The INSTITUTE of MARINE ENGINEERS

Founded 1889. Incorporated by Royal Charter, 1933.

SESSION 1942. *Transactions* Vol. LIV. Part 2.

Patron : His Majesty The King. President: Sir Percy E. Bates, Bt., G.B.E.

*"The Conversion of Blast-Injection Diesel Engines to Airless-Injection," by C. C. Pounder (Member): Discussion and Author's Reply.

Mr. S. B. Freeman, C.B.E., M.Eng. (Member) wrote: It is regrettable that this valuable addition to the economy and efficiency of older motor ships has not been more widely adopted in this country. The writer's experience is that at the time the change should have been made from blast-air to airless-injection, say about 1930/1935, it was unfortunately the case that our shipping was under a cloud of unemployment and every possible economy, both in the use of ships and in capital expenditure, had to be practised. When the tide turned in 1935/1939, all our ships were kept too busy trying to make good the losses sustained in the lean period to be held up for alterations. The cost of conversion estimated by the author looks attractive and it is sincerely to be hoped that we can keep to such a level of expense when the time comes after the war to do this work. The author's attitude in dealing with the possible or probable economy due to conversion reveals him as a sound philosopher. In the Company in which the writer is employed, ship and machinery results are compared on a three-years' average performance basis, over which time the variables have tended to flatten out.

For new ships the airless-injection system has evidently come to stay and it is good news that the manœuvring and reliability of engines converted from the blast-air system have been as satisfactory as those built for airless injection in the first instance. The fact that so many different systems of conversion are now available shows that the change-over has commended itself to a wide circle of both engine builders and users.

The author has given a detailed picture of the different systems which so far have been developed. It would seem that there is little choice between them, but that the least complicated systems are those which have been put forward by Burmeister & Wain, Götaverken and Kokum. This is not to imply that Eriksberg's and others do not work well. There has been only one disturbing comment which has come to the writer's notice; this is that the cylinder escape valves frequently lift when the engines are started from cold. This is not a serious matter but it is an unnecessary disturbance. The author, in his description of the Archaouloff system, tells us, "When starting up, the fuel valve spring is slackened and a low injection pressure adopted until the engine is warmed up". This may be the remedy for the above difficulty.

In the early days of oil-engine development it was considered that blast-air injection would allow the use of a heavier fuel than airless injection and some rather far-reaching claims were made in this connection. It was also thought that the small size of the holes in the fuel nozzles combined with the necessary high pressures would result in rapid depreciation of the nozzles. Both these anticipations have been found incorrect. On the other hand, the disadvantages of the blast-air injection system have become more and more apparent as ships and their equipment have grown older. The upkeep of the compressors and of their air-cooling systems is both difficult and expensive, and if there were no fuel economy in the abolition of the compressors, there would be an economy in upkeep expense and greater reliability in the performance of the machinery, and the reasons for the change-over from blast to airless injection will be as much on account of this running expense in connection with the blast injection as with the merits of the airless-injection system. To keep the compressors, their pistons, piston rings, valves and valve seats in order is a matter for constant care. The air compressors suffer from the wear and breakage of the high-pressure pistons and the failure of the air-cooling arrangements. As regards the pistons, it is obvious that the clearances must be extremely fine and any irregular wear causing loss of alignment soon produces a crop of troubles in the way of broken piston rings, scored compressor walls and loss of efficiency. In the engines of the type with which we are most familiar, the high-pressure air is cooled by being passed through a copper coil, with sea-water circulated outside. In the course of time this pipe, which is of very heavy gauge, wears thin on the side subjected to the erosive effect of the stream of air entering the coil. On three or four occasions this wear has been exceptionally rapid and the coil has burst, wrecking the cast-iron casing and putting the compressor out of action. The air from the intermediate compressor is cooled by contact with a series of brass tubes arranged in a circular nest with salt-water passing through the tubes and the air circulating round them. Here the tubes have been immune from attack by salt water but have depreciated on the side exposed to the blast of the incoming air. The tubes eventually are worn down to paper thickness, and as they are closely spaced in the tube plates, it is not always possible to discover which tubes have been thinned in this way. In addition to the repair costs entailed, these accidents involve the immediate stopping of the main engine, which may of course be a very serious matter from the navigational point of view.

As the author has pointed out, the advantages of adopting airless injection for new ships include the saving in space, the lesser first cost, greater reliability in manœuvring and the very considerable saving in upkeep and repair expense effected by the elimination of the compressors and the power necessary to drive them, and of the blast-air bottles, air coolers and piping.

In the earlier days of oil engines, some builders adopted the "common rail" system for the injection of fuel. This system which at first sight was attractive, was tried and found wanting. Separate pumps for each firing end of each cylinder were found to be necessary. The fact that in these conversion systems the original fuel pump can be kept as a measuring device to reinforce, as it were, the efficiency of the fuel pump is an additional attraction, making a regular and correct service possible.

The excellent illustrations have added much to the pleasure and interest of studying the paper. Our Members will realize and envy the author's familiarity with the varied and ingenious developments of Continental oil engine practice and his acquaintance with the up-to-date and efficient works which produce these modern engines. It is to be regretted that no entirely British adaptation could be adduced. It is a matter for congratulation that our Institue has been able to offer its Members such a masterly review of the various possibilities of increased efficiency now open to the shipowners operating with the older type of engines, and our thanks are again due to the author. To have undertaken this work at a time when he has so many other duties and calls on his time adds to our debt to him.

Mr. F. C. Bryant wrote: The Members of The Institute, and indeed all interested, are again indebted to Mr. Pounder for a very able, lucid, and complete, not to mention most convincing paper on the conversion of blast-injection Diesel engines to the airless- or solid-injection type. The diagrams and drawings of the mechanical details accompanying the paper make it entirely exoteric.

It will come as a surprise to a great many to learn that (as so often happens), Continental owners have given the lead, and that already some 200 installations have been so converted. This, coupled

* Paper published in October, 1941 Transactions, *Vol. LIII, No. 9, pp. 145-156.*

with the fact that practically all newly-built marine Diesels are now of the airless-injection type, gives impetus and added support to the argument in favour of such conversion.

In retrospect, the type of injection adopted was very much like the poet's last definition of "greatness"—the blast- or solid-injection method being "thrust" upon one according to the experience and design of the maker. However, we have now had enough experience with both types, and experience goes a long way towards convincing one that solid injection is by far the superior on all-round merit. In ships with blast-injection, one recollects the reported difficulties experienced in manœuvring—burst air coolers and other anxieties, overhauling compressor valves (a fairly constant and tedious job), non-existent with the solid-injection type.

Turning to the economic aspect, owners can only speculate with very mixed feelings on the post-war conditions of the shipping industry and trade generally, as evidenced by many expressions voiced by several of the leading exponents. There is one outstanding fact, however, mentioned by Mr. Pounder and which the writer may confirm, and that is the need for the utmost economy both in regard to design and maintenance in post-war projects.

The conversion of Diesel machinery as outlined, undoubtedly has a place in schemes for economy, with of course certain limitations. The paper indicates a gain of at least 6 per cent. saving of fuel, with a tendency towards perhaps a maximum of 10 per cent. Mr. Pounder has investigated the effect of various savings and indicates probable returns on the basis of 250 working days. The writer, from time to time, in investigating various economic problems of ship maintenance, has usually found that for the ordinary cargo ship the vessel is actually under propulsion for about 180/185 days per annum, so that by substitution of this figure and by making allowance for the usual rates of depreciation, interest and insurance, it would take probably about 7 to 8 years for extinction of cost. In the meantime, of course, installations that might be converted are not getting any younger. Assuming such vessels and machinery are at present "well kept" and have say, an "expectation" of at least 27 years (ships will probably have to "live" longer in the future until replacement overtakes losses) from original handing over, then the writer would suggest that there is every likelihood of such conversion proving profitable in ships built say no earlier than 1927, if the conversion could be carried out within the next two or three years.

The conversion and resulting economy would, of course, be concurrent with the greater expenditure sometimes associated with the later years of Diesel machinery on shipboard. As Mr. Pounder says, such conversion may not be considered as practical politics just now, but provided that our "new order" for the future includes, *inter alia*, the quicker turn round of ships in port, now happily part of the "go-to-it" programme, then vessels should approximate nearer the 250 days under propulsion, and conversion will no doubt be seriously considered for suitable tonnage, and may possibly be an integral part of post-war refit programmes.

Mr. H. S. Humphreys (Member) wrote: The author has given a clear and concise summary of the different methods which may be employed to convert blast-injection engines to airless-injection. He has mentioned that there have been instances where engines have been converted by completely taking out the fuel injection system and replacing it with a straightforward airless-injection arrangement such as that fitted to a new engine. This is a costly process entailing probably the re-design and renewal of existing cylinder covers and pistons to ensure a satisfactory combustion space, also the renewal of the camshaft or the installation of an additional camshaft for the fuel pump drive, in addition to the new fuel pumps and various fittings. In many cases this would not be possible as the strength of the crankshaft would not be sufficient to cope with the increased load.

The question to be considered, therefore, is whether it would be justifiable to convert from blast injection to the Archaouloff or similar airless-injection system. No doubt the change-over which has been carried out to many vessels before the war has been beneficial, but the problem to be faced is the present and the future. At present, owing to wartime priorities it is out of the question to consider such changes. As to the future, one cannot foresee when we shall be in a position to carry out such modifications but it may be assumed that this would not be until a year or two after hostilities cease. Seeing that very few Diesel jobs were built after 1930 with the blast-injection system, it may be taken that most vessels still fitted with this system will be at least 15 years old before conversion could be considered.

With the existing cylinder covers and pistons, and taking into account that the maximum pressures in the cylinder cannot in many cases be raised after conversion due to the strength of the crankshaft, etc., the only gain in performance is that derived from the removal of the main air compressor which is estimated at 6 per cent. The cost of conversion of say a 3,000-b.h.p. 8-cylinder Diesel engine after the war would probably be about £3,500 and after making due allowance for the saving in fuel and the slightly increased cargo carried due to the lesser bunkers, it would probably take about 10 years to neutralize the extra capital cost. It therefore appears unlikely that many more conversions will be carried out.

The author assumes that the saving in the maintenance costs of the main compressor is offset by the cost of upkeep of the converted fuel system. If this is the case then there seems to be very limited grounds for the conversion as, in my opinion, the great attraction of the conversion would be the elimination of the main air compressor which is one of the chief sources of expense, annoyance and delay in the air-injection Diesel engine.

The writer entirely agrees with the author's remarks regarding the tendency in some cases to over-estimate improved performances. Comparisons should be made over extended periods under service conditions, since results obtained over short periods may be misleading due to weather conditions, currents, state of vessel's bottom and the like.

The future of the systems under review appears to rest with the possibility of their competing in new jobs with the straightforward airless-injection systems, and the writer would like the author to put forward a comparative case.

Mr. Thomas Petty, A.M.I.Mech.E., wrote: Mr. Pounder's paper constitutes a comprehensive descriptive treatise on the various conversion methods by which a shipowner may be enabled to avail himself of the advantages conferred by the substitution of an airless- for a blast-injection system.

The subject covers a field which is necessarily limited, and is essentially a transient one, but this has not deterred the author from dealing with it in complete detail, and with that thoroughness and wealth of illustration which is characteristic of him.

Sections I and II are of very great technical interest, but to the writer, with memories of the vast number of what may be termed "accessories" which have been launched from time to time in the firmament of the engineering world, and the glowing claims (not always fully substantiated subsequently) with which their enthusiastic sponsors have bemused engineers and shipowners called upon to make technical decisions, section III would seem to be of particular importance.

Here we are given not only unbiased estimates of the cost of conversion and its probable results as regards reduced fuel consumption, but the necessity is clearly demonstrated for considering these against the background of the secondary effects as regards general maintenance, and the time available for amortization prior to final obsolescence, either or both of which may be the ultimate deciding factors, and which in so many cases render any change inadvisable, as being likely to lead to disappointment.

Mr. A. C. Hardy, B.Sc. (Associate Member) wrote: Few marine engineers have enjoyed longer or more varied experience of four-cycle engines than the author, and few therefore are better able to deal with the important subject of the conversion of air to airless injection.

The four-cycle single-acting and, indeed, the double-acting type have been good friends of the shipowner for a number of years. The writer, for one, has always felt that the demise of the former, in larger powers, was hastened by the march of events, rather than by any inherent defect in the machine itself. The march of events was, of course, the development of the two-cycle engine and, in very general terms, the ability which it conferred of being able to place rather more power in less space.

Protagonists of the two-cycle engine were apt to forget, however, that whereas this latter always brought a parasitical friend with it, *i.e.* the scavenge load, the former, if working on airless-injection, *i.e.* with the blast air compressor eliminated, was completely self-contained. They were apt to forget, too, that the heat of exhaust from the four-cycle engine could be very conveniently employed to generate steam in exhaust gas boilers while its velocity operated a turbo-driven blower supplying supercharged air. The wheel of fashion swung, and there are few who to-day would dispute the high state of perfection to which two-cycle operation has been brought. Nevertheless, as the author himself says, there are still large numbers of ships afloat with the four-cycle engine. After the war, the nations of the world will be faced with the immense task of rehabilitating to peaceful pursuits a battered and somewhat tattered collection of tonnage.

Any thoughts for the future which will help the attainment of this desirable end in the quickest possible manner in post-war days, are welcome. Indeed, now is the time to plan for the future. There is, of course, nothing fundamentally new in the conversion of air-injection to airless-injection. Devices have been on the market for some time, and the principal of these are described by Mr. Pounder in some detail. There are two methods open to shipowners to improve the old four-stroke blast-injection engine. One is to supercharge and the other to convert to airless-injection. Many ships on the Continent have been converted in the last few years to airless-injection, but for some reason which is not too clear, the matter has not been taken up by British shipowners; hence this paper is all the more valuable at the present time.

The matter is presented fairly and without any obvious enthusiasm. A plain, straightforward story has been put forward, which should be of interest to every member of The Institute. It would seem that Mr. Pounder has introduced some points with a view to interesting shipowners, although no attempt has been made to exaggerate savings in fuel consumption, nor to minimize the cost of conversion, the time taken, etc. The cost of upkeep of the blast-air compressors, which is one of the factors which may well determine whether or not any specific proposition is worth covering, is not, it is noted, discussed by Mr. Pounder. Presumably he feels that this matter is best left to his readers, and particularly to the superintendent engineers, who are well-qualified to pass an opinion on this point.

Next to Norway and Denmark, Great Britain has probably more air-injection four-cycle engines than any other country. It seems to the writer, as a student of the subject, that the elimination of blast-air compressors, with possibly supercharging of the thus simplified machines, would provide the shipowner after the war with virtually an entirely new engine, with upwards of 35 per cent. greater power, and none of the periodic trouble associated with the compressor.

Mr. L. F. P. Sorge (Member) wrote: The subject matter of the paper is of the greatest interest to those concerned with the running of blast-injection installations. The comparison of the different conversion systems is dealt with fully and most impartially and it is not the writer's purpose to discuss their merits or demerits. The main thing from his point of view is that all offer the total abolition of that bugbear, the blast-air compressor. As an early pioneer of the Diesel engine the writer speaks with feeling. The air compressor of those early days was little short of a lethal engine. Many engineers lost their lives and the writer, amongst others, will carry scars to the end of his days resulting from failure of compressors.

The Diesel engine designer of those days proceeded very lightheartedly with the compressors, and the unfortunates who handled them bore the brunt of the resulting trouble. When the writer thinks of some of the valve arrangements as then used, he is horrified. As time went on the compressor naturally improved in performance and safety, but even to-day it is subject to numerous troubles. Such minor defects are sufficient to cause the start of serious trouble, and not infrequently the early stages of disaster are not observed by the attendant engineers. The compressor itself, however, does not remain the only source of trouble. The fuel injection valve quite frequently is completely destroyed due to the valve sticking open while the engine is running, resulting in the end of the valve spindle being burnt off and the body so badly damaged as to need renewal—frequently an expensive item. In cases where there is a combined starting and fuel valve this trouble is emphasized.

The writer need not go into the question of explosions in compressors, so many of these having occurred that the results will be familiar to members.

The conclusion is that, irrespective of any economy, the successful conversion to airless injection is highly desirable. The shipowner will benefit from fewer breakdowns, loss of time and expense; the superintendent will be saved a few grey hairs, and an inestimable boon will be conferred on the ship's staff.

That there will be economy is certain, since the generally accepted figure of 6 per cent. loss due to compressor drive refers to the latter in absolute efficient order, which the writer fears it seldom is after a comparatively short period of running, and this, not of necessity, from neglect. It would only be avoided by piston ring and valve overhaul and renewal of an order that would be outside practical economics.

The ordinary airless-injection fuel valve and pump are so efficient that periodic cleaning and overhaul suffices to keep them in running order almost indefinitely. A large number of pipes, with their numerous joints, all a source of trouble, are got rid of, and the valve itself, being so much smaller than its predecessor is far more easily handled.

Mr. A. E. Crighton (Vice-President) wrote: Study of Mr. Pounder's valuable paper reveals that the time is fast passing when this conversion can be profitably made on the score of economics alone, for having regard to the fact, as the author states, that the year 1932 saw the last of the new blast-injection installations, they will by now, or at any rate by the end of the war, have lived more than half their useful life. At the most then, it would appear that 8-10 years only could safely be allowed for amortization of conversion costs.

Insofar as the maintenance of main-engine compressors is concerned, the writer endorses the views of the superintendent quoted by the author as saying that, apart from fuel saving, the elimination of the blast-air compressors and intercoolers and their attendant trouble is sufficient inducement to carry out the conversion.

The writer presumes that if the compressors are removed some compensation must be made in the way of counterbalancing the crankshaft—the cost of this does not appear to be included.

Another fact which should not be overlooked is that during manœuvring periods the surplus air from the blast-air compressors is "leaked-off" to the starting air reservoirs—in the case of some vessels the power of the electrically-driven manœuvring air compressor absorbs more than the electrical output of one generator. In certain circumstances full reliance must of necessity be placed upon the main-engine blast-air compressors to maintain an adequate amount of starting air. Consequently, if they are eliminated an additional generator should be fitted to provide against the use of the starting-air compressor, except in special circumstances. This may of course be an isolated instance, but tends to prove that each individual proposal should be judged on its merits.

A further point arises from the writer's own experience that the mechanical-injection engine prefers a better-class fuel than the more inferior grades with which the blast-injection engine is satisfied. Even if it is considered not essential to purchase a more expensive fuel, it will probably be found advisable to install a centrifugal purifier which was not always considered a necessary auxiliary to the blast-injection engine.

Mr. George Rooks (Member) wrote: There is surely little to criticise in the principle of conversion from the superintendent engineer and seagoing members' viewpoints, as the cutting out of the compressor eliminates certain troubles, the causes of which are sometimes never revealed, and reduces the amount of routine work to be done at the end of each passage.

The writer's experience with Harland & Wolff blast-injection engines for the past 15 years has been, comparatively speaking, free from compressor or indeed other troubles. This speaks well for this engine, particularly as the 11 motorships supervised now average over 14 years. At the same time it must be admitted that there have been rare occasions when loss of pressure in the air compressors, through no apparent cause but assumed to be due to elusive particles of carbonized lubricating oil, has proved costly to the owners and a nerve-racking experience to the ship's engineer officers.

As the writer understands that certain successful conversions were carried out before the war on the lines of the Russian engineer Archaouloff's original patents, it is to be hoped that after hostilities have ended, such capable leaders of the engineering industry as the firm with whom Mr. Pounder is connected will undertake the whole job of conversion.

From the owners' point of view, surely the outlay of, say, about £5,000 maximum would be well worth while, especially as the life of the engine is being extended and a reduction secured in consumption expense for the same ship speed.

Mr. C. T. Adams (Member) wrote: Mr. Pounder, in his most interesting paper, made no mention of the possibility of carrying out this type of conversion on oil-engine-driven dynamos on motor ships.

Shortly before the war, the shipping company by whom the writer is employed decided to convert from air to airless injection a 200-kW. four-stroke cycle generator engine which was originally fitted with a three-stage air compressor and intercooler mounted on an extension of the engine bedplate.

A high pressure injection pump unit was designed to mount upon the crank case of the old compressor unit, chain driven at half engine speed by means of a sprocket wheel which was fitted to the compressor crank disc. This was necessary because it was considered that the existing cam shaft drive was insufficiently strong to allow high-pressure fuel pumps to be driven by it.

The load imposed by the higher maximum pressures with airless injection of fuel was carefully considered in relation to the sizes of connecting rods, shafting, framing, etc., but no engine alterations were considered necessary. Likewise the shape of the combustion space, involving cylinder covers and pistons, remained unaltered. The mechanically-operated air-injection fuel valves were replaced by spring-loaded fuel injectors.

The work of removing the compressor and fitting the new parts was completed in under six days and the engine was actually running as an airless-injection unit on the sixth day.

It should be emphasized that this conversion was carried out as a commercial proposition and it has proved a complete success, both commercially and mechanically. The chief engineer of the ship was rather dubious about this experiment and requested that the compressor parts and other fittings should be left on board in case he had to re-convert the engine during the voyage. At the end of the voyage, however, he suggested that it would be a good idea to convert the other engines in his ship.

Combustion was good, but this no doubt was due in part to the fact that it is a constant-speed engine, for which the nozzles could be specially designed to give good combustion in a combustion space which was not ideal.

Fuel oil consumption was carefully checked during 3½ months' voyages before and after conversion and the saving amounted to 16½ per cent. The explanation of this high figure is that generator engines run at an average power very much below full power, and thus the power percentage required to drive the air compressor is on the average much greater than the figure of 6 per cent. quoted by Mr. Pounder, which only applies to full power working.

