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*Cargo Ships and Propelling Machinery adapted to War Conditions—Discussion.

Mr. H. J. Wheadon (Chairman of Council), opening the discussion, said: The author's novel proposals demanded very careful consideration. Although he understood that the author claimed his proposed "cargo warship" would be suited to post-war commercial cargo liner services, in the national interest our foremost consideration at this time should be to focus attention upon the urgent need for ways and means to overcome the submarine menace.

The beam of the author's proposed ship was in the region of 80ft. Had he considered the question of drydocking and labour facilities? The situation in the former connection was already acute, and only with difficulty could accommodation be provided for vessels with beams exceeding 70ft., while abroad of course it was still more difficult. The effect of a fleet of vessels of 80ft. beam must be considered in these respects.

Speed of cargo handling was second in importance only to sea speed. The ship the author proposed had six holds, and as frequently cargo was discharged from one side only, there would therefore under such conditions of working be less than one crane per hatch, from which it seemed that the cargo-handling machinery was very inadequate for a vessel of 12,000-14,000 tons with six hatches.

Finally, could not the author make his design even less vulnerable by the following means: If Diesel-electric or turbo-electric propulsion were adopted, could not the engines be superimposed upon a water-tight deck above the propulsion motor? It was possible the propulsion motor could be of the submersible type, in which case the flooding of the motor room would not render the propelling machinery inoperative. With a remote-control system the engine-room personnel would be above the water line and consequently subject to considerably reduced risk than at present. Mr. Saunders, who was present, would be able to say whether a submersible motor was a proposition, even if air pressure had to be imposed within the casing and glands not relied on for sealing purposes.

Mr. J. Calderwood, M.Sc. (Vice-Chairman of Council), said: The author seemed to suggest—and he (the speaker) thought there was perhaps something in the suggestion—that the problem had been wrongly tackled at the beginning of the war and since, in that we had tried with the existing marine engineering and shipbuilding facilities to get a maximum tonnage on the ocean and not by adopting and increasing these facilities to get the maximum carrying capacity of ships. If the proposals in the paper had not been considered before, they should be now; and even if they had already been considered, they were worthy of reconsideration.

The elimination of the bedplate to save weight and man-hours of labour he agreed was, in general, a very sound idea, but there appeared to be difficulties. Boring out and the bedding of the shaft would be much more difficult, and it would have to be done after the ship was launched with a resulting considerable increase in the time required in fitting out the ship.

In discussing the question of engine noise the author did not stress sufficiently the importance of the type of noise, and in this connection he was very surprised that the author proposed turbo blowers. These gave a type of noise which was most penetrating. Generally on Diesel-engined ships with turbo blowers, it was very difficult to confine the noise to the engine-room, and if it could get out of the engine-room it could be assumed that it would get out of the hull and would be picked up by the detecting gear in submarines.

In an engine-room fitted with a single-acting two-stroke engine, the noise generally was not greatly different from that of a four-stroke engine, but from outside the engine-room it sounded more quiet. The take up of the bearing clearances in double-acting or in four-stroke types seemed to produce a noise which travelled through the ship's hull, and that was an important advantage for the single-acting two-stroke type engine in which bearing loads were always in one direction.

The author referred to really high-speed engines and electric drive, and the ultilization of the aircraft-engine industry. He thought that was going too far to-day and, he was afraid, for some time ahead. There was no existing design of high-power high-speed engine which could be relied upon to run to Australia and back without breakdown. As a war-time proposal the use of really high-speed engines did not seem practicable, but he would like to hear the author's further ideas on that point.

The author then referred to the subject of high speeds and propeller efficiency. He agreed that engine speeds had been tied down too much by propeller designers. He had always believed that it was possible to design propellers almost as efficient at 250 r.p.m. as at 100 r.p.m. Some years ago he had dealt with an enquiry from Canada in connection with a Lake boat. The engine speed was specified at 300 r.p.m. and that sounded so revolutionary that he had requested that the cable be repeated. The reply was 300 r.p.m. again, and when the enquirer subsequently visited this country he (the speaker) had suggested that this was a terribly high speed for a boat with a block coefficient of 0·88 and a speed of 8 knots. He had been assured that the Company concerned had ships with engines running at that speed, the slight difference in efficiency due to the high speed being more than offset by the reduction in cost, weight and size of machinery.

Speed was limited rather by engine design, and for single engines of the powers which the author had in mind, a speed of 175 r.p.m. was about the highest for which an engine could safely be built to-day. In that connection he rather felt that the author's original idea for propulsion machinery was better than the present proposal, *i.e.* that there should be some propulsion machinery forward and some aft. With this scheme the power of individual units would be halved, or with twin screws at each end the separate engines would be only a quarter of the output of the engines discussed in the paper. Engines to give the power wanted for this arrangement could be designed to-day with a speed of about 350 r.p.m., and the engine weight would be down to 40 to 60lb. per h.p. This could be done from established designs without any risks in the nature of experiments. Whatever was done on the engine side, fundamentally new or revolutionary designs must not be adopted at the present time.

