The INSTITUTE of MARINE ENGINEERS

Founded 1889. Incorporated by Royal Charter, 1933.

SESSION 1943. **Transactions** Vol. LV. Part 2.

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

*Cargo Ships and Propelling Machinery adapted to War Conditions

Discussion (continued).

Mr. James MacLeod: The author has presented in his proposals for the production of high-speed cargo vessels an able attempt to reduce, and as far as possible to eliminate, the ravages of enemy action on marine transport, and in this he earns the respect and gratitude of all those engaged in this hazardous duty. Experience has shown that speed is the essence of efficiency, particularly in modern warfare, and any worthwhile contribution to this end in any direction merits immediate attention by the responsible officials of state.

The author proposes a vessel of 12,000-tons d.w. cargo capacity to operate at 18 knots in service on 12,500 s.h.p., but as it is not stated whether single- or twin-screw propulsion would be employed it is assumed this would be determined by minute investigation of the most suitable propeller for both fully loaded and ballast conditions on limited draught.

If single-screw propulsion were adopted geared turbine units of 12,500 s.h.p. of the type shown in Fig. 21 would meet specified requirements. This unit weighs 40 tons and when supplied with steam from a pair of light-weight high-efficiency marine-type oil-fired watertube boilers, the fuel consumption for a transatlantic voyage of 3,000 miles would be 510 tons.

Twin-screw propulsion, however, although heavier (65 tons weight as compared to 40 tons for single-screw propulsion), offers certain important advantages in hull design, propulsive efficiency, and a higher degree of immunity from total disablement with increased manœuvrability, which may finally justify its adoption for high-powered vessels of the type proposed, the boiler equipment and fuel consumption being the same as for the single-screw arrangement.

Marine propulsion units of this type are well suited to mass production methods of manufacture. The production costs are less than that of the corresponding reciprocating engine of equal power

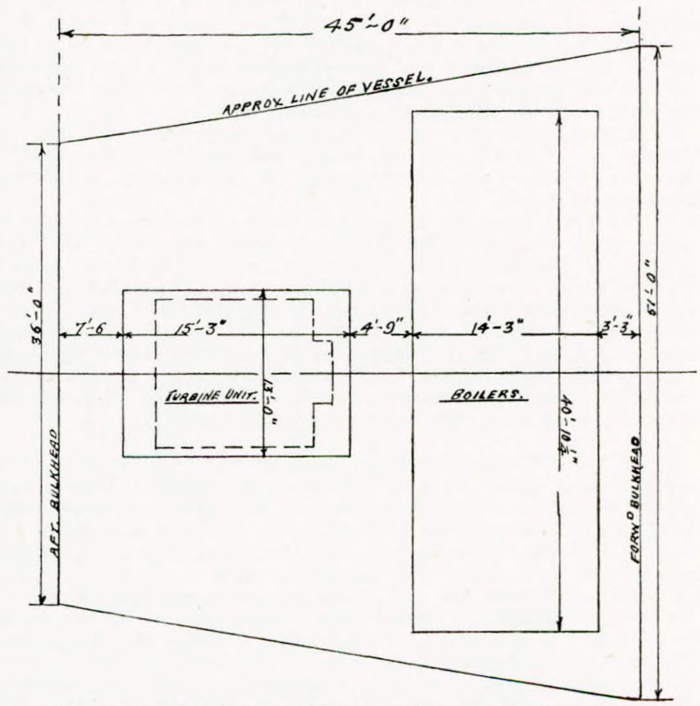


FIG. 22.—*Plan showing combined engine and boiler spaces for 12,500-s.h.p. geared turbine unit with watertube boilers, single screw.*

and, due to the self-contained unit design and light weight, may be produced in factories external to the existing shipbuilding and engineering establishments and delivered aboard ship where the only operation required is the lining up and coupling to the propeller shaft. This method was adopted with success in the production of the 2,500-s.h.p. unit built by Messrs. Belliss & Morcom, Ltd., Birmingham, the gear section being supplied by Messrs. David Brown & Son, Ltd., Huddersfield. In this way shipbuilding establishments would function as assembling stations with considerable increase in production of finished ships.

The complete geared-turbine unit installation for single-screw propulsion would weigh 222 tons for 12,500 s.h.p. and the fuel consumption for the round transatlantic trip of 6,000 miles would be 1,020 tons. The twin-screw installation would weigh 247 tons with the same fuel consumption.

The machinery spaces would be arranged as far aft as possible,

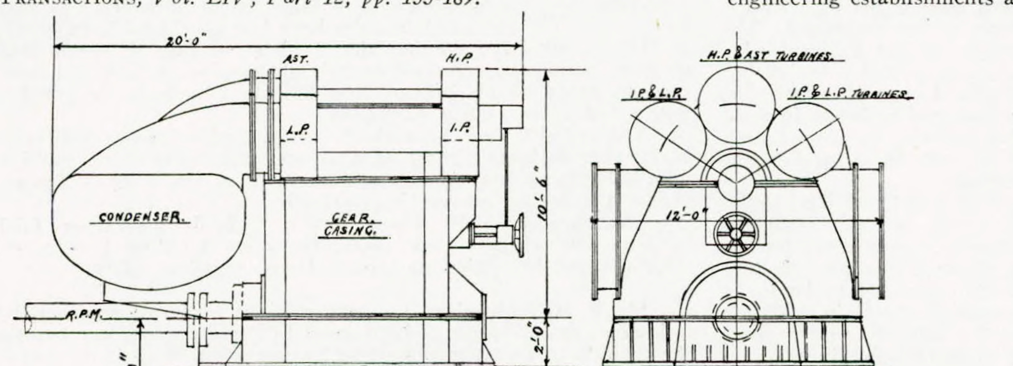


FIG. 21.—*12,500 s.h.p. geared turbine marine propulsion unit (combined total weight, 40 tons approx.).*

This paper, by W. S. Burn, M.Sc. (Member of Council), was published in the November, 1942 issue of the TRANSACTIONS, *Vol. LIV, Part 10, pp. 129-146. The first part of the discussion and author's reply was published in the January, 1943 issue of the* TRANSACTIONS, *Vol. LIV, Part 12, pp. 155-189.*

limited only by the overall width of the boiler casings, thereby reducing the length of the tunnel and propeller shafting to a minimum, while retaining for cargo that central portion of the vessel which is most effective. Fuel and water would be carried in the double bottoms and on both sides of the machinery spaces if possible. With light-weight machinery such an arrangement would appear feasible without adversely affecting the trim of the ship under light and fully-loaded conditions.

It will thus be seen that a considerable saving in weight has been accomplished, and this saving may be increased by a suitable increase in boiler ratings without materially affecting the efficiency, the extent to which this could be made depending upon the ratio of weight saved to additional fuel carried.

Mr. W. L. S. Moore (Member): One of the writer's criticisms is the difficulty in organizing this new project. It appears that the necessary experiments, alterations of plans and drawings, and possibly reorganization of shipyards to meet the new design would cause the first ship to take between two to three years to complete.

So far as the writer can ascertain there are only about nineteen dry docks in Britain capable of accommodating a vessel of 80ft. breadth, only one of which is on the East Coast, and whilst these may be adequate for a small number of these cargo warships, they would not be sufficient for the subsequent needs of an ambitious shipbuilding programme. The writer finds, generally, that the existing dry docks are insufficient for present needs.

Further, there are many important harbours which are not capable of efficiently accommodating such vessels as these, which would have the effect of interfering with the efficient and speedy handling of traffic.

The great pains the author has taken to design an unsinkable vessel are praiseworthy, but the writer cannot understand why he is content to propel it with a Diesel engine, which in the writer's opinion is not so reliable as a turbine engine. The writer's experience is that most Diesel engines require constant repair and overhaul after each voyage, so much so that several repair shop managers have stated that "if all British vessels had been driven by Diesel machinery in 1939, the Battle of the Atlantic would have been lost in 1941". Many good turbine vessels run for years without any overhaul, except for the usual classification surveys.

Mr. T. U. Taylor: This paper is an attempt to solve comprehensively a very large and very controversial problem. That a case could be made out for the building of fast cargo warships might be generally admitted, but it is also clear that such a policy would involve a drastic alteration in our naval strategy, and in our present methods of shipbuilding and ship-management.

The writer does not feel competent to express any opinion on these high matters, but would offer some comments on the design put forward by the author. In the writer's opinion this design propounds more problems than it solves. An instance of this is given by the author's proposal to fit flush watertight covers to the weather-deck hatches, and blast-proof hatches to the second deck. The author's design is largely dependent on the satisfactory practical embodiment of these two features in a ship which is to be mass produced. Yet no indication is given of the lines on which these admittedly difficult problems are to be solved. Many designs of watertight hatch are on the market, yet it would be admitted that no wholly satisfactory solution has been found in the case of the large hatches of ocean-going cargo steamers of low freeboard. The necessity of making the hatches also airtight against a considerable pressure head due to flooding, and the proposal to make the hatches *flush*, complicates the problem immensely, and even if practicable, would certainly make them costly to produce and maintain in good order. The production of blast-proof hatches for the second deck raises similar problems. The fastenings of such large hatches, for instance, would need to be immensely strong.

Turning to the design generally, it will be noted that the length/depth ratio is 15½, an exceptionally high figure, and this combined with very large hatch openings would necessitate very heavy topside scantlings, and a very uneconomical use of steel. Another feature is the freeboard of 8ft. proposed for a ship intended to land aircraft. This is absurdly low, as the deck would be awash in moderate weather. This criticism also applies to the catapult on the forecastle, which is so near the waterline as to be unusable in anything but a dead calm.

The internal "blister" also strikes one as being totally inadequate. The author quotes data from the last war, but the technique of destruction has advanced considerably since then, and it seems probable that very much more extensive and elaborate side protection would be necessary.

Another feature which raises problems to which, in the writer's opinion, only an extremely expensive solution could be found, are the cargo lifting appliances. The radius of the cranes proposed appears to be about 35ft. with a lift of 25 tons. The provision of even 5-ton lifts on a crane of this radius would mean a heavy and costly piece of apparatus. It may also be remarked that the Admiralty are at present asking for lifts of 80 tons from the main hatch in vessels of this size, and it is difficult to see how this requirement could be met without lifting gear very much more costly and elaborate than the derricks now fitted. Incidentally, the author remarks that the height of the crane posts is such as to be below the underwing height of most high-wing aircraft. The writer thinks it is correct to say that all modern warplanes are, for reasons of aerodynamical efficiency, of the low-wing type. Apart from this, however, it is to be doubted if anything but a completely clear flight deck could be considered acceptable. In the event of a faulty landing (a not remote contingency in bad weather), the pilot is unable to "fly off", and has no alternative to a probably fatal crash.

There are many other difficulties raised by this design which can be only briefly indicated. The beam of the ship, for instance, is 80ft., which places a limit on the number of ports which can offer docking and drydocking facilities. This raises the question of the degree of adaptability required of our merchant tonnage. If we are short of shipping, and have to envisage at least the possibility of becoming progressively shorter, it seems we cannot afford to build ships which are incapable of being switched at short notice from one route or service to another.

Another feature which calls for criticism is the alleyway which completely encircles the inside of the ship. There is not much doubt that a torpedo hit would immediately flood this alleyway and the remainder of the ship on the second deck with which it communicates. The only portion of the waterplane remaining intact would be that confined by the bulkheads of the undamaged cargo holds, with possibly disastrous effects on the stability and trim. This alleyway, moreover, is the sole means of access for the crew apart from any escape hatches which might be arranged in the flight deck and it is probable that the whole of the crew below decks would be trapped without warning.

The author's general remarks in justification of his design are also open to criticism. He remarks that "it is not generally realized that a ship fitted with watertight steel hatches is much less liable to sink than a ship with loose or loosened hatches". If the author's paper were intended for publication in the daily press this remark might be justifiable, but since it is a contribution to the proceedings of a technical society, one is entitled to ask, "by whom is it not realized?" It is in fact realized to the extent of being embodied in recommendations of the Ministry of War Transport affecting the safety of oil tankers in danger areas, and so far as other types of ship are concerned the question is not one of realization but, as already indicated, of finding a practical solution to the problem. To this the author makes no contribution.

Similarly, the author's remarks on longitudinal subdivision are truisms, but he does not seem to realize that "blisters" are a form of longitudinal subdivision. The "blisters" shown in his own design, would not, it is true, cause a very large heel if open to the sea, but, as pointed out, they are probably inadequate. The problem which confronts the ship designer is to make the "blisters" of sufficient width to protect the main hull, and yet not so wide as to endanger the ship by producing a large angle of heel when open to the sea. The British Admiralty have had considerable experience of this problem, and the fact that neither our own ships nor those of other nations have proved capable of standing up to well-directed torpedo attack, simply indicates the difficulty of solving the problem, not a failure to realize its nature.

The criticisms of the author's design outlined above will strike every ship designer almost at a glance, and many more could be added, but they are all fundamental and, in the writer's opinion, render the design entirely impracticable.

That cargo warships of some kind could be designed seems fairly obvious, but whether they would be worth building is a matter which cannot be settled on technical considerations alone.

Mr. P. H. Bothamley: The writer is not a marine engineer, but a designer-draughtsman of high-speed I.C. engines, and has attacked the problem in a manner diametrically opposite to that of the author. Instead of a large, heavily-defended ship, the writer submits that a large number of small, fast ships, dispersed over a wide area of ocean is equally worthy of consideration. Sailing in convoy is simply asking for concentrated attention and wasteful of escort vessels, whereas a small isolated unit would not be worth attacking in force. If these small boats had a good turn of speed, say 20 knots, and were armed in the rear by a gun, supplemented by AA. armament (and, possibly, depth-charges), they would be a tricky proposition to tackle.

Further, the writer understands that a torpedo must travel about 10ft. below the surface in order to obtain accuracy, so that a boat drawing only, say, 8ft. draught, has a good chance of avoiding a hit. Also, a low freeboard would help in avoiding detection and shell-fire.

Such vessels would have to be capable of quick and cheap production in large quantities, easily manned, and incur no serious loss if destroyed. Peace-time standards in marine engineering must be overridden, and if these ships saved the situation, they would have done their job and could be scrapped when the war ends.

Fig. 23 illustrates the sort of thing the writer has in mind. It is 200ft. long, 25ft. beam, 8ft. loaded draught, total depth 16ft., and has an approximate loaded displacement of 1,000-tons. The whole job is like a submarine in character—decks awash, low freeboard, etc., and a welded steel "stressed skin" construction is used for the hull. The machinery, fuel, crew's quarters, conning tower, armament and lifeboat are all grouped aft, the main body being cargo space. It is almost flat-bottomed, and could be beached for loading and unloading. A crew of six or eight could man her across the Atlantic.

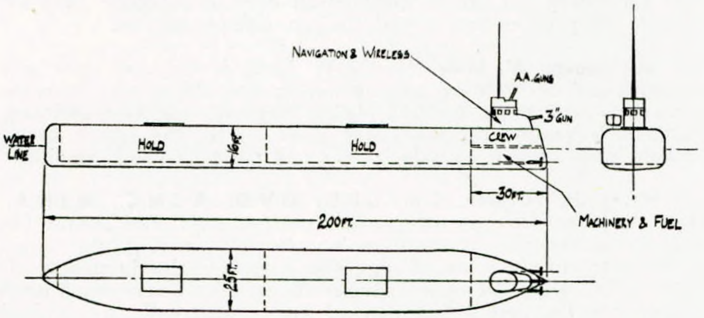


FIG. 23.—*20-knot cargo ship (1,000 tons total displacement).*

According to the writer's calculations, a shaft-horsepower of around 3,200 would be required to produce 20 knots, and four 800-h.p. Diesel engines of modern high-speed type could be employed, geared to twin screws, through a reduction and reversing gearbox. Actually, there are Diesel engines available, with which the writer has been concerned, of 400 b.h.p. (unsupercharged) when revolving at 2,200 r.p.m., weighing about 35 cwts. complete, and measuring only 4ft.×4ft.×3ft. Although their crankshafts may not conform to the rules of Lloyd's Register of Shipping, they may be run for 100 hours and more continuously at maximum power without trouble, and can be produced in quantities by semi-skilled labour for under £1,000 each. Eight of these engines would be ideal for the purpose, if the transmission problem could be solved.

Reckoning on a fuel consumption of 0·38lb. per b.h.p./hr., about 80-tons of fuel would have to be carried for a 3,500 mile range, and that, the writer agrees, is a lot of fuel for such a small carrying capacity. The estimated weights are as follows:—

Hull structure	120 tons.
Main engines and accessories	20 „
Transmission and propellers	10 „
Fuel	80 „
Navigation equipment	5 „
Crew's quarters	5 „
Armament and ammunition	5 „
Loose fittings, etc.	5 „
	250 „
Cargo, or useful load	750 „
	1,000 „

Normally, the writer knows, such vessels would be uneconomic in fuel, material, man-hours and docking space, but it is suggested that any plan to transport a given mass of freight across the Atlantic under present conditions must take sinking losses and escort vessels into account. If a proposal eliminates (or vastly reduces) these latter, then it starts with an extremely heavy advantage.

To sum up, the writer's proposed vessels would have a low sinkage rate, owing to their high speed, low freeboard, shallow draught, and dispersed usage; they could be built quickly and cheaply *with existing facilities;* they may be built and manned by low-grade easily-trained labour; they would be flexible in use, and need no docking space; they would have a quick "turn around", and be "cheap to lose".

Their seaworthiness in heavy weather may be open to question, but submarines and trawlers appear to survive the mid-Atlantic. After all, comfort is now rather a minor consideration.

The writer knows the author will agree that something must be done, and done quickly. Perhaps the writer is wasting the author's time, but not being a marine man, he sees few snags. Perhaps the author would be kind enough to enlighten the writer.

Mr. H. S. Humphreys (Member of Council): Whilst fully appreciating the author's initiative and originality in his proposed design, the writer's first reaction on reading the paper was that the proposed cargo warship was of such revolutionary design as to rule out any hope of its adoption or development as a feasible proposition during the course of present hostilities. The proposed vessel could not come "off the drawing board" with any guarantee of its immediate success, and much work of an experimental nature would be required in the course of its natural development after being built. Also, as regards actual construction the time factor would be decidedly unfavourable in comparison with the more or less standard type vessels and engines now in production. There is also the present extreme difficulty in obtaining the necessary skilled marine engineers for such vessels and the writer considers it can hardly be said that the fourth year of war is a suitable time for the introduction of anything demanding such experimental or research work, he being of the opinion that the greatest need to reduce losses is the provision of a super-abundance of escort vessels, rather than any major alterations in the design of cargo carriers.

It is extremely difficult to contribute except at great length but in view of the appeal made in the January TRANSACTIONS for further discussion an attempt is made to present another aspect.

The position of the British shipbuilding industry at the outbreak of hostilities was analogous to the position of our military equipment after Dunkirk. In short our shipbuilding industry had to start more or less from scratch, seeing that in the year of Munich only some quarter of a million tons of shipping was produced in this country. It is no use blaming any one person or any one government for this lamentable state of affairs in our island nation. We are all to blame for having lived in a "fool's paradise" for some 20 years prior to the war. We all know that the Royal Navy was strained to the limit and undoubtedly the first consideration was to concentrate on escort vessels and to "make do" with existing facilities for building merchant vessels until the necessary skilled labour, equipment, etc., could be built up to the required standard for improvements in design, etc.

In the proposed design sufficient consideration as regards size of berths, drydocks, port facilities and manpower does not seem to have been given. The proposal to fit a propeller and rudder at the forward end of the ship appears to be impracticable on account of the damage which would be sustained. Also, to those who have spent many years at sea in the Western Ocean trade, it does not need much imagination to observe that the flight deck in the original design would be under water at many periods of the year.

It is suggested that the sparks emitted at the funnel by the type of engine proposed might cause more losses due to the ship's position being given away to a night marauder than a higher superstructure. Furthermore, machinery reliability is of the utmost importance in wartime, for although in peacetime—provided a Diesel vessel has ample spares—machinery defects can be rectified at sea, in wartime the vessel must go on or return to port to rectify these defects; otherwise she becomes a "sitting bird" for the enemy.

As regards new construction the tendency is for speeds to be increased, but with powers such as would be required for the 18-knot proposal, *i.e.* 15,000 b.h.p. service, serious consideration should be given to turbines with high-pressure water-tube boilers which can now be constructed with very high power/weight and power/space ratios, and their reliability is beyond dispute.

It appears to the writer that the time has arrived when the tonnage rules should be modified, seeing that with either turbine or Diesel prime movers, ample machinery space can be provided in less than the 13 per cent. now required to obtain the 32 per cent. deduction from the gross, and it is of course recognized that the smaller the engine-room space the less liable is the vessel to become a loss in the event of damage in the engine room.

The writer agrees that tankers, except for fire risk, are more immune from the result of torpedo action than cargo vessels, but there are many border-line cases where tankers could be saved in the loaded condition if the engine room were made smaller and certainly if an upper poop deck were fitted to give more reserve buoyancy aft. Incidentally, the fitting of an upper poop deck would allow of better accommodation for the extra crew which is now required for defensive armaments, but there is one accommodation space which should be deleted in all vessels and that is the engineers' messroom; the engineers should of course live and dine with the other officers. It is suggested that any improvements which might save life and ships, should not be penalised by tonnage considerations.

It is noted that the author has amended his design in several respects, e.g., to improve accommodation and to raise the flight deck. Has the author considered that the aircraft carrier steams into the wind when the aircraft take off, which has the effect of increasing the run, but if the 'plane has to take off from aft this would greatly reduce the run?

An air salvage and fire-fighting equipment is now fitted in tankers and it is suggested that when sufficient Diesel-driven compressors are available an air line should be fitted in all types of vessels, as not only is this most beneficial from the point of view of blowing tanks, fire fighting, etc., but the air line can be used for steering gear, windlass, etc., if the steam line is put out of action. It is also suggested that an air whistle should be fitted on the foremast in all vessels as an aid to navigation in avoiding collisions, etc., in foggy weather.

Mr. W. Veysey Lang (Member): The time seems too advanced in the war period to re-arrange our shipyards and engineering shops. New plans, designs, tests, patterns and foundry equipment would take many months to improve. U-boats must be combated not competed with in 1943-44. After the war, the need of gross tonnage will be greater than speed itself can provide; much time will be lost in loading and discharging cargoes at damaged quays and due to railway congestion in war areas.

Extra speed of vessels can only be attained—upon a given deadweight—by increased dimensions of hull, propelling power and cost.

Probably the most *economical* speed to transfer cargoes of 5,000-7,500-10,000 tons d.w. is eight knots (or 200 miles per day of 24 hours). The modern tendency has been to specify 10 knots which, on *any* deadweight, increases the $L \times B \times D$ and power and cost.

Extra power means extra first cost, fuel consumption, bunker space, crew accommodation, and maintenance, on a comparative d.w. of cargo carried; or less cargo on a comparative $L \times B \times D$ and power. For world-wide trading purposes the *less* the $L \times B \times D$ is —on a definite d.w.—the greater the number of ports, harbours, docks, locks and drydocks available for entry and exit. Draught controls accessibility to harbours, berths and river bars.

In a paper some years ago, on cargo ships, the writer was able to illustrate, from an analysis of Lloyd's Appendix, that as the dimensions increased so the available accommodation of docks, locks, and drydocks seriously decreased all the world over. Port accommodation must be greatly improved if larger d.w. tonnage is required, and much better loading and discharging appliances provided if it is to be worth while to increase ocean speeds.

Economy in sea transport is entirely a question of the cost per ton per mile from one port to another. The advantage in speed is not so manifest when it is considered that quoted freights for d.w. cargoes of coal, grain, oils, timber, etc., are not referred to with any stipulation as to speed. Eight knots speed being (approx.) 200 miles per day, ten knots is only 240 m.p.d.—that is across the open seas. But for narrow waters—rivers and canals—the lower speed would be at no disadvantage where navigation is controlled. In inland waters, a slow speed governs *all* ships regardless of *power*. A fast ship has no advantage whatever over a slow ship (of similar d.w.) when it arrives at tidal rivers or bars. In fact, the greater the draught the longer the wait may be, and *vice versa*. As to time in loading and discharging, there is no difference as between any speeds and powers of equivalent d.w. cargoes.

Generally speaking, the faster ship only gains on a long voyage. For short voyages economy is undoubtedly with the lower power and cost.

Two ships of 10,000-tons d.w. and 8 knots speed could probably be built at the same cost and in half the time of one of 16-knots speed and same d.w. Our well-informed and experienced shipbuilders and engineers could soon settle that point—re cost.

Shipowners of 30 years ago made fortunes by fleets of 8-knot ships—built at about £5 per d.w. ton; with the rise in pre-war days to 9-10 knots, the cost was around £10 per d.w. ton. But at 18 knots the cost would be £20 and over—a good deal over the writer expects!

Future shipowners are going to run ships on business lines—as in pre-war days—and not on altruistic ideas. Shareholders will only invest with a prospect of a return on their capital.

So much for a general comparison of speed versus economy.

The new suggestion the writer has to put forward is on the basis of a 10,000-ton d.w. and 10-knot vessel, with single-screw power amidships, and coal-burning of the usual type. For wartime service or for extra speed for special voyages, a pair of oil engines right aft (with port and starboard wing propellers) might be fitted to attain a maximum speed when required.

Comparatively small powers would increase the speed to 12 knots, or even 14 knots, and the least valuable of ship space would be occupied, *i.e.*, in the after run, with little encroachment on cargo space or of d.w. High engine seatings and shaft lines and, of course, smaller propellers at high revolutions are suggested.

Oil fuel would be carried in the after ballast tanks, but only on such special voyages as the extra speed and power were required.

The wing propellers could be feathering or centering, or uncoupled by clutch and run free when not under power, or even taken off afloat before loading. Such auxiliary engine power could be taken out at any time—if so provided for.

N.B.—Any propeller forward would interfere with anchors and cables. The backwash would be against the hull.

Finally, it should be borne in mind that coal is our only national fuel for power and can be obtained all over the Empire. We are almost solely dependent for oil fuel on foreign sources.

Mr. George W. Muir (Member): There is only one sure way to safeguard an existing transversely-framed ship under wartime conditions—strengthen the hull plating externally and longitudinally, particularly around the machinery space. Save the engine room, and the ship with its valuable power and pumping plant remains.

Mr. J. H. Narbeth, C.B., C.B.E., M.V.O., R.C.N.C., M.I.N.A., (late Assistant Director of Naval Construction): The author has shown commendable goodwill in his efforts to modify the design as necessary to make use of suggestions made in the discussion. It appears, however, that some of the issues raised are very much more grave than the author has realized and consequently the revised design is far from perfect.

The writer would have much preferred to discuss these serious issues before a committee, where perhaps some members might have assisted the author to appreciate the gravity of the issues, and to benefit from their experience. While the writer still admires the courage and ingenuity of the author he must state very clearly that concurrence in the proposals is quite another matter.

Those revised proposals must be considered, not as a sort of general invention, but as a particular and definite proposal to build a ship. "Wishful thinking" must therefore give place to scientific method and the hard logic of practical experience. The following remarks have been prepared on that basis and are submitted with the greatest diffidence. It is an unpleasant task which is attempted only because of a strict sense of duty and loyalty to truth.