The load capacity of the engine has been increased by at least 12kW. and the engine is much more flexible and will accept sudden increases in load whilst cargo is being worked without faltering. This extra load capacity has proved very useful in dealing with the D.G. requirements under war conditions.

The engine is more easily started and is more reliable. Most superintendent engineers will agree that the air compressor is the component of the blast-injection oil engine most likely to give trouble in service.

Overhauling work and costs, including cost of spare parts, are reduced, and it is considered that if main and generator engine compressors could be dispensed with, an engine room staff of nine engineers could be safely reduced to eight. In any case, the engineers would be able to carry out other work instead of overhauling compressor valves or coolers and this would lead to a reduction of the work which it would be necessary to put in repairers' hands at the end of the voyage.

The total cost of carrying out this conversion amounted to £564, and the saving in fuel oil costs (with fuel at 50s. per ton) amount to £108 per annum. Other savings, as outlined in the foregoing, are estimated at £30 per annum.

From these figures it will be appreciated that this represents a paying proposition on all but the oldest oil-engined ships with electric auxiliary machinery.

Mr. W. Kenneth G. Allen (Associate) wrote: The subject, so clearly dealt with by the author, will be of immense interest to superintendent engineers who are responsible for vessels with blast-injection machinery, both for main and auxiliary units.

Speaking in connection with auxiliaries only, the advantages of airless injection from the ship's engineer's point of view are as follows:—

Firstly, an auxiliary engine is expected to accommodate itself automatically to the changes in electrical demands of the vessel, whereas manual operation is always associated with change of speed or power of the main engine. The result is that the auxiliary engines are often working under inefficient air-blast conditions for the particular load on which they are operating.

Secondly, on many designs of blast-injection engines, it would be true to say that half the routine maintenance is lavished upon the compressor, its valves, its intercoolers and associated parts; this is dispensed with after conversion.

Thirdly, greater fuel economy is achieved at the original load with reduced exhaust temperatures.

Fourthly, in most cases, if desirable, it is possible to increase the rating by some 5 to 10 per cent., arising from the power available by the removal of the compressor. A further slight increase is obtained in certain cases where the speed of blast-injection engines has been limited by considerations of torsional vibrations. The removal of the compressor slightly increases the natural frequency of the crankshaft system; by conversion to airless injection it is possible to run the engine faster with correspondingly increased power.

The above advantages are based upon the assumption that the compressors on the auxiliary engines are not relied upon for charging their own starting air receivers or those of main engines. Where independently-driven compressors are available, no difficulty is encountered, but if the retention of the compressors is essential, much of the incentive to convert is lost. In such cases increased fuel economy and overload capacity are sacrificed and the only appreciable advantage is the ability of the engine to accommodate itself to change of load without adjustment.

It is not wise to generalise on the ease with which conversions can be made, but it is possible in most cases to effect conversion on board within three days without modifications to or replacement of any major parts.

It is usually possible to fit suitable solid-injection nozzles into the space formerly occupied by the blast-air valves. The next problem is to provide a drive for the fuel pumps. On engines where the top of the camshaft is not enclosed by the main casting, it is possible to fit new cams and mount the fuel pumps on suitable brackets above the camshaft troughs. The control shaft can then be parallel to the camshaft for the regulation of the fuel pumps from the governor.

Another arrangement consists of the removal of the compressor from the free end of the engine and the mounting of another assembly on the same facing.

The assembly consists of a short camshaft for driving the fuel pumps, a high-speed governor and a tachometer, all forming a compact unit. This is driven by a vertical roller chain from a sprocket secured to the crankshaft web formerly used for driving the compressor.

In these days it would seem a good policy to ease the duties of marine engineers and obtain increased economy by adopting the comparatively simple procedure of converting main and auxiliary engines.

Mr. H. W. Brady (Member) wrote: The author's valuable collection of information bearing on the question of conversion from blast- to airless-injection has not been presented too soon. The paper will still be available to interested shipowners after the war, and the economic part of it is an example of the service a technical society can render outside the technical interests of its own membership.

The ingenuity applied to the technical requirements of a satisfactory conversion is seen to be very great and astonishingly varied, but it centres mostly around the problem of combining fuel measurement with fuel pumping while avoiding the wholesale scrapping of existing parts, and yet not putting impossible stresses on the retained parts. The original Archaouloff device took charge of the heavy pumping stresses, though itself relatively light, very simple and without "motion" members calling for lubrication or occasional rebushing. This and the other systems since evolved, including Archaouloff's own later elaboration, "ring the changes" on combinations of the pneumatic piston, the accumulator, and the fuel metering valve. If one fairly obvious combination is absent, no doubt it is because of an objection equally obvious to those in practical contact with the problem, which the writer is not. This is the possibility of using an Archaouloff pump (without the regulating gear shown in Fig. 9, but preferably with the oil seal shown in Fig. 20) on each cylinder; each of these to deliver, not into its own engine cylinder, but into a "common rail" to which a simple accumulator is connected, and from the rail to each cylinder via a branch pipe. The supply of fuel to each cylinder would need to be regulated by a timed fuel valve, and this would of course sacrifice two of the advantages which are incidental to these pneumatic pumps as against the ordinary mechanically driven pump, ***viz.*** that the starting time of injection is not affected by air in the fuel, nor the speed of injection affected by engine r.p.m. On the other hand, the arrangement would appear to satisfy the original ***desideratum,*** the elimination of intense pressure load from rods and levers continuously in motion; and it would appear to have also the advantage of affording a standby in case of the derangement of a pump, assuming each of these to be made capable of supplying somewhat more fuel than is required by one cylinder when not curtailed either by throttling down at cock *G* (Fig. 8) or at the feed pump (ex fuel pump).

The writer feels that the author is to be thanked for giving us, and not for the first time, a paper that is of commercial service as well as of professional interest.

Mr. J. C. Lowrie (Member) wrote: The simplifying of Diesel engine parts has been one of the governing features tending to make Diesel machinery attractive, especially so for the propulsion of sea-going vessels. Mr. Pounder advances one more step in this direction when he advocates the conversion of engines from blast- to airless-injection. This will be borne out by the marine engineer at sea who has had experience of both types.

Under the heading of "General" Mr. Pounder clearly states that a detailed scheme must be furnished before such a conversion system be attempted and there is no doubt that what he prefers is of the utmost importance.

The cost and time to convert will vary somewhat with the age and power of the machinery; here another point is raised, worthy of consideration, namely the required sea speeds in the near future.

It is with regret that the subject Mr. Pounder has so ably dealt with did not come to the notice of Diesel engine users at a much earlier period. It was known that conversions of such a nature had taken place around 1929, but the system adopted then could not be compared with those of the present day.

The blast-injection engine built around the year 1924 was, at that time, considered the finished article and it was not until about 1929 that part consideration was given to conversions. Since then, of course, rapid and vast strides have been made towards the development of the Diesel engine, such that blast-injection engines of the lower horse powers were considered out of date. Such, of course, was not the case. Nevertheless, they received little attention with a view to improvement.

The centre of attraction, and rightly too, was newer designs such as the airless-injection types of the simplest construction, of which a great deal can be said in favour.

Mr. A. K. Bruce wrote: The writer has read with very great interest Mr. Pounder's valuable description of means for effecting the conversion of blast-injection Diesel engines to airless-injection. It is, of course, well known that blast-injection was not used on the very earliest of the engines developed by Rudolf Diesel and his collaborators, nor indeed was blast-injection first proposed by Diesel. As for the use of the engine compression pressure for the purpose of injecting the fuel, this did not originate with Vadime Archaouloff, since at least as long ago as 1910, the Maschinenfabrik Augsburg-Nürnberg constructed (at Nürnberg) a Diesel engine in which the blast air was taken from the compression space of the working cylinder and led to a water-cooled air receiver fitted to the cylinder jacket. The compression pressure was about 40 atmospheres and at this pressure (varied by the calibration of the spring tension of the spill valve) the air was used for injecting the fuel. This engine (of the vertical single-cylinder trunk piston "A" frame type) was designed by Lucian Vogel, who, in 1895, had taken a prominent part in converting the rather vague ideas of Diesel into an engine which would work. The M.A.N.-Vogel engine of 1910 was shown at the Turin Exhibition in 1911, but as a commercial machine it did not realise expectations and, so far as the writer knows, was never put into production.

The Archaouloff system is, of course, on very different lines to Vogel's, though the contents of Archaouloff's patent of 1925 shows and describes an arrangement much inferior in its practical detail to the arrangement which, developed later, is so well illustrated in Mr. Pounder's paper (see Figs. 9 and 10). The cylinder head arrangement originally described by Archaouloff would very soon prove impracticable from the point of view of its serious discontinuities, particularly if it were embodied in a four-cycle cylinder head which has already discontinuities enough. With the differential piston built up as an entirely separate unit (Fig. 9), the thing becomes more of an engineer's job, but it seems to involve operating difficulties if fitted on any engine which, like a marine engine, must frequently operate under manœuvring conditions in both directions of rotation. This is a point on which the writer would be very interested in knowing something about the actual operating results, with the engines at very low r.p.m. and reversing frequently. Possibly, Mr. Pounder will refer to this in his reply to the discussion.

The writer cannot see any reason to prefer the Archaouloff system to the system of using an injection pump with accumulator, an arrangement not affected by changes in compression pressure, engine speed or direction of rotation. Some time ago the writer was concerned in the conversion of some large two-cycle single-acting crosshead type engines in which the fuel pump and accumulator plan was used, injection being timed by a slide valve operated from the camshaft, no spring-injection being employed. The engines so converted worked almost as quietly on direct-injection as they had on blast-injection. It seems to the writer that in large marine engines designed originally for blast-injection, it must be necessary to make very certain that there will be no trouble with the original piston skirts and motion work details due to the higher maximum pressures when operating with direct-injection. If such trouble occurred, it would be likely to wipe out any possible commercial advantage due to the improved efficiency and the suppression of the blast-air compressor. The writer agrees that the primary advantage of such conversions is the elimination of the blast-air compressor, not only with a view to increasing the nett engine output for a given fuel consumption rate, but so that the maintenance cost due to the compressor may be avoided. Regarding the wear in converted engines, it would be interesting to know whether Mr. Pounder has been able to collect any figures showing the effect of conversion (if any) on the rate of liner wear.

A very interesting part of the paper is Section III dealing with the economics of conversion. It can be seen from the figures on page 156 that the scope for the reduction in operating costs will not provide for any material increase in wear and tear, or for replacements should (for example) direct-injection be fitted on blast-air injection engines which are getting to the weak side or which have no appreciable margin for carrying, in any significant position, the higher loading due to higher maximum pressures.

In conclusion, it is interesting to note how Diesel engines are now being altered in such a way as to leave the combustion to itself, so to speak, a procedure specifically objected to by Diesel as contrary to the "Process" which he claimed in his patent. The truth is that such a thing as a Diesel engine is no longer built, though for some utterly inexplicable reason oil engines in which the fuel is added to the air at the end of compression are almost invariably described as "Diesel" engines. It is time this nomenclature was changed and some credit allowed to the British and American engineers who first put the oil engine on its feet.

The Author's Reply to the Discussion.

The paper was essentially concerned with the impartial presentation of the facts involved in the subject, expressions of personal opinion being reduced to negligible dimensions. This has had its counterpart in the written discussion, which has been less concerned with opinions than with matters of an experiential nature. The loose ends left by the paper have been so well tied together by the various contributors, that little remains for the author to say.

Mr. Freeman effectively summarizes the various points as they appear to a superintendent engineer of a large and efficient fleet. He is correct in stating that the ideal time for changing from blast-injection to airless-injection was during the period 1930-1935, when the advantages of airless-injection had been proved in new engines and when blast-injection installations had a long expectation of life. In addition to the explanation which he gives as to why the advantages of a change-over were then not seized upon, it may be mentioned that, at that time, it was probably felt that there was not sufficient conversion experience available upon which to base a programme.

Mr. Freeman refers to two systems which are not described in the paper, *viz.* Götaverken and Kockum. It was essential, by reason of present circumstances, to compress the paper to its limit and accordingly the two systems which Mr. Freeman mentions were omitted—descriptions of them will, no doubt, be found in the pages of the technical press—in favour of descriptions of the systems with which the author is most familiar, *viz.* those of Burmeister & Wain and Harland & Wolff, which had not previously been described.

As a member of an important firm of consulting naval architects and engineers, Mr. Bryant is in a position to give a slant on the subject which is different from that of an operating engineer or engine builder and it is this distinctiveness of outlook as a widely experienced naval architect which adds to the value of his comments.

The remarks of Mr. Humphreys upon the economic aspect of conversion are unquestionably sound. It is necessary to put this aspect of the matter in its proper perspective, as technical men are sometimes rather too apt to weigh-up problems in terms of technical interest rather than of commercial advantage. In the last paragraph of his contribution Mr. Humphreys touches upon an important point. He states that the future of the systems under review appears to rest chiefly upon the possibility of their being able successfully to compete, in new installations, with airless-injection systems as normally fitted and he desires the author to put forward a comparative case.

An engine of small size is in hand, at the present time, with an airless-injection system similar to one of those described in the paper and until data become available from this engine the author hardly feels able to express a sound opinion. Some people consider that, in direct competition with normal injection systems, the alternatives are not likely to prove competitive. But it is hard to say. According to the author's understanding, the Archaouloff system itself did not become a real commercial venture until Krupp's took the matter in hand, thus proving once more that between the technical excellence of a proposition and sound commercial success there can be a great gulf.

In the paper the assumption was made that the upkeep of a converted fuel system was about the same as that of a blast-injection system. The maintenance costs of the air compressor should always be a direct saving. This, in some proposals, can be the greatest factor.

The remarks of Mr. Petty are of particular personal interest to the author. As a designer of wide and long experience Mr. Petty is in a position to appraise very soundly the value of innovations. The sight of his name takes the author back to the days of his callow youth when it was his good fortune to come under Mr. Petty's charge. The sound engineering notions which Mr. Petty instilled into the author's head at that time proved an invaluable background to the many varied phases of experience, in wider and more strenuous fields, which were to follow.

Mr. Hardy refers to the demise of the four-cycle single-acting engine for larger powers and how it was hastened. It is surprising how strong a preference there still is in various quarters for four-stroke engines. In fact the author has before him, at the moment, proposals by certain very successful shipowners to adopt single-acting four-cycle supercharged machinery for new tonnage in preference to two-cycle engines; and this after the matter has been thoroughly considered in all its aspects, involving ship, machinery, trade route, first cost, maintenance, etc. The owners in question do not regard their proposals as retrograde, or even unprogressive, as in their opinion the four-stroke supercharged engine, utilizing exhaust gases for steam generation, fully satisfies their requirements. Admittedly the four-stroke engines, which are the standard of reference to these owners, are machines of a very high order of excellence which, after some years of running, are giving as great a degree of satisfaction as ever. Mr. Hardy mentions that there are two methods open to shipowners to improve four-stroke blast-injection engines: one to convert to airless-injection, the other to supercharge. The crankshaft is the factor upon which many supercharged proposals fall-down, as frequently it does not possess a sufficient margin of strength to take the additional piston load represented by a worth-while supercharge.

To some Diesel engineers of the rising generation, who are in the habit of seeing engines run week in and week out with clock-like precision, the remarks of such a veteran as Mr. Sorge will perhaps come as a surprise. Recently the author met an engineer, who was a contemporary of Mr. Sorge in one or more of the ships which he, no doubt, had in mind, and this engineer—on recounting some of his earlier experiences—referred to one Diesel ship which actually succeeded in running for thirty-six hours without a break-down, an event so notable and outstanding that the captain of the ship felt impelled to celebrate the occasion with appropriate ceremony.

Mr. Crighton mentions an interesting point arising out of the practice of utilizing the surplus air from the blast compressors by leaking-off to the starting air reservoirs. Regarding some of the other points: the installation of a centrifugal purifier should be considered as necessary for a converted installation as for a normal airless-injection engine. In a six- or eight-cylinder four-cycle engine, without a compressor, the primary and secondary forces and couplings are balanced. Where there is a direct-coupled compressor, it is customary to add weights to the crosshead of the engine cylinder adjacent to the compressor to compensate for the disturbance created by the compressor crank and its running gear. With the removal of the compressor crank, these reciprocating weights should be discarded.

The contribution of Mr. Rooks, while brief, is very interesting, especially his reference to the operating success of his eleven motor-ships of the Harland & Wolff type. He mentions these as being free from troubles. One of his engines, however, was once the innocent first cause in a string of circumstances which eventually led to both Mr. Rooks and the author being taken ashore in the Sea of Azov and presented gratis to the O.G.P.U. That was trouble enough. That, however, is a story of another kind.

Mr. Adams is correct in stating that practically no mention was made of the possibility of converting dynamo engines. In fact, reference to this matter in the paper was confined to one paragraph wherein it was stated that auxiliary engines also could be converted in a manner similar to that adopted for main engines. The contribution of Mr. Adams to the discussion is an epitome of all the technical and commercial points involved in the conversion of generator engines, and it will be much appreciated by readers.

The factors for and against the conversion of auxiliary engines, as seen by the engine builder, are summarized by Mr. Allen. He correctly states that if in any proposed conversion scheme the retention of air compressors is essential, much of the incentive to convert is lost, the only appreciable advantage then being the ability of the engine to accommodate itself to changes of load without adjustment.

Mr. Brady puts forward a very ingenious alternative scheme which in itself represents a new system, and is worthy of more consideration than the author has been able to give to it, up to the moment of writing.

There is a great deal in what Mr. Lowrie writes. Years ago, when conversions might more profitably have been made, but when they were not so well-understood nor so well-established as they are now, it was only natural that some hesitancy should be shown by operating engineers, if only for the reason that "better the devil you know than the devil you don't". At the best of times the way of the progressive engineer, like that of the transgressor, is hard.

The contribution of Mr. Bruce, whose wide experience has lain outside of marine circles and who is thus able to look at marine matters from a different angle, is very welcome. The Archaouloff patent of 1925 shows, as Mr. Bruce states, an arrangement which is much inferior to the actual arrangement which is now standard practice for conversions on the Archaouloff system.

The author does not possess any figures showing the effect—if any—on the rate of liner wear of converting an engine from blast-injection to airless-injection.

While the paper was concerned entirely with marine engines, there must be many land Diesel engines which could advantageously be converted from blast-injection to airless-injection.

Regarding the nomenclature of the Diesel engine, the author can say very little that is useful. The word "Diesel", while it may be something of a misnomer, is brief and simple, it slips easily from the tongue, and every engineer understands what is implied. It is also a word of international usage. There appears little likelihood of an alternative name, as widely acceptable, being forthcoming. The author has to admit that what interests him more than the label is that engineers of Britain and Northern Ireland should take such a live part in Diesel engine evolution that the Continent is outstripped as regards excellence of design, soundness of manufacture, and efficiency of operation.

The information given in the paper, so strongly supplemented by the wealth of comment represented by the written discussion, should provide the archives of the shipowner and superintendent engineer with a fairly complete statement of everything that is involved in projected conversions from blast-injection to airless-injection. This, no doubt, was the intention of The Institute when requesting the paper.

The author takes this opportunity of thanking Messrs. Sulzer Bros., and especially Mr. J. Calderwood, for the material so freely placed at his disposal regarding the systems used by this firm.

JUNIOR SECTION.

Naval Architecture and Ship Construction (Chapter XV).

By R. S. HOGG, M.I.N.A.

The Effect of Water Pressure on Bulkheads, Tank Tops, etc., Centres of Pressure, Panel Stress.

It is fairly evident that the pressure on the bottom of a cylindrical flask filled with water is that due to the weight of water in the flask, Fig. 170. Conversely, if an empty flask of the same dimensions be forced down into a tank of water until its lip is flush with the water surface, there will be an upward pressure on the bottom

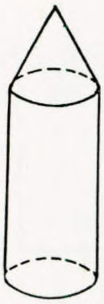


FIG. 170.

equal to the weight of water displaced. This is not so evident, but it can be demonstrated as follows :—

Take a glass cylinder open at both ends, and clamp it so that it stands vertically inside a suitable tank. Place on the bottom of the cylinder a glass disc just large enough for the purpose. This can be held in position by means of a rubber washer secured to a piece of string. Now fill the tank with water, and if the contact between the flask and the disc is good, no water will enter the former. When the water reaches the lip of the flask the washer may be pulled away, and water pressure alone will suffice to keep the disc in position. Coloured water can next be poured into the flask, and it will be found that the disc will not fall off until it is practically filled. Thus it is seen that a force equal to the weight of water in the flask is necessary to balance the upward pressure on the bottom. A faint smear of grease on the disc will enhance the chances of success in this experiment.

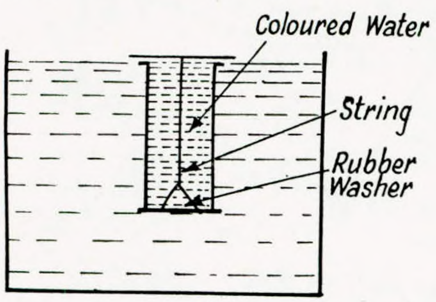


FIG. 171.

Archimedes Principle states :—*When a body is immersed in a liquid it experiences an upthrust, and the amount of this upthrust is exactly equal to the weight of the displaced liquid.*

The foregoing experiment supports this contention, and it also illustrates an important law in connection with hydrostatic pressure, *viz.*:—

Water pressure varies directly with depth.

Example 54.

Find the pressure per sq. in. on a horizontal surface at a depth (*a*) of 1ft. below the water surface, (*b*) of 33ft. below the surface. Take water as weighing 64lb. per cu. ft.

(*a*) Pressure per sq. in. at depth of 1ft.

$$=64\times1\times\frac{1}{144}=\frac{4}{9}\text{lb.}=\frac{1}{2{\cdot}25}\text{lb.}$$

This is another way of saying that pressure in sea water increases at the rate of 1lb. for every $2\frac{1}{4}$ft. of depth.

