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Modern Developments in Ship Design with Special Reference to Propulsion.

READ

BY JOHN TUTIN, D.Sc. and A. C. HARDY, B.Sc. (Associate Member),

On Tuesday, December 9th, 1930, *at* 6 *p.m.*

CHAIRMAN: MR. H. J. VOSE (Chairman of Council).

The economic conditions which govern the shipping and shipbuilding industries are peculiar, if not unique. Shipping enjoys a virtual monopoly, since it is not appreciably affected by competition from land and air. Shipbuilding is perhaps the only major industry which exists solely for the purpose of supplying the needs of an important monopoly. It is obvious that if these twin industries find themselves suffering from a period of depression, the remedy must come from within. From the point of view of world shipping, State subsidies must inevitably tend to reduce the gross earnings of the industry as a whole.

The shipowner has no direct interest in the prosperity or otherwise of the shipbuilding industry. The shipbuilder, on the other hand, is entirely dependent on the potential profits of the shipowner. The logical remedy for depression in the shipbuilding industry is for the shipbuilder to build ships that are more efficient. He has it in his power to compel shipowners to scrap existing tonnage on a large scale, if he can produce new tonnage so efficient that in competition with them the older vessels can no longer earn profits.

Freight rate levels are governed, not by the rate at which the bulk of tonnage available can show a reasonable profit, but by the rate which can be accepted by the most efficient tonnage. The capital cost of a new ship, the book value of an existing ship, or the sale price of a second-hand ship do not necessarily bear any real relationship to profit earning. A period of low freights may, as we all know, last a few years, and if, during that period only the most efficient new tonnage can make a trading profit, it is cold comfort for the owner of a second-hand ship to congratulate himself on not having so much depreciation to provide for when his ship is again able to operate at a profit.

Reverting to the shipbuilding industry, it is evident that the policy of rationalisation and concentration of building facilities cannot directly stimulate the placing of contracts. A concerted policy of improvement over existing tonnage is the final solution of the problem. Every ship launched which is no better than existing tonnage is in effect an economic boomerang which will recoil on the shipbuilding industry as a whole, whereas a new ship of super-efficiency is an economic torpedo which may cause many vessels to be towed to the scrap yards. What is needed is an organisation which, by research, experiment and invention, will succeed in effecting a material and comprehensive improvement in ship design, not necessarily by radical changes, but by cumulative improvements in detail.

THE MORE EFFICIENT SHIP.

In considering the problem of the more efficient ship, it is essential to form a mental picture of first cost and of operating cost. Figure 1 shows in diagram form, an approximate analysis of the capital cost of a typical tramp steamer.

Figure 2 shows a corresponding analysis of the operating cost expressed in terms of the freight rate at which the owner's profit is zero. Both these diagrams are instructive. The former shows that unless the shipbuilder is also an engine builder, about two-thirds of the cost of the ship goes to the manufacturers of materials and machinery. What scope there is for economy in construction is therefore largely limited to the remaining third of the total cost, and the cost of shipyard

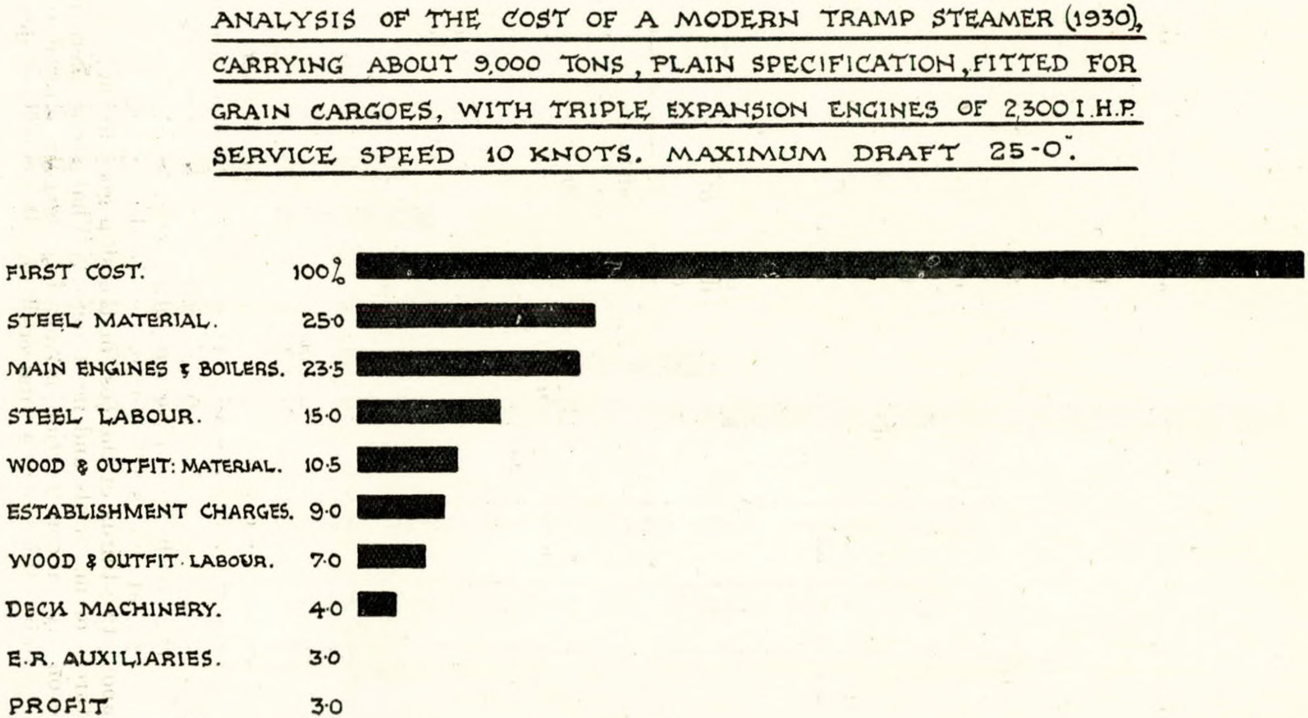

ANALYSIS OF THE COST OF A MODERN TRAMP STEAMER (1930), CARRYING ABOUT 9,000 TONS, PLAIN SPECIFICATION, FITTED FOR GRAIN CARGOES, WITH TRIPLE EXPANSION ENGINES OF 2,300 I.H.P. SERVICE SPEED 10 KNOTS. MAXIMUM DRAFT 25-0".
FIRST COST. 100%
STEEL MATERIAL. 25·0
MAIN ENGINES & BOILERS. 23·5
STEEL LABOUR. 15·0
WOOD & OUTFIT: MATERIAL. 10·5
ESTABLISHMENT CHARGES. 9·0
WOOD & OUTFIT LABOUR. 7·0
DECK MACHINERY. 4·0
E.R. AUXILIARIES. 3·0
PROFIT 3·0

Fig. 1.

PERCENTAGE OF FREIGHT EARNINGS ABSORBED

BY OPERATING EXPENDITURE (1930)

Tramp Steamer, 9,000 tons deadweight

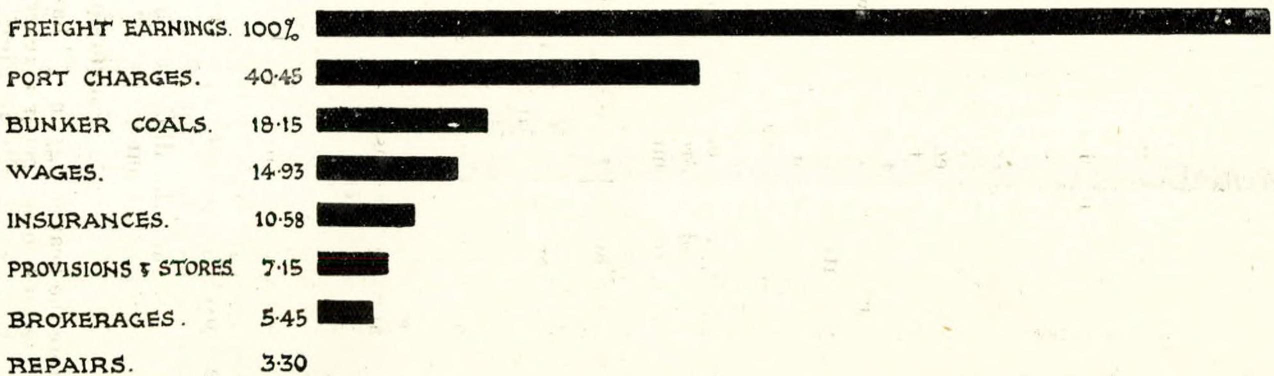


Fig. 2.

labour is responsible for the bulk of this. Although these figures relate only to a modern tramp steamer, it is evident that the position is very inflexible. It is only when the builder is able to build a series of vessels from a successful standardised design that there is much scope for reduction in capital cost.

Turning to the operating cost, we see that from the point of view of increased efficiency the bulk of the charges on the freight earnings are for all practical purposes outside the shipbuilder's control, namely, port charges, insurance, repairs and brokerages, which collectively absorb about 70 per cent. It is understood of course that the relative percentages will vary appreciably for different ships and for the same ship on different voyages. They may be taken, however, as giving a fairly accurate indication of the position.

Crew's wages and provisions absorb an amount which is normally of the same order as the cost of propulsion. It is therefore evident that economy in personnel on board ship is almost as important as economy in propulsion. It is conceivable that inspired research in this direction might yield valuable results. For example, on tramp steamers, pending the perfection of pulverised fuel firing, there is a strong case for a simple, compact and reliable mechanical stoker.

From the point of view of cost of propulsion, these figures do not, however, tell the full story. The *real* price per ton of fuel for propulsion is the nominal price plus freight rate and minus the cargo handling costs per ton of cargo. Consider, for example, a 10,000 ton tramp steamer burning 30 tons of coal per day at an average price of £1 per ton, for 200 steaming days per annum. Suppose the average freight rate, after deducting cargo handling expenses and allowing for ballast and "capacity" voyages, is 10/- per ton. The real price of bunkers is therefore £1 10s. 0d. per ton and the real cost of propulsion is £9,000 per annum in lieu of the nominal figure of £6,000. Are we not apt to overlook this point, and assess the value of say 1 per cent. propulsive economy at £60 per annum in the above typical instance, whereas its true value is £90 per annum? The capitalised value of a £90 per annum economy is about £1,800, and this illustrates most forcibly, the importance of securing the last ounce of propulsive efficiency.

PROPULSION.

Before the heat energy in fuel has been converted into useful work, serious losses occur at every stage of the process, as shown diagrammatically in Figures 3 and 4. The diagrams

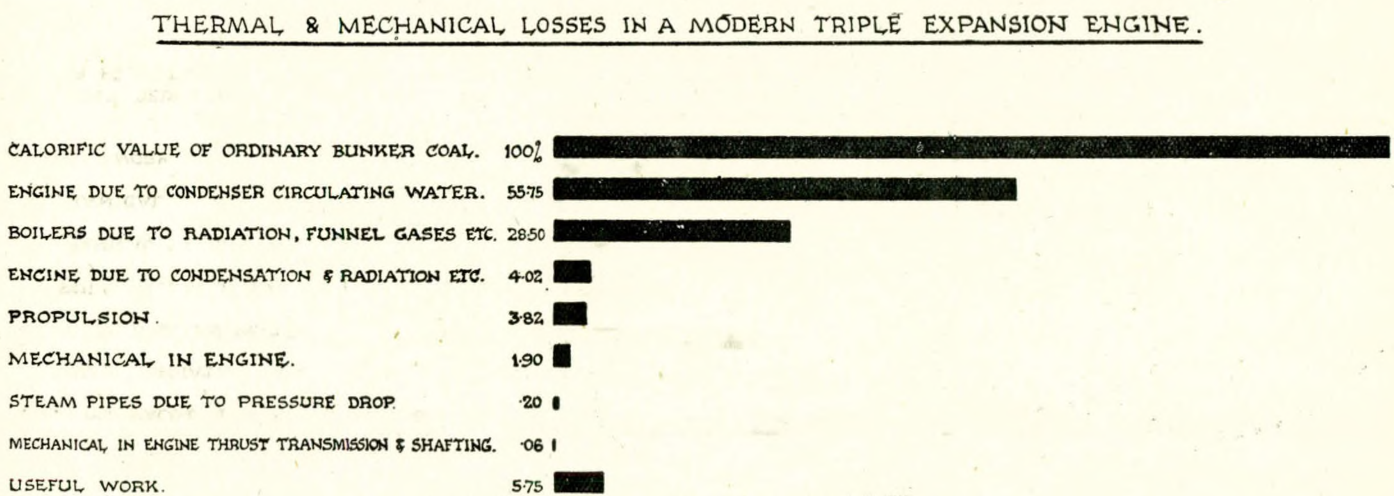

THERMAL & MECHANICAL LOSSES IN A MODERN TRIPLE EXPANSION ENGINE.
CALORIFIC VALUE OF ORDINARY BUNKER COAL. 100%
ENGINE DUE TO CONDENSER CIRCULATING WATER. 55·75
BOILERS DUE TO RADIATION, FUNNEL GASES ETC. 28·50
ENGINE DUE TO CONDENSATION & RADIATION ETC. 4·02
PROPULSION. 3·82
MECHANICAL IN ENGINE. 1·90
STEAM PIPES DUE TO PRESSURE DROP. ·20
MECHANICAL IN ENGINE THRUST TRANSMISSION & SHAFTING. ·06
USEFUL WORK. 5·75

Fig. 3.

THERMAL & MECHANICAL LOSSES IN A MODERN DIESEL ENGINE.

* AFTER DEDUCTING AN ALLOWANCE FOR HEAT DUE TO PISTON FRICTION.

Fig. 4.

relate respectively to a modern triple expansion engine of about 2,500 i.h.p. and to a corresponding modern Diesel engine. When one contemplates the almost microscopic amount of useful work which is ultimately extracted by thermal and mechanical processes from the latent energy in one pound of fuel it is not surprising that devices for effecting economies at almost every stage are being continuously developed.

It is interesting to note the perhaps not altogether fortuitous occurrence of equivalent thermodynamic devices in the case of steam and internal combustion engines. Thus the Bauer-Wach exhaust turbine and the exhaust turbo-electric auxiliary drive correspond to exhaust gas boilers. Super-charging corresponds thermally to forced draft and so on. It is possible that the diesel engine may be responsible for a tendency to eliminate the slide valve. Certainly the rivalry between coal and oil has been highly stimulating and mutually beneficial.

The problem of the propeller remains partially unsolved. A simple design, of the correct diameter and surface and of uniform pitch, is very difficult to improve upon, for, as in a thermodynamic system, certain losses are absolutely inevitable. It is impossible to recover any of the linear energy of the slip stream without destroying thrust. As for the rotational energy, which is a direct consequence of the torque, the whole may be recovered theoretically, and a large percentage of it in practice.

Another unavoidable loss is in the skin friction of the blades, and as the loss may be considerable, efforts should be made to minimise it. It is surely false economy to use cast iron even for a tramp ship propeller. A cast iron propeller may be as efficient as, or in some cases more efficient than bronze, when new, but the surface pitting after perhaps a few months' service may easily result in an important if not immediately apparent loss of efficiency. The most serious loss, particularly in the case of a single screw ship, is in "thrust deduction," or the suction of the screw on the after body. Due partly to the naval architects' presentation of this factor in analysis, the actual magnitude of the effect is partly concealed, otherwise steps might have been taken to reduce it. A thrust deduction factor of 1·34, which is quite normal for a tramp ship, means that the suction amounts to 34 per cent. of the thrust. Expressed as a fraction of the hull resistance, however, we find that this means an increase in resistance of no less than 51·5 per cent. The so-called "wake gain" does not really compensate for this, because if there were no wake the propeller could be redesigned with substantial increase in efficiency. To reduce thrust deduction either the after-body must be specially fined with this specific object in view, or the propeller must be carried farther astern. The latter alternative implies a radical departure from the normal type of stern, but it opens up the possibility of a substantial gain. In the case of twin and quadruple screw ships, the ideal position for the propellers is obviously amidships, because the " thrust deduction " then becomes a negative instead of a positive resistance. The screw suction is exerted on the fore body and reduces the hull resistance. The form wake, if any, is negative and this makes it possible to secure a higher propeller efficiency. This idea has been developed by de Meo, the Italian Naval Architect.

The post-war discovery that there is a substantial economy to be picked up in the propeller slip stream by the use of certain well known devices needs no comment here beyond the fact that the application has hitherto been largely to single screw ships. The extension of corresponding methods to twin screw ships demands twin rudders, one immediately abaft each screw. A lead in this direction has been given by the designers of the new Dutch Motor Liner *Colombia*, and no doubt other vessels will be similarly equipped in the near future.

HULL IMPROVEMENTS.

Considering the question of hull design generally, it is certain that even with conventional forms of hull, new vessels continue to be built with lines which fall somewhat short of the optimum. A more serious matter is that the experiment tanks in this country are so fully occupied with routine commercial testing of normal types of hull, that there is little or no time for systematic research work on departures from conventional designs. Our Classification Societies can certainly be relied upon to facilitate the development of new types which might ordinarily be prejudiced by the rigid application of standard scantling numerals.

From the shipbuilders' point of view, the most desirable innovations are those which cannot readily be adapted for the purpose of increasing the efficiency of existing tonnage by direct fitting to an existing hull, and of course new hull forms are ideal in this respect.

Skin friction, for the bulk of tonnage, is the most serious component of hull resistance. The reduction of this item can be attempted in various ways. First, forms can be developed, such as that due to Maier, which permit of a reduction in wetted surface on given displacement and dimensions, and which in addition allow the stream lines to take a shorter path.

Secondly, our methods of coating the underwater hull are far from perfect. A smooth surface which would remain smooth would reduce fuel bills enormously. Marine growths cannot in general attach themselves to hard surfaces such as glass, porcelain or clean steel. By applying a soft coating of paint we make it possible for fouling to take place, and we are then compelled to apply " anti-fouling " coatings, which rely either on their poisonous properties or on their ability to fall off when growths attach themselves. Neither method is fully effective and since rustless steel has not appeared in a form suitable for shipbuilding, we must look for an anti-corrosive composition with an ultra-hard surface. Is this too much to expect of modern chemical research?

Shell butts and edges are responsible for quite a small percentage of the total resistance, but if small gains are to be accumulated, here is one of them. In France and Germany there is an increasing tendency to have the shell butts facing forward, on the principle that the resistance of a cone is less when towed apex aft than with apex forward. This change over involves no extra cost. Further, a ship alongside a quay is just as likely to move astern as ahead.

Bilge keels are usually too resistful from the point of view of longitudinal motion and not sufficiently resistful from the point of view of rotational motion. In both respects the not too distant future should see an improvement.

Wave resistance is naturally an important factor for large vessels of the liner type on the one hand, and for small vessels of the trawler type on the other. Between these extremes lies the tramp steamer, and because its wave resistance is relatively small it is almost invariably neglected. Nevertheless it is a fact that for a series of tramp vessels increasing in size from, say 5,000 tons deadweight to 10,000 tons deadweight there are at each stage certain combinations of l.b.p. block coefficient and service speed which should be avoided if maximum efficiency is to be attained in each case. By keeping clear of synchronism between the bow and stern system a small but not negligible economy is inevitable.

On fast vessels of the liner type, the design characteristics are not always capable of sufficient adjustment to prevent synchronism, hence the bulbous bow. This brings the primary bow wave further forward, thereby altering the positions of the secondary wave crests along the vessel's length. Obviously a bulbous bow is useful for certain combinations of length and speed, but not for others. Wave resistance is almost entirely governed by the vessel's form at the bow, and the amount depends largely on the energy absorbed by the bow wave, and is roughly proportional to the square of the wave height. For example, with a bow wave 3 feet in height, flattening the wave by 2 inches will reduce the wave resistance by 10 per cent. This very desirable effect can be achieved by the simple but rarely practicable expedient of fining the lines. Alternatively a horizontal fin can be fitted in way of the bow wave crest. Tank experiments confirm the beneficial effect of such a device, but it is not a seaworthy arrangement for ocean-going vessels. A more practical method is to design the contour and lines of the bow in such a way that the bow crest has no tendency to occur at any given point, in other words the crest is spread out and thereby flattened. This is precisely what the Maier form does, and referring to Figure 5 it will be seen how the effect is achieved. There is not sufficient scope in the lines of a full vessel of block coefficient greater than ·76 to effect an extensive modification of this nature. The method is ideal for vessels of relatively high speed and somewhat full forms for that speed, and also for shallow draft vessels. For vessels having block coefficient below about ·68, the advantage falls away.

PASSENGER SHIP DESIGN.

In passenger ship design there are certain points of special importance which are worthy of comment, as for example cabin arrangement, stabilisation and vibration. Space does not, unfortunately, permit of their being dealt with as fully as would be commensurate with their importance.