It has not often been the writer's duty to undertake such an undesirable task. During his official career there were a few important occasions on which he felt compelled to do so, but he has the satisfaction of knowing that the authorities of the periods accepted his efforts with very great benefit to the Navy and the Nation. It is therefore hoped that the following remarks will be accepted with the same goodwill with which they are offered and in which previous remarks were accepted.

To make the matter as impersonal as possible it is proposed to summarize the remarks as an assumed

Draft Report of Committee on Design.

(1) Essentials Lacking.

A shipowner desires a statement of weights showing amounts of fuel, stores, provisions, etc., for a round voyage; water for ship and machinery; outfit of boats, anchors, cables, etc.; total deadweight; and remnant available for paying cargo; also a rough estimate of gross and nett tonnage and of cargo capacities in cubic feet. He also wants to know average sea speed expected after allowing as usual for weather and for condition of fouling of outer bottom; estimated time of an Atlantic crossing, say from New Orleans to Liverpool, allowing for a devious course, zigzagging on that course, margins for diversions to avoid any submarines reported, and for reasonable bunker at the end of the round voyage. He also wishes to know how many round voyages could be made per annum, making reasonable allowances for times for turn-round, for regular overhaul, and for annual refit.

A naval architect wishes to see a midship section with full particulars of scantlings of all steel materials, and a fuller statement of weights showing requirements for torpedo protection; guns, mountings, ammunition and accessories; aircraft and incidentals such as bombs, stores, workshops, flying-off and arresting gear; main machinery and auxiliary machinery separately; as well as stores, including lubricating oil for the round voyage. He also desires to see a metacentric diagram together with curves of stability under various conditions of lading; as well as flooding and girder calculations under usual assumptions.

None of the foregoing particulars is supplied, except deadweight which appears to be a nominal figure only.

(2) *Not a General Cargo Ship.*

Many years ago when Sir William White suggested more watertight bulkheads in merchant ships he earned the undying hostility of a well-known shipping magnate. Bulkhead legislation which followed the loss of the s.s. "Titanic", also aroused bitter resentment, of which a very powerful echo was heard in Newcastle only ten or eleven years ago.

The one outstanding safety feature of the design is to fit so many more bulkheads that the main holds are only 24ft. in length. Since 1920 the cry has been "Hands Off Merchant Shipping", so that the proposed vessel would not be accepted by the shipping community as a general cargo ship. Good use could no doubt be made of a number of such ships as freighters for transport of boxed cargo, bales and packages.

(3) *Classification Doubtful.*

The upper and main decks are so badly cut away that there remains *no strength deck* in the ordinary sense, and the classification rules of Lloyd's Register for 100 A1 ships would probably not be applicable. The registration societies might, however, be willing to advise what strengthening would be necessary to enable them to permit a special certificate to be issued.

(4) *Structural Stresses High.*

The overloading of the ends of the ship by large weights of machinery combined with the very poor type of midship section as regards inertia, will tend to produce unusually severe stresses in the upper works of the ship when riding over waves, and will provide considerable risk of the ship breaking her back if struck amidships by a torpedo. As a result of the high stresses, the seatings for the hatch covers will be in a constant state of motion at sea, thus tending to break the joints and cause flooding of the holds. Any idea of making such joints airtight seems rather far-fetched. Handling the large hatch covers when the holds are opened will need special care, otherwise they would be liable to damage and distortion by rough handling, thus increasing the difficulty of keeping them watertight. In addition very special care would constantly be required when securing the covers to prevent them becoming loosened and washed overboard in heavy weather.

(5) *Torpedo Protection Doubtful.*

The forces let loose by a torpedo explosion are so immense that the "chequer-board" stiffening of the side would be of very doubtful value. It would, however, absorb a large amount of labour which is not available. Any weight of steel to spare should preferably be put into the transverse framing leaving the outside plating to act in the nature of a yielding, elastic covering rather than as a rigid beam.

When the plating bursts inwards the high-pressure gases will follow and will tend to be bottled up by the horizontal corrugations of the protective plating. The corrugations should be vertical rather than horizontal, so as to encourage the high-pressure gases to rush up to the vent plates. As arranged, the hammer blow of an explosion would be likely to tear the protective plating away from end to end of the compartment, damaging both transverse bulkheads in the process and so flooding three compartments by one explosion.

The protective plating is shown to be 3 to 4ft. from the ship's side. This is not considered to be sufficient. Even if fitted at a much greater distance the explosive gas pressure would still be very violent. At the foot of this plating a strong longitudinal or shelf should be fitted to permit of complete access and maintenance. Any proposal to fill the lower portions of the wing compartments with sand seems of very doubtful value; and in case of damage the entry of sand into the pumping systems and valves in the ship might introduce some serious difficulties. Coal acts as a shock absorber, as energy is spent in pulverising the coal.

(6) *Results of Low Freeboard.*

The principle of low visibility so as to reduce the risks of discovery, identification and destruction at sea is one of primary importance. It is therefore most desirable that smoke, funnels, masts, deck-houses and other top-hamper, as well as freeboard, should be reduced to the lowest possible limits consistent with safe navigation and the maintenance of efficient wireless systems and other means of communication with, and identification by, friendly warships, etc. It was carried out in "P" Boats of the last war with considerable success. There are, however, some disadvantages which must be considered in the design of the cargo-warship.

Low freeboard means a small reserve of buoyancy, and so tends to nullify the advantages of better watertight subdivision. Owing to the absence of forecastle and deck-houses, habitability will be distinctly prejudiced. The whole of the upperworks will often be swept by the sea and difficulties will thus arise in connection with air supplies and exhausts, especially for the machinery compartments at the bow and stern. The escape of men from a mess deck in a torpedoed compartment would perhaps be difficult.

For such a lone, long ship, good clear all-round views of sea and sky are necessary from positions at bow and stern and on each side amidships. Without these the ship becomes purblind and an easy prey to the U-boats.

First-rate all-round views are absolutely essential to enable observers to spot the tell-tale line of bubbles of an approaching torpedo while it is yet so far away as to give the ship some chance of manœuvring to avoid the torpedo. Such clear look-outs are also essential for detecting and identifying enemy aircraft, as well as the submarines themselves or their periscopes, at the greatest possible distance. First-class manœuvring qualities in the ship will be necessary.

If steaming head to sea, waves would rush up over the bows and break over the hangar in great clouds of spray, which would signal the ship's movements for miles around. Seas would also continually break against the boats and the samson posts, and so create revealing clouds and trails of foam which would exaggerate the visibility of the ship.

(7) *Effects of Great Beam.*

The beam of 80ft. in conjunction with the draught of 28ft. implies a very large metacentric height which would sometimes make the ship a quick roller and such an unsteady gun platform that good aiming of the guns would be very difficult. As the deck edge rolled under, seas would break over it and so help to reduce the rolling; meanwhile they would be likely to damage the boats, and to send up great revealing clouds of heavy spray which would fall and sweep heavily across the hatchways and other portions of the flying deck.

The great beam would often make the vessel too lively, an unsteady platform and a bad sea-boat.

(8) *Manœuvring Power Poor.*

For a vessel 525ft. long and 28ft. draught, a main rudder about 7ft. by 12ft. seems much too small and likely to give the ship very indifferent manœuvring qualities. This defect again would tend to make the vessel an easy prey to U-boats waiting for her to come along. The slow manœuvring would very seriously increase the risks while turning the ship into the wind to send off aircraft. Much better manœuvring qualities could be obtained by fitting twin screws with a large spade rudder behind each. The duplication might also prove of very great advantage in case of accident or enemy action.

(9) *Bow Rudder and Propellers Risky.*

A bow rudder is notoriously inefficient when steaming ahead, but it may be a useful expedient on a channel steamer which has to back out of a narrow harbour.

Bow rudders and propellers would be liable to be jammed by flotsam and jetsam or by ropes and wreckage. If used at sea they would be liable to send up clouds of revealing spray.

A strong clear bow is needed to enable tugs to come alongside, or to nose against the bows, when handling the ship in harbour; it is also most desirable to enable the ship to nose herself into position alongside a jetty or a dock wall.

A clean strong bow is also required to enable the ship to crash through ice-fields and ice-floes, to ram submarines if the chance occurs, and to mount the paravanes. A bow rudder and bow propeller are incompatible with these requirements.

(10) *Disadvantages of Machinery Plans.*

The overloading of the ends of a ship by the propelling machinery makes the longitudinal inertia of the ship excessive; the ship will respond comparatively slowly to the movement of the sea, and so tend to behave "like a log" on the water. In passing over large waves the reversal of stresses in the upper works will be made unusually severe. As the machinery is so near to the ends of the ship an attacking U-boat would know exactly where to aim, and as the vital portions of the machinery are above water the ship could be completely stopped by a few shells from almost any gun now carried by a submarine. The result might be obtained by damaging engine, motors or electric cables. It seems unwise to rely on a single propeller and shaft for such a high-powered, valuable ship.

Two sets of machinery aft, well separated and placed below water, would involve less risk, as the number of torpedoes available would be much less than the number of shells and the chance of hitting is in favour of the shells.

(11) Well-proved Engines Required.

It must be recognized that although engines of the aero type are being used for motor boats, their use for ships still belongs to the Jules Verne period; their endurance at present must be reckoned in days not in weeks, but it is pleasing fantasy to imagine what might be done at some future date.

This is not an occasion for special efforts at economy of weight or of economy of fuel. Reliable engines of the simplest type possible should be preferred, not only so but such engines should be repeats of examples in pattern and power which have proved satisfactory and efficient under strenuous conditions of actual service. In addition they must be of such a character as can be rapidly produced by the man power and plant now available in this country. Admiral Land, who may be trusted to prefer Diesel engines, has stated that conditions of rapid production have compelled the U.S.A. to continue to build steam engines for propulsion, and it may well be that in this country also workmen skilled in the manufacture of internal-combustion engines are more urgently required for the Services.

(12) Speed versus Cargo.

It is perhaps a truism that in the event of single combat higher speeds improve the chances of a merchant ship escaping from a submarine. But speed is costly. As power increases the amount of fuel required to transport cargo across the Atlantic rapidly increases until the tons of fuel become very great and the tons of cargo very small; so that with high speed a very uneconomical position may be reached.

The latest German system of using packs of U-boats arranged *en echelon* on the ship's path has proved very dangerous to convoys, but it would appear to mean sure disaster to any single ship which ran into the trap, no matter how great her speed. Experience may again repeat itself if an attempt were made to send unescorted ships across the ocean. The question of economy versus risk can only be settled by experience. It has been officially reported that both in this country and the U.S.A. the authorities fully realize the advantages of speed, and it appears that the faster vessels are classed and run in faster convoys. In both countries the production side imposes very unpleasant limits to large experiments on this subject. In addition to requiring increased quantities of fuel the high-powered ship involves very much greater demands on labour in her construction, thus increasing the difficulty of producing numbers of fast ships.

(13) Gunnery Inefficient.

Experience with vessels of the "Attendant" Class indicates that the cargo warship would not roll heavily, even in very severe weather, although it could be what the sailors call a very "wet" ship.

In the R.A.F. "Attendant" the seas broke in freely over the main deck shelf, and no doors of any kind were permitted in the fore and aft trunkway bulkheads. The same process would operate with great advantage in the cargo-warship in many circumstances. But then all the doors and openings in the cargo trunkway bulkheads would need to be specially well secured to prevent water from entering the ship.

The main deck is shown 7ft. above the water, and this height would prevent this action occurring so freely as in the small ships referred to. As a result a quick, jerky roll of 7° to 8° from normal to wave slope would be expected, and the ship would then be an unsteady gun platform. If the sea is heavy enough for the waves to break over the shelf and induce this steadying action, the gun positions would probably be untenable.

Long experience in the Royal Navy has shown the futility of placing quick-firing guns too close to the water. Such guns require to be quite a good height above the water, and to be so placed that the gunner has a wide range of vision of sky and sea. The guns shown on the drawings are much too close to the water, and the vision of the gunners far from satisfactory. Even if these guns were efficiently placed they are not sufficient in number to have a reasonable chance if under attack from air or sea. No vessel should venture alone on the ocean without a good battery of revolver-cannon to keep aircraft away if possible, and if not to bring them down. No guns of this type are shown on the drawings. The gunnery arrangements therefore appear to be inefficient and inadequate.

(14) Aircraft Arrangements Unworkable.

The proposal to send off aircraft from such a ship without the use of a catapult is considered quite impracticable. The proposal seems to be to turn the ship until the stern faces the wind, go full speed astern, let the plane start itself from the hangar, run aft over an uneven deck which is in constant motion and possibly swept by heavy spray. This is too dangerous a task to invite any airman to undertake, but if the plane could get away, the ship has to stop again, go ahead and swing round on to her course. The double manœuvre and delay involve such extraordinary risks from U-boats and enemy aircraft as to emphasize the need of protection from aircraft and U-boats being provided from other ships—which means the convoy system.

There is no suggestion in the paper that the usual paraphernalia of arresting gear should be fitted on the ship. Even if so fitted the width of deck, 54ft. amidships, is considered to involve too grave a risk to be considered a practicable proposition. Then if landing were attempted the ship must *swing* round and steam full speed right into the eye of the wind. If the plane did succeed in alighting and running along the deck it would be liable to serious danger by air eddies before reaching the hangar, and the coaxing of the plane into the hangar would be attended by very grave risks to all concerned. These aircraft arrangements are therefore considered to be unworkable.

(15) Weather Deck Troubles.

The great expanse of hatch covers would make the ship very liable to serious damage by bombs, while the absence of topsides and rails would make fire-fighting etc., at sea, very difficult and dangerous.

The edge of the main deck would be continually in and out of the water, and the process of filling the boats and getting them away in an emergency, whether for escape or rescue work, would be very hazardous. Corresponding hazards would be encountered on return to the ship. For similar reasons temporary outside repairs to damage at sea would be practically impossible.

The flying deck aft is flush. There are no capstans, windlass, bollards, or fairleads for handling the ship in harbour or in dock, which any skipper would consider a very unseamanlike arrangement. For the same reasons the ship would not be able to render assistance to any other vessel in distress. All these incidental difficulties emphasize the doubt as to the wisdom of attempting aircraft services on the ship.

(16) Ship Unsafe Without Convoy.

The great disturbances of the water created by the ship exaggerate visibility and at the same time the low freeboard makes the ship half blind. The aircraft arrangements sacrifice the value of speed and are considered unworkable, so that any aircraft carried would be of no offensive or defensive value while the manœuvres required involve most extreme danger. The gunnery arrangements are inadequate and inefficient for protection against aircraft, U-boats, or surface craft, so that the ship furnishes an excellent example of the essential necessity of convoy protection.

(17) A Lesson from the Navy.

About 1900 the Fleet reported that ships' 6-in. quick-firing guns could not be relied upon to prevent torpedo attack from being pushed home, while the smaller guns were unable to stop the attackers. A demand arose for screens of fast vessels to accompany battleships for their protection, and thus the torpedo-boat destroyer came into being. No fleet will now proceed to sea without a "screen" of destroyers. Recent experience with aircraft points the same lesson, and no battleship would care to proceed to sea without an "umbrella" of aircraft. So likewise screens and umbrellas must be provided for merchant ships, and the convoy system is re-established as essential although even then great risks must remain.

(18) Summary.

Although it has been necessary to deal definitely with some of the impracticable and incompatible matters relating to the proposed cargo-warship, it is desired to pay tribute to the courage and pertinacity with which the author has pursued his task, and the extraordinary ingenuity exhibited by many of the details shown on the drawings. It is hoped that the general proposal and the discussions will prove a stimulus and a help to the responsible officers of the Merchant Shipbuilding Department who are able, successful, alert, and progressive gentlemen of world-wide reputation. The same may be said of the Deputy Director of Naval Construction. In turn it may be said that he has access to all the accumulated information resources at the Admiralty.

In particular these officers have knowledge of the comparative value of the work done by ships of various speeds, as well as a constant flow of information as to the merits and demerits of the convoy system, but it is evident that all this information cannot be broadcast to the world.

All these officers are eager men who are following events at sea with the greatest earnestness and will have studied the author's proposals and the discussions thereon as an important duty, and it may well be hoped with advantage to the welfare of the merchant shipping of the Allied nations.

(19) *Conclusions.*

The basic objects of the design, namely, low visibility, high speed and increased watertight subdivision are fully concurred in. The value of low visibility, in particular, cannot be over-estimated. They should all be regarded as leading principles in the design of wartime vessels of all descriptions which may be liable to U-boat attacks, but each one if pressed too far involves difficulties in other matters; all that can be hoped for is to secure an acceptable compromise. Although the author has shown great courage and remarkable ingenuity in many details of the cargo-warship design, it seems that he has not sufficiently realized some of the grave consequences which have been set out above and that the effort to combine the functions of cargo-carrying and fighting in one useful ship has not been successful.

The practical difficulties remarked on above have been set out, not by way of destructive criticism, but as a practical contribution to the work of all designers who are engaged in the difficult but vital task of maintaining "THE ATLANTIC LIFE LINE".

Mr. N. Blair (Graduate). During this war the writer has sailed in an ex-German reciprocating-engined cargo ship of 1914 vintage, and has found that the modern cargo vessels of this type differ in no major detail, so that Mr. Burn's suggestions are certainly needed in these days, if this appalling state of affairs is not to be perpetuated.

The idea of dispersing prime movers about the ship in the form of a minimum of four Diesel generators driving a submersible motor seems attractive, but hardly seems practicable in view of the man-power situation.

Whilst the submersible motor could be depended upon to behave itself, to expect the generators with their auxiliaries to do so would be too optimistic. Allowing one engineer per two generator rooms, there would need to be at the least seven engineers for, say, a 5-10,000-ton vessel, against the four engineers of the turbine or reciprocating-engined steamer. This would be another problem for Mr. Bevin, especially in that greater technical training would be required of the engineers for the ship proposed.

In any case, if a hit even on this fast ship were scored, disabling one or two of the engines, the remainder would not be able to propel her at sufficient speed to evade the submarine, which naturally would not surface to present a target, but would approach the disabled ship and fire further torpedoes into the damaged vessel.

The writer was surprised to find no mention of such a compact steam generator as the Velox boiler, which would be fitted in the engine room and thus dispense with the extra space of a boiler room, in a turbine-driven vessel.

One wonders whether the gas turbine could not be utilized as an alternative. We seem to have neglected this promising engine in this country, but if it were developed it would be, the writer thinks, ideal for marine propulsion.

The present lead of firemain, along the main deck, is very vulnerable and this demands attention, as damage thereto might mean the loss of a vessel through fire.

Fortunately the fitting of portable petrol-driven pumps tends to lessen this danger, but there is room for improvement.

Finally, the writer would suggest that the utmost use be made of fabrication, as castings are liable to fracture in explosions. Such items as valve chests (ship's side valves in particular) and plummer blocks could be fabricated easily.

The present practice of boxing cast-iron ship's side valves in concrete is helpful, but would not save the valve covers from fracture, as for obvious reasons these could not be cemented over.

Mr. W. E. McConnell (Vice-President). The object of this paper was quite clearly to suggest a design for a ship which would have a better chance of survival and service under war conditions. The author, whose industry and ability are only matched by his courage, set out single-handed to produce a design which would answer the purpose in view, and the question as to whether he has succeeded or how far he has progressed towards success is still under discussion. He has, however, beyond all doubt succeeded in doing something which may not have been part of his original objective, and that is that he has jolted the whole shipping fraternity into activity and created interest in both Houses of Parliament and the Ministries concerned.

Any attempt at detailed criticism of the proposals in these comments would be redundant, the contributions received from so many and such distinguished critics already covering an area greater than that accorded to any paper in recent years. Not since the great battle of transmission systems, when Parsons, Ferranti and Föttinger met shortly after the last war, has such a widespread interest been aroused and the achievement is worthy of high praise.

But on the face of it the proposal as a whole has no prospect of realisation. The ship is a war-time proposal, and it could not by any conceivable means be produced as a standard design, that is for repetition work, in less than, say, 2½ years; the plans alone would require many months of discussion, comparison and compromise, and as for engines, only a minor war in our own camp would bring a decision about them. In this connection it should be borne in mind that the idea of using a large number of small self-contained units, each supplying current to a large driving motor, was first proposed by Mr. Ricardo and acknowledgments are due to him when this scheme is considered; but it has not found favour anywhere in this country so far.

The diversity of views revealed in the discussion shows how formidable is the task undertaken by the author. If the way of the transgressor is hard, what of the path of the innovator?

The design, to be of service during the war, would have had to come under consideration at least four years before hostilities began, and if we had had statesmen as good as our technicians it would have been considered. But the quite incredible record of the pre-war Governments, who were all bent on appeasement and disarmament and were wilfully blind to the gathering signs, leaves us with the sorry problem of making the best of the situation, and this precludes any benefit from the design offered by the author during the hostilities now in progress.

The Author's Reply to the Discussion.

Mr. MacLeod. Mr. MacLeod confirms the practicability of constructing self-contained steam turbine units of high power but low weight, which could be obtained from non-marine firms. Actually two identical single-screw units should be used, one forward and one aft. Whilst Mr. MacLeod shows his water-tube boilers below, the author thinks they could with advantage be moved above and to the sides of the turbine unit—a modification of the excellent American high boiler practice—and the type of boiler settled accordingly. The La Mont forced-circulation type would be particularly suitable for this purpose as well as being very light and efficient.

The author is confident that it is completely practical to adapt certain types of highly efficient and proven types of boilers to fit into a tween deck above sea level, well away from torpedo—if not bombing—effects.

With careful scheming and freedom of boiler type, *i.e.*, considering German or Swiss types built under licence in pre-war days in this country, a reliable and proven boiler plant could be produced which in size, disposition and weight would be vastly—and this is a reasoned adjective—superior to even that proposed in the latest cargo liners *from a war condition* point of view, and the author hopes boiler experts will follow this up.

A defect of the geared turbine from a war condition point of view is the small power astern—especially the U.S. Maritime Board type—and the lag in response to bridge instructions due to the momentum of the high-speed turbines.

With regard to the former, the use of an ASEA magnetic coupling and a separate, relatively large astern turbine may offer advantages with ahead economy and yet give superior manœuvrability.

Whatever the design of turbine, it should be a naval light-weight type and not pre-war merchant design, the propeller revolutions being nearer the 200 than the 100 mark and every endeavour should be made to use single reduction to ease the production of gears. After the war the turbines could be adapted to double reduction and lower propeller speeds.

Mr. MacLeod's figures support the author's contention that it is possible to obtain propelling machinery which will give the high speed necessary to combat the U-boat *without* increase of weight over that of the engines fitted to our low-powered low-speed standard cargo vessels, which themselves require high-speed light-weight vessels to protect them.

Mr. W. L. S. Moore. The author realizes the organizing difficulties of the new project, but this would depend on the spirit of the parties concerned in splitting up the work of design, development and manufacture amongst a number of firms, each firm doing *more and more* of less and less.

The epic work of the Americans in delivering within a year Ocean vessels, which were in effect an absolutely new type as they were completely redesigned to suit welded construction (and moreover building the yards to build the ships as well) shows what can be done. The author does not believe we could build the proposed vessels without similar new designing and building facilities on a national basis, and the same thing applies to the question of dry docks and harbours as has been indicated in the reply to Mr. Silley (*January, 1943* TRANSACTIONS).

The author takes the view that most of our shipbuilding and repairing facilities are obsolete and anti-social, and that if we do not pull ourselves together we shall be complete backnumbers in ship production after the war, just as our relative position in world shipbuilding is rapidly receding during the war.

Whilst we must be eternally grateful for having such a shipbuilding ally as America, is it fully realized the sort of position Germany would have put us in without this help? *British shipbuilding has not yet produced a reply to the U-boat,* and even its replenishment of torpedo fodder is only a fraction of the U-boat's capacity to destroy.

Much the greatest "make-up" comes from the U.S.A., and to the vital flexible spirit in American shipbuilding this country owes and will continue to owe its very existence. Having seen before our very eyes what can be done with the right spirit of national co-operation and competition, why not let us go one better? The Americans would respect us more. Why keep tagging along behind, resisting progress at every step?

The author cannot but completely agree with Mr. Moore on the score of the relative reliability of the large oil engine and the steam turbine. In many ways large oil engines are mechanical abortions which have been responsible for great toil and suffering on the part of operating marine engineers. Engines for which the author has been responsible are no exceptions. There is no denying, however, the fuel economy of oil engines, large or small.

The author believes it is possible to marry fuel economy, reliability of operation and social suitability by using small high-speed multiple units with electric drive. In view of the many years the author has spent in developing large oil engines, it is only natural that this "technical vested interest" should creep in and want satisfaction, but this evil spirit has now been completely exorcised in the cold light of logic.

It would be possible to use either turbo-electric or Diesel-electric with the minimum of variation, much of the installation being common to either system. Both systems should be developed simultaneously just as America is doing to-day.

The development of modern high-efficiency geared steam turbine installations for cargo liners has been very backward in this country, and the American developments in these units since the last war demand great respect. The author recently visited an American water-tube boiler and geared-turbine vessel built just after the end of the last war (like some of Mr. Moore's own British units) and noted the extraordinary reliability of these engines. Seeing that we are now using an American type of boiler, it is surprising that the Admiralty did not take a licence to build the well developed C3 American turbine unit, rather than hurriedly get out new designs in wartime which cannot be anything like as well developed from a manufacturing point of view. Such a policy would have made for greater standardization between Allies, and repairs on either side or manufacturing bottlenecks could be dealt with more efficiently.

Mr. T. U. Taylor. Mr. Taylor has been superlatively destructive rather than constructive; nevertheless his remarks are very acceptable. The idea of the paper was "to set the top spinning" and a whip is needed for this. The author compliments Mr. Taylor on his use of the whip and the effective spin he has given to the top.

Mr. Taylor states the author has attempted to solve comprehensively a large problem. It is a *vast* problem and it is therefore realized that in the initial stages many details will be deficient. It was first necessary to draw in the broad lines; opportunity is now taken to fill in the detail.

When the author was engaged in the actual design of oil engines, had he had to wait for all the answers to all the details before settling on the broad design, nothing would have been done. A start must be made even though adjustments may follow.

Moreover, the object of the paper was to propound, no less than to solve, so as to get the help of others.

Mr. Taylor comments on the length/depth ratio, but surely the tendency in ship form is towards higher ratios for functional efficiency, in spite of natural strength laws. The author would stress that the factor of safety from a simple strength point of view is easy of solution compared with the factor of safety from explosion effects. In wartime, ship architecture must be subordinated to naval construction.

It was an answer to the U-boat menace that was wanted. This is so far a lone effort. Had the author a good shipyard, engine works and drawing office, at his disposal, a practical project could be evolved. Of that the author has no doubt. Having no associations whatever of this description the solution will be obviously a slow and laborious process.

Mr. Taylor is not correct in saying that all modern warplanes are of the low wing type for aerodynamic efficiency. The accepted most efficient type is the mid wing, then the high wing and lastly the low wing. For marine aircraft the high wing type as used in flying boats is fundamentally correct, and the author fully believes is the future type for sea-drome aircraft. The writer and other contributors to the discussion have commented on the low flying deck as a serious fault, as it will often be awash. As a result of further thought the author has reluctantly raised the flying deck to 15ft. instead of 8ft., but what does it matter if the deck is awash? A flying boat must come down on the salt sea waves, and the author does not see why a landing craft cannot be adapted to land on a merely wet or lightly awash flying deck.