(*b*) Pressure at 33ft.

$$=64\times33\times\frac{1}{144}=\frac{44}{3}=14{\cdot}7\text{lb. per sq. in.}$$

i.e., 33ft. of sea water produces a pressure of 1 atmosphere.

Further, the pressure per sq. ft. at 33ft. depth
$=14{\cdot}7\times144=1$ ton, nearly.

The pressure exerted by water upon any plane surface immersed therein, acts normally to the surface, and is equal to the product of the weight per unit volume of water, the area of the surface, and the depth of its centre of gravity below the free surface of the water.

Let w = wt. per unit volume of water in lb. per cu. ft.
a = area of the surface in sq. ft.
d = depth of the C.G. of the surface below W.L. (Fig. 172) in ft.

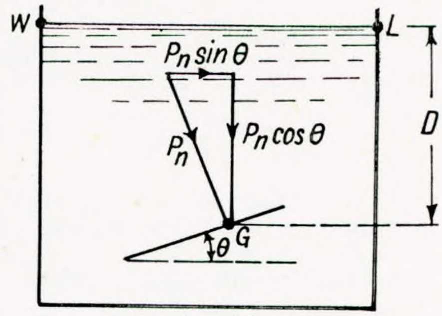


FIG. 172.

Then total normal pressure on the surface $=P_n=w\,a\,d$ lb.

P_n can be resolved into its horizontal and vertical components of presssure $P_n \sin\theta$ and $P_n \cos\theta$, respectively.

Hence, horizontal component $=P_n \sin\theta=w\,a\,d \sin\theta$ lb.
vertical component $=P_n \cos\theta=w\,a\,d \cos\theta$ lb.

Now $a \cos\theta$ is the horizontal projected area of the surface, and clearly $a \cos\theta\times d$ is the volume of the vertical column of water immediately above that surface, $\therefore$ $w\,a\,d \cos\theta$ is the weight of this column of water; from which it can be concluded that :—The vertical pressure acting upon an immersed surface is the weight of the vertical column of liquid immediately above.

The foregoing conclusions are important and a few of their implications may be mentioned with advantage.

(*a*) A rectangular tank is fitted with a stand pipe and is filled with water to a height h in the pipe (Fig. 173).

If w = weight per cu. ft of water and other dimensions are in feet then vertical pressure on AB
$=w\times$ area of $AB\times h$ lb.

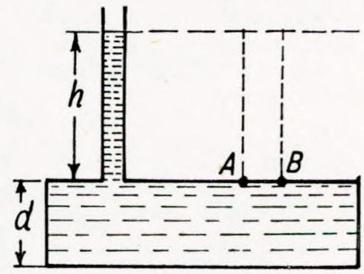


FIG. 173.

Example 55.

A double-bottom tank measures 60ft. long, 40ft. wide and 4ft. deep. It is filled with water to a height of 30ft. in the stand pipe. Find :—(1) Intensity of pressure on the tank top, (2) total pressure on the tank top, (3) intensity of pressure on the bottom. Take the water as weighing 64lb. per cu. ft.

(1) Intensity of pressure on the tank top is that due to a head of 30ft.
$\therefore$ pressure per sq. ft. on tank top $=64\times1\times30$
$=1{,}920$lb.

(2) Total pressure on tank top
$$=\frac{1{,}920\times60\times40}{2{,}240}\text{tons}=2{,}057\text{ tons}$$

(3) Intensity of pressure on bottom is that due to a head of 34ft.

$\therefore$ pressure per sq. ft. on bottom
$=64\times1\times34$
$=2{,}176$lb.

(*b*) The vertical pressure on the curved surface of a *cone* of height h and diameter of base d standing with its axis vertical and *apex* down is equal to the weight of water contained in the cone (Fig. 174).

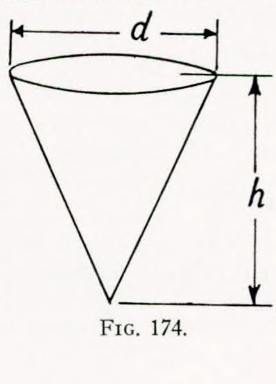


FIG. 174.

If w=wt. of water in lb. per cu. ft.

d and h are in feet,

$$\text{Vertical pressure on curved surface} = w \times \frac{1}{3} \times \frac{\pi d^2}{4} \times h$$

$$= \frac{w\pi d^2 h}{12} \text{ lb.}$$

(*c*) The vertical pressure on the bottom of a *cone* standing vertically on its *base* (Fig. 175) is equal to the weight of water which would be contained in the circumscribing cylinder. Hence vertical pressure on the bottom

$$\text{equals } w \times \frac{\pi d^2}{4} \times h$$

$$= \frac{w\pi d^2 h}{4} \text{ lb.}$$

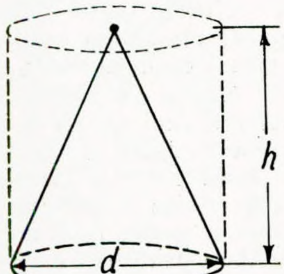


Fig. 175.

(*d*) The total vertical pressure on the lower half of the curved surface of a sphere filled with water (Fig. 176) is equal to the weight of water contained in the lower half plus that which would be contained in a cylinder of radius $\frac{d}{2}$ and height $\frac{d}{2}$.

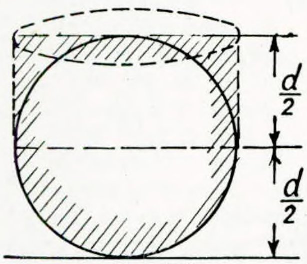


Fig. 176.

Vertical pressure on lower half

$$= w \times \frac{\pi d^3}{12} + w \times \frac{\pi d^2}{4} \times \frac{d}{2}$$

$$= w\pi d^3 \left(\tfrac{1}{12} + \tfrac{1}{8}\right)$$

$$= \tfrac{5}{24} w\pi d^3.$$

(*e*) The total vertical pressure on the upper half of the curved surface of a sphere filled with water acts of course in the opposite direction (*i.e.* upwards) and equals the weight of water contained in the circumscribing cylinder of height $\frac{d}{2}$ and radius $\frac{d}{2}$ minus the weight of water contained in the upper half (Fig. 177).

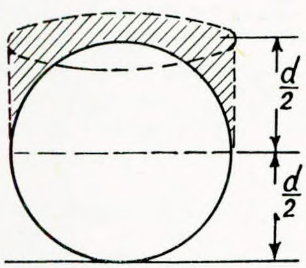


Fig. 177.

Total vertical pressure on upper half of sphere

$$= w.\frac{\pi d^2}{4}.\frac{d}{2} - w.\frac{\pi d^3}{12}.$$

$$= w\pi d^3 \left(\tfrac{1}{8} - \tfrac{1}{12}\right)$$

$$= \frac{w\pi d^3}{24}$$

It is interesting to note that the difference of the results for (*d*) and (*e*) gives $w\pi d^3\left(\frac{5}{24} - \frac{1}{24}\right) = \frac{w\pi d^3}{6}$, which is the weight of water in the sphere. This is, as might have been foreseen, the net vertical pressure exerted by all the water on the whole surface, and is again a measure of the force exerted by the sphere upon the surface on which it is resting.

If a hollow sphere be weighted so that it floats when just fully immersed in a tank of water, the pressures calculated in the previous sections will be numerically the same but reversed in sign.

Hence the net vertical upthrust acting upon the sphere (Fig. 178)

$$= \frac{5w\pi d^3}{24} - \frac{w\pi d^3}{24}$$

$$= \frac{w\pi d^3}{6}$$

i.e. the upthrust equals the weight of water displaced.

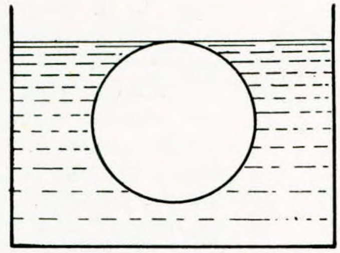


Fig. 178.

Example 56.

Find the pressures on the ends and sides of a tank of triangular section 10ft. long, 6ft. wide and 4ft. deep when filled with water weighing $62\frac{1}{2}$lb. per cu. ft. (Fig. 179).

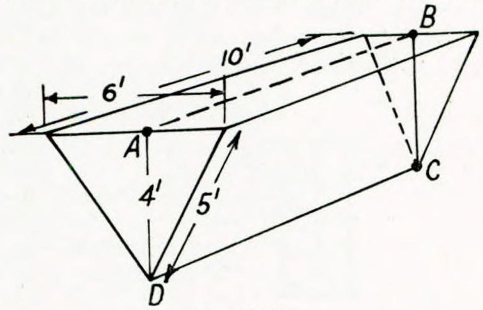


Fig. 179.

(1) Pressure on one end

$$= w \times a \times \text{depth of C.G.}$$

$$= 62{\cdot}5 \times \frac{6 \times 4}{2} \times \frac{4}{3} = 1{,}000\text{lb.}$$

(2) Normal pressure on side

$$= w \times \text{area} \times \text{depth of C.G.}$$

$$= 62{\cdot}5 \times (10 \times 5) \times \frac{4}{2} = 6{,}250\text{lb.}$$

(3) Vertical component of pressure on side $= P_n \cos\theta$ (where θ is the angle the side makes with the horizontal).

$$\text{Cos}\,\theta = \frac{3}{5}.$$

$$\therefore \text{ Vertical component} = 6{,}250 \times \frac{3}{5} = 3{,}750\text{lb.}$$

Vertical pressure for both sides $= 2 \times 3{,}750 = 7{,}500$lb., which will be found to be the weight of water in the tank.

(4) Horizontal pressure on one side $= P_n \sin\theta$

$$= 6{,}250 \times \frac{4}{5} = 5{,}000\text{lb.}$$

This is of course the same as the pressure on the vertical longitudinal bisecting plane, *viz.*:—

Pressure on plane $ABCD = w \times \text{area} \times \text{depth of C.G.}$

$$= 62{\cdot}5 \times (10 \times 4) \times 2$$

$$= 5{,}000\text{lb.}$$

Example 57.

A certain vessel has a draught of 24ft. Due to the omission of a shell rivet a double bottom tank 50 × 40 × 4ft. deep becomes flooded. Find (*a*) the intensity (*b*) the total pressure on the tank top.

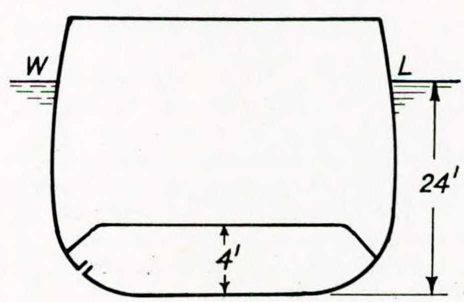


Fig. 180.

(*a*) The intensity of pressure is that due to a head of 20ft.

$\therefore$ pressure per sq. ft. $= 64 \times 20 = 1{,}280$lb. per sq. ft.

(*b*) Total pressure = intensity of pressure × area of tank top

$$= \frac{1{,}280 \times 50 \times 40}{2{,}240} \text{tons}$$

$$= 1{,}143 \text{ tons.}$$

Example 58.

The tank top in the previous question was supported by longitudinal girders and floors in such a way as to divide it into panels of plating measuring 10ft. by 2·5ft. Assuming the attachment between plating and girders to consist of a single line of rivets $\frac{5}{8}$in. diameter and 7 diameters centre to centre spacing, approximate the pull in each rivet and the tensile stress thus incurred.

$$\text{Total vertical pressure on the panel} = \frac{1{,}280 \times 10 \times 2{\cdot}5}{2{,}240}$$

$$= 14{\cdot}3 \text{ tons (approx.)}$$

Spacing of rivets $= \frac{5}{8} \times 7 = 4\frac{3}{8}$in.

Number of rivets securing each panel

$$= 2(10 + 2{\cdot}5) \times 12 \times \frac{1}{4\frac{3}{8}}$$

$$= \frac{25 \times 12 \times 8}{35} = 69$$

$$\therefore \text{ pull per rivet} = \frac{14{\cdot}3}{69} = 0{\cdot}21 \text{ tons per rivet.}$$

$$\text{Tensile stress} = \frac{\text{pull}}{\text{sectional area}} = \frac{0{\cdot}21}{\frac{\pi}{4} \times \left(\frac{5}{8}\right)^2}$$

$$= 0{\cdot}68 \text{ tons per sq. in.}$$

Example 59.

A manhole in a bulkhead is 20in. × 14in. deep, the ends being semi-circular. The pitch line of the studs holding the cover plate is 1·125in. from the edge of the manhole. The major axis is horizontal and is 3ft. from the bottom of the tank. There is 20ft. of oil of specific gravity 0·9 in the tank. The door is held by 16 studs each having an effective cross sectional area of 0·307 sq. in. Take the area inside the pitch line as giving the effective area under pressure and find the stress per sq. in. in the studs. (See Fig. 181).

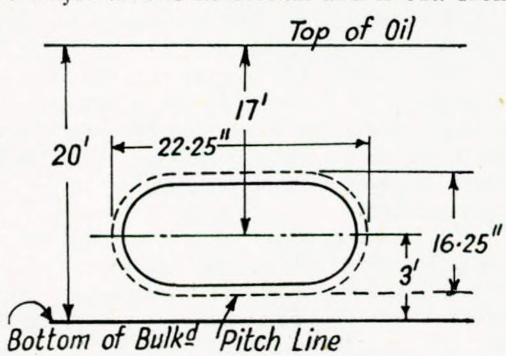


FIG. 181.

Effective area of plate

$$= (22{\cdot}25 - 16{\cdot}25)16{\cdot}25 + \frac{\pi \times 16{\cdot}25^2}{4}$$

$$= 97{\cdot}5 + 207{\cdot}4 = 305 \text{ sq. in.}$$

Total horizontal pressure

= area × depth of C.G. × wt. per cu. ft.

$$= \frac{305}{144} \times 17 \times \frac{900}{16 \times 2{,}240} \text{tons}$$

$$= 0{\cdot}904 \text{ tons.}$$

$$\text{Stress per sq. in. on studs} = \frac{\text{total pressure}}{\text{effective area of studs}}$$

$$= \frac{0{\cdot}904}{16 \times {\cdot}307} = 0{\cdot}184 \text{ tons per sq. in.}$$

Water Pressure on a Bulkhead.

The pressure exerted by water upon a bulkhead will be wholly horizontal. It will be zero at the top, and will reach its maximum value at the bottom.

Consider a vertical strip 1ft. wide and let the depth of the bulkhead be h.

At any depth "y" the intensity of pressure is $w \times y$ lb. per sq. ft.

The pressure at the bottom is wh lb. and if BC (Fig. 182) be set off to represent this, AC will be a curve of intensity of pressure on the bulkhead. The pressure at any desired depth can be obtained by scaling off from the diagram.

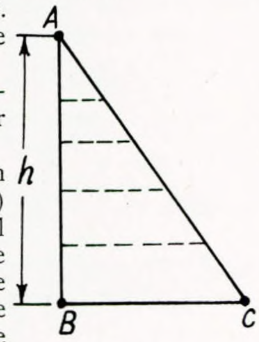


FIG. 182.

Centre of Pressure.

The centre of pressure on a submerged surface is that point at which the total pressure on the surface might be considered to act so as to produce the same moment of force about any specified axis.

Consider a plane surface standing vertically in a tank of water (Fig. 183). Let w = wt. of water per unit volume.

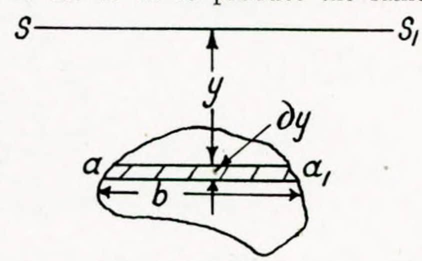


FIG. 183.

The pressure on any horizontal element $a\,a_1$ is given by $w \times \text{area} \times \text{depth of C.G.}$

$$= w \times b \times \delta y \times y$$

The moment of pressure on this element about $s\ s_1$

$$= w \times b \times \delta y \times y \times y \quad = wby^2\delta y$$

and the total moment of pressure for the whole surface about $s\ s_1$ = the sum of all such quantities

$$= w\Sigma by^2\delta y.$$

Now from previous work it will be recognized that $\Sigma by^2\delta y$ gives the moment of inertia of the surface about $s\ s_1$.

Whence depth of centre of pressure

$$= \frac{\text{moment of pressure}}{\text{total pressure}}$$

$$= \frac{w\Sigma by^2\delta y}{\text{total pressure}}$$

$$= \frac{w \times \text{moment of inertia about } s\ s_1}{\text{total pressure}}$$

Example 60.

Find the depth of the centre of pressure of a rectangular plate $B \times D$ standing vertically with one edge on the surface of the water.

Depth of C.P.

$$= \frac{w \times \text{moment of inertia about } s\ s_1}{\text{total pressure}}$$

$$= \frac{w \times \frac{BD^3}{3}}{w \times B \times D \times \frac{D}{2}} = \tfrac{2}{3}D$$

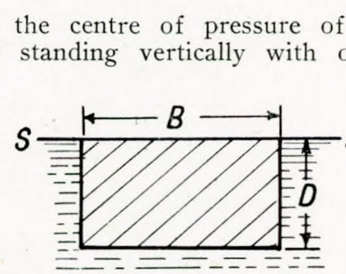


FIG. 184.

Example 61.

Find the depth of the centre of pressure of a triangular plate standing vertically with one edge in the surface of the water.

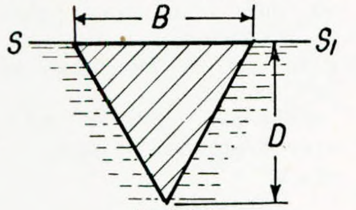


Fig. 185.

Total pressure on plate

$= w \times \text{area} \times \text{depth of C.G.}$

$= w \times \frac{BD}{2} \times \tfrac{1}{3}D = \frac{wBD^2}{6}$

Moment of inertia about top edge $= \frac{B \times D^3}{12}$

$\therefore$ Depth of C.P.

$$= \frac{w \times \text{moment of inertia about } s\,s_1}{\text{total pressure}} = \frac{w \times \frac{BD^3}{12}}{w \times \frac{BD^2}{6}} = \frac{D}{2}$$

Example 62.

Find the depth of the centre of pressure of a triangular plate standing vertically with its apex in the surface of the water.

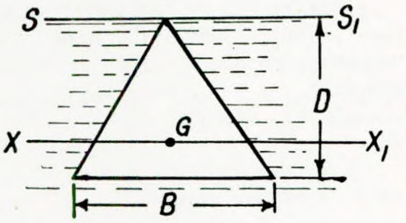


Fig. 186.

Total pressure on plate

$= w \times \text{area} \times \text{depth of C.G.}$

$= w \times \frac{BD}{2} \times \tfrac{2}{3}D$

$= \frac{wBD^2}{3}$

Moment of inertia about $s\,s_1$ can be derived by using the theorem of parallel axes:—

M.I. about $s\,s_1$ = M.I. about $X X_1 + Ah^2$ where h is the depth of the C.G. and A = area of plate.

$$\therefore \text{ M.I. about } s\,s_1 = \frac{BD^3}{36} + \left(\frac{BD}{2} \times \frac{4D^2}{9}\right) = \frac{BD^3}{36} + \frac{2BD^3}{9} = \frac{BD^3}{4}$$

Depth of centre of pressure

$$= \frac{w \times \text{moment of inertia about } s\,s_1}{\text{total pressure}}$$

$$= \frac{w \times \frac{BD^3}{4}}{w \times \frac{BD^2}{3}} = \tfrac{3}{4}D.$$

Example 63.

Prove that the centre of pressure of a circular disc of diameter D standing vertically with a point on the circumference in the surface of the water is at a distance $\tfrac{5}{8}D$ below the surface.

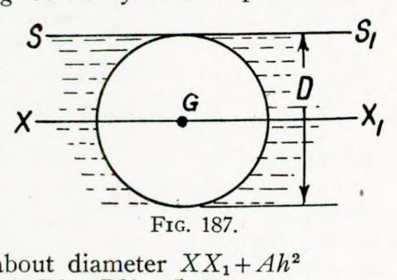


Fig. 187.

Total pressure on disc

$= w \times \text{area} \times \text{depth of C.G.}$

$= w \times \frac{\pi D^2}{4} \times \frac{D}{2} = \frac{w\pi D^3}{8}$

M.I. about $s\,s_1$ = M.I. about diameter $XX_1 + Ah^2$

$$= \frac{\pi D^4}{64} + \left(\frac{\pi D^2}{4} \times \frac{D^2}{4}\right) = \frac{5\pi D^4}{64}$$

$$\text{Depth of centre of pressure} = \frac{w \times \text{M.I. about } s\,s_1}{\text{total pressure}}$$

$$= w \times \frac{\frac{5\pi D^4}{64}}{\frac{w\pi D^3}{8}} = \tfrac{5}{8}D.$$

A Note on the Stresses Developed in Flat Plates Subjected to Uniform Pressure.

This is a subject of great mathematical difficulty. The treatment for circular and oval plates is dealt with fairly exhaustively in Dr. Morley's "Strength of Materials" (Longmans, Green & Co., Ltd.), and the Ministry of War Transport quote empirical formulæ for stayed and unstayed flat circular plates. The literature available for the general reader in respect of rectangular plates with clamped edges is, however, very limited, and a brief account of some of the work done on this subject may not be out of place.

Mathematical solutions to the problem have been put forward by Grashof, whose formulæ are often employed, and by Prof. Inglis (Trans. I.N.A., 1925). Prof. Inglis' solution is based on the theory of elasticity and is claimed to be true when the edge constraint is nearly perfect. In his paper he quotes the Grashof formulæ and compares the results with his own. There is a considerable measure of agreement.