If the demand for passenger ships is to be stimulated, they must be made far more comfortable where comfort is needed, and less ostentatiously luxurious where luxury beyond a certain limit can add nothing to the amenities of the vessel. Cabins must be larger so that every first-class passenger has a bed rather than merely a super-bunk. There would be fewer cabins, but there might well be more passengers. There is already a tendency in this direction, particularly in Dutch vessels and in the more modern French liners, but even so, many passenger ships to-day suffer too much from the tendency to keep to old style fittings in cabins. Witness, for example,

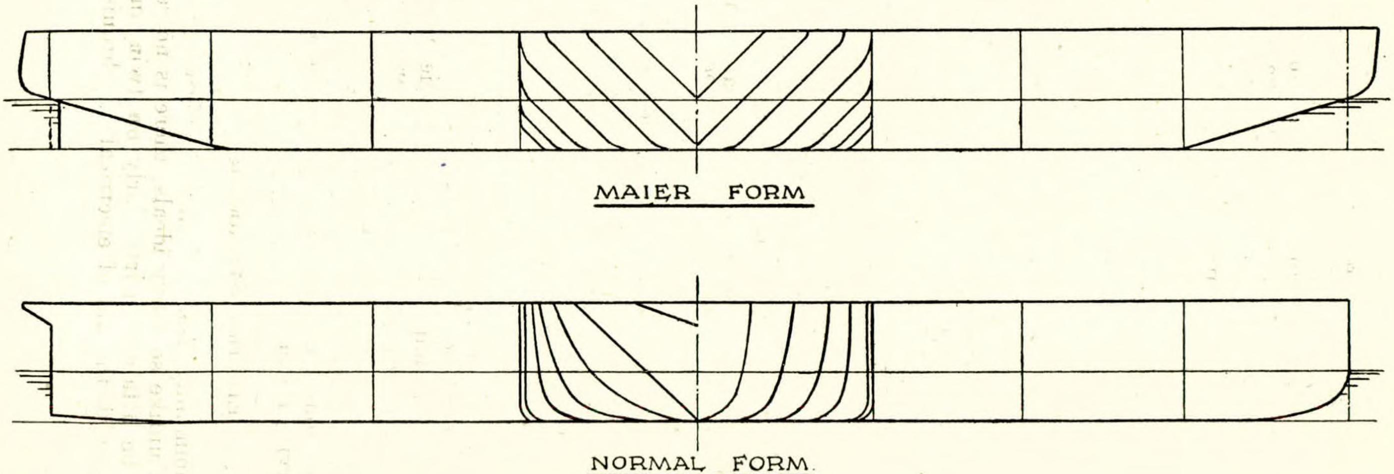


Fig. 5.

how long it has taken to get anything like a universal adoption of running water in cabins, in contrast to the individual tank systems for each cabin. The clinging to "excrescences" such as bunk curtains and standby candle lamps are other cases in point.

On a large passenger ship pitching is not of much consequence, but rolling undoubtedly does more to make potential passengers deny themselves the joys of ocean travel than any other single cause. It is unlikely that rolling will ever be eliminated, but it should be mitigated by anti-rolling tanks and/or by gyroscopic stabilisers, both of which are fitted, but by no means as extensively as they should be.

Alternatively and preferably, would it not pay shipping and shipbuilding interests a thousand-fold to devote a substantial sum for intensive research directed towards the discovery of a scientific cure for sea-sickness? The results of such a discovery would undoubtedly be far-reaching.

VIBRATION.

Second only to mal-de-mer in its disagreeable effects on passengers is vibration. Frequencies above 1,000 per minute are audible and are commonly known as "noises." Below 1,000 the vibration ceases to be audible, but the forced oscillation of the tympanum of the ear persists, with the drumming effect with which we are all familiar. It is no exaggeration to say that many modern passenger ships leave much to be desired from the point of view of vibration. This applies equally to ships propelled by turbines and by any form of reciprocating machinery. Fortunately, during the last three years the mathematical treatment of the subject has advanced sufficiently to permit of the principal natural frequencies of the hull and shafting to be calculated with a degree of precision previously unattainable. This is of the utmost importance, because it means that in the initial stages of the design precautions can be taken to avoid the occurrence of critical speeds over the range of service r.p.m.

ELECTRIC SYNCHRONISATION.

Absolute immunity from vibration is, however, the ideal to aim at, and unlike so many ideals, there is no reason why it should not be attained, particularly on twin and quadruple screw ships, with the aid of electrical synchronisation of the

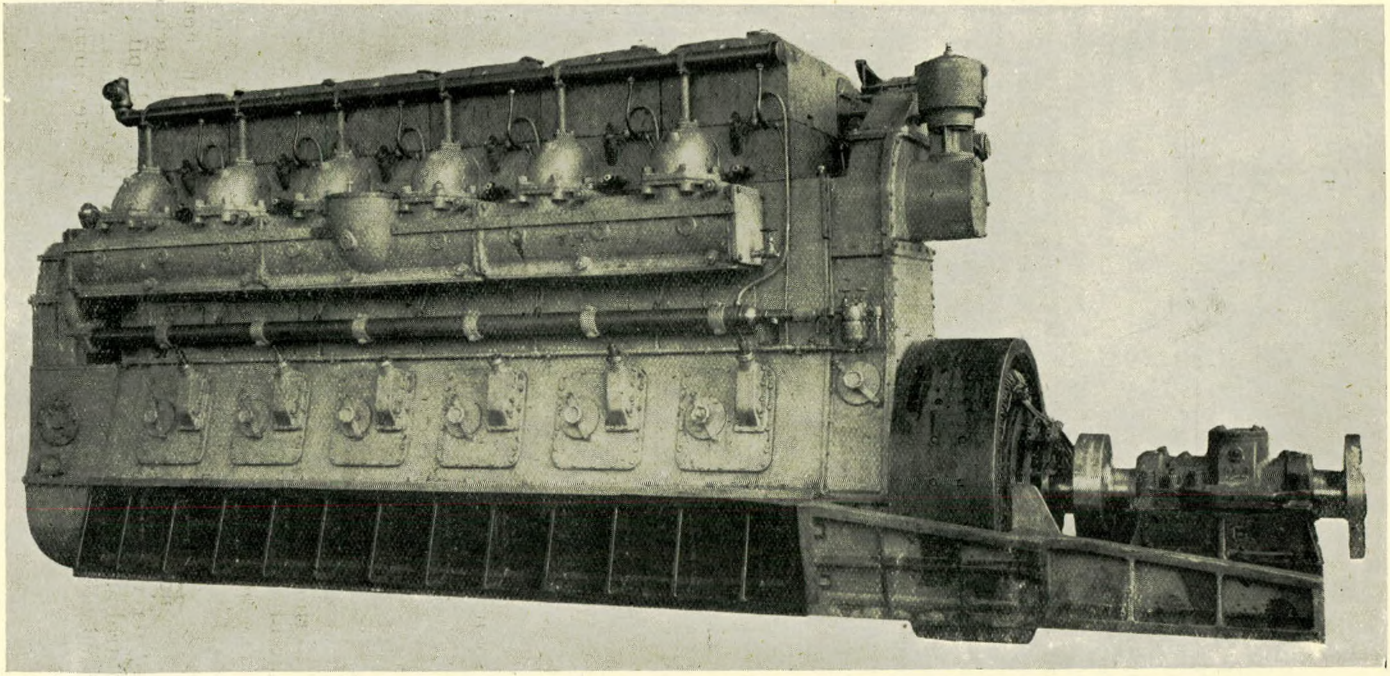


Fig. 6. One of the Winton 4-cycle Airless Injection Main Engines of the M.Y. "Olive K." showing the synchronising Flywheel Alternator.

main engines and propellers and the "isolation" of all auxiliaries. The main engines would be equipped with alternating current generators in lieu of flywheels, the two generators being electrically coupled so that the engines could be run at exactly the same revolutions and in any specific phase relationship. This system would also permit of the elimination of vibration from the propellers, because the port and starboard screws could be keyed to the shaft in such a way that the blade impulses on the hull annul each other. The new motor yacht *Olive K* has been fitted with such an installation by her owner, Mr. Charles F. Kettering, Vice-President of General Motors Corporation, and Director of their research laboratories. This vessel must be considered as epoch making in the sense that she is probably the first mechanically propelled vessel without any perceptible vibration at any speed. On the *Olive K*, the synchronising gear consists of two contact heads driven at cam shaft speed, connected through a high tension coil. Synchronism can be obtained on any firing sequence of the cylinders by means of a "synchroscope," which projects an intermittent spot of light on a rotating disc.

Specialised Ship Types.

It is by no means unusual for shipbuilders to design, on their own initiative, specialised types of ship to satisfy the needs of a particular service, as, for example, the standard fruit carriers built by a well-known Swedish firm. Quite frequently supply creates demand, and the development of new types of hull and machinery may, and often does, provide a solution for a previously unexploited service. Since the tendency of world shipping is pointing continuously towards a higher degree of specialisation, shipbuilders should realise that this tendency is in their own interests and should do their best to promote it by intensive study of the technical requirements of every service and trade route.

During the last few years we have seen turbo-electric and diesel-electric propulsion solve the problem of maintaining a high propulsive efficiency at both full speed and cruising speed. In refrigerated fruit and meat carriers the maximum 'tween deck space is a *sine qua non*, and for such ships the horizontal diesel engine solves another problem. For vessels such as tugs and ferry-boats, battery-electric propulsion and pilot house control make it possible to dispense with the engine room staff. Re-charging can be dealt with at the base or terminal.

A tramp steamer need not be attractive, but it must be efficient. A passenger ship must be attractive—to passengers—and must partially sacrifice efficiency for speed. There is an intermediate class of vessel, of rapidly increasing importance, which must attract both passengers and freights. We have attempted to indicate the main avenues by which greater efficiency and greater attractiveness may be achieved, and which, if pursued, would, we believe, stimulate a progressive demand for new tonnage.

DISCUSSION.

Mr. J. HAMILTON GIBSON (Vice-Chairman) stated that the Authors had rather disarmed criticism by the introductory remarks of Dr. Tutin, but he wished to say that had time permitted the Papers Committee would have asked the Authors to amplify certain parts of their paper and if possible give more details where only general statements appeared. It was hoped that in order to make the paper more understandable, these necessary additions might be made by the Authors in their considered reply after the discussion. For instance, he thought that more might have been made of the proposal to place the propellers amidships instead of at the stern, and that some details of Mr. de Meo's scheme would have been useful. It may be that some of the Members would know what that scheme was. He must confess that he did not until he came across a reference in *" The Engineer " of December 5th last. It would occur to many that paddle wheels provided a well-known example of amidship propulsion, and it seemed pertinent to enquire whether comparative data was available showing the advantage, from a hull resistance point of view, of paddles versus screws. It seemed to him that here was a good starting point in advocating any such change.

With regard to factors of " thrust deduction " and " wake gain," and the effect of rudders on the propeller slip stream, he wondered whether the Authors had considered the Kitchen reversing rudder. He thought that some useful data might be obtained in this connection. With this rudder, although the propeller thrust on the thrust block was always ahead, the rudders could be manipulated so that the slip stream might escape aft, or it might be all projected forward; they could be so held that the vessel would remain stationary, in which case the thrust deduction must be 100%; or go half speed astern,

* See abstract on page 1032.

when the thrust deduction would be in the neighbourhood of 50%.

Dr. Robb, in his paper read before the Institution of Naval Architects at Liverpool last year, compared certain ships. In one case the thrust h.p. was actually 15% less than the effective h.p., although the effective h.p. usually represents the irreducible minimum. Certainly there were substantial economies to be picked up in the propeller slip stream, but he suggested that it was rather an exaggeration to say that it was in any sense a post-war discovery. Two vessels to which Dr. Robb referred were sister ships, in which the tow rope h.p. was 723. In one ship the thrust h.p. was 757, which is about normal, whereas in the other, which had a different form of rudder and stern fitting, the thrust h.p. was only 627, i.e., 15% less than the tow rope or effective h.p.; a very remarkable and suggestive result.

Turning now to Figs. 3 and 4, in which the modern steam reciprocating engine was compared with the modern Diesel engine, he thought one must be careful not to be misled by mere words and phrases. He strongly suspected that the Authors' example of a modern tramp steamer was no more modern than 40 to 50 years ago. The figures of superheat and vacuum should be given. He had just received some remarks from Mr. John Neill, of the North Eastern Marine Engine Works, who was well known to Members of the Institute, in which he pointed out that the percentage of useful work would be increased if they took into account super-heated steam. He put forward the following revised figures as against those quoted in Fig. 3 of the paper:—

Engine due to condenser circulating water	55·75%	(as quoted)
Boilers due to radiation, etc. ...	27%	
Engines due to condensation, radiation, etc.	3·93%	
Propulsion	4·49%	
Mechanical in engine	2·22%	
Steam pipes due to pressure drop ...	·20%	(as quoted)
Mechanical in engine thrust transmission and shafting	·07%	
Total useful work	6·74%	

Mr. Neill went on to say that these figures were, of course, obtained by taking this so-called "modern" reciprocating engine and adding superheat to it. With a superheated quadruple job, the useful work would be increased to 7%. If, however, one considered a modern high pressure turbine installation such as that of the *Empress of Japan*, the useful work would be 15%, which was even better than the Diesel installation, taking into account the cost of fuel.

In their reference to vibration, the Authors stated: "This applies equally to ships propelled by turbines and by any form of reciprocating machinery." A sweeping statement of that kind, he submitted, simply could not stand. He did not think it carried any weight with those who, like himself, had had many years experience with reciprocating engines, including some of the most perfectly balanced reciprocating engines of their time, and turbine machinery. He did not think that the running of any combination of reciprocating engines could ever compare with the pure rotary motion of a turbine or an electric drive. If they could abandon reciprocating machinery altogether, both main and auxiliary, there was little need to worry about vibration at all. In a purely rotary job vibration did not occur except at the propeller, as referred to in the paper.

The Authors had thrown out so many challenges and the paper was so full of controversial matter that there was room for almost endless discussion. It was hoped, therefore, that subsequent speakers would rise to the bait and thus throw more light on the many interesting points which had been raised.

Mr. C. D. FARMER (The Sperry Gyroscope Co., Ltd.) (Visitor) said that the Authors in their most interesting and stimulating paper had alluded to rolling, and the desirability from the passenger's point of view of preventing it. Rolling was one of those parasitic losses to which the Authors had referred. Ships were fitted with bilge keels, and they caused a resistance to propulsion of three or four per cent. As a ship rolled, the resistance was increased by 2 to 3% or more. Rolling meant more rudder, wide angles of rudder and consequent parasitic losses. From the passenger's point of view there was the sea sickness trouble, therefore it was very desirable to prevent rolling. One very definite way of doing so which had been used in thirty or more ships, was the use of the gyroscope. A certain number of warships had been fitted with this device; one was an aircraft carrier, the gyroscope being fitted to facilitate landing. A large proportion were very luxurious yachts of 1,000 to 2,000 tons displacement. The results had been so successful that the owners could afford to pay for a stabiliser. It imposed no strain on the hull. A ship did not roll heavily until a number of waves in harmonic succession acted on the ship. In practice the waves passed under the ship. It was a very vexed question, and undoubtedly the first cost of a stabilising plant had stood in the way of its adoption in merchant ships, but the stabiliser had now reached the merchant shipping world. It was his privilege to announce that the Lloyd Sabaudo had ordered a large stabiliser plant for their new ship *Conte di Savoia*. The plant was being built in England by the Sperry Gyroscope Company under the Sperry patents. That ship would go to sea within the next year, when the results would be seen. It was bound to cause considerable stir among passengers and shipping companies, who would wonder what had caused the Company to take this step. It had probably been consideration of the passengers' psychology and with the idea of attracting trade.

Mr. J. CALDERWOOD (Member) stated that the Authors' comments on propellers suggested, though possibly they did not intend this, that the standard propeller was as efficient as any that could be designed under normal conditions. This was possibly true at the revolution speeds common twenty years ago, but the modern tendency among engineers was towards higher engine speeds; this, however, was checked by the fear of loss of propeller efficiency with the type of propeller available. In this connection the various tank authorities had allowed their research on propellers to lag far behind modern requirements. A few researches had been carried out on special blade sections with the object of improving efficiency at the same speed, without any great success having been attained, but no attempt had been made to attack the much more important problem of retaining at much higher speeds the same efficiency as that of the normal type of propeller. What was required was research on propeller blade sections corresponding in characteristics to "high lift" aeroplane wing sections. In this way propeller diameter could be kept low, and thus a good pitch ratio obtained at high revolution speed. When naval architects had tackled and solved this problem, engineers would be ready to take full advantage of the higher speeds allowed, and in this way machinery would become lighter and cheaper and require less space, which was what the naval architect was certainly demanding.

The Authors had suggested that the paper was intended to promote the placing of new tonnage, but if the table in Fig. 2

was correct, the shipowner would hardly be encouraged to do this. If this table was examined, it would be noticed that the charges amounted to 100% of the freight earnings, leaving no profit. Perhaps the Authors could explain the various items in the table more fully. In particular it would be interesting to know what was covered under the heading "Port charges," as this seemed to be excessively high.

In the various tables of comparison given, the tramp steamer running at 10 knots had been taken as a basis, but he suggested that under modern conditions there was so little demand for that class of tonnage that few if any orders were likely to be placed. The ship that was demanded to-day by the shipper, which the shipowner must provide if he wished to remain in business, was a vessel running at 12 knots or more; in many trades speeds of 15 knots were demanded and the tendency was towards further increase of speed. He suggested that the value of the paper would be enhanced if the Authors included in their reply comparison tables relating to the modern fast cargo liner.

As an advocate of the heavy oil engine it was possibly not his place to point out that the Authors had been rather hard on the steam engine in the table given in Fig. 3. He must agree with Mr. Hamilton Gibson that modern steam machinery could put up a much better performance than that shown, and even a very old triple engine should show somewhat better results. He did not think that it was to the advantage of the heavy oil engine to compare it with an out-of-date steam engine, for it would stand comparison with and show better results than the very best modern steam machinery, whether turbine or reciprocating.

Electric synchronisation had been referred to by the Authors, but the problem was not so simple as it appeared. If the unbalanced forces from two engines were out of phase, vertical hull vibration would be negligible, but torsional hull vibration would be at its worst. On the whole it seemed that it was easier, cheaper and more certain to estimate the engine speeds at which vibration was liable to occur, and design the normal engine speed in service to be as far clear as possible from any of these speeds. If this was done and an engine of sound design was fitted and mounted on suitable seatings no vibration trouble would be experienced.

The suggestion to use the synchroniser to supply auxiliary power was interesting, but it had serious drawbacks, chief among which was the fact that in most cases the main engines were not running at the times when most power was required, and as auxiliary generators had to be provided for these requirements, it was best to use these for the auxiliary power at sea, leaving the full output of the main engines available for propulsion. In connection with this the Authors' suggestion raised the question of A.C. auxiliaries, and there seemed to be many advantages to be gained by adopting these, yet in spite of the fact that a number of successful A.C. installations were running in service further development in the use of this system seemed to be very slow.

In conclusion he thanked the Authors for their very interesting paper.

Mr. W. A. Christianson (Member) said that the paper dealt mainly with ship design, and was perhaps primarily a naval architect's paper, on which subject he was only a layman.

Referring, however, to the machinery side, and Fig. 3 in particular, he would like to see the figures also given on an "efficiency ratio" basis to show what was practically possible under existing limitations of the steam cycle. For instance, it was impossible to recover the bulk of the heat rejected to the condenser, and making allowance for this item only, the Authors' figure of 5·75% for useful work would, on an "efficiency ratio" basis, become about 13%.

The question of machinery types and efficiency was a very large one and worthy of many independent papers. Having selected the most efficient machinery, steam or Diesel, as each particular case called for, everything should then be done to obtain as much heat recovery as possible, internal and external to the machinery installation proper. In regard to steam installations particularly, which required relatively large quantities of condenser circulating water, he thought more use might be made of scoops to reduce the power taken by the circulating pumps, or possibly make the running of these unnecessary in vessels of high speed.

Electric synchronisation was very interesting, but not without some difficulties and complications in design and operation. The idea of alternating current for the auxiliary motors, which might be a further development of this synchronisation scheme, was interesting on other accounts; e.g., it would permit the use of induction motors which were of the simplest possible design, eliminating commutators, brush gear, etc., but it was very doubtful if even these advantages would justify A.C. motors on all auxiliary drives on board at any rate. With regard to direction of rotation of propellers, it was usual for these to turn outwards on both twin and quadruple screw ships. He had heard it suggested, however, that on quadruple screw ships the forward and outward screws should turn inwards so as to promote a current of water towards the inward screws. The Authors' views on this point would be interesting. The Authors' suggestion regarding medical research for sea-sickness was a good one, and a contribution on this subject from a member of the medical profession would be interesting.

Engineer Rear-Admiral W. M. WHAYMAN, C.B., C.B.E. (Vice-President), stated that he had listened to the reading of the paper and the remarks of the previous speakers with great interest. With regard to mal de mer, it would be a most excellent achievement if some remedy could be discovered for it, but it was a very difficult matter for the medical profession to deal with. One suggestion, nearly as far fetched, which would help the marine engineer considerably, would be that our coal owners should give us a better coal without ash! It was a scientific problem, but possibly capable of solution. Another suggestion was that instead of using air for combustion, why not use the oxygen only and get rid of the nitrogen somewhere else! He thought these were two suggestions which might be considered.