The monstrously high decks of present aircraft carriers do not appear the final solution. The top hamper not only makes them dangerously visible to U-boats, but they have been proved to be unstable under war conditions. After torpedo action they have all toppled over and sunk even when the reduction in buoyancy due to torpedo action was not in any way critical.

One desires low freeboard for low visibility and high freeboard for dry decks. The present U-boat menace suggests low visibility, and on *that the author has found complete unanimity of opinion amongst submarine commanders.* Mr. Taylor, as a ship designer, knows full well that design is a compromise. The provision of a high deck is simple; the provision of a low deck is technically difficult but the author believes worthy of solution.

Coming to the blisters which Mr. Taylor says are "totally inadequate", the author believes that here he (the author) has made a contribution to naval construction, as for the first time to his knowledge the inner wall of the blister is specifically shaped to withstand high pressures, that is, it is curved and free of stress concentration. It may be an engineer's way of tackling the problem, but it is an engineer's job to deal with pressures. The shaped pressure skin idea has been developed in the earlier replies to the discussion.

Now the author wants to make a point clear once and for all. The idea of the blisters, that is the special ship side protection, is to serve as the first line of defence to the hatch cover, not to give complete ship's side immunity. *The object is to endeavour to avoid having major explosions within the lower holds.* The second defence zone is the special cargo to be put in the lower holds, that is bales, bags and boxes, which are deadening material, to protect the lower deck hatches. Then there is the "expansion box" effect of the upper hold with its air spaces between vehicles, war tanks and large "pieces" so that the eventual pressure on the flying deck hatch covers is reduced so as to make their design a practical proposition. The author would prefer that his design be considered as a whole as well as in separate detail.

This brings us to the criticism of the side alleys—since moved upwards and inboard—which were so placed to give greater longitudinal strength to the "top corners" of the vessel. Some criticism here is justified, but again it must be remembered that liquid cargo space is specifically provided to give a large measure of positive control over buoyancy and trim, in which case the side alleys could always have been maintained above water level. As Mr. Taylor points out, the problem which confronts the ship designer "is to make the blisters of sufficient width to protect the main hull and yet not so wide as to endanger the ship by producing a large angle of heel when open to the sea". Now the volume and the safe

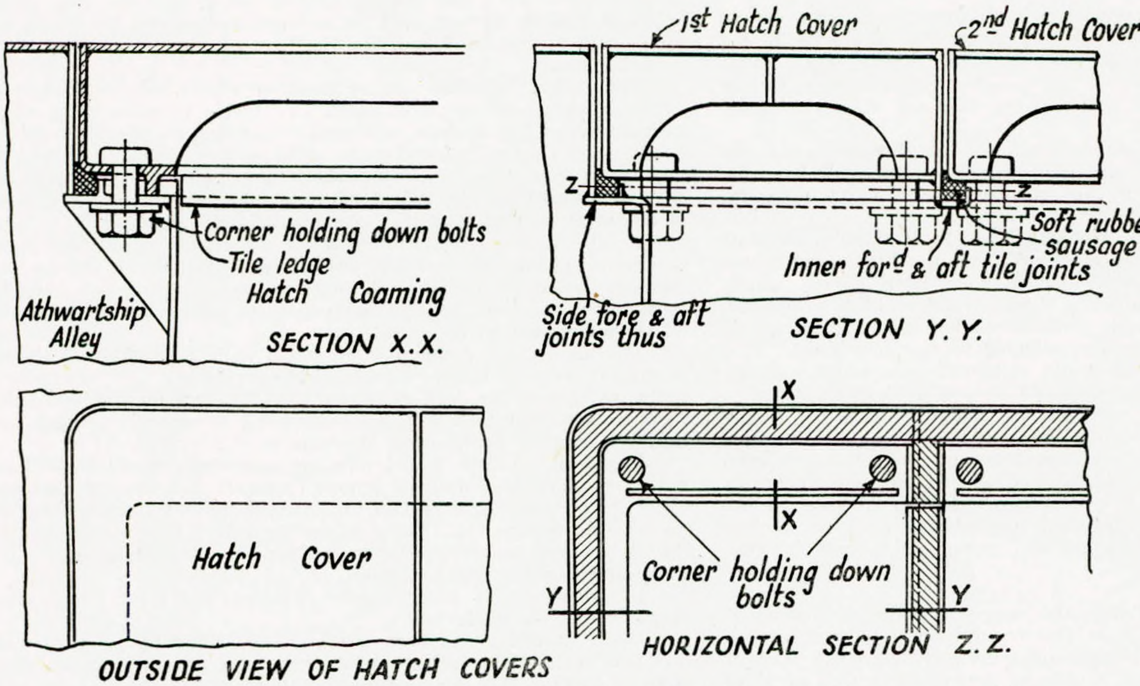


FIG. 24.—*Flush fitting welded steel watertight flying-deck hatch covers for cargo warship.*

on the lines of merchant shipbuilding section reports that the author has before him. The author's intention—which is surely now obvious—is solely to be constructively helpful in solving the U-boat menace; no other motive whatsoever exists.

Mr. Taylor says the author has made no contribution to the hatch cover problem, but surely he has made many, first by suggesting a means of removing or reducing the forces on the lower side of the top deck hatches by the introduction of side protection—this is a fundamental improvement. The second is by introducing strong explosion-breaking hatches in the lower deck. The third contribution is in reducing the size of the hold per hatch, thus reducing the effect of a given hatch. The fourth is by a specific cargo stowage plan to suit explosion effects, *i.e.* liquid outermost, then bale cargo, and then assembled parts such as vehicles or tanks under the top-most hatch cover. The fifth is by proposing hatches short in length longitudinally and well subdivided athwartships to accommodate any natural ship flexure. The sixth point is the sacrifice of ease of removal or replacement for simple sectional steel boxes which can be bolted down from inside the transverse bulkhead cross beams. The seventh feature is the use of a new "tile" principle to make jointing simple and avoid the use of removable girders.

It was not possible to show such details in the original paper but they are now shown in Fig. 24.

The author is anxious to know Mr. Taylor's other criticisms which he states "are all fundamental and render the design entirely impracticable" and trusts he will make a further contribution.

explosion pressure within the blister are correlated; if the inner wall can be designed so as to be fundamentally suited to high pressures without undue weight of steel, then higher pressures and smaller volumes are permissible. The author believes, however, that much more can be done in improving the efficiency of the available volume by the use of suitable specific filling substances and suggestions have been made in earlier replies. Briefly, the author believes that there is great scope for development now that welded constructions are available.

In addition to specialized ship's side protection, a cargo-carrying vessel has great advantages over a conventional warship due to the shock absorbing nature of the contents of most cargo holds, and herein lies immense possibilities which may lead to a new conception of naval vessel types.

The design in Fig. 18 (*January* TRANSACTIONS) seems to be a considerable improvement on the original design, and the author is developing the design still further.

Then comes the hatch question, and here the author would like to state that, from his own personal observations and investigations, the merchant shipbuilding section have not been sufficiently "steel-hatch conscious", nor does he believe they were conscious of the special wartime need for maintaining deck air tightness; otherwise much more would have been done. The facts, the policy, are all there to demonstrate that steel watertight hatch developments have been virtually stopped since the war started. To get 100 per cent. airtightness would be impossible, but to get a measure of airtightness, such that small leakages could be made up by a compressed air supply, is within practical politics.

Quite apart from saving permanently the ship from sinking, if sinking can be delayed to enable the boats to be properly lowered, this would be of great value in saving life. Many vessels sink in a few minutes. The author would state that from all points of view the present cheap wooden hatch covers and tarpaulins should be abandoned and replaced by steel hatch covers of a design specially suited to war conditions. Not steel hatches designed so as to be removed and neatly stacked in the minimum time, but covers of rugged construction well bolted down. Such hatch covers could be designed. The late Mr. Foster King evolved an attractive design for normal cargo vessels.

Whilst the author's paper was not originally intended for the daily press, *he now sees the great value and power of the daily press in bringing points of national utility to the notice of technicians.* In fact it would be of interest to know how Mr. Taylor himself became interested in the author's paper, as he is not a Member of the Institute. The author suggests that the daily press was most likely, directly or indirectly responsible.

Incidentally, the author is psychologically interested in the condemnatory attitude of Mr. Taylor's contribution, which is so much

Mr. P. H. Bothamley. The author is glad to have a contribution from an exponent of the small ship as the use of innumerable small boats which are almost immune from torpedo action has often been proposed.

Now in normal times it is preferred to use vessels of not less than 5,000 d.w.t. for Atlantic crossings for safety, speed and comfort, but, as the writer remarks, the protecting corvettes which can "ride the waves", and the enemy U-boats, are even smaller than the writer's proposed vessel.

The writer's hull weight, however, is much too low and a figure of nearly twice that of 170 tons must be allowed, say 320 tons, making the cargo carried only 600 tons.

The disadvantages of such a small vessel for ocean traffic would be:—

(1) The difficulty in maintaining anything like the stated speed except in calm weather and the great discomfort affecting crew efficiency.

(2) The crew with gunners would not be less than 16-18 men instead of the 6-8 suggested.

(3) To carry the same cargo as the cargo warship, no less than twenty such vessels would be required. Therefore the crews required, the armament and the man-power needed to build these vessels would be greatly in excess of a single large ship. The number of vessels required would be further increased in moderate or bad weather, due to the impossibility of keeping up a high average speed.

Contrary to the proposal for small ships, even if safe, there are very strong arguments to build the largest practical size of ships—ships of 500-550ft. long are none too large for fast ocean traffic, and even another 25ft. increase on the author's proposals would be functionally advantageous even if constructionally less attractive.

The new American Liberty ships are larger and longer, being nearer the 500-ft. mark.

The author believes largeness in itself provides a large degree of torpedo immunity, and in his later designs he has gone to the greatest practical depth to get the average torpedo depth more nearly about the neutral axis of the vessel where provision can be made to "take it"—exactly the opposite thinking to the shallow draught vessel.

There is, however, a "natural" use for small vessels, and the author hopes much greater use of coastwise traffic will be made *by special vessels* in view of the practicability of a 100 per cent. protective coastwise air umbrella.

There is great scope for vessels such as Mr. Bothamley suggests for the coastwise distribution of cargo from the high-speed trans-Atlantic ferry, with its specially adapted terminal ports. Many more coasters need to be built and these should be of low draught, have watertight hatches, low visibility and much higher speeds than at present—in short, coasters adapted to war conditions.

Many of our smaller yards could be turned over to the building of such vessels, leaving cargo warships to new modern shipyards.

Coming to detail design, a better case could be made for single-screw electric propulsion with the motor aft, but with the multiple oil engines forward. The deck structure and the accommodation also should be forward, like a small edition of the cargo warship. The use of a Kort nozzle has definite possibilities in view of the shallow draught and also forward propulsion, to give perfect manœuvrability in small and congested ports, and should be considered.

Mr. Humphreys rightly calls the cargo warship revolutionary, but surely the U-boat menace is also revolutionary to naval architecture. Take the last six months of admittedly moderate U-boat activity, when it is computed from the American figures of ships built, British estimated construction, and Mr. Churchill's figures of excess of building over sinkings, the figure of vessels sunk is still the grave one of 5¼ million tons deadweight. What the cargo tonnage amounts to is difficult to estimate, but it will surely amount to not less than one-and-a-half times this figure, allowing for many return trips as being largely in ballast. Is this staggering loss not worth the most intense experimentation and development to find a true antidote to the U-boat.

Agreeing that the scheme is revolutionary, the author would say that any non-revolutionary scheme compared with peace-time practice is either illogical or merely stupid.

While 100 per cent. success would not be immediately obtained, it is inconceivable that given a combined technical effort, a large measure of success would not be initially achieved. The author has at least that much faith in the dormant British capacity to design. While so many developments in pre-war years were foreign, this was due to repression and not to inherent incapacity of British technicians.

The fact that operating staffs are difficult to obtain is all indicative of the need for large and fast ships to carry more cargo with a given ship and crew. The present sinkings and inevitable casualties to the crews are only making the personnel problem progressively difficult.

Escort vessels are not only uneconomical of crew but are wholly non-productive. The author does not agree that research work should not be started during the fourth year of the war; for all we know we may have another four years to go and as far as technological efforts are concerned there should be no relaxation of effort, whatever the prospects.

The author is very glad, however, to have Mr. Humphreys' agreement—as superintendent of the largest British tanker fleet—on the need for a small engine-room space. The author is sorry Mr. Humphreys does not see the need for duplicate engine-rooms to give better wartime assurance of never becoming a "sitting target".

Absolute reliability must be a *sine qua non*, hence the need for at least two engines if Diesel, and preferably more; actually eight separate units are proposed in the major engine scheme.

The desirability of fitting steam turbines is fully concurred in, but even then two widely separated sets of propelling machinery are desirable.

In the author's opinion a *well submerged* small diameter bow propeller and rudder would be not only adequately safe from a marine risk point of view, but in any case if damaged the aft unit is always available. It will, however, reduce the war risk immeasurably more than it increases any marine risk and it would appear that the combination of bow and stern single screw will be of about equal combined efficiency with a fine-lined ship to that of a twin-screw combination.

Present-day tankers could be improved in speed and safety by fitting such divided and duplicated machinery, just as they could be made almost 100 per cent. safe from sinking by the fitting of some form of internal blisters on the lines of Fig. 18 (*January, 1943* TRANSACTIONS).

The tanker, whether for mineral or edible oils, molasses or grain, is the simplest of all types of vessels to convert to cargo warship principles, as there is virtually no hatch or derrick problem.

In view of the importance of welding for explosion resistance and the special desirability of welding for tankers, it is suggested that *all tankers* for the Allied effort should be built in the U.S.A., where ideal welding facilities are immediately available.

In the author's opinion there is no reason why high-speed tankers could not only be made 100 per cent. safe—from sinking, not damage—but developed into the ideal *useful* escort vessels—steady, hard to see and hear, always down to their marks, complete control of buoyancy, and so on.

The use of the double-bottom tanks with a "backbone" should be considered for below bottom explosion effects. A continuous centre portion of the deck connected with a centre longitudinal bulkhead to the duct keel will give improved structural strength and only one central below deck alleyway need be fitted.

The deck problem would offer no practical difficulties, and no cranes or derricks would be required as full and efficient facilities could be provided for loading and unloading at terminal ports on *terra firma* where the U-boat is no menace. This would reduce the weight and cost of the ships, reduce the *sea upkeep* and solve many ship construction problems.

In other words, the Atlantic, Russian and Far East cargo ferries would be made safe.

Much comment has been made of the difficulty of providing air- and water-tight *large* hatches, but there is certainly no difficulty in making two rows of *small* hatches water-tight. It is suggested that not only tanker or bulk cargo vessels can be given 100 per cent. U-boat immunity, but that if somewhat larger hatches are provided, the same safety can be given to vessels carrying bale or box cargoes of normal package size.

Furthermore, there is no reason why a great many large pieces cannot be split up; for example machine tools can be split up into sections or individual component parts and transported in boxes or bags of the optimum dimensions.

In fact the author ventures to suggest that one tanker type of ship could be used for all liquid, bulk and bale cargoes, and thus enable the transportation of *all* our fuel, food and fibres, most machined and manufactured articles, and almost all raw materials, with nearly 100 per cent. safety from sinking. Such a vessel, if welded, should be no more expensive than a normal oil tanker.

Given ultra rapid loading and unloading—which is a finite problem capable of solution—and a replace engine system of maintenance as with aircraft, who can doubt the superior wartime carrying capacity of such a vessel for a given weight of material and ship and engine building man-hours?

Of all vessels, "dead" ship's side protection of tankers will give the greatest human and material reward. The author is sure that the colossal fountain of petrol which is thrown up into the air after torpedo action and which often comes down into the tanker itself and the surrounding sea as a cloud of flame, could be replaced by a more local and solid flow of petrol and flame on the sea.

It is an ideal to aim at. The blister would give longitudinal strength and the extra steel weight would be to a large measure useful from a constructional point of view.

Remaining is the vital problem of the war transport of large and heavy war material. That can only be done by providing large hatches and special retractable cranes as shown in Fig. 18. Who can doubt the capacity of British brains to solve the hatch cover problem if they are given the chance? Steel hatch cover designers and makers have been kept in bondage during this war, and herein lies one of the most profound blunders of the shipbuilding policy.

Coming to details, the possibility of the emission of sparks at night is fully appreciated by the author, who is fully aware of the design and practical aspects of the matter and in fact scientific provision had been made in the exhaust heater.

It is agreed that the engineers' messroom should be a thing of the past, but a small watch messroom should be provided near the engines and much better facilities should be provided for washing and changing below.

The day when the mammoth Diesel engine disappears, with its need for constant laborious overhaul and inspection, and smaller engines of greater refinement make their appearance, the lot of the engineer will start to improve. The author is a believer in the multiple high-speed oil engine with electric drive as much for the possible social amenities as for the potential shipping economy; similarly the use of welding in shipyards will offer great social improvement to shipyard workers as well as being functionally an improvement on riveting.

The author has considered many alternative deck structures and flight decks and methods of aircraft landing and take off, including the obvious and orthodox. So far the best compromise appears to be that proposed on Plate 3 (*January, 1943* TRANSACTIONS). That is, for landing, the ship will go full speed ahead into the wind, which in the Atlantic will mean a forward speed of some 40 m.p.h. This, with a flight deck of 400ft., is considered ample—certainly if a Swordfish type of plane were used it would be very safe.

For take off, rather than consider an elaborate catapult gear, it is considered that use should be made of the long flight deck and the capacity of the ship to manœuvre quickly to get the wind from astern and then either to slow down the ship's speed or, if necessary, actually reverse engines. Bow propulsion gives complete astern control and therefore it seems desirable to use this capacity and avoid catapult complication. The whole design is a matter of compromise, but an *efficient ship* was considered a prime essential. Electric drive makes rapid reversing a safe operation with either turbine or Diesel engines.

The author agrees with the compressed air equipment which would be essential for all water-tight hatch cover proposals.

Mr. W. Veysey Lang. Mr. Lang says it is too late to re-arrange shipyards and engine works; if so there is no alternative but to fight the war to the last American ship. The author, however, emphatically disagrees with such sentiments; it is never too late to mend.

In any case let us be quite clear. The U.K. production of ships is now such a small proportion of the total Allied production and is getting progressively smaller that the position is that if no U.K. cargo ships were produced the effect would not be appreciable. In fact it seems desirable that a fair proportion of workers and shipyard equipment could well be transferred to terminal ports to ensure that existing tonnage suffers the minimum loss of time in repairs. The delay in repairs in U.K. ports appreciably reduces the effectiveness of our existing tonnage.

The author does not recommend building cargo warships in 90 per cent. of existing yards, owing to the lack of suitable welding and prefabrication facilities. Either new British yards or the new yards in U.S.A. should be considered.

Again, if extra harbour facilities are required, then they must be provided; the man-hours lost by U-boat action is far greater than the man-hours required to adapt harbours, docks and locks to war conditions. There is no *need* to keep to our ancient port facilities. The author can state that he has seldom returned to this country from abroad without feeling ashamed of our ports, which are, with few exceptions, inefficient compared with Continental and Transatlantic ports. Our ports as well as our cities will require rebuilding after the war, if not during it.

Because the author is not proposing a peace-time "economical tub", this need not imply that he is not aware of the peace-time commercial shipping aspects, but he would point out here with *all the force at his command that the object of the cargo warship is solely to defeat the U-boat.* If we can stop the sinkings by the use of more petroleum by all means let us use it. The price of petroleum products is arbitrary; the fundamental cost of extraction from mother earth is even less than coal.

The great oil-producing nations of the earth are our allies; let us therefore use their resources; in the author's opinion not an ounce of coal should be used on new ships except perhaps for the captain's and officers' lounge fire. We need the coal at home, and we need any surplus coal-producing man power for other purposes.

Relative costs of ships, *i.e.* whether two eight-knotters can be built for the cost of one cargo warship is hardly relevant; one is torpedo fodder, the other is designed specifically to be relatively immune. Our slow coal-burning ships could well be used in safe parts of the world, especially for coastal traffic with land-based air protection.

Mr. George W. Muir. Whilst it is agreed that the engine room should be protected, there is evidence that something more than just strengthening of the plates is required—some form of double plating is necessary with an explosion damping space or chamber between. Most important is the need for an engine room of a size such that, even if flooded, it will not dangerously affect the trim of the ship. Therefore engines short in length are preferable, suggesting double-acting two-stroke or Vee single-acting two-stroke if direct drive is considered. In the case of the turbo-electric system, the boilers and generators must be above the water line and only the propulsion motor below. Many existing engine rooms could be fitted with specially constructed side tanks as in Plate 1 (*November, 1942* TRANSACTIONS) with the auxiliary equipment above rather than below. Even a reciprocating steam engine could be adapted to war conditions by replacing the Scotch boilers by water-tube boilers and placing these above and forward of engines with the auxiliaries below, and replacing the usual engine-room wings by side tanks. There seems little doubt that the volume of present engine rooms could be reduced by half without inconvenience. The American idea of using high-speed forced-lubrication steam engines has much to recommend it on the score of size, if reciprocating steam engines must be used.

Mr. Narbeth. The further contribution by Mr. Narbeth cannot fail to add to the general knowledge on the subject and it is surely very commendable for such attention to be given to this subject by one in well-earned retirement. In the opinion of the author the design of ships of war and ships of peace have too long been considered as separate departments and interests and the chief object of the author in giving this paper has been to try to find some basis on how the different functional requirements of these two classes of ships could be brought together; it is admitted that the difficulties are great, but that is no reason why the problem should not be tackled.

As far as this country is concerned it must be remembered that the primary essential is the transport of cargo; the defence of the merchant fleet is essential but can be considered secondary. The author believes there should always be a wartime cargo vessel—a cargo warship—which should be continuously developed in peace as in war.

Mr. Narbeth's remarks on the responsible officers of the Merchant Shipbuilding section and others will be appreciated. It should be noted, however, that the relative success of the U-boat and our own British incapacity to cope with it without vast external help has placed this country in an entirely new and unpalatable position.

The author will not reply separately in detail to Mr. Narbeth's both critical and suggestive remarks, as so many have been already dealt with elsewhere.

One basic fact must, however, be appreciated in the case of both ship and engine design; great changes are needed to meet the difficult specific war conditions. Let us first appreciate the new design requirements and then strive to solve them without bias. The U-boat menace is only a menace if we will not face up to the facts and try to bolster up unsuitable designs because of mental incapacity or apathy. For example, the author has striven to find the solution to the engine problem as *it exists in this country to-day,* and here the author feels he must reply vigorously to Mr. Narbeth. Naturally, the author first turned to large direct-drive oil engines, to the study of which he has given a substantial part of his life. These proved unsuitable in weight, space, man-hours and production capacity. Many alternative designs of engines and arrangements were considered to improve all these factors. Eventually, after much thought and investigation, the author has come to a definite solution, namely the use of multiple de-rated aero engines (using an available grade of petrol as fuel) which have low weight, low space, low man-hours, enormous available production capacity, a lower fuel consumption than any variety of steam turbine, and at the same time will give a fundamental reliability because of the multiplicity of the units and the proven reliability of each unit within the required limits. All these are facts—facts which can be proved and can only be a Jules Verne conception to the uninformed on this particular subject.

Other points are dealt with in the author's general notes, most of which had been written prior to Mr. Narbeth's contribution being received.

Mr. N. Blair. Whilst the author originally envisaged the use of a new type of oil engine for generating purposes, he now proposes the use of adapted "marinised" aero engines using petrol, the development of the heavy-oil engine to be simultaneously carried out.

The use of multiple engines will require a new conception of engine room personnel, especially as engine control is from the bridge. A much greater number of electricians will be required and the maintenance work will be of a more regular and less laborious nature, the daytime engineer or fitter being more in evidence. The additional mechanical equipment about the ship also will require extra maintenance, but a much greater proportion of this will be below deck or enclosed and more suited to proper overhaul and repair.

Referring to the Velox boiler, had such a boiler been in production it would have had great uses for ship propulsion, but unless a device is on the way to becoming obsolete from a world point of view the British marine-engine manufacturer is not to be interested—devices of an experimental nature are not looked upon with favour.

Regarding the vulnerability of deck mains, the fore and aft deck trunks will have definite advantages in giving proper war-time protection to lines like the fire main, compressed air and electric mains.

Mr. W. E. McConnell. Mr. McConnell suggests that the prospect of actual cargo warship production is small, but the author is confident that some such scheme, *i.e.* the production of cargo vessels specifically adapted to precise war requirements, is inevitable. The author's proposals merely serve to illustrate the principles; no more is possible in the circumstances. Much spade work, however, has been accomplished, knowledge of the subject is increasing throughout the length and breadth of the country and the author has evidence that the interest is far deeper than even the discussion would indicate. The potentialities of design as distinct from production are being appreciated by an ever-widening body of people. That was the object of the paper.

There is a growing realization of the undoubted truth that the technical capacity of the country is neither mobilized nor harnessed to combat the U-boat.

There is yet time for Britain to master the U-boat by the organized combined action of our technical capacity throughout the country. We can only hold up our heads as a great maritime power if WE can remove this German menace by our OWN naval and mercantile superiority.

THE AUTHOR'S FURTHER NOTES AND THIRD REVISED DESIGNS.

Combined Sea and Air Operations.

An airplane, however efficient, must always come home to roost. In that respect it is not permanently at home in the air as a ship is in the sea. The author believes that the chief offensive weapon of sea-borne craft is an air-borne craft carrying explosive charges, rather than projectiles propelled by explosives directly from the ship itself, and therefore a ship of the immediate future must above all consist of a mobile landing platform or sea-drome as a prime essential.

Furthermore, the sea-borne craft's chief purpose must be the transportation of goods or war material. The conception of a ship being a platform for artillery alone, with heavy armour to withstand enemy projectiles is, in the author's opinion, obsolete.

This war has established in no uncertain manner that the Navy's chief function has so far been the protection of merchant ships carrying goods. It cannot be said that it has done this efficiently. The numbers of cargo and naval vessels at the bottom of the sea establish this fact. The author believes it is essential to realize the fundamental fact that the comparatively microscopic weight of steel and numbers of naval personnel of the U-boat fleet has not only destroyed a vastly great weight of steel and material and numbers of men, but has kept our vast Navy engaged on defensive duties and immobilized the greater part of our shipbuilding effort, in producing cargo-carrying craft. In addition, great numbers of Coastal Command aircraft are required for offensive action against U-boats directly, and lately a large amount of our bomber capacity is being diverted to bomb U-boat manufacturing centres or U-boat bases. As the war proceeds more naval escort vessels are wanted and yet more air cover.

The author propounds that the only economic solution is to make each cargo-carrying vessel immune from U-boat offensive action in itself, firstly by making it difficult to see, hear or otherwise detect, giving it the capacity to run away from U-boats, giving it a deadly rapid-firing multiple gun capacity in case the submarine surfaces, and above all giving it a detachable offensive weapon in the form of ship-based aircraft which can seek out, bomb, depth-charge or torpedo the Nazi underwater weapon.

