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Patron : HIS MAJESTY THE KING. President : Engineer Vice-Admiral SIR GEORGE PREECE, K.C.B.

Whither Coal?

Read by the Secretary on behalf of G. B. BAIRD.

On Tuesday, 13th July, 1943 at 5.30 p m.

CHAIRMAN : J. CALDERWOOD, M.Sc., (Chairman of Council).

Synopsis.

This paper has been prepared by a group of engineers interested in the future of coal and is presented on their behalf by a spokesman. The paper faces up quite frankly to the dilemma in which coal—with shrinking world marine markets—will find itself after the war. The question is posed "how can such ship types as will then logically present themselves for coal use be retained?" The answer which the authors put forward is twofold-mechanisation and the development of the gas engine. The latter is considered from two points of view—bottled gas and the use of producers with W-shaped bunker in front of the producers. The part of the paper dealing with the twofold-mechanisation discusses how coal can be mechanised from mine to bunker door and from bunker door to furnace front.

Coal as a marine bunkering commodity stands at the cross roads. In one direction lies extinction: in the other, a fair measure of prosperity may be obtained by supplying such ships as can still logically use coal and by fostering new methods of using. In this age of mechanisation the employment of clumsy hand-operated fuel is no longer acceptable—either dynamically or, still less, thermodynamically.

Yet the decision as to which road to take is one entirely for the coal industry itself to make. The marine world is no longer coal-minded: some countries have even forgotten its use. So coal must carve its own future, taking a leaf from its energetic rival, oil, in doing so. If coal is to maintain a position in the marine field, as against oil fuel, it must offer equivalent advantages in the direction of efficiency, economy, ease of firing, convenience, and amenities such as cleanliness, etc. In the present disturbed position of coal and oil prices and the difficulty of assessing their relative values in post-war conditions, it is considered that no accurate review of the economies or relative value of the two fuels can be made. It is, however, considered essential that a firm technical foundation should be established as regards the relative merits of the two fuels, and that an exploration should be carried out as to the directions in which the use of coal can be improved so as to provide the keenest competition with oil, with its acknowledged advantages in certain respects, such as uniformity of quality, ease of bunkering and utilization on board ships.

An examination of the situation is not easy, because of the many allied matters. The authors have judged the best way is to ask themselves a series of questions and to attempt to supply such answers as are available in the light of modern experience. Before coming to the broader aspects, some questions occur in considering a typical modern shelter-deck tramp vessel of 10,000 tons d.w.t. Comparing the merits of coal burning, oil burning and Diesel engines for this size of vessel:—

What is the economic life of vessel? The economic life in each case is 25 years.

What is the cargo-carrying capacity? This averages 10,000 tons. Owing to present tonnage measurement laws, the motor ship is unable to take advantage of her smaller machinery space needs.

What is the capacity and facility for standardisation of vessel and engine? Consider that this is equal in each case. What is the cost of repairs? the period of idleness for repairs? and the difficulty of obtaining proper repairs on voyage?

Cost of repairs: Normal running repairs would work out at £5 per day per ship in each case. Survey costs every four years would average £2,500. Period of idleness for repairs should be no greater in any type, provided proper maintenance is always carried out. There should be no difficulty in obtaining proper repairs on voyage, assuming ships visit "normal" ports.

How does the time taken in loading bunkers compare? This is in favour of fuel oil. Each bunkering should save about 30 hours, compared with coal.

What difficulties are experienced in obtaining the right kind of coal or other fuel, and consistency in quality? There is less difficulty in obtaining oil fuel than coal of right quality. This is mainly due to the fact that oil fuel is supplied by half a dozen or so large companies who are reliable, as against hundreds of small coal bunker suppliers who, in the words of an experienced tramp shipowner, "by cutting each others' throats to get business, are wholly unreliable as to quality and quantity". Furthermore it is easier to ascertain the quality and consistency of oil, than that of coal—a pointer in the direction of the need to set up world-wide coal advisory services.

What is the length of voyage possible on full bunkers? This can best be illustrated as follows. The permanent bunkers of the 10,000 ton cargo ship take, say:

Maximum of 1,500 tons of coal—for sample steamer
900 tons fuel oil in double bottoms—for oil burner
800 tons Diesel oil for motorship.

Without refuelling, therefore, the length of voyage possible would be:—

$$\text{Coal}\frac{1{,}500}{35}=42{\cdot}8\text{ days; fuel oil }\frac{900}{18}=50\text{ days; Diesel oil}\frac{800}{10}=80\text{ days}$$

assuming a tons-per-24-hrs. figure of 35, 18 and 10 respectively for Scotch boiler and steam reciprocating (unsuperheated), oil-burning Scotch boiler and steam reciprocating, and a good Doxford-type standard motor.

What is the Present Position of Coal and Its Utilization?

Compared with land practice, very little information appears to be available as to the technical results obtained on marine boilers, particularly of the Scotch type. The performance of ships' propelling machinery is generally expressed as lb. of coal per s.h.p. or lb. of coal per i.h.p. per hr. These overall comparisons are not, in the light of land practice, sufficiently analytical, as two distinct departments are concerned, those of steam generation and steam usage. To assess correctly the performance of such a plant, the exact performance of the boiler must be determined as well as the performance of the steam-using machinery. The expression "lb. of coal per s.h.p. per hr." is only of value when it is known that steam generation is carried out under the most efficient conditions compatible with the type of boiler plant, and similarly the conditions of the steam-using plant are such that the most economical use is made of the steam, again taking into consideration the type of machinery installed. In land practice, the performance of the boiler would be assessed by quite simple methods in terms of efficiency, and this figure would be supported by data such as the efficiency of combustion in terms of CO_2 value, the temperature of the uptake, the carbon loss in ash, and from the weight of coal consumed and the water evaporated, the lb. of steam per lb. of fuel consumed would be determined.

It cannot be learnt that any such methods are usual in marine practice, and it may be stated that with the simplest type of boiler equipment the difference between good firing practice and poor practice can quite easily result in a loss or gain of 10 per cent. in fuel consumption. It is further concluded that the general routine of marine firing lends itself to inefficient boiler practice: the rate of firing is relatively low, being approximately 17lb. per sq. ft. of grate per hr. as against 24lb. and over in land practice; the firing intervals are widely spaced, generally one-hour intervals, fires are re-fuelled heavily, and as on the whole bunker fuel is a relatively good grade coal, the necessary steam production can be obtained even with an inefficient standard of firing. Support of these observations is contained in the trials carried out by Messrs. Bennis Combustion, Ltd., prior to the installation of mechanical firing on a cargo liner, the performance for hand-firing being quoted as 69·4 per cent., whereas with good technique this could be increased to 76 per cent. The technical data accompanying this statement indicates that the standard of firing was low and obviously capable of considerable improvement, particularly when it is kept in mind that when tests of this nature are in progress the general standard tends to be higher than usual.

Unless information to the contrary is forthcoming, it is evident that the performance of the average hand-fired marine boiler can be improved by elementary technical control, and it would appear that this method of control is not either understood or appreciated by marine personnel. Mr. H. L. Pirie, in his *paper "The Correct Utilisation of Coal in Marine Boilers", makes a rather striking statement to the effect that marine engineers who applied for positions with the Coal Utilisation Joint Council were lamentably weak in their knowledge of combustion, and that it was evident that most of these men had spent the greater part of their sea-going time in the engine room rather than in the boiler room. It may be mentioned that the schools for marine stokers now established in different parts of the country under the auspices of the Shipping Federation are training men in methods of firing which have as their primary objective the elimination of smoke, principally by the use of excess air, and that the question of fuel economy has to take second place. Whilst this state of affairs may be necessary in war-time, it is probably establishing methods of firing which in peace-time will need some revision. The establishment of an elementary form of technical control does not require any involved or complicated apparatus. Draught gauges and dial thermometers suitable for sea-going purposes are readily available, and even certain types of flue-gas analysers are suitable for marine work. It must be emphasized that such apparatus will only prove of value if there is the desire or inclination on the part of the engineering personnel to understand the principle of these instruments and the value of their indications. So far as the output of steam is concerned (as measured by feed water input) meters of the rotary type cannot be overlooked, whilst fairly accurate measurement can be obtained by means of continuous counters on feed pumps of the reciprocating type.

What Improvements Can Be Effected by Semi-mechanisation of Firing?

With the exception of forced draught, very little appears to have been carried out in the adoption of what might be termed semi-mechanisation of firing, and even forced draught has not been adopted to the extent it might have been. Numerous vessels rely on funnel draught only, and the ease and facility of steaming is to some extent dependent on weather conditions and also the use of coal of a particular type. The installation of forced draught would render such vessels more independent of outside factors, and improve their steaming capabilities. So far as semi-mechanisation is concerned, the use of rocker bar grates might be instanced as a possible means of improving the efficiency of the marine boiler, and it is further suggested that these could be developed so as to be power-operated, either by steam cylinders or electrical means. This type of grate, to a very considerable extent, relieves the fireman of the necessity of manually handling the fires, and its simple assembly precludes any hazards from breakdown. Another method of semi-mechanisation which is making progress in land practice is the self-cleaning and agitating grate. It is thought that on the marine side, such methods of reducing labour and widening the range of coals which can be used and of improving efficiency of boilers should be investigated with an open mind, and that such improvements should not be condemned on the grounds that they present potential mechanical difficulties or breakdown.

What is the Position of Mechanical Firing?

Mechanical firing as applied to water-tube boilers can be taken as a *fait accompli*—the experience of the Canadian Pacific Steamships, the Koninklijke Paketvaart-Mij., and of the several examples of mechanically-fired steamships owned by the railway companies is proof of this. These examples are, however, criticized on the grounds that these vessels are on regular runs and have the facility of bunkering with fuels chosen for their suitability to the stoker equipment, and that the position of the tramp or cargo liner vessel picking up bunkers of differing characteristics would not be comparable. The obvious answer to this is, cannot the marine stoker be developed to deal with a wide range of coal and is the difference between one coal and another so great as to present a serious obstacle? So far as the Scotch marine boiler is concerned, experience in this direction is not so wide as in the case of the water-tube boiler, but the experience of Messrs. Bennis Combustion, Ltd., and Messrs. Manchester Liners, Ltd., cannot be overlooked. It is claimed that the Bennis stokers installed on Messrs. Manchester Liners Ltd.'s ships were able efficiently to handle a very wide range of fuels of varying characteristics, and it is thought that they have made a very valuable contribution towards the development of Scotch boiler firing.

The economics of mechanised firing appear to be well established. For example Mr. J. Johnson of the Canadian Pacific Steamships, quotes efficiencies of 82 per cent. on water-tube boilers, Messrs. Babcock & Wilcox, Ltd., 84 per cent. on similar boilers and Messrs. Bennis Combustion, Ltd., 84 per cent. on Scotch boilers. These efficiency figures approximate to those obtained by oil firing, and definitely indicate that coal burning under modern conditions will develop efficiencies on a par with fuel oil. Compared with good-class hand firing, the increased economy obtained by mechanical firing is approximately 9 per cent. with the added advantages of higher maintained speed (a quarter to a half knot), lower boiler maintenance costs and reduction of boiler room personnel. At the present time, installation charges are difficult to assess, but Mr. Johnson gave a pre-war figure of 5d. per ton consumed plus 1d. per ton maintenance. It is considered that the development of the marine stoker and incidentally the land stoker can be so framed that the anticipated difficulties of handling various types of coal can be overcome, and in this direction the performance of the Bennis, Erith Roe and Taylor Stokers are indicative. The factors influencing the behaviour of a fuel can be summed up as those relating to size, volatile content, ash content, ash fusion point, and degree of agitation required by the fuel bed.

How Can Complete Mechanisation be Effected?

The solution of the whole problem of bunker fuel is mechanisation. In the authors' proposals the coal bunker is logically arranged in the form of a "W" straddling the engine room. Hoppers are attached to the points of the "W" and feed the coal automatically into the water-tube boilers on the wings of the engine room.

By that means gravity bunkering is as easy as bunkering oil. The bunker itself is self-trimming and a steady flow of fuel to the boiler is possible, thus making for good combustion; the disposal of ash, which is also a highly mechanised process, remains the principal disadvantage.

It is feared that the ordinary Scotch boiler will gradually disappear because of its still far too great fuel consumption, and the excessive space which it occupies for the power it develops.

Highly developed fuel valve or forced circulation type boilers would enable a geared turbine or an up-to-date "Dieselised" steam reciprocating engine to operate on less than one pound of coal per horse power per hour. The type of ship contemplated is not a large passenger liner. The arrangement could be adapted to such cross-Channel ships as remain after the war, but is essentially applicable to the post-war tramp, that vessel which, when normal building is again resumed, will tend in speed and in equipment to resemble the pre-war cargo liner, with speeds of upwards of fifteen knots.

Then there is the question of the gas engine. The W-shaped bunker with the automatic conveyors to the gas producers is again adopted. One of the difficult problems in this case, it is understood, is to find suitable coal for burning in the producers and to dispose of the waste products. It is submitted, however, that this should not be an insoluble problem. Indeed, its solution is of vital importance to the future of the marine coal interests, and it is suggested that contact be established with a suitable manufacturer of producers, who has had appropriate experience in the past.

* Trans. of Institute of Marine Engineers, Vol. XLVII, Part 11, December, 1936, pp. 372-381.

An alternative is the possibility for short coastwise voyages of carrying gas in bottles or other containers. By this means the coaster would "bunker" at the local gas works. It is understood that this scheme whilst presenting difficulties, is not impossible.

What is the Type of Coal Necessary to Meet Post-war Requirements?

Originally, the question of bunkers was always associated with large coal; following this, blends of large and small or sized coal, washed or unwashed were adopted. There is still, however, some insistence upon a percentage of large coal and it is thought that this is due to the impression that large coal is some guarantee of a low ash content. Large coal requires breaking down before use and even then it is not sized down to correct dimensions for efficient firing. The point arises whether marine boiler fuel should not be delivered to the consumer of a size ranging from 0 to a maximum of 3-4in. for hand firing purposes and 0 to 2½in. for mechanical firing. Such coal would, no doubt, facilitate bunkering and trimming, and would present the marine user with fuel giving easy handling and utility in as much as no further preparation before firing would be required. For mechanical firing purposes, contrary to general opinion, the mechanical stoker is not necessarily committed to a sized fuel. Land installations are in every way capable of developing the required steam outputs, coupled with high efficiency, on coals of a size from 2½in. to 0, and this at a much higher rate of combustion than is required of the marine plant.

To secure amenities such as cleanliness and the prevention of dust clouds, it is thought that the use of washed or water-sprayed coals might give some assistance, but the dust-proofing of bunker coals by other known and approved means should be kept in mind.

What View is Taken of Coaling Depots?

It is considered that coaling depots abroad should act, in relation to the British coal trade, as shop windows and, in addition to selling their products, should be complete servicing stations for the convenience of the customers. The coal should be prepared to a specification for particular types of mechanical stokers. Crushers might be installed at the depots for the breaking down of the coal, even to the pulverised state.

It would require an understanding on these lines between producers and depot owners, which should not be difficult to achieve. It is common knowledge that abuses exist in certain depots due to various causes. These abuses should be eliminated, with a view to putting coal on a more competitive basis in this respect with the oil interests, who supply more or less a standard product.

Thus it will be seen that an attempt has been made to deal with a problem vital in the national interests in a series of questions and answers.

It is not pretended that a complete answer has been given in every case but it is submitted that a cross-section of what exists to-day has been put forward. As a world bunkering commodity coal is no longer acceptable. It depends for its survival upon the way in which it is sold to the marine world.

The answer is mechanisation. Make no mistake, the coal industry is not apathetic in these matters. Indeed at no time in its history has it been more aware of the need for the energy which it must display if it is to survive.

It is regretted that in this paper some of the ideas suggested could not be illustrated; conditions being as they are this was not possible, but it is desired to make the point that if members desire to explore any particular aspect in more detail, such information as is required will gladly be supplied.

Discussion.

Major W. Gregson, M.Sc. (Visitor), opening the discussion, stated that he had listened to the paper with great interest; he fully concurred with the remarks in the second paragraph of the paper and stated that the Marine Committee of the Combustion Appliance Makers' Association had in hand the exploration of the fundamental technical and economic grounds which must form the basis of any true assessment of the relative merits of coal v. oil for different classes of tonnage operating on a wide variety of services.

He (the speaker) asked what class of service the authors had in view for the 10,000 ton cargo vessel which they mentioned as burning 35 tons of coal per day? The 10,000 ton 10/11 knot tramp, with a 1938 conception of steam machinery, only called for about 20 tons of coal per day—hence he presumed that a speed of the order of 13 knots was now envisaged? Whereas he agreed with the authors that there was plenty of scope for improved technique in hand coal-firing at sea in many instances, it was unsound to hold up land practice as being so much better. He (the speaker) believed that investigations made into the operation of hand-fired boiler installations ashore in connection with the drive for fuel economy showed figures which were well below what could possibly be accepted at sea—if only for the fact that the ship's bunkers would be hard put to it to last out for the voyage at such reduced economy. Major Gregson agreed with the authors that most of the steamers which had been fitted with mechanical coal-firing equipment were to operate on definite runs—and on definite coal supplies; but this did not mean to say that the mechanical stoker had an unduly limited field for bunkers. For instance, the series of Scotch-boilered Elders & Fyffes ships which his Company had fitted with mechanical stokers some few years ago had two normal sources of supply—a high volatile series of Yorkshire coals (bunkered at Garston) or Glamorgan coal (bunkered at Swansea) and it would be difficult to find a wider range in British bituminous coal supplies than these. The point was to design the stoker to maintain its required heat-output under the most difficult set of conditions which would be met in service and that was where land practice differed from marine technique. The grates on land installations were invariably higher rated, owing to their normal adherence to one particular grade of coal. Incidentally, the general change over of ships to new and varying services during the war showed how versatile the mechanical stoker really was and he (the speaker) instanced as an example several of the British India Co.'s vessels, mechanically equipped to burn Indian coal, but now operating on a wide variety of supplies.

Advances would still be made in improving mechanical firing equipment so that higher combustion ratings could be maintained with the widest possible varieties of supplies.

The overhead or "W" bunker was attractive and he (the speaker) had in mind one very successful mechanical coal-burning ship with which his Company was associated, where overhead bunkers removed all coal-handling problems—but the difficulty was that this arrangement was limited in capacity by requirements of stability.

Regarding the reference to the Scotch boiler—he agreed that this design must in due course disappear owing to its space requirements and weight—and he would add, slowness in getting up steam and general lack of flexibility, but he could not agree with the authors' contention that the Scotch boiler would disappear owing to its "too great fuel consumption". A Scotch boiler with appropriate additions by way of air preheaters, etc., can be just as *efficient* as a water tube boiler, when fired by oil or mechanical stokers. If hand fired, the difficulty of working the high wing furnaces militated against proper combustion control and so tended to reduce efficiency. He could not see why the authors needed to go to forced circulation or "fuel-valve" boilers to get down to under one pound of good boiler coal per s.h.p./hour. Why not use an ordinary sturdy water tube boiler? Incidentally, a coal consumption of under 1lb. of good coal per s.h.p./hour has already been attained with modern steam machinery.

He (the speaker) was intrigued with the idea of gas-engine drive, especially for low-powered coast-wise shipping, with engines of less than, say, 1,000 s.h.p. Of the three fuels available—anthracite, bituminous coal, and coke—the first could be ruled out owing to localised supply; many grades of bituminous coal could be used in a modern mechanical producer, but the main problem was tar disposal from the scrubbers—particularly in port. Maybe the tar could be tanked and then utilised for donkey-boiler firing in port, although the real solution would be a producer which would convert the tar into fixed gases instead of allowing it to leave the producer in the form of tar-vapour. Except for its bulk—which would not matter greatly for short coastal trips with frequent bunkerings—coke seems to be the ideal fuel; surely rather than bunker compressed gas from the local gas works as suggested by the authors it would be better to bunker gas works coke?

The steam yield from a waste heat boiler on a gas engine exhaust is double that per s.h.p./hour compared with the 4-stroke Diesel engine and nearly four times that from a 2-stroke Diesel. This gives an adequate supply of steam for all the engine room and ship's auxiliaries, as well as for the operation of an evaporator for saturating the producer blast from sea water.

Major Gregson agreed with the authors' sentiments regarding the activities of coaling depots abroad—but emphasised that the correct fuel must be available at prices competitive with oil as the shipping industry, subjected as it was to the keenest type of international competition, could only afford to use coal if coal proved the economic choice after weighing up the fuel problem from all angles.

The speaker pointed out that the effect of two divergent factors was one of the main difficulties to be overcome in furthering the use of coal at sea; on the one hand low-powered machinery could better stand the differential in bunker weights, coal v. oil, over a given steaming distance, but as the second factor, high-powered machinery offered better scope for more advanced technique and consequent higher potential overall cycle efficiency.

At pre-war machinery and bunker fuel costs it could be taken as an average figure that it paid to spend £1,000 as extra capital cost for every ton of coal saved per day, with a ship at sea 200 days per annum. For greater time at sea, this figure of £1,000 would go up proportionately higher. The higher the power the easier it was to capitalise additional plant for greater fuel saving as the price of these additions did not rise directly as the power of the ship, but because less and less per s.h.p. as power increased.

Major Gregson considered that with a truly modern conception of steam machinery—including mechanical firing as only one of a series of important factors in the complete machinery assembly—there should be a good case for coal (*a*) for low-powered vessels and (*b*) for medium powered vessels, provided the runs between appropriate bunkering ports are not of long duration.

Finally, the possibilities of alternative coal or oil firing were attractive on certain trades where coal was the economic "buy" at some ports, and oil at others.

Mr. J. C. Bennett, Director, British Coal Utilization Research Association (Visitor), said that he had read this paper very carefully. It seemed to him that the authors put forward a very definite point of view, namely, that mechanization was going to save coal bunkers. The question which he wanted to ask was why mechanization did not make more progress before the war. Why was it that, as far as he knew, there was no mechanically fired tramp in their merchant navy or any other? There were mechanically fired ships on fixed runs, but not mechanically fired tramps.

One obvious answer was that suitable bunkers could not be found everywhere, and they had to go into any port. But the installation of crushers, as the authors pointed out, was an easy answer to that objection. The problem of quality would necessarily remain after the war, whatever the British coal trade might do, because unfortunately this country did not supply the whole of the bunker coal of the world and foreign countries supplying bunkers might not be able or willing to supply suitably prepared coals.

In the ten years before the war a very earnest effort had been made to persuade shipowners, including those with substantial coal interests, to put mechanical firing into tramp steamers that they were building, and very remarkable offers were made to secure this end by both the coal industry and the marine engineering interests concerned. In order to help forward the movement a proposal was made to subsidize the whole of the additional cost in so doing. If, for example, a ship was to cost £120,000 as a hand-fired job, the extra cost of £10,000 or even more for full mechanization would have been borne by the coal or the marine engineering interests which desired to further that experiment. But no shipowner was prepared to take the offer. Now, the shipping industry was well run and highly efficient. That, indeed, was one of the main sources of our international strength, and the industry had stood up to severe international competition. It was hardly to be supposed that shipowners would not have adopted mechanical firing if they had thought that it would enable them to operate their ships more economically. Therefore there must be some reason for their refusal. There was a very long history of mechanical firing at sea, going back, he supposed, for thirty or forty years, and the question was why it had not made more progress. He thought that Major Gregson had put his finger on the sore spot, namely, the difficulty of justifying the extra capital cost by means of the saving in fuel and labour that could be shown for it.

If Major Gregson's figure were taken according to which a ton a day saving in coal would justify a capital expenditure of £1,000, certainly it was very hard to justify a complete mechanization of a tramp steamer on this basis. Another point must be borne in mind, namely, that one of the greatest enemies of coal at sea was the improved design of ships' hulls. Immense progress had been made in hull design with a resulting reduction in the actual fuel required to drive a ship, so that a large reduction in fuel consumption had come about whatever system of propulsion was used.

The figures of 35 tons of coal a day given by the authors for a 10,000 ton cargo ship suggested a ship of fairly inadequate hull design, in which case the percentage savings on the small tonnage justified less capital expenditure. But who could say that the end of progress in hull design had been reached?

It seemed to him that the difficulty with coal at sea was not to be met simply by saying: "Go in for complete mechanisation". If the authors were right in thinking that tramp ships after the war were going to have speeds of 15 knots—a thing on which he would like to learn the opinion of the experts—it would mean quadrupling the horsepower as compared with the present day ships. There were not many cargoes the value of which would justify the big increase of running costs involved in a speed of 15 knots with a 10,000 ton tramp. One of the strengths of our merchant marine had been that it resisted the temptation to run after spectacular speeds and had gone in for economic operation. But he was speaking now as someone completely outside the industry, and possibly had a complete misconception of what the post-war position might be. Of course, there would be a tremendous number of fairly fast ships from across the ocean, but he would have thought that the whole basis of their competitive position was that they would have more economical tonnage than some of these high-powered ships which had been built under the special conditions of war.