The author mentioned the vee double-acting engine, but there were a number of fundamental problems to be solved in getting that to the stage where it could be safely fitted in a ship.

Mr. C. Wallace Saunders (Member) said: The author had mentioned that the fore and aft parts of his proposed ship were of tanker construction, a remark which was made in connection with the safety of the ship. In the past year or so there had been three or four tankers some of which had received as many as three torpedoes but by a very ingenious use of compressed air they had safely reached port. One of them had steamed 900 miles and kept herself trimmed by means of this compressed air, and had actually discharged most of her cargo by the same means through salvage pumps put aboard for fire purposes; the ship's pumps were out of action. The author showed water- and air-tight hatches, and this

** This paper, by W. S. Burn, M.Sc. (Member of Council), was published in the November, 1942 issue of* Transactions, *Vol. LIV, Part 10, pp. 129-146.*

being so perhaps this same compressed air safety equipment might be used on a vessel of this type. This compressed air system had been instrumental in helping the tanker "Ohio" to Malta, and this together with other episodes seemed to point to the fact that it should be investigated further.

Mr. Wheadon mentioned the question of the 80ft. beam of the suggested ship in relation to dry-docking. Surely even before dry-docking came into the picture, there was a shortage of actual berths in the shipbuilding yards where ships of this beam could be built because of commitments in other directions.

He noted the accommodation for the engineers was almost the length of the ship away from the engine room, and he considered the engineers should be nearer to their jobs.

The two lifeboats stowed away as they were, away from machine-gun fire, looked very attractive, but he did not see how the gravity davits mentioned by the author had head-room to function without encroaching upon the accommodation above.

With the oil fuel in the side bunkers right aft, the proposed vessel looked like a tanker but without the facilities of a tanker for trimming the ship if she were in ballast.

It was proposed that the 12,500 s.h.p. machinery should be accommodated in a length of 68ft. He thought turbo-electric machinery complete with boilers would save frame spaces, if there was room to put the motor at the thrust block, with the turbo-alternator forward of that, and the boilers on either side of the turbine. He believed the two water-tube boilers could be accommodated in that side space now allowed for cargo—here the speaker indicated this point on the illustration.

The weight of the actual propelling machinery complete with the condenser, closed-feed heat system and boilers, would be about 450 tons, which would probably show a saving in weight over the suggested Diesel engine.

A Diesel engine of 12,500 s.h.p. of whatever type would appear to be quite experimental in these times.

Mr. Calderwood had given some very good reasons against the proposal to eliminate the bedplate of the Diesel engine. The alignment of the crankshaft and the boring for the bearing housings, etc., would have to be done after the ship was launched, *i.e.* water-borne, which would probably be very difficult.

In connection with noise and the submarine menace, aero engines of fairly high speed (such as 1,600 r.p.m.) for ship work as proposed, would probably emit a fairly high note, and if driving electric generators there would be an additional high note which might be picked up readily by a submarine. If the use of these aero engines was with electric transmission, here again were experimental problems for this power. With the slower-speed straight Diesel engine as shown, the blowers would be high speed with the same disadvantage.

The separate pump rooms, forward and aft, again raised the question of personnel and also piping, in the former case putting a big strain on the personnel and in the latter case a complicated system.

As regards the future, he held the view that all valuable cargo, which was generally in small packages, together with most passengers would be transported in the air by the big bombers used to-day for war purposes. For those who wanted to travel more slowly there would probably be a few passenger liners of about 24 knots. The bulky general cargo of the world would be carried in a great number of sailing ships giving a continuous flow, the ships being fitted with 600 or 800 s.h.p. auxiliary engines to see them through the Doldrums, and a small crew. This would have the effect of solving a great number of engineer's problems, would give a good life for those who wanted to go to sea, and would carry the world's merchandise in the cheapest possible way.

Finally, he thought it would require a great deal of experimental work over a long period before the value of the proposals made by the author could be established, and he considered that we must keep to the engines which had been tried out and were at our disposal now. In short, he thought the war period was not the time to embark on such highly experimental projects as suggested in the paper.

Mr. E. G. Warne (Member) said: The author mentioned the double-acting V-type engine as being a desirable means of propulsion. Undoubtedly that would be so, provided its overhaul by the personnel found in the average ship could be arranged. But there was going to be no technical improvement in personnel in the near future, and for that reason he would prefer the vertical double-acting two-stroke engine with its comparative ease of handling and repair.

There was a large amount of piping in the author's proposed ship owing to the distribution of the machinery forward and aft and for other reasons. He wondered whether the author had considered a duct keel or a fore and aft tunnel.

In considering the elimination of the bedplate, it was quite easy to see that with strong welded construction there would be little vibration and a minimum of stress concentrated in a fore-and-aft direction, and therefore one might visualize the absence of the bedplate without any great horror. But athwartships there was a lateral strain which might have an effect on the bottom of the ship and this stress would be transmitted to certain parts of the ship's structure and framework, perhaps giving an unknown factor of weakness. Had this point been taken into consideration?