Mr. H. H. CROCKFORD (Companion) said that he was entirely a layman as regards the main questions discussed in the paper, being only a poor electrical engineer! The question they were up against was really a very limited one. They were bound by the power given to them, by the naval architect and the shipbuilder, and the designer of the propeller, and even one stage further, by the engine builder. The savings they could possibly make on the electrical end of the installation were of the order of perhaps one or two per cent. only. It was in the losses prior to the conversion to electrical energy where there was room for improvement, assuming they were considering the question of electric drive with which the majority of marine engineers had not got very far yet. The possible gains in efficiency as far as electrical engineers were concerned were very small.

On the question of vibration they might be able to help considerably. The electric machine was essentially a machine developing a constant torque, and any vibrations which were due to characteristics of the structure, machinery, etc., were smoothed out to some extent by the electric machinery. The question of electric synchronisation was extremely interesting to him; it was a new subject in this country which deserved thorough investigation.

Mr. J. C. AYLING (Visitor) said that the shipbuilder depended entirely on the shipowner for the means of earning his living. For economic reasons, the shipowner could not assist the shipbuilder in matters of experiment or research. In countries such as Italy and America, both shipping and shipbuilding were assisted by subsidies, and shipbuilding was considered to be one of the most important of their industries. In no country in the world was shipbuilding a more vital industry than in this country. But no shipowner could possibly make a profit with freights at their present level, and shipbuilders suffered accordingly. He referred to a statement by Mr. McGovern, in a paper recently read before the North-East Coast Institution, in which it was stated that some savings might be effected by a process of standardisation of ship types. He (the speaker) had analysed every type of cargo ship built since 1925 in this country for British owners, single deck, two decks, etc., and the more he studied the figures, the more convinced he was that if shipbuilders were to draw up and agree upon a standard hull form for cargo ships of 5,000, 6,000 and 7,000 tons d.w., they would save themselves and their clients, the shipowners, a great deal of money. At present, if a shipowner invited tenders for a ship of, say, 7,000 tons, each shipbuilder had to draw up plans. It should be quite easy for one central authority to prepare and supply the necessary plans to all the shipbuilding firms concerned. The ideas of shipowners in this country varied considerably; they wanted different superstructures and erections, internal fittings, deck and engine room auxiliaries, but they could not have different basic bare hull forms. There were no grounds for anticipating that increased freights would be obtainable in the near future. The economic cargo ship of to-morrow had to be so designed as to cover her running and maintenance costs, provide for her depreciation and earn a modest profit on her capital cost at freight rates much about the average of those current on the open freight markets in 1929 and 1930. It was urgently necessary to design cargo ships so that all their cargo would be carried in 'midship holds of approximately the same dimensions. The Great Lakes freighter and the tanker could provide the models. He agreed with the Authors that somehow or other standard cargo ships of various deadweight carrying capacities should be designed, that they should work towards getting the most efficient and economical hull forms and build the bare hulls to these bare standard specifications; in this way it should be possible to reduce shipyards costs by something like 25 per cent. In the six years from 1925 to 1930, 346 cargo steamers of the single and two-deck types were built for British owners. The single-deckers averaged 370·9 ft. in length by 23 ft. in draught, and carried 7,210 tons d.w.; the two-deckers 393·6 ft. in length by 24·5 ft. draught, with an average carrying capacity of 8,120 tons d.w. Much of the present depression in the freight markets arose from the fact that in recent years too many ships of 8,000 to 8,500 d.w. had been built, thereby destroying the whole symmetry of the business. It was not true to say that the bigger the ship the more her relative profit would be. That was true during the immediate post-war years, when stocks of all raw materials and foodstuffs in the consuming countries had to be brought up to normal. But to replenish these stocks in normal times, the big cargo carrier was neither desirable nor, in point of fact, an economic proposition. Nevertheless, the owners of these big cargo carriers must find some use for them, and this they could only do by developing regular services, with a consequent circumscribing of the sphere of influence of the purely tramp ship. In every freight market, during the last three or four years, from the timber trade in the Baltic to the coal trade of this country, there had been a definite shortage of ships of 5,000 tons d.w. and less. British shipowners had only built 44 ships of these particular sizes in the last six years. The 5,000 tons unit of ship capacity was commensurate with the normal average consumptions of bulk cargoes, i.e., this type of ship was the most economical and efficient to fulfil the rôle of a bulk cargo carrier in normal times. At present there was an hiatus in the whole organisation of tramp shipping which was very serious indeed. It must be remembered that for every type of ship, whether liner, cargo liner, coaster, tanker or tramp, there was an optimum size beyond which it was sheer folly to go. For the tramp ship that optimum was between 5,000 and 6,000 tons deadweight carrying capacity, an optimum which was to-day being exceeded by about 20 to 25 per cent. For these reasons, he emphasised that the Authors of this paper were quite correct in their statement that we ought to standardise our ships.

Mr. A. F. EVANS (Member) congratulated the Authors on having written their paper in terms of the future. The more they had of that the better. There was far too little forecasting and far too much retrogressive thought amongst both shipowners and shipbuilders. The Authors said that demand created supply; unfortunately, in nearly every walk of life the manufacturer waited for the customer to dictate what should be built or made, but where one found manufacturers creating demand, they were noticeably the successful ones, Henry Ford for instance.

One point on which he ventured to disagree with the Authors was with regard to the efficiency of the Diesel engined ship. He did not quite understand the Authors' figures. It had been said that the steam figures were wrong and he did not understand how the figure of 20·6% overall efficiency stood for the Diesel ship. He had with him a paper just to hand by Mr. Pye of the Research Board which gave particulars of a Diesel engine capable of fairly big outputs at 120 lb. b.m.e.p., 1,200 f.p.m. piston speed, and an efficiency of 38%. Where was the discrepancy between these figures and those of the Authors? Was there an error or was he reading the figures incorrectly?

Dr. TUTIN stated that the figure in question was the useful work delivered by the propeller.

Mr. EVANS acknowledged this correction. With regard to electric synchronisation by means of two alternators, that was a proposal made two years ago to a firm of marine engineers, and he did not know of any proposal which had received so much abuse. It appealed to him as a sound idea, although it was received with such opposition, and he was very glad to hear that it was being re-introduced.

He considered that the dual rudder was a great advantage, as was also dual steering. Many years ago he had a small, shallow draught boat in which he fitted twin rudders for constructional purposes. He tried the experiment of using twin steering and found that they could do almost anything by way of manœuvring with it. He was sure that a large twin-screw ship could use the same system with advantage. They wanted to cut down losses; they could do that in the Diesel engine by heat conservation in the engine itself and outside the engine by the utilisation of waste heat. Messrs. Blohm and Voss were saving 10% of fuel by using exhaust boilers.

As regards improving the efficiency of steamships, he could not think why mechanical stokers were not used more at sea. Finally, he would like to know whether any investigation had been made as to the use of cellulose for coating ships' bottoms.

It was very hard and it stood up far better than white lead paint in certain circumstances. He had been told that it would not hold up in salt water, but that was not his experience from experiments he had made.

The CHAIRMAN said that he noticed that the point always came up that economy was to be obtained by a reduction of wages. As a wage earner he always dissented from that view and thought it was a wrong policy.

Efficiency was the first consideration and that could only be obtained by efficient workmen, and always by paying efficient wages. His experience was that wherever the employer had taken that view, he had never lost money by it, and he thought any advance must not make any toll on wages.

A vote of thanks was enthusiastically accorded to the Authors and the meeting terminated.

BY CORRESPONDENCE.

Mr. E. F. SPANNER (Member) said that he must confess himself very disappointed with this paper. Perhaps the title led him to expect too much. He found in the paper a brief resumé of some few of the many improvements which might reasonably come under the classification "Modern Developments," but even this resumé was very incomplete, and, in his view a little misleading. For instance, Dr. Tutin could hardly mean us to accept his suggestion that the fitting of two rudders, one behind each of two screws in a twin screw ship, was so novel an idea that the designers of the *Columbia* might rightly be said to be giving the world "a lead in this direction." The idea was very old indeed. It was practically forced upon designers of Maier form ships owing to the form of the ship aft, and the merits or demerits of twin rudders would not be assessed from the performance of that ship by any designer of long experience.

In reference to the Maier form, too, he would like Dr. Tutin to justify his statement that the Maier form permitted "a reduction of wetted surface on given displacement and dimensions." It would be helpful to have the arguments which satisfied him that he was on sound ground in affirming this. Certainly for twin screw jobs the possibilities of the Maier form merited exploration and a detailed reply from Dr. Tutin on this point would be helpful.

In his final paragraph Dr. Tutin remarked that "A passenger ship must be attractive—to passengers—*and must partially sacrifice efficiency for speed.*" The writer would be grateful to Dr. Tutin if he would kindly explain just what he meant by the words in (the writer's) italics. He found it very difficult to follow him.

On a few points he was frankly at a loss. No doubt Dr. Tutin would be able to amplify his remarks to satisfy him that they were correct. He would like to question (1) the skeleton statement that " It is impossible to recover any of the linear energy of the slip stream without destroying thrust." He thought this skeleton required to be more fully clothed.

(2) That " A cast iron propeller may be as efficient as, or in some cases more efficient than bronze, when new". Surely there would be, unavoidably, a difference in scantlings which would seriously prejudice the case for the cast iron propeller.

(3) That " Marine growths cannot in general attach themselves to hard surfaces——" and that we must, therefore, " look for an anti-corrosive composition with an ultra-hard surface." To start with he presumed Dr. Tutin meant " ultra-smooth and hard." Even so, he would be glad to know Dr. Tutin's authority for these pronouncements.

(4) That " on a large passenger ship pitching is not of much consequence " so far as sea-sickness was concerned. That statement was far too sweeping. There was an element of humour in Dr. Tutin's last paragraph in the section dealing with the subject of sea-sickness—and particularly in the last sentence of this paragraph.

On one point he must congratulate Dr. Tutin, and that was in his reference to the idea on centre propulsion for which Signor de Meo was responsible. Until Signor de Meo pointed it out, of course, the idea of placing the propellers amidships was very far from " obvious." The use of this word " obvious " by Dr. Tutin, however, suggested that it might not now be long before Signor de Meo's ideas received proper recognition and development.

It was interesting to note that Dr. Tutin was of the opinion that an organisation was needed " which by research, experiment and invention, will succeed in affecting a material and comprehensive improvement in ship design." For some years, of course, Signor de Meo had been strongly advocating the creation of a Marine Technical Association which would devote its attention particularly to unravelling the uncertainties existing in matters concerned with ship propulsion.

A good deal of sympathy towards this ideal had already been extended to Signor de Meo in this country and abroad, and no doubt time would see the bringing about of the development for which he had worked so consistently.

If he had unwittingly attributed some of Mr. Hardy's material to Dr. Tutin, he was sure Mr. Hardy would forgive him. He had assumed that Mr. Hardy was more concerned with the commercial than the technical side of this paper.

Mr. W. STANLEY HINDE in a written communication said that he would like to congratulate the Authors on the courage of some of their statements in the opening paragraphs of their paper, and as a shipowner, he would like to make some observations in so far as the tramp ship was concerned.

Much as he disliked the thought that it was within the power of shipbuilders to produce vessels so much more efficient than existing ones that the latter must be scrapped, he must confess to being in accord with that view, and he had no doubt whatever that, as far as the ocean-going tramp ship was concerned, a 1932 vessel would be propelled on approaching 50% less fuel than a similar sized ship built in 1922.

In parenthesis, he would like to observe that, in so far as the shipbuilding industry was concerned, the problem was not that of inducing shipowners to build efficient ships so much as affording them a means of being able to do so. The stumbling block was the disposal of existing tonnage, which, day by day, became more obsolete, and the very severe depression in freight rates during the last year or so had sadly depleted the coffers of the bulk of British shipowners. Unfortunately, the matter did not end there, for the British shipowner had also to contend with the competition of foreign ships, whose running costs were considerably less and who were not burdened to the same extent with heavy taxation. It was true that in times of depression freight levels were governed to a large extent by the rates which could be accepted by the most efficient tonnage, but the factor of paramount importance was, and always would be, that of supply and demand. It should be remembered that the fluctuations in rates of freight were overwhelmingly greater from time to time than any differences in running costs. Whilst the capital cost of a new ship did not necessarily bear any real relationship to profit earning, it should be borne prominently in mind that as an investment, or, should we say, a profit earning proposition, capital cost was of outstanding importance. In watching the progress towards efficiency in new design, the prudent tramp shipowner would keep his eye glued on the proposal which gave him efficiency at low capital cost, and with the prospect of low running charges.

The naval architect had done excellent work in improving the hull form, and this, coupled with an improved type of rudder, had substantially reduced the amount of propulsive effort necessary to drive the hull through the water, and he would urge a further concentration of research on these lines as being a means to economy of the right kind.

The problem from the shipowner's point of view as to the means to be adopted for producing power necessary for propulsion was full of pitfalls. One could not help being impressed with the Authors' analysis of the thermal and mechanical losses in the modern triple expansion engine with ordinary Scotch boilers. There was ample scope for the elimination of waste, and this applied in particular to the boiler room. For the past four years he had been making a study of boiler room practice as applied to natural draught boilers in tramp ships and was satisfied that by introducing a simple semi-mechanical method of firing, efficient circulation, and efficient lagging, the boiler efficiency could be substantially raised. The point which seemed to have been neglected in natural draught boilers was that coals of varying characteristics required different conditions of combustion, and the ordinary fixed grate afforded little scope in this direction.

Using a well-designed type of rocker bar grate, combined with a controlled secondary air bridge, it was astonishing how closely foreign coals could be made to compare with the best home coals and how far it was possible to go in shipping cheap mixtures of home coals, and still obtain consistent steam.

As a tramp shipowner, he put the factor of liability in the place of prominence, with low upkeep charges and depreciation a close second. Given a high boiler efficiency, he had yet to be persuaded that real economy could not be obtained without the introduction of super-heated steam and expensive auxiliaries.

He believed that the naval architect would still further improve the hull form, and, to take a basic example, he saw no reason why the 7,800 tonner of 1932, using saturated steam and having highly efficient boilers, should not be propelled at 9 knots on about 14 tons of coal as compared with the 7,800 tonner of 1922, which had a consumption of about 28 tons a day.

Mr. E. L. CHAMPNESS (Palmers Co., Hebburn), in a written contribution said that this paper by Dr. Tutin and Mr. Hardy was a constructive effort in general terms to point out the need for " something better " when the revival in trade came, as it must with the turn of Fortune's wheel. Many shipbuilders who had given serious thought to this problem, in particular of late months, were fully equipped to turn out that improvement in detail which was indicated generally by the paper.

When we considered that approximately 325 million pounds of capital was concerned in British shipping companies alone, the hint in the paper that the industry could benefit by a research association was worthy of very serious consideration. Such an association would be the clearing house of problems of common interest to owners—a source of unbiased scientific reports on matters of vital concern to them. It was only necessary to mention such problems as the corrosion of oil tank vessels and the considerable expenditure involved, as well as other matters (including sea-sickness) mentioned in the paper, to realise the possibilities of economies by the pooling of such problems.

He would like to add one further point to the Authors' remarks on passenger ship design: it was a curious survival of antiquity that one could walk into the leading steamship companies' offices to book a first class passage of some three weeks duration and find that the standard fare was based on sharing a cabin with some two or three other total strangers. He could not imagine why, if we would be amazed at a reception clerk in a hotel making such a proposal, we should be expected as a matter of course to look upon it as a normal suggestion in sea travel. Even to-day the three and four berth first class cabin was being perpetuated in new passenger vessels, though to a lesser degree than formerly. The supplementary fare for the privilege of privacy might prove a source of revenue, but it also produced a sense of irritation, particularly when one might discover subsequently that one was paying for that privilege when the ship was not booked up. He would commend to the large passenger lines the suggestion that they might give some employment in these days by the conversion of a large number of such cabins in their older ships, to conform to modern requirements.

Mr. W. J. LOVETT (Director, Messrs. Workman Clark, Ltd.), in a written communication said that he had read with much interest and approval Dr. Tutin's and Mr. Hardy's paper, and trusted that it would focus attention on the great need for British shipowners to scrap wherever possible pre-war vessels.

Technical readers of marine engineering literature had been well supplied with information regarding the great gains in economy achieved in the engine room, but the greater gains achieved on the ship side had had a less profuse press. It was probably an understatement to say that a pre-war vessel compared with a present day vessel was 20% less efficient, and by far the greater saving had been achieved on the hull side. For cargo vessels shipbuilders of the present day could readily offer over 20% increase in deadweight for the same power and speed. We were still suffering from the infliction of the large fleet of old tonnage forced upon us after the war in lieu of reparations, whereas the merchant fleets of enemy countries to a large extent were built up of modern vessels. It was possible that the properly designed present day vessel could make a small profit on existing freights when a pre-war vessel could only be run at a considerable loss.

Engine room improvements in efficiency had sometimes been effected at the cost of increased power to drive the auxiliaries responsible for the improved efficiency, and from a shipowner's point of view it was questionable whether some of these improved efficiencies had been real economies.

A committee of shipowners and shipbuilders to determine the specification for the most efficient ship would require to be a permanent one, because improvements were being effected every month, and the most efficient ship of even five years ago would not be the most efficient to-day. On such a committee it would be almost necessary to obtain co-operation of dock authorities, because while loading and discharging appliances of British ships could be considerably improved, the rapid reception of their discharged cargoes on present day British dock sides would only be possible by a drastic overhauling of the appliances in most of our British ports. Two days saved in discharging on an Atlantic voyage would be almost equal to an increase of two knots in the speed of a cargo vessel.

The Maier form of hull had been referred to, but he thought the most recent experience in that connection suggested that the greatest gain from the Maier form would be in the fore body, and that the after body could remain almost as it was at present.

The shipowner who placed an order for a vessel to-day with a firm that was not thoroughly up-to-date in scientific knowledge was running a grave risk of being left with a ship which was old before it was built.

The comparison of motor cargo vessels with steamers was always of intense interest, and finality of opinion regarding their comparative economy was not yet possible.

The only natural wealth that this country possessed was coal, and it was not beyond the realms of possibility that we might yet be able to burn coal in some form direct in the cylinders of an engine. It was admitted that the area of economic operation of a coal burning steamer was becoming more restricted, and that the future use of coal for marine propulsion would be dependent on the research of the chemist and engineer. It seemed possible that the greatest future for the cargo steamer would lie in services where coal or oil might be burned alternatively during different portions of the voyage, and for this reason it would seem that particular attention should be concentrated on a solution of the problem of the burning of coal in pulverised form, since this means could most conveniently be embodied in conjunction with oil fuel firing. This was particularly with reference to high pressure steam, and the use of water tube boilers.

He could not see the practical operation of a committee which would standardise the most efficient type of merchant vessel, because we had at present the resources of the Teddington Tank, and when this was added to the individual skill of engineers and naval architects in particular firms, we had a combination which would always challenge any standardising committee, however composed.

He wished to thank Dr. Tutin and Mr. Hardy for their able and suggestive paper, and he trusted that much good would accrue from it.

Mr. A. L. AYRE (Chairman, The Burntisland Shipbuilding Co., Ltd., Burntisland), said that the paper was a most timely reminder of the necessity for the nationally important industry of shipping to provide itself with the most efficient and economical vessels that our shipbuilding industry could now make available to it. It was reasonable to presume that we were at, or very near to, the upward trend of the trade cycle; many economic factors pointed to this. Just as it behoved a shipbuilder at the present depressed time to have sufficient faith in the future to cause him to revise and improve his equipment in preparation for the forthcoming improvement in world trade, and the resultant demand that would be made on him, so also was it necessary to look round and see to what extent our shipping could be brought up to the highest available standard of efficiency. The Authors, considering the space into which they had compressed their review of the position, had ably drawn attention to many matters which, in the aggregate, could be responsible for large economy. Such aggregation amounted to successful ship design. Future highly competitive conditions in ship operation most vitally demanded such considerations.

While appreciating the general effect of the statement, he did not think it was entirely correct to say that freight rate levels were governed by the most efficient tonnage, as he believed there were instances to-day in which the owners of such vessels were not depressing the markets as they might, without incurring loss, but were allowing the vessel of somewhat lower efficiency to make the rate. This was a sensible attitude resulting to the profit of the modern highly efficient vessel and, while these remained relatively few in number, this attitude would, no doubt, continue, excepting only in case of emergency. As the number of these modern vessels increased, so would the tendency occur for them more definitely, in competition amongst themselves, to govern the rate in which case the inefficient would be found in a most hopeless position.