If they did come back to the speeds, perhaps not of 8 or 9 knots as before the war, but of 12 or 13 as a maximum, the justification for mechanization might be a little greater, but the real problem, as he saw it, was to concentrate on the tramp tonnage, if we were to maintain our position as a coal-bunkering country. He felt that a note of warning should be sounded as to whether there was quite such a simple answer as the one suggested. What they should underline was the absolute necessity for finding an answer, because it was going to be a very serious thing for this country if this particular class of tonnage went off coal. They had been told by no less a person than Secretary Ickes of the Interior in the United States that oil for ships' bunkers was going to run short within the lifetime of ships now being built. If, on the other hand, one thought of the needs of this coal-producing country and the general world trend as regards the availability of fuel oils, the problem of tramp tonnage on coal was one which must be solved in the national interest. It might be that, looking forward to the future when the disparity between coal and oil prices might tend more and more to favour coal, something would have to be done to facilitate, by special subsidies or otherwise, the provision of machinery for mechanical firing. After all, the whole of the weakness turned on the capital expenditure. If that could be overcome, the case for mechanical firing then became quite unanswerable. But the problem was how to justify those extra thousands of pounds over and above what would be immediately counterbalanced by the saving in fuel, labour, and operating conditions. There might be a period of ten or fifteen years to bridge over before the world's mercantile marine would have to turn very much to coal. It might be a question which would have to be solved nationally in seeing that the ships now built, whose lives would stretch well over into the period of oil shortage, should be so built as to be able to use coal efficiently.

That was the only feeling which he had in reading this most excellent paper, namely, that the paper made it appear too much as if the whole thing was solely a matter for the coal industry and the shipowners, that the coal industry had to prepare its coal and the shipowners had to make use of the obvious merits of mechanization and thereupon coal was saved. It was a very great thing, as the authors pointed out, that the coal industry was now fully alive to the position, and that it was prepared to put forward its coal, whether for hand or mechanical firing, in a way never contemplated in the past. Undoubtedly this called for surveys and so on, which would be made. The marine engineers had the possibility of improving the engineering side, but to do that the whole position must be made attractive. There must be a feeling that a large number of ships were going to be built with mechanical firing, and he did not think that, unless something was now done about it, that would be the case.

Mr. W. R. Beswick, The Power Gas Corporation, Ltd. (Visitor), said that the remarks which he had to make on this interesting paper were confined to the gas-producer side since he must admit to being a layman in the matter of marine propulsion. It was somewhat interesting in view of the remarks at the bottom of page 132 to recall that there had been some early experience with gas engines for marine propulsion before the last war. He had hoped to give further details of these experiments but the records seemed to have disappeared, possibly as salvage in the interests of war economy, and therefore he could only mention that there were some barges fitted with gas engines, and gas producers on one ship which had a wider range.

Why was it that from this early start the system did not develop? It might be that although at that time gas generation of power in land installations was on quite a considerable scale, for a variety of reasons—one of them the fact that the recovery of sulphate of ammonia had ceased to be an economical proposition—gas producer power installations gave way to electricity generated by the grid system. At the same time the Diesel engine was developed and found useful for smaller vessels as also for small land power installations, so that the gas engine, except in certain special cases, had not been adopted as had been expected in those earlier days.

What was the position to-day? It would seem that because of its wide use for industrial heating applications the producer had now developed substantially from that earlier time. It was mechanized, and its efficiency and adaptability had increased. The gas engine also appeared to have developed, perhaps in conjunction with the experience of the Diesel designers. He understood that one could now get a thermal consumption of something like 7,000 B.Th.U.'s per h.p., which was a marked advance on the older days. It had to be borne in mind that whereas one could doubtless design a gas producer plant for marine purposes, with a gasification of say 20 tons of fuel a day, and for all three fuels—anthracite, coke and bituminous coal—one would have to legislate for the most difficult of them, namely, bituminous coal. That involved auxiliary equipment in the way of tar cleaning and handling and tar storage, the latter being essential for port use and in tidal waters or until it was possible to go out to sea again. It would not be very pleasant to discharge tarry effluent even out at sea, and certainly for coastal work one would hardly recommend a bituminous plant because of the tar. It was from land installations with residual tar burned under boilers that a solution might be found.

He wished to make one comment with regard to the "W" bunkers mentioned. Whereas the boiler, as he understood it, was fed at its lower part, the gas producer was fed from the top, and to take advantage of the mechanical feeding and mechanical ash discharge which could be arranged, the height of that installation would probably be of the order of 20 or even more feet, so that possibly one would wish to arrange for fuel elevation rather than to instal such high bunkers with the fuel, of course, stored higher still.

One possibility which had occurred to him was the use of the gas-Diesel engine, which might widen the range of ocean-going vessels. With that engine one could go out on producer gas from one's own home fuels and, if suitable fuels were not available overseas, come back on oil. The economics of this and the dual storage facilities required were points on which he was not qualified to touch.

Mr. H. L. Pirie, Chief Engineer, Coal Utilization Joint Council (Member), said that any remarks he made were purely personal and were not made in his official capacity. This was a most interesting paper, and he was extremely glad to note that the authors considered that it was not sufficiently analytical to compare the two ends of a process. He thought it was essential to take the boiler efficiency as distinct from the steam engine side of the work. The authors were good enough to make reference to a paper which he had communicated to the Institute in 1936 in which he stated that marine engineers who applied for positions with the Coal Utilization Joint Council were weak in their knowledge of combustion. That was really no reflection on the marine engineer, it was merely a statement of fact and had been confirmed more recently since he had been adviser to the Ministry of Fuel in regard to the selection of engineers. If, as the authors stated, firing intervals at sea were generally at one-hour intervals, point was given to the argument. Fortunately the Ministry also required steam engineers, and marine men were excellent in their knowledge of the distribution and utilization of steam. He understood that a number of classes were being arranged now in connection with firing practice both for land and marine purposes, and he hoped that these would continue because he felt that a great deal could be done in the efficient combustion of coal.

Coming to mechanical stokers, the authors asked whether the marine stoker should not be developed to deal with a wide range of coal and whether the difference between one coal and another was so great as to present a serious obstacle. With the class of coal which was being supplied to many industries on land at the present time a great deal of difficulty was being experienced with mechanical stokers in general in that most of them were selective, and he did not think a stoker could be designed which would burn everything satisfactorily. The stoker had to be designed within limits for the coal which was available. Probably the best combination was forced draught with a sprinkler stoker, but that did not rule out other types of stokers.

As to the factors influencing the behaviour of fuel, he was rather surprised that the authors had not mentioned caking, because that was one of the most important characteristics with mechanical firing. A strongly caking or a coking coal was undesirable.

Coming now to the size of coal, the authors had given sizes ranging from 0 to 3-4in. for hand firing, and from 0 to 2½in. for mechanical firing. There was a good deal of talk at the present time in connection with the size of coals, and he thought there was a feeling that instead of the sizes being from 0 to 2½in., everything below $\frac{1}{16}$th in. should be taken out. Anyone who had had experience with mechanical stokers would certainly agree with that. Whether a coal of minus $\frac{1}{16}$th in. would be acceptable by the collieries he did not know.

He thought also that in connection with servicing stations the coal industry, if they wanted this market, would have to do a good deal more in the marine field than in the past. On the other hand, the shipowner would have to buy fuel of a quality to suit the equipment which was installed, and not simply buy down to a price. He was entirely in favour of mechanical stoking and he only hoped it could be applied with success to marine work.

Engineer Vice-Admiral Sir George Preece, K.C.B. (President), said that there appeared to be a danger of the discussion drifting into one on mechanical stoking and nothing else. He wished to ask one or two questions of the authors.

He had no particular fondness for coal burning, and indeed he might say that he had probably seen as much coal burn as anyone present and did not want to superintendent the burning of any more, except in the domestic grate; but it was important that a fair survey of the subject should be presented.

In the first place, whilst he was not prepared to give any figures himself, he wondered whether everyone present was satisfied that the costs of repairs to a Diesel ship were in fact equal to those of a conventional coal burning steamship.

Another thing that seemed to him a little hard on the coal burning ship was the suggestion that 30 hours more were required to bunker 1,000 tons of coal than to take in the equivalent quantity of oil. He did not think that ought to be the case, since in the last war in a battle-cruiser they worked up to being able to take in 2,000 tons of coal in 8 hours and trim the coal into between 60 and 70 comparatively small bunkers. Why should it take over 30 hours to take in 1,000 tons of coal into relatively quite large bunkers?

He was also a little dubious about the figures given for fuel consumption for different types of ships. It appeared that Major Gregson did not think that they were appropriate to modern steam installations, whilst Mr. Bennett had said that the hulls themselves appeared to be old fashioned ones. Possibly the figures given for coal were a little pessimistic and might be modified if modern installations and modern hulls were taken.

He thought that he ought to qualify his remarks about coaling times because in the case he had quoted there had been an engine-room complement of about 500 all told; but even so it was a problem to stow this quantity of coal rapidly in a large number of comparatively small bunkers.

Another point that perplexed him was the suggestion that the methods adopted for preventing smoke were carried out entirely at the expense of efficiency. He did not think that was a fair way to put it. Many years ago it was the practice to force in jets of air over the fires in Belleville boilers, not only to reduce smoke but also to improve the efficiency of the boilers by burning gases which would otherwise escape unconsumed for lack of the necessary air for complete combustion. The device was not often used because unfortunately the blowers of that period took more steam than the extra steam that the boilers produced. He knew that the experiments at the Fuel Research Station had certainly indicated no loss of efficiency but in general a gain as the result of supplying secondary air over the top of the fires. The air supply was regulated and had to be varied to suit the different kinds of coal that were being used. He did not think, therefore, that it was done necessarily at the expense of efficiency. He was also a little surprised to hear that in the Merchant Navy most officers spent the greater part of their time in the engine room. When he was young he was told that his place was in the boiler room where the steam was made, and he suggested that some advantage would be forthcoming if more attention were paid to that point of view. The firing interval of one hour seemed unacceptably long, he recalled that the shortest interval on his Kilroy stoking indicator was 3 minutes.

He thought that there was some difference of opinion with regard to the practicability of the W bunker. He agreed with Major Gregson that the carrying of coal that way would result in a high centre of gravity of the ship. Some cross-channel steamers had this arrangement, but in such cases, if a section were taken through the ship, coal would be seen extending from the level of the boat-deck to that of the tops of the boilers. In such ships one could coal, if necessary, at the end of each voyage across the channel, but it was a different matter in the case of a ship required to steam long distances.

He would not have thought that the disposal of ash was a very difficult matter. He remembered the tons of ashes which he himself had seen blown overboard. The performances of underwater expellers and above water ejectors had been quite satisfactory.

He was rather doubtful about the use of gas carried in cylinders except for very short voyages. Such cylinders had the disadvantage of being very heavy.

He supposed that most people knew—although he could not quote the sizes of the ships—that there was quite a number of ships on the rivers in Germany that ran on gas producers.

A Member: And in Russia.

Sir George Preece: Therefore for short voyages this system was quite possible.

He was not quite clear what the authors meant by water-sprayed coals. Were they sprayed in the ship? He would certainly not like to have damp coal in the bunkers.

Mr. John H. Anderson (Member), said that it was only with a certain amount of diffidence one could discuss a paper presented as this one has been—prepared by a group of engineers who were, in a popular phrase, "still on the secret list", and still so nervous about their actions that they had appointed an agent to carry their responsibilities for them. Who were the authors? The whole paper from beginning to end was hypothetical. There was no need for this to be, as there were plenty of examples and experiences which could have been considered, which would give one solid facts on which to base discussion.

There was an affront to the Institute in the paragraph which suggested that marine engineers did not understand or appreciate control of combustion owing to the lamentable weakness of their knowledge of the subject. He suggested that this slur on the character and ability of the profession should be withdrawn with apologies, then we could endeavour to give the authors of the paper a fresh start which might stimulate discussion and lead to constructive criticism. One should consider the first idea put forward by the authors whereby they were going to bring salvation to the coal trade by means of gas producers or by providing W shaped bunkers in the wings of the engine room to feed water-tube boilers in their hypothetical tramp steamer of 10,000 tons, or by the application of mechanical stokers to the Scotch boiler—a good servant that would remain with us, he was sure. Not many years ago, in this country we had thousands of gas engines, using both town gas and producer gas. Where (if we omitted the use of engines using gas which was a by-product from the works where they were installed, thus incidentally getting their fuel free which otherwise would go to waste), were these to-day? He admitted there were numbers of producers being used to-day because of the necessity of economising spirit for other purposes, but this was only a temporary measure, as the loss of power in the same engine, irrespective of untold inconveniences, would not be tolerated in ordinary circumstances. He referred principally to the noise and smell, both of which would prohibit their use for marine work. The reason why these gas units were discarded was, of course, the convenient supply of electricity, and at this point he might say that this resulted from centralization and standardization, not by low cost of steam production, as even in the old days (*see Volume XXXI of the* TRANSACTIONS *of the Institute of Marine Engineers, pages 182 to 185*) we could get a thermal efficiency of boiler and economiser in a marine type Babcock & Wilcox boiler of over 86 per cent. with coal firing by chain grate stoker. In *Volume XXXIII, page 548,* a test was shown that gave a thermal efficiency of a marine return tube boiler of over 83 per cent. with oil firing.

Bearing these remarks in mind, would the authors still justify the added capital costs to thousands of plants at gas works whereby they would bottle gas at a pressure, thereby creating a trade for the transport of bulky and awkward parcels each of which would have to be separately and riskily manhandled, and in addition returned when empty? Would this be preferable to our handling of coal in bulk even under the present conditions of alleged inefficiency? The authors very conveniently considered a vessel of 10,000 tons, they assumed that repairs were equal for both steam and motor ships and that no difficulty would be experienced if ships ran to normal ports. Shipping experience proved different from this, particularly if one took the hull into consideration; then again one could not rely upon going only to normal ports for the convenience of repairs. He thought that the authors would agree that it was usually the abnormal ports that the tramp steamer went to! He did not understand the authors' difficulty in ascertaining the comparative values of liquid and solid fuels. They were both good fuels and of course initiative had to be exercised to get the best results from either; and it was here that the marine engineer had the responsibility in practice, and in his life-long experience of fuel of all sorts, solid and liquid, he gave the marine engineer all credit for what he had done. If one looked back for many years it would be remembered that most of the advertisements for shore power station engineers generally stated that the candidate should possess a Board of Trade certificate, which showed that engineers with seagoing experience formed the backbone of the power production schemes, and much credit should go to them for methods in operation to-day. He was afraid the authors did not appreciate the value of the returns made by the marine engineer on every voyage; he probably did not have the same kind of scientific aids as his shore colleague, but all the gadgets in the world, many of which were not so reliable as their claims implied, did not alter the fact that given a true analysis of his fuel he could then determine his efficiency from his evaporation from and at 212° F. from actual weight of coal provided by merchants who supplied coal weighed by an independent certificated weigher water measured in tanks—not taken haphazard by revolution counters or even by so-called water meters, thus neglecting variations of temperature of the water. He would know the amount of air requisite for best results, and what was more to the point he would check up with actual results of wind, weather and mileage with draught of vessel and compare results with previous voyages. Ultimately he would answer the question—how much had it cost his owners to carry so many tons from one place to another? and he would answer it either in terms of coal consumed, water evaporated, steam produced or even in £.s.d. on any convenient unit basis. What he could not control was the weather and the amount of extra resistance and additional mileage caused thereby, which latter factor depended on the way the ship was managed by other departments.

If an efficiency of 80 per cent. could be obtained in the stokehold there was not much to complain of; there was a bigger field for economy in the utilization of steam after it was generated, and he suggested that this was where the research was required. There you would find 70 per cent. or so to play with; what was being done about that?

The following extract (TRANSACTIONS *of the Institute of Marine Engineers, Volume XXVIII, page 173*) was written during 1916: "The greater use of modern high speed engines or turbines with much higher steam pressures, high superheat, and good vacuum, with the speed reduction done electrically direct to propeller shaft without any gearing or tunnel shafting, is a method of economy that should be pursued".

In considering the matter from a national point of view it was evident one must use coal; there was not time during the war to investigate either the foregoing or many other suggestions as one would wish. However, in the writer's opinion, the use of water-tube boilers in conjunction with the engines previously mentioned would be the most promising combination. Burning oil in furnaces was a bad practice which we should regret in years to come.

Finally, (1) would the authors tell us if they really considered the use of 900 tons of oil fuel stored in double bottoms as a good idea, and if so how much of this 900 tons would be used to render the remainder fluid for pumping, say, in the North Atlantic in winter?

(2) Did the authors seriously consider that it was a good idea to store 1,500 tons of coal over the top of high-pressure boilers? If so, would not the ship have to be specially designed for this, and would the coal be likely to give any trouble by self-ignition?

(3) Were any of the authors aware that handling of bulk material such as coal depended on local requirements? 16,000 tons could be loaded or discharged in 2 or 3 hours, and in a plant not far away a ship of 2¼ thousand tons had been discharged in 2½ hours, including clearing up and replacing beams, etc.

(4) Regarding the use of washed coal, would the authors agree that washed coal might contain, say, 10 per cent. of free moisture, and if so how much of the remaining 90 per cent. of coal would be required to evaporate this moisture in the furnace, irrespective of the cost of transport and handling?

Mr. W. S. Burn, M.Sc. (Member of Council): The authors asked, "Whither Coal?" The speaker would suggest the "withering" reply that as far as ships were concerned it should be left unmolested in the ground and those fuels concentrated upon which were more congenial socially. The amount of coal used for the bunkers of British ships is only about 6 per cent. of the total coal produced in this country, and therefore the significance of the shipping industry as a consumer of coal is not so great as is commonly thought. The national effort should be directed rather to the manufacture of mechanisms with a greater labour requirement per ton, such as machinery for burning small quantities of fuel like oil than attempt to keep alive an obsolete and worn out fuel. Let us hope that coal will soon follow the path of wind as a motive power for ships. The speaker did not envisage any serious "come back" of coal on a pre-war basis of coal burnt under boilers with hand firing, and only a gradually narrowing market could be anticipated in this respect, which meant low prices and low profits. Some new and greatly improved method of burning coal was needed. The trouble with the use of coal in the past was that it had invariably been associated with steam and external combustion, which was an inefficient working gas and process compared with air and internal combustion. The use of high efficiency gas engines and gas producers was one solution, which would require much development, but there was another more direct and attractive solution which seemed more applicable to the use of coal and the impurities it contained. This alternative was to burn pulverised coal in a "gas" turbine which would drive a generator, which in turn would use an electric reduction gear for the transmission of the power to the propeller. If electric motor drive were provided for all auxiliary purposes by using Diesel auxiliary generators, which would also supply the power for manœuvring and astern running, there seemed to be no fundamental reason why thermal efficiencies of 25 per cent. should not be available—and much higher in the future as the metallurgical aspect was developed. The combined low fuel cost and high thermal efficiency would then make an attractive commercial proposition.

The gas turbine would no doubt digest the ash particles inseparable from coal utilisation, and there would be no tar problem as in the case of the gas producer. The port and cargo handling charges would be equivalent to those of the normal Diesel installation. The gas turbine would no doubt be started up with oil and switched over to coal burning for all steady running. The practical development of the gas turbine, especially if dissociated from mechanical gearing and reversing, could be considered to have emerged from the experimental stages, and great progress was believed to have been made in this country. Thermal efficiencies not greatly below oil engine efficiencies are available in the case of units of a few thousand H.P. using fuel oil, and it was up to the coal interests with comparatively ash free coal to apply to the Government department concerned. Vastly improved methods of preparation, washing and form for distribution and bunkering would be required, and perhaps the ultimate form will be as semi-fluid, cleaned, ash free, granulated particles ready for final pulverisation. It will always be desirable to have such gas turbines as will burn oil or coal, so as to permit bunkering in the cheapest market in peace time and at available sources in war time.

Contrary to the commonly expressed opinion, the speaker believed that the future of coal was rather with cargo liner types of 6-8,000 b.h.p. on regular routes, where suitable coal was available and a relatively complicated installation permissible. For coasters or tramps of medium power, the oil engine was in a very strong position and certain oil engine types in present use could be relied upon to give irreproachable economy and reliability.

The future of the oil engine, in fact, was never brighter, especially with the advent of the indirect drive, and it would be only by decisive technical action, backed by much capital, that coal would be made a future competitive fuel on an international basis. The coal industry would have to give far greater co-operative technical attention to the actual use of coal to render it socially congenial and economical, if coal was to compete with oil on a profitable basis.

Engineer Rear Admiral W. M. Whayman, C.B., C.B.E. (Vice-President), desired to supplement the remarks by Sir George Preece with regard to the coaling of ships. Speaking from memory, one of H.M. battleships in which he served took in 1,000 tons of coal in 2½ hours—but it had a thousand men to do it.

He desired to make a few concrete suggestions generally to the coal and shipping industries. He thought there was a general consensus of opinion that they should use coal if possible in the future for marine purposes to an even greater extent than in the past. Therefore he would say first of all from the point of view of the coal industry that they should endeavour to put their best goods to the front and try to persuade the shipowner and the marine engineer that it was the best coal that paid in the end.

He thought that he would be right in recording here that he thought the greater amount of coal that had been shipped abroad in the past for marine bunkers had been either Welsh coal or Durham coal and in a sense that was a general guide to what he might describe as the best coal for marine purposes. He did not want to lay down any particular rule. He wanted only to offer a basis for future reference, namely, that for marine bunkering purposes the best coals only should be used.

Another point which seemed to him of some importance was to pay regard to the distribution of fuels in the world. If one took the trouble to look at the fuels available in the different continents and countries it could be said roughly that Europe had coal and the Americas had oil, although of course, America had coal as well. There was perhaps a better supply of oil in the East than there was of coal. Thus there might be an advantage in having ships built so that with steam machinery they could use either coal or oil. They could go out from this country on coal and come home on oil. If that suggestion was worth anything it might be possible for the coal industry and the industries generally to regulate the ports to which they would export coal for marine bunkers and not to seek to export all over the world. They would take a number of ports only, namely, those in which an economical proposition for the use of coal as compared with oil could be established.

Of course, there were arguments for and against such a course. Shipowners might say that it was not financially possible to provide boilers with both oil- and coal-burning equipment without some slight increase in transport cost, but the proposal deserved careful consideration.

His last point concerned the selection of coal. Mr. Pirie had said that he thought some attention should be paid to the caking qualities of the coal. That was the most important characteristic of the coal to be considered from the marine point of view, whether for hand firing or for mechanical firing. The next point was to consider the ash content to see that the coal did not require too much extra attention during combustion on account of the ash content, both from the point of view of its physical properties and its fusion temperature. Finally came the question of size, this coming after the other two. The remaining characteristics of coal, he thought, might then probably even be found to take care of themselves to a great extent.

Mr. E. C. Warne (Member), said that he was known to some of them as being principally interested in motor ships. He had nevertheless read this paper through from beginning to end with very considerable interest. Even the first line of the synopsis interested him, with its reference to an anonymous group of engineers. He desired to ask this group why it was that they gave in their comparison of fuel consumptions 900 tons of fuel oil in double bottoms for oil burners and 800 tons of Diesel oil for motor ships. It was quite possible for a 10,000-ton motor ship to carry (if desirable and if arrangements were made to that end), 1,000 tons of oil in the double bottoms. Plans could be seen in which that was demonstrated. Thus, the radius of action without rebunkering was 100 days for the motor ship, against 50 days for the oil-burning steamer and 42·8 days for the coal-burner.

Coming to a rather more general point, the suggestion was made that much stress must be laid on the efficiency of the boiler as distinct from the steam engine. What it amounted to in the long run was the quantity of fuel per h.p.-hour which was used. The shipowner was not interested whether the boiler efficiency was 75 per cent. or 80 per cent. He was concerned only that the fuel consumption was not too high or the cost too great and therefore he would have one fuel or the other, and the whole machinery, engine plus boiler, became to him general and not divisible.

One point which had not been raised was that when this question of coal had been disposed of and regard was paid to the most efficient method of using the coal, one grave problem was left, namely, the stokehold staff. More than one superintendent engineer had stated that when he had got rid of his firemen half his troubles were over, and the fewer he had the happier he was. He thought that the use of coal would have to go rather more into the background than come into the foreground.

Mr. S. Hogg (Member), proposed a vote of thanks to the authors and expressed on behalf of marine engineers their obligations to the Fuel Research Station.