It would be of interest to learn what induced the author, who had very properly made out a case for the strictest fuel economy, to install Diesel-electric propulsion at the forward end of the ship. Such a plan was open to the objection of, say, a 10 per cent. loss due to transmission, added to the complication of the general lay-out and did nothing to help the standardization of the ship's machinery. The operating conditions laid down by the author, 1,500 b.h.p. at 250 r.p.m., were so clearly suitable for a direct Diesel engine drive that a fuller explanation of the author's object in fitting an electric motor to the forward screw would be appreciated.

Mr. W. A. Christianson (Member) said: The whole basis of the author's proposals mainly related to oil engines, and though he mentioned steam turbines, oil would be the source of power in this case too. Were we quite sure that oil would win us the war? We had lost the Burma and East Indies oilfields and we nearly lost the Iranian source of supply. If we had lost the latter, where were we going to get oil? Secondly, what about interruption of our oil supplies by submarine attack? With luck on the enemy's side, matters might have gone downhill, and we ought to consider carefully whether oil engines were the solution of our difficulties or possible difficulties.

The speaker suggested that the safest solution would be to use both coal and oil burning vessels, the latter including both steam and Diesel vessels.

The author's proposals showed a single-screw job. What about twin-screws with machinery aft? This arrangement would lend itself to higher propeller speeds, and the engines and parts would become lighter on account of these two factors, added to which there would be greater security by the twin-screw arrangement.

The speaker considered that a great deal might be said for the single-acting trunk-piston engine especially in war time, where production and maintenance were most important considerations.

The author referred to the vee-type double-acting engine. What about the vee-type single-acting trunk piston engine in twin-screw arrangement? With the higher propeller revolutions previously mentioned, this arrangement would result in further considerable saving in space and weight.

If these 16- or 18-knot ships could be built, would they sail alone or would they have to accompany convoys? Obviously the speed of the convoy was the speed of the slowest ship, and there would be no advantage in these fast ships unless they sailed alone or in fast convoys. Also, was it necessary to keep at high speed all the time or only in submarine zones?

Noise in Diesel engines came from various sources, including the exhaust. He did not know how serious the exhaust noise was from the war point of view, but a great reduction in the volume of this could be effected by water injection silencers, and perhaps sound-proofing the engine-room would assist a solution.

The author mentioned nothing about supercharging, which would give an increase of power and speed. There was also the possibility of getting extra power from the auxiliary units, some of which might be standby units not fully utilized. Why not use this available machinery to transmit electric power to motors on the propeller shaft, and thereby augment the power when it was necessary to get extra speed? The extra power thus obtainable was not just the added auxiliary power, but the extra main engine power due to the increased revolutions.

Mr. H. O. Farmer, M.C., B.Sc. (Member) advocated the application of the small high-speed Diesel engine to ship propulsion. The proposition was by no means a new one, and no one in the marine-engine world had taken it seriously. In the author's design of the proposed ship, the hull was divided up into small sections by decks and bulkheads in order to isolate damage from a torpedo. It seemed to be the obvious thing to divide up the engine, if possible, so that a direct hit in the engine room would not put the ship out of action. Instead of that, decks and bulkheads had to be cut away to accommodate the very bulky boilers in the case of steam drive, or engines in the case of direct-Diesel drive.

Had anyone ever considered dividing up the boiler into a number of small units which could be isolated by watertight bulkheads? Possibly this was not practicable, but in the case of the Diesel-electric drive it certainly was feasible to divide up the power unit into a number of small independent generators.

There was in operation in this country to-day an installation of this type, which was used to supply power to a factory running 24 hours a day. There were some 100 engines running at speeds in the region of 900 to 1,200 r.p.m., the power output of each unit being about 100 h.p. The engines ran day and night for thousands of hours, and any failure of the power supply was unknown.

In the early days of the war a scheme was put forward in America for propelling a ship by means of a number of small petrol engines. On arrival in this country, the ship was to be broken up for steel plate, and the engines used for tanks, trucks, etc. Unfortunately, the engines chosen were not suitable, and were never designed for a steady output at constant speed; they were rather the road-vehicle or motor-boat type. Though giving excellent service for such work, they were a failure when applied to ship propulsion where a constant output over long periods was called for. It must be emphasized that the motor-vehicle type of engine was not suitable for marine propulsion work. It was, however, quite feasible to use small engines giving some 200 or 300 h.p. each and running at speeds in the region of 1,000 r.p.m., to give the same reliability as the large marine propelling engine. The very fact that a large number of small and independent units were used increased the reliability and gave freedom from complete failure.

The geared-Diesel drive was an interesting omission from Mr. Burn's paper. The German pocket-battleships appeared to have given a satisfactory performance and were an instance of the use of a number of high-speed engines geared to one shaft.

Mr. H. D. Adam (Member) said: The author asks "Why not evolve a basic national marine oil-engine?" The speaker would suggest that we might further develop a well-tried type of engine which was of vital importance to us at the present time, namely, the submarine-type oil engine.