Progress in merchant ship design was stultified owing to the war, and it had to be remembered that the immediate post-war ship was, in its design, merely that of 1913. The general progress attained in more recent years had been so rapid that it represented what might normally and gradually have been its extent over the whole period. In effect, it could be said that the average 1920 built ship was now about 17 years behind the times in so far as economical design was concerned. But what of the still older vessels? It was no exaggeration to say that in fuel consumption for a given deadweight cargo, at a given speed, the improvement over the past 17 years represented more than thirty per cent. reduction due solely, and simply, to the more close application of scientific knowledge in practical design, and this without addition to capital cost, while to this had yet to be added the effect of mechanical improvements and additions to the power producing plant, the whole of which, if utilised, would bring the figure for improvement up to about fifty per cent. Such figures might at first sight appear astounding, but they were, in one form or other, actually being attained to-day.

The Authors drew attention to the important effect of economy in fuel consumption which was passed on to deadweight and therefore freight-earning. An important instance of this was the modern 7,800 tonner which, because of the reduced amount of fuel to be carried, was practically equivalent to the 8,100 tonner of a few years ago, and carried three firemen less.

It was perhaps not generally realised that such vessels to-day average nine knots, loaded, port to port on Plate voyages on only 1,000 I.H.P., this average speed entailing a large number of days' runs being done at 9½ knots. It was not so very long ago that 1,500 I.H.P. was common for such a vessel on such a voyage.

The reference to economy to be picked up in the propeller slip stream being a post-war discovery was hardly correct. This was a British invention of, I believe, Mr. Arthur Rigg in 1864. The suggestion to carry the propeller further astern was also far from being new; in the early volumes of the Transactions of the Institution of Naval Architects there were many references to the valuable effect to be obtained from this. There might be practical difficulties here, and it would be interesting if the reasons could be made known for both of the ideas—originating as far back as the middle of last century—having been dropped.

In so far as the paper suggested methods of attack on the part of the shipbuilder, he believed he was safe in saying that the shipbuilder appreciated every one of them. But the shipbuilder's style was often cramped in having to produce what was already designed for him, even to the extent sometimes, of having, much against him own better judgment, to build a vessel which, excepting in relatively small detail, was a reproduction generally of a twenty year old design. One of the largest steps of progress recently made in tramp vessel design was done by the builder himself after his proposals were for some years continuously turned down. In this instance the "spec" ship proved the design and many followed her. This was an instance of the well-known commercial fact referred to by the Authors of "supply creating demand," but it is not one that could be too liberally applied in a "heavy" industry, like shipbuilding.

The successful application of our modern knowledge of ship design to practical operating conditions, a study and knowledge of the latter being essential to the shipbuilder, most largely depended, however, on the closest mutual consideration being given by the owner and builder in the designing stages. It might be that, in many instances, the nature of the competition for the building contract prevented this.

Mr. C. P. HARRISON (General Electric Co., Ltd), in a written communication, said that he was pleased to see that the Authors had drawn attention to the advantages to be obtained from electrical supercharge, *i.e.*, electric auxiliary drive, which might of course be of the exhaust turbo-electric type, either from steam engine exhaust or Diesel exhaust boilers, augmented by oil burners, or for that matter Diesel-electric auxiliary drive. These methods certainly were very good means of increasing the useful work available from any prime mover, by making use of what would otherwise be losses.

Complete electric drive schemes should contribute considerably to the comfort of passenger ships by assisting in the elimination of vibration. Quite apart from the pure rotary motion associated with turbo-electric drive there was the advantage of the steadier propeller drive with consequent absence of propeller churning when getting away and racing under bad weather conditions.

The scheme mentioned for electrical synchronisation of propeller shafts was extremely interesting, and the fact that it had been successfully installed in a private yacht proved that it was a practical scheme, although further information as to the output of the alternators in relation to the output of the engines would be interesting. The Authors mentioned that it was possible to use these alternators for driving auxiliary plant once the ship was away to sea, although one might expect trouble under extreme conditions in rough weather, where one alternator was called upon to prevent the other engine from racing, which would probably result in both engines slightly increasing their speed. Such an occurrence would, of course, result in fluctuations in the supply to the auxiliary load. In addition to this, since the engines must be manipulated separately for manœuvring, a separate A.C. supply would have to be installed for driving these auxiliaries during manœuvring periods, and there would be the trouble of changing over from one system to the other. Whilst agreeing that squirrel-cage motors would be ideal from the simplicity and the first-cost point of view, experience showed that engine room auxiliary makers almost invariably required variable speed motors, which would mean slip-ring motors with rotor resistance for speed control, and this was far from satisfactory. Assuming constant speed auxiliary motors to be acceptable, however, there seemed to be no reason why this electrical synchronisation should not be carried a step further than that outlined in the paper, namely, to combine it with Diesel-electric drive. This would mean in the first place putting fly-wheel alternators on the engines to synchronise the engines, which could then remain synchronised throughout the manœuvring and sea-going conditions and thereby give a constant A.C. supply to auxiliaries. In addition to this it would be possible to insert alternators in the propeller shafts so that once at sea the two shafts driven by their direct-current motors could be synchronised with a definite propeller blade relationship. These two further alternators were admittedly adding to the first cost of a Diesel-electric scheme, but the results would probably prove this to be well worth while, as we should then have the combined advantages of electric drive plus absence of disturbing vibrations.

Mr. WILLIAM P. JENKINS (Chief Chemist to Messrs. J. Dampney & Co., Ltd.) in a written communication stated that he noted that the authors were of the opinion that an ultra hard surface, if it could be produced on the under water hull of a ship, would prevent the adhesion of marine growths. This theory was doubtful and it was the opinion of his Company that it had not been proved. At the Hancock Museum at Newcastle, for instance, might be seen some beautiful specimens of barnacles which had attached themselves to a bottle which was found at sea.

In the latter days of the wooden ship it was thought to be almost a matter of compulsion to cover the bottoms with copper sheeting, and it appeared that copper sheeting in contact with sea water was so effective in keeping down the quantity of possible adherent marine organisms that certain authorities of that period predicted that the iron ship, which was then commencing to become popular, was doomed to failure, firstly, on account of the impossibility of preserving iron which was submerged in sea water, and secondly, because they said that the iron bottoms would become extremely fouled. In short, they were firmly of the opinion that copper sheeting was the only metal from which satisfactory hull exteriors could be constructed.

The theory of the peculiar ability of copper to combat fouling appeared to have been shared by two schools of thought; one school held that the copper formed toxic salts which were poisonous to marine organisms; the other that copper possessed the peculiar property of corroding in thin layers which were not strongly attached to the metal, and that it was through this formation of loose layers that copper was able to throw off the adherent organisms by exfoliation.

Which of these theories was correct was doubtful; perhaps neither alone accounted for the efficiency of copper bottoms, but the two theories formed the basis of two distinct types of antifouling composition as manufactured to-day. Firstly, there was the type of antifouling composition which was loaded with toxic materials, and secondly, there was the type which was constructed so as slowly to decompose at the immediate surface, forming a soft or chalky film to which sea organisms failed to adhere. There was lastly, a type of antifouling composition which owed its efficiency to the fact that it was so designed that the film never became hard, but remained soft and more or less oily, thus presenting a surface to which marine growths could not cling.

To revert again to the idea of an ultra hard surface, the first principle in the production of paint for the protection of iron was to commence with something which was most opposed to water, for water was the prime factor in the cause of corrosion of iron. Oily matter was the only material which was capable of repelling water, and for this reason all paints and compositions were made on a basis of some oily type of material. Now these materials by their very nature could not be made very hard, and therefore ultra hard surfaces could not be designed for the production of rust-preventing paints. It was, therefore, too much to expect of modern chemical research that an ultra hard preservative could be made for the protection of iron. The only coating of this nature which could be applied to iron was vitreous enamel, but this was outside the scope of paint research, and indeed formed quite an impracticable means of protecting the hulls of iron ships. Vitreous enamels were fused at high temperatures on to the iron surface, and of course this was possible only with relatively small objects. They also were prone to chip off.

He was of the opinion, therefore, that there was no immediate prospect of producing an extremely hard and smooth composition which would reduce friction to a minimum and would function as a preservative for iron submerged in sea water, also at the same time acting as an antifouling film.

DR. J. LOCKWOOD TAYLOR, in a written contribution, stated that the Authors prefaced their most interesting and stimulating paper by some remarks on shipping economics, tending to show that improvements in design gave an impetus to new construction. While this was no doubt correct, it was hardly permissible to infer that freight rates would at any given period be determined entirely by the efficiency of the most up-to-date units. In the first place, the owner of an efficient vessel would not accept a rate lower than that which enabled him to keep his ship employed in competition with the majority of vessels, having only average efficiency; while in the second place, an owner would naturally maintain in service an older vessel, even though it was earning only a proportion of its true depreciation, rather than sacrifice practically the whole value by scrapping it. A minor point in connection with the diagram (Fig. 2) showing the percentage of freight absorbed by different running costs, was that the use of the net freight rate (as in the calculation of virtual fuel price) with a consequent reduction in the percentage shown for port charges proper, would perhaps give a clearer picture of the incidence of the various items. The absence of interest and depreciation in the figure was also rather difficult to understand, unless it was to be assumed that in these hard times none was being earned. One might also suggest a slight adjustment of Fig. 4 to indicate the presumably less propeller efficiency of the Diesel vessel, with its higher speed of revolution.

The Authors stated on page 966 that "it is impossible to recover any of the linear energy of the slip without destroying thrust"; there was, however, a fundamental way of reducing the linear energy for a given thrust, viz.: by acting upon a column of water of greater area, and it was believed that service data confirmed this inherent advantage of the large-diameter propeller, even beyond the point where the ordinary design methods would show that the maximum efficiency had been reached, owing to the counteractive effect of the growth of other losses. This point must also be emphasised in connection with the suggestion to place propellers amidships, when the restriction on diameter would tend to become acute. It was difficult also to see how a negative thrust deduction would be attained by this arrangement, since the suction of the propeller would hardly extend to the part of the fore-body where it would be valuable, while there would be strong suction on the plating immediately forward of the propeller, where the shaft passed through the shell.

The fact that the net wake gain was less than the actual, consequent on the necessity of designing the propeller for a speed of advance less than that of the ship, was a very interesting point, which one would like to have seen further elucidated by means of some actual figures. There would appear to be a very definite possibility of gain with most types of machinery, due to the higher speed of revolution which would be permissible if the wake were less and the speed of advance greater, and it would become a question to what extent this should be taken advantage of in preference to simply redesigning the propeller for the same revolutions.

It was certainly to be hoped that the Classification Societies would, as stated, give favourable consideration to new hull designs which would be prejudiced by the application of the usual scantling numerals, presumably owing to increase in overall dimensions for a given displacement. This hope was, however, hardly strengthened by their persistent refusal to give any allowance for fineness of form, which was essentially the same problem.

With regard to shell butts, had the advantage of reversing the direction been definitely confirmed? And if so, would it not be desirable in any case to chamfer the butts, in which case the advantage might not be maintained?

Electric synchronisation was an interesting proposal, which would doubtless in many cases reduce vibration, although it was difficult to be quite as optimistic as the Authors on this point. An owner who was prepared to spend money on reducing vibration might find that he could achieve his object by fitting suitable dynamic balancers at appreciably less cost.

The keying of the propellers of the electrically coupled units could certainly be arranged so that the forces of one particular type would cancel each other—presumably the primary impulses, having the same frequency as (no. of revs. × no. of blades) would be so dealt with, but the secondary impulses would become additive and there would remain an alternating couple of the same frequency as the primary impulse, due to the forces acting at different points. Similarly, certain engine forces—the torque reaction impulses—would cancel, though applied at different points, while others—the inertia forces—would be in the same phase for both engines. However, all attempts to deal with the vibration problem on a basis other than empirical deserved every encouragement, and it seemed certain that in future a much higher standard of comfort in this and other respects would be demanded.

Mr. C. RETTIE, in a written communication, said that the statement of the Authors on the question of state subsidies might be all right in theory, but did it work out in practice? Mr. R. D. Holt, one of our leading shipowners was a great believer in the open door and unrestricted trade, and in a speech he had given during the discussion on Sir Norman Hill's paper before the Institute of Transport, on the occasion of their last visit to Liverpool, when referring to the restrictions imposed by foreign countries on our shipping, said that as far as they were concerned, they were not afraid and were quite prepared to meet any competition. However, he thought that public opinion was changing and that it required a lot of faith to believe that this country would eventually come out all right in face of the heavily subsidised industries on the Continent and in America.

He quite agreed with the Authors' suggestion to shipowners to build ships that were more efficient. At the same time he would like to point out that in seeking further economies a great deal of harm might be done. This country was coal bearing and everything should be done, even at an extra cost of maintenance to see that coal was used as much as possible as the fuel in our ships. The internal combustion engine was not all that was claimed for it, and with regard to the question of economy, it had recently been decided to adopt the turbo-electric drive on the new French liners, purely on the grounds of the comfort of the passengers.

With reference to the problems of the propeller his late father was greatly interested in these, and about 25 years ago made a model to demonstrate his ideas. The model had two shafts on each side running fore and aft with a number of propellers spread out over the shafts. He did not agree with his father at the time on account of the difficulties that might arise in the construction of a large ship and the installing of the machinery to drive the multiple propellers. However, it demonstrated that his father was working on the right lines and was getting near to Mr. de Meo's idea of amidship propellers. His father was a sea-going carpenter and served his time helping to build the Aberdeen clippers and he was always working out some problem connected with ships. He never made any money out of his inventions. His principal invention was the tell-tale used in connection with the ship's telegraph. He sailed in the old Allan Line and had crossed the Atlantic 400 times.

Mr. H. C. CAREY, in a written contribution said that when first reading this paper one was liable to get the impression that modern ships were after all not so modern as one could wish, but a second reading showed that the Authors had given careful thought to their subject matter. Although their economics might be open to question, there was little doubt that as far as this country was concerned our only hope was to look to the future, by embarking on a policy of scrapping and rebuilding on a large scale. Questions of finance, unfortunately, did not rest with the marine engineer or naval architect.

When discussing the more efficient ship, the Authors assessed one per cent. gain of propulsive efficiency at 50% over its actual value on account of the extra cargo that could be carried. In practice, even at the best of times, tramp steamers made ballast voyages, and at present a 10,000 ton tramp steamer loaded down to its marks would be almost a phenomenon.

The overall thermal efficiency of a steam plant, given in Fig. 3 as 5·75%, would appear to be on the low side, even with tramp steamer machinery, and this figure could naturally be much improved. The effect of the rivalry between coal and oil had been, as the Authors remarked, highly beneficial, but the statement would be still more correct if "steam" was substituted for "coal." This country was dependent on the increased use of coal, but it was the increased use of oil in conjunction with high pressure steam that had caused the real recent advances in engineering. These advances had been so rapid of late years that marine engines were progressing far more rapidly than ship structures, and it was to be hoped that the ship side would in turn produce its own revolutionary changes. One of the few real advances made by the naval architect in recent years was the recovery of energy from the propeller slip stream, and real economy had resulted by using the rudder for this purpose.

He was in absolute agreement with the Authors in their appeal for more facilities for testing hull forms in this country. If the tank authorities could satisfactorily demonstrate that economies could be effected by the adoption of any unusual underwater form, shipowners would certainly take advantage of the fact, and perhaps, in the fulness of their hearts, subscribe to provide further research facilities

With regard to passenger ship design, it did appear that as a direct result of competition between shipowners, ship decoration had reached a far higher standard than was really necessary. The primary demand of passengers was comfort, and they would be more attracted by comfortable cabins than public rooms with expensive futurist decorations. The statement that on a large passenger ship pitching was not of much consequence was perhaps rather sweeping, as would be well realised by those who have made a westward crossing of the North Atlantic in mid-winter, but there was nothing more disturbing than a big sea on the quarter, and it was in this case that the use of stabilisers or anti-rolling tanks would be of great benefit. Apparently the shipowner did not know enough about them to justify the necessary expenditure, and here again a little practical research and propagada was justifiable.

The vibration problem in passenger ships presented one of the greatest difficulties in ship design, but the system of electrical synchronisation mentioned in the paper appeared to be the best solution as yet put forward. Anyone acquainted with twin screw Diesel machinery would appreciate the advantage of being able to control the phase relationship of the main engines, and the idea of automatically controlling the relative timing of blade impulses was also a step in the right direction. It was difficult, however, to see why the system should give complete freedom from vibration. Main engine vibration could certainly be eliminated in this way, but perhaps the Authors would enlarge upon their brief remarks and state why "isolation" of all auxiliaries would prevent local vibration from this source. Such vibration was generally of small degree, but it was extremely difficulty to avoid.

The Authors were to be congratulated upon the concise manner in which the paper had been presented, and if shipowners would give their full consideration to modern developments and at the same time adopt the Authors' optimistic spirit, there was no doubt that the progressive demand for new tonnage would be stimulated.

Mr. A. JOBLING (Member) in a written communication stated that interesting as the paper was, it only earned the approbation and applause of the shipbuilder and engine builder. The shipowner, whom most of our engineering and shipbuilding experts to-day looked upon as a secondary consideration, seemed to him the only one that counted. In a few cases there were well placed owners who could afford to experiment with their new tonnage, and they were to be congratulated upon their keenness.

But what about the average tramp owner, who was only just able to scrape sufficient capital together to keep his fleet up to his requirements? Of what interest was it to him to know that he could build a 12,000 tonner with a speed of $15\frac{1}{2}$ knots and all the latest gadgets, possibly of about the cost of £170,000, when he only wanted a 7,000 tonner at $10\frac{1}{2}$ knots for his particular trade, which he could get, say, for £75,000, answering all his requirements?

We had recently read with a certain amount of blasé interest an argument between a naval architect and a shipowner's superintendent regarding their new vessels being obsolete before they left the ways. It was all a point of view. The shipowner was the man to know what suited his trade and more particularly his pocket. Capital meant interest, and the more his ship cost the more it had to earn and the more to put by for depreciation. The standardisation of ships had been mentioned, and a Continental yard cited where vessels were built to one plan. How could anyone suggest standard ships to the British owner? Certainly an owner might build his own fleet to a standard plan, but that would not suit another owner, His vessels must conform to his own style and their trade, which were necessarily all different to one another.

Dealing with the last paragraph of the paper, the Authors of this paper could not be serious when they suggested to members of the Institute of Marine Engineers that there was no reason why in a small class of vessel the engineers and their staff should not be entirely dispensed with and the vessel managed from the bridge.

Mr. JOHN MCGOVERN (Furness Shipbuilding Co., Ltd.), in a written communication said that the Authors had set themselves the difficult task of exploring highways and byways which might lead to greater efficiency of the modern ship—the culminating achievement to be the production of vessels which would speedily render obsolete, on a large scale, existing tonnage.

A review was given of technical progress, and the means for economy which were now available, and were being employed to a greater or less degree according to the inclination of those who were responsible for guiding our shipping companies.

There could be no doubt as to the value of the constant and careful study of these developments, and it was to shipowners to whom the Authors' remarks would more particularly apply.

He had already placed on record his belief in the value of certain of the devices mentioned in the paper, but had no doubt that the Authors would agree that some difficulties arose when one was asked, very properly, to justify beyond doubt the actual value to a shipowner of the extra outlay which might be entailed by some of these improvements. Changes such as shell laps facing forward were easily made on request, but in view of the experimental results quoted by Mr. G. S. Baker in 1915, further guidance, especially in respect to "scale" effect of appendages, was desirable. He was interested in the Maier form shown; it appeared to be a variation of the straight line form on which his Company had conducted considerable research work with very successful results, both from the view point of propulsive efficiency and ease of construction.

The Authors illustrated very effectively the limited scope which was available to a shipbuilder for reduction in initial costs. This reduction was practically confined to labour and part of the establishment charges and a reduction of 10% in these items would not lower the final cost by more than 2%.

He could assure the Authors that the search for improved constructional designs, more efficient propulsion, and the intensive study of the fine points in "lay out" and general economy went on unceasingly. However, he believed that past experience did not encourage the belief that cumulative improvements in detail would ever speedily compel shipowners to scrap existing tonnage on a large scale.

He regretted to find himself in disagreement with some of the opening pronouncements, especially with the statement that the remedy for depression in the shipowning and shipbuilding industries must come from within. No practical readjustment of freight rates, initial or running costs, could neutralise the effects of severe reduction in the demand for overseas transport, as present conditions surely indicated. The production of the super-ship was an academic conception and rather beyond the scope of useful discussion. Rationalisation was not directly concerned with stimulating the placing of contracts; it was merely the logical process of adjusting supply facilities in accordance with present and prospective demands and as such had long been part of industrial organisation.

MR. F. G. BROWNLIE (in a written contribution) said that this paper covered such a wide field that discussion of the whole would be impossible within reasonable limits of time, so he confined himself merely to one or two points which appealed to him.

The introductory paragraphs he found extremely unconvincing. From the evidence available, he saw no justification for the view that shipping differed in any essential feature from other industries. The relation between the shipbuilder and the shipowner appeared to him exactly the same as the relation between any other manufacturer and his customer.

Regarding the suggested central technical organisation, there appeared to be no guarantee that such an organisation would lead to more rapid improvement in ship design than at present, and he felt that any advancement in technical matters, such as this organisation promised, would be fairly expensive in realisation.