Mr. W. A. Christianson (Member), seconded the vote of thanks. It had been a very good paper and he hoped he was not too late to make a small contribution to it. It was difficult to follow all that had been said and to form a definite opinion. Accordingly he would like to see a tabulation of possible figures and results with different types and powers of steam and oil machinery, perhaps set out also in graph form. An oil engine installation took a fairly definite form and its results and performance was not very widely different for different powers, but with steam plant, the possible combinations made the question a very much bigger one with wider variations in capital and operating costs. Such a comparison might take into account reciprocating engines, exhaust turbines, straight turbines, cylindrical and water tube boilers and different methods of firing, etc. In making such a comparison on the operating side, fuel costs would of course have to be relative to each other whether based on past, present or future figures. He believed that a general comparison on these lines would be a great help to everybody concerned.

A vote of thanks to the authors was duly accorded, together with, on the proposal of the **Chairman**, a further vote of thanks to the Secretary for reading the paper, and the meeting terminated.

BY CORRESPONDENCE.

Mr. H. C. Semple hoped that his remarks would add in some measure to the general interest and discussion on the subject of the paper, which in the light of progressive developments in the rival type of fuel was of such vital importance to the British nation, if advantage was not taken to utilise our natural mineral coal wealth to the full.

In order to compete effectively it was essential to realise and appreciate in full measure the advantages of that with which one had to compete in an endeavour to produce something at least as good if not better. Applying this maxim, the present advantages of oil were patent as the competitive fuel to coal for burning under boilers or for Diesel engines, e.g. cleanliness and speed in bunkering, use to a large extent of D.B. tanks as bunkers giving increased d.w. or alternatively measurement earning space, lower engine room complement, consistency in quality and higher calorific value resulting in lesser consumption and more consistent speed, etc.

So far as passenger liners were concerned, it was common knowledge that coal had been displaced by oil for these reasons and this also applied to a large extent to cargo liners and he believed tramp owners were also adopting Diesel engine propulsion in increasing measure. This obviously meant that despite the efforts claimed for the coal owners in effecting improvements in the preparation of coal, there was so far failure to produce a type of fuel which gives the same benefits as oil. Until and unless this was achieved, under normal conditions of competitive trading, coal must continue to give place to oil.

It would be realised that in adopting oil in increasing measure as the type of fuel for propulsion, shipowners did not do so in order to support the oil companies any more than, taking the reverse, it was with the object of depriving the coal owners of business. This was dictated purely and simply by economic facts which the shipowner could not afford to ignore. It was obvious that as vessels were normally built for a life of 20/25 years, the coal trade were the losers for this period, and in increasing measure as obsolete coal burning vessels were replaced by oil.

What was the answer? He suggested that much more could be done with the unlimited scope offered for the scientist and scientific engineer in research with, if need be, financial assistance from the government, to produce a fuel in sufficient volume from coal or alternatively propulsive machinery which could use coal or a coal-produced fuel with no less advantages than oil offered. When this was achieved, the coal trade would once again come into its own with the accompanying vital advantage to the national well-being.

The recent reply of Major Lloyd George to a Parliamentary question to the effect that research work on oil from coal processes is being continued by the Ministry of Fuel and Power and that the subject is being considered in connection with the post-war development, is not without interest. It would be interesting to know the views of the coal trade in this regard and what steps the trade itself has taken or is taking to ensure that no opportunity is lost to take full advantage of development in this direction.

Mr. J. A. Jaffrey, M.Sc. (Member): Various statistics appear from time to time on the number of years which will elapse before the oil supplies of the world are used up. Apparently the oil will be exhausted before coal, but in any case decreasing supplies will automatically increase the cost of oil. It seems, therefore, that coal will return again but increased efficiency in its utilisation is necessary. The chief advantage of oil over coal is, broadly speaking, due to the fact that it can be easily handled.

For marine purposes there are four main problems in the use of coal:—

(1) getting the coal on to the ship,
(2) getting the coal from the bunkers to the boilers,
(3) burning the coal, and
(4) getting rid of the ash.

It is not easy to assess the individual effect on overall cost due to the four items mentioned above, but there is no doubt that 1, 2 and 4 are many times greater than 3. The position appears to resolve itself into one where coal is put into the furnaces, and due to the relative inefficiency of the other three items, almost superhuman efforts have to be made to try and improve the general efficiency.

In other words, very decided advantages would result from the efficient solution of items 1, 2 and 4, compared with what could be expected from an increased efficiency in item 3.

It cannot be said that mechanisation with the present kind or form of coal will provide a solution, and there appears to be no doubt that the solution does lie in providing the coal in a form in which it can be easily handled. Moreover, it is practically axiomatic that if the coal is in a form that can be easily handled, equipment for the efficient burning of such coal is easy to arrange.

The use of oil for steam raising is peculiarly a marine one, for one would not expect to find large steam power stations on land using oil for the boilers instead of coal, even in the oil producing countries. On land the two main problems often are the question of atmospheric pollution, and the disposal of the ash. As a result there is a tendency to use washed coal and with a constant ash quantity. Apart from ash disposal, the handling problem as such does not exist on land, for there is space for equipment to deal with it, and the problems of stowage in bunkers, etc., do not exist.

It does not appear, therefore, that the answer to the marine handling problem can be found in land practice, but some benefit in the type of fuel that may be available as a result of land practice may be of assistance in certain cases. It is very possible, however, that the methods of ash removal used on land will be applicable to marine practice.

Mr. J. Jones, Chief Engineer, The National Gas and Oil Co., Ltd.: It is gratifying to note that the marine world is displaying some interest in coal-fuel ships, and that the coal industry appears to be interested in cultivating a market for coal. It is surprising, however, that so many activities are being carried out to improve the coal market, and each body seems to have little knowledge of the research work carried out by the other interested parties. I refer later to this difficulty.

The answer to the marine coal fuel problem is obviously the gas engine, but before this type of engine can be produced the fuel supply must be considered and settled. The paper refers briefly to gas engine installations with a mechanized producer, obviously of the type already well known with its many defects. What is this type?—a simple producer with rotating grate and mechanical feeding, plus gas cooling and washer. This type could only be used for marine purposes with special fuel of the non-bituminous type, such as anthracite, coke, etc., with obvious disadvantages of supply and high cost. If an attempt were made to run such an engine on bituminous fuel, the problem of gas cleaning would have to be considered. The usual method would be to instal centrifugal tar washers with their high power consumption, therefore we have an installation as follows:—

Gas engine thermal efficiency 27 per cent.

Producer (Scheme A) non-bituminous fuel—efficiency of producer 80 per cent.

Therefore, overall efficiency of the plant would be 21·6 per cent.

Scheme B would be the same installation with the addition of centrifugal tar washers, using bituminous fuel. The efficiency of this plant would only be 75 per cent., and when allowance is made for the centrifugal tar washers it would not be higher than 73 per cent. Therefore, the overall efficiency would only be 19·7 per cent., but the cost of bituminous coal is approximately half the cost of anthracite. I should like to ask the authors what objection, if any, there would be to the tar being washed overboard from the centrifugal tar washers.

The cleaning of producer gas made from bituminous coal is not an easy matter, and a method used successfully by the writer is the electro-static precipitation method, which is most efficient both from the point of view of power consumption and removal of the tar, the latter efficiency being approximately 99·8 per cent.; the power consumption being 1 k.w. for 250,000 cu. ft. of gas per hr.—equivalent to 3,500 b.h.p. Using this method the bituminous producer would have an efficiency of 75 per cent., but the tar would still have to be discharged overboard.

Taking the authors' figures, the length of voyage possible from this type of plant would be:—

(*a*) 900 divided by 18=50 days.
(*b*) 900 „ „ 19=47·5 „
(*c*) 900 „ „ 20=45 „

The above only relates to present practice; some progress has been made on the engine side by using high compression ratios, and while this has been successful with small cylinder diameters and spark ignition, it has only been successful with larger diameters and pilot oil ignition. The Dual-Fuel engine would appear partly to answer the problem, but it is the production of gas that must be tackled.

The writer suggests that future gas producers must supply the gas engine with gas free from tar and sulphur. The producer should consume its own tar and be fully mechanized, and have an overall efficiency of not less than 80 per cent. A high calorific value gas should be aimed at to permit the engine builder to give the maximum output from the engine. The alternative is to make gas under pressure. Under these circumstances Dual-Fuel engines could be used, only bunkering oil when in those parts of the world where oil fuel is cheaper than coal. With this type of producer total gasification would take place and clean gas under pressure would be available for the engine. It is suggested that the gas be produced at 20 atmospheres pressure. The Dual-Fuel engine would have a small compressor to raise the pressure to, say, 65 atmospheres, requiring only 1 per cent. of the engine power. The gas would be re-heated after compression by means of the engine's exhaust gases and so increase the efficiency. It seems reasonable to estimate a thermal efficiency of at least 40 per cent. for the engine, and with a gasification efficiency of 80 per cent. we should have an overall efficiency of 32 per cent.

Such a gas producer as described above has been the subject of research by the Institution of Gas Engineers, and it is at this point that co-operation is necessary between the various interests. A brief description of the gas producer is as follows: coal is fed into the top portion of the machine and is subjected to hydrogenation; the hot coke then produced is used in the bottom portion of the producer to make hydrogen for the first process; the hydrogen is produced from the coke by the admission of steam and oxygen. The research carried out by the Institution of Gas Engineers has shown that cooling, cleaning, and removal of H_2S is more efficient under high pressure than at atmospheric pressure.

It seems to the writer that co-operation between the engine builder, marine engineer, shipowner, coal owner, and gas engineer would do much to solve the coal problem, and add much to the prosperity of this country in post-war years.

Mr. W. J. Middleton (Member): Assuming that it is in the national interest that we should consume in the best and most economical way all the coal that can be produced, then, we must change the attitude of the marine world which from an operational point of view is strongly in favour of oil firing as compared with coal, fired under the conditions in practice in most vessels.

The author is quite correct in stating that hand-firing is obsolete but there are two statements in the paper which made me wonder if the author is familiar with conditions at sea. On page 2 he states: " . . . . On the whole bunker fuel is a relatively good grade coal, the necessary steam production can be obtained even with an inefficient standard of firing" . . . . followed later in a reference to draught gauges and dial thermometers and C.O.2 recorders: " . . . . It must be emphasized that such apparatus will only prove of value if there is the desire or inclination on the part of the engineering personnel to understand the principle of these instruments and the value of their indications".

I wonder how many marine engineers would agree that English bunker coal generally, shipped in the United Kingdom and abroad, is good grade coal, not varying in calorific value more than say 1,000 B.Th.U.'s; often it is muck, only fit for burning in a refuse destructor.

My first experience of dial thermometers and C.O.2 recorders in a ship was over 20 years ago and I can assure the author that every effort, and I believe it was an intelligent effort, was made by the ships' engineers to maintain efficient combustion, but often on account of the poor quality of the coal it was a physical impossibility to do so. There are more suitable places for burning inferior quality coal than in a ship's boiler.

The author refers to the absence of suitable instruments to maintain correct combustion and in some cases to the absence even of forced draught. The marine engineer is aware that it is impossible to maintain correct combustion if the requisite instruments are not available and it is quite reasonable to assume that the shipowner knows it too, and I would suggest to the authors that combustion instruments, mechanical stokers and water tube boilers have not been fitted in ships to the same extent that they have in land practice because of the desire of the shipowner to keep initial costs as low as possible.

I would also remind the authors that for the same shaft horse power generated, the staff operating a land installation would most likely be at least 50 per cent. higher than the personnel expected to run and also to maintain a ship's engines and boilers and with the larger land units the staff would include chemists and combustion engineers who could not and would not be expected to tackle the numerous odd jobs the marine engineer is expected to do. Further, climatic conditions at sea are not comparable with those ashore, and it is not uncommon in many vessels for the entire stokehold staff to transfer at the end of one or two voyages. There are few land installations that work under the adverse conditions that are common at sea.

It is agreed that the introduction of high pressure water tube boilers, superheaters, mechanical stokers and geared turbines would result in considerable saving of fuel, but there must also be more uniformity in the quality of coal for power purposes both at sea and in land practice.

There are now British Standard Specifications that are applicable to almost every phase of industry so why not a specification controlling the quality of coal supplied for use on board ship. A British Standard Specification would too, automatically supply the initial machinery of co-operation between the coal owner and the shipping companies, as I assume that it would necessitate the setting up of a joint committee of the coal owners, coal exporters, shipping companies and the marine engineers. It has always been my impression that the coal industry is notoriously apathetic both as regards the absolete methods and machinery at most collieries and as regards the welfare of the miners so that some external control or guidance would be advantageous. I would therefore suggest that at every colliery there should be an independent fuel expert employed by the Ministry to ensure that quality and output are maintained at as high a standard as possible.

Coal for marine bunkering has often to be transported long distances so that it is surely desirable from an economic point of view that as much ash and other impurities in the coal should be removed before the coal is shipped.

A fair proportion of coal is now treated at the pit head, but if coal is to compete successfully with oil, then all coal for marine purposes must be pure coal freed as far as possible from ash and other foreign matter.

Here are two extracts from the South Wales Coal Buyers Handbook published in 1924: "Practically speaking all such unburnable impurities could, and should, be separated from the commodity at the pithead, and the cost of labour necessary to treat and prepare any and all Welsh Large Steam Coal to satisfy even the most fastidious consumer, should mean only an infinitesimal charge in the colliery cost sheet".

"Few of our coal seams are perfect in all respects, but there are scarcely any containing impurities which cannot be separated from the coal by the application of the necessary skill, labour and expense".

If such was the position as far as Welsh coal is concerned as far back as 1924, it does not seem unreasonable to assume that an alert industry aware of its national responsibilities would by now have taken the necessary steps to treat all coal before it leaves the pithead.

Oil fuel will always have a decided advantage over coal for marine purposes apart from combustion considerations, in that oil can be carried in the double bottoms while coal bunker space usually means a corresponding sacrifice of cargo space.

If the shipowner can be persuaded to make this sacrifice of cargo space, then, with the modern methods suggested by Mr. Baird there might be a reasonable chance of coal replacing oil where it is now used, as fuel for the Merchant Navy.

Mr. E. K. Regan, Chief Combustion Engineer, Powell Duffryn Associated Collieries, Ltd.: As a part contributor to Mr. Baird's paper, and also as a strong supporter of mechanical or semi-mechanised firing, I would point out that since the original matter was compiled some further information relative to one of the proposals has been obtained, this referring to the use of rocker-bar grates. It is now found that quite a number of first class coasting vessels have been equipped with rocker-bar grates for some time, and one firm owning a fleet of vessels are of the opinion that grates of this type are responsible for a fuel economy of anything from 5 per cent. to 10 per cent. So far as mechanical maintenance is concerned, these grates are stated to give excellent results and, further, give no difficulty in operation. It is stated, however, that firemen are rather inclined to avoid rocking the grates, a matter which obviously calls for semi-mechanical or electrical assistance, as was suggested in my original memorandum. It is known that such an arrangement has been brought out by an interested firm, but that the exigencies of war-time have prevented further development.

So far as boiler and combustion conditions in the average cargo vessel are concerned, further evidence is forthcoming that there is considerable scope for improvement, or most of the evidence available indicates that this is the position.

A contributor to a discussion on a paper recently given before the Institute of Fuel makes a comment which is here repeated for what it is worth. He states that the worst criminals (sic) in fuel wastage were marine men. He himself was one and he was bound to say that the results were simply awful. He further states that if it was impossible to plan for better efficiency on board ship with the fuels available, then improved efficiency would never be obtained on land, and that excess air was the worst factor in fuel wastage. The contributor goes on to discuss at length the apathy and neglect of ship owners and superintendents towards boiler room technical equipment.

The authors' reply to the foregoing discussion will be published in a later issue of the TRANSACTIONS.

Cargo Ships and Propelling Machinery adapted to War Conditions.

By W. S. BURN, M.Sc. (Member of Council).

Discussion—Continued from page 49.

Mr. C. W. B. Raimes (Member): The paper has aroused a nation-wide interest, as well as that of our members, and the author deserves that his well-thought out efforts should be given the greatest consideration. It is of vital importance to us as a nation, and particularly to our merchant seamen, that every means to defeat the U-boat campaign should be investigated thoroughly.

Now, at last, it seems that consensus of opinion is that we must speed up our cargo ships. The Japs, who are no fools, and who are first-rate naval men, went in for speed many years ago for their cargo ships, and their policy, which has been dictated by their naval men, has been to increase speed. They built with an eye to war. Ordinary commercial considerations should not be allowed to intrude in the circumstances.

Higher speed is essential to obviate shadowing by U-boat packs, and to give greater power of manœuvring. Of course even our fastest ships can be waylaid, but the element of chance is greater, and systematic attacks would be reduced to a minimum. The U-boats would be outpaced unless they surfaced. We must see to it that surfacing is fraught with extreme danger to them.

Although the primary object of cargo ships is to carry cargo, in wartime they must be warships too. All our ships are armed for defence. It would be well if we also armed them for attack.

Despite the fact that the author's suggestions have been most summarily dealt with by the Admiralty, the ideas which he has set forth and invoked are indisputably sound, even if the exact method of attaining our objectives requires further review.

Briefly, the writer suggests that we should aim at an air cover for our convoys during all the hours of daylight throughout the entire passage. Shore-based aircraft can and do provide a guard against submarine and air attack to a limited extent, and small aircraft carriers on the lines of the author's proposals would seem to be indicated for the hiatus.

Giving air escort at all times would force U-boats to remain submerged and a 15-knot convoy would outpace them and prevent shadowing. If some of the smaller but speedier cargo ships were given depth charges and other anti-submarine devices, they could also attack the U-boats when spotted in the vicinity of a convoy. In effect the convoy would be self-protective except against large surface raiders. Even with these, air reconnaissance would be most helpful.

Tankers have been the object of most vicious and sustained attacks. Oil could be carried in bulk in the double bottoms of every ship trading to oil-producing countries, even if it were to the exclusion of other cargo. Submarine oil-carriers could be used for this purpose also at a pinch.

The author's contribution in regard to subdivision and anti-explosion chambers deserves a great deal more consideration. We might learn about this from the Germans—*e.g.* the "Bismarck". The ability of tankers to withstand a considerable amount of damage has been very marked, and it cannot be credited, one submits, to the nature of the cargo. In the first place a torpedo depends on liquid for transmitting its forces.

The proposal that small mass-produced, internal-combustion engines should be used in conjunction with electric drive is a possibility of the future. Certainly Diesel-electric drive is more than a practical possibility, and so is turbo-electric. It is necessary to have a nicely balanced proportion of each to utilize the different grades of oil.

However much we may advocate the use of our national fuel (coal) in peacetime, it seems present policy ought to be that all ships plying to oil-producing countries should use oil as fuel, and our home produce kept for home industry, coastal and other vessels.

The idea that we may be deprived of oil for our purposes goes to the very root of our problem; while we keep the sea routes open we get what we require, and America still produces something like 75 per cent. of the world's oil output.

By increasing the propeller speed to about 250 revolutions there are obvious advantages to offset a small loss of efficiency. But it is doubtful if propellers would stand up to this speed. The writer has in mind the disastrous effect of this speed on phosphor-bronze propellers of destroyers after merely progressive trials.

Assuming that some form of miniature aircraft carrier-cum-cargo ship were adopted, the matter of winches, etc., for cargo handling ought not to perturb us unduly. Present-day port facilities should allow of rapid handling of cargo from the shore end. One sometimes wonders why this costly system of cargo handling has not been superseded long ago on certain trades. There are certain obstacles one admits, but none that could not be obviated.

Placing the propulsive machinery at the end or ends at the present time has much to commend it—the chances of evading a torpedo aimed fore or aft are greater than if the usual midship section were the target.

It is to be hoped that the author's efforts, which must have entailed a tremendous amount of thought and work, will not be entirely in vain.

Mr. T. U. Taylor, A.M.I.N.A.: The author's substitution of the word "vast" for "large" as a description of the size of the problem he has attempted to solve, has the writer's full concurrence. This term seems applicable also to the dimensions of the discussion which is being printed in the TRANSACTIONS, and as the writer does not think he can add much of value to what has already been said in criticism of the various designs, he will confine his remarks to what seems to him the essentials of the problem. The first design has been adequately dealt with, and the second has been comprehensively condemned by Mr. Narbeth's "Draft Report". A third design is under way, but this seems to differ in detail only from the first and second, and there does not seem much point in discussing the details of designs which are fundamentally unsound.

The author asks for constructive criticism. As the writer indicated in his previous remarks, the solution of this problem cannot be based on technical considerations alone, but calls for the consideration of high matters of policy with which the writer professes no competence to deal. The first essential in solving a problem of any sort is to state it clearly, and it seems the most helpful thing to do would be simply to state the problem as the writer sees it.

It should be sufficiently obvious that the prime purpose of a cargo ship is to carry cargo, and the prime purpose of a warship is to fight the enemy. The question one must ask is, "is it more economical to combine these functions in one unit or to build highly specialized units for each purpose?" If a large number of units are being built, the answer is definitely "specialization". This seems to rule out cargo warships at the outset.

Turning to the military and special features of the author's designs, these may be summarized under four heads:—

(1) High speed.
(2) Greater ability to withstand torpedo damage.

(3) Low visibility.

(4) Carriage of aircraft, and provision of a flight deck.

With the exception of item (4), these features are defensive rather than offensive in character. Ruling out item (4) on the ground that it is a warship characteristic and can be better embodied in ships of that special type, and item (3) on the ground that it is incompatible with the provision of the additional reserve buoyancy required by (2), we are left with item (1), high speed, and item (2), greater ability to withstand torpedo damage. The question to be asked here is, "how far will these special features interfere with the vessel's primary function, which is to carry cargo?" A very little consideration will show that whether we take items (1) and (2) alone, or include all four, a very severe penalty is involved in the shape of loss of deadweight on given dimensions, or increase of dimensions for given deadweight. This brings us to another question —optimum dimensions or optimum deadweight? The author has decided for optimum deadweight, which is certainly the more economical solution, but it means also a very big increase in dimensions, and a serious limitation of the adaptability of the vessel in service. The question of increased cost the author has evaded by suggesting that increased use of welding, prefabrication and standardization, would enable these vessels to be constructed with very little increase in cost. If, however, we are not now making the maximum use of welding and prefabrication, any improvement in this respect could be just as well applied to present construction, since vessels of an experimental type having high speed and fine lines are not better adapted to prefabrication but less so. The ratio of increased cost per deadweight ton carried per annum remains therefore unaltered, or is, if anything, less favourable to the special design.

The question of permissible increase in cost of construction per deadweight ton carried, or permissible loss of deadweight tons carried for a given cost of construction, can only be answered by those in possession of all the data relating to our wartime shipping position. Moreover, any answer given presupposes than an accurate estimate can be made of the effectiveness of the special features of the proposed design in reducing the rate of sinkings and damage. The data on which such a decision must be made is confidential, and in consequence no answer can be given by the technician, as such. But some idea of the serious penalty in loss of deadweight tons carried per annum involved in a moderate increase in speed alone can be gained from figures given in a paper by Mr. Ramsay Gebbie ("Fast or Less Fast Cargo Ships") read to the North-East Coast Institution, abstracts of which appeared in the April, 1943 number of "The Shipbuilder".

The foregoing is, in brief outline, a statement of some of the factors in the problem to be solved. It is not, of course, by any means a complete statement. In trying to solve the problem the author, it seems to the writer, has handicapped himself from the start by his obsession with the requirement of low visibility. This may be an eminently desirable feature, but it is perfectly plain that it is incompatible with the provision of a flight deck, and of adequate reserve buoyancy to meet the consequences of damage by enemy action.

The writer has stated what he thinks are the elements of the problem. So far as the solution is concerned, he does not profess to have the necessary data. But on general grounds his own feeling is that it will be solved by fighting the U-boats, not by building cargo ships fast enough to run away from them. Fighting the U-boats with maximum efficiency means specialized weapons with which to fight them, that is, special ships and special planes, with specially-trained personnel, leaving the cargo ship to its own special function, the carriage of cargo. The real reason the cargo ship has been so vulnerable to the U-boat is that we have not had these special weapons in sufficient quantity, because the enemy's preparations were in advance of our own. We are aiming to get these weapons now, and it appears we shall get them eventually. This, it seems to the writer, is likely to be the most economical, and therefore the most scientific solution of the problem. The question of higher speeds for cargo ships is really a problem in itself, and it is not only a wartime problem. If a speed as high as that proposed by the author is required, there seems no doubt that a length approaching 600ft. is required to attain economically and to maintain it in average weather. It looks as if a straightforward investigation into this question together with that of an improved standard of watertight subdivision would be more profitable than that undertaken by the author, which involves many additional experimental features, all of which exact heavy additional penalties in reducing the efficiency of the ship as a cargo carrier.