Considering the amount of work being done with these engines, and the care which had been taken in their development, he had no doubt they had proved very reliable and could be adapted for use in cargo boats. The two-cycle type of engine—rated at 2,400 b.h.p. —could be reduced in speed to 350 r.p.m., giving a weight of something in the region of 45lb. per b.h.p.

According to the size of the cargo ship, for the smaller ship four engines could be used coupled direct to the propeller. A considerable number of engines might be preferable in big ships coupled to standard type generators, so that the propellers (one or more) could be driven by motors, thus allowing for engines to be installed in the most convenient position. The advantages of electric propulsion would also be obtained and these are considerable.

If all available resources were combined in the design and manufacture of this type of engine, present needs for service purposes could be met and surplus supplies could be put to immediate use at a further date. This type of engine could be supercharged by auxiliary engines in case of necessity for high speeds for short periods. Air supply from supercharging sets could be used to put up pressure in the hold to keep out water. These auxiliary engines could also be used for quick discharge of cargo in port.

A system of repair and overhaul by complete removal would prevent delay of ships by extensive overhauls of plant on board.

Personnel with good knowledge of this plant would be available in large numbers and they could serve in any ship; sea-going engineers would be interchangeable with the repair staff, making it possible for the ship's staff to take a spell ashore, and shore staff to have running experience at sea on the engines they overhauled.

On the proposal of **Mr. A. F. C. Timpson** (Member of Council), seconded by **Mr. C. Wallace Saunders** (Member), a very cordial vote of thanks was accorded to the author with acclamation.

BY CORRESPONDENCE.

Mr. E. F. Spanner, R.C.N.C., ret'd. (Member) wrote: The following comments must be regarded merely as first thoughts. Obviously such an important paper requires full digestion.

(1) The ratio steel weight/ton deadweight will tend to be high in a vessel with so large a breadth/depth ratio, especially one with a heavy horizontal deck at neutral axis level.

(2) Unless special pumping arrangements are made, or the vessel is divided into short sections with individual pumping systems, there will be difficulty in localizing the effect of damage to pumping systems should side or bottom damage be sustained.

(3) The low width/length ratio will tend to make the vessel more rather than less vulnerable to direct hits from air attack by bomb, although she will be less vulnerable to the effect of torpedoes or near bomb misses by reason of the proposed underwater internal side protection. The author is on the right lines in his suggestions in this connection, but the writer prefers the sort of arrangement shown in the accompanying illustration (Fig. 6), taken from a paper "Ship Structural Design" which the writer contributed to the Society of Naval Architects and Marine Engineers, New York, in 1934.

(4) The proposed subdivision of the propelling and steering effort between bow and stern is decidedly interesting, but the use of ordinary rudders appears to be needlessly inefficient. Time and again it has been demonstrated that ability to swerve without loss of speed is of vital importance in dodging bombs, and also torpedoes. The rudder is a most inefficient means to use for such movements. We badly need a new method of steering which will not impose a "drag" on the vessel. The writer would like to see a modification of the author's machinery layout providing two screws abreast of Nos. 3 and 4 holds, and two screws abreast of Nos. 9 and 10 holds, with either (*a*) small propellers in rotatable Kort nozzles, or (*b*) Gill propeller pumps, at bow and stern, to give the required steering effort clear of the main propellers. All propellers would be electrically driven, and the main generating plant could be of light weight type.

(5) Naturally, perhaps, the writer is reluctant to see waste-heat boilers dismissed as being too heavy, although the author has some reason for using this adjective in connection with old-fashioned designs. The writer hopes that we shall all have opportunity to discuss requirements and put forward proposals before any drastic changeover is made which will eliminate the use of steam for heating, cooking, auxiliary and fire extinguishing services.

(6) The writer considers that the author is making a mistake in attempting to subdivide his vessel by means of a stout horizontal deck at neutral axis level. If the width of the vessel is to be as much as 80ft. at upper deck level, it would be preferable to reduce the length between transverse bulkheads, and stick to the old-fashioned deep hold with the largest dimension of the upper-deck hatch arranged athwartships. The worth of the proposed explosion-resisting hatches to the lower hold is extremely doubtful, and it would surely be wiser to plump for shorter holds of full depth, but restricted length, with strong bulkheads, but upper-deck hatch covers of no more than normal strength. Better to let a torpedo—or such part of the effect of a torpedo as got past the underwater side compartment—vent itself by blowing off upper deck hatches, and flooding a restricted length of the vessel, than place faith upon the explosion-resisting capabilities of an intermediate deck and the airtightness of large upper deck hatches. Frankly, the writer thinks this upper and lower hold idea is a great mistake. The author refers, very understandably, to the remarkable ability of an oil tanker to stand up to underwater attack, but has he made allowance for the fact that subdivision alone does not account for this "toughness"? A very great deal of it is due to the fact that torpedo explosions take place up against plating which is supported from the inside by the oil contained in the compartment. There will always be a tremendous difference in the effect of an explosion against the side of a hold filled with ordinary cargo, and against the side of a hold, or tank, filled with oil, petrol or even molasses.