For a rectangular plate in which the proportions of length to breadth are 2 to 1, it is found that if the edges be clamped the maximum stress is experienced at the middle of the longer edge, and according to Grashof should be given by $p = \frac{0{\cdot}4706\,P\,a^2}{t^2}$,

where P = tons per sq. in. intensity of pressure,

a = smaller dimension in inches,

t = thickness in inches,

p = tensile or compressive stress in tons per sq. in.

For the same case Inglis suggests the formula $p = \frac{0{\cdot}4976\,P\,a^2}{t^2}$, the symbols having the same meaning. It will be seen that the agreement is fairly good, but unfortunately the experimental work of Dr. Montgomerie (Trans. I.N.A., 1919) and that of Dr. B. C. Laws (Trans. I.C.E., 1921-2) do not support the mathematical results. It may be suggested that the discrepancies are due to the imperfect clamping of the plates in the experiments, although the contention is refuted by the experimenters.

Dr. Montgomerie restricted his efforts to plates measuring 48in. × 24in. and of varying thicknesses. By very painstaking methods he measured the strains and deflections at a large number of points on the surface of the plate, plotted the results, and employing a mathematical analysis which need not be quoted here, reached the conclusion that the edge stress at the middle of the long side could be given by the formula $p = \frac{0{\cdot}067P}{t^2}$

where p = edge stress in tons per sq. in.

P = intensity of loading in lb. per sq. in.

t = thickness in inches.

If Prof. Inglis' formula is reduced to the same form it gives $p = \frac{0{\cdot}128P}{t^2}$. That is, the mathematical solution suggests a stress nearly double that found by experiment.

Dr. Laws obtained a formula which is at once simple to apply and general in its form. When applied to the Montgomerie plate it reduces to the form $p = \frac{0{\cdot}073P}{t^2}$, and is therefore in close agreement. Before quoting the formula it should be pointed out that it has not yet been possible to settle the argument as to which group of workers has reached the sounder conclusions. Maybe further light will be shed on this difficult subject in the future, but for the present it is the practice to determine shell thicknesses and bulkhead thicknesses by applying the well-known beam theory. The thicknesses thus obtained appear to be well on the safe side so far as panel stress is concerned.

Dr. Laws gives the formula for the edge stress at the middle of the long side of a rectangular clamped plate as follows :—

$$p=\frac{n^2}{2n^2+6}\cdot w\cdot\frac{B^2}{t^2}$$

where n = ratio of long to short side,
w = intensity of pressure in tons per sq. in.,
B = dimension of short side in inches,
t = thickness in inches,
p = tensile or compressive stress developed in tons per sq. in.

As a point of interest it is proposed to apply this formula to the panel of plating used in Example 58.

Example 64.

The panel of plating in Example 58 measures 120in. × 30in. and is $\frac{3}{8}$in. thick. The intensity of pressure under a head of 20ft. of water was found to be 1,280lb. per sq. ft. Using Dr. Laws' formula for edge stress in clamped rectangular plates, determine the maximum tensile stress incurred.

$$\text{Intensity of pressure in tons per sq. in.}=\frac{1,280}{2,240}\times\frac{1}{144}$$

$$n=4$$
$$B=30$$
$$t=\tfrac{3}{8}$$

$$\therefore\ p=\frac{16}{38}\times\frac{1,280}{2,240\times144}\times\frac{30^2}{(\frac{3}{8})^2}$$
$$=\frac{16\times1,280\times900\times64}{38\times2,240\times144\times9}=10{\cdot}7\text{ tons per sq. in.}$$

This stress is rather higher, but would be reduced materially if the plating were increased slightly in thickness, or if an additional side girder were introduced in the double bottom.

W. W. MARRINER MEMORIAL PRIZE.

The Council have accepted with great pleasure an offer by Lieut. (E) G. T. Marriner, R.N. (Associate Member of Council) to found, in memory of his father, the late Mr. W. W. Marriner (Member), an annual prize of the value of £5 to be awarded each year to the candidate who submits the Engineering Knowledge paper (Steam or Motor) of the highest merit in the examinations for Ministry of War Transport Second-Class Engineer's certificates.

Among the many pleasing aspects of the late Mr. Marriner's character were an exceptional interest in the work of young engineers and an ever-ready willingness to encourage and assist them. The Council accordingly feel that this annual prize, open to all young marine engineers aspiring to Ministry of War Transport certificates, will form a most fitting memorial. The Chief Examiner of Engineers, Ministry of War Transport, has kindly consented to co-operate in the adjudication of the award.

ELECTION OF MEMBERS.

List of those elected by the Council during the period 1st January to 21st January, 1942.

Member.
James Joseph William Middlemiss.

Transfer from Associate Member to Member.
K. F. Lilauwala.

Associates.
John Albert Affleck.
Joseph Davenport.
Richard Cecil Gerred.
Stanley Hunt.

Transfer from Associate to Member.
John Bernard Norris.
R. A. Preshaw.

ADDITIONS TO THE LIBRARY.

Purchased.

Manual of Seamanship, Vols. I and II. H.M. Stationery Office, 7s. 6d. and 4s. respectively.

Presented by the Publishers.

The following British Standard Specifications:—

B.S. 24 : Part 4 : 1941.	Steel Forgings, Blooms and Castings (Railway Rolling Stock Material).
B.S. 24 : Part 1 : 1941.	Axles (Railway Rolling Stock Material).
B.S. 806 : 1942.	Ferrous Pipes and Piping Installations for and in connection with Land Boilers.
B.S. 638 : 1941.	Electric Arc Welding Plant and Equipment.
B.S. 977 : 1941.	Flexible Cables for Electric Lifts.

The Red Duster at War. By Warren Armstrong. Victor Gollancz, Ltd., 192 pp., 10s. 6d. net.

This book should be read by all who are interested in the Merchant Navy, and that should be everybody, in view of the benefits they receive from its service. The uninitiated might think that there was a Dickensonian degree of exaggeration in some of the statements in the book, but from personal experience the reviewer can vouch for their truth, even to the point of understatement when the author deals with the everyday conditions of life of the seamen from the point of view of accommodation and sanitation. It must be borne in mind that the author is concerned with the ordinary tramp steamers which form the bulk of British shipping, and not with the luxury liners. About ten years ago the reviewer visited a Russian vessel in the Port of London with a view to comparing the crew's accommodation with that of our own vessels, and found that there could be no comparison in regard to the care and thought expended in the case of the foreign ship. Why is it that responsible authorities or owners will not do the obvious until people with a passion for justice make a nuisance of themselves, as did the Suffragettes and others? The legal phrase "an existing ship" generally provides a sufficient excuse. As the author points out, what would be our position to-day as a nation without the willing service of the men of the Merchant Navy whom the public acclaim as "heroes" and rightly so, yet after the last war officer heroes were to be found acting as watchmen on laid up ships at a bare living wage. Why is it necessary to wait for a disastrous war before giving the seamen a "square deal"? We are told that in a normal time the shipping industry cannot afford to do this, and yet one of our largest tramp-ship owners, who died a few years ago, paid through his executors about six millions in death duties. These last two wars should teach all who are willing to learn that finance or money as it is generally understood plays a very small part in considerations which are for improvement or progress, provided the authority representing the people will decide to act.

The author has served a good purpose in putting on record many of the injustices meted out to our seamen heroes. The pension scheme to which he refers still seems to lack the security of a Government basis. A reading of this book can be confidently recommended to any who wish to understand the case for the merchant seaman and ensure his getting a "square deal" after the war.

The Science and Practice of Welding. By A. C. Davies, B.Sc. Cambridge University Press, 436 pp., 328 illus., 10s. 6d. net.

This is a well written and constructed textbook. The subject of welding is carefully led up to, ensuring that the welding engineer or student has the requisite knowledge of heat, strength of materials, chemistry and metallurgy so necessary to appreciate and analyse the varied and many-sided problems that the welding engineer has to deal with. The fundamental facts in other spheres affecting welding are presented in a readable co-ordinated form, so that one starts to consider the welding problems with the relevant facts fresh in mind.

The whole field of gas and the various kinds of electric welding is dealt with, the chapters are well illustrated, and useful examples worked out. The appendix has some useful data and tables, while the two examination papers at the end on oxy-acetylene and electric welding should enable the student to test his own knowledge.

Generally, the book is a most useful and complete study of all kinds of welding.

High Speed Diesel Engines. By A. W. Judge, A.R.C.Sc., D.I.C., Wh.Sc. Chapman & Hall, Ltd., 4th edition, 536 pp., 443 illus., 25s. net.

The demand for this book has been so considerable that since it was first published in 1933, three further editions have been necessary. The statement that this is a book which can be highly recommended hardly, therefore, requires emphasis.

Opportunity has been taken in this new edition to include a considerable amount of new material. This includes up-to-date information concerning fuel injection systems and research results relating thereto; nozzle cooling and protection; later methods of engine governing; new types of two-cycle engines; more recent automobile and aircraft engines; starting methods and devices; the latest rail-car and locomotive types of compression-ignition engines; performances and details of rail-cars and locomotives to which these engines have been fitted. Some additional information has also been included on the subjects of supercharging and altitude performance and on the cetane and dupo ratings of fuels and other fuel properties. In the course of the revision no less than 100 pages have been added and over 90 new illustrations have been included.

Practical Metallurgy. By G. Sachs, Dipl. Ing., D.Eng. and K. R. van Horn, B.S., M.S., Ph.D. The American Society for Metals, Cleveland, Ohio, 567 pp., 332 illus., $5 net.

This book is already in its second edition, being first published in 1940. There will always be a demand for books published under the auspices of the American Society for Metals, and this volume should prove no exception.

The authors, in the preface, state: "This book presents both the theory and practice of the making and shaping of the commercial metals and alloys in a concise manner. In addition, the physico-chemical and physical relationships of metallurgy are discussed in a fundamental, but simple way. More detailed information can be readily obtained from numerous listed references of important and recent publications concerning any particular subject. The carefully selected and uniformly reproduced illustrations constitute an integral part of the book as they offer information in addition to that of the text".

In an excellent appendix a collection of useful information and data of the commercially important binary alloy constitutional diagrams takes up 24 pages, the diagrams have been revised according to recent reliable investigations. The authors have taken many of these constitutional diagrams from the *Metals Handbook,* 1939 edition.

This book is of wide application and well written, and is divided into two parts. Part I, dealing with the principles of physical metallurgy, contains sections on: The constitution of alloys; grain structure of alloys and segregation; crystal structure of metals and alloys; phase changes in the solid state; deformation and re-crystallization.

Part II on the manufacture of metals and alloys, deals with: furnace and general melting problems; castings (production, mechanical properties, special castings, alloys and methods); ingots; mechanical working (fundamentals, rolling, forging and extrusion, drawing, straightening and fabricating); heating, annealing and heat treatment; heat treatment of steel; heat treatment of nonferrous metals.

The book is admirably illustrated with a number of up-to-date works photographs. The photomicrographs have been reproduced very well indeed. The paper is thick and has a fine glossy surface.

It was Hugh Quigley, writing of the democratic order, who said: "We can't become more comfortable unless we become better men, from better living conditions and better training, technical proficiency forming no small part in this order". This book makes a useful contribution to that ideal. It will have a wide appeal to students, engineer and metallurgist alike. It is a most up-to-date treatise, much of it taken from modern practice, and is excellently indexed.

OBITUARY.

THE LATE MR. JOHN JACK McKENZIE.

It is with deep regret that we record the death, which occurred at Walton-on-Thames on Thursday, 29th January, 1942, of Mr. John Jack McKenzie (Vice-President and Member 5096), at the age of 56 years.

Of Scottish birth, Mr. McKenzie served his apprenticeship with Messrs. Alley & McLellan and Messrs. Dunsmuir & Jackson of Glasgow, and was subsequently engaged for some years at sea in ships of Messrs. Glen & Co., Ltd. of Glasgow, with which Company he rose to the position of second engineer.

He was then for a time employed as assistant manager by Messrs. Smith's Dock Co., Ltd., and during the last war he served in the Royal Navy (Special Reserve) as an engineer lieutenant. After demobilization he assisted his father, the late John McKenzie, consulting engineer, of Glasgow, and then became a superintendent engineer with The British Tanker Co., Ltd. For the past 20 years he has been chief superintendent engineer of the Company.

The late Mr. John Jack McKenzie.

Mr. McKenzie was a Member of Council of The Institute from 1926 to 1928, and in 1929 he was elected a Vice-President, which office he held until his death.

The funeral took place at Glasgow on Monday, 2nd February, 1942, at which The Institute was represented by Mr. Alfred Davis. A large number of Mr. McKenzie's friends from among his colleagues on the Council and the membership attended a memorial service in St. Andrews Presbyterian Church, Walton-on-Thames, on Thursday, 5th February, 1942.

Abstracts of the Technical Press

Engineers for H.M. Forces.

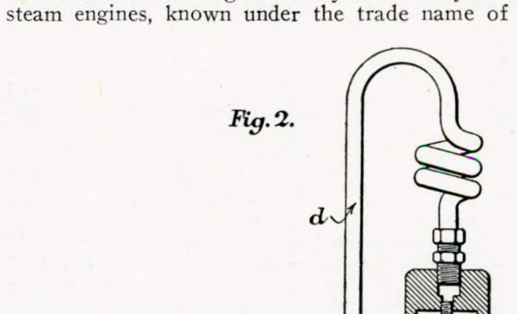
A special circular containing information for qualified engineers who may be contemplating joining the Services has been compiled by Lord Hankey's Technical Personnel Committee for the use of the various professional institutions concerned. As regards the Royal Navy, there are vacancies for engineer officers up to 40 years of age who possess a university degree or are members of an engineering institution of professional standing. A good standard of physical fitness is required. The duties of these officers will consist of service in H.M. ships and maintenance work ashore, and commissions will, in the first instance, be granted to them in the rank of Probationary Temporary Sub-Lieutenant (E), R.N.V.R., with pay at the rate of 9s. a day, plus allowances, rising to 11s. 10d. a day on confirmation in rank. On promotion to Lieutenant (E), the pay is increased to 16s. 4d. a day. Newly-commissioned engineer officers are eligible for confirmation in rank after three months' service, on the recommendation of the Commanding Officer. They may be recommended for promotion to Temporary Lieutenant (E) after four months' service or on attaining the age of 25, whichever is the later. The Royal Marine Engineers are prepared to accept candidates up to the age of 45, who have had a sufficiently wide experience in heavy constructional work, preferably on harbours, docks, or similar work. The rank on entry depends on the extent of this experience, and the general duties are vaguely described as "general marine engineering work, aircraft maintenance and electrical engineering"; presumably, in view of the character of the qualifications specified, more of a civil engineering nature than the use of these terms would generally imply, or, at least, in connection with shore establishments. The starting rank is that of Temporary Second Lieutenant, with pay at the rate of 9s. a day, plus allowances. After a period of service which will depend upon the age of the individual, the rate of pay rises to 13s. 6d. a day. The age limits for the Royal Army Ordnance Corps range from 21 to 50, although the standard of professional qualifications laid down makes it improbable that many candidates of 21 will have attained these in their entirety. To meet this probability a special category of "ungraded" officers has been introduced to permit the entry of candidates who have not attained the full standard on either the theoretical or the practical side. Candidates for commissions as Ordnance Mechanical Engineers must have served an apprenticeship of at least three years' duration and must also possess a university degree in engineering or graduate membership of the Institution of Mechanical Engineers or the Institution of Electrical Engineers, or qualifications exempting them from the examinations of those institutions. The starting rank is that of Lieutenant, O.M.E., 4th Class, R.A.O.C., with pay at the rate of 16s. 4d. a day plus allowances. Candidates who have the necessary practical experience but lack the full academic qualifications enumerated above, may be considered for appointment to the Mechanical Engineering Branch of the Royal Army Ordnance Corps as Second Lieutenants (ungraded) with pay at the rate of 12s. 2d. a day, plus allowances. The general duties of all these officers of the R.A.O.C. includes the maintenance and repair of guns and gun carriages, mechanised vehicles (wheeled and tracked), optical instruments, and various miscellaneous equipment such as petrol cookers, mobile laundries, bath equipment, hydraulic gun mountings, tanks, armoured cars, etc. The Royal Air Force is in need of suitably qualified electrical or mechanical engineers between the ages of 19 and 60 years. Candidates for the Mechanical Engineering Branch must have had practical experience in mechanical engineering, commencing with an apprenticeship and followed by a number of years of employment on the erection, maintenance and overhaul of internal-combustion engines or aeroplane structures. Knowledge of the properties of engineering materials is also necessary. The general duties of all R.A.F. engineer officers comprise responsibility for the airworthiness of aircraft, the control of Service tradesmen, diagnosis of faults, rectification of troubles, etc., in addition to which mechanical engineer officers have to deal with internal-combustion engines, pipe-lines, airframes, hydraulic systems, and engine and hydro-dynamic instruments. These officers enter with the rank of Pilot Officer, with pay at the rate of 14s. 6d. a day, plus allowances. The allowances referred to in connection with the various Services (which, in the case of married officers can be supplemented by extra allowances for wives and children) are not usually subject to income tax; so that the amount of tax payable is lower than that applicable to a corresponding remuneration in civilian employment.—*"Engineering", Vol. 152, No. 3,962, 19th December, 1941, pp. 486-487.*

Efficiency of D.R. Gears as Influenced by Lubricating-oil Temperatures.

The efficiency of a double-reduction gear is almost equal to that of a single-reduction gear at full power, but is considerably less than that of the S.R. gear at cruising speeds. Thus, whereas the efficiencies of S.R. and D.R. gears at full power are 98·3 per cent. and 97 per cent., respectively, these are reduced to 97 per cent. and 91·6 per cent. respectively at one-fifth of full power. The losses in a reduction gear are chiefly due to: (*a*) oil friction in the bearings; (*b*) tooth contact losses; and (*c*) rotational loss. Of these three, the first is by far the greatest. The author endeavours to show how oil friction in the bearings is affected by the temperature of the oil at the inlets to the bearings of the gear, and that it is possible, within limits, to control this loss through regulation of the lubricating-oil temperature by shutting off the cooling-water supply when the ship is steaming at cruising speed. He contends that any objection to this proposal on the ground that the increased oil temperature would involve more frequent renewal of the oil in the lubricating system, is greatly outweighed by the saving in fuel oil which would be obtained by the reduction of the oil friction in the bearings of the gear.—*Paper by R. Michel, "Journal of the American Society of Naval Engineers", Vol. 53, No. 4, November, 1941, pp. 756-765.*

Atomising Device for Steam Cylinder Lubrication.

A new lubricating accessory for the cylinders of reciprocating steam engines, known under the trade name of Lube-o-Mizer, has been developed by a firm in Memphis, Tennessee, U.S.A. This device, however, does not function as a means for supplying measured quantities of lubricant to the cylinder, its utility being in its capacity for reducing such quantities to an effective condition for application. The actual supply of oil is derived from any mechanical or hydrostatic type of sight-feed lubricator. The construction of the Lube-o-Mizer is shown in the sectional drawing (Fig. 2), from which it can be seen that the atomiser is connected to the supply lubricator at *a*, and that the lubricant is forced up into the tubular cup *b*. This cup contains water derived from condensed steam from the engine supply pipe *c*, the condensate



reaching the cup through the exposed pipe *d*, which incorporates a coil to increase its cooling surface. As the cup is continually surrounded by live steam, the mixture of oil and water in it is kept boiling with the result that an emulsion is formed and foams over the top of the cup into the chamber surrounding it, where it is drawn into the main steam pipe by the flow of the steam supply past the angled end of the feed pipe *c*. The oil, when it joins the main stream, is very finely divided or atomised, *i.e.*, it is in the best condition to give effective lubrication to the piston, valve, piston rod and valve rod, etc. The makers state that a large Unaflow engine which was originally provided with six lubricating feeds (two on the cylinder top, one to each admission valve, and the remaining two on the piston and tail rod, respectively) had this system replaced by a single Lube-o-Mizer on the throttle valve, one of the oil feeds being diverted to it. The lubrication of the engine is reported to have been improved, maintenance work reduced, and the lubrication cost halved. In another case a pair of marine reciprocating engines of 1,000 i.h.p., using steam at a pressure of 275lb./in.^{2}, superheated to 650° F. at the throttle, were originally equipped with a cylinder-lubrication system comprising 12 oil pumps on the twin engines. All but two of these pumps have now been replaced by a single Lube-o-Mizer on each engine, the two pumps retained being coupled to the Lube-o-Mizers. It is reported that, up to the present the consumption of cylinder oil has been reduced by approximately 66 per cent., while further savings are expected. There has also been a marked improvement in the condensate delivered to the first-stage feed heater, whilst the speed of the engines has been increased from 152 r.p.m. to 212 r.p.m., and the condition of the cylinders, piston rings, rods, etc., much improved.—*"Engineering", Vol. 152, No. 3,062, 19th December, 1941, p. 497.*

The Influence of Corrosion on Propeller Shaft Maintenance.

The author points out that surface conditions have a very definite effect on the fatigue properties of a material. In a cylindrically shaped member, torsionally loaded, such as a propeller shaft where the maximum stress occurs at the outer surface, the surface condition is a factor of major importance. The presence, in varying degrees, of torsional vibration only serves to make this condition more predominant. The case of the P. inboard propeller shaft of the U.S.S. "Pennsylvania", which failed in 1932, as a result of the simultaneous action of fatigue and corrosion, is then discussed, and the results of experiments for the determination of the corrosion-fatigue limits of various grades of steel in salt water, free from air, are analysed.—*Paper by H. L. Setz, "Journal of the American Society of Naval Engineers", Vol. 53, No. 4, November, 1941, pp. 735-744.*

Diesel Tanker "T. W. Drennen".