The writer hopes that the author will consider these remarks in the spirit in which they are offered, and not as an example of the wilful obstructionism which, he seems to think, characterizes the whole of the shipbuilding industry, and those connected with it. Looking again over the first design, about which he was so uncomplimentary in his previous remarks, the writer is astonished at his own moderation.

THE AUTHOR'S REPLY.

Mr. Raimes. The author is glad to note Mr. Raimes's agreement with the principles of the proposals, and in connection with the possibility of using multiple high speed units the author would like to take advantage of the opportunity to make some further remarks on the subject. It was suggested by a contributor that the author proposes something on the lines of what Mr. Ricardo proposed some years ago, but actually this is not in any way the case. There is no need to use more than the normal number of Diesel electric units, i.e. four to six generators per propeller, and preferably only one engine per propeller, using multiple propellers. The latest aero engine, of 1,000 b.h.p. continuous rating, could be depended upon to give 1,000 hrs. running between overhauls, and the author is authentically informed that the cost of an overhaul on normal aeronautical lines would cost about £200 per engine. Therefore an installation of 5,000 s.h.p. would cost about £1,000 per 1,000 hrs. running. A larger engine of the Diesel type could be produced, and no doubt will be produced, for civil aircraft after the war to give 2,000 marine b.h.p. per engine at about 1,000 r.p.m., requiring little more maintenance cost than the above figure, and it would appear that we can look to installations of 8,000 s.h.p. (with one extra engine for excitation and auxiliary) requiring a maximum maintenance cost—most likely undertaken by the engine makers as part of the contract—of no more than £1,000 per 1,000 hrs. actual running, which in 250 days at sea would amount to £5,000 per annum. This, the author suggests, is a better figure than any given by a direct drive engine if actual figures from a number of shipowners for the years before the war could be taken as a basis. The saving to the shipowner in maintenance of his schedules would be very great. The carriage of a couple of spare units, even at £4,000 a time and weighing, say, two tons each, would be a first class insurance. The author believes that the advent of such marine installations will bring back the Diesel to shipping on a sound and sure commercial basis. It is realised that the cost of the electric transmission motors and gear is not inconsiderable, about £3 per b.h.p. and the weight as much as about 35-40lb. per b.h.p. (on the basis of 1,000 r.p.m. generators and 150 r.p.m. motors), but the cost of the engine would not exceed about £2½ per b.h.p. (on the basis of reasonable aeronautical production).

The author has suggested that the aeronautical industry offers the best scope for marine engine expansion if given assistance by research and development on the specific marine engine aspects, as then it will be possible to utilize the most efficient machinery for engine production this country possesses (mostly Government financed), or has indeed ever known, and the author feels it his duty to place the responsibility for action *now* fairly and squarely on the Admiralty. The author has made adequate first hand investigations to satisfy himself of the precise possibilities. In order to compete effectively in engine production after the war, this country has much leeway to make up. This will necessitate the use of technical brains, research equipment and production machinery outside the present orbit of marine engineering if we are to have shipping security, propulsion reliability, low weight and space, low production man-hours, ease of maintenance (often utilizing women labour in the case of aero engines) and low fuel costs. What more can the shipbuilder want?—unless he has marine engine interests which fetter his judgment, or is ruled by organisations which have a closed circle of manufacturers.

We have every reason to be proud of our British aero engine developments and productions; let us graft the same skill to our ship production industry to keep it alive and productive. Bearing in mind the vast sums of national money already poured into the aero engine industry, the author suggests that even if £1,000,000 per annum were spent now on the adaptation of part of it to marine Diesel engine production, this fertilising sum would bring in rapid and sure returns. This country is no longer a major producing country as far as raw materials are concerned, and it will be on the products of our brains rather than on the products from the ground and our muscles on which we must depend in the future.

Early in 1937 the author indicated, in the concluding paragraph of a paper read before the Institution of Naval Architects, that the future of marine oil engines would be with the mass produced small high speed type on the lines of the engine developed by Messrs. General Motors, Ltd., in the United States of America (from a visit to whose works the author had just returned). Since that date the U.S.A. have produced literally millions of horse power of this type of engine for the propulsion of ships; we, on the other hand, have still not produced a single full sized ship propelled on these lines. In point of fact the U.S.A. have produced, since the war started, more horse power of this type than our *total* merchant ship engine horse power during the war, and the author suggests that the sooner the Admiralty checks up on the actual figures the better. It may be thought that there is a great difference in cylinder dimensions between the General Motors engine and a modern aero engine, but this is not the case. The General Motors engine has twelve to sixteen cylinders of 8in. diameter and 10in. stroke, the latest aero engine has eighteen cylinders of 5¾in. diameter (6⅛in. in the U.S.A.) and 7in. stroke (7½in. in the old Pegasus). Consultation with aero engine specialists indicates that post war civil aviation requirements will demand safety fuel or Diesel oil engines of considerably greater cubic capacity than the latest developed types. It is in the development of this later type that shipbuilding should be interested and on which joint development work should be commenced forthwith.

Some exploratory work, since superseded, was done by the author in "The Application of the Two-stroke Heavy Oil Engine to Aircraft Propulsion", a paper read early in 1940 before the North East Coast Institution of Engineers and Shipbuilders, which sets out some of the problems involved. The chief obstacle to any marine engine progress in this country is that there is no competent official marine engine service or department to develop our marine engineering resources. If a comparison is made of the Government personnel provided for aero engine development whether at the Air Ministry, the Ministry of Aircraft Production, or the Royal Aircraft Establishment with that of the Admiralty (and the Merchant Shipbuilding Section in particular), the extraordinarily Cinderella-like position of marine engineering in the Government scheme of things will be appreciated. The author suggests that the microscopic representation of marine engine technicians in high places is a major reason for our complete inability to build more than a very few high speed ships, in fact the numbers of ships over 14½ knots actually delivered are as microscopic as the engineer's representation in affairs.

Bearing in mind the large proportion of engineering man-hours essential to the production and running of the modern ship, it is manifestly a major defect in our Government organisation that this should be controlled by shipbuilders and not by engineers. When one considers the great scope given to pure scientists in posts of control it is to be deplored that applied scientists such as marine engineers are not being permitted to contribute their quota to the winning of the Battle of the Seas instead of being sidetracked by the passing over of war time problems to the U.S.A. If a comparison were made between the U.S.A. marine engine production of the various types and our own, particularly Diesel electric, Diesel geared, turbo electric and turbo geared, the difference will be nothing short of staggering. All these comparisons will be made public one day, and in the interests of all but a few the sooner the better, and our complete lack of enterprise exposed. The position is so serious that the author feels the time for soft pedalling is past and that the facts be brought to the notice of members of the Government who may have imagined that all is being done that can be done, and that all resources had been tapped.

Mr. Raimes is certainly right in pointing out the need for the use of a nicely balanced proportion of each grade of oil (partly to control oil prices), and it will be essential for high speed engines to use ordinary Diesel oil. It is hoped that some internal combustion use of coal will be found, perhaps on the lines of the author's contribution to another paper.

Mr. Taylor. The author is glad to welcome Mr. Taylor back to the fray because his last attack caused him to evolve a fundamental solution (which will be published in due course) to the hatch cover problem, which is in reality the key to the combined use of aircraft carriers as cargo carriers about which there is now, fortunately, no argument—this much we have progressed.

Mr. Taylor may consider the author's proposals fundamentally unsound, but would he then suggest that the *pre-war* ship was *fundamentally* sound? The author has spent some time studying the historical development of ships, and as a result has come to the conclusion that the future development of ships is almost infinite. Unfortunately to-day we are so cluttered up with many artificial things like Tonnage Regulations (at one time a fit and proper safeguard), old fashioned docks and building slips, that fundamentals have to take a back place. For example, suppose that there were no practical limitation to beam, would the tendency not be towards aerofoil formed ships instead of developments from rectangular blocks with pointed ends, especially if a few yards built a large number of ships so as to make straight sections relatively immaterial for reasons of manufacture?

On the question of propulsion, the author dallied for some time with the natural history aspect. Did a fish exist with a caudal or tail fin only? It did not, all fish have a measure of bow propulsion with pectoral fins. Again, did mammals like dolphins or whales, having a later natural choice of development, evolve a measure of forward propulsion? It was observed that the forward flaps are indubitably strong, so that fundamentally the single stern propeller seems to be "fundamentally unsound". In the days of sail power the centre of pressure was forward rather than aft and perhaps after all twin propellers at the shoulder and one at the stern may prove the most correct layout for propelling ships.

The hatch cover problem may have seemed insoluble to Mr. Taylor (and therefore unsound), but it is capable of solution nevertheless. Take the interesting case of the Vee double acting machinery—the balance was not too good; Dr. Dorey ably confirmed this, but shortly afterwards the author was able to solve the problem by merely using two cranks (3 webs) at 180° per Vee pair of cylinders and procured lovely dynamic balance, good turning moment, reduced loading on the main bearings, reduced torsional oscillation tendencies, etc. Wholesale condemnation gets one nowhere, and even though the full solution to all details may not be apparent, if the principle is sound thought and work will do the rest.

Mr. Taylor may have thought that Mr. Narbeth was wholly condemnatory, but the author on the contrary considers he was extremely helpful, and shortly hopes to be in a position to satisfy all Mr. Narbeth's requirements—and more.

It is agreed that the requirement of low visibility imposed serious problems, but this was a property no less desired by Mr. Narbeth than recommended by everybody who has been in submarines, and, one may say, is an essential to a vessel which is intended to sail without convoy. In spite of new scientific appliances, common or garden human vision plays a vital part in practical naval operations, and low visibility can be considered a first line of defence, speed being the second line, underwater silence the third, and so on. Mr. Taylor suggests that "standard" watertight subdivisions would be more profitable than those proposed by the author, but how is one to get large hatches on to small holds? Only, the author suggests, by an athwartship design, and with the design proposed the hatch area can be actually increased compared with normal practice. Warships have watertight subdivision, but still fit blisters.

On the question of ship speed the world commercial tendency was towards increased speed, especially by those countries which lived on world marine transport, in spite of the arithmetic of the Paper mentioned, which incidentally was not intended to have any connection with war strategy. The problem of the supply of the higher powered engines in quite different from the strategic justification of speed, and is capable of solution.

Mr. Taylor states that the Battle of the Seas, which incidentally is only partly U boat, would be best solved by fighting the U boats; it is now apparent that this is a solution, and moreover, that aircraft in various forms are the true antidotes to U boats. Nevertheless there is the other solution, namely that if the U boat cannot find its prey, can never get to grips with its prey, and can always be seen first by its prey, its "sting" is rendered impotent, and it is as inoffensive as a whale.

The author believes that war accountancy will eventually eliminate special naval escorts for merchant ships on the score of economy, and that each ship can and will be made more potent that any naval escort other than an aircraft carrier. In other words, the most economical way will be by the redesigning of our cargo carrying ships so as to permit our warships to meet and fight warships and not spend their time escorting cargo. As the range of aircraft increases so will attack from aircraft increase, and this will require efficient fighter escort always on the spot—which can be provided by the cargo warship itself. A cargo vessel, the author believes, should not only be seaworthy but warworthy if it is to deliver its cargo to its destination and not to the bottom of the sea.

The author does not suggest that British shipbuilders are all obstructionists; they are perhaps inclined to be technically and productively somnolent and unprogressive compared with other vital new industries, but during the war they are dominated by Admiralty personages and the success or failure of our merchant shipbuilding has been entirely in the hands of those who have directed its policy. Indeed, taking the broadest national view, the non-expansionist policy of our shipbuilders and marine engineers may well prove to have been most providential as, due to the relatively small calls they made on manpower and new machine tool capacity, the immense aircraft industry has been in part made possible, which in turn has been able to smash the U boat from "the cradle to the grave". It was, without doubt, very fortunate that the U.S.A. took up the burden of shipbuilding and above all that our merchant sailors and engineers were able to stick it out until succour came. Let us hope that we may be guided by the lesson of American shipbuilding, and that in the future we shall build the fine ships which our Merchant Navy so richly deserve, and that "per se" our ships are so designed to be as free as possible from wartime menaces.

It is perhaps remarkable that whilst the Controller of the Navy is a sailor, the Controller of the Merchant Navy is a shipbuilder; the author submits that in the future the Controller should be a sailor of the Merchant Navy, a high officer of the Royal Naval Reserve, who has had wide seagoing experience in war and peace, so as to ensure that ships of a design to suit war and peace requirements are developed and built. This suggests that there should always be a Controller of Merchant Ships and that the development and construction of cargo vessels adapted to war conditions are continued during peace time as a national security. Co-incidentally the training of R.N.R. personnel should be given full encouragement while the vessels are gainfully employed carrying cargo. Under the united direction of Directors of Merchant Ships and Marine Engines, research and development would be unceasing and not left until war actually occurred, and it is hoped that victory will not deflect us from consideration of our basic maritime needs, which are always greater and not less in wartime.

ADDITIONS TO THE LIBRARY.

Purchased.

Instructions for the Treatment of Boiler Feed Water and for the Operation and Maintenance of Feed-Water Apparatus. United States Navy Department—Bureau of Ships Manual, Chapter 56, price 15 cents.

Presented by the Publishers.

Memoranda Nos. 1 and 2 on Fuel Economy. The Paper Makers' Association of Great Britain and Ireland. Prices 1s. 6d. and 3s. 6d. respectively.

Heat-Treatment of the Wrought Aluminium Alloys. Part I: Practice. Part II: Equipment.

Fusion Welding of Wrought Aluminium Alloys. Wrought Light Alloys Development Association.

Life-Saving Measures for Merchant Seamen in Time of War. International Labour Office. Price 1s. 6d.

Pocket Book for Mechanical Engineers, by D. A. Low, Wh.Sc., M.I.Mech.E. Longmans, Green & Co. New edition revised, 1943. 1,000 illustrations, 778 pp. Price 15s. net.

The new edition of this well known and valuable publication contains further information covering units and standards of measurement employed at the National Physical Laboratory; tables concerned with the measurement of oil in bulk; an extended table of equivalent temperatures, together with notes on up-to-date practice in measuring temperatures; and a revised section on compressed air. The book is still of a very convenient size, clearly printed, and altogether an excellent work of reference for engineers and draughtsmen in practically every section of mechanical, marine and constructional engineering.

Applied Mechanics, by Arthur Morley. Longmans, Green & Co., 1943, 360 pp., illustrated by diagrams, price 7s. 6d.

The author requires no introduction to engineers as his text books on Strength of Materials, Theory of Structures, and Elementary Applied Mechanics have been used very successfully in technical colleges for many years. The book under review has been written to cover the Final Year (S.3) of the Ordinary National Certificate course in Mechanical Engineering, and includes sections on statics, friction and machines, kinematics, principles of dynamics, circular and oscillatory motions, hydrostatics and hydraulics, and strength of materials and structures. The notation of the calculus, applied to dynamics, introduced in Chapter I, will certainly show the engineering student, at the S.3 stage, some real applications of a branch of mathematics which he usually regards with a certain amount of mystery. The application of the principle of work to the solution of problems on mechanisms is very clearly shown in Chapter III, and the simplicity of the method is well illustrated in dealing with the Roberval balance, the toggle joint, and Rapson's slide.

Each chapter contains plenty of worked examples, in which the dimensions of the physical quantity is shown at every stage of the working. At the end of each chapter there are plenty of well chosen examples, with answers at the end of the book, from which the reader may test his knowledge of the subject.

The book can be well recommended to those students who are in the S.3 year of the Ordinary National Certificate course and to those who are studying the subject either for the Associate Membership examination of the Institute of Marine Engineers or as candidates for the Lloyd's Register Scholarship.

Britain's Merchant Navy, by various authors. *Odhams Press, Ltd., 253 pp., 40 illustrations, price 5s. 6d., de luxe edition 6s. 6d.

*Copies obtainable only from Odhams Press, Ltd., Book Dept., Hazelwood, Huntonbridge, King's Langley, Herts.

This is a collection of articles by various authors arranged in book form. It is profusely illustrated with interesting photographs and drawings and deals with the many and varied aspects of all the types of vessels that form the Merchant Navy. Each author is an acknowledged expert in the subject on which he has contributed the chapter under his name.

As might be expected at the present time the articles deal principally with the conversion of the independent units of the Merchant Navy into one immense organisation adapted solely for war purposes and for the manifold duties and activities of the organisation for the successful prosecution of the war. The whole range of vessels is dealt with, from the mine sweeper—ex trawler to the troopship—ex passenger liner.

The contribution detailing the case of an ordinary tramp ship at sea on the outbreak of war is particularly interesting. The description of the captain opening his sealed orders and realising he is no longer his own master but that his vessel has become an integral part of a vast and complex war machine, the voyage to the U.K. and the shepherding of the vessel into harbour through minefields, the installing of the defensive equipment against mines and aircraft, the thousand and one requirements necessary to enable the vessel to play her part with the utmost safety and efficiency, in fact everything right up to the moment the vessel sails with the convoy outward bound makes fascinating reading.

Though the book is serious in tone yet there is romance in the contribution "Freedom of the Seas". Beginning with the era of ocean trading, which opened when Queen Elizabeth declared to the Spanish Ambassador in London "The use of the sea and the air is common to all", this article briefly describes the rise of the sailing ship to the Clipper class and further until the advent of the steam ship, which finally ousted the sailing vessel in favour of mechanical propulsion. There is romance also in the description of the rise of some well known shipping companies, companies whose names are honoured in all the seven seas.

The most human and gripping contribution, "Battles Against Great Odds", tells in vivid words, though perhaps too briefly, the story of Germany's savage war on merchant ships. The outstanding cases of well known engagements with the enemy, e.g. of the "Rawalpindi" and of the "Jervis Bay", and the rescue of the prisoners from the hellship "Altmark" by H.M.S. "Cossack" are retold in the spirit of their grim heroism.

The story of long voyages in open boats made by survivors of torpedoed vessels is very briefly sketched, but enough is written for one to imagine the privations the survivors underwent and the seamen's unconquerable determination to hold on. This chapter eloquently epitomises the spirit of the personnel of the Merchant Navy, the spirit that all the blows of the Axis powers cannot subdue. It may truly be said, "The Merchant Navy deserves well of the country".

A very readable book, and one to enhance the pride we have in our incomparable Merchant Navy.

Abstracts of the Technical Press

Rising Cost of New Tonnage.

In the course of a Press interview on the occasion of the launch of a new cargo steamer from a Sunderland shipyard, the managing director of the yard in question stated that he was not altogether in favour of all-welded construction. He thought that as regards British yards, riveting was cheaper than welding, in addition to being faster and stronger, as long as a good supply of efficient riveters is available, as is the case in this country. These conditions do not obtain in America. The managing director of the shipping company which placed the order for the new cargo steamer —a shelter-deck vessel of 8,600 tons d.w.—said that the ship would have a speed conforming to Admiralty requirements, which meant a daily consumption of 30 tons of coal, whereas a vessel of 9,500 tons d.w. built for his company in the same yard just before the war did 12¾ knots on a daily coal consumption of 25 tons. The company's fleet used to include a vessel built on the N.-E. Coast in 1898, which had a higher speed on a lower coal consumption. This shipowner expressed the view that a 15-knot ship might be very useful in a limited cargo liner capacity, but for ordinary tramp trade he considered the soundest proposition to be a ship with a speed of about 12½ knots, both for war-time and for post-war trading. He thought that with a little alteration of the Admiralty building programme vessels of this type could have been constructed. At the present time there appeared to be no prospect of any tramp owner being able to place contracts for further new ships, except in one or two yards, which would give reasonable delivery at a price of some £60,000 more than the price ruling last year. The price of the vessels just built for his company was about £20 per ton, but that for any further new vessels would be in the region of £30 per ton.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,925, 1st April, 1943, p. 8.*

"Faster Vessels for War Transport".

A letter contributed to the correspondence on the above subject contains a suggestion that high-speed ships built to meet the present demand for such vessels should have their propelling machinery arranged in such a manner as to facilitate conversion to post-war requirements. The writer expresses a preference for triple screws, with three engines on three shafts, so that when the speed is to be reduced after the war, it will be feasible to remove (*a*) the two wing engines and fair off the bosses, or (*b*) the centre engine and fair off the stern post. The writer is opposed to the idea of having two or more engines in tandem on a single shaft, because a lay-out of this type involves an after crankshaft capable of transmitting the power from the forward engines in addition to that of its own unit, whereas from a manufacturing point of view it is desirable that the crankshafts of all the engines should be of the same dimensions. The easiest conversion arrangement would, it is suggested, be a centre engine aft and two wing engines in a compartment forward of it. If Diesel engines were adopted, the removal of the two forward engines would enable this compartment to be made into another cargo hold. In the case of steam engines, the installation of watertube boilers on a special deck over the engines would make it possible to remove the boilers over the two forward engines together with the latter, thereby leaving the space clear for cargo, as in the Diesel arrangement.—*"The Shipping World", Vol. CVIII, No. 2,599, 7th April, 1943, p. 328.*

N.F.S. Aid in Ship Repair.

In order to carry out repairs on board a large ship of foreign construction, it was necessary to keep her auxiliary machinery running while she was in dry dock. In the port where she normally used to undergo refits a 12-in. pipe was permanently fitted in the dock-side to supply circulating water for her condensers. As a substitute here a triple syphon was erected by the National Fire Service of 6-in. piping similar to that used in the streets of most large cities, a special manifold being employed to connect the syphon to the ship's circulating system. The pipes were connected by Victraulic joints designed primarily to withstand internal pressure, and there were some misgivings as to how these joints would behave in a system involving syphoning and suction, so some preliminary experiments were carried out before the ship's arrival. These proved satisfactory. When the vessel was being dry-docked, two crews of N.F.S. men trained in pipe-line work rigged the connections, using more than 1,600ft. of piping, with the necessary valves, bends and expansion-jointed sliders. The syphons lifted water about 8ft. to the top of the dock gates, dropped it to the horizontal lines on the dock floor 36ft. below and then lifted it 16ft. to the inlet on the ship's side. The system was primed from hydrants, through open T-pieces at the top of the syphons with the 12-in. valve forming part of the ship's circulating system closed. When this valve was opened syphoning started immediately and gradually pulled through the air which had not been excluded from the horizontal piping at the top of the syphon. A ship's pump was brought into action and it is estimated that the flow, thus accelerated, exceeded 3,000 g.p.m. This was maintained without difficulty for six days, after which the same N.F.S. crews quickly dismantled the installation.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,931, 8th April, 1943, p. 7.*

Crew Accommodation in Merchant Ships.

The author begins by discussing the present-day regulations concerning the accommodation to be provided for the officers and men on board British merchant ships, and points out that they leave room for many improvements. He suggests that due recognition of the needs of the catering department, the elimination of engineers' messrooms, the provision of changing rooms for the E.R. staff, direct access to the engine room from the upper deck without having to enter or pass through any of the crew's living quarters while the ship is undergoing a refit, and better protection from the weather, are all matters which call for attention. The second part of the paper is devoted to interior arrangements and fittings, and deals with lighting, heating, washing facilities, ventilation, the materials used in the construction of accommodation, furnishings and cabin fittings. The last part of the paper deals with the trend of future design and includes suggested arrangements of accommodation in a typical motorship of the tramp class of about 8,000 tons d.w. and 2,400 i.h.p. and on board a cargo vessel with a crew of 46 in single-berth cabins. The paper is illustrated by a number of plans of accommodation, as well as by photographs of typical officers' cabins, saloons, bathrooms and other living spaces.—*Paper by J. E. Church, "Transactions of the Institute of Marine Engineers", Vol. LV, No. 4, May, 1943, pp. 51-66.*

Sabotaging of Liberty Ships.

Several workmen, formerly employed as welders on Liberty ships under construction in the Bethlehem Fairfield (Maryland) shipyards, have been arrested on charges of sabotage. It is stated that the men admitted doing faulty welding in order to increase their piecework earnings. Many of the defective welds were in vital parts and were only discovered through the use of X-rays. In view of the failures which have occurred in American welded ships, either immediately after their completion or when they were on the high seas, the quality of the welding done in U.S. shipyards is now receiving very careful attention. There does not appear to be any record of a case in which riveters had to face similar charges, but this fact is no indication of the relative moral standards of the two classes of workmen, for, if a riveter does his job badly, he cannot expect to get away with it and is obliged to rerivet the work correctly. The inspection of riveting differs from that of welding in that faulty rivets can easily be detected, and, provided that the essentials necessary for the preparation of the work are observed, a routine hammer test of the completed work is all that is required. In the case of welding, on the other hand, there is no positive test after completion. The efficiency of a welded joint can be judged to a certain extent by the final appearance, but so many factors are involved, such as the size and quality of the electrode, the current, length of arc and speed of deposit, that a continuous control by well trained and efficient supervisors is of vital importance. The fact that X-ray photographs had to be taken in connection with the case mentioned is an indication of the difficulty of deciding, without detailed knowledge of the conditions observed during the actual welding process, the efficiency of a welded joint.—*"Fairplay", Vol. CLX, No. 3,130, 6th May, 1943, p. 528.*

Fishing Vessel Design.