With the suggestion that the *real* cost of propulsion involved a freight charge upon bunkers, he entirely disagreed. There could not be propulsion without bunkers any more than there could be propulsion without propelling machinery, and there was already a debit entry in the freight account due to bunkers. The 9,000 ton vessel in question could not earn *freight* upon even one ton when laden with 9,000 tons; she might earn warehouse charges, that was all.

The Authors' opinion that material, diameter, pitch, and surface, were the essential matters in propeller design, and that any increase in efficiency, due to variations outside these four factors, would be but small, would meet with general approval, and he thought they might emphasise the fact that a bronze propeller was not *necessarily* superior to cast iron in all circumstances.

The remark regarding " wake gain," he did not quite follow. The fact that the existence of wake was prejudicial to the attainment of highest propeller efficiency did not affect " wake gain." He took it the Authors did not deny the existence of " hull efficiency " greater than unity under appropriate conditions?

The midship propeller position was not yet within the realm of practical politics, but he was unable to follow the reasoning which suggested that this location of propellers converted thrust deduction into an asset. If the screws were sufficiently close to the hull to exercise suction upon it, they necessarily interrupted the streamline flow, which surely meant thrust deduction?

He would also like further elucidation of the expression "negative" wake: he found this expression unintelligible. Did "negative" real slip not logically follow such a conception?

In conclusion, he would like to express his thanks to the Institute for affording him an opportunity to comment on this thought-provoking contribution to their Transactions, a privilege which was much appreciated.

THE AUTHORS' REPLY TO THE DISCUSSION.

The Authors very much appreciated Mr. Hamilton Gibson's suggestion that certain parts of the paper were worthy of further amplification. It would be readily appreciated, however, that many of the subjects dealt with could not be discussed in detail because no details were at present available. For example, in the case of central propulsion there were no doubt, a number of alternative methods by which this system of propulsion could be carried into effect, but so far as the Authors were aware, no details whatever had been published.

The Authors were familiar with the Kitchen reversing rudder, and as Mr. Hamilton Gibson pointed out, although this rudder was hardly suitable for large single screw ships it might well be used with the object of elucidating certain problems in regard to thrust deduction.

It would certainly be an exaggeration to say that the economies to be picked up in the propeller slip stream must be regarded as a post-war discovery. It was, however, most definitely a post-war discovery that these economies were so large. Before the War no one would have anticipated that an improvement in efficiency up to, say, 15% was possible by fitting devices in the slip stream abaft a screw propeller. Even now ships were occasionally built, the owners of which preferred to retain the pre-war constructions of rudder and stern frame in the mistaken belief that the economies made available by modern methods were of negligible importance.

Mr. Gibson was no doubt quite justified in his criticism of the use of the word "modern" in regard to the triple expansion engine on which Fig. 3 was based. The data for this diagram was very kindly placed at the Authors' disposal by one of the most progressive marine engineering firms in the country, and they had their assurance that the figures were correct for an ordinary triple expansion engine with Scotch boilers, but without forced draught, superheat or high pressure steam. Many vessels were fitted with such machinery in 1930, and they therefore claimed that it was legitimate to use the word " modern " in the sense that the figures did represent the result of modern practice, although it was obvious that they would be considerably modified if advantage were taken of the many devices now available for improving the efficiency of the triple expansion engine. The figures supplied by Mr. John Neill, of the North Eastern Marine Engineering Works were a valuable contribution to the paper since they indicated most forcibly the increase in the useful work available as a result of the introduction of superheated steam.

It was stated by Mr. Hamilton Gibson that " in a purely rotary job vibration did not occur except at the propeller." The Authors regretted that they were unable to confirm this statement, because it was within their experience that on certain direct driven turbine steamers, quite unpleasant vibration had been experienced other than that due to the propellers. Vibration was also by no means unheard of in the case of purely rotary auxiliaries, for example, a turbo-electric auxiliary generator.

It was most interesting to note from Mr. Farmer's remarks that a gyro-stabiliser was to be fitted to a new Lloyd Sabaudo liner. It would remain to be seen whether the gyro would give sufficiently powerful resistance to rolling to give passengers a substantially higher degree of comfort, but in any case there was no doubt whatever that the mere fact that a gyro-stabiliser was fitted would make the vessel in question considerably more attractive to potential passengers.

With regard to Mr. Calderwood's remarks, the problem of retaining at much higher speeds the same efficiency as that of a propeller running at normal r.p.m. was one of the greatest interest and importance, and it would be a distinct advantage if there could be a certain degree of co-ordination of research between the experiment tank and the wind tunnel, with a view to exploring the possibilities of much higher propeller revolutions than those at present adopted.

Mr. Calderwood's query in regard to freight earnings was answered by drawing his attention to the statement on page

960, where it was pointed out that in Fig. 2 the operating cost was expressed in terms of the freight rate at which the owner's profit was zero. A corresponding analysis of the freight earnings of a modern fast cargo liner was published in "Fairplay" on October 16th, 1930, in the form of an extract from a speech by Sir Frederick W. Lewis. It would be noticed that for this type of vessel, the item relating to port charges was even higher than in the case of the tramp steamer.

It was anticipated that electric synchronising gear would very shortly be installed on a new British motor yacht, and it would then be possible to demonstrate the extent to which vibration could be eliminated with this system. In the case of a motor yacht it was standard practice to use a tunnel dynamo driven from one of the main propeller shafts by chain drive, so that the auxiliary engine generators could be shut down when the vessel was cruising. Synchronising alternators as described in the paper would make it possible to dispense with the tunnel dynamo.

Mr. Ayling's remarks concerning standard tonnage were well worthy of consideration. It was pointed out in the verbal replies to the discussion how far the Scandinavian shipbuilding countries had gone in this connection.

Mr. Evans' remarks were very interesting, and it would have been interesting to have had further information in regard to the attitude of the firm of marine engineers referred to, on the subject of electrical synchronisation by means of two alternators.

With regard to the question of mechanical stokers Mr. Evans raised, these had been used successfully at sea, particularly on the Canadian Pacific cargo vessels. They represented in a way an alternative to pulverised coal firing, and the reason that they had not been more used might be due to the activities of the pulverised coal people.

With regard to the fitting of twin rudders to the M.Y. *Colombia*, Mr. Spanner evidently did not appreciate the fact that this was the first occasion on which twin rudders had been specially designed and fitted with the object of improving the propulsion. He said "it was practically forced upon designers of the Maier form ships to use twin rudders." This was rather overstating the case. There was merely an inducement. There were now over 20 vessels built on the Maier form, but the *Colombia* was the first one to have twin rudders, so that it was distinctly misleading to suggest that the Maier system "practically forced " twin rudders in the case of twin screw ships. There was no need to justify the statement that the Maier form " permitted a reduction of wetted surface on given displacement and dimensions." It was a statement of fact and not of argument.

The statement that " a passenger ship must be attractive—to passengers—and must partially sacrifice efficiency for speed " must obviously be considered in relation to its context. In the case of a passenger ship, speed had an absolute value, apart altogether from consideration of efficiency. Sheer speed was a definite attraction to potential passengers as individuals, and more generally it was of enormous publicity value. When the speed of an Atlantic liner, for example, had been definitely fixed on a purely economic basis, taking into account all the purely numerical factors involved, such as passenger receipts, bunker bills, etc., the speed must be increased beyond that point because speed was attractive to passengers.

Dealing now with Mr. Spanner's points, 1, 2, 3 and 4:

1. They were not acquainted with any theoretical or practical mechanism whereby the linear energy of the slip stream could be recovered without destroying thrust. If there was such a mechanism available, Mr. Spanner should disclose it.

2. On the majority of vessels, the maximum diameter was usually fixed by the tip clearances, and as between a cast iron propeller and an alternative bronze propeller, the alteration in design was usually limited to the pitch, the blade surface and the blade thickness. Cast iron involved relatively thicker blade sections than bronze, and under certain conditions the thicker section was an advantage, particularly at large angles of incidence.

3. On the subject of fouling, Mr. Spanner would be interested in the contribution to the discussion from the Chief Chemist of Messrs. J. Dampney and Co., Ltd., and the Authors' reply thereto.

4. Whether the statement criticised by Mr. Spanner was too sweeping or not was largely a matter of personal opinion. Presumably Mr. Spanner would agree with the Authors that on a large passenger ship rolling was distinctly more important than pitching.

They were very pleased to have a contribution to the discussion from Mr. Hinde, and to note his qualified approval of the economic section of the paper.

Whilst the fluctuations in rates of freight were certainly overwhelmingly greater than differences in running costs due to fluctuations in efficiency, the fact remained that over a period of years, rates of freight must necessarily fluctuate about a mean value which was sufficient to give world shipping as a whole some return on capital invested. Nevertheless, who could deny that the owner of the most efficient tonnage was in a position to set the pace, and no doubt Mr. Hinde himself as an owner and operator of highly efficient tramp tonnage was inevitably compelling competitive owners to consider the construction of vessels perhaps even more efficient than his own.

Mr. Champness's remarks contained suggestions of very considerable importance, and in particular his point in regard to first-class passengers on many modern liners being expected to share a cabin with some two or three total strangers. This "curious survival of antiquity" as Mr. Champness described it, was something which must be eliminated as quickly as possible from first-class passenger vessels.

Possibly it attained its most unpleasant form on night service cross-channel vessels, because although the voyage was infinitely shorter, cabins were much smaller, and particularly in bad weather such intimacy as a small cabin imposed could be extremely unpleasant. They would suggest that railway companies at least should follow their own very excellent sleeping car practice in the arrangement of large numbers of small single berth compartments, rather than waste a large amount of space on cabines de luxe.

Mr. Lovett pointed out that most of the economies which had been effected in recent years had been achieved on the hull side, and that engine room improvements in efficiency were sometimes effected at the cost of increased power to drive the auxiliary machinery necessary in connection therewith. He might have added also that these improvements were usually gained at the expense of a substantial increase in maintenance costs.

The question he raised as to using coal in the cylinders of internal combustion engines was attractive and would at once go to solve a great many of our industrial problems. They would point out that such experiments were made in some of the earliest Diesel engines, but later, for a variety of reasons, had to be abandoned.

It was very encouraging to note that in Mr. Ayre's opinion they were at, or very near to, an upward trend of the trade cycle.

Mr. Harrison raised one or two interesting points in connection with electrical synchronisation. The output of the alternators was normally about one-fifth of the output of the main engines. In exceptionally heavy weather resulting in a specified torque difference between the two shafts, the alternators were automatically disconnected, and under the same circumstances it would also be desirable to use the standby plant for the auxiliary load. With Diesel drive there was no doubt that the scheme outlined by Mr. Harrison, consisting of flywheel alternators on the engines to synchronise the engines, and alternators on the propeller shafts to synchronise the propellers, would be a distinct advantage from the point of view of freedom from vibration. The increase in cost would possibly be more than compensated by the increased comfort to passengers and consequently the greater popularity of the vessel.

Mr. Jenkins' remarks on the question of anticorrosive and antifouling compositions were extremely interesting, although it was at the same time disappointing that Mr. Jenkins considered there was no immediate prospect of solving the particular problem at issue. The subject was certainly one which fully deserved further ventilation, and if possible, more exhaustive research.

Dr. Taylor pointed out that it was possible to reduce the amount of linear energy for a given thrust by increasing the propeller diameter, but this was not, of course, the same as recovering that energy when once it had been transmitted to the slip stream. On very few vessels was it possible to make any material increase in propeller diameter, even in the design stage. In the case of single screw ships the diameter was limited by the height of the engine seating above the base in association with the rake of the shaft, and also by conditions of propeller immersion in the ballast condition. On twin screw vessels, for a minimum clearance between the blade tips and the hull, an increase in diameter could only be obtained by carrying the shaft bossing further aft.

With central propulsion there would unquestionably be a negative thrust deduction under ideal conditions, but as Dr. Taylor pointed out it was quite possible that this effect would be minimised by constructional requirements. It was gratifying to have Dr. Taylor's appreciation of what was certainly an important point in regard to their conception of wake gain. The expression was apt to be misleading, and the net wake gain, if any, must be arrived at after making allowance for the higher propeller efficiency which would in most cases be obtainable if there were zero wake.

In regard to shell butts, it was understood that the advantage of reversing the direction had been definitely confirmed by tank tests, but in course of the same experiments it was also found that when the butts were chamfered, the margin of improvement became almost negligible.

The cost of fitting synchronising alternators was quite moderate and compared very favourably with the installation of other anti-vibration devices such as dynamic balancers. It must also be borne in mind that in many types of vessel the synchronising alternators could be used for supplying auxiliary power at sea, thus making it possible to dispense, in the case of a motor yacht for example, with shaft driven dynamos. It was a distinct advantage on small vessels with limited engine room staff, to be able to supply all the power required at sea direct from the main engines.

Mr. Rettie's arguments in favour of coal represented the standard arguments of those people who did not see shipping as a world-wide international business, and in reply they could do no better than refer him to the reports of Mr. Sterry B. Freeman's remarks at the Annual Conference of the Institute of Fuel last year.

In assessing the value of one per cent. gain of propulsive efficiency at about fifty per cent. of its apparent value, Mr. Carey would see on referring to the context, that due allowance had been made for ballast voyages, and also for "capacity" voyages when the vessel was not loaded down to her marks, but nevertheless had full holds.

Mr. Carey's comments on passenger ship design and on vibration were much appreciated. In the matter of vibration set up by auxiliary machinery, the Authors used the term "isolation" in the sense of mounting auxiliary machinery on special pads or seatings, known generically as isolators.

Mr. Jobling's remarks on the average tramp owner only being able to scrape just sufficient capital together to keep his fleet up to his requirements scarcely fitted in with the tenor of the modern shipping business. The point they were making in the paper was that if the average tramp owner could not "scrape sufficient capital together" even to build an obsolescent type of ship, then he certainly would be unable to make money in any case and had therefore better retire from the business. They would emphasise that it was not an economic position to build an old-style 7,000 tonner to-day, and they would suggest that Mr. Jobling should be much more explicit in his term " all the latest gadgets." If standard tonnage suited the Scandinavian owner who was rapidly getting hold on business to-day on world trade routes, then it would necessarily have to suit the British owner too if he was to get his fair share of charters. With regard to the last paragraph of Mr. Jobling's contribution, they were perfectly serious in their suggestion, and would refer him to some of the electric ferries in New York where there was only one man on watch below managing the entire engine-room, and he had nothing to do. Battery-electric propulsion would dispense even with this one man.

Mr. McGovern's remarks were a valuable contribution to the discussion, and it was interesting to note that whilst, as he pointed out, shipbuilders were working continuously towards more efficient design, there were still a number of hitherto unsolved problems which were nevertheless capable of immediate solution in the experiment tank, to the benefit of the industry generally.

Mr. Brownlie could see no justification for the view that shipping differed in any essential feature from other industries. Consider, however, the coal industry for example; the coal owner corresponded to the shipowner, and it might be assumed for the sake of argument that the manufacturer of cutting machinery and other equipment corresponded to the shipbuilder. Whereas shipping met with no appreciable competition from other methods of transport, coal on the other hand was faced with acute competition from other forms of fuel. Consequently the shipbuilder was unquestionably in a stronger position than the manufacturer of coal cutting tools, or for that matter, the manufacturer of oil boring equipment.

They did not quite follow Mr. Brownlie's argument in the question of cost of propulsion. The fact remained that for every extra hundred tons of bunkers, one hundied tons of freight earning cargo was lost. It was, therefore, only logical to debit each ton of bunkers with the current freight rate, provided, of course, that the vessel was assumed to be loaded down to her marks.

On the subject of wake gain, they would refer Mr. Brownlie to their reply to Dr. Lockwood Taylor.

With propellers amidships, any alteration in pressure on the parallel middle body in no way affected the resistance of the ship.

Mr. Brownlie was quite right in pointing out that with negative wake, negative real slip automatically became a possibility. He was no doubt aware that in the case of high speed vessels such as torpedo boat destroyers, there might actually be negative wake at the stern if a hollow in the transverse wave system occurred at that point, due to the orbital motion of the particles in the wave.

ABSTRACTS.

MARINE BOILER DESIGN IN 1930.

"The Engineer," January 9th, 1931.

Without doubt, the most interesting phase of marine engineering practice in 1930 was the advance we have to record in boiler design. Successful efforts were made to reduce the number of boiler units required in a large liner, with a corresponding saving in space, weight, and first cost, and a smaller number of boiler attendants. One of the most original of the new designs was that of the Johnson boiler which is associated with the name of Mr. J. Johnson, the superintendent engineer of Canadian Pacific Steamships, Ltd., who, in recent years, has done so much to advance high-pressure, high-temperature, geared turbine propulsion. In Mr. Johnson's opinion, the existing types of water-tube boilers all bear traces of their original design, which was produced for hand-firing with coal. Now that injected fuel in the form of either oil or powdered coal is used, it becomes possible to enclose the furnace, so that it is surrounded by water tubes, all of which are exposed to radiant heat and some fraction to heating by convection. We reproduce two views of a "Johnson" water-tube boiler, which was built by Yarrow and Co., Ltd., for the C.P.R. steamer *Princess Helene*. It will be seen that two large-diameter drums are employed. They are supported on the front and back walls of the boiler in such a manner that free expansion can take place. The tubes are curved round to form a cylindrical surface, and there are also—as shown—a central and end walls of tubes. Air-cooled or water-screened refractory material is arranged at the front of the furnace to support the temperature of combustion and to shorten the flame. The diameters of the tubes are so proportioned in relation to their length and duty that good circulation on the Yarrow principle is obtained without priming. The size of the furnace is so fixed that the requisite

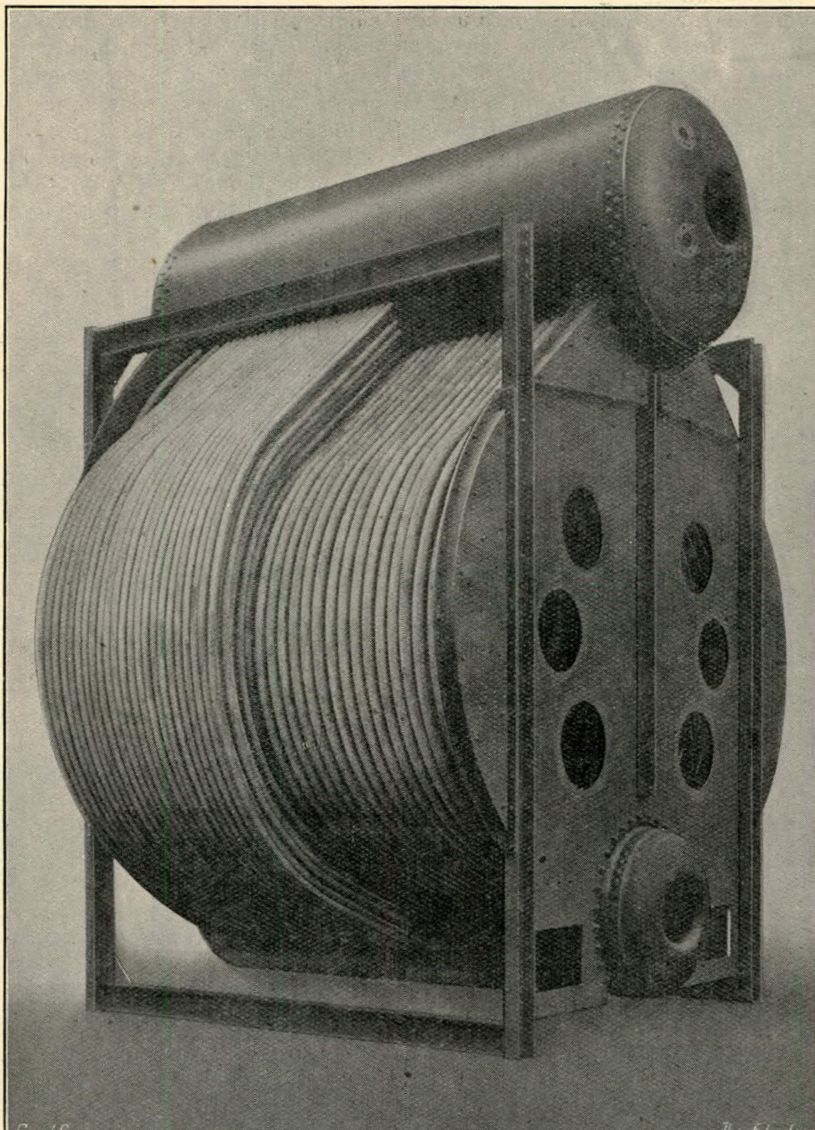


Fig. 1. Johnson Boiler Tubed ready for Outer Casing.

length for complete combustion is obtained before the gases leave the boiler. A feature of the boiler is the use of preheated air at a temperature of 500 deg. Fah., which heat is obtained partly by an air heater arranged above the boiler, and partly by contact with the front part of the furnace walls. Tests which were made on the boiler installed on the *Princess Helene* and on a 10,000 S.H.P. single-ended boiler built by John Brown and Co., Ltd., at Clydebank, forming part of the boiler

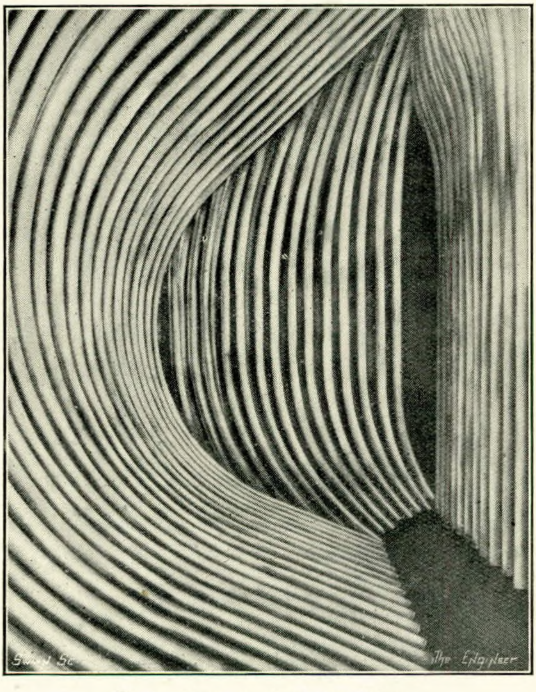


Fig 2. Furnace of Johnson Boiler.

equipment of the *Empress of Britain*, show that at mercantile ratings and for the same efficiency, the Johnson boiler will yield for the same weight of boiler and air heater, double the output of the three-drum water-tube boiler. The average transmission rate over the whole tube surface is shown to be doubled, while the mean transmission rate in the furnace tubes is reduced. It is claimed that the inside of the tubes are easily examined, and brushed, and brickwork renewals are reduced to a minimum. Spare tubes are carried in straight lengths, and can be bent in the boiler-room should they be required. Designs have already been prepared for single-ended and double-ended Johnson boilers with designed outputs up to 10,000 and 20,000 S.H.P. respectively, and the special requirements of naval service have not been overlooked.