In addition such a vessel must be able to stand hard underwater knocks from torpedoes and still keep afloat and under way. The author believes it will be much easier to make a cargo-carrying vessel unsinkable than a purely naval vessel packed with guns, armour and men.

By adopting a modern attitude towards ship mechanisms, whether high-powered propelling machinery to give speed at sea, or rapid cargo-handling facilities in port, it is believed that a given weight of steel could be made to carry three times the cargo of slow convoyed ships with certainty of safe delivery.

The real problem is how the specialized technicians concerned can be mobilized into a concerted effort.

This is the real problem of the Battle of the Atlantic. We have the operating skill and courage to man such vessels once they are built, we have the craftsman and the skill to build them, scattered about we must have adequate technicians. Can we organize the design and development to produce a correct design? The author ventures to say that if merchant vessels in peace time were occasionally subjected to some strange marine underwater upheaval, having the same effect as a torpedo, which caused the loss of say six ships per annum, courts of inquiry would be held presided over by the finest judges, experts would be subpœnaed and new rules for the design and construction in due course evolved. In war-time, many hundreds of vessels seemingly can be lost, and all that is done is fatalistically to accept the technological aspect and commence on a world orgy of replacement—*with ships of identical design to those already sunk.*

Is this the considered will of the Government of those who go to sea in ships, of those who build them or those who design them?

It is late, but surely now is the time to enquire anew into the whole question without fear or favour.

Flight Deck and Bridge Structure.

The design in Plate 1 (*November, 1942* TRANSACTIONS) was an attempt to provide adequate aircraft landing length and also a forward catapult. Evidence suggested that it did not provide a long enough catapult run and, moreover, the provision of a hangar presented certain practical difficulties. To obtain a practical solution would have meant encroaching on the holds and hatches. In the second scheme, in Plate 3 (*January, 1943* TRANSACTIONS), the idea of a catapult was abandoned and advantage was taken of the ability to steer the vessel full speed astern, as with electric propulsion this was considered a practical proposition. Advantages were that it provided an excellent streamlined bridge structure and hangar for the airplane. The chief disadvantage was that a false landing entailed a rather tricky banking action on the part of the pilot; a less serious disadvantage was the need for going astern into the wind.

From an aircraft point of view the ideal would be to have no deck structure whatsoever. Certainly, if possible, there should be a clear fore and aft flight deck, and there should also be no side structure to interfere with the holds and cargo handling.

It is therefore proposed to revert to a development of the scheme in Plate 1, but to reduce the size and height of the side control towers to that necessitated by aircraft wing clearance requirements. The proposal is to move the control tower outwards into swellings on the topsides to give a clear view forward and aft in spite of the low height. Two retractable periscopes will be provided for long distance vision, but the lookout from the control tower will suffice for navigational purposes *provided* relatively high-wing aircraft *only* are considered. It is considered that this aircraft design concession will greatly reduce the problem of practical ship's deck equipment with an efficient flight deck. If a special nosewheel aircraft could be considered on the lines to be suggested later the whole problem of aircraft landing on a pitching and rolling platform is brought within practical possibilities. The stern counter shape also can be improved.

To facilitate aircraft landing it is desirable that the air should move with the greatest possible velocity over the after part of the flight deck, in the opposite direction to the alighting plane and, moreover, that there should be freedom from eddies both over the deck and immediately abaft the ship. A low freeboard and finely streamlined stern favours the latter, but undoubtedly there is a tendency for a proportion of the air at the vital landing spot to have undesirable differential velocities. Some attempt to improve matters was made in Scheme I by the use of the forward hangar door, which during landing was raised to give a nozzle effect to concentrate a stream of air on to the deck. In Scheme II the air flow was made worse by the presence of a forward bridge structure, even though it was streamlined, but some attempt was made to improve matters by side shields or nozzles forward of the guns.

In the latest scheme, the elimination of any bridge structure will be advantageous, but in addition it is proposed to provide a synthetic wind from two side deck apertures, fitted with propeller fans driven by electric motors. Two air streams will converge on the deck and unite over the after deck into an astern moving stream of some thirty m.p.h., and thus ensure an easy landing when the forward speed of the vessel and possible favourable natural head winds are taken into account. The object of the synthetic wind is to make a heading movement into the wind unnecessary except in unfavourable circumstances, so that the ship's course need be altered as little as possible. The provision of artificial winds over a narrow deck is a practical possibility and should increase the time element to such an extent as to make deck landing relatively free from hazard in circumstances to-day considered impossible.

It is considered that some 500 electrical horse power expended in this way will be well worth while—seeing that ample power is available.

The "bridge" will now be below deck, complete with all navigation equipment, chartroom, wireless, submarine detection apparatus and ship's office.

In fine weather and for port work, the tops of the control towers can be used for navigational purposes, as with submarine conning towers. It is now proposed to lower the fore deck slightly to provide a square end to the flight deck for take-off.

After landing, the aircraft will come to rest at the forward arresting wires just abaft the control towers; adjacent will be provided an athwartship steel rope connected to bogies running on rails at each side of the flying deck which in turn are both connected to suitable fore and aft hauling gear. The athwartship rope can be coupled to the aircraft to enable it to be hauled back to the afterdeck to the take-off position where deck fixing gear is provided to secure the plane. No hangar is provided as most aircraft maintenance is expected to be carried out ashore, the plane leaving as the ship approaches port.

U-boat Explorers for Cargo Warships.

The more fundamental the consideration given to the antidote of the U-boat menace, the more it is appreciated that air and sea problems are closely interlinked.

The ship is primarily a carrier of cargo, the aircraft the chief weapon of defence. The problem is to effect a marriage—not to provide sparring partners. The author has already endeavoured to show the need for a new ship type, and he would now like to propose a new aircraft specially adapted to the protection of ships. As the chief function of such an aircraft would be the exploration of the seas, the term "U-boat Explorer" will be used.

After considerable thought and investigation, the author suggests that both Sea Hurricanes or Seafires are even less suitable than either the Swordfish, the Albacore or the Skua, nor could the Grumman Martlet or Avenger be considered suitable types for cargo warship air collaboration.

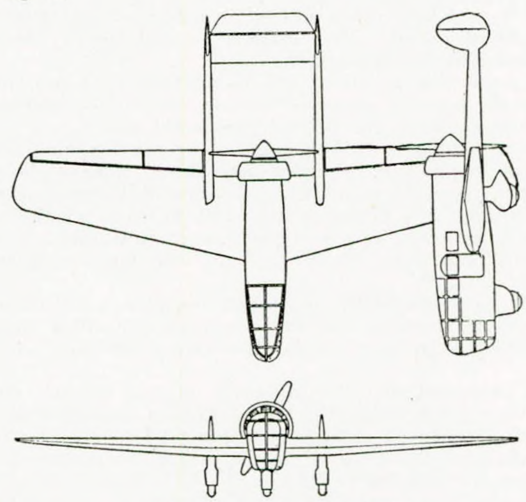
Let us consider the cargo warship requirements. These are :—

(1) Exceptional forward and downward view for U-boat detection.
(2) Very low cruising speed as an aid to U-boat detection.
(3) Provision for an engineer-cum-gunner as well as a pilot observer.
(4) Low take-off and landing speeds.
(5) Higher maximum speed than a long-range air raider, say 275 miles per hour.
(6) Dorsal revolving gun turret for air-raider offence and defence.
(7) Adequate depth-charge carrying capacity to destroy a U-boat. (Depth charges to be capable of being aimed accurately).
(8) Tricycle undercarriage to give deck holding capacity for landing on a pitching platform, and a single point landing for a rolling platform.
(9) High wing to make the most of the forward ship speed, and to give good wing clearance for side deck fittings.
(10) Twin underwing tail booms to serve as buoyancy floats in case of sea landings, as fairings for rear wheels and bomb and depth-charge carriers.
(11) Pusher screws, high up and of small diameter, preferably contra propellers.
(12) Means for rapid evacuation of fuel and surplus weight in case of forced landings in the sea.
(13) Radiolocation apparatus for U-boat detection during day or *night.*

The author believes in the case of a moving platform, such as a ship's flying deck, the most effective use of the forward velocity can only be obtained when the wings are as far removed from the platform as possible, and hence the high-wing monoplane is desirable, preferably with an appreciable dihedral angle. It is also desirable on account of the possible presence of water or spray, so as to reduce the need for a high and dry platform. For the same reason the propeller should be placed as high as possible and should be of the pusher type like the old Walrus.

Such an aircraft would solve the problem of landing on a "dirty" deck; this in turn would solve the problem of the flight deck with low freeboard and hence low ship visibility.

It so happens that an aircraft filling many of these requirements has been already developed in U.S.A. This is called the Abrams "Explorer". A photograph of this is shown in Fig. 25 and the outline in Fig. 26.



The Abrams "Explorer."

FIG. 26.—*Span 36ft. 8in.; length 26ft.; maximum speed 200 m.p.h.; cruising speed 175 m.p.h.; landing speed 60 m.p.h.; b.h.p. 365 (Wright Whirlwind); accommodation, two in tandem.*

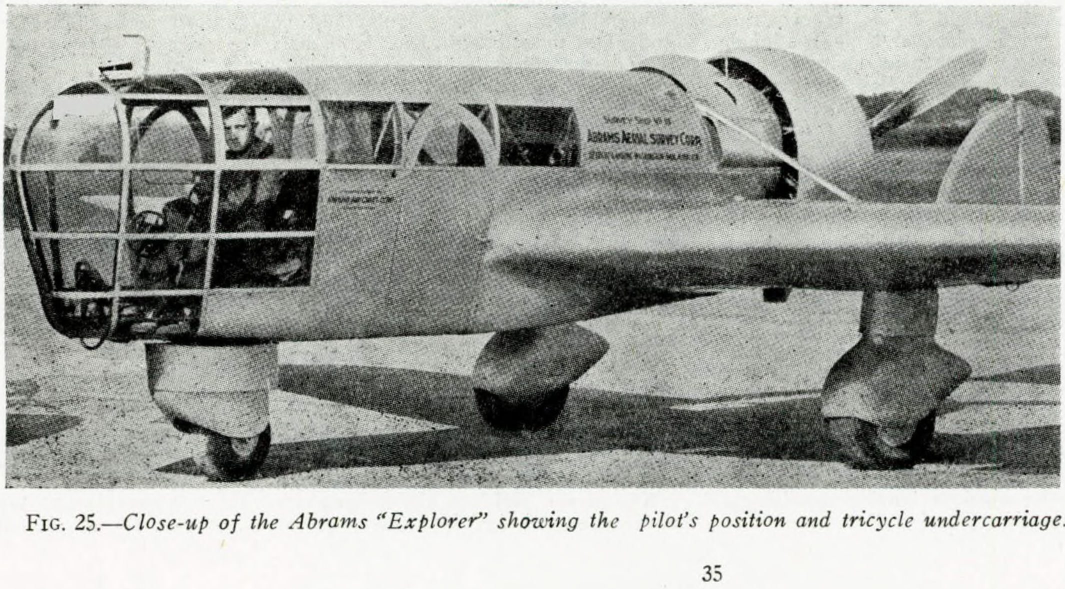


FIG. 25.—*Close-up of the Abrams "Explorer" showing the pilot's position and tricycle undercarriage.*

The author suggests that this type of plane would form the basis for a fundamentally correct cargo-warship based aircraft.

The modifications suggested by the author are :—

(1) The use of a Bristol 14-cylinder sleeve valve engine of 1,600 total b.h.p., with special slow-running adaptations (instead of a Wright 365 b.h.p. engine). This should make high or low speeds possible.
(2) The use of contra propellers to give improved landing control and propellers of minimum diameter. When high up and used as pusher screws they will be relatively clear of water spray.
(3) The nosewheel should be particularly strong, not

made retractable but buried to a greater extent in the fusilage nose, and the springing improved to suit moving deck landing conditions.

(4) The rear wheels should be buried in the tail booms, retained in a non-retractable form but with lighter springing. More reliance must be placed on the nose wheel and less on the rear wheels. For ship-based aircraft it would appear that relatively delicate retractable undercarriages should be avoided.

(5) The tail booms should be attached to the underside of the wing, increased in width and depth, and the tail given an upward sweep as in flying-boat practice.

(6) The ship flying deck retarding wires should *contact the nose wheel fairing* instead of the usual tail hook, and incidentally the retarding wire (one only) should be located *towards the forward end* of the flying deck so that it will be contacted only at the lowest landing speeds *after* the plane actually touched the deck and applied brakes.

(7) A dorsal gun turret of established design but of the largest possible calibre would give ample air raider defensive and offensive capacity.

(8) The tail booms should be divided to serve as watertight floats and as depth-charge carriers, with emergency inflatable floats in the spaces for the torpedo or bombs.

(9) All petrol should be carried in the bottom portion of the fusilage and adequate watertight floating capacity also should be provided. The intention at present is not that the aircraft should take off from the water but merely that it should be capable of landing safely on the water and remaining afloat. The fusilage and tail booms can be made aerodynamically very efficient.

Such a machine would lay the foundations of a true amphibian type, not only for war purposes but for many peace purposes when small but safe planes are desired for world use.

Such an airplane could remain in the air for long periods at slow speeds but would not have—nor would it need—long fighter speed range, as it is primarily an offensive U-boat weapon. It would normally only cruise around and in front of the vessel at such periods as would ensure U-boat immunity within a given range on a broad path over which the cargo-warship would eventually traverse.

It will be subsequently noted that the plane's engine will have many spares in common with the ship main propelling engines, and the maintenance can be common, thus saving complication and man power.

It is suggested that the proposed type of aircraft will prove superior for marine duties than the Lockheed Lightning triple fusilage type which has proved to be such a practical type of fighter. For its normal duties the plane would be greatly overpowered, but this is necessary for safe take-off from the deck to avoid catapult complications which are more difficult than may be imagined; also it gives the plane fighter powers and speeds as and when this is necessary without the need for great fuel range.

The use of contra propellers not only provides for the minimum propeller diameter with efficiency, but also gives almost constant landing properties due to the centrally placed propellers and a more constant air stream over the tail plane.

The duties of the engineer-gunner would be to relieve the pilot of everything but the control of the plane and observational duties. Most of the engine instruments would be in the rear compartment as in larger aircraft; so would the wireless and radiolocation instruments.

The use of the remote gearbox drive for auxiliaries forward of the engines will enable the main-engine units to be of basic simplicity for overhaul, whilst leaving the auxiliaries undisturbed and with the simplest of controls adjacent to the engineer's position.

Only one plane is suggested per ship, as cargo-warships would no doubt invariably sail in small convoys of two to five vessels and therefore the aircraft duties could be divided up so as to give virtually continuous air cover.

The combination of air-based radiolocation and ship-based Asdic apparatus would appear to afford a remarkably efficient system of U-boat detection.

It is believed that the proposed aircraft with the modified cargo-warship flight deck arrangements affords a true solution for combined air and sea operations.

Final Proposed Dimensions of Cargo Warship.

It is proposed to increase the length of the vessel to 550ft. and the draught to 30ft. to give better airplane landing conditions, greater carrying capacity, increased stiffness of hull, greater immersion of propellers and improved torpedo explosion resisting properties due to the increased depth. The deadweight will be increased to 13,500 tons and the displacement to 21,000 tons. The power required for 18 knots will be increased to 16,500 s.h.p.

Additional cargo-hold length is provided and the engine and pump rooms rearranged to give a better utilization of space. The proportion of deadweight allotted to cargo carrying is now increased to 8,000 tons, and the liquid cargo bunkers and stores to 5,500 tons, excluding the blister capacity.

In view of the part-tanker construction, it will always be possible to discharge liquid cargo first for any draught adjustment.

Engines for Cargo-warships.

In the original paper the author stated that by using high-speed ships the problem of producing more cargo-carrying capacity was transferred from the shipbuilder to the marine-engine builder. Further investigation proves, however, that this is impracticable. The problem of high-speed is one of producing large horse powers, but that part of the marine-engine industry left to merchant building has a very small horse power building capacity. In fact, compared with other industries, the amount of weight and man-power per horse power is quite remarkably high. The author has fully explored the possibilities of marine-engine design to reduce weight and man-hours, but the immediate prospects are extremely poor. The only industry which has immediate colossal capacity, produces the greatest horse power per unit of weight and man-power, is the aero-engine industry. Moreover the industry is vital and progressive. Although petrol is the basic fuel, the best fuel consumptions are to-day as good as the normal large marine Diesel engine.

Whilst it is acknowledged that the working life of a normally-loaded aero engine is very short compared with that of a large marine engine, there can be no doubt that there is a certain power of an aero engine at which its workable life brings it into the realms of practical marine use. The author suggests that if an aero-engine—say a liquid-cooled sleeve-valve 14-cylinder radial engine—is reduced to half its international commercially rated full power, its running period without any maintenance is more than that required for an Atlantic crosssing in a cargo-warship, and even then only minor attention to plugs will be required.

Provided a sufficient number of such engines are used to enable one or more engines to be continually maintained, complete propulsion reliability with such engines becomes a reality.

The problem of connecting such engines to the propeller is simply solved by the electric reduction drive with the aid of the efficient electrical industry. No immediate technical or production problem exists provided priority is given.

No problem of trained personnel exists, as the organization has been already developed for aircraft requirements; the same may be said of maintenance and spares organization.

We then come to the question of fuel. On the operational side there is no fundamental objection; special precautions are needed against fire, but these are all well known and capable of simple solution. *It is when we come to the availability of petrol that the author has made a discovery of prime importance when it is appreciated that there exists in U.S.A. to-day an actual glut of 60 octane automobile type petrol* due to the reduced use of vehicles caused by rubber shortage restrictions and Government control of the use of automobiles. This petrol could be obtained at a cost even slightly less than that of Diesel oil, half the price of 80-90 octane petrol, or one-third of the price of 100 octane petrol.

Provided the compression pressure and output is reduced to suit this lower grade and cheaper petrol, there is no reason whatever why it should not be used for marine war transport. The fuel consumption would increase from the 0·4lb. per b.h.p. of the modern aero engine with 100 octane petrol, to between 0·5 and 0·55lb. per b.h.p. with the low octane petrol.

We have therefore distributed part of the problem to the petroleum industry, to produce progressively higher octane fuels at Diesel oil prices. Here therefore we have light economic engines available which have been fully developed in service and also a fuel available in sufficient quantities for all the cargo warships that can be built.

It is submitted that it would be a simple matter to fit up an entire working installation of 8,000 b.h.p. and test it out immediately to establish maintenance periods and the various technical adjustments to suit the low-grade fuel.

With regard to post-war requirements, the author believes we will always be in good hands if we hitch up to the aero-engine industry and use whatever fuels are produced for its needs.

The future fuel is in the melting pot. There is every possibility that the post-war fuel is a safety petrol rather than Diesel oil, but there is scope for unlimited post-war engine development. Meantime the liquid-cooled sleeve-valve petrol engines, high in speed, low in weight, low in man-hours to produce, and economical in operation, are immediately available for marine naval service.

It is suggested that a 14-cylinder radial engine should be coupled to each end of a generator running at 1,500 r.p.m. to give a total power of 1,500 b.h.p. Six such generators would be required, together with one extra for covering electrical losses and one for the auxiliary load. Two or three spare engines could be carried for ship maintenance.

The engines would be of elementary simplicity with no superchargers or auxiliaries, these latter being common to all engines as in marine practice. Such engines would be comparatively quiet, vibrationless and easily removed for overhaul.

A common oil sump and first-class oil filtration equipment would all tend to long life of bearings and working parts.

In subsequent engines, full advantage could be taken of new engine and fuel developments with the minimum of renewal expenditure of the installation as a whole.

The steady load of a marine engine is ideal for a petrol engine, just as the variable vehicle load is ideal for a Diesel engine.

This solution the author believes could open the way to unlimited cargo warship developments with the absolute minimum of interference to the present production of normal merchant vessels. The total weight of fuel and engines will be much less than any other available type of engine and its fuel. The relative fuel costs will not greatly exceed those of the steam turbine, as fuel prices are largely arbitrary.

Fuels and Engine Types Resurveyed.

In view of the Admiralty's suggestion that there was a lack of definite engine proposals in the author's scheme, some further notes are given. In the paper the author was, quite frankly, groping for the solution of the high-powered engine problem. Logically, the small multiple unit system had most in its favour, but a suitable engine was not available and the author was also anxious to find a solution which would utilize the present marine-engine production capacity with the greatest efficiency.

It was obvious that the American solution of geared or electric-drive turbines was mechanically sound but economically somewhat extravagant in fuel. No experiment was involved, but the basic fact remained that as powers increased the need for reduced fuel consumption and costs also increased, and it was therefore illogical to throw aside the definite pre-war tendency which was away from steam power. The reversion to coal-burning steamers on the part of the Merchant Shipbuilding section could only be explained on the grounds of technical conservatism, lack of naval experience of U-boat warfare, and the influence of certain reactionary tramp shipbuilders.

The geared-turbine system was not considered suitable by the author for cargo-warship propulsion, owing to the lack of full astern power, the high frequency noise from the gearing, the sensitiveness of the whole unit to explosion effects and the serious lack of production capacity of gearing in this country to ensure anything like a substantial building programme. As far as this country is concerned, we appear to be largely limited to the manufacture of the crank type of engine, and crankshaft utilization will be the dominant factor in engine production as long as large or medium sized engines of conventional design are considered.

Hence the fundamental advantage of any engine which can use a simple built-up crankshaft in an economical manner. Of large engines the simple straightforward double-acting two-stroke is unique in this respect, and non-appreciation of this fact early in the war has meant serious loss of development during the early years of the war—to such an extent indeed that it cannot be considered sufficiently established for major production for war use.

Production of large crankshafts requiring webs, pins and journals in a combined forging, is also limited in output especially in the larger sizes, and therefore one is forced to consider engine solutions not in a pre-war programme. The type of engine *par excellence* from a crankshaft point of view is, of course, the radial type engine, which has been developed with such success for aeronautical purposes.

The radial principle is restricted in its application to cylinder parts that can be manhandled, but a horizontal form of radial engine offers practical advantages in this respect. The latest General Motors Diesel engine for naval craft is of this horizontal radial form.

Although the past application of the radial principle is almost entirely limited to the aero engine, there is no reason why it should not be applied to light but proven two-stroke Diesel engine types of auxiliary engines up to say 7½in. bore, running at say 750 r.p.m. for electric generation. This, however, involves some degree of experiment, and the only engines immediately available are four-stroke petrol aero engines of 5⅜in. bore running at speeds up to a maximum of 2,750 r.p.m. and at 1,500 r.p.m. for continuous operation.

Generally speaking, the crankshaft bottlenecks are largely mental bottlenecks if indirectly-coupled multiple engines are to be considered.

The present design of certain aero engines with sleeve valves instead of poppet valves puts this class of engine in a much more favourable light from a marine running and maintenance view point, and moreover the type is most suited to petrols of relatively low octane value.

The only experiment is the adaptation of the compression ratio and the carburettors to use an automobile grade of petrol, which is in abundance in parts of the world under Allied control.

With the advent of the liquid-cooled sleeve-valve engine the type is put right into a marine light, either as a twelve-cylinder horizontally opposed type or as a double bank radial engine.

Shipowners are now giving serious consideration to air transport. This will inevitably mean taking an interest in aero engines. The author's suggestion in respect to the use of lowly-rated aero engines for ship propulsion is surely a step on the right road to combined sea and air transport.

The aero engine represents the quintessence of internal-combustion engine design for low weight, low fuel consumption, ease in production and reliability at exceptional power ratings.

Admittedly it requires, as yet, petrol as a fuel to give this high performance, but the airplane of the future will require a fuel to give low running costs as well as low combined engine and fuel weights. There is in fact serious doubt as to whether the future lies with the Diesel principle; indeed the whole tendency at present is definitely towards high-compression petrol engines rather than compression-ignition engines, for very good reasons. The problem of fuel combustion for example—the bane of the Diesel engine—is relatively simple; the author has knowledge of test mean pressures being obtained of 350lb. per sq. in. at 3,500 r.p.m.—figures unknown in the Diesel world. For marine purposes a figure of 125lb. per sq. in. is proposed.

The early virtue of the Diesel engine was its capacity to employ high compression pressures to give fuel economy, but this is now seriously challenged by the petrol engine, which due to the extraordinary developments in petrol technology has gradually advanced to compression ratios of 10 to 1 (that of the Doxford oil engine), and no limit is in sight; so much so that to-day the best aero engine fuel consumptions are equal to the best large marine Diesel engine consumptions.

Let us now consider the comparative geometric type and design; the high point of Diesel engine type has been considered to be the vertical double-acting two-stroke until the author suggested the Vee type, which is the equivalent of four single-acting strokes on a given crank. In the case of a radial aero engine, however, no less than *nine* cylinders can operate on a given crank, which is even superior from a material utilization point of view. Such a design is only possible with assured clean combustion. *Given this and sufficiently good lubricating oil filtration, which is possible on a ship,* there is no reason why bearing wear should not be reduced to quite exceptionally low figures, thus justifying the policy of high-speed engines and engine replacement rather than periodic detail adjustment.

There can be no doubt that the marine engine of the future will depend more and more on technological developments of the transmission of engine power to the propeller to utilize such engines, and on the fuel technologists' capacity to produce improved and specialized fuels to give increased economy. The use of *raw* fuels like coal or crude oil will be internationally uneconomic. Derived petroleums from coal are more suited to petrol engines than Diesel engines and this may have some future significance.

World engine capacity is already greater in the higher speed range due to the influence of the automobile and the airplane and, in the author's opinion as already expressed in the paper, the future function of marine engineering works will be at least in part that of installing bought-in engines from specialized high-speed engine manufacturers.

In the present national emergency there is no reason why this principle should not be adopted immediately to obtain the high engine power and high ship speeds which the U-boat makes imperative, even though it means the acceptance of a fuel hitherto barred from use on shipboard for reasons of personal safety.

If and when the aero engine adopts the two-stroke cycle with single or double action, which will necessitate the petrol injection principle, it will be seen that there will be little difference between the Diesel or compression-ignition engine type and the high-compression petrol engine. It is even not beyond the powers of the engine designer to make such an engine that with small adaptation could use either fuel so as to take advantage of any fuel situation. Petrol can be given a "safety" property that is almost as good as Diesel oil, and the production of such safety petrols is looked upon as a definite post-war development. We then have the possibility of a battle between the production of high octane petrol on the one hand and high cetane Diesel oil on the other, both highly developed fuels which appear to have similar production costs at the refinery. So far, the high octane petrol is making vastly greater strides.

Whichever type of oil is found to be the most suitable, the type of engine to use either oil will be almost the same and, moreover, most probably will be primarily developed for air and land transportation.

Fundamentally, therefore, the author believes sea transport propulsion should envisage, at least in part, such an arrangement of engines as will efficiently utilize whichever engine and fuel is developed. This suggests the multiple engine with electric transmission, starting to-day with developed petrol engine types and leaving the future to the outcome of the engine and fuel battles which will be fought in airplane-engine developments.