Among the papers recently presented for written discussion to the Institution of Naval Architects, was one bearing the above title, by A. R. Taylor. In it the author discusses various characteristics of trawlers and drifters, and gives curves from which dimensions, speed and power, and stability particulars may be obtained. He points out that the relatively high coal consumption of a trawler usually makes it necessary to carry coal in the after fish hold on the outward voyage; for that reason the use of oil-fired boilers or Diesel engines for propulsion has the advantage that the fuel can be carried in independent tanks of smaller volume for the same duration of voyage. The author expresses the opinion that, if the intermediate processes which come between the catching of the fish and its ultimate sale to the consumer could be rationalised, the industry might experience a degree of prosperity which would result in the more highly skilled personnel required to maintain Diesel engines being attracted to it. At the same time he recommends that the trawl winches should be electrically driven on the Ward Leonard system, an arrangement which could only be adopted conveniently with Diesel machinery. Among other suggestions put forward in the paper is one concerning the refrigeration and insulation of the fish holds. These should, in the opinion of the author, be made up of a series of well-insulated chambers, each having a capacity for an average day's catch.—*"Fairplay", Vol. CLX, No. 3,130, 6th May, 1943, p. 530.*

Shipbuilding Problems in the United States.

It seems that there is a "big dispute" between the War Production Board and the Navy Department on the one hand and the U.S. Maritime Commission on the other, concerning the proposed change-over from the construction of 11-knot Liberty ships to 15-knot Victory ships. The War Production Board contends that in the interests of simplicity and standardisation of design, there should be no attempt to build fast cargo vessels other than those already in production and, further, that the change-over to Victory ships will involve production delays which will more than offset the gains from the additional speed. The Victory ships are to have Lentz steam engines and, as they become available, turbines or oil engines. The designed speed of the Lentz-engined ships is 15 knots and that of the ships with turbines or oil engines 17 knots, as against the 11-12 knots of the Liberty ship with its three-cylinder triple-expansion engine of 2,500 i.h.p. The Lentz engines to be installed in the Victory ships are stated to be four-cylinder compound units with two h.p. and two l.p. cylinders, rated at 5,500 i.h.p., but as no Lentz engines of such a size have yet been produced, the War Production Board considers that more experience with such machinery should be obtained before attempting to use it on the scale invisaged. The Maritime Commission, however, point out that there is nothing experimental about their programme for the construction of Victory ships, and that there is no intention of installing high-powered Lentz engines until the exhaustive tests which they intend to carry out with them have been successfully completed. They also point out that "since the Lentz engine would require some 30 per cent. more man-hours than the present engine, the existing engine factories, with certain alterations, will be able to produce a new type of engine at approximately 70 per cent. of the maximum volume of output scheduled for the present type, without any interference with other phases of the merchant shipbuilding programme. It will also be possible to modify the factories, if desirable, to produce the greater output, but in re-designing the Liberty ship to use the Lentz engine, provision has been made for the possible use of turbine or Diesel propelling machinery which, if available, is preferable to reciprocating steam engines".—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,966, 20th May, 1943, p. 6.*

Concrete Shipbuilding in America "Expensive and Slow".

The report of the U.S. committee on the construction of reinforced-concrete vessels states that the results have been "most disappointing" and that the cost of building the concrete barges with their tugs will be at least 250 million dollars, added to which the programme is behind schedule. The expectations that concrete barges could be constructed cheaply and rapidly with unskilled labour instead of shipyard labour, and that available stocks of low-grade steel could be utilised for the purpose, have not been realised. The committee report that the programme "has actually been appallingly expensive and extremely slow". Changes in design and materials, and the adoption of steel pre-fabrication methods have made it necessary to obtain more and more experienced welders in competition with the shipyards building steel vessels and to make use of increasingly large quantities of high-grade steel. The report points out that "little benefit has been obtained from the programme to date, and the extent of later benefit will not be proportionate to the cost either in dollars or materials". Under these circumstances, it is not surprising that Admiral E. S. Land, head of the War Shipping Administration and of the Maritime Commission, should have stated "I am not an enthusiast about concrete ship construction".—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,966, 20th May, 1943, p. 6.*

Motorship to be Built of Oak.

The Greenland Administration of the Danish Government is reported to be contemplating the construction of a ship to replace one of the two vessels lost during the present war. The hull of the new ship is to be built of oak, owing to the shortage of steel, but an ice-resisting skin will be provided at the bow. The vessel will be 140ft. in length and 35ft. 4in. in breadth, with a draught of 15 to 16ft. The hull will be stiffened internally against ice pressure by special 'tween deck members. The propelling machinery will consist of a 600-h.p. Diesel engine designed to give the ship a speed of 10 knots, and the two steel masts will be arranged to carry emergency sails. The fuel-oil tanks will have a capacity of 100 tons. In addition to between 550 to 600 tons of cargo, the vessel will carry 20 passengers. Tenders are shortly to be called for from shipbuilders, and it is anticipated that the ship will be completed in about two years.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 21, 27th May, 1943, p. 491.*

A New Ship's Lifeboat.

An improved type of ship's lifeboat, claimed to be the safest in the world, has been designed by Mr. F. H. Lowe, joint managing director of the Lamport and Holt Line. The boat, which can if necessary be lowered from a vertical position hanging from one fall, was recently subjected to a special test before Ministry of War Transport officials on the Mersey. The test showed that the boat was still stable when it was listing at an angle of 100° from the horizontal, whereas the usual type of boat goes over at about 80°. The improved lifeboat, which is about 29ft. in length and weighs 3½ tons, has accommodation for more than 50 persons. It is decked over fore and aft, giving protection from sea and weather and eliminating faults in launching. When righted after being deliberately capsized, it still remains afloat, even when full of water and with two men standing on it. The drinking-water tanks are of twice the usual capacity and the buoyancy tanks are supplemented by additional compartments, further buoyancy being provided by a stout cork fender fitted outside the gunwale.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 21, 27th May, 1943, p. 476.*

Fireproof Lifeboats for Oil Tankers.

Under the chairmanship of Mr. John Lamb, technical manager of the Anglo-Saxon Petroleum Co., Ltd., the Tanker Tonnage Committee have for some months past been investigating the possibility of a fireproof ship's lifeboat for supply to oil tankers. Among the demonstrations and tests carried out under the auspices of this committee were some tests made with an ordinary 24-ft. lifeboat designed to carry 32 persons. Alterations to the hull of the boat included sheathing of the woodwork above the water-line with thin metal plating; the addition of metal coamings extending 12in. above the gunwale; and the provision of metal turtle-backs forward and aft. There was also a canopy or hood of asbestos-treated canvas, in three independently operated sections. The entire hood can be closed instantaneously to cover the boat in completely. The lowering hooks are reached through hatches in the turtle-backs and Mills patent releasing gear is provided for use with any existing davits of standard capacity. Spray pipes are led along both sides of the boat and athwartships fore and aft, by means of which the canvas hood, the turtle-backs and the whole of the exposed parts of the boat can be covered with a water spray. The spray pipes are fed with water from two semi-rotary hand pumps drawing water through cocks in the bottom of the boat. A small bilge pump is also provided to deal with any water which may enter the boat. Extra buoyancy and stability is ensured by metal blisters, filled with expanded rubber and sheet asbestos, on either side of the boat. The latter is steered from inside by a steering wheel connected to the rudder head by wire ropes. Propulsion is by Fleming's patent hand-gear which enables the boat to be manœuvred away from the ship's side at right angles, two boats' lengths away in 14 seconds. The additional gear in the lifeboat has reduced its carrying capacity from 32 to 27 persons, but the metacentric is nevertheless greater than that of an ordinary lifeboat. One test involved placing the boat in a small water-filled concrete tank, and pouring a mixture of 25 gall. of petrol and Diesel oil on to the water in it. Two semi-rotary pumps fitted outside the concrete tank were operated to enable the spray pipes to cover the boat with a water spray, and the inflammable mixture around the boat was then set alight by means of petrol torches. For four minutes (during which the boat could have been propelled nearly a quarter of mile away from a ship) the tank was a raging inferno of fire, the heat from it driving the spectators back on all sides. The fire was then put out and the temperatures inside the canvas hood were taken. They proved to be 72° F. forward, 114° F. amidships and 85° F. aft. No appreciable damage to the canvas hood or wooden hull of the boat was caused by the intense heat of the burning fuel around it. A second test of a similar kind, but of only three minutes' duration, was carried out with 10 persons led by Mr. Lamb himself, under the canvas hood and working the semi-rotary spray pumps fitted in the boat. Beyond getting rather wet, the party suffered no discomfort under the hood from the smoke or heat around them.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,978, 3rd June, 1943, p. 8.*

Superheat Control Development.

In order to have full control over the heat supply to a superheater it is necessary to be able to adjust both the gas temperature and the gas flow in accordance with requirements, and to meet this condition the Foster Wheeler Corporation have developed a twin-furnace type of boiler with a combination superheater comprising both radiant and convection units, the former lining the walls of

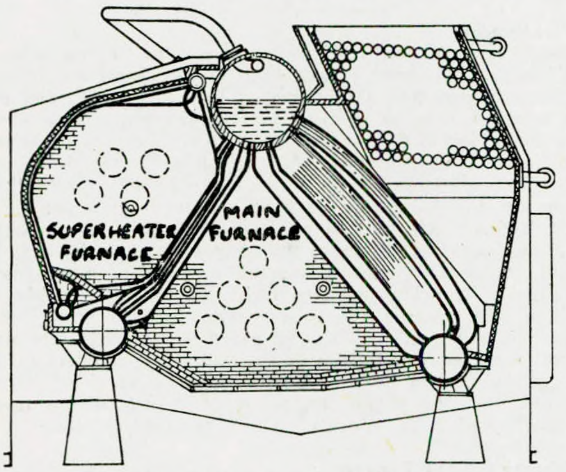


FIG. 1 *(left).—Arrangement of separately fired superheater boiler (Foster Wheeler).*

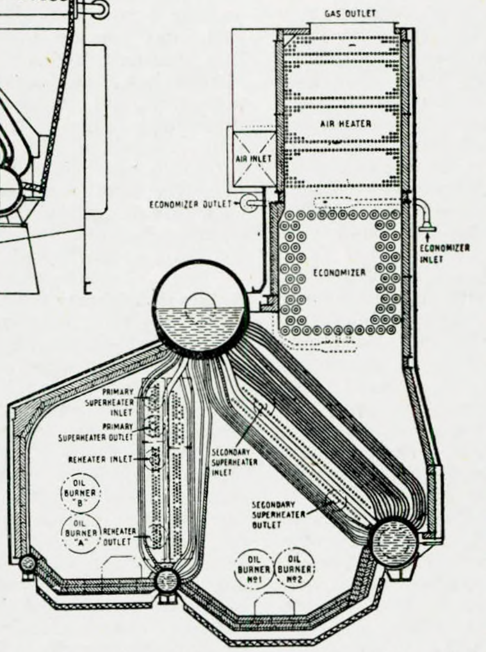


FIG. 2 *(right).—Babcock & Wilcox marine type boiler with separate furnaces for superheating and reheating.*

one of the furnace halves. It is claimed that this twin-furnace design provides effective control of the heat supplied to the radiant unit by appropriate adjustment of the respective furnace heat inputs. This adjustment can be extended over a very wide load range. The twin-furnace design also makes it possible to raise steam in the boiler solely by means of the oil burners in the furnace devoid of radiant superheater surface, thus eliminating any risk of damage to the radiant superheater tubes during the lighting-up period. A number of large units of this type are reported to be giving excellent service in the U.S., and at least one large plant of this kind was placed in service in Germany just before the war. While in this type the furnaces are operated in parallel, the three-drum oil-fired marine boiler design evolved by the same firm represents a further development in the isolation of the superheater from the boiler. This is achieved by making the radiant superheater furnace an appendix to the main furnace proper, as shown in Fig. 1. The boiler evaporation is controlled by the heat supply effected by the burners in the main furnace, while the degree of superheat maintained is entirely dependent upon the rate of firing maintained with the superheater furnace burners. The flue gases of the superheater furnace are discharged into the main furnace. A two-furnace high-pressure marine boiler, in which the heat supply to the convection-type superheater and reheater is derived from a special furnace, has also been developed by Babcock & Wilcox, Ltd., and is shown in Fig. 2.—*"Engineer and Boiler House Review", Vol. 57, No. 6, June, 1943, pp. 162-165.*

American Coastal Tankers.

A large number of motor tankers for coastal service are being built in America for the U.S. Maritime Commission as well as for various private owners. The oil cargo capacity is 2,800 tons and the fuel-oil tanks abreast the engine room hold 70 tons. The twin screws are driven by two 680-b.h.p. four-stroke Diesel engines and the whole of the auxiliary and deck machinery is electrically operated, the requisite current being supplied by two 150-kW. generators driven by 225-b.h.p. Diesel engines. Each of the two cargo pumps is coupled to a 75-h.p. electric motor, whilst the smaller pumps in the main engine room are driven by 60-h.p. motors.—*"The Motor Ship", Vol. XXIV, No. 281, June, 1943, p. 81.*

Remarkable Salvage Feat.

Some details were recently disclosed of a remarkable case of salvage by the officers and men of the N.Z. Shipping Co.'s 14,000-ton liner "Hororata". The ship was torpedoed without warning in very bad weather on the afternoon of 13th December, 220 miles off Flores Island (Azores). Although she developed a heavy list to port as the result of a huge hole in her side, she managed to reach Flores early on the following morning, by which time her condition had become critical. The vessel was drawing 43ft. of water aft, the gunwale bar on the P. side was awash, and the flooding of the 'tween decks had almost completely destroyed her stability. As it was clear that the ship would capsize if the water reached the shelter deck, the port authorities persuaded the master, Capt. F. S. Hamilton. who had already landed most of the crew, to come ashore with the remainder. Throughout the following night he, with his chief officer and chief engineer, kept watch on the ship from the shore and discussed ways and means of improving her condition. At daybreak, the captain and his officers went off to the ship in a motor-boat, in spite of the bad weather, started up the auxiliary machinery, and got steam on the main engines. They also succeeded in improving the vessel's condition by flooding one of the D.B. tanks. Late that night the wind drove the ship to seaward, dragging both anchors, but the salvage crew managed to bring her back to the anchorage. Two days later the captain of the "Hororata" realised that it would be impossible to attempt even the most elementary repairs at Flores. He therefore decided to make a dash for Horta, 130 miles distant, but the journey had to be made secretly, owing to the presence of enemy agents who would be certain to signal the ship's movements to U-boats lurking outside. Most of the crew were therefore left ashore, and with the few men on board at action stations throughout the voyage, the "Hororata" made the perilous trip to Horta during the hours of darkness, arriving there on the morning of 18th December. The refrigerated cargo from the three shelter decks was thereupon discharged in order that temporary repairs might be effected. A wooden pad was first of all secured over the damaged area to enable the vessel to be pumped dry. The structural strength of the hull was then restored by means of a frame of girders placed horizontally and vertically over the hole in the side, a concrete reinforcement with 1-in. round bars being superimposed on this framework. The lack of a dry dock and workshop facilities at Horta, as well as shortage of materials, made the completion of these repairs a difficult matter. The underwater work was carried out by a local diver, trees were cut down on the hills beyond Horta to supply the timber, and scrap railway lines were fabricated into girders. There were no modern tools, and bolts and rivets had to be made by hand. By 23rd January the ship had been pumped dry; the frame was in position on 14th February, and the cementing was begun four days later, a total of 320 tons of cement mixture being poured into the frame by 24th February. On the advice of a local expert 14 days were allowed to elapse for hardening the concrete, and on 6th March the "Hororata" received a certificate of seaworthiness. She sailed for home with a patch 45ft. by 32ft. over the hole made by the torpedo, and a week later was discharging her cargo of 9,600 tons of dairy produce and meat at a British port.—*"The Syren", Vol. CLXXXVII, No. 2,440, 2nd June, 1943, p. 235.*

Gross and Deadweight Tonnage.

The policy of building closed shelter-deck ships instead of open shelter deckers during the war, has completely altered the relation between gross and deadweight tonnage. For instance, a standard vessel about 420ft. in length b.p. with a beam of 56ft. 6in. and a draught of 26ft. 10½in., built as an open shelter decker, used to have a gross register of 5,200 tons and a d.w. capacity of 8,700 tons, the ratio of gross to d.w. tonnage being about 60 per cent. A ship of similar type and equal dimensions, now constructed as a closed shelter decker with a draught of 27ft. 4½in., has a gross register of 7,250 tons and a d.w. capacity of 10,300 tons, the ratio of gross to d.w. tonnage being 70 per cent. The gross register of the American "Liberty" ships is about 7,100 tons, and the d.w. capacity 10,500 tons, the former being about 68 per cent. of the latter. These facts must be borne in mind in view of the practice established in the U.S. of regarding deadweight as the standard for tonnage, whereas in this country it has long been customary to employ gross tonnage as the standard. When comparisons between the two are being made, those who have been accustomed to a ratio of gross to d.w. tonnage of 60 or 65 per cent., may forget that this ratio is no longer applicable. All the closed shelter-deck ships can, of course, be converted to open shelter deckers, if desired, and it may be assumed that this will be done after the war.—*"The Motor Ship", Vol. XXIV, No. 281, June, 1943, pp. 71-72.*

Novel Form of Construction for H.P. Feed Heaters.

An interesting form of construction intended to eliminate the need for heavy bolting with feed-water heaters for very high pressures is the Lockhead design developed by the Foster Wheeler Corporation which has already been applied to many large feed heaters in American power plants. The main features of the high-pressure closure of such a feed-water heater are shown in Fig. 7. They comprise a single-piece steel forging in which the heavy head block transmits the pressure load by means of segmental shear pieces engaged on their periphery in an internal groove of the housing. The joint is sealed by a ring of studs holding the heavy rim of the diaphragm plate against the gasket.—*"Engineering and Boiler House Review", Vol. 57, No. 6, June, 1943, pp. 150-156.*

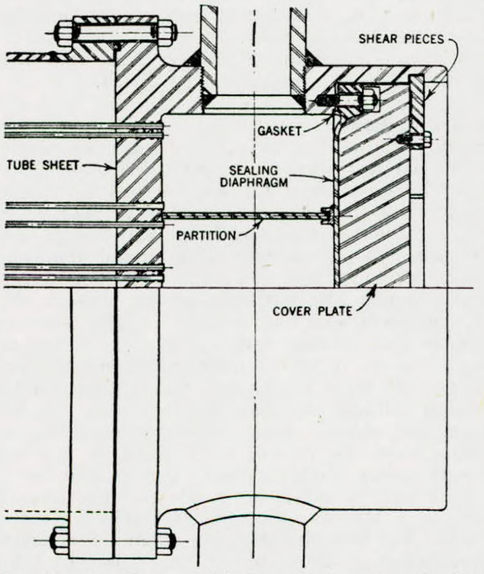


FIG. 7.—*Section of Lockhead showing flexible diaphragm transmitting pressure load to head plate.*

Refrigerated Motorship for Service on German Inland Waterways.

The motorship "Kühlschiff I", described as the first European refrigerated vessel for service on inland waterways, was placed in service on 11th May, and a second ship for the same owners is expected to be delivered in eight week's time. The owners are a new company formed in Magdeburg in association with an old-established firm of forwarding agents. The "Kühlschiff I" was built at Waterhuizen, Holland, and was engined and fitted out at Harburg. The propelling machinery consists of a 375-h.p. Deutz Diesel engine, a similar engine of 100 h.p. being provided for the refrigerating plant. The vessel's two insulated holds have a total capacity of about 28,250 cu. ft., sufficient for the stowage of over 500 tons of meat, fish or other foodstuffs. There are two sets of refrigerating machinery, and the temperature in the holds can be reduced to 5° F., if required. The accommodation arranged for the crew is unusually spacious, whilst the master and engineer, who are accompanied by their wives, are each provided with a suite consisting of a living room, bedroom and kitchen. The ship has a collapsible bridge structure to enable her to pass under low bridges. The main engine can be manœuvred directly from the bridge.—*"Lloyd's List and Shipping Gazette", No. 40,103, 2nd June, 1943, p. 4.*

Recent Developments in Turbine Rotor Fixing.

It is common knowledge that where a turbine rotor is made a shrink fit on the shaft, any sudden variation of temperature, whether due to overspeed or too rapid putting into service of the unit, may produce unequal expansion of the rotor and shaft, thereby loosening the shrink fit and causing vibration in the shaft. Turbine designers have made efforts to remedy this trouble, but up to the present no standard method of fixing the rotor to the shaft has been evolved. In some cases the built-up rotor is bolted to the shaft, whilst in others the shaft and rotor wheel are machined from a single forging. A disadvantage of this latter method is that in a heavy forging of this nature the quality of the metal may vary considerably, more especially at the centre. Brown, Boveri & Co., have now developed an improved method of attachment between the rotor and shaft, in which the above disadvantage is eliminated by the employment of lip welding in the manner shown in Fig. 1. This lip welding of two thin lip-shaped circumferential projections, one each on the shaft and the rotor, is claimed to be quite insensitive to any changes in the diameters of the shaft or rotor hub because a slight breathing action takes place between the two parts. A higher torque can also be transmitted with a relatively low stress. This improved method of attachment does away with the precarious fixing by keys and is claimed to be a definite advance on the shrink fitting of the rotor and shaft. It has also been applied to built-up turbine shafts of separate rotor parts in which it eliminates overstressing due to differences of temperature and expansion.—*H. Doughty, "Mechanical World", Vol. 113, No. 2,946, 18th June, 1943, p. 674.*

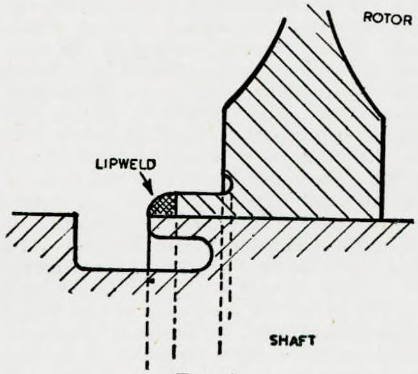


FIG. 1.

Replica of Destroyer Escort Vessel's Engine Room for Training Engine Room Personnel.

It is reported that over 1,000 engineer officers and engine room ratings of the U.S. Navy will have completed courses of instruction during the present year in the full-size engine room which is a replica of the machinery compartment of a destroyer escort ship at the Syracuse works of the General Electric Company. This "land" engine room contains turbo-electric propelling machinery, switchboards and auxiliary equipment of the type being installed in the destroyer escort ships built or building by the firm for the U.S. Navy. It was recently "launched" by Mrs. Knox, wife of the Secretary of the Navy, who opened a valve which admitted steam to the turbine.—*"Marine Engineering and Shipping Review", Vol. XLVIII, No. 5, May, 1943, pp. 210-211 and 220.*

"Fire Down Below".

Four days out from Great Britain on her voyage to a North African port, the s.s. "Benedict" was found to be on fire in a cargo hold filled with army stores and vehicles. The latter had their petrol tanks full and were loaded with spare drums of petrol and large quantities of ammunition, in readiness for immediate action after being landed. The chief officer donned a smoke helmet and attempted to locate the source of the fire in the hold, but the flames prevented him from doing so, whereupon he plugged the hold ventilators, turned on the steam injection and played a hose through a hole cut in the ventilator shaft. In response to a signal, an escort vessel came alongside, and from her a warrant engineer boarded the ship with two sets of breathing apparatus. Soon afterwards a loud explosion took place in the hold. Wearing the breathing apparatus, the chief officer and the warrant engineer entered the hold and found a loaded vehicle on fire. The heavy rolling of the ship in the foul weather prevailing at the time made it extremely difficult for the two officers to fight the fire, and after two hours it became necessary to batten down the hatch and turn on the steam injection again. An hour and a half later the two officers re-entered the hold to find two more vehicles on fire, with ammunition exploding in all directions. It was therefore found necessary to close the hold again and to turn on the steam injection. Repeated attempts to reenter the hold were made during the night, but it took about 12 hours to overcome the fire and it was daylight before it was finally extinguished. While examining the electric cables in the hold which were suspected of having caused the fire, the chief engineer of the ship, Mr. J. H. Johnson, sustained injuries by being crushed between the ship's side and the swaying vehicles. Some difficulty was experienced in discharging the cargo from an adjacent deep tank when the vessel reached her destination owing to petrol fumes, and it was found necessary to make use of some special type breathing apparatus from one of the warships in the port before the deep tank could be entered and the cargo discharged.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 22, 3rd June, 1943, p. 512.*

The Use of Steam for Refrigeration.