Noteworthy developments took place with regard to the Yarrow water-tube boiler during the last year. Six large boilers of this type were constructed to Yarrow designs by the Fairfield Shipbuilding and Engineering Company, Ltd., for the *Empress of Japan*, one of which is shown. They are side-fired, and the normal output of the installation is 30,000 S.H.P. Eight Yarrow boilers are being constructed at Scotstoun and Barrow for the new P. and O. turbo-electrically propelled liners *Strathnaver* and *Strathaird*, which are being built by Vickers-Armstrongs, Ltd., at Barrow-in-Furness. Four of these boilers form the main boiler installation in each ship, and they are accommodated in a boiler-room, having a length of 60 ft. 6 in. and about 80 ft., the full width of the ship. The heating surface of each boiler is 12,500 square feet, and the working pressure 425 lb. per square inch, with 750 deg. Fah. total superheat and temperature. The four boilers will provide steam for 28,000 S.H.P., and two of them are designed to give the ship a speed of 16½ knots. For auxiliary and port use, two smaller 3,000 square feet boilers, operating under the same steam conditions, are fitted in each of the ships. Towards the end of the year it was announced that the design of the boilers for the new Cunarder had been entrusted to Messrs. Yarrow, and that they would be built at Clydebank by John Brown and Co., Ltd.

Messrs. Babcock and Wilcox have under construction a demonstration boiler designed for a working pressure of 1,575 lb., and a superheated steam temperature of 850 deg. Fah., and have also in operation a 550 lb., 750 deg. marine water-tube boiler with powdered coal. A feature of this boiler is the water-cooled smooth ashpit floor, which produces a flaky friable ash of a non-caking type. The two 500 lb. high-pressure water-tube boilers on the *King George* have given uninterrupted and satisfactory service, with easy steaming.

A new boiler of 1930 was the Babcock and Wilcox sectional express type, which was designed and built by the American Company, and was tested in the Philadelphia Naval Yard. As the illustration shows, the boiler follows to a large extent normal B. and W. design as regards its circulation, but the

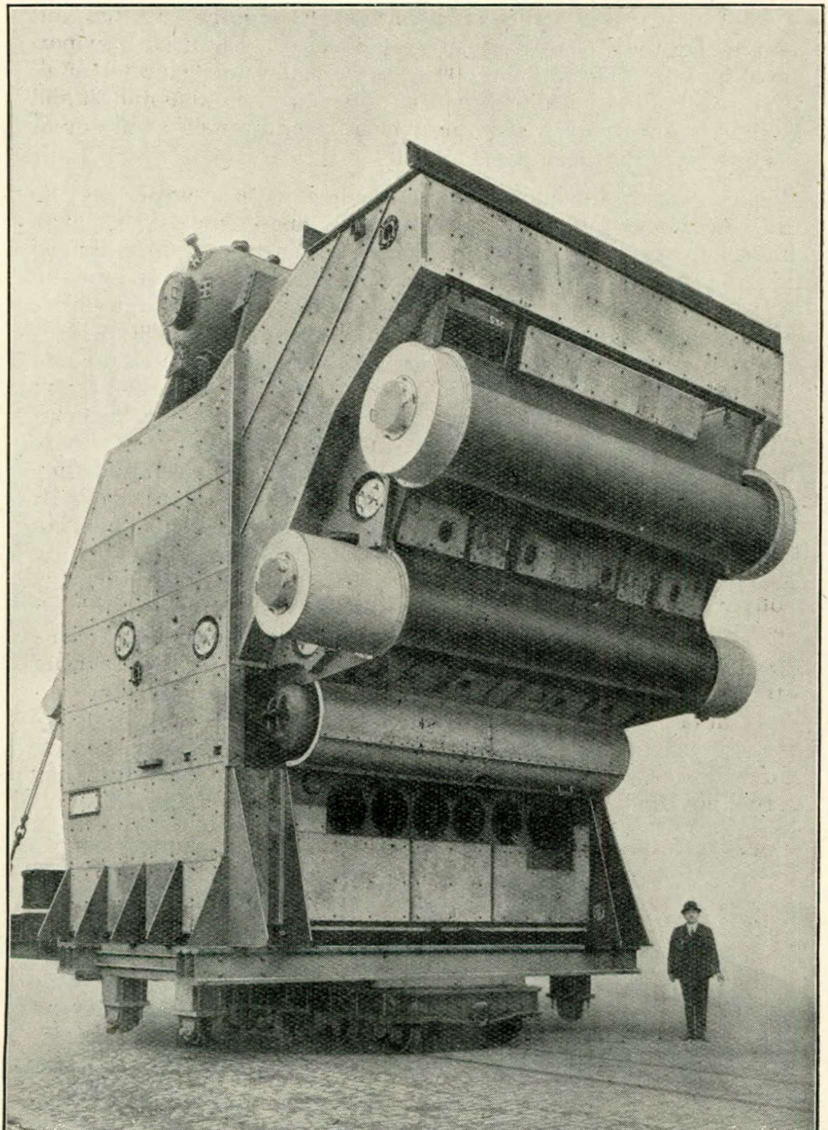


Fig. 3. Side-Fired Yarrow Boiler for "Empress of Japan."

headers are cylindrical in form, each of the elements comprising two headers and the associated tube bank. The lower portion of the boiler heating surface consists of a tube screen with the tubes expanded into horizontal bottom headers. All connections between the steam drum, bottom drum, and headers are made by standard nipples.

The bottom two rows of tubes have a diameter of 2 in. and are followed by four rows of 1½ in. diameter tubes, which form the lower section of the heating surface. The remaining tubes can be 1¼ in. or 1 in. in diameter, and are arranged to give a deep nest with a high heat transfer efficiency. A superheater of the interdeck type is placed between the lower tubes and the sections. The first boiler of the sectional express type was tested by Commander J. G. Broshek, of the United States Navy, and gave boiler, superheater, and furnace efficiencies varying from 84·62 to 82·75, when burning from 0·25 lb. to 1 lb. of fuel oil per square foot of heating surface, and operating at 300 lb. working pressure. Further tests at 600 lb. pressure showed overall efficiencies of over 80 per cent., all tests being carried out without air heaters. The design is one which, we learn, will be put forward by the British Company for those conditions in which a light boiler of the narrow-tube type is required.

An interesting boiler development in Germany was the installation by Blohm and Voss, of Hamburg, of a Siemens-Benson critical pressure boiler,* on the Hamburg-America ship *Uckermark*. This ship has been working from Hamburg to Port Said, with, we understand, very satisfactory results, and a fuel consumption of about 0·55 lb. of oil per horse-power hour has been obtained, although steam is used at a lower pressure and temperature than that at which it is generated, and the latest fuel saving arrangements have not been fitted.

Improved Superheaters for Scotch Boilers.

The good results which have been obtained with high-pressure, high-temperature, water-tube boilers, have caused more attention to be paid to the gaining of higher superheat temperatures with Scotch boilers, which are usually designed for working pressures of 250 lb. to 275 lb. per square inch. With the new design of combustion chamber superheater, which during recent months has been tested in service by the North-Eastern Marine Engineering Company, Ltd., and the Super-

* 3,200 lb. per sq. in. This is one additional experimental boiler, supplying h.p. steam to a small h.p. "booster" turbine. (ED. Trans.)

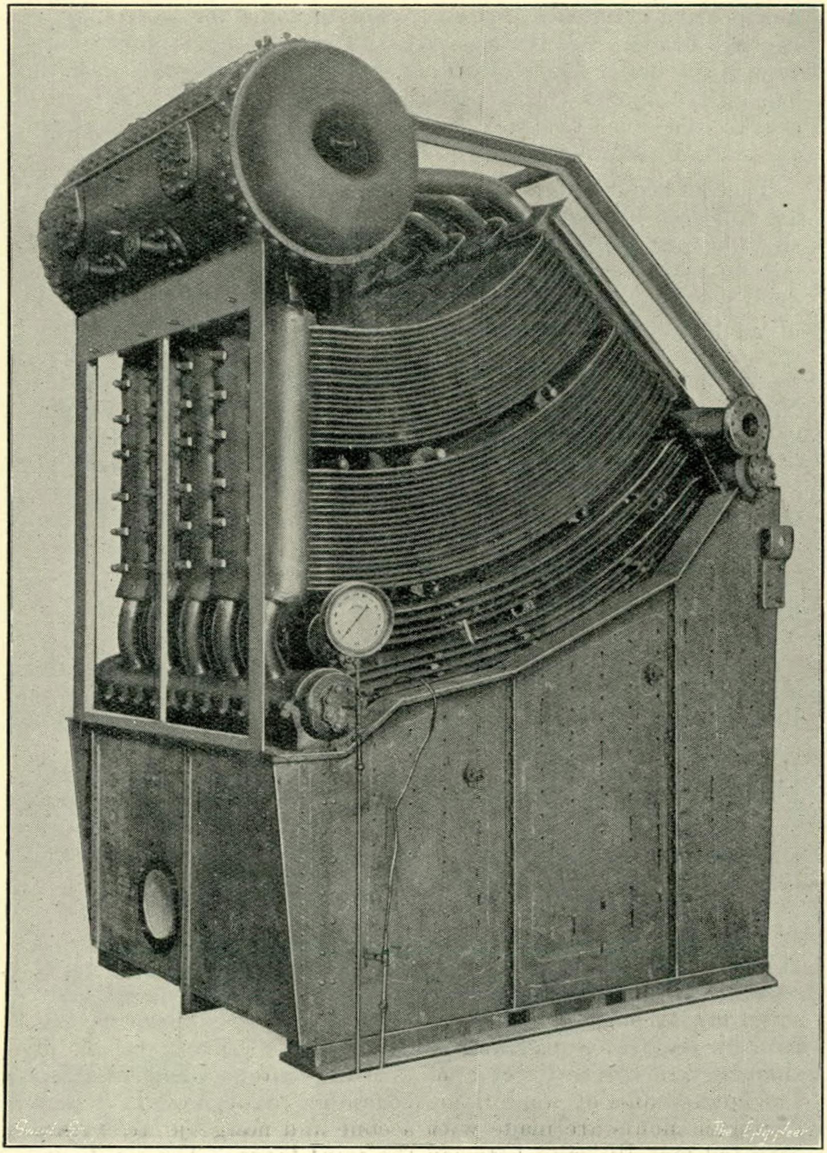


Fig. 4. Babcock and Wilcox Sectional Express-Type Boiler.

heater Company, Ltd., temperatures of 680 deg. Fah. to 725 deg. Fah. are now obtainable at the turbine stop valves. Such superheaters have been fitted in the Canadian Pacific liners *Montcalm*, *Montclare*, and *Montrose*, and in the P. and O. liner *Mongolia*, and have, we are informed, given most satisfactory results. As shown, the superheater tubes, which are usually $1\frac{1}{4}$ in. diameter 9 w.g. solid-drawn steel tubes with forged spear

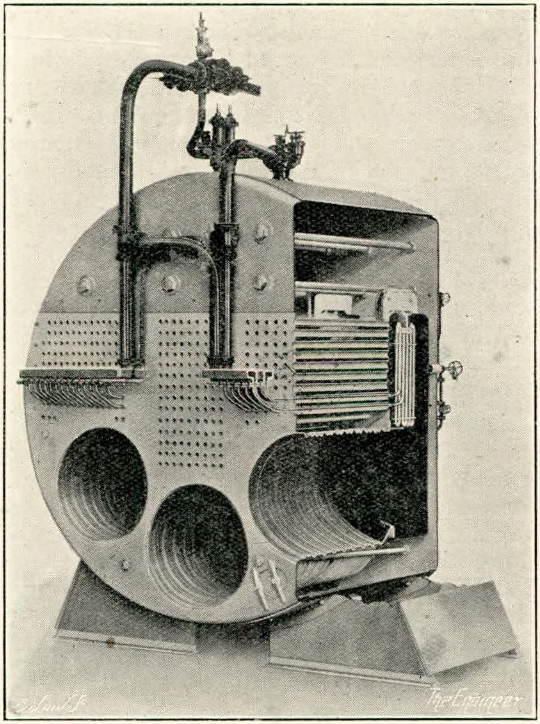


Fig. 5. Combustion Chamber Superheater.

ends, are arranged vertically, and are supported from a mild steel girder, which is arranged in a cool part of the combustion chamber and is in direct contact with water-cooled surfaces. The connections between the inlet and return legs of the superheater elements are made with a cone and flange joint, with a serrated metallic ring between the joint faces. The joints are easily accessible and can be tightened or hardened up after steam pressure has been applied. The size of the headers and the elements is so chosen that the steam temperatures of the metal skin is retained at a safe figure, while the pressure drop through the superheater is not more than 10 lb. to 15 lb. It has been found possible to obtain the necessary heating surface without using the total number of furnaces in any given boiler. Thus, in a three-furnace boiler, only the two side furnaces would have superheater elements at the back of the combustion chamber. When manœuvring, therefore, under which condition less steam would be flowing through the superheater than normally, the side furnaces could be eased and the heat fully maintained on the centre furnace only, which arrangement would give considerable latitude in the matter of superheater temperature regulation. By using steam blowers, the tubes can be kept clean and the high efficiency maintained. In the earlier designs of combustion chamber superheaters, the spear ends, which are staggered in relation to each other to give an even gas flow, were slightly baffled. Such a baffle has been shown by practical running to be unnecessary, and the spear ends are now continued well into the throat of the furnace, so that the full effect of the furnace heat is utilised.

For a smaller degree of superheat, namely, about 120 deg., the uptake superheater designed by T. Sugden and Co., Ltd., of London, was supplied to twelve ships, including *Bank* and *Clan* liners and the whaling factory *Tafelberg*. The operation of this type of superheater at sea has shown that very steady superheat temperatures can be maintained, and so far, we are informed, not a single element has had to be renewed, which shows the long life of this type of superheater. Standard smoke tube superheaters were also fitted to ships by the principal makers of these auxiliary appliances.

We are indebted to "The Engineer" for the loan of the blocks illustrating the foregoing abstract.—ED. Trans.

SOME RECORDS OF THE OUTPUT OF MARINE MACHINERY, 1930.

"Engineering," 2nd January, 1931.

The engines for 13 single-screw steamers, making together 35,300 i.h.p., were constructed by Messrs. David Rowan and Company, Limited, Elliot Street, Glasgow, during the year. Two sets, each of 3,750 i.h.p., were supplied for the steamers *Benledi* and *Benlawers*.—Triple-expansion engines for three steamers, aggregating 5,540 i.h.p., have been supplied by Messrs. Blair and Company (1926), Limited, Stockton-on-

Tees. Marine boilers representing 19,770 i.h.p. were also constructed.—Messrs. McKie and Baxter, Limited, Copland Works, Govan, Glasgow, S.W.1, constructed 15 sets of steam engines, totalling 10,300 i.h.p., and comprising machinery of various classes.—The total s.h.p. of marine geared turbines constructed by Messrs. The Parsons Marine Steam Turbine Company, Limited, Turbinia Works, Wallsend-on-Tyne, was 47,300. The total s.h.p. of mechanical gearing, to be used in association with marine steam turbines, amounted to a further 74,600. In addition, gearing aggregating 80,000 s.h.p., for use with marine turbines, has been cut for licensees.—Messrs. John Dickinson and Sons, Limited, Palmers Hill Engine Works, Sunderland, have engined the steamers *Runswick* and *Stakesby*, and supplied three additional boilers, the aggregate i.h.p. involved being 4,370.—In addition to supplying 179 oil-burning installations for marine and land work, and to constructing 25 marine boilers, Messrs. The Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, have supplied the propelling machinery, the total power of which is 118,400 i.h.p., for 11 vessels. These include twin-screw geared turbines for H.M.SS. *Brilliant* and *Bulldog*. The remaining nine vessels were motorships.—Messrs. R. and W. Hawthorn, Leslie and Company, Limited, St. Peter's Works, Newcastle-on-Tyne, constructed the propelling machinery for 10 steamers, the total h.p. of which was 80,850. Among them were the 34,000-s.h.p. sets of engines for H.M.SS. *Blanche* and *Boadicea*.—Six vessels were engined by Messrs. John Readhead and Sons, Limited, West Docks, South Shields. The total i.h.p. amounted to 15,750, the largest set, for the *Registan*, being of 4,550 i.h.p.

THE NEW JUGOSLAVIAN FLOTILLA LEADER.

"The Engineer," 7th November, 1930.

The new flotilla leader for the Royal Jugoslavian Government, which has been ordered from Yarrow and Co., Ltd., of Scotstoun, Glasgow, bears the distinction of being the largest and most powerful ocean-going vessel of this type yet built in this country, either for the British or any foreign navy. We are indebted to the builders for the following information concerning this interesting vessel. Her displacement will be about 2,400 tons, and she will have a length of 371ft. 6in., a beam of 35ft. and a depth of 22ft. 9in. She will be propelled by a twin-screw arrangement of geared turbines, the whole of the power being transmitted through single-reduction gearing of the double helical type. Special care will be taken to balance dynamically the turbine rotors and gearing to avoid vibration and obtain smooth running. The designed output of the turbines will be about 42,000 shaft horse-power. Steam will be supplied from three boilers of the latest Yarrow water-tube type, with the firm's own design of super-heaters and air heaters. The main armament of the new destroyer is to include four $5\frac{1}{2}$in. guns and two triple torpedo tubes. All parts of the ship are to be fitted with the most modern equipment, and with a view to service in hot climates, very roomy and comfortable accommodation is to be provided. The order for the ship was placed at the end of last year, and the work on her hull and machinery is now well in hand.

A "Minor" Explosion!

"The Engineer," 7th November, 1930.

In commenting on a minor boiler explosion on board a small cargo vessel, caused by the fracture of a combustion chamber stay, the Engineer Surveyor-in-Chief says:—"The corroded condition of the screw threads at the end of the fractured stay and in the stay hole in the combustion chamber plate indicates that leakage had occurred for a considerable time, and it is probable that the leakage resulted mainly from local bulging of the plate. Heating surfaces should be kept clean to avoid risk of overheating and consequent bulging of the plates, but where bulging does occur and it is not so serious as to necessitate renewal of the plates, it is desirable to remove the screwed stays in the vicinity, retap the distorted holes a larger size and fit correspondingly larger stays. If it is not practicable to arrange stays normal to the plates, suitable tapered washers should be fitted under the stay nuts."

The Marine Oil Engine Trials Committee and the New Blue Funnel Motor Liner "Polyphemus."

"The Engineer," 7th November, 1930.

At the end of last week the official trials took place of the new Blue Funnel motor liner *Polyphemus*, which has been built and engined by Scott's Shipbuilding and Engineering Company, Ltd., of Greenock. The new ship is one of four, three of which have been built at Scott's, specially designed for the Java trade of Alfred Holt and Co. She is a 6,400 gross tons cargo liner with a water line length of 426ft. 6in. and a beam of 56ft. with a depth of 31ft. 9in. Her propelling machinery, which comprises a twin-screw arrangement of four-stroke six-cylinder motors working on the single-acting supercharged principle with air injection, is of special interest owing to the fact that the engines are of British design and, with the exception of the Büchi supercharging device, are entirely free from any patents or monopoly devices which would prevent them from being constructed by other builders. They each have a designed output of about 2,700 S.H.P. at 138 r.p.m. The trials to which we have referred took place on the measured mile at Skelmorlie, and after the builders and owners had been satisfied, early on Thursday of last week the ship was made available for the Marine Oil Engine Trials Committee. The trials were continued throughout Friday and part of Saturday, and there were present several members of the Committee and the official observers, headed by Dr. J. S. Brown, a principal surveyor of Lloyd's Register of Shipping, and Mr. C. W. J. Taffs, the Secretary of the Committee. The same methods and sequence of trials adopted in the case of the other five ships tested by the Committee were employed, and it is understood that very complete information as to the performance of the ship in her partly loaded condition was obtained under the very favourable measured mile trial conditions which prevailed.