The coastal motor tanker "T. W. Drennen", recently delivered by the R.T.C. Shipbuilding Company, of Camden, N.J., to the Spentonbush Fuel Transportation Company, is the largest all-welded tanker ever built in Camden. She is a single-screw vessel of 1,738 gross tons, 260ft.×42ft.×18ft., with a cargo capacity of 22,000 barrels (about 3,000 tons), and a maximum load draught of just under 16ft. The propelling machinery, which is located aft, consists of a 7-cylr. 2-stroke Fairbanks-Morse engine developing 1,225 b.h.p. at 300 r.p.m. and designed to give the ship a service speed of about 10 knots, fully loaded. The auxiliary machinery and pumping installation of the vessel is electrically operated, the current for this purpose being furnished by a 60-kW. generator driven by a 6-cylr. 4-stroke F.M. engine of 90 h.p. When the main engine is running, however, electric current is supplied by a shaft-driven dynamo which works in conjunction with a storage battery. The latter is installed on a flat above the E.R. floor, together with the main switchboard. The battery cells are enclosed in a special cabinet, with a tool rack mounted on its front. A distilled-water tank is fitted above the battery cabinet and connections from this tank are led to all the accumulators. The main-engine control platform is arranged at main-deck level, and in addition to the usual control levers and valves, the engineer on watch is provided with push-button controls for the various pumps, with pilot lights to show whether they are stopped or running. There is also an instrument panel on which are mounted a pyrometer, a revolution indicator, and the usual pressure gauges for air, oil and water. The CO_2 fire-extinguishing equipment is likewise operated from the E.R. control stand.—*"Motorship and Diesel Boating", Vol. XXVI, No. 11, November, 1941, pp. 662-665.*

American Motorship "Island Mail".

The American Mail Line's new 7,400-ton cargo liner "Island Mail" differs from the Maritime Commission's standard type of C-2 class motorship in being slightly longer (the length, o.a., being 474ft.) and in having propelling machinery of somewhat higher power. In lieu of the two 3,000-h.p. engines geared to a single propeller shaft installed in the other C-2 motorships, the "Island Mail" is equipped with one 5-cylr. Sun-Doxford engine of standard design driving the propeller direct. The normal output is 7,500 b.h.p. at 92 r.p.m., but the maximum power is 9,375 b.h.p. at 102 r.p.m. The service speed of the ship, when fully laden, is 16 knots. The total bale capacity of the five cargo holds is just over 530,000 cu. ft., of which 30,600 cu. ft. is refrigerated cargo space in No. 4 lower 'tween decks. There are five Freon refrigerating machines, one of which is provided for the ship's cold stores. The ship can carry 2,200 tons of fuel oil and 240 tons of fresh water. The total complement is 43 officers and men, and there is also accommodation for 12 passengers in six two-berth staterooms. The new ship is intended for the owners' trans-Pacific service.—*"Motorship and Diesel Boating", Vol. XXVI, No. 11, November, 1941, pp. 666-671.*

Shipbuilding and Ship Repair at Kingston.

The shipyard of the Kingston Shipbuilding Co., Ltd., of Kingston, Ont., has been in existence for over a century and is claimed to be the oldest in Upper Canada. Ship repairing has been the chief occupation of the firm, but during the last 30 years the yard has also been building ships. Twenty ships, including four corvettes, have been produced there during the present war, and two minesweepers of a new type are now under construction. Although the equipment of the platers' shop resembles that of most other yards, the procedure adopted in it is somewhat different. All frame-work angles are joggled in the shop, thereby eliminating the need for liners; a longer and costlier process, but one that makes for better construction. Approximately 50 per cent. of the total steel work in the new ships is of welded construction, the welded parts including oil tanks, fore-and-aft bulkheads, frame-to-deck connections, castings, doubling plates, etc. An unusual practice followed in the yard is the making of certain standard small parts, such as brackets, clips, holders, etc., of cast manganese steel instead of fabricating them of structural steel. This is claimed to make a quicker, cheaper and sounder job. Much pre-fabrication is carried out in the shops and yard, bulkheads and other assembled sections being built up near the ways so that they can be easily picked up by the large hammer-headed crane and placed in position in the hull. The dry dock is 376ft. long, 56ft. wide and about 30ft. deep, and can be pumped out in about three hours. The vessels built in the yard are launched sideways into the side basin in Lake Ontario.—*A. C. MacNeish, "Canadian Shipping and Marine Engineering News", Vol. 13, No. 4, November, 1941, pp. 9-10.*

Criticism of U.S. Maritime Commission's Programme.

Criticism is being expressed in American shipbuilding and shipping circles regarding the design of the "Liberty" or EC-2 type cargo steamers, of which 312 are already under construction for the Maritime Commission. Representations are being made to replace the 418 additional vessels of this type authorised by Congress, or a good portion of them, by cargo liners of the Commission's long-range programme, as the "Liberty" design is considered to be too slow to meet the present-day and post-war requirements for fast cargo carriers. Notwithstanding the various proposals made to increase the speed of these ships by the installation of high-speed oil engines or geared turbines, it is pointed out that such a course is impracticable, as the form of the hull of the EC-2 type is relatively box-like in appearance and only suitable for propulsion by low-speed engines, whereas the long-range C types have finer lines. It is not considered feasible to instal a high-powered engine in a hull design like that of the "Liberty" ships, as full power could not be realised and operating costs would be higher.—*"The Syren" Vol. CLXXXI, No. 2,361, 26th November, 1941, p. 240.*

U.S. Maritime Commission's New Cargo Coasters.

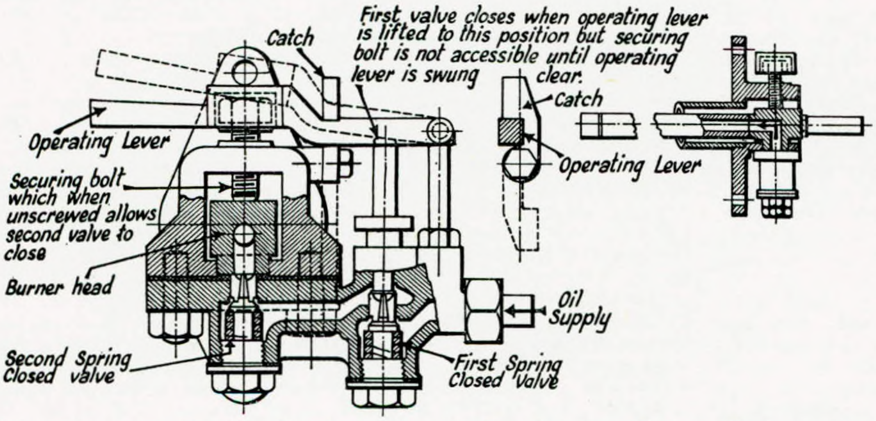
The 45 coasting steamers to be built under the Lease-and-Lend Act in various American shipyards, including some on the Great Lakes, are designed for use in British waters. They will be single-screw vessels of 1,700 tons gross with an o.a. length of 259ft. 9in., a moulded breadth of 42ft. 1in., and a moulded depth of 20ft. 5in., having a d.w. tonnage of 2,800 tons and a cargo capacity (bale) of 101,900 cu. ft. The propelling machinery will consist of a set of triple-expansion engines, 20in. by 33in. by 50in. by 40in., developing 1,300 i.h.p. at 80 r.p.m. when supplied with steam at 200lb./in.^{2} at the throttle, with a 26-in. vacuum in the condenser. There will be two watertube boilers, each capable of generating 14,000lb. of steam per hr. at 220lb./in.^{2} pressure and 450° F. total temperature, with a feed temperature of 230° F. The boilers will operate under forced draught, the air supplied by a turbo-driven blower being pre-heated to 100° F. The deck machinery will include six steam cargo winches. —*J. E. Schmeltzer, "The Shipping World", Vol. CV, No. 2,530, 10th December, 1941, pp. 449-452.*

Faster "Emergency" Ships.

In August the U.S. Congress approved the construction of 418 additional ships for the "Emergency" or "Liberty" fleet, to supplement the 312 vessels of the EC-2 type already in hand. No contracts for any of the additional ships have yet been placed, and it is now suggested that some or all of these vessels should be replaced by faster ships of the cargo-liner type more or less similar to the 374 cargo liners built or building for the U.S. Maritime Commission. As it would presumably be well into 1943 before any of these supplementary "Liberty" ships are completed, the suggested modification might appear to be worthy of consideration. Machinery of 4,000 s.h.p. would give ships of the EC-2 type a speed of 14 knots, and if the large marine Diesel-engine builders in the United States are now fully occupied, a good case could be made out for Diesel-electric propulsion based on the installation of, say, four 1,200-b.h.p. 750-r.p.m. G.M. Diesel engines coupled to generators supplying current to a single 4,000-b.h.p. motor. There should be time to organise the large-scale production of such units for this particular purpose, as the type has already been standardised for passenger locomotives, as well as for high-powered tugs and similar craft.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 275.*

A Safety Burner Holder.

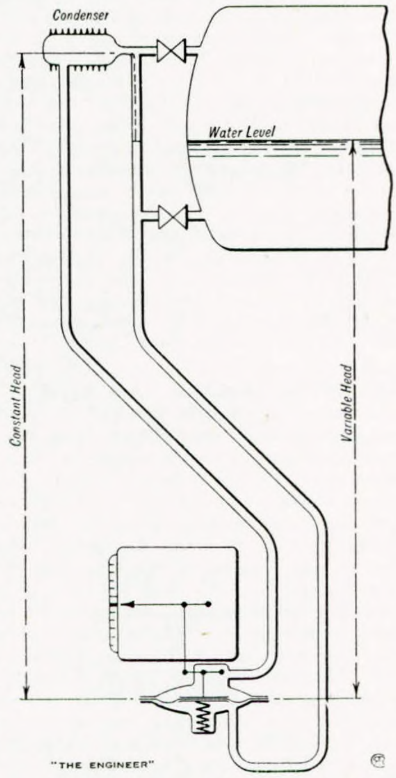
The accompanying sectional sketch illustrates the construction of a safety holder for an oil-fuel burner, developed and patented by a well-known engineering firm in Northumberland. The main feature of this fitting, which is of gunmetal, cast iron and forged steel, is



the employment of valves in place of cocks for shutting off the oil supply when removing the burner. It will be noted that the incoming oil passes through two spring-loaded valves on its way to the burner. When it is necessary to remove the latter, the catch holding down the operating lever is released and swung clear, as shown in dotted lines, when the first (or right-hand) valve closes under the action of its spring, thereby shutting the oil supply off from the burner, which may then be disconnected. As can be seen, the centre securing bolt holds the burner head down and also bears hard upon the ends of the wings of the second valve, thus preventing its accidental closure in normal service. When this bolt is screwed back to allow the burner to be withdrawn, the pressure of the spring under the second valve lifts the burner head as the bolt is slacked back and closes the valve. The burner can then be removed with the knowledge that there is a double shut-off in operation to prevent possible scalding of the operator by hot oil and to eliminate the risk of a stokehold fire. Whilst the burner is withdrawn any accidental movement of the operating lever cannot restart the flow of oil, as might be the case with cocks. Not until the securing bolt is screwed back to at least the position shown in the sketch can the lever be properly swung back and depressed (to the full-line position) so as to open the first valve. Even in the unlikely event of some meddlesome person doing this, no oil leakage on to the "operator" or stokehold floor would take place, as the second spring-loaded valve cannot be opened until the burner is in place. Furthermore, the burner cannot be replaced unless the securing bolt gives sufficient clearance for its entry—*i.e.*, unless the first valve is also closed.—*"The Marine Engineer", Vol. 64, No. 773, December, 1941, p. 255.*

Remote Water-level Indicator for Boilers.

The increasing size and height of present-day high-capacity watertube boilers makes the accurate reading of water-level gauges from the stokehold floor plates difficult, and to overcome this difficulty various forms of remote W.L. indicators have been evolved. A North-Country firm of boiler-mounting specialists have now developed a so-called direct-acting type of instrument which is operated directly by the actual level of the water in the boiler, the pointer swinging exactly as the water in a gauge glass. Internal illumination, a clearly-marked scale and a prominent pointer enable the position of the water level to be seen at a glance from a considerable distance, whilst the curved front of the indicator gives a maximum range of view—over 180° of vision—making it unnecessary for the water tender to stand immediately in front of the instrument. The indicator can be supplied in a form suitable for flush-panel mounting, and electric connections may be fitted to a hooter which gives audible warning of excessive high or low water, while, in addition, signal lights can also be provided for further indication. The operating element consists of a large, sensitive diaphragm, one side of which is connected to the steam space of the boiler and the other to the water space. A condenser at the boiler drum maintains a fixed head of water on the steam-space side, while the water-space side is subjected to a varying head dependent upon the water level in the boiler. This varying head is balanced by a spring in the instrument and causes the diaphragm to move in accordance with the water level. The full boiler pressure, being on both sides of the diaphragm, is therefore balanced and has no effect on the movement of the diaphragm, which is actuated solely by the difference in heads. Ample power is obtained by the use of a large diaphragm, a variation of 1in. in the head on the latter producing an operating force of nearly 1lb. The indicator responds to very small variations in water level. A small stainless-steel spindle, passing through a self-sealing frictionless gland, transmits the motion of the diaphragm to the outside of the diaphragm chamber, where it actuates a lever mechanism giving a straight-line movement of the pointer along the scale, which corresponds accurately to that of the water in the gauge glass. The standard indicator is calibrated to read exactly 1in. on the scale for a 1in. movement of the water level, but the instrument can be arranged to indicate a larger movement on a smaller scale, when required. A lamp of the opal tubular type provides the illumination, and the graduations are marked directly on the glass of the lamp, which thus forms the scale. A resistance is incorporated in the instrument to reduce the voltage to the lamp, thereby cutting out glare and prolonging the life of the filament. The general arrangement of the W.L. indicator is shown in the accompanying diagram. The equipment, it is claimed, is easily installed, as it is only necessary to run two ½-in. bore pipes between the drum and the indicator.—*"The Engineer", Vol. CLXXII, No. 4,485, 26th December, 1941, p. 460.*



Arrangement of W.L. Indicator.

German Views on After-war Propelling Machinery Types.

In a recent issue of the German shipping journal *Hansa*, Herr Bleicken, superintendent engineer of the Hamburg-American Line, gives his impressions of the probable development of propelling machinery for "the reconstruction of the German mercantile fleet after the war". He analyses machinery types from the standpoint of fuel cost, space occupied, weight and personnel, and expresses the view that despite the relatively low cost of home-produced coal and the employment of the most modern machinery with water-tube boilers and high-pressure superheated steam, combined with mechanical stokers, the fuel cost "is greater than when boiler oil or Diesel oil is used in oil-fired steamers and motorships respectively". After giving particulars of the prices paid by his company for coal, boiler oil and Diesel oil in various parts of the world, the writer states that the mean fuel costs per 1,000 b.h.p./hr. were recorded as Rm. 8·50, 6·92 and 5·88 for coal-fired steamers, oil-burning steamers and motorships respectively. Coal firing involves the greatest space and weight, whilst boiler oil takes up only about half the space of coal and can be carried in double-bottom tanks. A heating installation is required, however, to make the boiler oil sufficiently fluid. The weight of a turbine installation with oil-burning boilers is substantially less than that of a similar coal-fired installation. Diesel oil is the simplest to carry, and the space taken up by the fuel in a motorship is only two-thirds that needed for the boiler oil in an oil-fired steamer. Heat is unnecessary. The weight of a Diesel installation depends on the type and speed of the engines and is greatest with direct drive, whilst with gearing the weight is equal to that of a corresponding turbine installation. The space required for geared and Diesel- electric drive is approximately the same as that with turbine propulsion. As regards personnel, the coal-fired ship requires the largest engine- and boiler-room staff, whilst motorships and turbine steamers call for an approximately equal number of E.R. personnel.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 297.*

The Sinking of H.M.S. "Ark Royal".

Some interesting particulars concerning the last hours of the aircraft carrier "Ark Royal" have been disclosed by a Chief Stoker who was one of the last men to leave the ship. He was in charge of a party of six volunteers who got permission from the Captain to go below after the order had been given for the greater part of the ship's company to abandon ship. This party were to do everything possible to keep the vessel afloat. They succeeded in raising sufficient steam to start up two dynamos, although the ship was already listing 19°, and they contrived to get eight of the submersible bilge pumps running, with the result that the vessel's list was reduced by 2°. The men went down to the boiler room at about 5.0 p.m. and for nearly eight hours continued the struggle to keep the ship afloat, but at about 3.0 a.m. she suddenly heeled over to something like 24½°, causing the water to run out of the feed tanks and the oil fuel to spill out of the boiler furnaces and catch fire. All the lights went out and, although the volunteer party quickly connected up running hoses, they were unable to subdue the flames. The boiler room had to be abandoned, but with the ship at such an angle this was no easy job. Great difficulty was experienced in opening the heavy watertight hatches, and it was fortunate that the precaution had been taken of rigging life-lines from deck to deck, as the ladders were unusable, and the men had to climb up the ropes hand over hand in the dark. When the Chief Stoker finally left the ship and got on board the tug at 4.30 a.m. he noticed that the S. side of the flight deck was no more than 2ft. from the water. —*H. C. Ferraby, "Shipbuilding and Shipping Record", Vol. LVIII, No. 23, 4th December, 1941, p. 523.*

Froude Constants.

The Froude system of notation for recording ship model experiment results is in fairly general use, with certain variations, in this country, and also to some extent abroad, particularly in America, although probably not to the extent visualised by its founder when he first introduced it. The basic principle, that of non-dimensional presentation, so that, apart from skin-friction effect, the figures are directly applicable to any size of ship irrespective of the size of the model, is now very widely recognised and accepted in all branches of engineering. This determines the general form of the so-called constants, and the way in which the different variables enter, although alternatives exist as to the selection of the variables and the precise method of their application. Thus speed may be related to either length or displacement, the former being probably preferable. Resistance and horse-power are invariably expressed in terms of displacement and speed, but there is a good deal to be said for the introduction of length into the resistance constant also. Besides being independent of scale, the constants incorporate a series of numerical multipliers mainly intended to make the values the same in any system of units, and to facilitate transposition from one system of units to another. Whether this is actually achieved, and whether it is really of sufficient importance to make up for the added complication involved are probably matters of opinion, but it does seem that a case for the modernisation of the system can be made out on the lines indicated.—*"Shipbuilding and Shipping Record", Vol. LVIII, No. 23, 4th December, 1941, pp. 519-520.*

Pitch as Liquid Fuel.

In a paper entitled "Liquid Pitch Fuel", presented at a recent meeting of the Institute of Fuel by Mr. E. Brett Davies, the author described some of the research work that has been carried out in this country in regard to the possibility of utilising liquid pitch in lieu of imported oil fuel. At first it was thought that hard pitch was most likely to develop as a pulverised solid fuel, but the work done during the past year has been almost entirely devoted to the adoption of normal medium soft pitch as a liquid fuel for use in the furnaces of steam boilers. It has been found that this fuel has a calorific value of 16,250 B.Th.U./lb. with an ash content of only 0·2 per cent., while the optimum temperature for atomisation for combustion is 392° F. Various forms of heaters were described by the author. Some of these use steam, whilst others employ a special grade of mineral oil or electricity, the latter type having a low wattage and being capable of the closest thermostatic control. A number of installations are now in operation, and if the price of pitch is sufficiently low, their use on board ship might be deserving of consideration.—*"Shipbuilding and Shipping Record", Vol. LVIII, No. 23, 4th December, 1941, p. 519.*

Reducing Fuel Consumption.

One of the dangers attending high-pressure propelling-machinery installations is that of fire due to failure of the lubricating-oil pipes at any working temperatures above 700° F. A serious outbreak of fire in the German steamer "Potsdam", where H.P. steam was used, has been attributed to this, while several cases due to similar causes have been experienced in power station turbines in the United States. As these fires were primarily due to the failure of joints, it has been advocated that welded connections should replace flanges where-ever possible. The main object aimed at in the relatively complicated and expensive high-pressure propelling-machinery installation of the new American s.s. "Examiner" appears to be a saving in fuel consumption of the order of 13 per cent., which means a consumption of 0·52lb./s.h.p.-hr. The old "Mauretania", with cylindrical boilers working at a steam pressure of 220lb./in.^{2} and temperature of 395° F., had a fuel consumption of 0·85lb./s.h.p.-hr., whilst the "Empress of Britain", built in 1931, having watertube boilers working at 425lb./in.^{2} and a superheat temperature of 725° F., had a fuel consumption of 0·57lb./s.h.p.-hr. It would appear, therefore, that reductions in fuel consumption at the present time can only be attained by very slow and painful steps, so that it must soon become a question whether the complication which is involved is, from a commercial aspect, justified by the slight decrease in consumption.—*"Fairplay", Vol. CLVII, No. 3,057, 11th December, 1941, p. 594.*

Oiling at Sea.

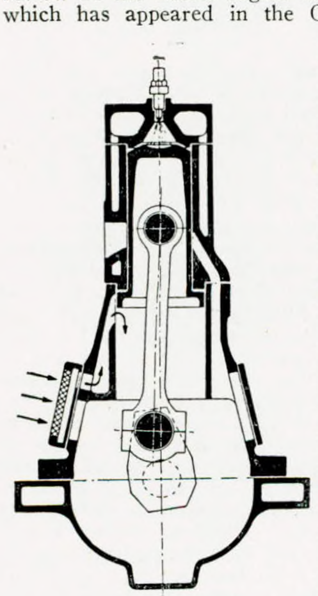
There are two methods of fuelling oil-burning ships at sea, the stirrup method and the trough method. With the stirrup method the oil tanker, or large warship, takes the vessel to be oiled in tow and a flexible pipe-line, supported at frequent intervals from a wire rope by "stirrups", is run over the stern of the oiler, taken inboard by the ship being oiled by means of a special fitting at the stem, and then led aft to the oiling connection. With the trough method, the vessels steam alongside each other with bow and stern mooring ropes connected up between them. The flexible pipe-line is led over the ship's sides and supported at the end going aboard the oil tanker by means of a derrick, which is used to adjust the direction of the pipe-line to suit the varying draughts of the two ships. Of the two methods, the trough method entails more risk for the vessels concerned if there is a sea running, but it is the method more generally used from the point of view of successful oiling at sea.—*"The Shipping World", Vol. CV, No. 2,530, 10th December, 1941, p. 447.*

Shipbuilding Difficulties.