In steam-jet water vapour refrigeration, the cooling effect is produced by evaporating a percentage of the water to be chilled in a partial vacuum. The process follows the vapour pressure law, *i.e.*, the absolute pressure in the evaporator is reduced until it equals or is slightly below the vapour pressure corresponding to the temperature of the water, whereupon "boiling" is maintained by extracting the vapour as formed and by providing means for a continuous flow of water through the evaporator. The conversion of this percentage of the water into vapour requires the supply of latent heat of vaporisation; so that since the evaporator is an insulated vessel, the heat is given up by the water remaining, thereby lowering its temperature. The "boiling-point" and vapour pressure are interdependent, *i.e.*, the lower the pressure the lower the temperature of the chilled water, as set out in the Calendar Steam Tables. The most economical range of final temperature for steam-jet refrigeration is between 40° and 60° F., and in this range the latent heat is about 1,000 times the heat given up by the same quantity of water cooling 1° F., so that for a temperature drop of 10° to 12° F. about one per cent. of the warm water entering the evaporator is flashed into vapour. The vacuum equivalent to 50° F. is 29·64 in Hg., and at such low pressures the volume of vapour is too large to be dealt with by reciprocating compressors and it becomes necessary to use multi-jet ejectors or therm-compressors. Steam-jet refrigeration requires more cooling water per ton of refrigeration than other methods, because the condenser has to handle the steam from the jets and air pumps in addition to the vapour from the evaporator. Generally speaking, the steam consumption is lowest when *(1)* the chilled-water temperature is as high as permissible; *(2)* the condensing water is as cold as possible; *(3)* the quantity large; and *(4)* the steam pressure is high. Although many steam-jet refrigerating plants are in operation in America and the Middle East, the only one of any size in this country is an installation used to chill the cell cooling water of the continuous wire electro-galvanizing plant at the works of British Ropes, Ltd. A line diagram of this installation, which is rated at 10,000 gall./hr. from 72° F. to 60° F. (=1,200,000 B.Th.U. or 100 tons refrigeration), is shown in Fig. 1. The evaporator is a vertical cylindrical vessel 4ft. 6in. in diameter by 12ft. 6in. high, with a water chamber in the crown. The centre portion of the base of this chamber is perforated to break up the water into spray as it falls, and so present a large surface from which the vapour can easily escape. The falling spray is surrounded by a guard trunk until it is well past the entrance to the vapour compressor to minimise the extraction of water droplets. The chilled water is extracted from the evaporator and delivered to the point of application by a motor-driven centrifugal pump running at 1,430 r.p.m. This pump is designed to operate against a high vacuum provided that its suction inlet is covered with about 4ft. of water, and it delivers against a 70-ft. head. The steam-jet ejector has seven jets set in a plate so that they converge at the entrance to the throat section of the ejector body, where the velocity is about 4,000ft./sec. This velocity is reduced in the diffuser section so that the vapour enters the surface condenser at approximately 500ft./sec. The circulating water makes eight passes through banks of ⅝-in. bore condenser tubes. The condensate falls into a leg situated centrally below the shell, and passes into a motor-driven extraction pump which is regulated to maintain a level of about 3ft. in the water gauge fitted at the side of the leg. Provision is made to by-pass a percentage of the condensate discharge back to the condenser through a spray nozzle situated centrally in the vapour stream as it enters the condenser. This by-pass is necessary to deal with the slight superheat in the vapour under certain load conditions. Air is extracted by a two-stage air ejector with an inter-cooler and an after-cooler, the condensate from which is led back to the condenser via a U-tube and trap respectively. The water level in the evaporator is regulated by an air-operated valve in the hot return main, the control air being supplied by means of a float-operated relay. An emergency valve is fitted in the steam supply to the main ejector to prevent the plant being started until the circulating pump is running, the solenoid which holds the valve open being in circuit with the pump motor and thereby safeguarding the plant in the event of current failure. The total steam consumption amounts to 2,100lb./hr. and the total running costs per hour are stated to be 42·6d. for 100 tons of refrigeration.—*J. Baker, "The Industrial Heating Engineer", Vol. 5, No. 19, July, 1943, pp. 57-59.*

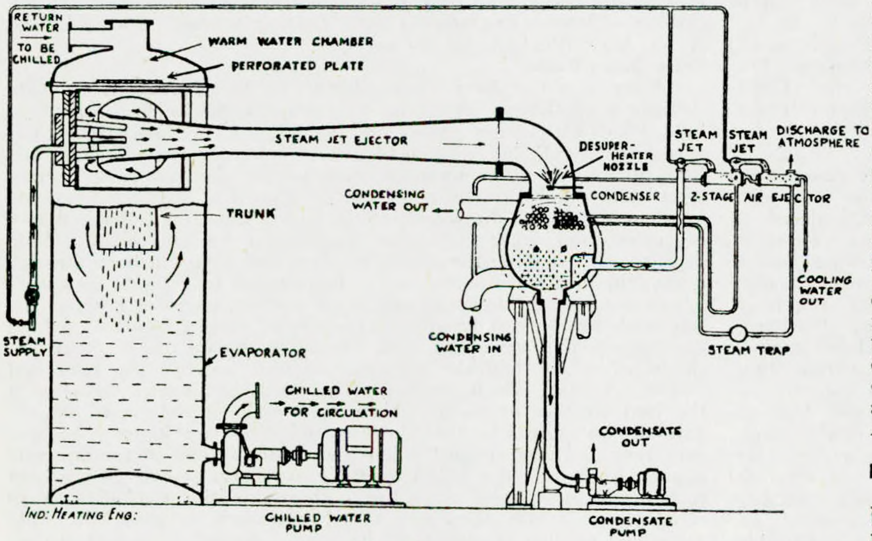


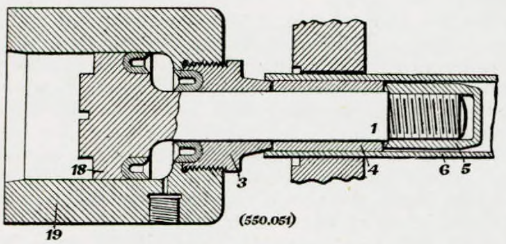
FIG. 1.

Converting Sailing Barges to Power.

Among the relatively small number of sailing barges constructed in this country since the last war were four spritsailed barges built at Yarmouth in 1925 for F. T. Everard & Sons, Ltd., of Greenhithe and London. They were steel-hulled vessels of 187 gross tons on dimensions of 97·6×23·1ft.×9·6ft. depth of hold, and had a d.w. capacity of some 300 tons. They carried cargo round the coast with a crew of only two men and a boy, and made a number of very smart passages. Shortly before the outbreak of the present war, the manning problem, the more exacting demands of the coasting trade in regard to speeds and regular delivery, and the disadvantages of handling cargo without powered deck machinery, decided the owners to convert two of these barges into full-powered motor coasters, sacrificing about 50 tons of their d.w. capacity for the purpose. As provision had already been made for installing an engine on the keel line when the barges were built, it was not necessary to run the propeller shaft through the quarter as is customary with converted barges, and a 4-cylr. F-type direct-reversing s.a. two-stroke Newbury Diesel engine of 200 b.h.p. was fitted on the centre line in what had been the skipper's cabin. The engine drives a three-bladed propeller at 330 r.p.m. A 2-cylr. H-type four-stroke Newbury engine developing 20 b.h.p. at 1,000 r.p.m. is provided for driving the generator, air compressor and bilge pump. The fuel consumption is about 8 gall./hr. for all purposes and gas oil is generally used. It was unnecessary to strengthen the after part of the hull beyond providing a bed for the engine, and the existing lines of the hull made it easy to add a counter. A fiddley was built over the engine room with accommodation for the entire crew. The latter now consists of a master, mate, two engineers, one A.B. and a cook. The fuel tanks are located in the E.R. wings, and ballast tanks are arranged in the fore and after peaks, the last-named being used for the circulating water of the auxiliary engine. A wheel-house is fitted forward of the fiddley, hand steering only being installed. Between the two hatches serving the single hold is a one-ton electric winch for working the two one-ton cargo derricks and also the windlass by means of a gypsy and snatch block.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 25, 24th June, 1943, p. 582.*

Babcock & Wilcox Hydraulic Tube Expander.

An improved form of tube expander developed by Babcock & Wilcox, Ltd., is the subject of a recently published British patent specification. Referring to the accompanying sectional drawing, the tube expander consists of a headed compression spindle (*1*) sliding through a compression piece (*3*), and a hydraulic piston (*18*) for moving the spindle. The spindle head (*5*) and the compression piece (*3*) are tapered to facilitate their entry into the tube (*6*). The head is loose in the bore of the tube and is screwed up against a shoulder on the spindle, this end of the head and the opposing end of the compression being countersunk.



An annulus (*4*) is a close fit on the spindle and is engaged by the head (*5*) and the compression piece (*3*). This annulus has an inner part of soft rubber, the outer wall and ends of which are covered by a strong textile reinforcement bonded to the rubber. An alternative construction utilises a sleeve of tough rubber with mild steel washers bonded to its ends. When a tube (*6*) is to be expanded, the expander is positioned as shown relatively to the tube and tube seat. When thus positioned the annulus (*4*) extends a short distance on both sides of the tube seat. Oil is then forced into the hydraulic cylinder (*19*) so that the spindle (*1*) is placed in tension and the head (*5*) and compression piece (*3*) exert a strong compressive force on the annulus (*4*). As a result the annulus is swelled radially and the tube is expanded against its seat, the end of the tube beyond the seat or tube-plate becoming bell-mouthed. When the oil pressure is released the annulus returns the hydraulic piston (*18*) to its normal position so that the component parts of the expander can readily be withdrawn from the tube. The entire device is compact and can be operated without difficulty in a restricted space. The expanding pressure is uniform all round the tube.—*"Engineering", Vol. 155, No. 4,040, 18th June, 1943, p. 500.*

Ventilation at Sea.

Two papers have recently been published in the U.S. dealing with the ventilation and heating of ships. The first was entitled "Warship Ventilating, Heating and Air Conditioning", and was presented at the 49th annual meeting of the A.S.H.V.E. at Cincinnati by Com.'r T. H. Urdahl, U.S.N.R. and W. C. Whittlesey, whilst the second paper, published in the February issue of *"Heating and Ventilating"*, was by J. W. Markert, Chief of the Ventilation and Heating Branch of the U.S. Maritime Commission. In this paper the author describes some of the improvements effected in the design of the ventilating and heating installations of American merchant ships during the past decade. Mechanical ventilation and automatic hot-blast or convector heating have now supplanted the natural ventilation and C.I. radiators common in older ships. The requirements for American merchant vessels are usually estimated on the basis of air-change and then checked for excessive temperature-rise, which is generally limited to 10° F. in living quarters, and 15° F. in working spaces, above that of the inlet air. The designed outside-air temperature for heating is generally assumed to be 0° F. or 10° F., which, it is stated, is low enough to include a fair factor of safety, since the average winter temperature at sea is about 30° F. Heating requirements are commonly based on an inside temperature of 70° F., except for the following spaces: working spaces, 60° F.; passages and stairwells, 65° F.; steering-gear compartment, 50° F.; and hospital spaces, 75° F. Standard heat-transfer data cannot, for obvious reasons, be directly adapted to marine structures. Fig. 1 shows a zone heating system which is commonly used in American merchant vessels. A single preheater, located at the fan intake, is thermostatically controlled to deliver tempered air at 60° F. The heated spaces are divided into zones, depending on their location, exposure, type of occupancy and other factors governing the heating loads. The reheater controls are straight-line compensated, delivering 70° F. air at 70° F. outside temperature and the maximum zone hot-air temperature at 0° F. outside temperature. The compensating bulb is located at the fan-room intake louvre (if the fan room is used as a plenum chamber), in the fresh-air duct, or on the weather side of that bulkhead which forms the chief exposure of the zone served. Tempered air can be furnished with this arrangement if the reheaters or booster coils are by-passed. This is commonly done with the air supplies to galleys, laundries and similar spaces, where the volume is not sufficiently large to justify a separate system for these compartments. A section of the paper is devoted to a description of the ventilation of dry cargo holds by a system which the author designates as process conditioning. This system is used to prevent the condensation of moisture and high humidity in cargo spaces which would cause rust, corrosion, water damage, mould, tainting or other damage to many cargoes carried (*see paper by O. D. Colvin and W. H. E. Hahne on p. 41 of* TRANSACTIONS *of the Institute of Marine Engineers, May, 1942*). The author also discusses details of heat-exchange surfaces, fans and motors, steam piping and the provision of adequate label plates and operating instructions as a means of obtaining the best results from any system by simplifying its operation.—*C. Tasker, M.Sc., "The Heating and Ventilating Engineer", Vol. XVI, No. 192, June, 1943, pp. 494-500.*

The Largest Self-propelled Floating Crane.

A self-propelled floating crane with a maximum lifting capacity of 350 tons, recently completed in Germany, is reported to be the largest of its type in the world. It was built by the Demag A.G.,

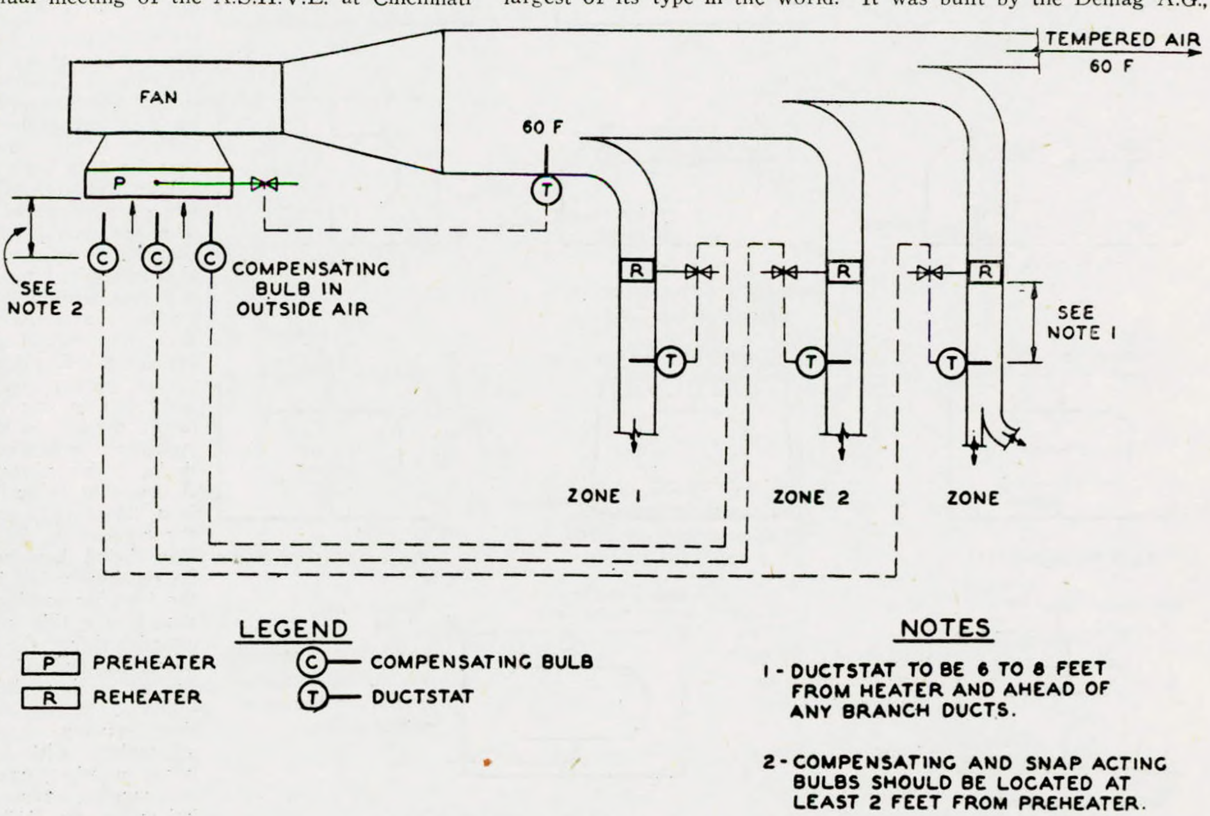


FIG. 1.—*Zone system used in U.S. Maritime Commission vessels* [*By courtesy of "Heating and Ventilating".*

and is fitted with Voith-Schneider propellers at each end, driven by electric motors. The current for these, as well as for the operating motors of the crane mechanism, is furnished by three Diesel-driven generators. The hull, which was built by the Deutsche Werft, has a length of 205ft. b.p., a breadth over frames of 108·2ft. and a depth of 17ft., the mean draught without load being 10·1ft. and the corresponding displacement 5,000 tons. The total complement comprises 3 officers and 20 men, for whom cabin accommodation is provided on board. There are three 8-cylr. M.W.M. type 4-stroke Diesel engines, with a cylr. diameter of 375 mm. and a piston stroke of 480 mm., the m.e.p. at full load being 72·5lb./in. and the corresponding output 900 b.h.p. per engine at 375 r.p.m. Each engine is directly coupled to an 800-kVA three-phase alternator supplying current at 850 volts 50 cycles to the main circuit. Two Voith-Schneider propellers are arranged one at each side of the after end of the hull, whilst the third is amidships at the bow end. Each propeller is driven by a 730-b.h.p. motor running at 325 r.p.m. Current for the auxiliary machinery, and for heating and lighting, is provided by a 220-volt system through two 200-kVA transformers. This circuit is also supplied by a 225-kVA three-phase generator driven at 500 r.p.m. by a 275-b.h.p. 6-cylr. M.W.M. Diesel engine. There is, in addition, an emergency generator of 14 kVA driven at 750 r.p.m. by a twin-cylinder M.W.M. engine rated at 20 b.h.p. The crane's maximum lift of 350 tons can be exerted at a radius of 60ft. from the hull side, the maximum lifting capacity at a radius of 160ft. being 50 tons. Trials of several days' duration were carried out with the crane and it is recorded that all conditions of the specification were satisfactorily fulfilled. An average speed ahead of just over 8 knots was maintained, whilst the average speed astern was 7·38 knots, the speed of the Diesel-engined alternators in each case being about 330 r.p.m.—*"The Motor Ship", Vol. XXIV, No. 279, April, 1943, pp. 12-17.*

Welding Contraction and "Locked-up" Stresses.

The possibility of "locked-up" stresses in welded structures is a matter which cannot be disregarded, but such stresses can be avoided if certain fundamental principles are fully understood. When a bar of iron is heated, as shown in Fig. 1, *i.e.*, with freedom in all directions, it returns to its original length and diameter on cooling, and there is no contraction or residual (locked-up) stress. When, however, a bar is heated, as in Fig. 2, with the ends restrained against expansion, all the excess volume of metal is displaced laterally and increases the diameter of the bulge. On cooling, this excess metal cannot return to its proper place, so that the bar contracts in length, leaving a permanent bulge, and the cool bar is shorter than the original length. In other words, the centre part of the bar has been "upset" by the application of the forces indicated in Fig. 2, while the centre was plastic. In the foregoing cases there has been no residual stress, but imagine that in Figs. 2 and 3 the ends of the bar had been restrained so that the bar could not contract; there would have been a residual stress (tension) in the bar after cooling, as shown in Figs. 4 and 5. From the above, the following points will be noted: (*1*) There will be no residual contraction or stress if the ends are free; (*2*) there will be no residual stress if the ends are free to contract; and (*3*) there will be residual stress, but no contraction, if the ends are prevented from expanding during heat and from contracting on cooling. In welding, these phenomena are essentially, but not exactly, the same. In practice, it is almost impossible to prevent some end restraint, and therefore there will usually be some residual contraction and some residual stresses. These can, however, be kept within perfectly safe limits if proper measures are taken to counteract the undesirable effects. In the following remarks it will be assumed that there is contraction at each weld, as is usual, owing to the progressive nature of welding, which is attended by restraint and "upsetting" due to the solidification of weld metal behind the arc. Fig. 6 shows a simple structure prepared for welding. After one leg has been welded, the conditions will be as shown in Fig. 7, *i.e.*, the overall length will have contracted, but there are no internal residual stresses. Fig. 8 shows the conditions after the second weld has been made. There are residual locked-up stresses, and it will be noted that these are entirely due to the second weld. This condition can be avoided by the procedure indicated in Figs. 9, 10 and 11. Strictly speaking, the wedge should be withdrawn half way before commencing the second weld, otherwise the cooled weld metal of the first few inches would act instead of the wedge, and the stresses shown in Fig. 10 would partially remain, but reduced by the contraction of the second weld. It should be noted that the stresses shown in Fig. 10 are the opposite of the residual stresses it is desired to avoid. It will also be noted that if a wedge were driven into the upper gap in Fig. 7, it would produce the same sort of stresses as shown in Fig. 10. This observation is of extreme importance in considering the application of these principles to a large structure such as a ship. It leads to the conclusion that the deck butts should be forced apart before welding. This is the exact opposite of what usually happens in practice. The common practice is rather to pull the joints together, thus producing tension instead of the desirable compression, and this tension is added to that caused by the contraction of the weld and therefore the residual or "locked-up" stresses are increased. It is therefore clear that unless proper precautions are taken a welded ship can easily develop quite a heavy tension in the upper parts of the structure, such as the sheer strakes and decks. She starts life with this stress. A new ship, being light, is very commonly in a "hogging" condition, which increases the tension in the deck. Again, a new ship, being launched, may not have all its machinery on board, which increases the hogging tension. Further, it may be that if the tide conditions, etc., are not exactly right, she may "tip"—*i.e.*, pivot about the end of the ways—producing a further serious increase in the tension. Other circumstances tending to increase this tension are: Excessively cold atmosphere with a relatively warm sea; heavy weather, causing alternate hogging and sagging stresses; state of loading and ballasting, etc. When, in addition to these conditions, there are geometrical features

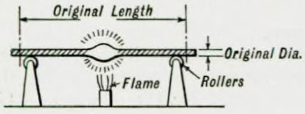


Fig. 1.

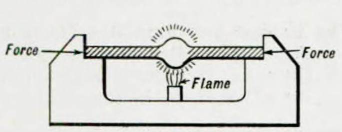


Fig. 2.

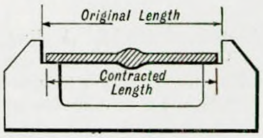


Fig. 3.

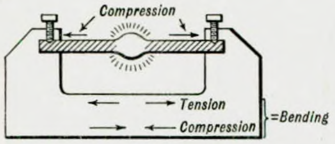


Fig. 4. HOT

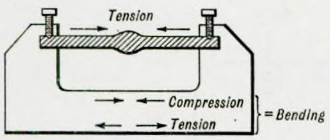


Fig. 5. COOL
(Note that locked up stresses are the reverse of stresses in Fig. 4.)

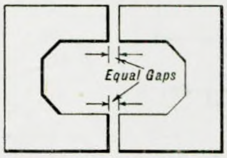


Fig. 6. BEFORE WELDING

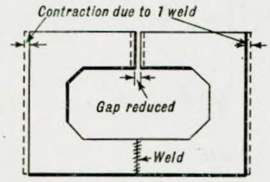


Fig. 7. ONE LEG WELDED.

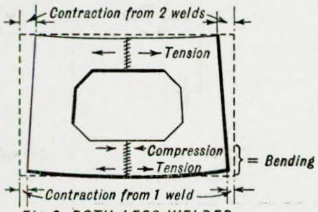


Fig. 8. BOTH LEGS WELDED.

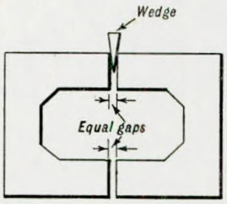


Fig. 9. BEFORE WELDING.

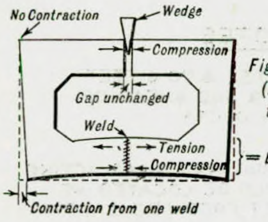


Fig. 10. AFTER FIRST WELD. (Note that stresses are the opposite of Fig. 8.)

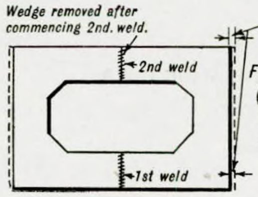


Fig. 11. AFTER SECOND WELD. (Note that contractions are balanced and there are no residual stresses.)

