"
Robertson, Alexander P. ...	1.C.	"
Brown, William S. R. ...	1.C.	Liverpool
Chesters, Philip F.	1.C.	"
Hoole, George	1.C.	"
Nolan, Patrick J.	1.C.	"
Williams, Percy	1.C.	"
Allan, Thomas H.	1.C.	London
Clarke, John D.	1.C.	"
Horsford, James R. ...	1.C.	"
Galley, Joseph N.	1.C.	Newcastle
Ridley, John J.	1.C.	"
Hunter, Thomas	1.C.M.	"
McArthur, Charles	1.C.M.E.	Glasgow
Storey, John A.	1.C.M.E.	Cardiff
Todd, Thomas W.	1.C.M.E.	Glasgow
Evans, John N.	1.C.M.E.	Liverpool
McCready, Allan D. ...	1.C.S.E.	"
Redford, Vernon	1.C.S.E.	"
Roberts, Walter H.	1.C.S.E.	"
Chisholm, Alexander N. ...	1.C.M.E.	London
Clifford, David A.	1.C.M.E.	"
Goodier, James B.	1.C.M.E.	"
Robertson, William H. H.	1.C.M.E.	"
Black, John M.	1.C.M.E.	Newcastle
Marshall, William	1.C.M.E.	"
Rispin, Charles H.	1.C.S.E.	"
Tandel, Govind V.	1.C.M.E.	"
For week ended 25th November, 1937:—		
Bridgewood, William ...	2.C.	Newcastle
Dillon, Richard F.	2.C.	"
Elder, William B.	2.C.	"
Gulliver, E.	2.C.	"
Hedley, Clement J.	2.C.	"
Clark, Alexander N. ...	2.C.M.	"
Gray, James B.	2.C.M.	"
Penny, George E.	2.C.M.	"
Dunne, John R.	2.C.	London
Lerpiniere, Walter S. ...	2.C.	"
Whincup, Harold	2.C.M.	"
Belford, William G. ...	2.C.	Glasgow
Coburn, Hugh	2.C.	"
Cowan, William	2.C.	"
Dickson, James A.	2.C.	"
Edgar, Raymond	2.C.	"
McBride, James	2.C.	"
Phimister, George	2.C.	"
MacLeod, Donald	2.C.M.	"
Miles, Malcolm W.	2.C.M.	"
Munro, Edward A.	2.C.M.	"
Duggan, Thomas P. ...	2.C.	Liverpool
McTaggart, Murdoch ...	2.C.	"
Nicholls, Frank R.	2.C.	"
Taylor, Edgar J.	2.C.	"
Slade, William R.	2.C.M.	"
For week ended 2nd December, 1937:—		
Hall, Herbert J.	1.C.	Newcastle
Johnson, Thomas M. W. ...	1.C.	"
Lynch, John R.	1.C.	"
Rooke, Stanley B.	1.C.	"
Norrie, Alexander	1.C.M.	"
Porter, Christopher W. ...	1.C.M.	"
Armstrong, John E. ...	1.C.M.E.	Belfast
McGuffie, David D.	1.C.S.E.	Glasgow
Cunningham, James B. ...	1.C.M.E.	"
Barkway, Alexander W. M.	1.C.M.E.	Liverpool
James, Thomas H.	1.C.M.E.	"
Owen, Robert	1.C.M.E.	"
Kenyon, Thomas J. C. ...	1.C.M.E.	"
Allan, John S.	1.C.	Glasgow
Leitch, John	1.C.	"
McDougall, Donald G. ...	1.C.	"
Fraser, John H.	1.C.M.	"
Pattison, Robert R.	1.C.	London
Third, Charles	1.C.	"
Adam, Thomas J. H. ...	1.C.	Liverpool
Douglas, Malcolm	1.C.	"
Pierce, John A.	1.C.	"
Speer, Reginald A.	1.C.	"
Milligan, John	1.C.M.	"
Pollard, John G.	1.C.M.	"
Coulson, Richard C. C. ...	1.C.	Newcastle
Gamble, Robert	1.C.M.E.	Liverpool
Stannard, Gordon J. ...	1.C.S.E.	London
Efford, Arthur C.	1.C.M.E.	"
Irvine, John	1.C.M.E.	"
Jackson, Tom M.	1.C.M.E.	"
Torrible, William H. ...	1.C.M.E.	"
Smith, Herbert W.	1.C.M.E.	Newcastle
Harrison, Cyril	1.C.M.E.	"
For week ended 16th December, 1937:—		
Taylor, Alan G.	2.C.	Liverpool
Rothwell, Stanley	2.C.M.	"
Butt, Henry T.	2.C.	London
Garden, James	2.C.	"
George, Alexander L. ...	2.C.	"
Hayman, Harold J.	2.C.	"
Bingham, Leslie C.	2.C.M.	"
Jewett, Matthew K.... ...	2.C.	Newcastle
Thwaites, George H. ...	2.C.	"
Graham, John	2.C.M.	"
Marr, Wilfred	2.C.M.	"
Tye, Ernest	2.C.M.	"
Davies, Charles A.	2.C.	Cardiff
Page, Arthur A.	2.C.	"
Pearson, Stephen	2.C.	"
Dunn, John	2.C.	Glasgow
Hendry, Alexander C. Mac.	2.C.	"
Parker, William	2.C.	"
Souter, John	2.C.	"
Taylor, Henry J.	2.C.	"
Higgins, James	2.C.M.	"
Walker, Andrew	2.C.M.	"
Wilson, Henry A.	2.C.M.	"
Hudson, William F. ...	2.C.	Liverpool
McConnell, Bernard ...	2.C.	"
Ratcliffe, James	2.C.	"
For week ended 23rd December, 1937:—		
Williams, Morgan D. E. ...	1.C.M.E.	Cardiff
Rose, Charles M.	1.C.M.E.	"
Ovens, James P.	1.C.S.E.	Glasgow
Ross, Bertie E.	1.C.M.E.	"
Morrisson, Thomas E. ...	1.C.M.E.	"
Turnbull, Norman	1.C.M.E.	London
Lillywhite, Sidney A. ...	1.C.M.E.	"
Campbell, John McL. ...	1.C.M.E.	"
Crawford, John H. ...	1.C.M.E.	Liverpool
Qualters, Francis J. ...	1.C.M.E.	"
Russell, Charles S.	1.C.M.E.	"
Smythe, Thomas D. ...	1.C.M.E.	Newcastle
Petrolino, Vincent	1.C.M.E.	"
Johnson, Mark A.	1.C.M.E.	"
Morris, Frederick T. ...	1.C.	London
McKenzie, James	1.C.M.	"
Peebles, Robert R.	1.C.	Glasgow
Couper, John G.	1.C.M.	"
Coombes, Leslie	1.C.	Cardiff
Trenchard, Lewis D. ...	1.C.	"
Forbes, Hume C.	1.C.	Liverpool
Kirby, John H.	1.C.	"
Rea, James H.	1.C.	"
Cannell, Douglas H. ...	1.C.M.	"
Cowey, Robert P.	1.C.	Newcastle
Footitt, John W.	1.C.	"
Johnson, William E. ...	1.C.	"
Ross, William	1.C.	"
Matthewson, Ralph	1.C.M.	"
Errington, James H. ...	1.C.M.E.	"
Dean, William H.	1.C.M.E.	"
Arkley, Lancelot B.... ...	1.C.M.E.	"
Milne, Alexander O. ...	1.C.S.E.	"
Quenet, Stanley P.	1.C.S.E.	"
Pollard, William	1.C.M.E.	"