Given the decision that all vessels built in this country should have high speed, even assuming much greater standardization and specialization of marine-engine manufacture, it seems evident that less than half the vessels could be equipped by the conventional marine-engine industry, bearing in mind that a minimum of three times the power of the present slow types would be required. This is without consideration of cargo warship machinery which requires six times the power of present standard ships. The remaining engines can be built either by the electrical industry in the form of turbo-electric units or by a combination of the electrical and aircraft industries. It is believed, however, that if the electrical industries build only the purely electrical requirements of the propelling machinery, this would be as much as they could handle as already such spare turbine capacity as is available should be used to help out marine turbine engine builders. Bearing in mind that the man-hours to build a suitable derated aero engine stripped of aircraft auxiliaries amounts to only some 5,000 man-hours, making the total engine man-hours only 60,000 for 7,500 b.h.p., it is unlikely that the turbines, condensers, boilers and necessary steam equipment will be less than this, and certainly will be much heavier in weight.

As already expressed in the paper, the author believes a high-speed compression-ignition type of engine should be immediately developed, preferably of the horizontal type, so as to serve as a future "within the wing" type of high cetane fuel aero engine, as well as an electric generating marine engine for electric propulsion. This would mean that shipowners, like plane owners, would eventually have alternative types to suit special fuel requirements throughout the world.

As the art and science of petroleum refining has advanced, the proportion of the crude oil which can be converted into petrol, Diesel oils and other marketable oils has greatly increased, until the proportion of residual oil available for use under boilers has dropped to a relatively small percentage of the total. There is reason to believe that the increases in fuel-oil consumption by steam turbine vessels built by the U.S.A. and by Allied naval vessels will absorb all the available supplies, and the author strongly suggests that this country should make every endeavour to burn such residual fuel in *slow-speed* direct-drive oil engines.

Certain oil engines with organized cylinder swirl can burn such oils. *It is here that slow-speed engines have special advantages over high-speed engines which should be exploited to the full.* Such engines will use little more than half the oil needed by steam turbine units, whether of the geared or electric type.

In slow-speed engines the author includes engines running at up to 200 r.p.m. and a direct-drive Vee double-actor, with a bore of 18in. and a stroke of 36in., operating at 175 r.p.m., could be made eminently suitable for using the type of heavy fuel proposed.

Generally speaking, the author believes that the future of fuel in this country for producing power lies in internal rather than external combustion, and the proposed use of the turbine and water-tube boilers is a temporary retrograde development brought about by lack of reliability and high initial cost of the excessively large single-screw oil engine, a defect which can be completely eradicated by the use of two or more smaller units of higher speed and more advanced design.

It must be remembered that we are not an oil-producing nation; every drop of oil must be transported and most of it from parts of the world not under our control. Therefore nationally we must use it with the greatest economy, substituting technical skill in its use for material resources.

We are fortunate in having available in this country an engine —the Doxford—which was almost "brought up" on residual fuels. Immediately, therefore, the soundest proposal is to concentrate on the building of such a size Doxford engine as records establish gives the best reliability, increase the rating, both revolutions and mean pressure, to the safe maximum and burn residual fuel oils. The author suggests that the present 520mm. size of engine, but operating at the increased speed of 130 r.p.m. to give 3,000 b.h.p. may well give the desired results. Two such engines with bow and stern propulsion should be used, and the various suggestions made in the paper regarding independent scavenge and service pumps, etc., all hold good. Further investigation has revealed that the reliability of the smaller engine is much superior to the larger mentioned in the paper, and therefore this should be the limitation. To suit this "reliable direct-drive power" of 6,000 s.h.p., the hull size and shape should be adapted to give a sea speed of 15 knots.

Every marine works with suitable capacity should build such engines, rather than either steam engines or turbines. Higher powers can be best left to multiple engine units and electric drive.

The present marine-engine industry technical development should be directed simultaneously towards improved utilization of material with smaller direct-drive engines to develop 4,000 b.h.p. at 175 r.p.m. at a weight not exceeding 45lb. per b.h.p. This, the author believes, is a practical possibility to which help and support should be given by the Government.

The auxiliary engines needed with such main engines should use a few cylinders of the same size as the main machinery—say four—so that there is a possible simplification of manufacture, spares, equipment and—most important—*knowledge of maintenance.*

There has been a tendency of late to consider auxiliary Diesel engine makers as potential suppliers of main engines with indirect geared or electric drive, but in the opinion of the author auxiliary Diesel engine capacity can be best used in a capacity complementary to *large main propelling machinery installations,* and greater effort should be made to ensure the auxiliary engines can burn residual fuel oil. The design tendency should be towards larger cylinders rather than smaller, and the general design made to harmonise with the main machinery.

The author believes it to be a profound mistake to have small high-speed "busyboxes" adjacent to large heavy-oil engines, as two maintenance mentalities are required instead of one.

The chief immediate utilization of auxiliary Diesel engine makers should be in the manufacture of the smaller parts of main engines on a specialized production basis. There are great possibilities in this direction. For example, in the case of the proposed 18-in. bore engine, all the cylinders and most working parts could be even more efficiently made at such works than in marine engine shops, and the proposed new engine has been considered with this in view from the outset. It is one reason for the smaller size of the cylinders and their greater multiplicity.

Most mercantile and naval requirements can be met by a few basic main and auxiliary engine types, which by virtue of much greater specialization in design development and manufacture will give vastly superior results than the present technically individualistic policy can ever produce.

Apart from the proven Doxford engine for ***direct drive,*** the only proven engine immediately available for ***indirect drive*** in an economic manner and in large quantities is undoubtedly some form of petrol aero engine. There is no alternative available at present, and tests on adapted marine aero engine types could be commenced at very short notice to give definite information on possible running periods, maintenance and fuel consumption.

Gunnery Capacity.

There has been considerable criticism of the guns suggested, although detailed particulars were not given as this was thought to be a secondary matter to the main subject of the paper.

Without having precise statistics, the author would suggest that few U-boats have been actually sunk by merchant-ship gunfire, although there can be no doubt that the mere presence of a 4-in. gun, even if obsolete and inaccurate, does force U-boats to keep their distance, maintain their invisibility and forces them to use valuable torpedoes instead of gunfire. Undoubtedly, to consider using smaller calibre—or more important closer range—guns than a U-boat possesses would be unwise. Therefore this suggests the fitting of two 4-in. or 4·7in. guns on each side deck aft. In a vessel like the cargo-warship, such guns would be much more effective than on either a corvette or a U-boat, or for that matter a destroyer. Care would be required to keep the overall height of the guns low and when out of action to have the minimum of Christmas tree effect so noticeable on a corvette.

Because of the low freeboard, weather protection should be given. The anti-submarine guns should be preferably arranged aft in barbettes, whilst the anti-aircraft guns forward should be arranged in revolving turrets as in aircraft practice, but much larger.

The original intention was to have only one size of gun on board—rapid-firing 3-in. Bofors—so as to get in a great weight of projectiles quickly over a broad target; actually both long-range and rapid-firing broad target guns are required. The placing of high and low angle anti-aircraft revolver cannon guns is limited to the side decks, and instead of the forward position it is now suggested that these be placed amidships on streamlined deck supports, so as to leave the forward side deck position free for the widely-spaced control towers.

This improvement in the gunnery section will put the cargo warship into a definite warship category, to an extent not initially contemplated, as now the vessel will be superior to a corvette or escort vessel in view of its size.

The fault of the corvette or escort vessels is their small size for Atlantic weather, which limits the safe speed at which they can operate. In fact their relative unsteadiness as gun platforms or submarine detectors, limits their use to depth charge operators, usually after the event. The cargo warship may well serve as the future gainfully-employed escort vessel for 14-knot convoys.

Not only would the cargo warship be a first-class escort vessel and aircraft carrier operating relatively unseen, but she would carry her full quota of cargo.

Minesweeping Gear.

Criticism has been made of the difficulty in fitting minesweeping gear, but actually no difficulty will be experienced in fitting an improved version of the common A-frame. The fine lines will facilitate an efficient fitting with the lower support on the propeller nozzle.

Cargo-warship Carrying Capacity.

Criticism has been made of the cargo-carrying capacity relative to normal peace-time cargo vessel types. If the cubic capacity of the proposed hull alone is considered, disregarding at present the fineness in actual form, it is apparent that the chief difference is that cubic space is taken up with crew accommodation and alleyways below deck instead of above deck. When the accommodation is above deck it must still be built of steel and other materials, and has the disadvantage of offering wind resistance, causes a reduction in speed with head winds and forces a slowing down in speed in bad weather due to its relative weakness to sea action. Aerodynamically and hydrodynamically a ship is better without deck houses. It is only necessary to make the hull form a little larger in volume, and the accommodation structure steel can be then gainfully employed in strengthening the below deck structure instead of being largely a mere excresence on the deck. The cubic space allotted to the ship's crew is then purely one of social assessment.

The engine-room space, in spite of the enormously increased power, will be less than the usual 13 per cent., hence nothing is lost in this direction. The carriage of so much liquid cargo ensures that every odd-shaped space about the bottom or ends can be usefully filled with liquid cargo. In spite of the fine lines, the solid cargo space is attractively arranged in the centre of the ship for efficient stowage.

The chief war-time penalty for security is the internal torpedo blisters, which undoubtedly take up space, but with the war-time heavy cargoes which such a vessel would carry it is doubtful if this feature will have any noticeable effect on the actual carrying capacity. It is, of course, necessary to make the blister as efficient as possible and consequently as small as possible—hence the proposed design.

In view of the desirability of gainfully employing the volume of the blisters, which means virtual elimination of damping materials other than useful liquids, it is now proposed to modify the design to enable this to be done to a substantial extent. Relatively non-inflammable oils only would be used in these spaces.

This space utilization further removes any criticism of reduced carrying capacity in a given hull volume.

The fact that the holds are smaller than usual does not detract from their efficiency. On the contrary, practical sea captains and stevedores have made favourable comments on the scheme, especially for cargo-liner cargoes as distinct from bulk cargoes. It is indeed claimed that the arrangement of holds, hatches and cargo-handling equipment is a definite advance on existing arrangements on cargo vessels.

No possible exception can be taken to the lower holds for general cargo, whilst the upper holds are not only suitable for bulky vehicles or aeroplane parts but the central portion is ideal for carrying the largest war tanks. No less than twenty of the largest tanks could be carried, or as many as forty Churchills. In order that large portions of certain British and Allied planes can be carried (which are now usually carried as deck cargoes) it is desirable that the hatches should be made wider and the figure of 25ft. is suggested instead of 20ft. This will enable parts to be carried below deck which was never before possible and the increased width will make for better crane action. The length of the holds will be increased from 24ft. to 28ft. 6in. With regard to troop carrying, the internal hatch coamings spaces, 42ft.×21ft.×8ft., could be made into highly suitable accommodation spaces if watertight doors to the alleyways are provided in the coaming sides. Complete military units could then be transported with all equipment and stores.

The large width of the holds will be found to be sufficient for the carriage of steel rails and other long parts in spite of the short length.

The flush lower deck hatch covers will aid removal of the 'tween deck cargo.

Cargo-handling Equipment.

Bearing in mind war tank developments, it would appear that a derrick or crane should be provided capable of lifting 60 tons at each hatch, and here there is great scope for efficient and ingenious design.

Since replying to the first part of the discussion on the paper the author has had the opportunity of further thought on this subject and has discussed the matter at length with a number of ship masters of vast experience. The conclusion reached is that the original proposal to use cranes rather than derricks will be much the better solution to give instant availability without the difficult rigging of heavy blocks and tackle.

Therefore a mixture of the first and second designs is proposed, *i.e.* hinged cranes of special design to enable a crane structure of sound proportions to be used and yet to secure a clear flight deck by simple retraction. The use of steel-plate pressings with welding will enable a box girder construction to be used which will be well adapted to marine conditions and yet maintain low weights. The winding drums and motors will be embodied into the crane posts, together with the swivelling mechanism. The retraction will be by means of gearing and motor arranged in the side trunk. A.C. motors will be used throughout and by making all cranes identical, standardization will keep the man-hours to a reasonable figure.

In view of the closeness of the hatches, it is proposed to have only six cranes per side and the endmost cranes will be able to deal with stores and engine-room requirements.

The author believes crane posts of correct structural shape will lead to economy of weight compared with the present ugly parallel samson posts. In order to cope with bale and box cargoes, in addition special rapid lifting arrangements can be made with the crane proposed.

Man-hours spent on good cargo-handling equipment will be fully justified for such a high-speed vessel. As there is ample electric power available the cargo-handling load can be quite phenomenal. The value of high speed at sea is lost if there is not corresponding speed of cargo handling in port.

Capstan and Warping Winches.

There is no reason why these should not all be below deck as in certain modern liners and the necessary cross deck space must be provided between the steering gears and the engine rooms. A comparison between the "Normandie" and the "Queen Mary" is interesting as depicting the new and the old style respectively.

Trunk and Side Decks.

The proposal to utilize the lower side decks and side trunks for the accommodation of the lifeboats, cargo-handling equipment and ventilators is new, but it must be conceded it is neat and could be made functionally very efficient. Not only can it be made to provide complete cover for the electric deck gear and deck mains, but it should be possible to devise a means of stowing and handling the wire ropes to reduce the labour entailed in the rigging of the cargo-handling gear.

Lifeboat Davits.

In the new design of ship it would be possible to use the well-developed Taylor gravity davits as illustrated in Mr. Blocksidge's recent *paper. Care would have to be taken to ensure the minimum vertical height, and the davit should preferably be of the cantilever type supported from the side trunk. The davit's runners would also serve as supports for the derricks when in the retracted position.

Side Torpedo Protection.

Since the various discussions some further thought has been given to the torpedo blister design.

It may be of interest to review the author's various "blister" proposals. The first design, which was not published, consisted of virtually a double wall and was the result of the study of past warship constructions. Then the author conceived the idea of a concave internal blister using air or liquid for damping.

This was distorted as in Fig. 1 (November TRANSACTIONS) for practical considerations. The next design consisted of a number of "blisters" which formed a corrugated pressure skin of great strength and had the intervening space fitted with specific explosion-damping material and secondary air vessels distributed throughout the mass.

It is now proposed to revert to the author's original conception of a true concave internal blister, but with increased support from the lower deck and oil tank top, and to use a combination of flat and curved surfaces to facilitate manufacture without impairing efficiency.

The greatest protection is arranged for in the most likely region of high pressure, *i.e.* at about mid depth. Instead of considering the blister as an air vessel, the blister is now open to the sea at all times at both top and bottom extremities, so as to facilitate the free dispersal of explosion pressures back into the air at the top and into the sea at the bottom, so as to avoid any locking-up of kinetic effects.

In order to "break the back" of the explosion, an inertia "piston" or "blanket" of sectorial form is lightly supported, so that an explosion will move it towards the pressure wall, simultaneously open it out and tend to trap the water behind it to form an effective liquid cushion, thus creating a distributed hydraulic pressure which the curved pressure wall must be capable of withstanding; the escaping water at high velocity is guided out of the top and bottom blister openings. The sectorial "blanket" has its inner convex surface of steel plate supported by vertical tee bars and the outer space filled with suitable plastic armour material. This protecting blanket is lightly welded to the top and bottom blister gussets.

One object of the proposed design is to obtain the greatest hydraulic support for the water skin from the pressure skin, without incurring pressure skin bursting pressures.

The proposed design is believed to combine an efficient outer hull with a strong pressure hull with the minimum sacrifice of weight and space.

After the war, the hull openings could be welded up after chipping out the plastic armour, and the space used for the carriage of liquid cargoes. The proposed construction implies a constant penalty in hull weight, but will not entail the sacrifice of speed such as any external net construction would entail and is at all times shipshape and suited to heavy weather.

Naturally only a qualitative construction is indicated—experiments would be needed to settle dimensions.

Below Deck Accommodation.

Criticism has been made of the lack of natural light, but here the author would indicate that modern scientific lighting systems could be employed. Modern factories in the U.S.A. are completely without natural light on the *score of efficiency*.

As long as provision is made for natural light in the communal day rooms and naval type deck exercises for the personnel are provided, there is no reason why the living conditions should not be made superior to even the best present ship standards.

It is taken for granted that scientifically correct heating and ventilation would be provided, which would be vastly superior for the health than existing ventilation on ship board, which is often of an indiscriminate character owing to the black-out.

In no case should there be more than two berths per cabin for the permanent crew, and the lounges for officers and men should be large and spacious in the interests of ship efficiency as well as personal comfort. In such relatively "safe" vessels, it would be hoped that eventually women would be introduced for the domestic and clerical duties as on Russian ships.

Structural Strength.

Whilst the bottom and sides are potentially stronger than normal practice, some doubt has been expressed at the unconventional deck construction. Provided the top of the longitudinal side trunk is free of stress concentrations—which it can be—the author sees no reason why with welded construction, the proposed design should not be made economically strong. It is not always possible to obtain ideal moduli of cross section; this must frequently be subordinated to function.

As mentioned in other parts of the paper and discussion, the conventional ship deck construction has many changes of section and stress concentrations, which torpedo action shows up only too drastically. A great many ships fracture across the deck and break in two, so conventional design is not by any means the last word.

Provided we can make the cargo warship difficult to be torpedoed in the first place and then successfully localize explosion damage to the ship's sides, the design of the deck to give marine safety will not prove an unsurmountable technical problem. It will not be possible to comply with any classification ruling, as classification societies have so far not legislated for the effects of enemy action. It would be desirable, however, to make the fullest use of the vast knowledge and experience of classification societies, although obviously the responsibility and rulings must be the Admiralty's, as the vessel is primarily a war type.

Welding versus Riveting.

In the paper the author suggested that the water skin should be riveted to make use of the relative weakness of riveted joints to restrict the tearing action, but that the inner structure and pressure skin should be welded on the prefabrication system to ensure down-hand welding. In the discussion the author was inclined to a welded water skin to make use of the much greater resistance of welding to explosion effects other than immediate torpedo effects. Further information and experience to hand suggest that the original proposal certainly has merit in controlling damage and enabling repairs to be executed in this country.

While the pressure hull and bulkheads must be welded, these parts need only have a fraction of the welding required for an all-welded water skin.

It would also appear that the blister transverse divisions should be primarily part of the water skin rather than the pressure hull, and made capable of easy renewal.

The author proposed transverse framing for a riveted skin and chequerboard framing for a welded skin. In this country conventional transverse framing with preferably more widely spaced and deeper frames will probably offer practical advantages until a full-blooded welding technique is evolved.

Metacentric Height.

The author believes that metacentric manipulation can safely be left for some little time yet, as the internal distribution of weight in a cargo-carrying vessel is vastly different to the "fixed" internal composition of a warship.

The main essential is to settle on the general compromise of design required; afterwards the naval architect must exercise his ingenuity to work in his experience and knowledge to produce a working design of proper stability and seaworthiness.

Prefabrication.

Throughout the various designings, the author has kept in mind the need for a minimum of welding, and therefore the transverse bulkheads are of the vertical corrugated type in the lower holds, but are flat and reinforced in the bottom oil tanks and upper holds. The transverse bulkheads are therefore in three distinct sections and the horizontal members, *i.e.* the lower hold bottom and the lower deck are continuous members. Such a division will aid prefabrication in horizontal as well as vertical sections, the lower hold transverse bulkheads, the outer skin and central part of the pressure skin, being attached on the slips.

Bow Propulsion and Steering.

Criticisms have been made of the proposal to have a bow tractor propeller. The possible effect of ice has been commented upon, but here the author would quote that a bow propeller is commonly fitted to many ice breakers—the idea being to cause a suction ***under*** the ice to make fracture of the ice easier. Bearing in mind the difficulty the author and his friends have had in getting data on the subject of bow propellers, most of the criticism of this feature must not be considered seriously. It would appear that the efficiency of the bow propeller can be expected to be 3-4 per cent. less than a stern propeller, but it may be even better. The strategic advantages of the bow propeller seem to be so great, however, as fully to warrant its adoption. Precise information on the steering

**February, 1943 issue of the* TRANSACTIONS *of the Institute of Marine Engineers, Vol. LV, No. 1.*

efficiency of a bow rudder *at speed* is also difficult to come by. This may be of great importance for avoidance action and only tank tests can prove the possibilities of both bow propulsion and steering.

Manœuvring Capacity in Port or Confined Spaces.

The capacity in this respect will be quite *phenomenal* due to the bow propeller and rudder and the electric propeller drive which gives complete bridge control of the relative powers at each end of the ship.

The cargo warship will be able to pivot about its own centre within a diameter little more than its own length. It will be able to move broadship on and off quays. It will be able to go full speed astern under complete control. It will be possible to keep position in cross currents or winds and the ship will have increased control against head tides or currents.

In fact just as the front and back drive is rapidly gaining ground for vehicle propulsion, so it seems probable that bow and stern propulsion has a future for ships.

These are all statements which can be proven at small expense by small-scale tank tests.

Propellers and Underwater Noise.

As the greater part of the underwater noise comes from the threshing action of the propeller itself (as distinct from any synchronous blade vibration such as singing, the presence of which would be criminal as it can be avoided by going to the right designers), it is essential that the propeller design and material and manufacture should represent the quintessence of all that is known by the well-known propeller specialists.

As we must face the realities of the U-boat underwater sonic apparatus and the acoustic mine menace, the author believes there is a definite war-time case for shrouded propellers on the lines of the Kort principle, even if this entails a small sacrifice in propulsive efficiency in smooth water. The combination of silent, vibrationless electric motor propulsion, shafting and propeller free of synchronous vibration, well-designed propellers with extra-fine adjacent hull forms and shrouded propellers should all greatly reduce detection especially from the beam, and withall should be highly efficient.

The Kort nozzle will give bottom support for the rudder posts and enable efficient Hydrogap or equivalent type rudders to be fitted, The shrouding will obviate entanglement of ropes or chains in the case of the forward rudder, aid the fitting of mine-sweeping gear and give a means of directional control of the propeller streams.

Bow Shape.

In order to avoid broken water, it is desirable to have little or no bow flare which turns over the water and makes a tell-tale white arrow to the air raider. The new forward design of flight deck permits a differential deck level and a water deflector which will permit of a "submarine" bow with at times a wet foredeck but reasonably dry flight deck. It is understood that the usual gear on the foredeck is below deck.

Conclusion.

The author believes that sufficient ventilation of the subject has been made to serve as a guide to the actual design of a cargo warship; the difficulties involved have certainly been exposed and it is hoped that sufficient interest has been stimulated to activate those professionally concerned to engage upon detail developments of the component parts or model tests of the various features.

THE ADMIRALTY AND THE CARGO WARSHIP.

The Council have decided to publish the following extract from the official report of the proceedings in the House of Commons on the 10th February, 1943, together with Mr. Burn's comments on the Admiralty's statement:—

Mr. Shinwell asked the First Lord of the Admiralty whether he has considered the proposals made by Mr. W. S. Burn to construct a cargo warship and vessels of fast speed?

Mr. Alexander. Yes, Sir. The Admiralty have given prolonged and careful consideration, both from operational and technical standpoints, to Mr. Burn's proposals throughout their various stages. It is not possible to set out adequately the results of these investigations within the limits of a short answer. For this reason, and in view of the special interest that has been taken in Mr. Burn's suggested designs, I propose, with my hon. Friend's permission, to circulate in the OFFICIAL REPORT a relatively detailed statement which I have had specially prepared.

Mr. Shinwell: I am obliged for that, but may I ask whether notice has been taken of the recent pronouncement of the Chamber of Shipping on the subject of speedy vessels, and whether that is also referred to in the statement to be circulated?

Mr. Alexander: The statement which is to be circulated deals entirely with Mr. Burn's proposals, but I have had notice taken of the Chamber of Shipping's proposals, and, of course, all the considerations they have in mind.

Following is the statement:—

PROPOSALS OF MR. BURN.

The Admiralty have carefully considered the various proposals of Mr. W. S. Burn for the building of "cargo-warships", whose object is to reduce the loss of merchant shipping tonnage from U-boat attacks.

(2) The principal features of the designs which Mr. Burn has proposed are:—

(*a*) Reduced visibility.

(*b*) Higher speeds.

(*c*) The fitting of a flight deck to enable an aeroplane to fly off or land.

(*d*) The fitting of anti-torpedo "blisters", or internal protection, and greater sub-division by internal bulkheads.

(3) The Admiralty have considered the "cargo-warship", both in its capacity as a warship—that is, its capacity to beat off enemy attack—and in its capacity as a cargo-carrying ship.

Capacity as a Warship.

(4) The principal defensive features of the design are high angle/low angle armament, flight deck and torpedo protection.

The anti-submarine and anti-aircraft armament shown in the design is very small and ineffective. Indeed, so far from possessing the armament of a warship, the proposed vessel would be considerably less well armed than the average British merchant ship, and the necessity for keeping the flight deck clear of obstruction would make it difficult to provide effective armament.

(5) The flight deck is obstructed by a large deck house forward which would make flying-on operations hazardous. In addition, the flying deck is so near the water-line that flying operations would only be possible in calm water. In order to make flying operations possible under any conditions, the whole of the flight deck arrangements would have to be re-modelled and the flight deck would have to be raised considerably higher above the water-line. This would entirely destroy the chief claim of the design, namely, invisibility.

(6) The torpedo protection provided in the form of an internal "blister", would be quite ineffective against torpedo charges of the sizes normally used. This view is based both on experiments and on war experience.

(7) It must be stated, therefore, that, as a warship, the design has nothing to recommend it.

Capacity as a Cargo Ship.

(8) The low freeboard, the absence of superstructure and the need to use part of the capacity of the main hull to house the officers and crew, leave the proposed vessel seriously short of cargo space, which is the fundamental requirement of a cargo ship.

(9) It is the policy of the Government to build as many fast merchant ships as the capacity for producing such vessels allows. It must be borne in mind that a great deal of capacity which would be suitable for this purpose is inevitably absorbed by the large numbers of high-powered naval vessels required for the protection of shipping generally.

(10) In fast merchant vessels, as in all other merchant vessels, the need for reliable propelling machinery which will operate continuously without failure, is imperative and especially so in war time. This need must often overrule the possible use of new types of marine engines of unproven reliability. The proposals for propelling machinery of the "cargo-warship" are not very definite. They would seem to cover Diesel-electric propulsion as well as turbo-electric, which latter the designer considers to lack the virtue of low fuel consumption, but they appear to incline towards the use of engines "of almost aeronautical type". It must be emphasised that the development of an experimental type of highly rated oil-engine would involve much effort which could otherwise be devoted to other forms of immediately useful production. In any case such an engine would require a considerable time to come into production. Moreover, highly rated engines of this type, to judge by aeronautical experience, would have a short life compared to that needed for continuous ocean service.

(11) There are other objections in the proposed design, but sufficient has been said to show that it fails in the fundamental objects for which it is intended.

The Author's Reply to Admiralty Statement.

The author was surprised to note that the cargo warship had been considered by the Admiralty as anything but a cargo-carrying vessel adapted to war requirements, as he had never the remotest intention of the vessel having in itself, any offensive capacity. The object was to give relative *immunity* to U-boat activity. Once the cargo warship can be made a sufficiently good sea platform for aircraft, however, there is no reason why a ship-based aircraft need not carry out offensive action to any desired extent on any enemy vessel.