(7) The author's reference to the "Bismarck" in connection with his remarks upon submarine and torpedo attack is very interesting, but it is doubtful whether the difficulty experienced in sinking the "Bismarck" arose simply from the extent of her subdivision. Various relatively simple schemes have been put forward from time to time for increasing the non-sinkability of warships, but for one reason or another our warship designers have preferred not to make use of them. One scheme involves the almost complete filling of wing compartments with expanded rubber. Another, the storing of deflated balloons in both small and large compartments, these balloons to be inflated after the compartment has been bilged. With judicious selection of size and shape it would be possible to expel a very large proportion of the water entering a compartment so equipped, without exposing the envelopes of the balloons to any undue amount of stress. The secret of success with such a scheme would be to arrange matters so that the balloons were so large in volume that the skin would never be fully distended. A further scheme is to provide that entrance to all underwater compartments is through downwardly directed trunks, open-ended at the bottom. This downward trunking of all access trunks or hatches results in providing a permanent air-pocket at the tops of such underwater spaces as torpedo rooms, magazines, steering engine rooms and so on. Of these ideas the use of deflated balloons and of downwardly

trunked access or escape hatches might be worth a second thought in cargo warships. They are mentioned to indicate some of the many lines along which suggestions have been put forward. Judging

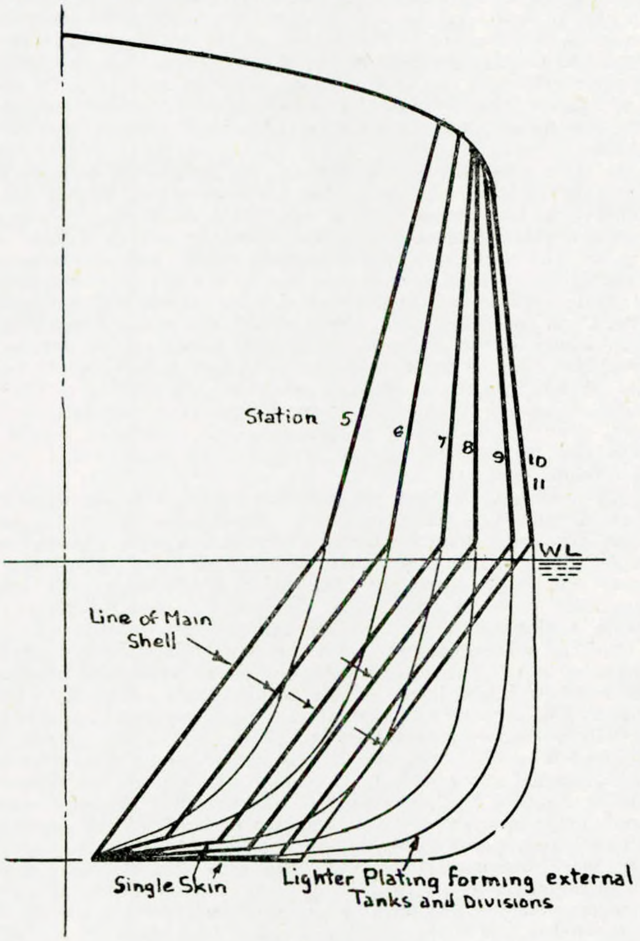


FIG. 6.

from hearsay, foreign warships do incorporate ideas not included in British vessels. Incidentally, the refusal of certain foreign warships to capsize may be put down to a combination of causes, *e.g.* better schemes for restricting inflow on one side, better provision for balancing inflow on both sides, greater initial stability, and greater range of stability. The provision of twin bulkheads, separately constructed and stiffened does not appeal to the writer as sound. It would be preferable to provide for "venting" an explosion through the hatch so as to save the bulkheads. Any explosion close enough to the pair of bulkheads to damage one of them would almost certainly damage both sufficiently to destroy the watertightness of the subdivision. For wartime service, the writer feels that the closely corrugated bulkhead recently put forward by Isherwood has something to commend it. It seems probable that it could absorb an explosive "punch" without doing more than "open out" in the corrugations. This type of bulkhead deserves close study by the designers of ordinary warships as well as cargo warships.

(8) The idea of carrying an aeroplane on the proposed cargo warships is very sound—the amazing thing only that the powers that be did not awake to the need until after many months of the war had been wasted. Way back in 1927 the writer wrote a book "Armaments and the Non-Combatant", urging among other things that "the Admiralty should investigate the problems of defensively arming merchant ships with aeroplanes". The writer even devised and read a paper about a type of gravity davit gear to enable the top decks of large passenger liners to be kept clear as flying decks. It is a source of satisfaction to see ideas of the same sort in Mr. Burn's paper.

It would be easy to write much more—there is so much to be discussed that it is difficulty to stop. The writer is personally very grateful to the author for all the trouble he has taken, and hopes that something of practical worth will result from his efforts.