Many of the technical difficulties which are met with in shipbuilding are not understood by critics who are not connected with the industry. For instance, it appears to be considered that after the plates and sections have been shaped and punched or drilled, they all fall into their places automatically and have only to be riveted or welded together, whereas one of the most important and delicate jobs in shipbuilding is that of ensuring that the correct shape of the hull is maintained and that the various parts of the structure are adequately faired. The building berth must be properly piled, and the keel blocks arranged so that the declivity for launching is correct. After the keel has been laid, it has to be sighted to ensure that it is in a straight line fore and aft, after which the plates must be levelled and placed so that they are square to the centre line, whilst the frames, when erected, have to be adjusted so that they are in the correct position. The framework of a ship under construction is usually retained in position by means of strakes of plating punched from moulds made in the mould loft, and, as the remainder of the outside and deck plating is put in place, it is necessary to keep a careful watch on the hull to make certain that the shape is maintained, any unfairness being corrected by means of shoring. Constant vigilance in respect of these matters is essential, more especially in the case of oil tankers, as the hull very often tends to "grow" at the top, with the result that the fore and aft ends may not be truly plumb. During the construction and tenting of an oil tanker the hull tends to settle down, and, in a fair-sized ship, this distance may amount to as much as an inch. The foregoing remarks are particularly applicable to fabricated ships, as although it is true to say that a completely fabricated vessel will, if proper attention is paid to the erection, fair herself, yet, on the other hand, if the form is allowed to deviate from the strict dimensions laid down in the drawings, the case is almost hopeless. Therein lies one of the troubles attending this form of construction, and it is well that it should be realised.—*"Fairplay", Vol. CLVII, No. 3,057, 11th December, 1941, pp. 593-594.*

A German Survey.

The accompanying sectional drawing is taken from a lengthy review of the Diesel engine in world shipping by Dr. Ing. F. Sass, which has appeared in the German periodical *Werft * Reederie * Hafen.* The author, now chief engineer surveyor to the German Lloyd classification society, was the original designer of the large A.E.G.-Hesselman double-acting two-stroke engine. The drawing in question is of a two-stroke engine which is little known in Britain and America, and is manufactured by the Arn. Jung Locomotive Works, of Kirchen. Built for both marine and stationary purposes, the design is an attempt to combine the simplicity of the old hot-bulb and crankcase-scavenging cold-starting types with the good economy, higher normal rating, and better weight and cost per b.h.p. figures of the more modern two-stroke with scavenge pump. The stepped piston provides an efficient form of scavenge pump and the cylinder is offset in relation to the crankshaft—presumably with a view to giving a "dwell" at the top and bottom dead centres in the interests of combustion efficiency and scavenging respectively. The engine is capable of running up to 1,000 r.p.m. and is said to have a low fuel consumption.—*"Gas and Power", Vol. XXXVI, No. 435, December, 1941, pp. 273-274.*



Producer-gas Plant for New Danish Motorship.

Some further particulars of the coal-burning motorship under construction by Burmeister & Wain, Copenhagen, for Danish owners (*see abstract on p. 156 of* TRANSACTIONS, *December, 1941*), are now available. She is a sea-going vessel of 3,000 tons d.w., propelled by a 6-cylr. four-stroke Diesel engine of the trunk-piston type developing 950 h.p. Two main gas generators, burning coal, will be fitted, the installation including coal-breaking equipment. These main generators will supply gas for the main engine when the ship is at sea and will use ordinary coal. The consumption is estimated at 6·7 to 7·8lb./i.h.p.-hr., using coal of 12,600-b.Th.U. calorific value. A separate auxiliary generator will provide gas for driving the auxiliary machinery when the vessel is in port. The entire producer-gas plant, together with a coal bunker containing sufficient fuel for 20 days' sailing, will be located at the forward end of the engine room and will occupy five frame spaces. The generators will require little attention in service, as the coal will be fed into them automatically from a hopper. The main engine will be of the normal four-cycle Diesel type except that it will have no fuel valves or fuel pump, and that special inlet valves will be fitted.—*"Lloyd's List and Shipping Gazette", No. 39,677, 14th January, 1942, p. 7.*

A Pioneer Gas-driven Cargo Vessel.

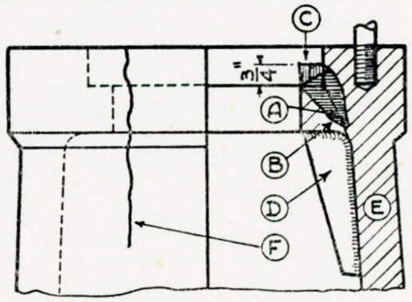
Among the British ships seized in French ports by the enemy and recently condemned to confiscation by the Hamburg Prize Court, was the 293-ton British coaster "Luffworth". This vessel will be remembered as the pioneer, gas-driven cargo vessel "Holzapfel I", built in 1911 by Eltringham's for the Holzapfel Marine Gas Power Syndicate. It was originally proposed to equip the vessel with an electric propulsion motor supplied with current by a generator driven by a producer-gas engine, but the owners acquired the British rights of the Föttinger hydraulic transformer, and that was installed with a gas engine of 180 h.p. running at 450 r.p.m. The vessel's machinery and equipment included a number of novel and ingenious devices, many of which have since proved to be wholly practical, and the ship was able to maintain 7½ knots on about 1½ tons of coal per day. The general lay-out of the machinery, however, was essentially faulty, and the vessel was constantly breaking down. In a bigger ship these defects in design could probably have been corrected easily enough, but the small hull made it impossible to do this on account of the stability problems involved. She was accordingly sold for conversion into an ordinary steamer, while the owners' intention of making use of the experience gained with her for the construction of a similar installation in a much bigger ship, which would have permitted the obvious faults to be eradicated, was abandoned on account of the rapid development of the Diesel engine.—*"Shipbuilding and Shipping Record", Vol. LVIII, No. 24, 11th December, 1941, p. 547.*

Producer-gas Installations for Dutch Inland Water Craft.

A committee of experts appointed by the Dutch authorities have been investigating problems connected with the employment of producer gas instead of fuel oil for running the Diesel engines of the miscellaneous craft on the inland waterways of Holland. These craft range from the large barges employed on the Rhine-Herne Canal to the small boats used for the carriage of fruit and vegetables. Owing to the limited supply of wood and peat available, it has been decided to utilise anthracite as the most suitable fuel for the producer-gas plants. Arrangements are being made to build gas generators for supply to owners of Diesel-driven craft on hire. The mass production of producer-gas installations for ships has, it is stated, now been put in hand, and it is hoped to have over 1,000 vessels equipped at an early date. Although anthracite will be the principal fuel used, some of the engines will be fitted to work on a mixture of coal dust and 10 per cent. gas oil, as it is claimed that this mixture provides an engine reliability equal to that achieved with oil alone. The fitting of the producer-gas installations will normally take three to five weeks, but a number of craft have already been converted. Tests carried out over a period of six months with a Kromhout engine converted last May are said to have been very satisfactory. The engine has a generator which normally burns wood, but is readily adaptable for use with peat. The engine runs on oil without load and automatically changes over to producer gas when the load is applied.—*"Lloyd's List and Shipping Gazette", No. 39,661, 24th December, 1941, p. 9.*

Welded Repair of an Engine Frame.

An uncommon and highly successful repair was recently carried out on the monobloc-type frame of a 220-b.h.p. 5-cylr. Atlas Polar Diesel engine, in the Argentine. An external crack in the jacket of No. 1 cylinder extended downwards for several inches through the face of the flange for the liner. This crack is marked "F" in the accompanying sketch. A second crack "A" ran from the sharp corner at the bottom of the recess for the liner flange, right through the material to the top of the jacket wall "E". An engineer who came to inspect the job from the nearby city of Buenos Aires estimated that welding repairs would take three weeks, so it was decided to attempt to do the job locally. The engine was dismantled and the crankcase cleaned out in readiness for welding. The damaged monobloc crankcase was handed over to the welder ready for him to work on with his portable machine in his own workshop by 8 a.m. on a Sunday, and the welded repairs were completed by



Location of cracks and method of repair and reinforcement.

5 p.m. on the following Tuesday, 47 hours being worked in all. The engine was immediately re-erected, and completed by the next afternoon, when a full-load test was made which proved the repairs to be thoroughly satisfactory. The engine has been in regular use since then and has continued to give every satisfaction. The whole of the welding work involved was performed by a single operator. Referring to the sketch, "B" shows where 7·75lb. of Ferroweld electrode was deposited in making the repair. It was considered desirable to build up the face at "C" ¾in., a corresponding thickness turned off the lower face of the top flange of the liner and the requisite alterations made at the bottom of the liner to ensure that the rubber-ring water joint would be tight. Thirty-two $\frac{5}{32}$-in. Softweld electrodes were used in building up the casting as at "C". The seating for the liner flange was reinforced by means of eight equally spaced supporting brackets "D", which were welded into place at the top of the water jacket. These brackets were of ½-in. iron plate, 5in. long and 1½in. in maximum width. After grooving and welding up the external crack "F", a ½-in. iron plate, 5in. long and 2in. wide, was welded over its whole length to reinforce it.—*"Gas and Oil Power", Vol. XXXVI, No. 435, December, 1941, p. 272.*

The Heating of Passengers' and Crew's Accommodation on Shipboard.

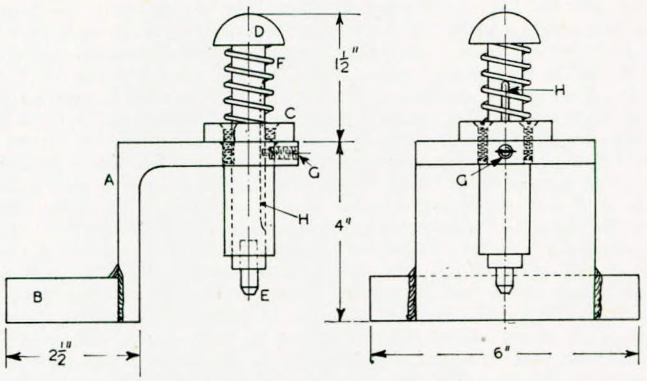
It is customary to maintain a temperature of about 65° F. in staterooms and approximately 68° F. in public rooms, whilst the Board of Trade require the heating installation for the crew spaces to be of sufficient capacity to maintain a temperature of 60° F., when that of the outside atmosphere is 30° F. The principal systems of heating used on board ship are: *(1)* coal or coke stoves; *(2)* hot-water radiators and pipes; *(3)* steam radiators; *(4)* hot air; and *(5)* electricity. The special features of these various systems are briefly described by the author and their respective merits compared. Tabulated data for hot-water mains, cast-iron radiators and low-pressure steam mains are given, together with simple formulæ employed for estimating the amount of heat required to raise a given volume of air to any desired temperature, and for calculating the thermal output of electric heaters.—*Paper by F. L. Bullen, "Bulletin of the Liverpool Engineering Society", Vol. XV, No. 5, December, 1941, pp. 5-16.*

Bulk Cargo Motorship "Arthur Hoyt Scott".

The 2,323-ton motor vessel "Arthur Hoyt Scott", recently completed at the Mathis shipyard in Camden for the Scott Paper Company, Chester, Pa., has been specially designed for the carriage of raw pulp in bulk from sources of supply to the owners' mills at Chester, Pa., as well as for the delivery of finished paper products to various ports on the Atlantic coast. The ship is of all-welded construction, 269ft. 1in. in o.a. length, with a moulded breadth of 42ft. 6in. and a depth of 25ft. 3in. The d.w. carrying capacity is 4,000 tons and the load draught 20ft. 6in. There are three cargo holds with a total bale capacity of 161,000 cu. ft., the propelling machinery being aft. The cargo hatches are of exceptionally large size to permit vertical lifts and drops from side to side of the ship, thus simplifying the stowage and discharge of bulk cargoes. The hatch coamings rise well above the level of the deck and form spacious cargo trunks, whilst the hatch covers are of steel box form, lifted in sections and stowed away during the time cargo is being worked. The vessel's cargo-handling equipment consists of a travelling crane operated by a Diesel engine running on fore-and-aft rails on the upper deck on the outboard sides of the cargo hatches. The propelling machinery consists of an 8-cylr. four-stroke Cooper-Bessemer supercharged Diesel engine rated at 1,300 b.h.p. at 277 r.p.m. and designed to give the ship a service speed of 9½ knots in a fully-loaded condition. Although the vessel is normally employed on a service which only involves short voyages, her fuel-oil capacity of 268 tons gives her a cruising radius of 10,000 miles. If necessary, fuel or liquid cargo can also be carried in the fore peak. The whole of the auxiliary machinery is electrically operated, current being supplied by a 15-kW. 115-volt generator, driven at 1,750 r.p.m. by the main propeller shaft. A set of storage batteries, charged by the shaft-driven dynamo, are available for harbour use, in addition to two 40-kW. auxiliary generators driven through gears by two 6-cylr. four-stroke Diesel engines.—*"Motorship and Diesel Boating", Vol. XXVI, No. 12, December, 1941, pp. 734-736.*

Inspector's Stamping Fixture.

The accompanying sketches show a hand punch for use in stamping components with their identification mark and also with the inspector's number. It is stated that the device has proved extremely useful and quick in operation. Part *A* is a piece of 4in.×4in. angle iron, 4in. long, and is welded to the base *B*, which



Inspector's punching fixture.

may be about 6in. long and, say, 1in. thick. This can, of course, be drilled for bolting to a bench or elsewhere. A 1⅛-in. hole drilled in the angle iron takes a shouldered bush *C*, which is a good fit in the hole and held down by four countersunk screws. The bush is bored out to ¾in. dia. to take a plunger *D*, which is prevented from rotating by a keyway *H*, located by a screw *G*. The marking stamp *E* is a driving fit in the plunger, although an alternative method is to hold it in place by means of a small grub-screw. A light coil spring *F* fits around the upper part of the plunger.—*"Mechanical World", Vol. CX, No. 2,868, 19th December, 1941, p. 449.*

Vast New Oil Discovery.

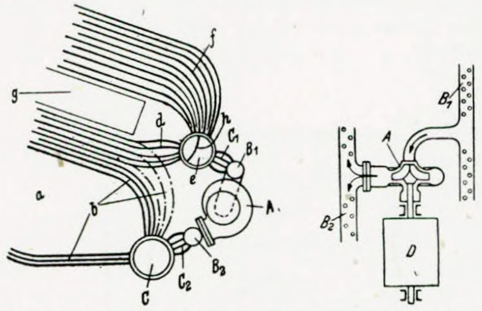
The present oil-field reserves of the world have been estimated at about 25 billion barrels. Yet in Northern Alberta, Canada, along the reaches of the Athabasca River and covering an area of many thousands of square miles, there is *ten times as much oil as is known to exist in the rest of the world.* A recent estimate of the U.S. and Canadian Governments puts the supply at 250 billion barrels. For years this, in all probability the largest potential oil field in the world, known to many explorers and geologists for the last 150 years, has remained untapped. Though the sands of this vast area are literally saturated and soaked with oil, no satisfactory and reasonably economic method of separating the oil from the sand had been discovered. Simple though this may sound, the operation defied every attempt of scientists and oil technologists, for each grain of these Northern Alberta sands is so coated with a film of oil that all efforts to separate one from the other failed. Under the impact of the abrasive sand, machines and tools wore out. Nor was this the sole difficulty. There was no known satisfactory way of extracting the sand. Wells were out of the question, for the oil so thoroughly mixed with the sand would not run; tunnelling was useless, for obviously the sand would cave in; to fortify tunnels with bricks or timber would make the cost uneconomic. Water and steam jetting proved equally unavailing. The only feasible means appeared to be the "open pit" method, but even this operation could only be profitable where the overlying surface of clean sand and rock to be removed was not more than a cubic foot for each ton of sand to be "mined". It was not until May, 1941, that the enterprise of two American engineers, M. W. Ball and J. M. McClave, overcame the formidable difficulties involved and led to the successful extraction of the first few hundred barrels of refined oil. McClave's invention of a simple device which he called the "quiet zone flotation cell" enabled the problem of oil separation to be solved. On the way from the "mine" to the cell, the sand is passed through a rotating steel cylinder called the pulper. Plates and coils inside this cylinder buffet the particles of sand against each other, so that the oil coating or film adhering to the sand is broken up into oil particles. The sand pulped with water is then fed into the quiet zone flotation cell, an inclined trough containing a moving spiral ribbon. The oil particles thus become mixed with water and float to the "quiet" surface as froth. The sand settles to the bottom, where it is stirred by the moving ribbon, and thereby releases any additional oil particles, which float to the surface on air bubbles. The oil is then piped to the refinery, where various types of fuel and lubricants are produced. The process enables over 99 per cent. of the oil to be extracted from the sand. Commercial exploitation of the Athabasca oil fields has now begun, and it is stated that from every 250 tons of processed sand, approximately 175 barrels (about 24 tons) of crude oil are recoverable. The latest figures available show an output of 400 barrels per day, and a new plant capable of producing 10,000 to 30,000 barrels of oil per day is to be erected.—*"South African Engineering", Vol. LIII, No. 1, January, 1942, p. 15.*

Insulating Block.

A new insulating block, particularly suitable for marine and industrial uses, has been developed by a Trenton, N.J., firm, who are manufacturers of rock wool products. The new insulant is stated to be practically impervious to the effects of moisture, laboratory reports proving that its moisture absorption is only 0·68 per cent. in a relative humidity of 65 per cent. at a temperature of 75° F. Due to its composition and physical properties, it is claimed that the material will not disintegrate, suffer structural break-down or decay. The new product is supplied in blocks which are 36in. long, 12in., 18in., or 24in. wide, and from ½in. to 2in. thick. It can be cut to fit irregular planes or odd corners, if necessary, and is said to be quite easy to apply.—*"Modern Refrigeration", Vol. XLIV, No. 525, December, 1941, p. 186.*

Circulation in Marine Water-tube Boilers.

A short time ago the German technical periodical *Werft* Reederei * Hafen* published a description of an improved method of ensuring adequate water circulation in marine watertube boilers, evolved and patented by Dr. Gustav Bauer, of Hamburg. It concerns boilers with at least two drums, from which either all or part of the radiation and conduction heating surface branches, and which receive their water from downcomers. Variation in steam demand or of the heat flow in the rising tubes, as well as the movement of the ship, will all produce irregularities in the water circulation. The arrangement proposed by Dr. Bauer is shown in the accompanying diagrams. In the ordinary arrangement the lower drum *e* fed by the downcomers *f* is connected to the drum *c* by tubes running directly between the two drums, whereas in the new arrangement a circulating pump *A* is interposed between the drums, the pump being driven either by an electric motor or by a steam turbine *D*. It is advantageous to have a collector B_1 and a distributor B_2 in the positions shown; there should also be a partition *h* in the drum *e* to divert part of the water delivered by the downcomer tubes *f* direct to the rising tubes *d* in order to ensure their water supply under all circumstances.—*"The Marine Engineer", Vol. 64, No. 773, December, 1941, p. 266.*



Left: Dr. Bauer's proposed pump-assisted circulation water-tube boiler.
Right: Arrangement of pump and pump drive.

Distilled Water Corrosion Tests on Nickel Steel.

In the course of a paper on this subject recently presented at a meeting of the American Society for Metals by D. J. McAdam and G. W. Geil, the authors drew attention to the importance of the fact that steady stress may, under certain conditions, accelerate the corrosion of steel in water, a feature of special interest in relation to the problem of corrosion in steam boilers. Simultaneous stress and corrosive attack may cause sharp, deep pits in the highly stressed parts of boilers, ultimately resulting in failure. In many cases the attack is intercrystalline. To account for such pitting, except possibly that in boiler seams, it has generally been assumed that the metal has been subjected to stress cycles. Intercrystalline cracking in boiler seams has often been attributed to the combined influence of high stress and a high concentration of caustic soda, but the results of experiments described in the paper indicate that there are a number of corrosion conditions under which the rate is accelerated by steady stress, and suggest that in some cases of boiler corrosion, too great emphasis has been placed on the location of the pits in relation to the grain boundaries.—*"The Nickel Bulletin", Vol. 14, No. 11/12, December, 1941, pp. 191-192.*

Mobile Power Stations for U.S. Navy.

Two mobile power stations are being built by the American General Electric Company for the United States Navy. Each will generate 10,000 kW. and will comprise a boiler equipped with an economiser and forced-draught fans; oil-fuel, feed-water, hotwell and booster pumps; a de-aerating feed-water heater and tanks for water and oil; a turbine and generator with exciter; a condenser, air pump, evaporator and various other auxiliaries, together with the necessary switchgear. The boilers are of the natural-circulation type and have an evaporative capacity of 140,000lb./hr. of steam at a pressure of 550lb./in.^{2} and temperature of 825° F. The generators run at 3,600 r.p.m. and produce 3-phase current at 13,800 volts, 60 cycles. Each plant consists of two units, one for generating steam and the other power, each mounted on a 16-wheel railway vehicle.—*"Mechanical World", Vol. CX, No. 2,869, 26th December, 1941, p. 475.*

Dry-docking Precautions.