"THE ENGINEER"

SWAIN Sc.

of the structure tending to cause local concentrations of stress, there is real danger of failure. The widespread belief that "locked-up" stresses tend to relieve themselves by local plastic deformation at the points where the stress is over the elastic yield limit is entirely fallacious because (*a*) plastic deformation only takes place at stresses above the yield point, and ceases when the stress is reduced to this point, so that stresses up to the yield point can remain in spite of the plastic deformation, and (*b*) the extent of plastic deformation is largely dependent upon the degree of restraint. In a narrow strip, such as a tensile test piece, plastic deformation takes the form of reduction in width and thickness, balanced by increase in length, so that the volume of metal is unchanged. In a large expanse of plate, the increase in length can only be compensated by reduction in thickness (not in width), and therefore fracture may occur at a much smaller elongation. Nevertheless, plastic deformation due to over-stressing does tend to equalise stresses, and is therefore helpful, *but*—it cannot reduce the overall type of stresses likely to develop in large structures due to disregard of the precautions suggested above. Furthermore, such attempts to equalise stresses by overloading are attended by considerable danger of failure, especially in complicated structures. The conclusion to be drawn from these observations is that locked-up stresses cannot be overlooked, but they *can* be avoided. The belief that contraction, distortion, and "locked-up" stresses are inherent and incurable defects, inseparable from welding, is solely due to lack of understanding of the nature, causes and cures of these troubles. Much the same attitude was formerly prevalent in relation to many diseases, such as smallpox and other plagues, before medical science "de-bunked" them. The tyro camper who goes to sleep leaving his tent guys tightly pulled up gets a graphic object-lesson in locked-up stresses when his tent comes down around his ears during the first shower in the night. He might well be excused for considering this an inherent risk of camping, but he might even give it up on this account. The experienced camper leaves his guys slack, so that when the ropes shrink with the wet they will just pull taut—and sleeps peacefully.—*Admiralty communication to "The Engineer", Vol. CLXXV, No. 4,559, 28th May, 1943, pp. 424-425.*

A New Prime Mover.

Some time ago the Swiss firm of Escher Wyss & Co. carried out extensive experiments with an entirely new type of prime mover operating on a principle somewhat similar to that of the modern combustion turbine, but utilising a closed cycle in contradistinction to the open cycle of the constant-pressure gas turbine. The new plant includes a gas heater, a regenerator, a compressor and a turbine. The heat is supplied through metal surfaces and the working medium is normally air, although other gases can be used, since the circuit is closed. Oil is used as a fuel in the gas heater, where the air or other gas is heated before entering the turbine. The exhaust from the latter takes place through a regenerator, and gives off heat to the air flowing from the compressor to the gas heater. This last does not come into contact with any cold medium, and a considerable amount of the flue-gas heat would be lost if the waste heat from the gas heater were not utilised for preheating the combustion air. After passing through the regenerator and being partially cooled in it, the air exhausted from the turbine is further cooled before delivery to the inlet of the compressor. The cooling water required for this type of plant is only a fraction of that which is normally necessary for a steam installation of equivalent output, especially as the temperature of the water can be raised considerably without causing any harm. Moreover, as the water does not come into contact with any delicate parts, it need not necessarily be particularly pure, and none of the difficulties of supply associated with high-pressure steam installations can possibly arise. The entropy diagram for the system is shown in Fig. 3. Expansion of the air in the turbine takes place along AB and the regeneration occurs along the lines BC or DE. The air is compressed isothermically from C to D, this being carried out in several stages with inter-cooling. The external heat generated thereby is applied to the working medium in the air heater along the lines EA. The area ABCD represents the work done, this being the difference between the work effected by the turbine and that absorbed by the compressor. The work carried out by the turbine is equivalent to the heat supplied externally, EAJH, whilst the work absorbed by the compressor is equal to the heat given up by the cooling water of the compressor, DCGF. If the maximum and minimum temperatures T_1 and T_3 are fixed, the thermal efficiency of an ideal cycle depends only upon the ratio of the pressures and not upon the absolute magnitude of the pressures between which the cycle operates. The smaller the ratio of the pressures, the higher the efficiency. This is a great advantage compared with the usual process where steam is the working medium, since the available heat cannot be used to the utmost efficiency unless the steam is at a high temperature and pressure. There is a large amount of heat in the gas (or air) after it has performed its work in the turbine, and further use must be made of this, since the waste heat in free discharge, as in gas turbine installations, would reduce the efficiency below that of a moderately economical steam plant. By keeping the fire out of the closed-circuit system and operating the entire circuit under pressure, the cross-sectional areas of the heat exchangers and piping can be of moderate dimensions, also the surfaces, and an efficient system can thus be arranged. Another advantage of the pressure circuit is that the coefficient of heat transmission on the gas side of the gas heater is better, so that the mean temperature of the wall is lower and moves considerably to the cold gas side, more so than would be the case with low pressure. The turbine and compressor can also be made much smaller in size. For example, if the initial pressure at the compressor inlet is 9 atmos. instead of atmospheric, as in the open-cycle gas turbine, the diameters both of the turbine and compressor can be reduced to one-third, the temperatures and speeds remaining unaltered. This represents a substantial saving in cost. A plant of this type has to be started up by external means, but the starting operation can be very much facilitated by lowering the pressure of the closed circuit. If the inlet pressure at the compressor is reduced to 1 atmos. instead of 9 atmos. the output is reduced to one-tenth and the ease of starting correspondingly increased. Many possibilities appear to be opened up for the application of this type of machinery to ship propulsion where fairly high powers are called for, more especially in conjunction with oil firing. Although no particulars of the efficiency attained by the experimental plant have been disclosed, it is understood that efficiencies equal to those of the combustion turbine have been obtained. Further development work is still in progress, which may lead to the adoption of the plant for marine propulsion after the war.—*"The Motor Ship", Vol. XXIV, No. 281, June, 1943, pp. 82-83.*

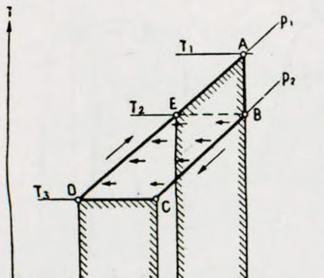


FIG. 3.—*Entropy diagram of the ideal process of aerodynamic heat power plant with perfect regeneration.*

A Portable Distiller for Ships' Lifeboats.

Among the various designs of distilling plant suitable for use in ships' lifeboats which have recently been described or put on the market, is one which forms the subject of a recent British patent and which is illustrated in the accompanying diagram (Fig. 3). The distilling apparatus, which is portable, can be suspended from the ball-and-socket joint (O) of a tubular frame (G), which allows for pitching and rolling to the extent of about 36°. The frame (G) can be taken to pieces for stowage. The apparatus consists of a tubular boiler (C), a surface condenser (D) and a tank (A) from which water is supplied to the boiler by gravity feed. The tank is supported on a metal stand (F) and holds about two gallons of sea water; it is made of canvas strengthened by a wire cage. A floor space of 12in. by 14in. is occupied by the plant when it is set up in working order, and it can be packed into the tank (A) for stowage, if required. When the assembly is set up in bad weather a strap (E) is attached round the base (K) and the complete plant is hooked on the frame (G). Both the fresh-water tank (B) and the boiler (C) are fitted with anti-splash rings (R). It is claimed that although the entire apparatus can be packed

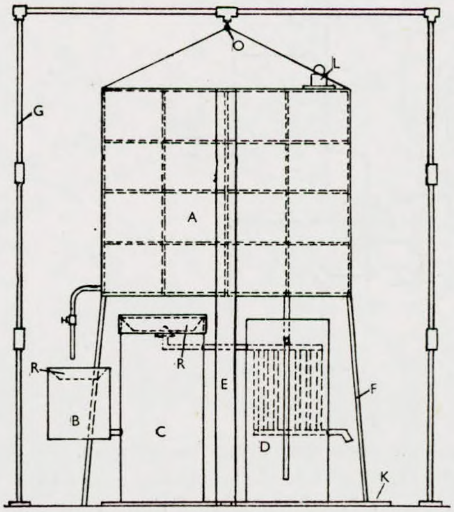
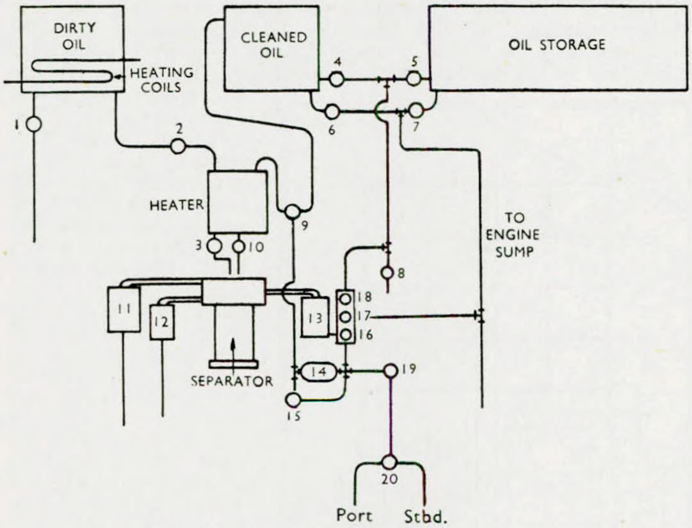


FIG. 3.

into a space of 14in. by 5in., it is capable of supplying a standard lifeboat taking 32 persons with sufficient fresh water for 30 days, using eight gallons of liquid fuel. With a larger boat holding 45 persons the corresponding period is 20 days. One gallon of liquid fuel is stated to yield eight gallons of fresh water from sea water. The case (A) with the plant inside may be fitted in a rubber bag, capable of being pumped up with air and providing enough buoyancy to support the person to whom it is strapped. An electric light (L) is fitted on the top of the case for signalling purposes.—*"The Motor Ship", Vol. XXIV, No. 281, June, 1943, p. 102.*

Operation of Lubricating-oil Separators in Motorships.

The author expresses the view that lubricating-oil separators in motorships should be operated continuously, and *not,* as suggested by some makers of marine Diesel engines ". . . . . during one watch every 12 hours". The writer goes on to say that he always made it a practice to run the oil separator continuously on the engine sump when at sea, and on the dirty oil tank when in harbour with the result that the engine oil, after many months of service, retained its original clarity and colour. One of the most general methods of connecting the separator to the engine oil lubricating system is to take a lead from the main F.L. pump discharge to the separator, and thence to the engine sump. The return side is correct, but the feed from the main pump discharge is unsatisfactory, as it results in the cleanest oil being received by the separator instead of the dirtiest. The separator should use its own pump and draw direct from the bottom of the main engine sump in order to pick up the dirt before it has time to settle. The separator pump suction should be taken from as near the bottom of the tank as possible and below the main lubricating-oil suction, so as to remove the dirt before it can reach the latter. Moreover, the water seepage, provided it is not more than the capacity of the separator pump, is thereby removed immediately it arrives, and is thus prevented from circulating in the lubricating-oil system. A suction well or "hat box" should be provided in every tank, if possible, but where the lubricating-oil sump is formed by several bays of a D.B. tank, it is, of course, necessary to rely on the slope of the hull. In some cases the lubricating-oil tank is formed in a dry D.B. tank on each side of the centre-line plate, the oil tank hanging from the tank top and the dry tank forming a cofferdam around the oil tank. As the centre-line plate in the latter is only wash-tight, twin hat boxes with twin suctions must be provided. When the suctions for the separator pump are fitted up, care should be taken *not* to use the same pipe lead as for the main pump. The disadvantage of this latter arrangement is seen when the drains to the sump from the bedplate are from two parts, say, the forward half of the bedplate draining to starboard and the after part to port. If a piston cooling-service pipe (water) starts to leak in the forward half, the water drains away to the S. side of the oil sump, filling up the suction well. The separator pump suction always prefers to pick up the lighter liquid first; hence, it will pump steadily on the P. hat box, leaving the S. one to fill up with water which, in time, reaches the main engine pump suction. It will then be circulated through the engine with detrimental results. Therefore, the writer strongly recommends the installation of independent suctions from the suction well to a change cock. Where heating coils are fitted for use with oil separators, the temperature of the oil should be raised to 170° F., but in no case above 180° F. When separating, a tapping should be taken from the drain side of the heater coils, and a trickle of hot water should be allowed to go through the separator with the oil. Separation should be carried out slowly, the output being kept well below the capacity of the apparatus. The best results will be obtained in this way, and when the separator is cleaned, the contents will be found practically dry and packed solidly around the rim of the bowl, whence it can be removed quite easily with a packing knife. The accompanying diagram illustrates an arrangement covering all the points mentioned above. It enables: (1) Oil to be drawn from the engine sump, P. or S., and returned to te engine sump; (2) oil to gravitate from the dirty oil tank and return to the clean oil tank; and (3) oil to gravitate from the dirty oil tank to the engine sump. The practice of installing separators behind the main engine, or the 'tween deck flat or, in a tanker, on the after flat, is to be deprecated. Separators should be located on the control platform, where they are constantly under the eye of the engineer.—*D. P. Peel, "The Motor Ship", Vol. XXIV, No. 281, June, 1943, p. 87.*

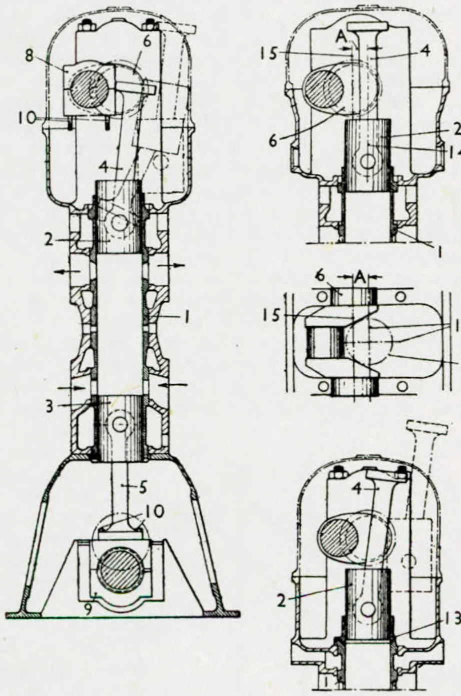


Proposed lubricating oil separating plant installation.

1.—Drain, water and sludge to bilge. 2.—Dirty oil via heater to separator. 3.—Feed regulation to separator. 4 and 5.—To daily service hand feed. 6 and 7.—Make-up to main engine. 8.—Daily service hand feed. 9.—Change cock separator to heater or cleaned oil tank. 10.—Drain, hot feed from heater coils to separator. 11.—Separator overflow. 12.—Sludge outlet. 13.—Clean oil receiver. 14.—Separator pump. 15.—Pump relief valve. 16.—Pump suction from receiver. 17.—Receiver discharge to engine sump. 18.—Pump priming from clean oil tanks. 19.—Pump suction from engine sump. 20.—Engine suction change cock.

Withdrawing Pistons from Sulzer Opposed-piston Engines.

A method of withdrawing the pistons and connecting rods from Sulzer opposed-piston engines has recently been developed and patented in this country by Sulzer Bros., Winterthur. Opposed-piston engines with two crankshafts—one at the top and the other at the bottom, connected in such a manner that both shafts run at the same speed—are difficult to deal with as regards the removal of the pistons, and even if only one of the latter has to be withdrawn in a multi-cylinder engine of this type, it is necessary to remove all the crankshaft bearings as well as the connecting-rod bearings, and to lift out the crankshaft. In order to simplify the operation of removing the pistons, the design of the engine has now been modified as shown in the accompanying illustration. The two pistons have the same length of stroke, but the connecting rod of one is longer than that of the other, the piston with the longer rod being the upper of the two and being designed to regulate the exhaust ports. The employment of a longer connecting rod for the piston which effects the exhaust-port control reduces the cylinder - surface pressure and increases the flow of air into the cylinder. Another feature of the design is that the axis of the cylinder may be displaced with reference to the crankshaft centre line, giving the necessary space for the piston to be lifted out, while a detachable sleeve can be fitted at the cylinder top, so that the piston and sleeve are dismantled together. It will be noted from the principal sectional elevation that the length of the connecting rod *(4)* of the piston *(2)* is greater than that of the rod *(5)* attached to the lower piston *(3)*. This arrangement provides enough space between the cylinder *(1)* and the crankshaft *(6)* to permit both pistons to be withdrawn with-



Method of dismantling pistons in Sulzer-opposed-piston engines.

out disturbing the crankshafts. After removing the crankhead bolts *(10)* and if necessary the crankhead *(8)*, the connecting rod and piston can be brought into the positions shown by the dotted lines and then pulled upwards. The connecting rod *(5)* can then be disconnected from the crankhead *(9)*, raised together with the piston *(3)* through the cylinder *(1)* and then withdrawn. The advantage of offsetting the line of the cylinder from the crankshaft is shown in the two upper right-hand diagrams. The axis *(14)* of the cylinder *(1)* and the axis *(15)* of the crankshaft *(6)* are displaced by an amount represented by the distance (A). By adopting this design, it becomes possible for the pistons and connecting rods to be lifted and withdrawn from the engine between the crank webs, as shown in the centre right-hand diagram. The limitations of this arrangement are, however, obvious. In the bottom right-hand diagram a modification is introduced. At the dismantling end, the cylinder *(1)* has a sleeve *(13)* formed as an extension which can be removed from the engine complete with the piston, after which the two parts can be separated for examining the piston. The dotted lines show also in this instance the position which will be taken up by the piston and connecting rod during their removal from the upper part of the engine.—*"The Motor Ship", Vol. XXIV, No. 282, July, 1943, pp. 110 and 134.*

Re-engined Vessel's Mishap.

When the small motor tanker "Nordvik" of Stockholm, was leaving a Malmö shipyard on 27th January, for sea trials after being re-engined, she met with a serious accident. The tanker, which has been sold to Germany, had just been equipped with new engines and an adjustable-blade propeller controlled from the bridge. When the ship was leaving the yard and the stern was some 150ft. from the quay, the captain found that the hydraulic control gear, by means of which he had attempted to reverse the propeller blades in order to drive the ship ahead, was inoperative. As the vessel continued to move astern, he ordered the main engine to be disconnected from the propeller shaft, but as the clutch was operated by the same hydraulic control gear as the propeller blades, his order could not be carried out, and the ship struck the quay, sustaining extensive damage to her hull plating. A subsequent investigation of the cause of the mishap revealed that the trouble was due to a badly packed gland in the hydraulic control system. This defect, which was the result of negligence, had allowed oil to leak from the system, causing loss of pressure. Subsequent tests of the hydraulic control gear and propelling machinery proved satisfactory.—*"Lloyd's List and Shipping Gazette", No. 40,085, 12th May, 1943, p. 8.*

Oerlikon Gas Turbine.

A recently published British patent granted to the Oerlikon Engineering Works, of Zürich, is for a gas turbine employing a radial compressor instead of the usual axial unit, as shown in Fig. 2. One stage of this radial compressor, which is turbine-driven, has a volute casing which is subdivided into two angularly separated volute chambers, each with an attached diffuser. A compressor of this type would have a high efficiency, even with a small delivery. A simple form of lay-out is shown in the top diagram, air being delivered from the compressor *(1)* to the combustion chamber *(2)*, from which the gases flow to the turbine *(3)*. The exhaust gases give up part of their heat to the compressed air in the heat exchanger *(4)*. It may be noted that the compressor and turbine are mounted on the same shaft and drive a dynamo or other required piece of machinery *(5)*. When the plant is operating on a reduced load, the amount of fuel in the combustion chamber *(2)* is limited accordingly and the heat drop in the turbine *(3)* is lower, while the compressor *(1)* has to supply a smaller amount of air. The factor determining the efficiency of the plant under a reduced load is the power consumption of the compressor. The power consumption of an axial compressor is represented by the line (A), that of a normal radial type by the line (B), and that of a radial compressor with divided spirals and attached diffusers by the line (C). The lower right-hand diagram shows the final stage of a multiple-diffuser machine with four volute chambers and diffusers. One of these *(11)* is designed in exact accordance with the requisite air for combustion, the air of the remaining diffusers *(12, 13 and 14)* being supplied to the combustion chamber beyond the nozzle *(16)*, which offers a certain resistance. With the multiple-diffuser arrangement, pressure to overcome this resistance can be generated directly with the same rotor, without the necessity for raising the air pressure in the other diffusers to the same level as that in the diffuser *(11)* supplying the nozzle. A radial compressor functions most favourably at a point on the right-hand portion of the pressure-volume curve (D), (volumes II-IV). So long as the resistance of the burner nozzle does not exceed the pressure difference (P), the diffuser *(11)* is capable of overcoming this resistance. The efficiency curve (E) is slightly reduced, but a special blower for the burner is unnecessary.—*"The Motor Ship", Vol. XXIV, No. 282, July, 1943, p. 134.*

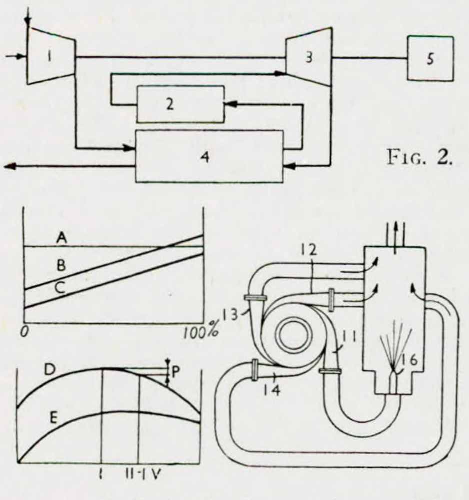


FIG. 2.

Escher Wyss Adjustable-blade Propeller Construction.

An improved form of packing for an adjustable-blade propeller has been patented by the Escher Wyss Engineering Works, Zürich, and is illustrated in Fig. 3. Means are provided for the correct location of the packing and its retention in the event of a blade breaking, so that oil inside the hub cannot escape. The blades *(2)* fitted in the hub *(1)* have stems *(3)* connected by bolts *(4)*, these bolts being undercut *(5)* in order to allow them to fracture and avoid damage to the mechanism in the event of a mishap. The blade packing comprises a ring *(6)* together with a disc *(7)* attached to the stem, in addition to a spring-loaded ring *(8)*. It will be noted that the blade can be removed without disturbing the packing, which remains effective even if a blade breaks. Since the disc *(7)* can be mounted on the stem *(3)* only after the packing ring *(6)* has been inserted, it can be ascertained that the packing is fitted properly. Referring to the top left-hand diagram, the method of assembly differs from the arrangement described, as in this instance the blade *(10)* has a stem *(11)* with an integral disc *(12)* forming part of the packing, which comprises a ring *(13)*. The closing ring *(14)* is divided into segments connected by a bayonet joint *(15)* to the hub of the propeller. The packing ring *(13)* bears on a spring-loaded ring *(16)*. By removing the closing ring *(14)*, the packing can be examined without any need to disturb the blade *(10)*.—*"The Motor Ship", Vol. XXIV, No. 282, July, 1943, p. 134.*

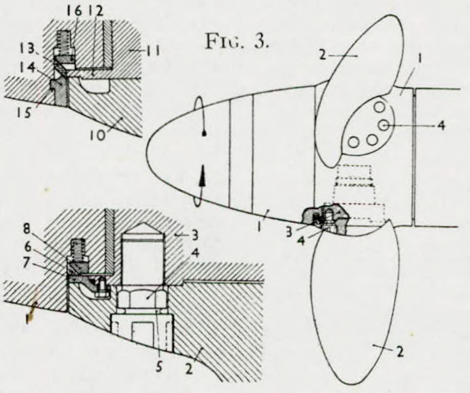


FIG. 3.

A Large Chinese Dredger.

An article by O. Kluckner in *Werft*Reederei*Hafen* describes a large suction dredger built by F. Schichau of Elbing, before the war, for the Whangpoo Conservancy Board, of Shanghai. The dredger was the second of two built for the purpose of dredging a channel of about 1,300ft. in width and 40ft. in depth over a length of some 15 miles near the mouth of the Yangtze. The owners stipulated that the vessel should be capable of dredging 10 million cu. metres per annum and able to operate in rough weather and in a current of six knots running at an angle of 45° to the direction of the channel. On a 10-hour basis and reckoning on 12 to 14 trips in that period, there remained a period of 15 to 20 minutes' pumping time in which to dredge about 4,000 tons, assuming a sp. gr. of at least 1·4, which corresponds to a water content of about 20 per cent. The dredger, which is named "Fu Shing", has a hold capacity of 120,000 cu. ft., which can be filled in less than 15 minutes by pumping at the rate of 12,000 tons/hr. with a density of 1·4 or 10,800 tons/hr. at 1·8 sp. gr. The hull dimensions are 400×62×28ft. and the maximum draught with 4,000 tons of silt in the holds is 18ft. The suction arm is located amidships and can reach to a maximum depth of 53ft. It is provided with four interchangeable heads of various widths, two of these being designed so that they can be adjusted up to 15° off the centre line in order to facilitate dredging in a strong cross-current. The holds are emptied by means of 12 conical valves, each 5ft. 3in. in diameter, operated by hydraulic cylinders situated at the main deck level. The weight of these conical valves is great enough to ensure tightness when resting on their rubber sealing rings, and as the upper part of each valve is arranged like a diving bell, the rubber rings can be examined or renewed without docking the ship. There are three vertical triple-expansion steam engines, each of 2,500 i.h.p., two of them driving the propellers, while the third operates the dredge pump. The designed speed is 11½ knots. Superheated steam at 225lb./in.^{2} pressure is supplied by four watertube boilers operating with both forced and induced draught, each having a heating surface of 40,000ft.^{2}. The boilers are coal-fired by mechanical stokers. Current for the all-electric deck auxiliaries is provided by two 225-kW. turbo-generators, one of which is sufficient for normal needs. A small Diesel-driven dynamo of 15-kW. is also installed. The main pump has a diameter of about 9ft. and on test with water alone gave a delivery of 23,000 tons/hr. The various valves needed for the operation of the dredger are all hydraulically worked, the controls being on the bridge; the main valves in the ship's bottom can, however, also be operated additionally and individually, from on deck. The suction-pump controls and the handwheel for raising and lowering the suction arm, are also on the bridge.—*"The Marine Engineer", Vol. 66, No. 789, April, 1943, pp. 92-93.*

Using Sealing Air for Sulzer Engine Pistons.