If an aircraft can be provided which is capable of accommodating a variety of offensive weapons from depth charges for submarines, bombs for destroyers and aerial torpedoes for battleships, and a ship-based aircraft offers the possibility of such alternative weapons, then an extremely useful offensive dual-purpose plane is the result. Therefore some thought has been given to the precise design requirements of such a ship-based plane in some further notes, which precede these remarks.

This question is associated with the criticism of the interrupted flight deck, to meet which a modified design has been evolved and is described elsewhere. A definite improvement has been effected due to this criticsm.

Following the advice of a completely clear flight deck, the visibility has been even further reduced, and in spite of the higher freeboard the vessel will be much less visible than present merchant or naval vessels other than submarines.

The First Lord's statement says "as a warship, the design has *nothing* to recommend it". On the contrary the author believes that time will show that a large cargo-carrying vessel—a cargo warship—with a suitable flight deck and specially-designed aircraft for combined operation, will provide a vessel not only independent of conventional warships but will have a striking air power unequalled by escort vessels, destroyers or even cruisers of present design. The author has a suspicion that the writer of the Admiralty statement does not appreciate the full significance of air striking power.

The detailed criticism of the armament was also surprising as the author had not made this a special feature of his design. It is, however, a section capable of great development and facilities are provided in the new design to accommodate armament superior to any present cargo vessel conception. The present armament on merchant vessels is thought by the author to be altogether too diverse and makeshift, and some fundamental reconsideration of artillery armament for new cargo-carrying vessels is thought to be long overdue. Some further remarks are made on this subject later, but it should be pointed out that the provision of a flight deck need not interfere with the provision of completely effective gunnery equipment.

The "blisters" are stated by the First Lord to be quite ineffective, but the author is unconvinced that such a design has ever been tried out on a merchant ship; *the proposals are not intended for a warship*—on this there must be no doubt. The idea of the "blister" was that it was intended to serve as a first line of defence to other protective arrangements.

The Admiralty apparently intend to be definite in the condemnation of the proposed attempt to give a measure of protection to the lower holds, but on one point there cannot be a particle of doubt—the present and latest designs of cargo-ship sides and holds are *absolutely ineffective against torpedo action.*

The proof is thousand fold. In spite of the First Lord's statement, the author is satisfied that proper progressive experiments with blisters, hold subdivision and watertight hatches have *not been carried out on merchant ships* to increase the resistance to torpedo effects. The statement given is calculated to mislead the public that more has been done than in fact has been the case, and is intended to cover up either lack of imagination or incapacity to appreciate the possibilities in the design of merchant ships to resist torpedo action.

The author can imagine no subject more fitting for an independent court of inquiry.

The case of a German tanker built in 1937 came to the notice of the author recently. This had been torpedoed five times and was still in service; in this vessel there was not only remarkable hold subdivison but also a system of "elastic" bulkheads.

The subject is so important that it is hoped the Admiralty will welcome any help which may come from such an inquiry even though it revealed sins of omission and commission.

The suggestion that the proposed vessel is short of cargo space cannot possibly be a well thought out statement, as on the contrary it is claimed that the enclosed steel space of the cargo warship is more efficiently utilized than in any existing merchant vessel. There is no fundamental law governing the cargo space for a given length, breadth and depth of ship. The object of the cargo warship, indeed the only measure of its efficiency, is its capacity to move with certainty the greatest amount of cargo in a given time with the minimum direct and indirect amount of steel and material and man-hours.

It certainly cannot be stated that the slow merchant ships which have so far formed the major part of the Admiralty's cargo-ship programme have proved successful. They are extremely slow in transportation of cargo, require much indirect cost in material and man-hours for protection, and a large proportion of ship and cargo material and man-hours go into Davy Jones' locker; indeed the equivalent of our entire pre-war cargo-carrying fleet and their cargoes are already in this locker. This particular statement of the First Lord's gives the key to the complete ineffectiveness of the Admiralty's criticism and frankly should "make one think".

The paragraph dealing with the subject of engines is worth analysis. First there is the implication—a dastardly one—that the author proposes to use unreliable engines, which in effect means that he has a total disregard for the safety of the crews. In fact the author proposes *in all cases* no less than two completely separate engine rooms. The danger a broken-down vessel is exposed to is too serious other than to contemplate two widely separate engines in wartime. In order to get assured reliability from engines of aeronautical type, the author makes a point of proposing ***multiple*** engine units, so that a dozen engines would all have to break down simultaneously to cause a complete lack of propelling power—which is absurd.

The practice of using single Diesel engines in wartime—which the Admiralty still supports—is considered by the author, as an experienced Diesel engineer, as giving neither the crew, the ship nor the cargo a sporting chance, and should be discontinued forthwith.

Criticism of fast-running engines was made because of their shorter life. To-day we are not concerned with long post-war lives of engines, as long as multiple engine units can be fully relied upon to operate with complete reliability within a stated maintenance period. As in aircraft practice, this will give completely effective reliability.

In the event of direct-drive engines being used for cargo warships the author would propose no less than four units, *i.e.* twin-screws forward and aft, and each unit would be fitted with a magnetic coupling to enable any engine to be overhauled at sea as and when required. Such an arrangement would give complete reliability with maximum economy, and enable established engines to be used.

The conclusion the author has regretfully come to is that the reaction of the Admiralty has been destructive, and gives the impression that suggestions are resented rather than sought.

The whole case suggests the complete overhaul of the Admiralty organization for dealing with the investigation and development of new ideas, and that a new Design Department should be set up immediately to deal specifically with design and development problems as distinct from the organization of production.

Such a new department should have facilities for testing out new designs in model and full-size form, free of any form of vested interest, whether professional or trading, and should form the basis of the fullest utilization of all the technical brains in the country.

OBITUARY.

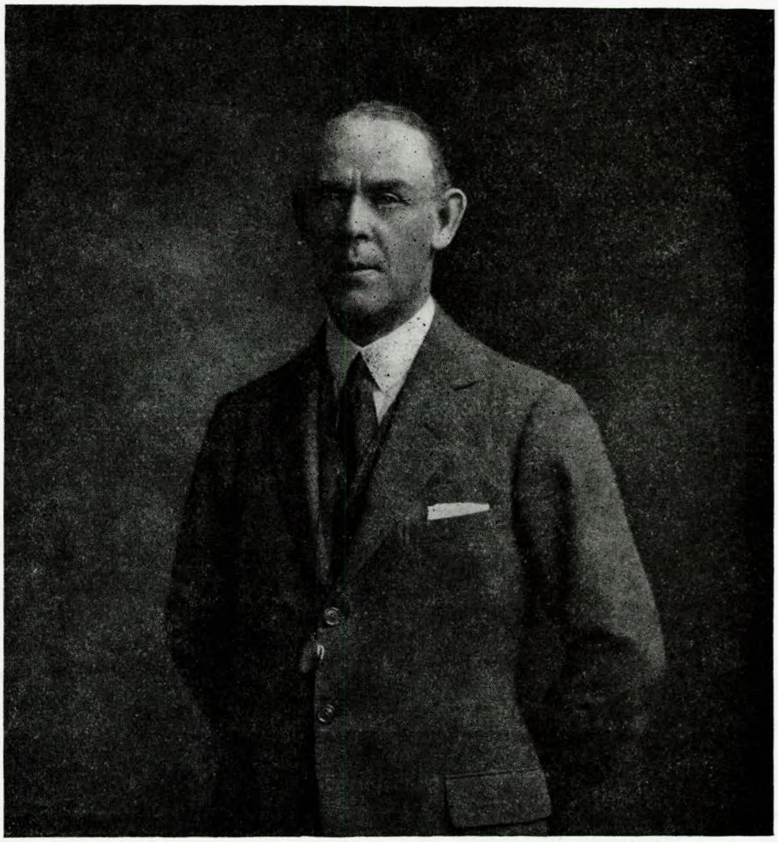
Lieut.-Comd'r. Sir AUGUST B. T. CAYZER, Bart., R.N. (ret'd.).

We deeply regret to record the death, which occurred at Roffey Park, Horsham, Sussex, on Sunday, February 28th, 1943, of Lieut.-Comd'r. Sir August B. T. Cayzer, Bart., R.N. (ret'd.), who was a Past-President of The Institute.

Sir August Cayzer was born in 1876, the third son of the late Sir Charles Cayzer, founder of the Clan Line Steamers. He was educated in H.M.S. "Britannia" and joined H.M. Navy as a cadet in 1892, serving until his appointment as Lieut.-Commander (Emergency List) in 1906. He became a director of the Clan Line Steamers, Ltd., and Cayzer, Irvine & Co., Ltd., in 1902, and after leaving the Navy his commercial and shipping career developed rapidly. He subsequently became chairman of the Clan Line Steamers, Ltd., Cayzer, Irvine & Co., Ltd., the British & South American Steam Navigation Co., Ltd., Clan Engineering Patents, Ltd., the Greenock Dockyard Co., Ltd., the Houston Line (London) Ltd., the Nalc Co., Ltd., the Scottish Shire Line, Ltd., and Turnbull, Martin & Co., Ltd., and was a member of the boards of the Commercial Bank of Scotland, Ltd., and the Suez Canal Co. He was created a baronet in 1921.

Sir August was elected President of The Institute for Session 1930, which office he held with distinction and efficiency. He was elected an annual subscriber to Lloyd's in 1917, and served as a representative on the Clyde Navigation Trust from 1907 to 1917. He was also a member of the Council of the Chamber of Shipping and of the committees of Lloyd's Register of Shipping, the British Corporation Register of Shipping and Aircraft, and the Liverpool and London Steamship Protection and Indemnity Association, and a Justice of the Peace for the City of Glasgow. At the beginning of this year he resigned his chairmanship of Cayzer, Irvine & Co., Ltd., the Clan Line Steamers, Ltd., and associated companies for health reasons, but retained his seat on the various boards.

The funeral took place privately at Gartmore, Perthshire. A memorial service was held in London at the Church of St. Andrew Undershaft, E.C.3, on Wednesday, the 10th March, at which Engineer Vice-Admiral Sir George Preece represented the President, Lord Mottistone, and the Council of the Institute, many other members also being present.



THE LATE LIEUT.-COMD'R. SIR AUGUST B. T. CAYZER, BART., R.N. RET'D. (PAST PRESIDENT).

*"Operation of Diesel Machinery in Cross-Channel Vessels"—Discussion.

Mr. F. A. Hunter. The above paper was very interesting and especially the information about the "Royal Daffodil".

The writer was closely connected with this ship's auxiliary engines when she first went into service and it was a pleasure to observe the care which the author, at that time the chief engineer of the vessel, bestowed on the running of the main engines and also the auxiliaries.

It was noted that special attention was given to the circulating water and exhaust temperatures, and doubtless the excellent results obtained with this ship in nearly four years hard service are due to such detail attention.

Mr. Train's criticism in the February, 1943, TRANSACTIONS (Vol. LV, Part 1, p. 19) in some cases is hardly applicable, in view of the fact that the 1921 main engine he is referring to is a totally different type, much greater in first cost and of course quite unsuitable for the type of ship referred to by the author.

Consider the ease of overhaul of the 12-cylinder 320 r.p.m. engine, mainly due to the great difference in weight of cylinder cover, piston and connecting rod. This would mean a big saving in labour cost of repairs compared with a 2,000-b.h.p. engine at say 100 r.p.m.

The writer firmly believes that the type of main engine described by the author will have a very great future in post-war ships of all types. It could be easily constructed by many of the present makers of marine auxiliary oil engines. Such design does not require great masses of heavy iron and steel castings, or alternatively expensive and complicated electrically-welded structures. This fact would permit many of the engine makers mentioned to utilize their existing machine tools and lifting gear.

For cross-Channel ships the direct drive cannot at present be improved on. However, for cargo liners and tramps, such engines could very well be used with 2½/1 or 3/1 reduction gearing in conjunction with Vulcan-Sinclair or other hydraulic couplings, with units of one, two or four engines connected to a single propeller shaft. Such installations would probably be considerably less in first cost than a 100 r.p.m. direct-drive engine.

Whilst Mr. Train's arguments about the main engine circulating water at starting from cold may be quite sound in large slow-running engines, the writer is sure that the author's views are correct about warming the jacket water before a cold start in a long multi-cylinder engine. Not only does it minimize a false start from cold, but gives the engineer on watch a greater feeling of confidence in a crowded harbour. Besides avoiding unequal and dangerous expansion, the cylinder liner and piston wear is much reduced in the writer's experience with smaller engines. All will be in agreement with Mr. Train that the jackets should be circulated until cold after stopping, but the process should be gradual. If the engines have to start again within a short time, the method mentioned by the author in his reply is the more satisfactory. Naturally the foregoing is more important with large cylinders than small, but it would be a great advantage in all engines if owners would run to the extra expense of it initially. Many seized pistons and carbonized rings would be avoided.

The writer was frequently aboard the "Daffodil" when the main engines started from cold, but he never saw a false start and within a few seconds they were running as smoothly and quietly as after several hours.

Auxiliary engines in many ships often seem to be "forgotten"

* *Abstract of a paper by J. W. Coulthard (Member) published in the December, 1942, issue of the* TRANSACTIONS, *Vol. LIV, Part 11, pp. 149-151.*

so far as cooling water is concerned. This does not apply to the author's ship. Probably 80 per cent. total load is on for a few hours—say when electric galley ranges are full on—then the load drops to probably 30 per cent., and this may be left to two engines and no adjustment of the circulating water is made and so two engines are running with almost cold jackets. If one engine were shut down the other would have a 60 per cent. load and jacket water could be maintained at, say, 90 degrees inlet and 110 degrees outlet. This would result in greatly reduced liner and piston-ring wear and less carbonizing of fuel injectors. Even on these small engines a connection from the emergency bilge or circulating pump for after cooling when shut down is a great advantage in avoiding carbonized piston rings.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

The following British Standard Specifications:—

No. 463-1943. Sockets for Wire Ropes for General Engineering Purposes.
No. 1,098-1943. Dimensions of Drilling Jig Bushes.
B.S. 1095-1943. Metric Screw Threads.
P.D. 89. Office Aid to the Factory. (Prospectus of work being undertaken by the British Standards Institution with the approval of the Minister of Production).

Ship and Machinery Rules, 1943. The British Corporation Register of Shipping and Aircraft.

The Motor Boat and Yachting Manual. Temple Press, Ltd., 13th edn., 267pp., copiously illus., 7s. 6d. net, postage 6d.

The new edition of "The Motor Boat and Yachting Manual"—the 13th—is now available. It is completely re-written, and as it is several years since the 12th edition was published, considerable progress has been made in the design and construction of boats and their machinery. In view of the ever-increasing employment of motor craft in the various Services, and the growing number of personnel in those Services, it is felt that the new volume will serve a specially useful purpose at the present time.

In addition to a special chapter on Naval and Air Force craft, illustrating many of the types which are now in use, the book covers all aspects of running and building motor boats; and the 19 chapters include sections on the design of hulls, navigation, sailing, propulsion systems, installation of engines, etc.

Naval Architecture and Ship Construction. By R. S. Hogg, M.I.N.A., Hons.C.G.L.I. The Institute of Marine Engineers, 322 pp., 212 illus., 7s. 6d. net, plus 4d. postage.

The lengthy series of articles on naval architecture and ship construction which Mr. R. S. Hogg, who is lecturer in naval architecture and ship construction at the L.C.C. School of Engineering and Navigation, contributed to the TRANSACTIONS, has now been published in book form.

These articles were written primarily to meet the needs of engineers and navigators in the Merchant Navy and the author endeavoured not to step beyond the limits of the syllabus laid down for the Ministry of War Transport Examinations for engineers. Nevertheless, the book will provide some useful preliminary instruction to draughtsmen, apprentices and others serving in the shipyards.

The sixteen chapters which comprise the book deal with: structural strains in ships; structural details; shell plating; bulkheads; pillars, girders and hatchways; engine seatings; the after part of the ship; the fore end of the ship; merchant ship types; classification societies, tonnage and freeboard; theory and calculations; moments, centres of gravity and centres of buoyancy; metacentric stability; trim; the effect of water pressure on bulkheads, tank tops, etc., centres of pressure, and panel stress; and, finally, resistance and propulsion.

The book is complete with an adequate index and the copious illustrations are a model of clarity and draughtsmanship. As in the case of The Institute's other publications, it is not published for profit and is on sale at the lowest possible price.

Press Tool Practice, Part 3. By P. S. Houghton. Chapman & Hall, Ltd., 167 pp., copiously illus., 12s. 6d. net.

This is the third part of a comprehensive work on the subject of press tool practice. Part 1 and Part 2 have already been published, the prices of these two volumes being 13s. 6d. and 21s. respectively. The concluding part (Part 4) is in course of preparation.

The four parts of the work deal with the standardisation of adaptors or false noses, blanking, raising, cupping, drawing, clipping, forming and combination tools. The processes of curling, beading, knurling, thread-rolling, trimming, stamping, marking, bending, piercing, methods of removing the scrap off punches, metal spinning, pillar die sets for blanking, piercing, combination tool compound tools, follow-on tools for single-action presses, and dies sets for double-action presses for blank and raise, or cut and cup tools, are included. Then the calculation for blank sizes when bending or drawing is dealt with, followed by notes on trigonometry as used when laying out press tools, or checking after jig boring. Estimating, production planning, tool recording, and the need for an up-to-date operation schedule are all touched upon. This applies also to the various metals manipulated under the press and how they should be ordered. The need for lubricating and well cleaning the work is stressed in the chapters dealing with this subject. For the designer and maker of press tools the chapter on the materials available for press tool construction should prove helpful, as it includes a list of the terms used when heat-treating steel and its alloys.

Part 3—the part now under review—deals with the various types of presses, and the setting of the press. This is followed by a chapter on safety including hints to press tool setters and operators of power presses. The next chapter on general notes on press tool design is followed by one on planning tool production. Trigonometrical notes on laying out press tools, etc., precede the final interesting chapter on the production of various articles.

ELECTION OF MEMBERS.

List of those elected by the Council at the Meeting held on Tuesday, 2nd March, 1943.

Members.
Alfred Cole.
Gilbert Filshie.
Ronald Kendrick.
John McMillan.
William Harry Strong.
John Matheson Watson.
Andrew Wilson.

Associate Member.
Ronald Henry Dickinson.

Associates.
Herbert Frederick Bates.
Quintin Blane.
Alfred Briggs.
Alexander Coutts Brotherston.
Henry McNeil Caldwell.
Edward Alfred Cleves, Lt.(E.), R.N.V.R.
John Vivian Davies.
Robert Gill, Sub. Lt.(E.), R.N.R.
Ronald George Iliffe.
Geoffrey Lloyd Jones.
Ross Edward Kavanagh.
Samuel Douglas Lomas.
Robert Tudor Owen.
William Smith.
Ernest Tye.
Harry Dale Williams.
Norman Williams.

Graduate.
Morgan Edward O'Connor.

Abstracts of the Technical Press

Belt Scrubbing Device for Ships' Bottoms to Obviate Drydocking.

A "belt scrubbing" arrangement which has been designed by Mr. R. S. Chipchase, C.B.E., chairman and managing director of the Tyne Dock Engineering Co., Ltd., in collaboration with the Ministry of War Transport, makes it possible to clean the bottoms of vessels afloat, either light or loaded, while at anchor. The arrangement entails the use of buoyant wire brushes of special design operated by the ship's winches. A working party of 24 men and one leader, working in four sections each manipulating one sweeping belt, can, it is claimed, thoroughly clean the whole of the underwater portion of the hull of a good-sized vessel in 48 hours. A steamer 440ft. in length has actually been cleaned in that period recently while lying afloat at buoys, the cleaned surface being quite bare when subsequently examined in dry dock. Abnormally foul ships may require two or more cleaning operations in order to remove the worst type of fouling formed by either shells or vegetable growth. The device has been accepted by the Ministry of War Transport and is being manufactured by Mr. Chipchase's firm. It takes about a fortnight to make, but designs have been furnished to the Ministry and these have been sent to overseas ports, where the gear can be manufactured on the spot. Where standard winch equipment is available, five scrubbers are utilised, but the necessary power can also be provided by another ship or barge alongside, if required. It has been proved that the device does all that is claimed for it, *viz.*, that it enables a very foul ship to be cleaned afloat to a reasonable and practical degree that allows her to maintain, within a small percentage, her original speed.—*"The Journal of Commerce", (Shipbuilding and Engineering Edition), No. 35,777, 8th October, 1942, p. 8.*

Wooden Ships Built in Denmark.

Under the Danish unemployment relief programme a substantial sum of money has been earmarked for distribution as grants towards the cost of building six wooden ships. The first of these vessels has already been delivered and the remaining five are to be completed before the middle of 1943. The State subsidy amounts to 60 per cent. of the cost of construction, secured by a first mortgage on the vessel; the remainder of the cost may be raised by way of a second mortgage, but the shipowner must also possess some capital. The d.w. tonnage of the six vessels is 200, 180, 150, 120, 180 and 180 tons respectively, and the propelling machinery is to consist of Danish-built Diesel engines of from 100 to 120 h.p.—*"Lloyd's List and Shipping Gazette", No. 39,902, 7th October, 1942, p. 5.*

Stress Concentration.

It does not often happen in engineering design that the stress at any part of a machine or structure can be considered uniform or that it varies in accordance with some simple law which enables the maximum stress to be accurately determined. Recent researches have shown, for example, that any sudden changes in shape or form may be accompanied by stress concentrations the magnitude of which may exceed the safe limit for the material. These stress concentrations can, however, be visualised by means of photo-elastic methods, provided the part under investigation is not of too complex a form, by passing plane-polarised light through models made of celluloid. Thus, photo-elastic tests on turbine blade roots have shown how one shape yields a far more uniform stress distribution than does another, both as regards the rim of the wheel and the root of the blade itself. Such records can also be made to yield quantitative results, the value of which must necessarily depend upon the degree to which the specimens can be made to reproduce the conditions in the part under consideration. This is a field of research which appears to be capable of yielding very important results.—*"Shipbuilding and Shipping Record", Vol. LX, No. 15, 8th October, 1942, p. 339.*

The First Bulgarian Motorships.

Four twin-screw motorships, the "Russe", "Widin", "Lom" and "Swistow", were recently delivered to Bulgarian owners, for service on the Danube. These vessels, the first motorships to fly the Bulgarian flag, are sister ships of an unusual type, being designed to carry a substantial amount of cargo on a shallow draught and to be capable of towing three 1,000-ton barges. The vessels are also able to maintain a speed of nearly 12½ knots in a water depth of approximately 20ft. The twin propellers rotate in tunnels and there are two rudders arranged directly behind the screws. The o.a. length of the hull is about 245ft. and the maximum breadth just over 28ft., whilst the d.w. capacity is 680 tons at a draught of 7·2ft. The hull is divided into 10 w.t. compartments, and the propelling machinery is aft. There are three large cargo holds with a total capacity of 24,000 cu. ft., the centre one being insulated and divided into four compartments for the carriage of refrigerated cargo. The deckhouse contains two single-berth cabins for passengers, together with a saloon and bathroom. The propelling machinery consists of two M.W.M. 6-cylr. four-stroke Diesel engines, each rated at 500 b.h.p. at 375 r.p.m., which are directly coupled to the propeller shafts and drive four-bladed steel propellers. The fuel consumption of these engines is stated to be 0·385lb./b.h.p.-hr. All the auxiliary machinery is electrically driven, d.c. at 110 volts being supplied by one 30-kW. and two 20-kW. dynamos driven by separate Diesel engines. The cargo-handling equipment comprises a 2-ton electric crane for the two forward holds and a 2-ton derrick and electric winch for the after one. An electric windlass is installed forward and a towing winch is fitted aft, this being driven by a 10-h.p. electric motor. The refrigerated hold is served by three NH_3 compressors, each driven by a 5-h.p. motor.—*"The Motor Ship", Vol. XXIII, No. 273, October, 1942, pp. 224-226.*

2,200-b.h.p. Diesel-engined Tugs.

Among the vessels being constructed for the U.S. Maritime Commission are 40 ocean-going tugs which are claimed to be the largest and highest-powered craft of this type in the world. They have a moulded beam of 37ft. 6in., and a depth of 21ft. 5in. All are equipped with two Enterprise supercharged four-stroke Diesel engines driving a single propeller through reduction gearing. The main engines are located amidships in an engine room which also contains the electric couplings and reduction gear, but the auxiliary machinery is arranged in a separate compartment immediately forward of the main engine room. Each engine drives one pinion of a double-pinion S.R. gear, the connection between the engine and the gear being formed by a Westinghouse electric slip coupling. The rated output at 350 r.p.m. is 1,160 b.h.p. per engine, the total shaft horse-power at the propeller being approximately 2,200 b.h.p. The engines are similar units of right- and left-hand drive. Each has six cylinders of 16in. diameter with a piston stroke of 20in., and is capable of developing 1,400 b.h.p. at 365 r.p.m. for four hours. An independently-driven Roots blower of the positive displacement type is provided for each engine, the output of these units being about 4,000 cu. ft./min. of air at a pressure of 4lb./in.^{2} at the manifold. The o.a. length of each engine is just over 25ft., including the slip coupling and gearing. Although separate reversing gear of the conventional sliding-camshaft type is fitted to the engines, there is a central control station at the forward end of the machinery compartment from which it is possible to control the engines, electric couplings and superchargers. Highly sensitive hydraulic governors are used for the main governing of the engines in combination with limiting devices on the throttle control so that the superchargers will not be in operation at outputs below the normal non-supercharged rating of the machinery. If the position of the throttle is advanced the supercharger starts up and continues in operation for full-throttle settings, but shuts down automatically when the throttle is brought back below the setting at which supercharging is required. An overspeed governor is also fitted and there are suitable interlocking devices in the reversing control and in the electric-coupling circuit, to prevent the engines from being reversed in an incorrect sequence of operations. The power of one engine cannot be applied against that of the other by improper switching of the couplings. It is believed that the engines are the largest built in the U.S. to have aluminium pistons. The latter are provided with special cooling arrangements. At the time they are cast a cooling coil of several turns of steel pipe is cast into the piston in the vicinity of the ring grooves. Lubricating oil is conducted up through the connecting rod, through the wrist pin into the piston-pin boss and thence into openings in the cooling coil. The oil then passes through the coil and is discharged from an opening inside the piston, being caught in a cup mounted within the crankcase below the piston. A separate drain for piston cooling is provided in each crankpit door, so that the temperature as well as the oil flow may be observed. The employment of aluminium pistons makes it possible to run these large engines at relatively high speeds without developing unduly large rotating-mass forces. The electric slip couplings are of standard design and have a diameter of about 10in. They are excited from the auxiliary generating sets of the tug. The outer rotors are mounted on the pinion shaft, while the inner rotors are secured to the engine crankshafts. There is a jacking device on the engine side of each electric coupling and a similar arrangement on the gear side of the coupling for handling the gears. The reduction gear has a ratio of 2·654 to 1. The total weight of the propelling machinery is just under 98 tons, *i.e.* less than 100lb./b.h.p. This is rather less than the corresponding weight of slow-running machinery of the d.a. two-stroke type direct coupled to the propeller, and much lower than that of s.a. direct-coupled Diesel engines. The efficiency of these tugs' engines is remarkably high, a fuel consumption of 0·34lb./b.h.p.-hr. having been obtained during trials. The exhaust temperature was stated to have been about 660° F. with a cylr. jacket outlet temperature of 140° F. and a lubricating-oil temperature of about 130° F.—*"The Motor Ship", Vol. XXIII, No. 273, October, 1942, pp. 206-209.*

Direct-coupled *v.* Geared Diesel Engines.