In these days, when seriously-damaged and fully laden ships have frequently to be dry-docked for repairs, special precautions are necessary for carrying out such an operation. The vessel must be upright and, as far as possible, on an even keel when she enters the dock, and, as the stability is reduced as the ship touches the blocks, care must be taken to see that the double-bottom tanks are either perfectly dry or quite full. When a fully-laden ship is docked, the dock bottom must be of strong construction, extra tiers of blocks should be fitted under the keel, and bilge blocks should also be provided. Probably the greatest risk to be faced is that of the keel blocks "tripping" as the vessel grounds, and to guard against this the end blocks have to be linked together to resist any such tendency. Some owners object to the docking of laden ships on the ground that the hull structure may be strained, but if reasonable precautions are taken, there should be no danger of this.—*"Fairplay", Vol. CLVII, No. 3,058, 18th December, 1941, p. 620.*

Optimum R.P.M.

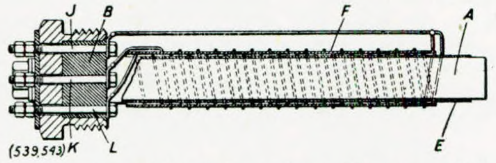
Much attention has been given to investigations of the question of optimum rate of rotation for maximum efficiency, from the purely propeller point of view, the extra weight and cost involved by the use of a larger slower-running screw being—no doubt rightly—regarded as of secondary importance. At the present time, however, the various mechanical and electrical forms of indirect drive available allow the problem of optimum engine r.p.m. to be considered separately and independently, and in this case questions of cost and weight are of far greater importance. Generally speaking, higher running speeds tend to reduce both the weight and the cost of the machinery, but after a certain speed of rotation has been attained, the cost remains more or less stationary, owing to the better quality materials, closer tolerances and more accurate workmanship required. Moreover, a limiting weight is eventually reached for any given horse-power and type of machinery, even when every feasible refinement is incorporated. A marine installation of this kind is probably justified only for special high-speed craft, but there appears to be little doubt that as progress is made in eliminating the objections to high running speeds in the form of extra maintenance work, vibration troubles and possible departure from maximum fuel economy, fuller advantage will come to be taken of its potentialities. —*"Shipbuilding and Shipping Record", Vol. LVIII, No. 25/26, 25th December, 1941, p. 586.*

The Manufacture of Crankshafts in High Test Cast Iron.

The object of this paper is to call attention to the possibility of replacing steel forgings by high test iron castings, and to present particulars of such results as have been obtained from experimental trials carried out with C.I. crankshafts. The physical properties of cast iron of importance to designers of crankshafts are briefly discussed, and a summary of tests made at the National Physical Laboratory on five crankshaft materials is given in tabulated form. The foundry technique involved is explained by the authors and the essential problems connected with the making of cast crankshafts are reviewed. Up to the present war, many cast-iron crankshafts had been made and were in successful service, having previously run trials extending up to four years in automobile and Diesel engines. C.I. crankshafts for small compressors and petrol engines are now becoming standard practice, and in America an 8-cylr. Diesel engine is being constructed with a 10-in. diameter crankshaft over 12ft. long, which is to be cast in Meehanite metal.—*Paper by E. M. Currie and R. B. Templeton. "Transactions of the Institute of Marine Engineers", Vol. LIII, No. 11, December, 1941, pp. 169-177.*

Engine Fault Indicator.

A British patent has been granted to a London engineering firm in respect of an indicating device for use on engines and machines, which gives warning of potential breakdown due to overheated bearings and moving parts. Referring to the accompanying sketch of the device, two nickel coils are wound on a metal rod *A*, fixed at one end in an insulated holder *B*, which, in turn, is mounted in a metal cap. The cap is screw-threaded to enable it to be inserted in the wall of the sump or collecting chamber into which the engine lubricating oil flows. The two coils have the same electrical resist-



ance, and one of them is wound upon an insulating sleeve *E*, which fits over the rod *A*. Over this coil is placed a second insulating sleeve *F* upon which the second coil is wound. The ends of the two coils farthest from the holder *B* are connected together by means of a common terminal *J*, whilst the other ends of the two coils are connected to their respective terminals *K* and *L*. When immersed in the engine lubricating oil, the outer coil, being directly in contact with it, will be more sensitive to any rise in oil temperature. On the other hand, the inner coil being shielded by the insulating sleeve *F* from direct contact with the oil, will be less sensitive to temperature changes. The two coils form part of an electrical bridge circuit, across which a polarised warning relay is connected. A rise in the temperature of the oil will increase the resistance of the coils in the bridge, but if this rise is gradual or does not exceed a predetermined rate, the lag in response on the part of the inner coil, while tending to upset the balance in the bridge, may not be sufficient to operate the relay.—*"Engineering", Vol. 153, No. 3,964, 2nd January, 1942, p. 20.*

Supercharged Diesel Engines.

In a paper entitled "Problems and Possibilities of Mechanical Supercharging of Diesel Engines" recently contributed to the American Society of Automobile Engineers by H. C. Knudsen, the author suggests that theoretical considerations indicate that for a given maximum pressure the limit of supercharging is only reached when the expansion ratio is unity, *i.e.*, when combustion is maintained up to the end of the piston stroke. For the theoretically maximum pressure of 860lb./in.^{2}, the maximum possible indicated m.e.p. would be about 730lb./in.^{2}. Tests on non-supercharged and supercharged engines showed that the friction horse-power tended to decrease with increased m.e.p., probably due to the reduction in the viscosity of the lubricant caused by the increased temperature, but at the same time, a more careful cooling of pistons and valves became necessary. The theoretical investigation applies, of course, to any type of Diesel engine, and suggests that an increase of supercharging is economically possible.—*"Shipbuilding and Shipping Record", Vol. LIX, No. 2, 8th January, 1942, pp. 35-36.*

Götaverken Opposed-piston Engine Crankshaft.

A British patent has recently been obtained by the A/B Götaverken, of Gothenburg, on the method of assembling the crankshaft of their opposed-piston engine. This method of assembly is shown in Fig. 1, from which it will be seen that the outer pins *(2, 3)* of the shaft *(1)* have their outside webs formed as discs *(6, 7)*, which act as the main bearing journals. These bearings *(9, 11)* are of the roller type. Each disc comprises half a journal and takes a corresponding portion belonging to the adjacent section of shafting, so that the pairs, when fitted together, are adapted to take the inner race of the roller bearing. The parts of the web-journals may be secured by bolts *(18)*, which engage closely-fitting sleeves *(19)*. Alternatively, sleeves *(28)* may be fitted, these being held in place by bolts *(29)*. Additional securing bolts *(30)* are provided if required. In the second arrangement it will be noted that the bearing *(29)* is shown as a plain type. When the shaft is assembled, as in the diagram of the opposed piston engine, the web-journals take up their position in the main bearings *(35, 36)*. The

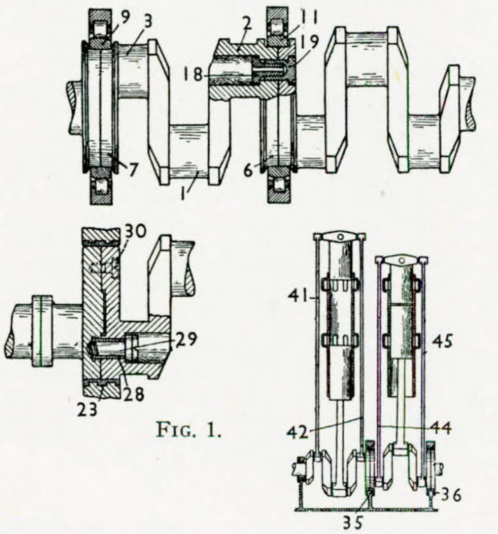
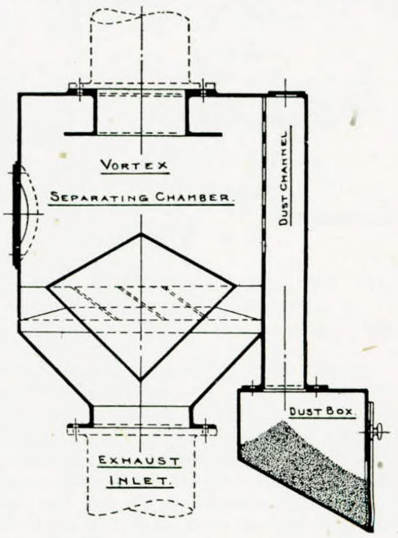


Fig. 1.

lower pistons of the engine drive the centre cranks through a yoke to which are attached side rods *(41, 42, 44, 45)*.—*"The Motor Ship", Vol. XXII, No. 264, January, 1942, p. 346.*

Spark Arresters.

The naval authorities insist on suitable precautions against the emission of sparks from the funnels of motorships proceeding in convoy, and various devices are employed for this purpose. Some of the measures recommended are, however, not always successful. One chief engineer who was instructed to fit steam jets in his Diesel-engine exhaust found that their use made no difference whatever, whereupon he fitted a wire-mesh sieve of ¼-in. mesh, umbrella-fashion, over the top of the main exhaust pipe. After about two hours in service, the screen was ejected from the funnel, so the sieve was refitted and secured in place by a metal hoop. The results did not prove satisfactory, as the sieve became choked and set up an excessive back-pressure. A considerable amount of research work has been carried out in connection with the removal of solid matter from waste gases, and there are, at the present time, several efficient spark-arresting devices on the British and American markets. One of the best-known is the Vortex arrester, the construction of which is shown in the accompanying sectional drawing. The Vortex arrester is of the dry type, in which the separating forces act one way across the gas stream and are strong enough to ensure the extraction of the finest particles of dust, etc., before they are discharged. The comparatively small chamber used relies for efficiency upon thin gas streams, acted upon by powerful non-reversible centrifugal forces. The designed stream thickness is determined according to the free speeds of various-sized particles and gas densities and the centrifugal force required, all the factors being related to the desired pressure drop through the arrester and the rate of gas flow through the separating chamber. Combined Vortex spark-arrester silencers are also available, the dimensions being no larger than those of ordinary silencers. In some cases spraying-tube spark arresters are employed, in which a reinforced cement lining is used to minimise the effects of corrosion. In general, however, the dry type of spark arrester is recommended for most purposes.—*"The Shipbuilder", Vol. XLIX, No. 390, January, 1942, pp. 7-8.*



Vortex spark arrester.

"Dry Ice" to Loosen Valve Seats.

An article by H. P. King in a recent issue of the American technical periodical *"Power"* describes how the seized brass valve seats of a boiler feed pump were loosened by an application of "dry ice" (solid carbon dioxide). The valve seats had seized so firmly that even "plenty of man power" on an 8-ft. handle to the wrench failed to move them. "Dry ice" was then placed on the seats to shrink them, and after a few minutes they could be removed by one man with a 2-ft. wrench. The author suggests that "dry ice" may usefully be applied in other instances to loosen tight parts by contraction.—*"The Power and Works Engineer", Vol. XXXVII, No. 427, January, 1942, p. 36.*

Training of Craftsmen for the Engineering Industry.

The author calls attention to the acute shortage of qualified craftsmen in the engineering industry, to the present lack of method in recruitment to the industry, and to the breakdown of the old apprenticeship system. He puts forward suggestions for recruiting engineering apprentices from three sources: *(1)* junior technical schools or technical high-schools, at 16 plus; *(2)* secondary or grammar schools or modern schools, at 16 plus; and *(3)* elementary schools, at 15 plus. Particulars of a proposed scheme of apprenticeship training in properly staffed and equipped "training workshops"—attached to a technical college or forming part of a special department in an engineering works—are set out and explained. The author expresses the view that an organized system of pre-apprenticeship training coupled with a properly organized system of continuous training, should enable the duration of the apprenticeship to be reduced to four years—or possibly less. This would enable a boy to complete his engineering training before being "called up" under the 1939 Military Service Act. Much experience has been gained during the present war with properly organized courses of training of short duration. Close co-operation between technical colleges and works is essential for the future development of the engineering industry, and part-time day release of apprentices from the works to attend college classes must be envisaged.—*Paper by F. H. Reid, B.Sc., Wh.Ex., read at a general meeting of the N.-E. Coast Institution of Engineers and Shipbuilders, on the 9th January, 1942.*

Mechanical Stokers or Pulverised Fuel for Post-war Cargo Vessels.

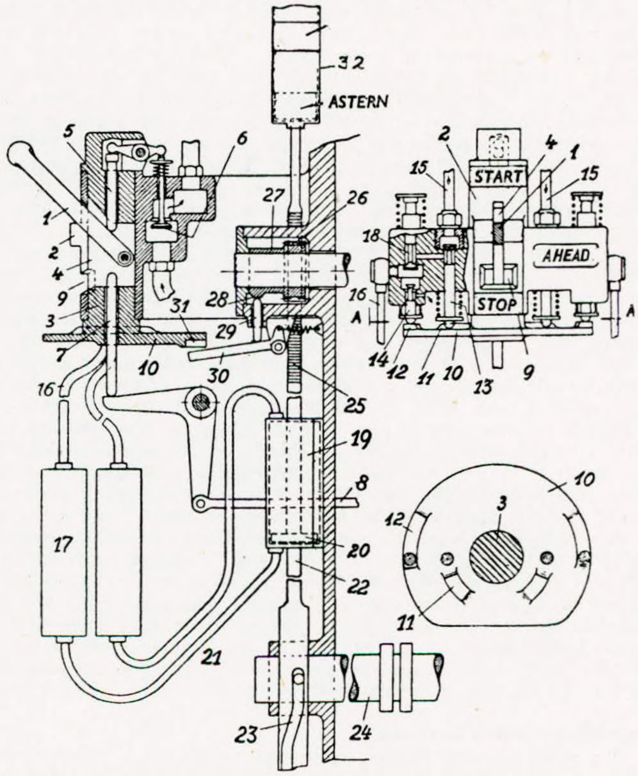
The average marine mechanical stoker, in spite of its excellence, is too expensive to attract sufficient owners, except for specialised service. It has been contended that the inability of the mechanical stoker to deal with the wide range of coals which must be bunkered by the ordinary tramp steamer has militated against its widespread use, but the better types of stoker are in fact, quite capable of burning a useful range of fuels. It is the high price of this equipment which has hitherto restricted its use. Despite past disappointments in the burning of pulverised fuel, recent developments in Russia, involving the use of a German type of pulveriser, indicate that P.F. firing still possesses considerable potential value for marine purposes. The pulveriser in question is the pneumatic type of mill, which eliminates all forms of paddle, ball, or other device for powdering the coal, and in its stead employs the abrasive action of high-velocity steam or compressed air. The mill is silent in operation, the high upkeep costs common to other forms of P.F. mill are eliminated, and the degree of fineness of the powdered fuel seems to be as good as is obtainable with any alternative form of mechanical mill. Admittedly the steam consumption of the pneumatic mill is a drawback, since this amounts to about 5 per cent. of the total output of the boiler, but no doubt this will be improved with further development.—*"The Shipping World", Vol. CVI, No. 2,535, 14th January, 1942, p. 53.*

The Future of Cargo-ship Propulsion.

In considering the competing claims of the steamer and the motorship in regard to possible post-war lines of development, it must not be forgotten that at the present time a good deal of attention is being devoted to the running of marine Diesel machinery on low-grade, relatively cheap fuel oil. If these experiments are so successful as to change the general policy in the matter of fuels for motorships, the resulting reduction in running costs might give the motorship an advantage over the steamship, but if, on the other hand, a corresponding rise in the cost of such low-grade fuel oil takes place owing to the increased demand for it—to the detriment of the more expensive high-grade Diesel oils—then the resulting position would not differ greatly from that of the present time. Furthermore, the employment of low-grade boiler oil in Diesel engines accelerates piston-ring and liner wear, thereby greatly adding to replacement and maintenance costs. The ordinary reciprocating steam engine is relatively cheap to build, and in its modern forms, such as the North-Eastern reheater engine, is a really efficient and in many ways particularly suitable form of prime mover for cargo ships of up to about 3,000 i.h.p. For higher powers, however, the ordinary type of reciprocating steam engine is unlikely to find favour, unless smaller, lighter and cheaper engines with a higher speed of rotation can be developed. In this connection, the White arrangement of a geared moderately fast-running reciprocating engine coupled to the same propeller shaft as a double-geared exhaust turbine, might be deserving of consideration. An installation of this kind, incorporating a high-speed, totally-enclosed reciprocating engine and employing fabricated welded construction for the reduction gearcase, engine framing and bedplate, might prove a serious competitor for the Diesel engine even up to powers of 4/5,000 s.h.p. In the light of recent American developments in the application of compact double-reduction geared-turbine installations of 3/5,000 s.h.p. to cargo-ship propulsion, it may be anticipated that British shipowners will, in due course, follow suit. The employment of Scotch boilers in conjunction with geared turbines can be ruled out, and it may be assumed that the adoption of watertube boilers will become more general, notwithstanding the reluctance hitherto displayed in some quarters to employ such boilers on account of the increased amount of attention their operation and maintenance would call for from the E.R. personnel. Whether British owners will accept automatic combustion and superheat control, separately-fired superheat boilers, automatically-controlled variable-capacity multiple-ram feed pumps, unit feed systems, and other recent developments, is more doubtful.—*"The Shipping World", Vol. CVI, No. 2,535, 14th January, 1942, pp. 51 and 53.*

The Latest M.A.N. Reversing System.

A new single-lever starting and reversing system for oil engines has been developed and patented by the Maschinenfabrik Augsburg-Nürnberg, and is shown in the accompanying sectional drawings. The main control lever (*1*) is rigidly attached to the manœuvring shaft (*3*), and is free to move in a direction parallel to this shaft or vertically. The manœuvring shaft is carried in a housing (*2*), in which are two slots at right angles (*4* and *9*), arranged in relation to each other in such a manner that movement of the lever to operate the reversing mechanism can take place only when the engine is stopped. When it is required to put the engine from ahead to astern, the lever (*1*) is moved down to the "stop" position, thereby depressing the plunger (*7*) and causing the lever (*8*) to move to the right. This cuts off the fuel supply and stops the engine. The lever (*1*) is then moved to the left in the slot (*9*) and the manœuvring shaft (*3*) carrying the cam disc (*10*) is turned. The cam (*11*) lifts the valve (*13*) and admits compressed air to the pipe (*15*) from the reservoir.



Sectional view of M.A.N. starting and reversing gear.

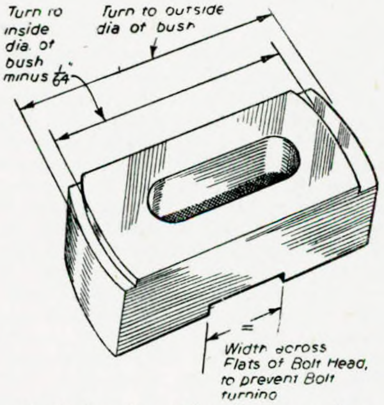
This compressed air passes through the valves (*13* and *18*) and the pipe (*16*) to the air chamber (*17*), which is under pressure from the oil operating the servo motor (*19*). The resultant increase of pressure on the under side of the piston (*20*) of the servo motor (*19*) causes the former to move upwards and lift the rod (*22*). As a result, the camshaft (*24*) moves to the left—the slot (*23*) being curved and the astern cams are, therefore, brought below the valve-operating levers. The gear is thus set for the engine to turn in the astern direction. In order to prevent the lever (*1*) from moving back to its centre position, and possibly to the starting position, before the camshaft has carried out its full movement for reversing the engine, the vertical motion of the rack (*25*) turns the pinion (*26*) and the hub (*27*), thereby freeing the stop (*29*) from the cam (*28*) and permitting the lever (*30*) to move into the recess (*31*) of the cam disc (*10*). This locking device is freed only when the pinion (*26*) and the hub (*27*) have made a complete revolution, when the cam (*28*) again presses the stop (*29*) down, so that the lever (*30*) is removed from the slot (*31*). The diameter of the pinion (*26*) is so chosen that it makes one revolution during the movement of the piston (*20*) from one end of the cylinder to the other. Any further movement of the lever (*1*) is thus prevented during the whole period of reversing. An indicating device (*32*) shows whether the gear is set for ahead or astern operation. When the reversing movement is complete the lever (*1*) is returned to the valve position, the stop valve (*13*) closes and the discharge valve (*14*) is opened by the cam (*12*). The compressed air is then discharged from the air vessel (*17*) through the pipe (*16*), and the piston (*20*) of the servo is also relieved of air pressure. The engine can then be started up in the new direction of rotation. The lever (*1*) is lifted upwards to the starting position. The action raises the plunger (*5*), opens the valve, (*6*) and allows starting air to enter the pipe (*31*) from the manœuvring-air reservoir. Air is delivered to the starting valves in the cylinders and the engine begins to turn. At the end of the starting period the lever (*1*) is moved to the running position and the valve (*6*) is closed.—*"The Motor Ship", Vol XXII, No. 264, January, 1942, p. 335.*

The Ice-breaker "Ernest Lapointe".