LAMPS WITHOUT FILAMENTS.

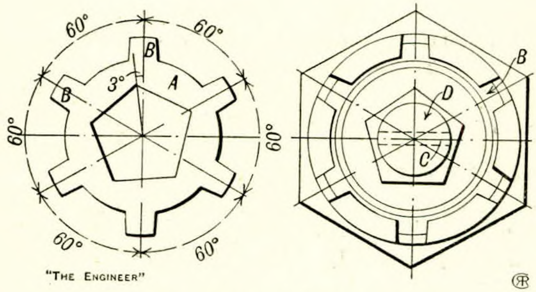
"The Engineer," 14th November, 1930.

In the course of a brief historical survey, Mr. H. Marryat, lecturing on "Luminous Electric Tubes" before the Junior Institution of Engineers on November 7th, stated that the present luminous tubes containing neon, helium and other rare gases so much in evidence in our cities for advertising and other purposes, were the lineal descendants of the Geissler tube, the scientific toy of more than fifty years ago. For a great many years practically no advance had been made in the application of the principle, but the notable discoveries of Professor Crookes, Sir William Ramsay and other scientists in connection with the separation of argon, helium, neon and other rare gases had provided the means for putting the exhausted tube containing various quantities of those gases to commercial and practical uses for illuminating purposes, and such was the present rate of progress in overcoming certain inherent difficulties in manufacture and operation that he predicted the time was undoubtedly coming when this system of illumination would supersede all others, mainly owing to its fundamental efficiency and its ready application to practically all kinds of illumination.

POSITIVE LOCKING.—A NOVEL CASTLE NUT.

"The Engineer," 21st November, 1930.

An interesting development of the castle nut arrangement, based upon the inter-relation of prime numbers, developed by Professor Rateau, is given in Comptes Rendus des Séances de L'Academie des Sciences. As will be seen from the illustration, the bolt carries a star piece A, having six branches B, which fit into the recesses on the castle nut, a clearance of about 3° being provided between the branches on the star piece and the recesses on the nut. The centre of the star is provided with a hole of pentagonal form, which is an exact fit on a corresponding pentagonal prism on the bolt D, the star being held in position by a split pin C. The angle of a pentagon is



Block kindly lent by "The Engineer."

108°, and that of a hexagon 120°, so that, five and six being prime to each other, in one of the five different positions of the star on the bolt agreement within 12° must be obtained between the branches of the star and the recesses of the nut. Turning the star piece over, agreement must be obtained within 6°, so that as there is a clearance of 3°, at the worst it is only necessary to turn the nut 1·5° either one way or the other in order that agreement can be effected. Thus, the lock is sensitive to within 1/240th of a turn, which, for all practical purposes, is negligible. In other words, a positive lock is obtained for all positions of the nut on the bolt.—" Faraday House Journal."

STEAM PIPE FAILURES.

"The Engineer," 28th November, 1930.

It is noteworthy that among the most recently reported "boiler explosions" there are three cases of the failure of solid-drawn copper steam pipes on board comparatively small steamers. In each case the accident is attributable to local stressing and failure to anneal the pipe sufficiently frequently. In one case, that of a steam drifter, the Engineer Surveyor-in-Chief says:—"The conditions of service of steam fishing vessels is recognised as being most severe, and the steam pipe ranges should therefore be designed having due regard to this. The main steam pipe range on this vessel was designed with bends, but heavy stresses due to the movement of the boiler and machinery were imposed on the pipe neck at the flange attached to the engine stop valve. This is the second time the pipe has failed. On the first occasion a repair was effected before an explosion occurred, and the second failure was hastened by the excessive vibration following on the breaking of the propeller shaft. A stay has now been fitted with the object of relieving the pipe neck of stress, but the owners would be well advised to consider a re-arrangement of the design of the range when a favourable opportunity occurs.

PULVERISED-FUEL PLANT ON THE S.S. "LORAIN."

"Engineering," 7th November, 1930.

A pulverised-fuel plant of an unusual, if not a unique, nature has just been installed on the S.S. *Lorain* by Messrs. Todd Dry Dock Engineering and Repair Corporation, Brooklyn, New York, U.S.A., and although the vessel is only now making her first voyage under the new conditions, so that performance results are not available, some account of the plant should prove of interest. The S.S. *Lorain* is owned by the United States Shipping Board, and is operated on the North Atlantic between the United States and France by a subsidiary company of the Cosmopolitan Shipping Company, of 42, Broadway, New York, U.S.A., viz., the American-France Line. The vessel is 395ft. 6in. long between perpendiculars, with a moulded beam of 55ft. and a moulded depth of 34ft. 11in. The draught, loaded, is 27ft. $0\frac{1}{4}$in., and the deadweight 9,759 tons. The normal speed at sea is 10·5 knots. She was built in 1919 and fitted for burning oil in three single-ended Scotch boilers, each having three furnaces and constructed for a working pressure of 210 lb. per square inch. Measured on the United States Shipping Board's efficiency scale, the S.S. *Lorain* was rated at better than 100% for vessels of her class. The standard set for comparison with pulverised fuel is, then, high, and it is to be hoped that when the results of the working with this fuel are made available, some log data on previous oil consumption will accompany them for comparison.

It is in this latter connection that the installation is unusual, as the whole of the original oil-heating and pumping equipment has been left in place, the only change made being that the oil-settling tank just forward of the stokehold bulkhead was moved a frame space forward to allow more space for the coal chutes, etc. The oil burners remain in the furnace fronts, being adapted for use as lighting-up burners for the pulverised coal, and a change over from coal to oil can be made when the ship is under way by simply changing the burner nozzles. The stokehold personnel would be the same in number with either fuel. The great advantage of this dual method of firing is, of course, that the vessel can utilise the cheapest fuel which happens to be available—that is, either coal or oil, the oil being bunkered, and handled exactly as before. From the point of view of comparing the efficiency of the two fuels it is, however, very valuable, in that coal could be burned for one-half of a long voyage and oil for the other, thus enabling results to be recorded for a vessel in practically uniform conditions of load, trim, and hull cleanliness. Dock and other trials have been run at New York on pulverised coal, which, we understand, have indicated a high degree of efficiency, but, as the vessel was light at the time, the results obtained are not considered of equal value to those which it is proposed to record under sea-going conditions.

The coal drawn from the bunkering port is stored in spaces between decks, which are filled through a coaling hatch on the boat deck just abaft the funnel and through two hatches opposite No. 3 cargo hatch. The latter hatch has been cased in to the upper deck and coal trunks provided on the outboard sides of the casing, so that both 'tween-deck spaces can be filled with the minimum of trimming. The raw coal is fed to a grizzly with 6in. squares fitted in the top of the service bin at the upper deck level, and from them passes into a crusher situated just below the grizzlies. This crusher has a capacity of 12 tons per hour, is fitted with a tramp-iron separating pocket, and is driven through speed-reducing gear, by a 15 h.p. steam turbine. From the crusher, the coal falls into the service bins. Other grizzlies at the top of the service bin allow the small coal, not needing crushing, to fall directly into the service bin. There are no elevators or conveyors in the entire system, the downward flow of coal throughout the processes of bunkering, trimming, and feeding to the pulverisers being effected by gravity. There are three triplex pulverising mills each driven by a 30 h.p. steam turbine, and connected to the Todd burners on the furnace fronts by steel flexible hose 4in. in diameter. The operating instrument equipment is very complete, and includes nine CO_2 connections, three smoke detectors, and nine thermo-couples connected to a nine-point selector switch voltmeter, as well as the ordinary draught gauges, pressure gauges, etc. The Fuel Conservation Committee of the United States Shipping Board certainly deserve the thanks of the American Mercantile Marine for their enterprise in experimenting with pulverised fuel in such a practical way as that described above. Previous installations with which it has been concerned are the S.S. *Mercer* and the S.S. *West Alsek.*

ELECTRICAL PROPULSION OF SHIPS.

"Shipbuilding and Shipping Record," November 27th, 1930.

The proof of the pudding is in the eating," and the fact that the P. & O. Company have ordered two more electrically-propelled passenger liners is sufficient proof that they, at least, are satisfied with their first electrically-propelled vessel, the *Viceroy of India.* There are, however, many marine engineers, particularly those who have been closely connected with the application of the geared turbine to the propulsion of ships, who remain unconvinced as to the superior merits of the electric drive. In this connection, it will be recalled that at this year's spring meetings of the Institution of Naval Architects, Mr. W. J. Belsey read a paper entitled "The Performance of two vessels with Electric Transmission Gear," the vessels in question being the P. & O. liner *Viceroy of India,* and the Atlantic Refining Company's Diesel-electric oil tanker *Brunswick.* In the course of the subsequent discussion a full report of which, together with an abstract of the paper, was given in our issue of April 17th last (see page 507, *et seq*), a number of speakers expressed their conviction that, from the point of view of fuel consumption, the electrically-propelled steamer was the inferior of a similar vessel driven by turbines connected to the propeller shaft through mechanical speed-reduction gearing. In particular, Mr. John Johnson, the superintendent engineer of the Canadian Pacific Line, gave a comparative table (which we reproduced in our report referred to above) showing the Admiralty coefficient, the fuel coefficient, and the specific fuel consumption of the *Duchess of York*, the *Empress of Australia*, and the *Viceroy of India*, in which it was shown that the performance of these vessels was in the order named, the *Duchess of York* being the most economical of the three. At the close of the discussion, Mr. Belsey promised that he would reply in writing to the various criticisms raised, and it is of interest to note that his reply is now available in the seventy-second volume of the Transactions, which has just been published.

It is always a difficult matter to make an exact comparison between the performance of two more or less similar vessels, because of the large number of variable quantities which have to be taken into account, and Mr. Belsey, in his published reply to the discussion on his paper, mentions some of the variables which militate against the accuracy of the comparisons made by Mr. Johnson. In the first place, the comparison is made between the *Viceroy of India* sailing at powers between 6,800 S.H.P. and 15,300 S.H.P. and the *Duchess of York* steaming at full service power throughout the complete voyage. In the second place, Mr. Johnson ignores the effect of vacuum, which in the *Viceroy of India*, on account of the temperature of the sea-water in the tropics, cannot average more than 28·1 in., whereas 29 in. is obtained in the "Duchess" ships, representing a difference of at least five per cent. in the steam consumption of the main turbine. Lastly, the fact that on the *Duchess of York* the auxiliary power is obtained from Diesel-engine driven generators, while on the *Viceroy of India* turbo-generators are employed also makes a difference in the "all-purposes" consumption, which, since Diesel oil costs twice as much as fuel oil, brings the consumption of the former vessel equivalent to 0·7 lb. per S.H.P., which is in excess of that returned by the latter. In order to make a comparison with an electrically-driven vessel which is sailing at a constant speed and developing about the same power as the "Duchess" vessels, Mr. Belsey takes the International Mercantile Marine Company's vessel *Virginia*, and is thus able to show that the electrically-propelled vessel is actually superior to the geared-turbine ship. The geared-turbine liner *Statendam*, according to the figures given in Dr. Meijer's paper read at the same meeting, has a total water rate of 9·55 lb. of steam per S.H.P. for all purposes, while under conditions closely approximating to those on the *Statendam*, the *Viceroy of India*, operating one turbine at full load, had an equivalent water rate of 9·1 lb. A last point on the subject of consumption made by Mr. Belsey in his reply is that the total fuel consumption of the *Viceroy of India* is being continually improved, the figures for a recent round trip being 3,150 tons, as against the 3,521 tons for the voyage referred to in the paper.

On the question of flexibility, particular value lies in the fact that the electrically-propelled vessel can exert its maximum power in the astern direction. This means that the ship can be brought to rest in 2 min. 50 sec. from full speed ahead, as compared with 3 min. for a similar geared turbine vessel with the usual arrangement of astern turbines. This 50 seconds is of great value, as it represents, perhaps, one and a half ship's length, which may be the difference between perfect safety and disaster. The value of this astern power is also exemplified by the fact that owing to the additional quickness in manœuvring, the *Viceroy of India* has made the passage through the Suez Canal in 11 hr. 35 min., as compared with the previous best time for a P. & O. ship of 15 hr. 30 min. Another point to which Mr. Belsey draws attention is the ease with which repairs can be carried out in the engine room with electrical machinery. Thus, if a partial "burn-out" were to occur, the affected coils could be cut out, and the vessel could proceed at slightly reduced power, while the repair even to the extent of a complete re-wind could be made without taking the machinery out of the ship. If, on the other hand, a mishap occurred to a gear wheel, the job of repairing it involved taking the wheel out and sending it to the shops. Further, owing to the absence of any rigid connection between the propeller and the prime mover, the risk of damage when striking any submerged object is considerably reduced. Finally, Mr. Belsey reminds his readers that those companies which have been persuaded to adopt the electric drive have invariably fitted it on subsequent vessels, and this, he considers, is conclusive evidence of the merits of this system of propulsion.

A NEW MARINE ENGINE.

"Journal of Commerce," 4th December, 1930.

Shop trials have been completed of a new six-cylinder two-stroke cycle, single-acting marine heavy oil engine, designed and built by Messrs. Scott's Shipbuilding and Engineering Co., Ltd. The new engine has six cylinders 27 in. in diameter, by 45 in. stroke, and 3,000 b.h.p. is developed at 112 r.p.m. Generally, the engine is similar to the Scott-Still machinery built at Greenock a few years ago for the Blue Funnel motor liner *Eurybates*. The well-known Still reinforced cylinder liner is used, but, naturally, no steam cylinders are provided in the new engine. Airless injection is used, and the fuel valve (each cover carries a single fuel valve in its centre) are automatic. Automatic starting air valves are provided, the result being a commendably clean cylinder top. As with the *Eurybates* machinery, the new engine is fitted with rotary supercharging valves adjacent to the exhaust ports. This feature enables the piston skirts to be of moderate length, and it should also make for economy in scavenging air. The scavenging pump is located at the centre of the engine between cylinders Nos. 3 and 4, while the fuel pumps are accessibly placed at engine-room floor level. This interesting new engine is being installed in the single-screw motorship *Anshun*, for the China Navigation Company, the hull of which has also been built by Scotts. The vessel is 350 ft. long by 60 ft. beam by 33 ft. deep, and is of about 3,200 gross tons, being intended for passenger and cargo service out East. It is worthy of note, in connection with the machinery installation, that a Cochran composite (waste heat and simultaneous oil firing) boiler is to be employed for generating steam for various purposes, this boiler being 15 ft. high by 6 ft. in diameter, and designed for a working pressure of 80 lbs. per square inch.

THE NEW CUNARD LINER BEGUN.

"The Engineer," 5th December, 1930.

On Monday last the contract between the Cunard Steamship Company, Ltd., and John Brown and Co., Ltd., of Clydebank, for the building of the new express liner was sealed and signed at a special Cunard board meeting held in Liverpool. For some time past the building berth has been in course of preparation and the laying down of the keel has now been begun. The principal dimensions of the new Cunarder were recently referred to in a parliamentary discussion and the gross tonnage was given as 75,000; the length as 1,018ft., and the capacity as 7,300,000 cubic feet. No official announcement has yet been made with regard to the propelling machinery for the new ship, but it is generally understood that quadruple-screw Parsons turbines with single-reduction gearing will be installed and that steam will be generated in a modern installation of high-pressure oil-fired boilers of the Yarrow water-tube type. The Clyde Navigation Trust has agreed to proceed with the widening of the river Clyde so that the new liner can be safely launched, and when completed can proceed down the river. The work of widening and deepening the Clyde will cost about £79,000. A section of land will have to be cut away from the west bank of the river Cart opposite to the Clydebank Shipyard, and the river channel will have to be widened at the bend at Rashielee Light, on the south side of the river nearly opposite the Dalmuir sewage works. The new liner is expected to be launched at the end of May, 1932, and will probably go down the river in the September of the following year.

A LARGE GRAVING DOCK FOR SOUTHAMPTON.

"The Engineer," 5th December, 1930.

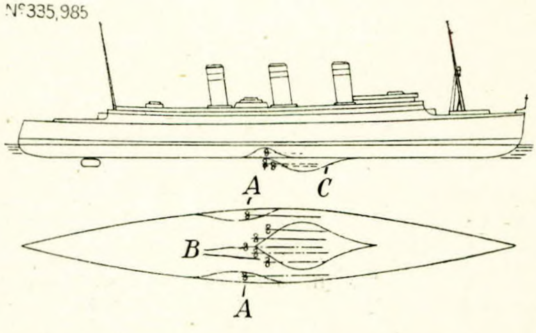
In order to meet the wish of the Cunard Steamship Company, Ltd., that dry docking accommodation should be available at Southampton for the new Cunard liner, the directors of the Southern Railway Company have agreed to build a new graving dock which will have a length of 1,200ft., an entrance width of 135ft., and a depth of 45ft. No definite site for the dock has yet been decided upon. One possible site is that adjacent to the new dock extension works on the Millbrook shore, which includes the new Cunard berths, part of which, it is hoped, will be ready for service early next year. Another alternative site is the Weston foreshore on the Netley side of Southampton Water, where land is owned by the railway company, and where in the past it has been suggested that a big dry dock might be constructed. The new 1,200ft. dry dock will be the seventh to be constructed at Southampton, if the floating dry dock be excluded, and it is hoped that it will be ready for service in 1933. The railway company has given serious consideration to the proposal to enlarge the present floating dry dock. The decision, however, to build a graving dock may be taken as a possible indication that although the construction costs for the graving dock may be heavier, the upkeep charges will be less. In order to prepare the bed for the present floating dry dock it was necessary to dredge to a depth of 65ft. and to remove about 940,000 cubic yards of soil, and the desired depth has only been maintained at a heavy expense for dredging, owing to the constant silting up of the bed. The new graving dock will be the largest in the world.

MR. J. DE MEO'S CENTRAL PROPULSION SYSTEM.

"The Engineer," 5th December, 1930.

335,985. July 5th, 1929.—PROPELLER SYSTEMS, J. de Meo.

The inventor proposes to set the screw propellers of vessels amidships, so that the pitching of the ship will not affect their submergence, and vibration of the machinery will, consequently, be minimised when steaming in a seaway. The inventor has, in the past, suggested that this *desideratum* might be



attained by arranging two side propellers as at A A in recesses in the bilges. He now suggests the addition of further propellers under the bottom at BB. The shafts of these propellers would emerge from the after end of the excrescence C beneath the hull, and the lines of this excrescence would be faired off into those of the hull proper. Several modifications of the same broad principle are described in the specification.—*October 6th*, 1930.

NEW TURBO-ELECTRIC LINERS FOR THE DOLLAR LINE.

"The Engineer," 5th December, 1930.

The first of the two new turbo-electric liners ordered in American shipyards for the Dollar Line service from California via Honolulu to Japan, China, and Manilla, is to be named *President Hoover*, and she will be launched on December 9th, the naming ceremony being performed by Mrs. Herbert Hoover. The new liners, which will have a length of 653ft., with a beam of 81ft., and a depth of 52ft., are to have a displacement of 31,000 tons, with a measurement of 23,000 gross tons, and 15,800 tons deadweight carrying capacity, including 67,000 cubic feet of refrigerated space. The number of passengers to be carried by the various classes will total 1,250, and there will be a crew of 300. Accommodation is to be provided for 320 first-class passengers and 140 passengers of a new special class, the remaining accommodation being allotted to the other ordinary classes. The new ship will be electrically propelled by a twin-screw arrangement of synchronous propelling motors, which will receive A.C. from two sets of turbo alternators, the steam being supplied by a modern boiler installation. The designed sea speed is to be 21 knots. The two new liners we have referred to are to form the first part of a building programme comprising four super-turbo-electric liners, which are included in the present building programme of the Dollar Steamship Line, of San Francisco. The *President Hoover* is being built at Newport News, Virginia.

PROBLEMS OF SHIP DESIGN.

"The Engineer," 12th December, 1930.

Some interesting and important considerations relating to the design of efficient ships were discussed in a paper which was read before the Institute of Marine Engineers on Tuesday evening last by Dr. J. Tutin and Mr. A. C. Hardy. The authors put forward the view that it lies in the power of the shipbuilder to stimulate orders for new tonnage by the design of super-efficient ships. The operating costs of a tramp ship were examined, as also was the performance of the propelling machinery. The possible improvements outlined in the paper included modifications in hull form, the re-designing of propellers and a fresh consideration of their best position in relation to the hull, the finding of a possible remedy for sea-sickness, including the automatic stabilisation of ships, and improvements in passenger accommodation. The idea that what was needed was an organisation which, by research, experiment and invention, will effect a comprehensive improvement in ship design by the cumulative effect of detailed improvements, follows the recent plea of Mr. John de Meo, for a reconsideration of the whole problem of ship propulsion and the co-ordination of the technical interests in each country in order to bring about this very desirable end. Mr. de Meo's proposal that future ships should be propelled by small screws at the centre of the hull, either in pockets at the sides or below the ship's bottom, was favourably referred to at the meeting.