The increasing use in America and Scandinavia of high-speed Diesel engines driving the propeller shaft through hydraulic or electro-magnetic couplings and reduction gears, has led to many proposals for the employment of such machinery in British vessels. At least two engines are provided for each propeller shaft, and the advantages claimed for this type of installation are that the propellers can be run at their most efficient speed; that in single-screw ships if an engine breaks down it can be disconnected without reducing the vessel's speed by more than about 25 per cent.; that an engine can be run up to speed without any load on it; that torsional vibrations and critical speeds are eliminated by the couplings; that renewals are smaller and lighter, while overhauls can be carried out more quickly and easily; and that engine rooms are shorter and lower. Some of the objections to high-speed engines have been modified in recent years by the development of harder and stronger metals, by improved methods of manufacture and by better lubrication; but even so, it is by no means certain that high-speed geared Diesel engines are better than direct-coupled engines operating at a slower speed. A direct-coupled engine running at less than half the speed is bound to wear twice as long before requiring a refit, whilst the loss of power in the hydraulic or electro-magnetic coupling, together with that in the reduction gear, is of the order of 5 per cent. In the case of ships making long voyages with quick turns round at the terminal ports, this loss, with its attendant increase in fuel consumption, is of some importance. At least two high-speed engines must be installed in a single-screw vessel instead of one. Twin screws driven by separate direct-coupled engines give the same advantages, except starting without load, with the extra safeguard against total disablement of having two propeller shafts and propellers. It is doubtful, also, whether a twin-screw installation entails a longer engine room, as the couplings and reduction gears for the high-speed engines take up a good deal of fore-and-aft space. Admittedly, the twin-screw direct-coupled engines must be larger and heavier than the high-speed engines, and that torsional vibrations and critical speeds must be guarded against in the former. Moreover, the engine room must be higher. These drawbacks apply more especially to a single, direct-coupled engine. On the other hand, it must be conceded that large numbers of single-screw motorships with single, direct-coupled engines have been operating for years in an eminently satisfactory manner; and that British shipowners seem to have no hesitation in continuing to specify this type of machinery for their new motorships. It is not suggested that the couplings or reduction gears of high-speed engines give trouble at sea, and it must be admitted that high-speed engines are lighter than the alternative direct-coupled engines, in addition to which they are slightly cheaper. The pros and cons for and against high-speed engines and those of the slow-running direct-coupled type would, however, appear to be sufficiently evenly balanced to justify the reluctance displayed by British shipowners and their engineering staffs for any departure from present-day practice. As for electrical transmission, it is difficult to see what advantages it offers for ordinary sea-going motorships, although in the case of harbour tugs, ferryboats and other special types of craft, an electric drive does confer some benefits. The first cost is higher than for reduction gears, while the space taken up by the generators and propulsion motors is greater. Furthermore, transmission losses are more than twice as great. The popularity of the system in the U.S.A. is largely due to the influence of the electrical industry in America, which is strong enough to engender a fashion for electric transmission for ship propulsion or for any other development which is likely to increase its profits.—*W. O. Horsnaill, "Shipping", Vol. XXXI, No. 563, October, 1942, p. 18.*

Pressure-charging for Still Higher Outputs.

Just before the war, the increased power output of oil engines equipped with an exhaust turbo-charging system was of the order of 50 per cent., with brake mean effective pressures of about 105lb./in.². Where electrically- or mechanically-driven blowers were employed the power increase was generally up to 30 per cent., and the full-load b.m.e.p. around 95lb./in.². Most engines of this type are designed to run at speeds of from 375 to 600 r.p.m. Present-day conditions call for smaller engines on account of space restrictions, and the running speeds of pressure-charged engines have gone up to 1,500 r.p.m. for the larger units of this type, and up to 2,000 r.p.m. for the smaller ones. The b.m.e.p. in common practice is usually about 124in./in.² at 100 per cent. load and the engines are absolutely reliable in operation. However, even this figure of 125lb./in.² is not likely to remain a common standard for long, as it is reported from America that in order to meet the demand for a higher output from engines for naval purposes, the b.e.m.p. has been increased to as much as 150lb./in.² at full load by the adoption of a high manifold pressure, valve-overlap scavenging and a blower pressure of about 11lb./in.². Where a somewhat lower output suffices, this has been attained merely by using an inter-cooler between the blower and the manifold, an arrangement enabling b.m.e.p. figures of 130 to 135lb./in.² to be achieved. The inter-cooler principle is, of course, comparatively simple to apply in marine installations, where a continuous supply of cold water is readily available, and it can be stated that the developments which have taken place in this direction in this country are keeping pace with those which have been noted in the U.S.A.—*"The Oil Engine", Vol. X, No. 114, October, 1942, p. 141.*

German High-powered Pressure-charged Engines.

Although German shipowners have always shown a decided preference for motorships with two-stroke engines of the single- and double-acting type, the Hamburg-American Line motorship "Steiermark", which was completed after the outbreak of war as a commerce raider and was subsequently sunk by H.M.A.S. "Sydney", was reported to have been the highest-powered four-stroke pressure-charged-engined cargo liner afloat. She had four 3,600-b.h.p. four-stroke 9-cylr. Krupp engines, with cylinders 570 mm. in diameter and a piston stroke of 750 mm. The full output of these engines was attained at 240 r.p.m., but the rated output of each unit unsupercharged was only 2,500 b.h.p., so that the additional output due to supercharging was 44 per cent. The normal Büchi system was employed and the exhaust-gas-driven blower was mounted at the end of the engine, level with the top of the cylinders. The total weight was about 143lb./b.h.p., the actual weight of each engine being 225 tons. It is stated that the total saving in weight effected by the adoption of supercharging amounted to 250 tons, besides which the length of the engine room was reduced by over 13ft. compared with a corresponding machinery compartment with unsupercharged four-stroke engines. The scavenging effect of the Büchi system gave a high thermal efficiency and showed a reduction in fuel consumption of between 8 and 10 per cent. compared with that of a normal four-stroke engine. The blower turbines were single-stage units running at speeds varying from 5,000 to 25,000 r.p.m., the temperature of the exhaust gases under normal load conditions being 625° F.—*"The Motor Ship", Vol. XXIII, No. 273, October, 1942, pp. 220-221.*

Standardising Pressure-charging Equipment.

Before the war is over, thousands of single-acting four-stroke marine oil engines will have been produced for ship propulsion or auxiliary purposes. Many such units of between 300 and 800 b.h.p. are installed in minesweepers, large fishing vessels, tugs and similar craft, and a large proportion of these engines are not supercharged. By the adoption of pressure-charging, an increase of up to 50 per cent. in the power output of such engines can be attained, and it has been suggested that the production of the necessary pressure-charging equipment would require substantially less labour than the construction of 50 per cent. more engines. Under present conditions very little pressure-charging equipment is being manufactured, and from the standpoint of effective output in b.h.p. in a given time its production is having little effect upon the oil engine situation. If, however, it were possible to standardise not more than two or three sizes of pressure-charging equipment and to organise its manufacture on a large scale in one or more well-equipped turbine works in this country, the extra 50 per cent. output from four-stroke engines could be attained by the employment of not more than 20 per cent. additional man-hours. A careful examination of the possibilities of obtaining such a result appears to be desirable, including an investigation into the design of the various types of oil engine now in use, with a view to ascertaining whether they could be adapted for use with one of a very limited number of standard supercharging plants, since it would not be feasible to introduce any important modifications in the manufacture of the engines. The design of efficient pressure-charging blowers is, of course, by no means a simple matter, but a considerable amount of experience of such work is available in this country, although it has not yet been collated. In America, two manufacturers have concentrated on the production of highly standardised exhaust-gas-driven pressure-charging equipment, and supercharged oil engines have recently been built or are on order to the total of one million horse-power.—*"The Motor Ship", Vol. XXIII, No. 273, October, 1942, p. 202.*

New Method of Scavenging Two-stroke Engines.

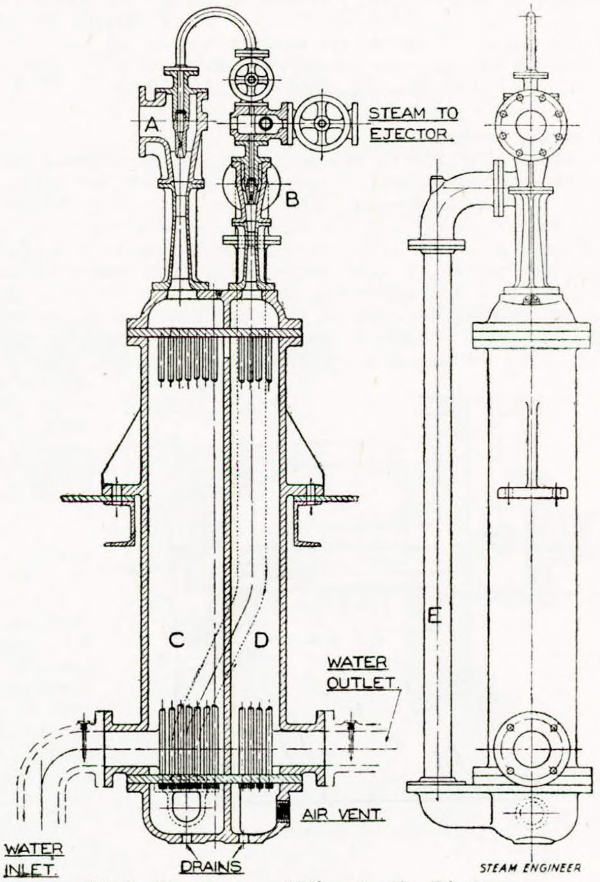
Recently, the A. B. Götaverken remodelled a design of two-stroke engine, introduced by them before the war, in which the lower ends of the cylinders were closed in and utilised as air pumps for supplying scavenging air to the working cylinders. To increase the supply of air beyond that provided by the swept volumes of the pistons, a supplementary single-acting scavenging pump is now worked off each crosshead. Another interesting feature of this engine is the complete ring of scavenging-air ports in each cylinder which are uncovered by the piston near the bottom of its stroke. Being more or less tangential, these ports give the air a swirl which rises in the cylinder and completely expels the exhaust gases through a single mechanically-worked exhaust valve in the cylinder head. This valve is opened by a fore-and-aft rocker, of which the outer end is pushed up by a cam on a crank balance weight. Hence the camshaft is only required for working the fuel pumps and for timing the admission of compressed air to the starting valves, as in normal two-stroke engines. The elimination of the friction entailed by a separate scavenging pump gives the new engine a higher mechanical efficiency, and another advantage claimed for it is the reduction in overall length by the omission of the usual scavenging pump at the forward end, with an extra crank to work it. A six-cylinder unit of this improved type, developing 5,600 s.h.p. at 112 r.p.m., has been installed in a tanker. Trials carried out in this vessel have shown that the brake m.e.p. of the engine is about the same as that of the usual type of two-stroke engine, despite the higher mechanical efficiency. With larger supplementary scavenging pumps much higher brake m.e.p.'s could be obtained, if found desirable. A smaller engine of this type, having a power output of 600 s.h.p. per cylinder, has also been developed.—*W. O. Horsnaill, "Shipping", Vol. XXXI, No. 363, October, 1942, pp. 18 and 20.*

The Effect of the Coal Shortage on the Operation of Coal-burning Steamships.

In accordance with instructions issued by the Ministry of War Transport, additional ballast capacity was to be provided in all new vessels of the tramp class in the form of water-ballast tanks in the after hold at the tunnel sides, abreast of the machinery space in motorships, and also in the forward hold. In coal-burning ships ballast, additional to the water carried in these tanks, took the form of coal in the reserve bunkers, so that two ends were served; the resources of the country were utilised and the necessity for removing rock ballast at the loading port was obviated. The present shortage of coal has, however, made it necessary to depart from this practice, and coal in the reserve bunkers is having to be replaced by rock, or other ballast, with all the disadvantages involved by such a change. A slight increase in the ballast capacity of coal-burning steamers can be effected by utilising the double-bottom tanks under the boiler room for the carriage of water ballast, but this increase is hardly likely to compensate for the trouble involved by the provision of extra ballast suctions, and the increased deterioration of the internal surfaces of the D.B. compartments which may result from the use of the latter for such a purpose. Present circumstances make it imperative to reduce coal consumption as much as possible, and this will inevitably lead to a more complicated machinery lay-out. It has hitherto been considered desirable to simplify the design of the propelling machinery at the expense of consumption, but it has now become necessary to balance the labour and material required for manufacturing machinery with that employed in the coal industry. The most important factor affecting the reduction in coal consumption is the employment of superheated steam, but this refinement has not been generally adopted in the cargo steamers being built in this country, although the 60 ships ordered by the Government from American shipyards are equipped with superheaters, and superheated steam is used in all the American "Liberty" vessels which are being produced at the present time. It is generally agreed that the use of superheated instead of saturated steam reduces the fuel consumption by anything from 15 to 20 per cent., and, as a well-known British shipowner pointed out in a recent letter to *The Times* on the subject, this is an important matter where large numbers of ships are concerned. In the case of the ships using non-superheated steam, operated by his firm, over 2,000 tons of coal per annum are wasted in this way, to say nothing of the loss of cargo space resulting from the necessity of carrying this extra coal. The technical arguments in favour of installing superheaters are overwhelming; therefore, the question boils down to one of priorities.—*"Fairplay", Vol. CLIX, No. 3,100 8th October, 1942, p. 430.*

Modern Air Ejectors for Condensers.

The accompanying drawings show the construction of a Hick, Hargreaves "Hivac" two-stage air ejector for the extraction of air and uncondensable gases from the surface condensers of turbine



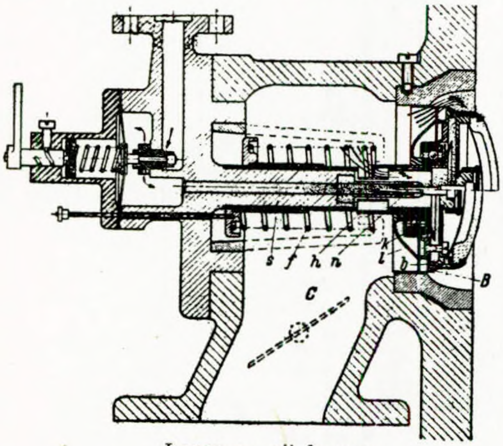
Hick, Hargreaves "Hivac" Air Ejector.

A—Primary steam-jet ejector.
B—Secondary steam-jet ejector.
C—Intermediate surface condenser.
D—Surface type feed-water heater.
E—Pipe connection from lower part of C to B.

installations. The device, which is characterised both by its high degree of air extraction and very low net steam consumption, operates by means of two steam-jet ejectors working in series with a small intermediate condenser. The air and gases from the main condenser are discharged into the latter by the primary ejector with a certain degree of compression, the cooling water used in the intermediate condenser being condensate from the main condenser extraction pump. The whole of the steam used by the primary ejector is condensed in the small intermediate condenser, whilst the air, after also being cooled, is then withdrawn by the secondary steam-jet ejector, which discharges through a surface type of multitubular feed-water heater forming a compartment adjoining the intermediate condenser, the entire apparatus constituting a single compact unit. By this means all the heat used by the ejectors is recovered in the feed water, whilst the steam is condensed without coming into actual contact with the main condensate. Furthermore, the drains at the base of the intermediate condenser are led to the extraction pump suction through a U-pipe of suitable proportions to balance the difference of pressure existing between the main and the small intermediate condenser. The apparatus also includes a stabilising valve which automatically prevents the jets from becoming unstable at low loads, *i.e.*, if the vacuum in the main condenser should become so high as to approach the unstable point of the secondary ejector, a small amount of atmospheric air is admitted to the suction side of the latter to maintain its stability. Under normal working conditions the stabilising valve does not operate, the entire energy of the steam being utilised for the extraction of air from the condenser. Should, however, there be a sudden rush of air into the system, causing the vacuum to drop, the ejector remains stable and the vacuum is quickly recovered. The ejectors are of simple design and have no moving parts. The various fittings on the unit include two steam valves, as well as pressure and vacuum gauges. In installations operating with an extra high vacuum a special design of three-stage ejector is employed. This has three steam-jet ejectors in series, the first two of which discharge to small intermediate condensers, and the third to a surface type feed heater. A stabilising device is fitted between the second and third stages to ensure stable operation at all loads and an equal division of the work between the three stages.—*"The Steam Engineer", Vol. XII, No. 135, December, 1942, p. 85.*

Novel Burner Design.

An article by F. Nistler in a recent issue of the German technical periodical *Feuerungstechnik* describes the Lorenzen burner, recently placed on the German market. This burner is specially designed for use with marine boilers, and for other purposes where an extremely short flame is essential. Two types of the burner are available, for oil fuel and pulverised coal respectively, both operating on the spinning-cup principle which has found such a widespread application in America for domestic oil burners. The general construction of the Lorenzen oil burner is shown in the accompanying sectional drawing. The air supply is controlled by a simple damper device, and the rotating burner head, incorporating the atomizer cup, is fitted with a vane ring which is caused to rotate by the passage through it of the combustion air. The burner head is free to move in the longitudinal direction, a helical tension spring tending to pull it out of the furnace and into the inoperative position in which the conical nozzle spindle extending from the spinning cup completely blocks the centrally-arranged oil-supply nozzle. This pull, however, is counteracted by the pressure of the combustion air acting on the vane ring, so that the axial position of the burner head—and with it the amount of opening of the oil-fuel supply valve—will establish itself at a point at which the opposing forces due to the pull of the spring and the action of the air pressure are balanced. This condition indicates that a definite relationship between the air and oil supply is achieved, and by an appropriate dimensioning and shaping of the nozzle spindle it is therefore possible to correlate the air supply and oil supply to the burner head in such a manner as to maintain optimum combustion conditions irrespective of the firing rate. The oil stream emerging from the annular orifice of the fuel-supply valve is mixed with a certain amount of the combustion air which enters the bush of the burner. The fuel-air mixture then passes into the cup proper, whence it is discharged in the form of a fine mist emerging tangentially from the radial openings of the atomizer cup. This mist is carried off into the furnace by the main stream of combustion air passing at a high velocity through the annular space between the outer periphery of the atomizer cup and the burner body, as shown in the drawing. The impact between the main stream of combustion air and the atomized fuel-air mixture discharged through the radial nozzles of the spinning cup ensures a most effective mixing of the oil and air which is reflected by a high rate of combustion and an extremely short length of flame.—*"The Marine Engineer", Vol. 65, No. 785, December, 1942, pp. 277-278.*



Lorenzen oil burner.

A—furnace side. *b—burner head.*
B—nozzles. *n—valve needle.*
C—air supply. *l—vane ring.*
s—hollow shaft. *h—bush.*
f—helical spring. *k—ball bearing.*

Problem of Hull Repairs to Welded Ships.

In the course of the Eleventh Andrew Laing Lecture delivered by R. C. Thompson, C.B.E., and H. Hunter, O.B.E., at a recent meeting of the N.E. Coast Institution of Engineers and Shipbuilders on "The British Merchant Shipbuilding Programme in North America", the lecturers stated that the question of repairing welded ships is one which requires special consideration. Generally speaking, repairers have been welding for longer than builders, but unfortunately this has resulted in repairers knowing far more about antiquated methods of welding than they do about modern methods. The 200-amp. welding set and bare-iron wire are still, in some cases, the ship-repairers' friends, while both are fortunately unknown in shipyards. The fundamental principle followed while building welded ships is to arrange the sequence of work in such a manner that *contraction* while welding can take place. This is sometimes impossible when carrying out a repair, and because of this, repairs in a highly stressed part of a welded ship's structure are going to be very difficult to effect by welding. Pending further developments, it may prove better to do the repairs in such areas by drilling and riveting. An example would be the renewal of a stringer or sheerstrake plate amidships. If a rectangular plate in such an area were cut out and a new plate welded in, trouble would probably follow owing to the combination of welding stresses and service stresses. This matter deserves the closest study by classification societies, and the suggestion is put forward that such a plate should be cut out and replaced in accordance with Sketch 1 in order to make the

service stresses cross and not combine with the inevitable residual welding stresses. Alternatively, the butts of such a plate might be doubled by diagonal patch doublers welded on the underside as in Sketch 2. If some such measures are not adopted, the combination of residual welding stresses and service stress conditions will almost certainly cause fractures at or near the welds, and the welding will get a bad name which it may not deserve as the cause will be "faulty application of welding".—*"The Shipping World", Vol. CVII, No. 2,581, 2nd December, 1942, pp. 463-467.*

Coal in Cross-Channel Steamers.

Some interesting references to the employment of mechanical stokers and coal-fired boilers were included in Major Gregson's paper on "The Propelling Machinery of Cross-Channel Packets", which formed the subject of the last Thomas Lowe Gray Lecture at the Institution of Mechanical Engineers. In the G.W. Rly. Co.'s Heysham-Belfast steamer "Duke of York", hopper bunkers are arranged to feed direct by gravity into the hoppers of the Babcock-Erith mechanical stokers fitted to the four Babcock and Wilcox boilers which supply steam to the 9,000-s.h.p. turbines of the vessel. No handling of the coal is necessary, and the ashes are only drawn after the ship has reached one of her terminal ports, to be subsequently expelled through the ash ejectors as soon as the open sea is reached on the next outward passage. Bunkering is carried out by means of six containers, which fit into a coal truck and are lifted out one by one by a crane, placed over the ship's coal hatch and the bottom opened, with the result that coaling is performed without dust. It is claimed that these arrangements make it possible to keep the boiler room as clean and the steam control as flexible as with oil firing, and to effect a saving of 20 per cent. in fuel cost as compared with hand firing. The coal used is graded smalls from East Glamorgan or West Monmouthshire collieries. In the Dover-Dunkirk train ferries hopper bunkers are provided to feed direct into the hoppers of the Taylor stokers fitted to the ship's Yarrow watertube boilers. Trials carried out with the "Twickenham Ferry" showed the remarkably low coal consumption of a little over 1lb. of Kent coal per s.h.p.-hr.—*W. O. Horsnaill, "Shipping", Vol. XXXI, No. 363, October, 1942,, p. 20.*

The Contra-propeller.

Some publicity has recently been given to the development of air screws, and the contra-propeller type in particular. The limiting speed of air screws—about 750 m.p.h.—having now been reached, the only practical means of absorbing the output of a modern aeroplane engine would appear to be the adoption of some alternative method of screw propulsion, and the most promising design to date has been the six-blade contra-propeller, which consists of two sets of three blades revolving in opposite directions, working one behind the other on concentric shafts on the same engine. The contra-propeller has been known to marine engineers for over a century, and was the subject of some extensive experiments in the Clydebank tank just before the last war. Propellers of this type have been fitted to several small vessels, as well as to one or two Italian naval ships, and it has been found that an increase in efficiency may be attained by their employment. It is doubtful, however, whether the complications inherent in this type of screw can be offset by the relatively small increase in propulsive efficiency which it renders possible, and for this reason there does not seem to be any future for contra-propellers in ordinary marine work, although they are extensively used for torpedoes.—*"Fairplay", Vol. CLIX, No. 3,101, 15th October, 1942, p. 458.*

Strain Gauges.

Considerable advances in the technique of the measurement of the strains in hull plating have been made since the days of the "Wolf" experiments, which aimed at determining the stress in the hull of a destroyer under known loads in dry dock by means of direct measurements with Stromeyer mechanical strain indicators. These instruments were not suitable for use at sea under actual service conditions, but other devices of a different type have since been used by various investigators with a certain amount of success at sea and elsewhere. Combined mechanical and optical magnification has also been employed with some success, this method being borrowed from land practice on structures such as bridges. More recently various electrical types of strain gauge have been evolved, notably the resistance type, in which the variation in the electrical conductivity of a special carbon element, cemented to the member whose stress is being registered, is employed. The robustness of this gauge may be judged by the fact that it is regularly used on air propeller blades rotating at high speed, the measuring current being led off by slip rings or commutators on the hub. Steady stresses as well as the more or less rapid fluctuations due to vibration or the passages of waves may be read off. The time may come when stresses in the main structural parts of a hull, such as a sheerstrake or deck stringer, will be recorded as a matter of regular routine, as there is little doubt that the statistical information which could thus be accumulated would be of immense value to naval architects, apart from the scientifically correct indication of heaviness of seas encountered telling when to search for possible structural damage which otherwise might be overlooked.—*"Shipbuilding and Shipping Record", Vol. LX, No. 18, 29th October, 1942, pp. 410-411.*

"Some Considerations in the Design of High-speed Cargo Vessels".

The author of the paper bearing the above title points out that the economical speed of a cargo ship depends upon a rather sensitive balance between several things such as earnings from cargo carried, loading and discharging times and cost, running and capital charges, insurance, etc. Continuing progress in marine engineering is tending to alter this balance. The cost of the development of power (in relation to other charges) is steadily diminishing, and the speed can be increased to maintain the balance required. Similarly, new methods of hull construction and improvements in hull form have improved the deadweight ratio and the average speed; these things likewise permit and, in fact, require a higher speed. The author then proceeds to consider the requirements of vessels having average speeds of 14 to 17 knots. Consideration of rolling and pitching in average Atlantic seas leads him to a definition of the metacentric heights to be avoided, of the conditions which cause bad rollings, and of the relation between rolling and pitching periods. After considering single and twin-screw propulsion, he goes on to show the broad effects of revolutions (which will vary with the type of engine) upon propulsive efficiency and screw diameter, where average hull-efficiency elements prevail, for a range of ship displacement, and deals with the restrictions on screw diameter imposed by pressure limitations. A section of the paper is devoted to a consideration of the effects of revolutions on liability to vibration, and approximate curves are given for ship natural frequency when in nearly loaded condition. The paper concludes with a general discussion of shape of hull and wave-making, as well as of the shape of the hull ends. Formulæ are given for determining length and prismatic coefficient, when speed and displacement are fixed.—*Paper by G. S. Baker, O.B.E., D.Sc., read at a meeting of the N.E. Coast Institution of Engineers and Shipbuilders on the 30th October, 1942.*

Tractor Unit for the Propulsion of Barges.

It is reported that the Chrysler Corporation have now in production a new type of marine propulsion unit for barges, scows and similar flat-bottomed cargo carriers. The company state that tests on the Detroit River and on Lake St. Clair, Mich., have proved that one of these units can drive a large and fully-loaded steel barge at a speed fully adequate for general commercial purposes. When two of these units were attached to a similar barge, a considerably higher speed was attained. These tractors can be readily attached to or detached from any cargo carrier and are thus able to provide for such craft independent power plants as efficient as if they had been built into the vessels. The tractors are particularly suitable for river work, inland seas, or the pushing of heavily loaded cargo craft across any reasonable smooth stretch of water.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,771, 1st October, 1942, p. 8.*

Diesel-built Motorship for Sweden.