Dr. G. S. Baker, O.B.E., wrote: This paper is one of those in which one has to be careful about the assumptions made, before accepting the author's conclusions. Unfortunately, these are rather scattered about the paper. The author starts with a statement that present bulkheads and subdivision "can be improved upon . . . and horizontal watertight subdivision is as necessary as vertical bulkheads". Admitting the former, the adoption of some other system of subdivision has to be considered from several standpoints. In particular horizontal subdivision such as that shown by the author is open to serious objection on stability grounds when damaged. Also the use of double bulkheads each with its own separate construction, and the doubled vertical plating at the sides adds to the hull steel weight as also does the relatively great breadth to depth and breadth to length ratio. Even the conclusion that oil tank construction is good because of the smaller loss of tankers relative to cargo boats (taking this statement to be true) is open to question. The differentiation may be due to the nature and density of the cargo carried and not to the construction as such. All this part of the paper requires detailed examination before it can be accepted.

On the question of the speed obtainable by such a ship, taking a vessel 525ft. by 75ft. (not the 80 suggested by the author) by 26ft. draught, prismatic coefficient 0·64, the *C* would be about 0·68, the quasi-propulsive coefficient about 0·7 and the 12,500 s.h.p. proposed would then be absorbed at 17 knots, not 18 knots as in the paper. This is for a vessel of 19,500 tons displacement, allowing the usual 15 per cent. for average fine weather at sea—in the North Atlantic this allowance would have to go up and the speed come down. The author suggests a prismatic coefficient lower than the writer has taken, which would increase this speed a little, but he is then getting into difficulties with the smallness of the cargo which can be carried.

It is when the author comes to deal with engine design that he is on much surer ground, and his comments and suggestions are clearly justified. One cannot evade the facts he produces—the contentment of British firms to pay licence fees and royalties to foreign firms, the reluctance of British firms to engage on large research on engine design, the consequent effect on the orientation of the shipbuilding industry—are all too evident.

His suggestion that engine designers and makers should get together to form a committee on design is most timely and the writer hopes the Institute will take this up seriously, and that as a result a development effort proportional to the problem and its urgency will be made.

Mr. R. S. Blackledge wrote: Referring to one or two of the subordinate issues raised by this paper, there is more than sufficient precedent to justify the author's advocacy of polyphase alternating current motors for the driving of auxiliaries, and in specifying the motor horse power care must be taken to avoid the American development era mistake of over-motoring, with its consequent low total power factor. The polyphase induction motor has sufficient overload capacity—in general at least 100 per cent. in torque for 15 seconds, or more depending on the enclosure—to render the over-motoring of drives not only unnecessary but uneconomical; furthermore, it would result in burdening the tare weight of the vessel with inactive material.

It will not be possible in general to take these marine motors from the "industrial stock shelves", because many are skirt mounted, and require to be provided with means for taking a considerable thrust load. It should be the object wherever possible to use single-speed squirrel-cage machines, although in some cases—notably the driving of ventilating fans—pole change motors will be necessary.

A usual figure for the speed range on ventilating units is 1 to 1·4 or 1·5, and in order to avoid undue complication in change-over switching arrangements it most probably will be desirable to utilize machines with two separate stator windings (as distinct from those in which a single stator winding is reconnected when changing from one number of poles to the other).

As the art of alternating-current electrification of ships' auxiliaries progresses in this country, doubtless it will be possible to offer a scheme for ventilating fan speed control alternative to that employing separate stator windings. Again, there is the possibility of requiring an even lower speed than the normal minimum; thus three speeds of ratio 0·7/1/1·4 or 1·5 might be required. This could be arranged quite conveniently by providing the combination in the one stator of a true pole—change winding and a single-speed winding—the former dealing with the two-to-one range 0·7/1·4 and the latter with unit speed. The switching arrangements are quite simple.

With regard to the axial flow ventilating fan in which it is usual to cool the motor by forced convection in the air stream itself, the induction motor will be at an advantage as compared with the direct-current machine, for the major portion of its losses are in conduction contact with the dissipative area, whereas in the direct-current machine by far the highest part of the losses is on the armature and this must be transferred by natural and forced convection in the motor interior to the inside of the shell, thence by conduction to the air-swept surface. The dynamical characteristic of the induction motor does not permit it to be so self-adjusting as the series-wound machine, but this would not appear to be a serious matter in connection with the axial flow fan p/v characteristic; in fact in some ways it may be regarded as a good feature.

In a recent *paper Lieutenant Commander H. G. Rickover, U.S. Navy, analysed the alternating-current auxiliaries necessary for battleship use; he stated that 85 per cent. of the installed a.c. horse power would consist of single speed, and 9·6 per cent. of multi-speed squirrel-cage machines. He stated also that wound rotor machines are used for winches, capstans, cranes and similar equipment.

The author is at pains to justify his higher propeller shaft speeds, and in this connection one recollects that the now moderately-aged U.S. battleships "Tennessee" and "Colorado" had four motors each developing 7,300 s.h.p. at a maximum speed of 170 r.p.m.