RUST CAUSES EXPLOSION.

"The Engineer," 12th December, 1930.

An unusual case of boiler explosion is recounted in one of the latest official reports. It is that of the safety valve fitting of a Scottish hopper barge. The boiler appears to have been about twenty-eight years old, although the vessel was built in 1864. The safety valve blew off under a pressure of about 30 lb. per square inch, and two men were rather badly scalded. It was discovered that four of the set screws used to hold the valve to the steam dome had been fractured for some time, and ultimately the remaining two failed. Their failure is attributed to a very small leak of steam, which was not visible, but was sufficient to moisten the joint and produce rust. The expansion of volume in the production of the rust was sufficient to break the screws.

OIL TRANSPORT BY PIPE LINE.

"The Engineer," 12th December, 1930.

A 760 mile pipe line from the Texas Panhandle to St. Louis, embracing many innovations in oil transport, is now under construction for the Phillips Pipe Line Company, a subsidiary of the Phillips Petroleum Company, to expedite movement of the company's petrol from the Texas oilfields to important retail marketing centres. Fifteen booster stations, placed at intervals along the line will receive the oil at about 50 lb. pressure and deliver it back into the line at between 750 lb. and 800 lb. pressure. The conventional motor-driven direct-connected circulating pumps at the booster stations will be displaced by gas engines driving very high-speed pumps, through speed-up gears. Gas from the company's fields, of which there is an abundant supply, will be "slugged" in liquid form into the pipe line and pumped between consignments of commercial petrol. These slugs of fuel will be withdrawn at the booster stations and stored in tanks, awaiting use by the pumping engines. Each booster station is to be equipped with three pumping units, two of which will provide for the line's designed capacity of 30,000 barrels a day, one being used only as an emergency standby. The engineers engaged in the construction of the line hope for a greater transport capacity at less cost per barrel for the long run when the line is completed. The pipe line products, on arrival at St. Louis terminus, will be shipped east, north and south, via the Mississippi River.

Boiler Explosion Report, No. 3100. Steam Trawler "Daniel Clowden."

The explosion occurred at about 2 a.m. on the 21st June, 1930, while the vessel was at the fishing grounds off the Galway Coast. No person was injured.

The boiler was of the cylindrical return tube type, and was 13 feet 6 inches internal diameter and 10 feet 6 inches in length. The shell plating was $1\frac{1}{8}$ inches in thickness. It was fitted with three plain furnaces, 3 feet 6 inches in external diameter and 25/32nds inch in thickness, each having a separate combustion chamber. The stays between the combustion chambers were of steel and were $1\frac{3}{4}$ inches in diameter. They were screwed 9 threads per inch and were fitted with a nut at each end. The boiler was said to have been constructed for a working pressure of 180 lb. per square inch and was fitted with the usual mountings including safety valves set at 180 lb. per square inch.

The boiler was made about 1919.

The following are the only repairs that can be traced. On the 1st May, 1927, 20 plain tubes and the adjacent stay tubes were re-expanded; in April, 1928, all plain and stay tubes were re-expanded, also 13 stays were renewed and some stays re-caulked; in November, 1928, the port and starboard furnaces were jacked up; in May, 1929, some girder stays in combustion chamber tops were renewed.

A piece of a broken stay, situated between the centre and port combustion chambers, in the second row from the bottom, was blown out of the centre combustion chamber wrapper plate, allowing the contents of the boiler to escape through the hole into the chamber. The boiler was rendered useless and the vessel was towed into port.

The screwed stay had broken within the thickness of the centre combustion chamber wrapper plate at some previous time, leaving a portion of stay in the plate. The thread of the stay and plate had corroded until it became so wasted that it failed to hold the piece of stay against the pressure in the boiler, with the result that the piece of stay was blown out.

The vessel on which this explosion occurred is a trawler propelled by reciprocating engines supplied with steam from a single ended boiler of the usual cylindrical return tube type. She was acquired by the present owners in 1927 and the machinery, including the boiler, was accepted for classification in

Lloyd's Register of 1928. The company's fleet was removed from Milford Haven to Fleetwood this year and a new superintendent engineer was then appointed. Complete records of the repairs to the boiler are consequently not available, but it is stated that 13 stays were renewed in April, 1928. The reason for these renewals or the position of the stays cannot be ascertained, but it is probable that they were combustion chamber stays.

While the vessel was at the fishing grounds in June last, a slight hissing noise was heard in the centre combustion chamber and it was concluded that a stay was leaking slightly but not sufficiently to be serious. At 2 a.m. on the 21st June, while the second engineman was on watch, there was a loud report in the chamber followed by the emission of water from the furnace mouth. The steam pressure at the time was 175 lb. per square inch, and as he was firing this furnace at the time and was uninjured, the explosion could not have been of a violent nature.

The boiler is stated to have been emptied in about 10 minutes and the two wing fires were then drawn, the centre one having been extinguished by the escaping water. An examination of the combustion chamber was made and it was found that a stay had blown out as previously described. The chief engineman then advised the skipper to send for assistance, and the vessel was towed into port by the steam trawler *Peter Carey*, belonging to the same owners.

When the vessel was visited by me, a new stay, 2 inches diameter, had been fitted, and, consequently, the thread in the stay hole could not be examined, but the thickness of the plating appeared to be well maintained. The plate was stated to have buckled slightly in the vicinity of the broken stay and was faired before the new one was fitted. The part of the broken stay, with nut, that was blown into the centre combustion chamber was produced for my inspection and it was found to have fractured at a cross section within the thickness of the wrapper plate. The fracture was not at right angles to the axis of the stay, but commenced level with the internal surface of the plate and terminated about half-way through its thickness. From the appearance of the fracture, the steel of which the stay was made was close grained and hard, and there was no local discoloration indicating any inherent flaw. The appearance of the fractured surfaces, however, indicated that the stay had been subject to a considerable torsional stress at some time, and I am of opinion that this was the primary cause of the fracture. There was no reduction of effective area at the point of fracture such as may be caused by corrosion. The nut was removed from the broken part of the stay and it was found that the thread was in good condition and not unduly strained.

The stay had probably been fractured some time before the explosion, and the threads of the small portion had gradually become wasted by corrosion until they failed to hold it against the pressure in the boiler and the explosion occurred. The end of the other portion of the fractured stay would remain close to the surface of the plate and partially obstruct the free passage of water through the stay-hole, which explains why the discharge was not more violent. The repairs to the boiler, after the explosion, included the fitting of 13 new combustion chamber stays, four of which were 2 inches in diameter.

The boiler was afterwards satisfactorily tested by hydraulic pressure to 1½ times the working pressure.

Observations of the Engineer Surveyor-in-Chief.

The fracture of the stay being within the wrapper plate probably accounted for this defect not being detected when the boiler was inspected. The explosion occurred when the threads, holding the small piece of stay in the plate, had become so corroded that they were insufficient to withstand the pressure in the boiler.

The consequences of the explosion in this case were not serious.

INSTITUTE NOTES.

JUNIOR SECTION.

Lecture: Types of Internal Combustion Engines.

On Thursday, December 11th, Mr. E. W. Cranston, Wh.Sc., Graduate, delivered a lecture at the Institute on "Types of Internal Combustion Engines." The Author, who is pursuing a course of special study in this subject, presented an orderly survey of the engines of all varieties of stroke and cycle which have become recognised as successful in the strenuous competition between British and foreign makers for a leading place in the market, both land and marine. This survey was combined with a masterly analysis of the essential features of each type and their special points of distinction. The lecture was illustrated by a very complete series of lantern slides and diagrams.

An interesting discussion followed, which indicated the close attention with which the audience had followed Mr. Cranston's discourse, and the speakers were unanimous in voicing their high opinion and appreciation of the lecture. There were nearly 50 junior members and visitors present on this occasion, and the duties of Chairman were ably discharged by Mr. E. R. Hall. At the conclusion of the meeting a hearty vote of thanks was accorded Mr. Cranston for his paper.

BOOKS ADDED TO THE LIBRARY.

Presented by the Publishers.

"Engineering Economics," by T. H. Burnham, B.Sc.Hons. (Lond.). Second Edition, 1930. Published by Sir Isaac Pitman and Sons, Ltd., Kingsway, W.C.2. Price 10/6 net.

It has been often said that many excellent technical engineers are comparatively of little value outside their technical sphere, and that for success an engineering business should have a good commercial man in supreme charge. This criticism is very frequently true, because in the past an engineer's training has been strictly technical, and no time has been allowed to anything outside. This state of things is due in large measure to the absence of competition, so that costs of production did not require such close watching as is the case to-day.

The Author devotes detailed attention to the commercial aspects of producing cheaply, and we commend it to the close study of all who are engaged in works management. It is clearly written and well printed, and will maintain the reputation of the Author and publishers alike.—G.J.W.

"Higher Mechanics," by Horace Lamb, D.Sc., LL.D., F.R.S. Second edition, 1929. Published by the Cambridge University Press. Price 15/- net.

This is a valuable addition to the Institute's Library. It is intended to be a sequel to the Author's " Statics " and "Dynamics"; it is, however, quite independent of them though occasional references are made to each. Whilst the book consists only of some 200 pages, it is very comprehensive, and written in the Author's well known concise and lucid style, and it covers the field.

It treats of three dimensional kinematics, statics and dynamics, and still claims to be an *elementary* treatise, although a fair knowledge of mathematics is necessary to read it. The Author's admitted mastery of mathematics leads to a very concise method of writing, which assumes that the student is capable of realising the deductions that may be drawn from the formulæ, also his ability to fill in the intermediate steps in the analysis. The book can be commended as a safe and lucid work on difficult subjects.—G.J.W.

The Bolinder Book (*Erratum*).—It is regretted that the Author's name was inadvertently omitted from the review of "The Bolinder Book" in the December issue, page 952. The Author is Mr. Walter Pollock, Member.

BENEVOLENT FUND.

A donation of 10/6 is gratefully acknowledged from A. L. Donald (Member).

ELECTION OF MEMBERS.

List of those elected at Council meeting held on January 5th, 1931:—

Members.

William Barr, 9, May Terrace, Giffnock, Glasgow.

William George Cranston Butcher, 25, Woonona Road, Northbridge, N.S.W.

Andrew Cockburn, 113, Wilton Road, Southampton.

Frederick George Cooper, York House, Malvern Link, Worcs.

John Herbert Davies, 1, Shirley Road, Roath Park, Cardiff.

William Frank Holman, The Eastern Telegraph Co., Ltd., C.S. "Transmitter," Freetown, Sierra Leone, B.W.A.

Robert Elliott Huggan, 51, Huskisson Street, Liverpool.

Herbert Maurice Laws, 43, York Road, Ilford, Essex.

Robert Roberts Liddell, 1380, Nanton Avenue, Vancouver, B.C.

Lewin Shirley Maxwell, 50, Aintree Avenue, East Ham, E.6.

James McCabe, 121, Manners Road, Southsea, Hants.

Francis Melrose McChesney, Morawel, Towyn, Merionethshire.

John Alexander Muir, 11, Princes Street, Stranraer.

Douglas Muras, 26, Falconer Street, Newcastle-on-Tyne.

Frank Thomas Newcombe, *c/o* McMartin, 6, Playfair Street, Bridgeton, Glasgow.

George Pickering, Lloyd's Register of Shipping, Hong-Kong.

Norman Stanley Rowstron, 9, Woodside, Sunderland, Co. Durham.

Koshiro Shiba, Mitsubishi Shipbuilding and Engineering Co., Ltd., Tokyo, Japan.

James Spray, 320, Plumstead Common Road, S.E.18.

Alexander Maver Suttie, 47, Shamrock Street, Dunfermline.

Ernest Ashley Tee, 80, Hill Lane, Southampton.

George Thomas, 64, New Station Road, Whitchurch, Glam.

Walter Henry Williams, Asiatic Petroleum Co. (North China) Ltd., Hankow, China.

James Oswald Young, The Shell Co. of Egypt, Alexandria.

Companion.

Richard Reginald Jackson, 27, Grayham Road, New Malden, Surrey.

Associate-Members.

Walter Ernest William Delo, Azoff, Row Hill Wood, Wilmington, Kent.

Thomas Hislop, 11, Maple Terrace, Meir, Stoke-on-Trent.

James Thomas Moore, 77, Castellain Mansions, W.9.

Vernon Motion, 165, Queen Victoria Street, E.C.4.

Sidney Charles Newton, Compton, Pendennis Road, Streatham, S.W.16.

Associate.

William Stuart Rae, Osborne House, Bryn Road, Swansea.

Graduates.

Maurice James Barrett, Sarnia, Jotman's Lane, South Benfleet.

Leslie Herbert Howe, 84, Grangemill Road, Catford, S.E.6.

Stanley Kendrick, 5, Woodgreen Road, Stoneycroft, Liverpool.

John C. R. Sundercombe, 27, Normanby Street, Middle Brighton, S5, Victoria, Australia.

Transferred from Associate-Member to Member.

George Webster Atherton, 234, Bedford Road, Rock Ferry, Birkenhead.

Alfred Harold Jobling, Rothes, The Square, Freshwater. I.o.W.

Transferred from Graduate to Associate Member.

William Denis Arnold, 12, Colworth Road, Addiscombe, Croydon.

Alexander Davis Bean, 732, Dumbarton Road, Dalmuir, Glasgow.

Transferred from Graduate to Associate.

Edmund Carlton Garratt, Crows-nest, Pear Tree Lane, Shorne, Kent.

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BOARD OF TRADE EXAMINATIONS.

List of Candidates who are reported as having passed examination for certificates of competency as Sea-Going Engineers under the provisions of the Merchant Shipping Acts.

For week ended 4th Dec., 1930: –

NAME.	GRADE.	PORT OF EXAMINATION.
Reid, Alexander S.	1.C.E.	Glasgow
Andrews, John H. J.	1.C.	,,
Asher, Roderick J. N.	1.C.	,,
Wallis, Cyril	1.C.	,,
Allan, Alexander	2.C.	,,
Davidson, Charles J. G.	2.C.	,,
Purves, John	2.C.	,,
Appleton, Thomas F.	1.C.M.	,,
Macdonald, William J.	1.C.	Leith
Bowie, George	2.C.	,,
Buchan, William	2.C.	,,
Mathers, Lyle Mackay	2.C.	,,
Young, James	2.C.	,,
Anderson, Frederick	1.C.	Southampton
Wells, Joseph S.	1.C.	,,
Brown, Ernest	1.C.	London
Hunter, Sydney D.	1.C.	,,
Tucker, Frank W. G.	1.C.	,,
Beauchamp, Claud W.	2.C.	London
Cay, William H.	2.C.	,,
Delo, Walter E. W.	2.C.	,,
Dick, William	1.C.M.E.	,,
Humphreys, Evan I.	1.C.	Liverpool
Roberts, Tudor L.	1.C.	,,
Hewitt, Charles L.	2.C.	,,
Hislop, Thomas	2.C.	,,
Kilvert, Francis E.	2.C.	,,
Mace, Henry A.	2.C.	,,
Stirling, Samuel H.	2.C.	,,
Venables, William H.	2.C.	,,
Cullin, Robert P.	1.C.M.	,,
Lightfoot, John K.	2.C.M.	,,
Jones, Evan R.	1.C.M.E.	,,
Dingwall, James L.	1.C.M.E.	,,
Harpur, Herbert J.	1.C.	Belfast
Venart, Charles H. S.	1.C.	,,
Findlay, Thomas N.	2.C.	,,
Davies, Ernest A.	1.C.	Cardiff
Jones, Windsor	1.C.	,,
Williams, William R.	1.C.	,,
Billot, Frederick E.	2.C.	,,
Lloyd, William K.	2.C.	,,
Phillips, Thomas W.	2.C.	,,
Whitney, Hugh	2.C.	,,
Cartwright, Alfred	1.C.	Newcastle
Taylor, William	2.C.	,,
Bottomley, Frank	1.C.M.	,,

For week ended 11th Dec., 1930: –

Maxwell, Lewin S.	1.C.M.E.	London
Patterson, Lionel J.	1.C.	,,
Stuart, Alexander	2.C.	,,
McGuinness, Thomas F. ...	1.C.M.	,,

For week ended 11th Dec., 1930—*continued.*

NAME	GRADE.	PORT OF EXAMINATION.
Bell, Matthew	1.C.	Newcastle
Little, Joseph	2.C.	,,
Todd, James	2.C.	,,
Wilkinson, Edmund O.	2.C.	,,
Coulthard, John W.	2.C.M.	,,
Grant, Thomas B.	2.C.M.	,,
Trotter, George D. S.	2.C.M.	,,
Graham, William	1.C.M.E.	Hull
Muras, Douglas	1.C.M.E.	Newcastle
Emmerson, Percival J.	1.C.M.E.	,,
Fleming, Francis W.	1.C.M.E.	Glasgow
Bach, Patrick F.	1.C.	Sunderland
Barff, Thomas C.	1.C.	,,
Carr, Thomas E.	1.C.	,,
Darke, Alfred W.	1.C.	,,
Parsons, Richard	1.C.	,,
Mowbray, Gowan	2.C.	,,
Stevens, William	2.C.	,,
Jeffries, Albert	1.C.M.	,,
Nordberg, George G.	1.C.M.	,,
Scott, Thomas	1.C.M.	,,
Black, William A.	2.C.M.	,,
Johnston, William T.	1.C.M.E.	,,
Baker, Leonard	1.C.M.E.	,,
Brown, Alexander B.	2.C.	Glasgow
Duncan, David	1.C.	,,
Gillespie, John	1.C.	,,
Sleven, John J.	1.C.	,,
Bain, John M.	2.C.	,,
Beatts, William K.	2.C.	,,
Headrick, Duncan G.	2.C.	,,
McEwan, James R. H.	2.C.	,,
McNaught, James A.	1.C.M.	,,
Pawson, Frederic A.	1.C.M.	,,
McIver, John P.	2.C.M.	,,
Dunn, Frank C.	2.C.	Hull
Kling, Sydney	2.C.	,,
Whitehead Arthur	1.C.	Liverpool
Wilson, Frederick J.	1.C.	,,
Barnes, James	2.C.	,,
Martindale, James O.	2.C.	,,

For week ended 18th Dec., 1930 :—

Mansfield, Harold V.	1.C.	Southampton
Harding, William R.	2.C.	,,
Lewis, Reginald E. B.	2.C.	,,
Clay, Tom	2.C.M.	,,
Aitken, Donald C.	1.C.	Liverpool
Ankers, Sydney	1.C.	,,
Coleman, Edward J. V.	1.C.	,,
Davies, Ernest W.	1.C.	,,
Jones, Harold	1.C.	,,
McConochie, Herbert A. ...	1.C.	,,
Ruddock, Valentine W. ...	1.C.	,,
Clegg, Arthur R.	2.C.	,,
Lloyd, Stanley T.	2.C.	,,
McDonald, Laurence A.	2.C.	,,
Wright, Lester A.	2.C.	,,
Taylor, John	1.C.M.	,,

For week ended 18th Dec., 1930—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Anderson, George	1.C.	Leith
McNulty, Henry	1.C.	,,
Miller, John	1.C.	,,
Watson, George A.	1.C.	,,
Ross, Thomas N.	2.C.	,,
Brown, Alasdair L.	1.C.	Glasgow
MacKechnie, Alexander ...	1.C.	,,
McWillie, Donald McK. ...	1.C.	,,
Matthews, James M.	1.C.	,,
Donnellan, Thomas J.	2.C.	,,
Smith, John	2.C.	,,
Sneddon, James R.	2.C.	,,
Wardil, Norman	2.C.	,,
Kerr, William	2.C.M.	,,
Scott, Ian H.	2.C.M.	,,
Rooney, Alfred W.	1.C.	London
Venn, Cecil A.	2.C.	,,
Davies, Arthur J.	1.C.	Cardiff
Grice, Douglas	1.C.	,,
Kelly, Eric	1.C.	,,
Jones, Herbert S. W.	2.C.	,,
John, Arthur E.	2.C.M.	,,
Johnson, Walter	1.C.	Newcastle
Mundell, Norman	1.C.	,,
Douglas, William S.	1.C.M.	,,
Smart, Stanley G.	2.C.M.	,,
Jones, William H.	1.C..E	Liverpool
Wells, Joseph S.	1.C.M.E.	Southampton
Leith, Ronald F. P.	1.C.M.E.	,,
Frier, Charles E.	1.C.M.E.	Newcastle
Edwards, Griffith	2.C.E.	Liverpool
Richardson, Frank E.	1.C.M.E.	,,
Whitelock, John K.	1.C.M.E.	Glasgow
Lawrance, Charles S.	1.C.M.E.	,,