Early in 1939 the Swedish Broström concern ordered from the Aalborg Vaerft two cargo motorships, each of 1,628 gross tons, designed for trading on the American Great Lakes. After considerable delay, the Danish yard recently delivered the first of these vessels, the "Laholm", which has been taken over by the Swedish Mexican Lines, of Gothenburg. The "Laholm" is a shelter-decker with a length of about 250ft., a breadth of 42ft. and a depth of just under 19ft. The d.w. capacity is 2,900 tons on a draught of under 12½ft. The propelling machinery consists of two Polar Diesel engines developing a total of 2,070 h.p. at 275 r.p.m., and driving a single propeller at 120 r.p.m. through electro-magnetic couplings and gearing. The engines are 6-cylr. units, 340 mm. in bore with a 570 mm. stroke. The propelling machinery, as well as the three 120-h.p. Diesel generator sets, were supplied by the Atlas Diesel Company, Stockholm. The "Laholm" was towed from Aalborg to Gothenburg, and ran trials on 6th July, when she attained a mean speed of over 13½ knots. She was subsequently laid up at the Eriksberg yard in Gothenburg.—*"Lloyd's List and Shipping Gazette", No. 39,920, 28th October, 1942, p. 9.*

New Turbine Oil.

The Shell Oil Company are reported to have developed an improved type of lubricating oil for marine turbines which combines powerful rust-preventive properties with superior oxidation stability. This new oil is the result of several years of scientific research and conforms to the latest stringent specifications of the U.S. Navy Department. The oil, which will eventually be supplied to all U.S. battleships, cruisers, aircraft carriers and destroyers equipped with turbine machinery, was subjected to severe service tests by representatives of the Bureau of Engineering. In addition to being used by the Navy, the oil is at present being used in many merchant ships and tankers along the coast-line and in convoy service.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,795, 29th October, 1942, p. 5.*

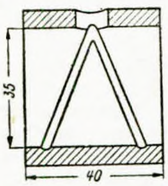
Fuel Comparison of Turbine and Reciprocating-engined Ships.

The oil-fuel consumption of the U.S. Maritime Commission's steamships equipped with D.R. geared turbines is stated to be under 0·6lb./s.h.p.-hr. for all purposes, and results as low as 0·56lb. have been claimed in some instances. The turbines of the vessels in question take steam at a pressure of about 400lb./in.^{2} with a superheat temperature of 750° F. Well-designed triple-expansion engines taking steam at 250lb./in. pressure and about 500° F. temperature may be expected to give a performance of about 1·0lb./i.h.p.-hr. of oil fuel or 1·5lb. of coal for all purposes, although the actual consumption must depend upon various refinements of design and construction. Small cylinder clearances, ability to utilise as fully as practicable the heat available before exhausting the steam from the

L.P. cylinder to the condenser, together with effective feed-water heating and air-heating systems, will tend to bring down the fuel consumption, but that of the EC-2 ships and their coal-burning counterparts, with either Scotch or large-tube watertube boilers, is about 50 per cent. higher than that of ships with modern geared-turbine machinery. Substantial improvements in the design and construction of the latest emergency ships may be expected to reduce this disparity in fuel consumption to about 30 per cent. The main factors contributing to the greater fuel economy of the geared-turbine installations are the ability to make use of higher steam temperatures and pressures (which accounts for nearly half the difference in economy), the ability of the turbine to extract more energy out of the steam at the exhaust end, smaller radiation loss and reduced friction loss.—*"Canadian Shipping and Marine Engineering News", Vol. 14, No. 3, October, 1942, p. 33.*

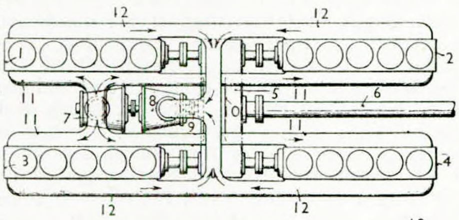
Gudgeon-pin Bush Substitute Material.

An article in a recent issue of the German technical periodical *Z.V.D.I.* gives an extract from the *Fourth Report of the Materials Economy Committee and Substitute Instructions of the Ministry for Armaments and Munitions,* in Germany, which describes how home-produced material was used to replace a special bronze containing 89 per cent. of copper and 11 per cent. of tin for making gudgeon-pin bushes for a certain type of 80-b.h.p. Diesel engine. The loading conditions were such that during combustion pressures of up to 5,600lb./in.^{2} had to be carried by the bush, and it was essential for the substitute material to be capable of standing up to emergency conditions such as running for a comparatively long time without seizing after a failure of the lubricating-oil supply. The small sketch shows that lubrication was by splash, the oil entering by a hole at the top and being distributed by oil grooves. The running temperature of the bush was 356° F., and the running clearance for the gudgeon pin was only three-quarters of one-thousandth of an inch. The pin had a ground-surface finish and was of hardened chrome-manganese steel containing 0·8 to 1·1 per cent. of chrome, 0·14 to 0·19 per cent. of carbon, 1·1 to 1·6 per cent. of manganese, and less than 0·34 per cent. of silicon. Without altering the dimensions, tolerances, material or finish of the gudgeon pin, the material of the bush was changed to an aluminium alloy of 86 per cent. aluminium, 12 per cent. silicon, 1 per cent. copper and 1 per cent. nickel. During a year of normal running the bushes have worked satisfactorily in every respect, whilst the resulting saving of 1·3lb. of bronze per bush constitutes a substantial amount with a mass-produced engine. —*"Gas and Oil Power", Vol. XXXVII, No. 447, December, 1942, p. 267.*



Sulzer Two-stroke Supercharged Engine and Shaft Transmission Arrangement.

Sulzer Bros. have recently developed and patented a design of propelling machinery installation comprising four two-stroke supercharged Diesel engines driving a single propeller shaft through hydraulic or electric slip couplings, arranged as shown in Fig. 2. The supercharging equipment consists of a rotary compressor *(7)* and an exhaust-gas-driven turbine *(8)* connected through a shaft *(9)* to transmission mechanism *(10)* which is associated with the gearing *(5)*. The engines *(1, 2, 3, 4)* drive through this gearing to the shaft *(6)*. Air is supplied by the compressor *(7)* through pipes *(11)* to all the engines, while the exhaust gases pass to the turbine *(8)* through the pipes *(12)*. At low powers the energy of the exhaust gases is not sufficient to drive the compressor *(7)* and it is necessary to supply additional energy to the supercharging set from the gearing *(5)* through the transmission device *(10)* and the shaft *(9)*. On the other hand, at higher powers an excess of energy is available from the supercharging set *(7, 8)*, and this is transmitted by the shaft *(9)* and the transmission device *(10)* to the gearing *(5)* and from there to the engines or to the shaft *(6)*, or to both. The engines being reversible, the transmission mechanism *(10)* has a gear arrangement *(13, 14)* for ahead and astern drive, as shown in the lower diagram. The shaft *(9)*, together with the supercharging set, can be kept running in the same direction at all times. For ahead operation, the set is connected to the driving gear of the engines through the shaft *(9)*, the magnetic coupling *(15)* and the gear wheel *(17)* of the transmission mechanism *(13)*. When running astern, the transmission between the supercharging set and the driving gear is effected through the shaft *(9)*, the magnetic coupling *(16)* and the gear wheel *(18)* of the transmission mechanism *(14)*. After the engines have been reversed, the supercharging set continues to run in the same direction as before.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, p. 302.*



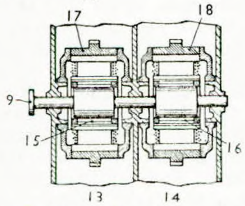


FIG. 2.

Conversion from Motor to Steam.

Owing to the shortage of fuel oil in Sweden a number of motorships and sailing vessels with auxiliary oil engines employed in the coasting trade of that country, have been converted to steam propulsion. One of the latest examples of such a conversion is the small composite motor vessel "Arjang" which has been fitted with a low-power marine steam engine constructed at Karlstads, Mek. Verkstad in 1885.—*"Lloyd's List and Shipping Gazette", No. 39,920, 28th October, 1942, p. 6.*

Götaverken Four-stroke Engine Reversing System.

The satisfactory results achieved with the new Götaverken reversing system for two-stroke engines (*for description see abstract on p. 107 of* TRANSACTIONS, *August, 1941*), have led the firm to produce an improved reversing mechanism for four-stroke Diesel engines, in respect of which patent protection has been obtained in this country. It is understood that this new reversing mechanism could also be adapted for use with two-stroke engines, if necessary. Part of one cylinder of a multi-cylinder four-stroke Diesel engine is shown in Fig. 1, the inlet, exhaust, fuel and starting-air valves

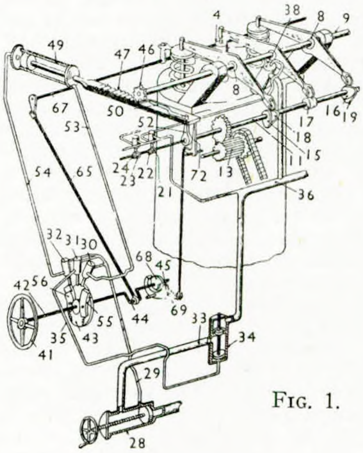


FIG. 1.

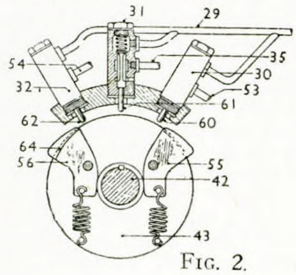


FIG. 2.

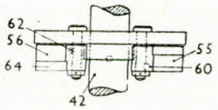


FIG. 3.

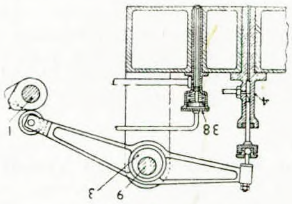


FIG. 4.

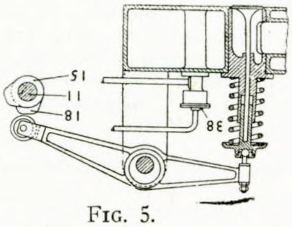


FIG. 5.

being at the top. The first three are actuated by levers pivoted on eccentrics *(8)* which are located on a shaft *(9)*. The camshaft *(11)* is driven by a chain and gear wheels *(13)*, and carries three pairs of cams *(15, 18)*, *(17, 20)* and *(16, 19)* for ahead and astern operation. Other pairs of cams *(21, 22)* and *(23, 24)* actuate the starting-air distributors which control the ahead and astern starting-air supply. Compressed air passes from the main valve *(28)* through a pipe *(29)* to a set of three valves *(30, 31, 32)* and through another pipe *(33)* to a pilot valve *(34)* which remains open or closed according to the position of the centre valve *(31)* to which it is connected by a pipe *(35)*. A branch pipe *(36)* is led from the pilot valve *(34)*, and has connections to the starting-air valves *(38)*. The engine is manœuvred by a control wheel *(41)* on the end of a shaft which operates different devices. There is a form of mechanism *(43)* for ahead or astern starting, according to the direction of rotation of the wheel, a stop *(45)* preventing the wheel from turning contrary to the motion required for the proper sequence of operations, and a crank *(44)* which moves the fuel-control rod *(65)*. This rod turns a shaft *(67)* which regulates the amount of fuel supplied by the plungers of the fuel-injection pumps *(4)*. When the engine is reversed, the valve-rocker levers are raised out of engagement with their cams, the camshaft is moved in a fore-and-aft direction and the levers are then lowered so that their rollers engage the second set of cams, as in Fig. 4. In order to effect this, the shaft *(9)* is fitted with a pinion *(46)* which meshes with a rack *(47)*, one end of which forms a spindle which enters the servo-motor cylinder *(49)*, while the other end has a guide slot *(50)* into which the pin of an arm *(52)* fixed on the camshaft enters. When the rack is moved along from the position shown in Fig. 1, it first turns the pinion *(46)* and the shaft *(9)*, causing the eccentrics *(8)* to take up the position shown in Fig. 5, the rocker arms being raised out of engagement with the cams. Further movement of the rack causes the pin of the arm *(52)* to follow the curve of its slot and thus carry the camshaft along with the arm until the second set of cams are in line with the valve-rocker arm rollers. The final movement of the rack is made without any alteration to the position of the camshaft, but the pinion *(46)* and the shaft *(9)* continue to turn, so that the eccentrics *(8)* lower the shaft and the second set of cams are therefore placed in engagement with the rollers. The action of the servo-motor *(49)* which moves the rack can be followed by noting that there are connecting air pipes *(53, 54)*, one of which leads to the right-hand control valve *(30)* and the other to the left-hand valve *(32)*. Accordingly, the movement of the control wheel *(41)* in one direction or the other determines which way the rack must travel to turn the pinion, lift the valve-lever shaft and move the camshaft longitudinally. The starting and reversing mechanism (Figs. 2 and 3) comprises a disc mounted on the control-wheel shaft *(42)* with two cams pivoted in position on the disc and normally held in place by light springs. When the control wheel is turned to the right, the cam *(56)* first actuates the valve stem *(62)* and thereby admits compressed air to the servo-motor cylinder through the pipe *(54)* and to the pilot valve *(34)* through the pipe *(35)*. The pilot valve then opens the air supply to the starting-air valves *(38)* in the cylinder heads. Continued turning of the control wheel causes the cam *(56)* to pass the valve stem *(60)* without actuating it, as this stem registers with a recess *(64)* on the cam. When the wheel is returned to the neutral position shown in Fig. 2, the cam *(56)* strikes the valve stems without displacing them due to the cam being swung away against the action of the spring. Turning the wheel in an anti-clockwise direction causes the cam *(55)* to actuate the valve stems *(60, 61)* in turn, thereby admitting compressed air to the opposite end of the servo-motor cylinder *(49)*; the rack then moves in the reverse direction and the whole of the engine-starting gear acts accordingly. The stop *(45)* (Fig. 1) comprises a cam *(68)* and a swinging wedge *(69)*. In one position this wedge prevents the control shaft from being turned to the left and in the other the shaft cannot turn to the right. The wedge is connected to a bell-crank lever *(72)* which is coupled to the rack *(47)*, so that the lever follows the movements of the rack. By this means the rack swings the bell-crank lever one way or the other and moves the wedge *(69)* into position for preventing the control shaft from turning in the wrong direction of rotation.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, p. 278.*

Propelling Machinery for Post-War French Merchant Ships.

On the 1st January, 1939, the total horse-power of the merchant vessels under construction for French owners was made up as follows: Turbines 55 per cent., reciprocating steam engines 4 per cent., and Diesel engines 41 per cent. The effects of the war on the industries of France make it probable that the conditions which will determine the choice of the type of propelling machinery for French merchant vessels after the war will be very different from those which prevailed in 1939. Thus, the oil refineries in the North and West of France have suffered heavily, whereas the French coal mines have remained more or less intact. At the same time many of the oil fields and refineries in other parts of the world are no longer in operation due to the war and are likely to be out of action for a considerable time. Bearing these facts in mind, it would appear likely that: *(a)* Most of the cargo vessels to be built for French shipowners immediately after the war for coastal service and for voyages between French ports and European ports, Algeria and Morocco, will be coal-burning steamships (possibly equipped with mechanical stokers or pulverised-coal firing); *(b)* ocean-going cargo liners making lengthy voyages will either be steam-driven or fitted with Diesel engines, provided that oil fuel or Diesel oil is readily obtainable at their ports of call; and *(c)* ocean-going passenger liners and tankers on routes between French ports and overseas ports at which fuel oil will be obtainable will be equipped with oil-fired boilers and geared turbines or with Diesel machinery. As regards the coal-burning steamships, it may be anticipated that the highly satisfactory results achieved with the D.R. geared-turbine cargo vessels of the U.S. Maritime Commission will encourage French owners to adopt similar propelling machinery in conjunction with lightweight watertube boilers equipped with mechanical stokers of the type which has proved so reliable in various foreign vessels. It must be remembered that whereas there are a number of important engineering firms in France capable of manufacturing marine steam turbines and gears, there are no corresponding facilities in the country for building high-powered marine oil engines, and some delay in their development must be anticipated. The use of electric motors, more especially those of the a.c. type, for driving auxiliary machinery on board ship is likely to be extended, the requisite power being furnished by Diesel-driven generators where practicable and, in some special cases, by dynamos driven by the main propeller shaft.—*Chr. de Neuville, "Journal de la Marine Marchande", Vol. 24, No. 1, 192, 15th October, 1942, pp. 1237-1238.*

Scavenging System for Two-stroke Engines.

An outstanding feature of the latest design of Deutz two-stroke engine is its scavenging system evolved by Dr. Adolf Schürle, of Stuttgart, which forms the subject of a recently published British patent. The exhaust gases are extracted from the cylinder through a duct which opens tangentially into a drum, as shown diagrammatically in Fig. 1. The arrangement comprises the cylinder *(1)* and piston *(2)* of a two-stroke Diesel engine, scavenging air flowing in through a port *(3)*. Exhaust takes place through the ports *(4)* before the scavenging ports open and the gases flow through the exhaust pipe *(5)* to the inlet *(6)* of the drum *(7)*, the final exhaust taking place through an opening *(8)* in the end of the drum. The function of the exhaust pipe is to conduct the exhaust gases from the cylinder tangentially into the drum at a velocity so high that they rotate and give the greatest possible extractor action and therefore the maximum scavenging effect. A modification of this arrangement is shown in the two lower diagrams. The exhaust gases from the pipe *(5)* enter the drum inlet *(6)* at the smallest diameter of the drum *(11)*, and the gases exhaust to the atmosphere at the point where the drum diameter is greatest, through nozzles *(16)* between the blades *(17)* of a guide ring. As the energy of flow of the exhaust gases in the nozzles *(16)* is converted into pressure, so that atmospheric pressure again prevails outside the ring, the resulting pressure difference causing a depression inside the drum.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, p. 302.*

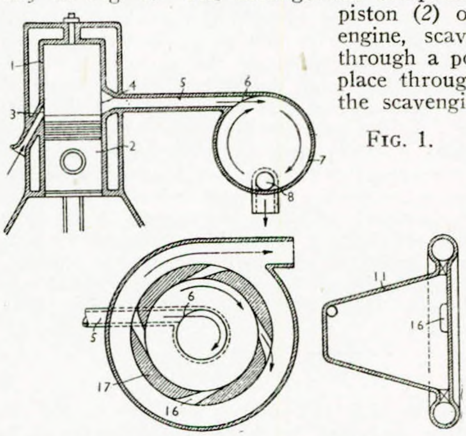


FIG. 1.

The Colloidal Fuel Problem.

The growing interest displayed abroad in the development of pulverised-fuel systems for marine purposes has been accompanied by intensified research into the colloidal fuel problem. The greatest obstacle to progress in this field has always been the difficulty of securing sufficient stability of the pulverised-fuel mixture, while next in importance is the achievement of a satisfactory viscosity of the mixture to enable it to be passed through pipes and to be atomised in the burner nozzle with difficulty. If coal of 1·35 sp. gr. having a calorific value of 14,500 B.Th.U./lb. is made into a 40/60 mixture with an oil of 0·9 sp. gr. having a calorific value of 19,000 B.Th.U./lb., the resulting mixture will contain 1,120,000 B.Th.U./cu. ft. as compared to 1,070,000 B.Th.U./cu. ft. for oil alone, and only 720,000 B.Th.U./cu. ft. for coal alone. Once the problem of the production of stable mixtures is solved, colloidal fuel is likely to be cheaper than oil, and it will be possible to handle it like oil in pipes and pumps, while the firing efficiency should be equal to or even exceed that obtained in oil-burning installations. Storage space will be much better utilised and the danger of spontaneous combustion, which has to be reckoned with in the case of coal, will also be eliminated. The ash and moisture content of the composite fuel would be less than that of coal alone, and it would be possible to utilise a wide range of low-grade coals. In the course of experimental work carried out by the Cunard Line some ten years ago, it was discovered that some fuel oils (more especially certain oils produced in cracking processes) formed stable suspensions without the addition of a stabiliser, and that a certain relationship existed between the carbon residue and the stability properties. Thus a coal mixed with a cracked fuel oil having a carbon residue content of not less than 5 per cent. was found to remain stable for nine months. A considerable amount of research into the question of fuel stability and viscosity has recently been carried out by J. E. Hedrick at the Kansas State College, Manhattan. He has found that with cracked residue fuel oils, no stabilising agent is necessary unless the fuel is heated to temperatures above 200° F. Therefore the stability problem does not arise in the storage of these mixtures, but only where they have to be heated to enable them to be pumped and burned. As regards stabilising agents in general, Hedrick states that the addition to a coil-oil mixture of 0·05 to 0·02 per cent. by weight of the condensation product of a fatty acid will produce a stable suspension. This is an agent of the surface-active type. Although the mechanism of stabilisation is not quite fully understood at the present time, it is known that a surface-active agent is selectively absorbed on the surface of the coal particles and causes a lowering of the interfacial tension between the coal and the oil. It also produces greater uniformity in the electrostatic charges on the coal particles. The electric charges on coal particles are presumably produced by the friction during grinding, and since coal is not a homogenous material, both positive and negative charges exist even on different areas of the same coal particles. The oil is such a poor conductor of electricity that these charges are only neutralised slowly, *i.e.*, the agglomeration of the particles with resultant settling-out proceeds slowly but definitely. The addition of the surface-active agent produces negative charges on all the coal particles. Surface agents do not increase the viscosity of the suspensions to any appreciable extent and are said to be effective over a wide range of temperatures. They can be used with any petroleum fraction, from petrol to the heaviest fuel oil. Hedrick's experiments have shown that coals of a size larger than 75 per cent. through 200 mesh are not satisfactory for making colloidal fuels as they cannot successfully be stabilised. Coal of a fineness of approximately 98 per cent. through 200 mesh is said to be most suitable.—*"The Shipping World", Vol. CVII,, No. 2,576, 28th October, 1942, pp. 371 and 373.*

Shipbuilding Records.

The achievements of the U.S. shipbuilding industry during the past year has been rightly described by the Prime Minister as "a record beyond compare", and the more closely it is studied, the more remarkable appears to be the feat of that industry—a relatively unimportant branch of American industrial activity in normal times —in creating and operating the organisation to build, engine and man such a mercantile fleet while, at the same time, pressing forward no less energetically with a huge naval programme. It may be questioned, however, whether the best interests of all concerned in this mighty effort are really served by such flights of showmanship as the launching from Mr. Henry Kaiser's Pacific Coast ship yard, on 23rd September, of a Liberty cargo vessel, the keel of which had only been laid ten days before. It was reported that the ship was launched 87 per cent. completed and with "steam up" in her boilers. Too much importance need not be attached to this last claim; much impressive smoke can be produced by burning a bucketful of oily waste in the uptake, and in any event, a newly-launched ship has little occasion for a supply of steam from her own boilers. There was a case in this country, many years ago, of a small steamer that was launched with her machinery in complete working order and almost a full head of steam on the boilers, and which proceeded to sea on trials half an hour later; but it is improbable that Mr. Kaiser's ship even approximated to that state of completion below decks. He was engaged, in fact, in a competition with himself, and it is only fair that this should be kept in mind. In August, he launched a ship in 30 days from the laying of the keel, and in the following month this time was reduced to ten days, the vessel being delivered ready for service ten days later. What would not be fair would be to attempt to compare this performance with the results achieved elsewhere, when the conditions are not truly comparable. By concentrating on this one stage in the construction, *viz.*, the period between the laying of the keel and launching, Mr. Kaiser (or his publicity agent) does much less than justice to the really exceptional organisation in the background, which has made the feat possible at all. Large portions of the ship's structure are fabricated on the ground, in adjacent shops, or even in fairly remote establishments such as bridge-building yards, and are transported complete to the building berth. In such circumstances, it is not difficult to improve considerably on the time that would be required to build the ship, frame by frame and plate by plate, in the traditional manner of most British shipyards; but it is idle to pretend that the time during which the berth is occupied is the true measure of the duration of building. If Mr. Kaiser could so arrange his procedure as to bring to the berth, in two lifts only, two completed halves of a ship, he could probably cut down the time of "building" to less than a week, but it does not follow that the true time taken in construction, from the date when the first man charged his labour to the job until the last man did so, would be reduced at all by this subterfuge. The only advantage would appear to be the reduced occupancy of the building berth, and that is considerably offset by the more extensive provision that must be made to carry out the work elsewhere. Stunts of this kind are not new, and, in certain circumstances, they may have been justifiable; but in the present instance, better justice would be done to the really excellent organisation responsible for the production of these Liberty ships if the overall time were given. This would at least afford a target at which other shipyards in the U.S. and in Allied countries might aim under anything approaching comparable conditions. The American shipbuilding industry would have nothing to fear from such a comparison; and the industry in this country, the operations of which have been shrouded in mystery as far as the public are concerned, might be encouraged if a few similar particulars were released on this side of the Atlantic, especially if some round figures of costs could be given as well. Rear-Admiral H. L. Vickery, vice-chairman of the Maritime Commission, has stated that the 56 ships delivered during August were completed in an average time of 83 days from the laying of the keels. Ships have been built in this country, and are being built to-day, at rates which compare favourably with this average, and which are almost certainly not inferior to it on a man-hour basis. Nobody wishes to see a revival of the somewhat absurd competition in riveting records that developed here in the latter part of the last war, and which began when a squad engaged on the construction of comparatively small craft put in, by hand, over 2,000 ⅝-in. rivets in some 6½ hours. Thereafter record was piled on record until, in the interests of good workmanship and the record-breakers' health, an official embago was placed on any more efforts. The present craze in the U.S.A. may possibly end in similar fashion. A proper appreciation of the magnitude of the American effort is more likely to be aroused by a true portrayal of the circumstances than by any exaggerations and distortions. They do not deceive the enemy, and there is no point in trying to deceive the peoples of the United Nations themselves by offering them a perversion of the facts when the plain unvarnished truth is so highly creditable to all concerned.—*"Engineering", Vol. 154, No. 4,003, 2nd October, 1942, p. 272.*

Welding and Freedom of Design.

In the course of a paper entitled "Developments in Welded Ship Construction" read at a recent meeting of the Institution of Engineers and Shipbuilders in Scotland, Mr. J. L. Adam, of the British Corporation Register of Shipping and Aircraft, said that welding was not the panacea for all the ills that afflicted ship structures. It did, however, permit of more freedom in designing many parts of a ship's structure where, at present, the controlling factor was the inability to get a riveted connection which would hold the various component members up to their work. It followed, he continued, that to get the best results, technically and commercially, from welding, the structure should be designed for it and not be a mere conversion of a riveted ship design. Mr. Adam proceeded to make the point that, in certain shipyards, preconstruction, especially for double-bottom structures, was restricted to 5-ton units, even where greater lifting facilities were available, because it was claimed that there was then the minimum of transport and interruption in yard operations. The larger the units, of course, the larger the mass of work which could be proceeding simultaneously, but where the welding facilities were as good on the berth as on the skids—and that was a *sine qua non*—preconstruction lost much of its advantage if carried beyond a point where it saved a large amount of overhead and vertical welding.—*"Fairplay", Vol. CLIX, No. 3,107, 26th November, 1942, p. 634.*