Rickover gave comparative figures of weight, space, efficiency and cost for alternating and direct current Diesel-electric propulsion equipment for a 12,000-s.h.p. twin-screw vessel having a propeller speed of 140 r.p.m.—particulars which have close correspondence with the case postulated by the author.

Many engineers are agreed that the electrical transmission and control of the propulsion power has definite advantages, and, whilst it would be most undesirable to resuscitate for the present field the "battle of the systems" which characterized electric traction development in this country, it might perhaps be stated that the synchronous, asynchronous, and direct-current systems have their merits, and that marriage to one or another without a full investigation of all factors would be an evil no less than was the "battle of the systems".

The writer finds no mention of the shock loads on machinery incident with torpedo or other explosion, and the risk, degree of importance of duty, and weight increment would require to be balanced carefully, otherwise the kernel of the author's proposals would be somewhat modified.

There is a deal of experience which has been accumulated over 20 years or more and relating to the behaviour on duty cycles amounting almost to fatigue tests of Class B insulation. Reduction in weight would result if such insulation and the higher temperature rises associated with it were adopted.

The difficult and variable ambient conditions would of course be taken account of in the fixing of the permissible temperature rise; Class B insulation would not be necessarily desirable in all cases, but in the larger machines it would be an advantage to give it consideration.

Many valuable data of alternating-current operation as it relates to ships are given in Rickover's paper referred to above.

Mr. A. E. L. Chorlton, M.P. (Member) wrote: The writer will not follow the author in his proposals for the ship design, inner blister, etc., but will confine his remarks to the oil-engine drive.

The author has recommended, somewhat violently, engines modelled on the aero engine. The engine he really proposes, however, is actually far from the low weights of the very high-speed real aero engine.

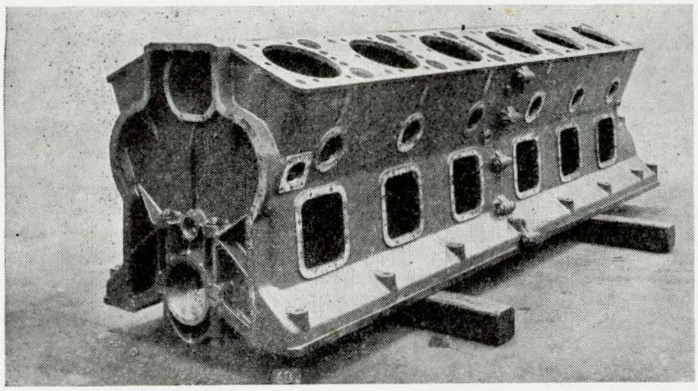


FIG. 7.

**Paper presented at the Annual Meeting of the Society of Naval Architects and Marine Engineers, New York, November 13/14, 1941, vide "Electrical Engineering", June, 1942, p. 1942 et seq.*

What he appears to indicate is somewhat the size of the engine the writer was concerned in building for the Canadian National Railways. This was of the vee type, the box frame being illustrated in the accompanying illustrations. It will be seen how near this

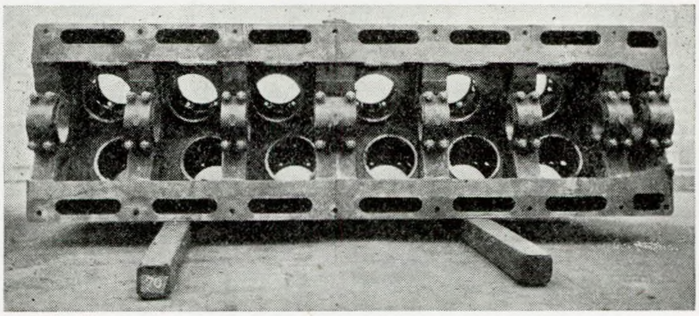


FIG. 8.

type of casing is to one suitable for welding, but at that time one could not depend upon this method of construction as being sufficiently developed to try out on an engine that had to go into service.

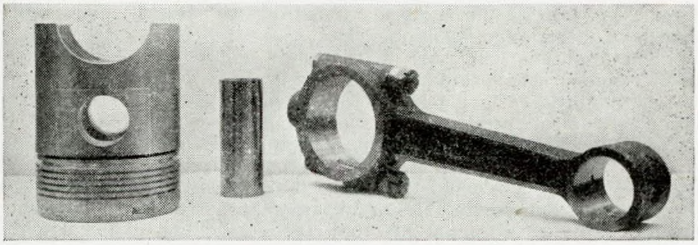


FIG. 9.

The vee engine shown has cylinders of 12in. × 12in. stroke, running at 750 r.p.m. When of the 16-cylinder type it gives 1,600 b.h.p. The pistons of this engine were of forged aluminium alloy, and have proved quite satisfactory in service. The engine used was for electric driving, but it occurs to the writer to suggest that gear driving might be used. This with a multi-cylindered engine, or a pair of them, allows of any reasonable reduction and a pretty big unit in power.

Eng. Lt.-Com'r. A. J. Elderton, R.N., ret'd. (Member) wrote. The author emphasizes that his proposals are essentially to meet war conditions. While endorsing his views in this respect the writer is of the opinion that a vessel such as contemplated has a definite advantage for the post-war period.