The well-known Swiss firm of Sulzer Bros., Winterthur, have recently developed and patented a method of introducing a blast of sealing air around the pistons of a Sulzer opposed-piston engine in the manner shown in the accompanying sectional diagram (Fig. 4). The air is supplied at a pressure in excess of the maximum in the combustion space and the timing of its introduction is controlled by the engine fuel pump (*4*), which delivers fuel to the injector (*5*). On the end of the fuel-pump casing there is a control block (*7*) which regulates the delivery of sealing air from the pipe (*8*) at definite intervals of time to the pipes (*9, 10*). These pipes are connected to nipples (*11, 12*) which communicate with annular spaces between the piston rings. The pump plunger (*17*) is actuated by a cam (*18*) and the fuel passes a valve (*19*) before reaching the discharge pipe (*20*) to the injector. According to the pressure, the accumulator piston (*21*) and the valve (*23*) are moved against the load of a spring (*22*). When the valve is lifted from its seat, as shown in the diagram, air can pass through the pipes leading to the engine pistons. If there are any leakages past the piston rings the air can escape in both directions, towards the crank chamber and also towards the combustion space (*6*). Thus, none of the products of combustion can enter the space between the rings and the pistons, and the formation of carbon is prevented. By the time that the fuel injection ends, the pressure is low enough to enable the spring (*22*) to force the accumulator piston (*21*) back to its original position and the valve (*23*) on its seat.—*"The Motor Ship", Vol. XXIV, No. 282, July, 1943, p. 134.*

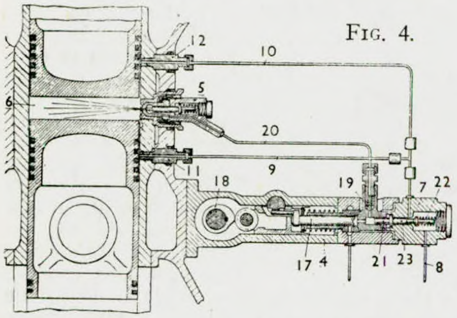


FIG. 4.

Engines for Tank Landing Craft.

Very large numbers of Gray 2-stroke Diesel engines are being employed for the propulsion of tank landing and other craft built both in this country and in America. Two models of the engine are utilised for this purpose, both being 6-cylr. units with a cylr. bore of 4¼in. and a piston stroke of 5in., but whereas one is a high-output engine developing 225 b.h.p. at 2,100 r.p.m., the second is a standard model developing 165 b.h.p. at 2,000 r.p.m. The basic design of both models is the same and the component parts are largely interchangeable, but the high-powered engine has an O.F. injector of 90 cu. mm. capacity, while the standard model is equipped with one of only 60 cu. mm. capacity. Injection occurs earlier in the high-powered engine, which also employs a higher mean pressure than the lower-powered unit. The Gray engine differs from most corresponding British types in the employment of exhaust valves in the cylinder heads, besides the combination of the fuel injector and pump in a single unit. There are two exhaust valves per cylinder and the air is delivered through a series of ports in the cylinder walls by a three-lobe Roots type blower. Fresh water is used for cooling the cylinders, the cooling system consisting of a closed circuit connected to an expansion tank through which a supply of fresh water is continually circulated by a centrifugal pump controlled by a thermostat in the line. The fresh water is cooled by a heat exchanger, which, in turn, is cooled by a flow of sea water from a gear pump. The latter also supplies the water for cooling the exhaust manifold. According to the speed of the boat, the engine is combined with a reduction gear of either 1·51 to 1 or 3·05 to 1, or, alternatively, is arranged with direct drive. In the reverse gears, there are separate dry-disc clutches and separate gear trains, one each for the forward speed and reverse. The propeller thrust bearing is built in. The reduction gears are of the large helical type. The weight of the engine, fully equipped, is 2,840lb., or 17lb./h.p. at normal rating. The overall length with direct drive is 73⅝in. and the overall width 28in. Forced lubrication is used, with a normal oil pressure of 45lb./in.^{2}. Most of the engines are fitted with a 12-volt starting motor and a 12-volt 250-watt shunt-wound generator with a voltage regulator mounted on the bulkhead near the engine, but with some units a 32-volt system is employed. For cold-weather starting at temperatures below 32° F. the high-output engines are equipped with a flame primer for use in preheating the incoming charge of air to the cylinders. It is mounted on the engine and replaces one of the hand-hole cover plates. It is a small pressure burner with electric ignition and is used only in cold weather when the engine does not start with the normal cranking interval.—*"The Motor Boat", Vol. LXXVI, No. 1,906, April, 1943, pp. 92-94.*

High-speed Steam Engines.

The present shortage of fuel oil in European countries is reflected by the latest developments in the design of high-speed reciprocating steam engines for marine propulsion. According to information which has reached this country from Germany, one of the most recent types of such prime movers to be built there is the "Meer" engine for the propulsion of tugs and river craft. It is a totally-enclosed compound unit with two cylinders of 200 mm. and 350 mm. diameter respectively, and a piston stroke of 240 mm. The engine has an output of 300 b.h.p. at 480 r.p.m. and drives the propeller through a 3 to 1 reduction gear. The total weight of the entire unit is only 4½ tons and the overall dimensions are correspondingly small. The H.P. cylinder takes steam at a pressure of 400lb./in.^{2} and 750° F. total temperature. Separate steam and exhaust passages are employed in both cylinders, and to reduce the stresses in the cylinder block, the separate H.P. and L.P. cylinder castings are mounted on the crankcase casting independently and are not connected together by side flanges. The piston valves are operated from a single common eccentric and two oscillating shafts, the eccentric sheave being driven by means of a pin from a lever secured to the crankshaft in such a manner that the gear is infinitely variable between the full ahead and full astern positions. Direct control is provided from the bridge as well as from the engine room. A number of Meer engines have been installed in conjunction with La Mont forced-circulation boilers. Another and somewhat better-known German engine of a similar type is the Wumag, which is said to have been built in powers up to 7,000 i.h.p. with a speed of 1,000 r.p.m., although it is normally manufactured in four standard sizes ranging from 310 to 1,000-i.h.p. This engine is a quadruple-expansion three-crank unit with the single-acting H.P. and first I.P. cylinders arranged in tandem. In order to keep the size of the engine to a minimum, the piston valves are arranged athwartships of the cylinders and are operated by means of cranks from a small lay-shaft set parallel with and at the same level as the main crankshaft, and driven from it by gear-wheels. Reversing is effected by a system of bevel wheels which permit alterations in the relative angular positions of the two shafts. The engine drives various auxiliaries from an extension of the main crankshaft at the forward end. The steam is reheated between the first and second I.P. stages, and forced lubrication is employed throughout, the oil circuit including filters and a cooler. High-pressure lubrication is provided for the main pistons, piston valves and glands.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 21, 27th May, 1943, p. 472.*

American-built Doxford Engines.

Some particulars of the design and performance of the Sun-Doxford engines installed in American ships were recently given in a paper entitled "Low-speed Direct-connected Marine Diesel Engines", read at a joint meeting of the American Society of Mechanical Engineers and the Society of Naval Architects and Marine Engineers, by Mr. H. G. McConechy, chief engineer of the Sun Shipbuilding and Dry Dock Co. These engines usually run at 70 to 100 r.p.m. in single-screw ships and at 125 to 130 r.p.m. in twin-screw vessels. The auxiliary machinery required includes F.W.

circulating pumps, coolers and sump tanks, S.W. circulating pumps. lubricating-oil service pumps and coolers, H.P. air compressors and storage tanks, and fuel-oil transfer pumps. A separate system is usually employed for lubricating the cylinder liners, the oil being injected at four or six points around the liner. The injection points are away from the combustion chamber, and the oil is driven between the piston rings towards the combustion space. The fuel oil generally recommended for these engines is between 16° and 20° Baumé (0·95-0·93 sp. gr.), as it has been found that lighter oil of the so-called Diesel grade is apt to cause excessive leakages at the fuel pumps and fuel injection valves. Heavier oils than these can be used successfully if preheated sufficiently to bring the oil to the required viscosity for injection. The average viscosity of the fuel oil used in most Sun-Doxford engines is 18·3 A.P.I. When Bunker C fuel is burned in these engines, the oil must be heated to between 160° and 190° F. and a booster pump is necessary. At this temperature a positive head must be provided for the suction of the engine fuel pump to prevent the oil from vaporizing during the suction stroke of the pump. A pressure of 6,000 to 8,000lb./in.^{2} is maintained in the injection system, dependent upon the grade of fuel, and the design of the fuel nozzles is also governed by the quality of the latter. Sun-Doxford marine engines have cylr. diameters of 13in. to 32in. and a combined stroke of from 39in to 95in., whilst the powers range from 750 to 8,250 b.h.p. continuous rating. This latter figure applies to the 5-cylr. unit which, together with its attached scavenge pump, weighs just under 600 tons, or about 160lb./b.h.p. The engine runs at 95 r.p.m. At the most conservative rating of 7,500 b.h.p. the weight of the complete engine does not exceed 177lb./b.h.p. Part of the heat in the exhaust gases is recovered in waste-heat boilers, and in one series of oil tankers with Sun-Doxford engines two 300-kW. generators are installed operating at 190lb./in.^{2} steam pressure and receiving their steam from the exhaust-gas-heated boilers. The dynamo engines exhaust at a vacuum of 26in. and the entire electrical load at sea, together with the auxiliary steam load, is carried by the waste-heat boiler. The overall fuel consumption in such an installation, including all requirements at sea, is only 0·360lb./b.h.p.-hr. with an average electrical load of 186 kW. In the case of six vessels each equipped with a 4-cylr. engine with a cylr. diameter of 32in. and a combined piston stroke of 95in., the average overall fuel rate is 0·384lb./b.h.p.-hr. The normal engine output is 6,000 b.h.p. at 92 r.p.m., with a maximum continuous rating of 6,600 b.h.p. at 95 r.p.m. and an overload rating for two hours of 25 per cent. The overall fuel rate includes the Diesel-driven generators which supply power for all the auxiliaries, except the steam-driven boiler feed pump, fuel-oil heating and the heating load for the accommodation. The average electrical load in the above overall fuel rate was 550 kW. In ships having 5-cylr. engines of similar dimensions developing 7,500 b.h.p. at 94 r.p.m. with a maximum continuous rating of 8,250 b.h.p. at 97 r.p.m., the fuel consumption is 0·370lb./b.h.p.-hr., including 190 kW. electrical load from Diesel-driven generators. All these records are officially authenticated. Tests were also made to determine the mechanical efficiency. They showed that the Sun-Doxford engine with an attached scavenge pump has a mechanical efficiency of 86 per cent., the mechanical efficiency of the engine without a scavenge pump being 88 per cent.—*"The Motor Ship", Vol. XXIV, No. 281, June, 1943, pp. 76-77.*

Multi-engined Ships.

A London firm of consulting engineers recently put forward proposals for multi-engined motorships of various sizes. One of these designs is for a twin-screw geared-Diesel vessel 390ft. in length, with a beam of 56ft. This ship, which has a block coefficient of 0·735, is driven by four 8-cylr. supercharged four-stroke engines of 1,200 b.h.p., running at 350 r.p.m. and coupled in pairs to two propeller shafts through 3·5 to 1 reduction gearing, giving a normal propeller speed of 100 r.p.m. A magnetic coupling is fitted between each engine and pinion of the reduction gear. The engine room is 42ft. in length, and the total weight of the engines and gearing is about 190 tons, or 88lb./b.h.p. at full rating. A second proposal concerns a motorship with propelling machinery of 6,600 b.h.p., having five 8-cylr. supercharged four-stroke engines of 1,400 b.h.p. running at 400 r.p.m. Each engine is coupled to a 1,040-kW. 3,300-volt alternator supplying current to two 3,300-b.h.p. propulsion motors running at 500 r.p.m. and driving a single propeller shaft through a S.R. gear with a 5 to 1 ratio, giving a normal propeller speed of 100 r.p.m. The two propulsion motors and the reduction gear are arranged in a compartment at the after end of the ship, whilst the switch gear and engine controls, together with the circuit breakers, etc., are located on a platform above the E.R. floor. A third design relates to a ship with four 8-cylr. supercharged four-stroke engines of 1,500 b.h.p. driving alternators which supply current to two 3,300-volt propulsion motors. Each of these motors has an output of 2,800 b.h.p. at 750 r.p.m. A S.R. gear reduces the speed of the single propeller to approximately 120 r.p.m.—*"The Motor Ship", Vol. XXIV, No. 281, June, 1943, pp. 84-85.*

Regulation of Crank Chamber Lubricating-oil Delivery.

A British patent on a simple device for the regulation of the oil feed to the crank chamber of an engine or compressor was recently secured by a New Zealand inventor. Referring to the accompanying sectional diagram (Fig. 4), a column of oil of a predetermined length is maintained in a pipe (A) with a spring-loaded N.R. valve (B) at its lower end. At the top of the pipe an air-lock chamber (E) is provided and oil is supplied to this chamber from a reservoir (D), which is fitted with a needle regulating valve (G). A test plug (K) enables the level of the column of oil in the pipe to be checked. The pressure due to the head of oil in the pipe tends to open the valve (B), while that in the crankcase (C) varies between a moderate pressure and a partial vacuum. The spring load on the valve (B) is adjusted so that it does not open until the crank-chamber pressure has fallen below atmospheric and is overcome by the static pressure due to the weight of the column of oil. The chamber (E) contains air at atmospheric pressure and is sealed from above by the oil in the pipe, the air-lock acting as a brake on the flow oil past the valve (B).—*"The Oil Engine", Vol. XI, No. 123, July, 1943, p. 82.*

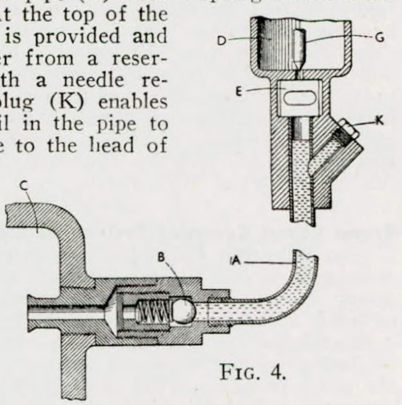


FIG. 4.

Admiralty View of Propulsion by Electricity.

In reply to a question recently raised in the House of Commons regarding the adoption of electrical propulsion for British-built ships, the First Lord of the Admiralty stated that electric drive was not acceptable for the propulsion of warships in view of the additional weight and volume of the machinery required, and because it was less efficient than the system of transmission used in the Royal Navy. The Admiralty were aware that electric drive was being adopted in a considerable number of smaller naval craft in the U.S.A., but the production and fitting-out facilities available in America were greater than those of this country. Electrical propulsion was, however, being utilised in a number of British submarines as well as for certain merchant vessels building in U.K. shipyards where production could be linked up with the necessary fitting-out facilities.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,043, 22nd April, 1943, p. 7.*

Chromising Steel.

Chromium applied to steel in the form of chromium plating or alloyed with steel, is used extensively at the present time because of its property of resisting atmospheric and other forms of corrosion. When alloyed with steel chromium likewise increases the strength and the surface hardness of the alloy. A disadvantage of chromium plating is that there may be a tendency for the thin layer of chromium to flake off, particularly if the metal is subjected to excessive bending. A process for impregnating the surface of steel with chromium, known as chromising, was recently described at a meeting of the American Institute of Mining and Metallurgical Engineers by Mr. I. R. Kramer. Briefly the steel is either exposed to gaseous chromium chloride or heated in containers packed with porous ceramic material saturated with chromium chloride at temperatures between 900° and 1,000° C. for periods up to 24 hours. The thickness of the chromised layer depends upon the original composition of the steel and it is suggested that for the process to be satisfactory active carbide-forming elements such as chromium or molybdenum must be present in the steel. When chromised specimens with a penetration of 0·06 to 0·09 mm. were treated with boiling nitric acid, the original steel was completely dissolved while the chromised layer was unaffected.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 20, 20th May, 1943, p. 446.*

Topping Units.

In order to increase the output and efficiency of existing electrical generating stations on land, it is becoming the practice, particularly in the U.S.A., to install so-called "topping units". These units, which are not unknown in marine engineering practice, comprise a high-pressure boiler supplying steam to a turbo-generator the exhaust from which is usually re-heated to the same pressure and temperature as the steam from the main boiler plant, so that it can be supplied to the main turbines. In a typical installation of this kind recently put into service in America, a single La Mont boiler with a steam output of 650,000lb./hr. at a pressure of 1,825lb./in.^{2} with a superheat temperature of 950° F., is employed to operate a turbo-alternator of 25,000 kW. capacity exhausting at a pressure of 400lb./in.^{2}. The exhaust steam is reheated to 760° F. and is then utilised for the existing machinery. Although equipment of such a capacity could not be installed on board ship, it has been suggested that the employment of topping units of this type might, in some cases, prove suitable for increasing the speed of existing ships after the war. By using a high-pressure forced-circulation boiler it should be possible to provide the necessary amount of steam in the minimum of space, and the power of the turbine which formed part of the topping unit could be applied to the propeller shaft by any of the methods which are already being employed with exhaust steam turbines.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 23, 10th June, 1943, p. 519.*

Brown Boveri Reversing System for Electrically-driven Ships.

An improved method of reversing the synchronous propulsion motors of electrically-driven ships has been developed by Brown, Boveri & Co., Ltd. In this system the greater part of the brake power is absorbed in resistances instead of by the motor itself, and it depends on the fact that a ship can be "braked" efficiently at the beginning of the reversing manœuvre with a slowly-turning or stationary propeller. The propulsion motor is switched off from the generator and braked electrically because the three-phase winding of the motor is switched on to the resistance to which it supplies current as a generator with normal excitation. The motor is braked more slowly or quickly according to the magnitude of the excitation and the dimensions of the resistances, and only when the ship has lost sufficient speed in this way is the propulsion motor again switched into connection with the generator and the asynchronous astern rotation commences. As only during the very short asynchronous period of operation of the motor in the astern direction is a larger current than the normal used, the generator and propulsion motor are thermally stressed to a lesser degree than with pure asynchronous reversal. A large number of manœuvres can be carried out without any risk of over-loading to the propelling machinery, as the change-over from generator braking to asynchronous reversing can be effected earlier or later, according to the respective importance of the rapidity of stopping the ship and the desirability to limit the stressing of the propelling plant. The manœuvring period is short and the ship can be stopped more safely and simply than with any other reversing system.—*"The Motor Ship", Vol. XXIV, No. 280, May, 1943, pp. 42-43.*

Some Notes on Gear Noises.

The origin of noise in a gear unit lies either in the note created by the engagement of the teeth or in the sound produced by some slight inaccuracy in design or manufacture. The amplitude of the initial sound may be quite small and is usually only a minute fraction of the total sound; yet due to the influence of induced vibrations and resonance, it can, and often does, result in the development of excessive noise. The main sources of sound or noise in gears can thus be classified under these two general headings. Precision-ground gears, operating in perfect order, usually emit a low-pitched humming or musical sound which is smooth, continuous and without any traces of beats or pulsations. Intermittent clicking, knocks or pulsating sounds which sometimes arise from gears are usually caused through uneven or irregular spacing of the teeth or by teeth that are mis-shaped. Poor finish on the tooth surfaces causes a high-pitched squeal, which may decrease to one of lower pitch after the surfaces of the teeth have been sufficiently run in and a condition of unequal wear has been established. Pulsating sounds approximately to a growl which rises and falls in intensity may be due to incorrect setting of the gears on their shafts, particularly if there is even a very small amount of eccentricity. Inaccurate alignment, however slight, tends to produce an unequal distribution of the load transmitted to the teeth of the gears; this results in rapid and uneven wear on the tooth surfaces. A high-pitched howl or screeching sound of a pulsating nature may be due to rough tooth surfaces, to inadequate bearing support or to the use of a shaft which is too small in diameter and therefore permits whipping or eccentric engagement of the gear teeth, especially at high speeds. Gears which are arranged to rotate in alternative directions may be noisy when running in one direction and perfectly quiet in the other; this defect is usually due to the fact that the teeth of the gears are not perfect radially. Rattle, as the term implies, is generally the result of a loose part somewhere within the gear unit; but where there is a variable-helix angle, it may also be due to natural interference in combination with some eccentricity or failure of the involute action of the gear teeth. Straight spur-tooth gears are probably the worst offenders as regards noise on account of the wedging action of the teeth when they come together in operation; the tips of the teeth tend to operate as struts to interrupt the motion of the gear rather than to favour it. In general the rate of wear on straight spur gears is faster than on any other type, and tooth inaccuracies are more likely to occur.—*"The Power and Works Engineer", Vol. XXXVIII, No. 443, May, 1943, p. 110.*

Growing Shortage of Sea-going Engineers in America.

As it takes nearly four times as long to train a marine engineer as it does to build a Liberty ship, the new Victory Fleet is faced with the problem of providing engineer officers of all ranks for these vessels. To meet this acute situation, a special recruiting campaign is being launched by the War Shipping Administration in the states of Illinois, Indiana, Wisconsin, Minnesota, Iowa, Nebraska, N. Dakota and S. Dakota. Certificated marine engineers who have left the sea are offered immediate employment, those whose certificates have expired being given refresher courses of one to four months' duration. During the training they receive pay at the rate of $126 per month, plus subsistence and uniform allowance. Suitably qualified mechanical engineers with no sea-going experience are also eligible for appointment as Unlicenced Third Assistant Engineers after undergoing a special course of one month's duration. The pay during this training is $126 per month plus subsistence. At sea, these officers draw monthly pay at the basic rate of $155 to $185 plus overtime plus voyage bonuses on certain routes of 40 to 100 per cent., in addition to port bonuses of from $40 to $125. After three to six months' sea service they may be examined for a Third Assistant Engineer's certificate. The basic pay of engineer officers in American merchant ships is stated to be 25 per cent. higher at the present time than it has ever been in the history of the U.S. merchant marine. Third Assistants get from $165 to $224 per month; Second Assistants $180 to $253; and First Assistants, $200 to $316. These rates of pay are exclusive of overtime payments and bonuses. —*"Motorship", Vol. XXVIII, No. 4, April, 1943, pp. 304-305.*

Amphibian Jeeps.

The amphibian version of the ubiquitous Jeep is built by the Ford Motor Company, at Detroit, and is a vehicle which can carry five men and is able to perform on land every task done by the ordinary type of Jeep. In addition it can cross rivers and lakes and operate in seas that any boat of comparable size can navigate. The amphibian is, in effect, an ordinary Jeep, around which is placed a complete and independently-built lightweight welded hull. A new frame or hull can be fitted in the same manner as a new body is put on a chassis. Special protection for the engine is provided to safeguard it from the effects of water breaking over the bow of the "craft". The controls are identical with those of the ordinary land version and no steering change-over is required from land to water operation. A power-driven capstan is fitted forward to enable the vehicle to pull itself up a steep river bank or sea shore, and the equipment includes a lightweight self-priming bilge pump with conveniently located controls.—*"The Shipping World", Vol. CVIII, No. 2,607, 2nd June, 1943, pp. 523-524.*

Fibrous Glass Electrical Insulation.

The first part of the paper comprises a short survey of the history and development of glass fibres. Glassmaking procedure and present-day methods of producing "staple" and "continuous" fibres are outlined and information is given on the system of numbering fibrous glass yarns in comparison with other textiles. The features of glass textile insulation are then discussed in detail, and brief references are made to the various electrical and non-electrical uses of glass fibres in types other than those employed for electrical insulation purposes. The health aspect of the handling of these fine inorganic fibres is considered and the paper concludes with a brief survey of the role played by glass textiles in enhancing the reliability of electrical plant.—*Paper by A. M. Robertson, B.Sc., "Transactions of the Institute of Marine Engineers", Vol. LV, No. 5, June, 1943, pp. 87-96.*