The new twin-screw ice-breaker "Ernest Lapointe" was designed by the Canadian Department of Transport, and was built by the Davie Shipbuilding and Repairing Co., Ltd., of Lauzon, Levis, Quebec. She is a dual-purpose craft, as, in addition to ice-breaking duties, the vessel is to be used for channel-surveying service and inspection duties. Unlike many other modern ice-breakers, the "Ernest Lapointe" is equipped with stern propellers only, the shape of the hull forward having been designed to permit the bow wave to be used to accomplish ice-breaking. This theory—which, it is believed, has been advanced for the first time by the responsible officials of the Canadian Department of Transport—has now been substantiated in practice by the new ice-breaker, and has been found to be particularly applicable in breaking out the ice in shallows bordering the navigating channel. The "Ernest Lapointe" is a steel-built superstructure-type ship of a most compact design, with "closed" shelter 'tween decks. The overall length is 184ft. 3in., the moulded breadth 36ft., and the depth moulded to upper deck 17ft. The vessel has a draught of 13ft. at a normal F.W. displacement of 1,540 tons. The hull is subdivided by eight transverse W.T. bulkheads which extend to the upper deck, and the double bottom extends from the after bulkhead of the forward trimming tanks to the forward end of the after ballast tank. Stowage for 194 tons of oil fuel is provided in deep tanks and D.B. tanks under the boiler room. In addition to the living quarters for a normal complement of 25 officers and men, the ship has accommodation for seven passengers in six staterooms, with a dining saloon and smoking room. A small cargo hold, 30ft. in length, is arranged forward. The hull structure is of very robust construction and the heavy shell plating which forms the ice-belt extends vertically from about 5ft. draught to 14ft. draught. The propelling machinery consists of two sets of double-compound Christiansen and Meyer steam engines with a total output of 2,000 i.h.p. at 140 r.p.m., supplied with steam at 220lb./in.^{2} and superheated 100° F., by two cylindrical oil-fired boilers equipped with superheaters in the uptake. The air supply and preheating is on the Howden system. The main engines were built by Marine Industries, Ltd., of Sorel, Canada, under licence from the patentees, who supplied the complete drawings.—*"The Shipbuilder", Vol. XLIX, No. 390, January, 1942, pp. 13-18.*

Skimming-up Valve Seatings.

The spring-loaded safety valves on a number of boilers were leaking badly. On examination it was found that the valve seats were pitted to such an extent that "grinding in" was not practicable. As the seats were press-fitted bushes, with a flange at the valve end, it was decided to withdraw them and skim-up in the lathe in preference to making and fixing a re-seating tool. There was some clearance all around the underside of the bush, but as there was no way of inserting a bolt and bar from the bottom of the mounting, a tool-steel bar was shaped, as shown in sketch, the slot-length being about two and a half times the diameter of the bolt. This bar was lowered by the bolt from the top of the bush obliquely through the hole. In the clearance space under the bush the bar was righted and held in place whilst a bridge piece was placed in position on the top of the mounting. Screwing down the nut and applying heat with a blow-lamp ensured easy withdrawal. —*V. Simons, "Practical Engineering", Vol. 4, No. 102, 1st January, 1942, p. 647.*



A device for skimming-up valve seatings.

Overcoming "Swell" in Bushes.

A correspondent describes a method of overcoming "swell" when bushes are pressed into housings. New G.M. bushes, accurately turned to the prescribed internal and external tolerances, had been made for the paddles of a paddle minesweeper undergoing refit. When the bushes were being pressed home, however, it was found that a considerable amount of filing and dressing was called for, and the internal diameter was eventually found to be 0·006in. too small for the pins owing to deformation of the metal. The trouble was subsequently overcome by cutting a $1/64$-in. external groove around the circumference of each bush at the centre of its length. This facilitated the pressing-home of the bushes and preserved the requisite internal clearance—*"Practical Engineering", Vol. 4, No. 104, 15th January, 1942, p. 701.*

General Motors Variable-pitch Propeller.

A British patent has been granted to the General Motors Corporation, of Detroit, U.S.A., for a variable-pitch propeller, the construction of which is shown in the accompanying diagrams (Fig. 2). The blades (*7*) are carried in the hub (*2*) and are moved by a spindle (*10*). In the root (*6*) are cut teeth (*11*) engaging a rack (*12*) in the spindle, the blade motion being limited by stops (*9, 13*) which enter recesses (*8*). A method of regulating the pitch is shown in the assembly diagram with part of the stern post (*50*) carrying a bearing (*51*) for the after part of the propeller shaft (*1*). The control-rod collar (*52*) is moved by a fork (*53*) and bell-crank lever (*54*). The upper end of the shaft (*56*) is connected to the control rod (*20*) by means of a resilient lost-motion device which comprises a spring (*21*) acting as a cushion for any severe shocks. Owing to the construction of the blades, which may have an aft rake, they take up a position of equilibrium according to the driving torque and relative stream velocity. The reaction thrust of the blade roots or spindles counteracts, or is added to, the centrifugal thrust. A shock absorber of the hydraulic type is also shown in the top right-hand drawing. On the rack spindle (*10*) is a piston (*10a*), which moves in a cylinder (*10b*) having front and rear orifices (*10c, 10d*). The piston is drilled for the restricted passage of fluid and the movements of the rack spindle are damped by the water in the cylinder.—*"The Motor Ship", Vol. XXII, No. 264, January, 1942, p. 346.*

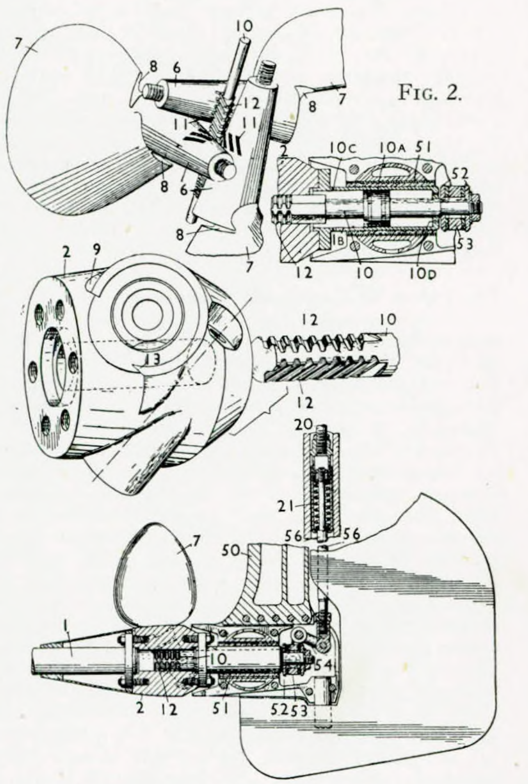


FIG. 2.

Escher Wyss Variable-pitch Marine Propellers.

Some particulars of the design and manufacture of variable-pitch propellers for air, water-turbine and marine work are given in a recent issue of the *"Escher Wyss News"*, published in Zürich, Switzerland. It is claimed that the problem of constructing a ship's propeller with blades that can be adjusted to forward and reverse has now been completely solved, and that the design of the boss is such that the operating mechanism within it does not impair the propeller efficiency. The installation comprises a control mechanism fitted in the ship on the shaft line forward of the after peak bulkhead and the gear in the hub of the propeller itself. The control mechanism is operated by oil under pressure supplied by a pump which is driven by a chain from the propeller shaft. The operation of this pump is controlled from the bridge by a mechanism which governs the pitch adjustment of the screw, an electric indicator in the wheel-house enabling the position of the propeller blades to be ascertained at all times. It is claimed that such propellers would be of great value for use with certain classes of ships, as it is possible to have the propelling engine running continuously at its maximum efficiency without having to reverse the direction of rotation for going astern. In the case of turbine machinery, separate astern turbines would be unnecessary, while in tugs and similar vessels where the propulsive conditions vary widely according to the size of the ships being towed, the pitch could be regulated to suit these conditions. Escher Wyss variable-pitch propellers have, it is stated, been fitted to two French fishing boats, one of which has an 80-h.p. engine and a speed of 7 knots and the other a 160-h.p. engine and a speed of 7½ knots. The propellers of these vessels are of a special design, enabling them to exert a high pull when dragging the nets, and, with the pitch adjusted, of giving good results when running free without the nets. The largest variable-pitch propellers so far ordered from the Escher Wyss Company are for a sea-going ferry boat for Holland. The length of this vessel is 235ft. and the displacement about 1,300 tons. The propellers are approximately 8ft. 6in. in diameter. Although there is little need for such propellers for vessels of the cargo-ship type engaged in general service entailing long voyages, there should be a considerable scope for their employment for cross-channel vessels, ferries, river craft, and similar ships. The claims made for the Escher Wyss type of screw are somewhat similar to those put forward by the designers of the Voith-Schneider propeller, but the fact that propellers of normal shape are employed by the Swiss firm may, perhaps, influence shipowners to utilise the Escher Wyss variable-pitch propeller in preference to the other.—*"Shipbuilding and Shipping Record", Vol. LIX, No. 1, 1st January, 1942, p. 14.*

Motor Passenger Vessel for the Lake of Thun.

Some particulars of the motorship "Thun", recently constructed at Zürich by Escher Wyss for the Berne -Lötschberg-Simplon Railway Company's service on the Lake of Thun, are given in the *"Escher Wyss News"*. The vessel has a length of 128ft. 6in., a maximum beam of 16ft. 6in. and a moulded depth of 8ft., the draught exclusive of the keel, being 3ft. 9in. She is equipped with a 250/300-h.p. Sulzer Diesel engine driving a variable-pitch propeller, reversing and speed control being obtained by alteration of the blade angle. The vessel is fitted with both bow and stern rudders operated from the wheel-house by chains. A change-over device enables the steering to be changed from one rudder to the other, the one not in use being locked. The designed speed, when carrying 300 passengers, is 23km./hr. (12·4 knots), and the fuel consumption is stated to be 7·4lb. of gas oil per nautical mile. The vessel carries a crew of only three men. The hull of the "Thun" was transported by road in two sections from Zürich to the western end of the Lake of Thun, a total distance of 60 miles. The largest section was 66ft. long and weighed 14 tons. The shell of the vessel was completely welded up to the deck stringer at Zürich. The shell plates overlap and are welded inside and out, all frames up to a point 28in. above the keel being likewise welded on all sides. The vessel has nine W.T. bulkheads. She was finally assembled on the beach of the Thun Municipal Bathing Establishment, a strip being cut from the edges of the shell plates and annealed plates inserted, butt-welded in position. The welded seams were staggered in each row.—*"Engineering", Vol. 153, No. 3,966, 16th January, 1942, p. 45.*

Scotch and Watertube Boilers.

Scotch boilers are half as heavy again as watertube type boilers designed for similar service and they occupy considerably more space; a fairly small ship having two boilers and a single screw can probably have its boiler-room space reduced by nine or ten feet if watertube boilers are installed and, in addition, can probably have the number of boiler rooms and stokeholds reduced from two to one. A point against the watertube boiler is that it requires a closed stokehold with all its inconveniences, whereas Scotch boilers work satisfactorily with open stokeholds. The watertube boiler is, of course, the more efficient steam generator and its adoption involves a substantial saving in boiler plates, thereby releasing valuable raw material for other uses, although in some vessels this may be offset by the fact that loss in machinery weights might involve sufficient loss in stability to require permanent ballast. The problem of personnel affects both the construction and maintenance of ships' boilers. The construction of watertube boilers is more intricate than that of cylindrical boilers and calls for a higher degree of skill on the part of the boilermakers; there are, however, a number of firms in this country that have the necessary labour available and which are capable of a substantial output of marine-type watertube boilers, while in America, the latter are definitely the more familiar of the two. The question of maintenance is more difficult, since the majority of sea-going engineers in British ships of the tramp type have never had to take charge of watertube boilers. Scotch boilers require almost as little attention in service as ordinary domestic boilers, and on many occasions during this war the entire engine-room department, including the boiler-room, has perforce been left to the attention of firemen and greasers. Watertube boilers require more care and attention. If, as has been stated, many of the American Liberty Fleet ships and all those of the new coaster type, are intended for transfer to Britain under the Lease-Lend Act, it is possible that many vessels of the tramp type equipped with watertube boilers will have to be manned by British E.R. personnel. In this event it might prove to be desirable to arrange for some form of training for the latter, so as to ensure that there will be an adequate number of engineers and firemen available to maintain these boilers in good working order. To save future difficulties, it might also be worth while for the authorities to make a census of all the services required and resources available—raw material, labour, constructional and repair facilities and personnel.—*"The Shipping World", Vol. CVI, No. 2,534, 7th January, 1942, pp. 7-8.*

French Oil-burning Steamers Converted to Coal Firing.

Shortage of oil fuel is making it necessary to convert all oil-burning steamships in the French mercantile marine to burn coal. This conversion reduces the speed very considerably, for the coal now being supplied to ships come from the Loire mines and is of inferior quality, with a very high ash content. Moreover, the boiler-room staffs are not used to coal firing and will need several months of training to acquire a reasonable standard of efficiency in keeping steam. It is stated that the speed of some vessels has fallen from 13 knots when burning oil to 9 knots when burning coal, and it is feared that serious difficulties will be experienced on voyages during the winter months if the quality of the coal does not improve.—*"Lloyd's List and Shipping Gazette", No. 39,677, 14th January, 1942, p. 4.*

Westward and Eastward Passages.

During a recent crossing of the Atlantic on the homeward passage very rough weather was experienced and, although the ship concerned was fairly large and high-powered, the speed was much reduced. The opinion was expressed that had the ship been going westward instead of eastward the severity of the weather was such that she would have been unable to make headway against the storm. It is the general experience of vessels on the North Atlantic service that better average crossings are made on the eastward passage than on the westward. Over a long period of service the "Lusitania" averaged nearly half a knot more on the home run than she did on the outbound trip. Some records of the "City of Paris" were given in a paper by Mr. Wilding, read at a meeting of the I.N.A. in 1924. He stated that on 29 westward passages of the ship the average resistance factor was 1·323, whereas on the eastward passages this factor was 1·213. The resistance factor was defined as the average i.h.p. for the voyage divided by the i.h.p. at the same draught and speed under trial-trip conditions. These factors are sufficiently accurate to apply to modern high-speed liners, and in the estimates for powering the margin to be allowed for average weather conditions is taken into consideration. Occasionally exceptionally severe weather is encountered, but when the average is taken over such a long period as in the case of the "City of Paris", the data express clearly the suitable allowance to make.—*"Shipbuilding and Shipping Record", Vol. LIX, No. 3, 15th January, 1942, p. 67.*

Welded Ship Repairs and Fabrication.

An interesting example of the application of electric welding to expedite repair work is given in a recent issue of *"The Keel"*, the house journal of the Todd Shipyards Corporation. A ship had sustained considerable damage through grounding during a thick fog, and was dry-docked for repairs. Close examination of the damage revealed that the stem casting was fractured and would have to be replaced, but as the local foundries were unable to promise early enough delivery, it was decided to fabricate a stem piece from 1½-in.

rolled steel plate. This work was completed in six days and the ship undocked after ten days. It is stated that it would have been impossible to have a casting ready in this time. Owing to the heavy pressure of work on foundries both in this country and in the U.S.A., it is frequently found advantageous to substitute structures made from welded plates for castings, and fairly complicated parts of ships, such as stern frames, are now quite commonly made in this manner. The completed structure is quite sightly, as well as very efficient. It is impossible, of course, to dispense entirely with castings in the production of a large stern frame, as the propeller-shaft boss must be a casting, but this is a relatively simple item to manufacture. Stern frames of smaller ships are now frequently made of rolled steel bars welded together instead of forgings, and the results have proved satisfactory. Care has to be taken in the welding of such parts to ensure that distortion, which would be detrimental to the efficiency of the work, does not occur, but if a proper welding technique is followed, this trouble can be avoided. It is likely that the fabrication of many parts of ships which were formerly forgings or castings will be common after the war, for, as shipbuilders extend their welding plants, such work can be done economically in this way. Deck fittings, such as bollards, hawse-pipes, stanchions, derrick fittings and the like, can be readily fabricated by means of welding, and, as experience is gained in their manufacture, it will become increasingly profitable to use electric welding for this purpose.—*"Fairplay", Vol. CLVIII, No. 3,062, 15th January, 1942, pp. 120 and 122.*

Engines for "Liberty Fleet" Ships.

On the occasion of the completion at the Worthington Pump and Machinery Co.'s works of the first engine for the U.S. Maritime Commission's EC-2 class of ships, some further particulars of the engines were announced in the New York *"Journal of Commerce"*. They are stated to be of the three-cylinder triple-expansion type, developing 2,500 i.h.p. and weighing approximately 150 tons. The height from the bottom of the bedplate to the tops of the cylinders is about 23ft., and the overall length is just over 32ft. The engines are completely erected in the Worthington shops, tested, taken down and shipped to various yards on the West Coast, Gulf Coast and East Coast for re-assembly in the ship's hulls.—*"Lloyd's List and Shipping Gazette", No. 39,677, 14th January, 1942, p. 7.*

Experiments on Riveted Connections.

An account of some interesting tests made with riveted joints was given in a paper recently presented at the annual meeting of the American Society of Naval Architects and Marine Engineers. A rough idea of the stresses on the various parts of the joint was obtained by coating the specimens with brittle varnish, which cracked along the line of local strains, while accurate measurements were taken by means of an electrical strain gauge consisting of very fine wires firmly cemented to the surface of the plate. As the surface of the plate is stretched these filaments are also stretched and the increased electrical resistance which follows is a measure of the extension of the plate. The joint which was tested was the type used in American naval construction and consisted of a butt joint with double straps. The outer row of rivets in one of the straps was widely spaced, an arrangement not permitted by Lloyd's Register. To the main specimen, side plates were riveted covering the butt joint, so that the assembly represented a portion of a ship's deck. First of all, the specimen was tested to the capacity of the testing machine, and the distribution of the stresses estimated from the cracks in the coating. Stress measurements were not taken on this occasion, so that when the load was again applied and the gauges read, the condition simulated was that of a ship which had encountered heavy weather, and "settled down". The conclusions drawn from the experiments were that unsymmetrical joints are not reliable and that the practice of omitting alternate rivets in the outer row of a riveted joint is a bad one, as these rivets take an undue proportion of the load on the joint. The extent of the slip of the riveted joint was also investigated. It is generally conceded that slip does occur in riveted joints after the pull on the joint exceeds about 7 tons/in.^{2}, but it should be borne in mind that the experiments from which this information has been derived were not entirely applicable to the structure of a ship, for, owing to the shift of the riveted butts, each joint is reinforced by a solid plate; in structural engineering, of course, such conditions do not obtain. In these experiments it was found that the slip occurred from the start of the application of the load, and not after an interval, as other tests have shown, and the explanation was assumed to be that the pre-stressing of the specimen had caused the difference between the results obtained and those commonly accepted as showing the behaviour of a riveted joint. On account of the constraint offered by the adjacent strips of plating, which were riveted to the main specimen, the slip of the joint was much smaller than that usually observed, although, as already stated, it was perceptible from the application of the load. The extension due to slip was found, to be about two-thirds of that due to the straining of the material, and it is clear that in a plated structure, such as the deck, or the outside shell of a ship, where each end connection is backed by a solid plate on each side, the extent of the slip will be much less than the figure cited. The explanation of these and earlier results, so far as they affect the behaviour of the ship as a whole, would appear to be that a riveted ship "finds itself", as it has been termed, by the riveted joints slipping, while a welded ship arrives at the same state through plastic flow of the more highly stressed parts of the structure. It would seem, however, that the first form of construction will be more flexible than the second, which may, in some cases, be disadvantageous. There is room for experiments with full-size ships, in order to determine the degree of extra rigidity possessed by a welded hull. No doubt this matter will receive attention after the war.—*"Fairplay", Vol. CLVIII, No. 3,060, 1st January, 1942, p. 16.*

The Raider "Steiermark".

The commerce raider "Steiermark", which sank the Australian cruiser "Sydney" and was herself sunk, was a remarkable ship. It is not unlikely that this Hamburg-American Line cargo vessel was actually designed to be used as a commerce destroyer, as her Diesel-electric propelling machinery of 14,400 b.h.p. made her the highest-powered cargo liner afloat and her low fuel consumption gave her an immense cruising radius. The "Steiermark" was built in the Krupp shipyard at Kiel and was only completed after the outbreak of war. She was a ship of 9,400 gross tons, 524ft. 9in. by 66ft. 3in. by 30ft. 5in., equipped with four single-acting four-stroke 9-cylr. Krupp engines pressure-charged on the Büchi system, each of 3,600 b.h.p. and running at 240 r.p.m., driving Siemens Schuckert alternators which supplied current to a single propulsion motor. Her nominal service speed was 16 knots, but she was easily capable of doing 18 knots. Her armament was known to include at least six 5·9-in. guns, a couple of aircraft, and underwater torpedo tubes, besides those fitted on deck. Her complement was 400 officers and men, so that obviously she must have been entirely reconstructed. Her sister ship, the "Ostmark", may also be serving as a commerce raider.—*"The Motor Ship", Vol. XXII, No. 264, January, 1942, p. 325.*

New Deutz Two-stroke Engine.

A new self-contained two-stroke engine has been brought out by the Klöckner Humboldt-Deutz A.-G., Cologne, for marine and stationary work. It is rated at 68 h.p. per cylinder at a speed of 410 r.p.m. The two-cylinder engines are non-reversible, but those with four or more cylinders are directly reversible. A special feature of the design is the rotary scavenge blower, driven by a chain, which delivers the air to a horizontal trunk. The starting-air compressor is directly driven, and the lubricating-oil, bilge and circulating water pumps are located at the end of the engine. It is reported that the Deutz works are now producing two-stroke marine engines with outputs of up to 2,000 b.h.p., whereas before the war the maximum output of Deutz engines was about 1,400 b.h.p.—*"The Motor Ship", Vol. XXII, No. 264, January, 1942, p. 335.*

B. & W. Coverless Engines.

It is stated that, in 1940, Burmeister & Wain constructed 10 double-acting two-stroke engines of the new coverless design, a type which has not yet been built in this country. The 10 engines comprised 62 cylinders, the diameter of which is 550 mm. and the piston stroke 1,200mm. The exhaust piston stroke is 400mm. and the maximum output is 1,400 b.h.p. at 140 r.p.m., or about 1,000 b.h.p. at 105 r.p.m. The adoption of this design, together with the employment of electric welding, has enabled the weight per h.p. to be reduced by 8 per cent. below that of the normal B. & W. double-acting two-stroke type of engine. An experimental unit of this design, which was run for 6,000 hours at full load—approximately equivalent to one year's service at sea—has since been dismantled for examination, and the wear on all parts found to be very moderate.—*"The Motor Ship", Vol. XXII, No. 264, January, 1942, p. 353.*