At the present time we are building large numbers of slow, inefficient merchantmen which, after the war, will be a drug on the market. No matter what the outcome of the war, sooner or later there is bound to be again keen international competition with, for a time, restricted markets.

In that the prosperity of individual countries is wrapt up with the well-being of all, it is essential that our enemies should enter into trade, and in so doing, add to our competitors, so that as a nation, if we are to regain markets and trade at a profit, we must be efficient. Our present mass-produced inefficient tonnage cannot help in this respect. Most of our competitors will start off from scratch, with no such burden.

As a nation we are agreed that a better post-war social condition is called for, but the cost of this can only be defrayed by our own efforts in developing past—and obtaining new—markets. Present wealth, if socialised, could only last for a limited period, so that ultimately our social well-being must depend on our successful trading in world markets.

Whilst for our present salvation it is essential to keep our present tonnage afloat, it would appear that with the termination of hostilities it would be in the national interest to sink or scrap it, unless in the meantime the inefficient tonnage had been replaced by vessels that could meet post-war competition.

In regard to the author's proposal to arrange for the cargo warship to carry aircraft, the writer would question whether the provision required for this is worth while, having regard to the protection provided by the speed of the vessel. Apart from the difficulty of taking off and landing in moderately bad weather, it occurs to the writer that in submarine infested waters the less the vessel loiters the better. Dispensing with the aircraft would give more freedom in design with regard to deck fittings and upper structure. In a vessel having high speed and low freeboard, the hangar door would appear to present difficulties, in order for it to have sufficient strength and yet be readily movable.

Eliminating the aircraft would also give freedom in the design of the fan inlets, which present difficulties because of the humidity of the intake air when the vessel is travelling at speed, and its possible effect on the controls of the electrical equipment. The position of the engine exhaust at upper-deck level must also affect the arrangement of the fan inlets. The position of the engine exhaust exit, too, is liable to impede the working of the ship when wind is aft or on the beam, particularly when manœuvring the vessel or going alongside. Possibly the author has in mind a hinged funnel for such occasions as may be required.

The author's remarks in regard to a basic national marine oil engine have much to commend them, and it is a pleasure to pay tribute to his past accomplishments in this direction. No doubt aero-engine technique will play its part in post-war oil engine design, and facilitate a national type which should have government assistance, either directly or indirectly. But it is too much to expect that basic national types of engines can be evolved for universal application; a further point is that it is questionable if it is to our advantage to become too insular, as if "Buy British" is pushed to its logical conclusion, ultimately, as a nation, we should do no more than take in our own washing.

The author's proposals to eliminate the engine bed-plate is revolutionary, but appears to be justified in view of the big advantage to be obtained. The machining of the crank bearings for waterborne alignment presents difficulties, but these are overcome if the hull and crankshaft bearing assembly is constructed of a strength that no distortion takes place, particularly when the vessel is wave borne. A deep box cellular hull construction adjacent to the structure superseding the crankcase may assist. Leakage from outside into the oil sump due to defective welding, damage after grounding, and near under-water explosions could be obviated, should it occur, by arranging the crank compartment to receive air pressure.

In regard to heating services for the vessel, and the possible elimination of oil firing, this must largely depend on the surplus heat available and the rate of heating required; for heating oil cargoes the length of time on passage between loading and unloading ports is an important factor.

The author's proposal to employ a forced-circulation closed hot-water system utilizing surplus heat in the exhaust gases and jacket water would give maximum economy, and is frequently carried out in land practice. Draw-off domestic services are easily arranged for by calorifiers of simple construction, which, in addition, could be electrically heated and fitted with thermostatic control, should it be required.

Using a closed hot-water system facilitates the use of a simple lightweight type of exhaust-gas water-tube heater, which could be fitted in both main and auxiliary engine exhaust lines. A possible refinement would be the substitution of a coiled-tube type of heater, which could form part of the exhaust line, and in that it would have no water joints in contact with the hot gases it could, if required, be run in the dry condition. The small quantity of water contained in the heater enables this to be easily carried out.

Mr. F. McAlister (Member) wrote: The author's paper covers an enormous field, and will no doubt receive considerable discussion as the many views expressed on naval architecture, engineering and vital state policy may be warmly disputed.

Although the essence of the paper is the adaptation of the cargo ship to war conditions, it is a pity that the paper had to be read during wartime when so many individuals, who would no doubt have much interesting criticism to make, are prohibited, either by office or by lack of time, from giving as much thought and attention to the paper as it so rightly demands.

As the cargo warship is not designed from a commercial point of view the arrangement of the ship must be therefore dictated by war considerations. It follows, of course, that the high degree of subdivision, w.t. decks, carriage of mixed cargo, heavy lift crane system, provision of landing deck, etc., are each and all definite advantages over and above the existing cargo ships for meeting war conditions. To all these matters the author appears to have given due consideration, and the design seems to be effective compromise for the design of a cargo warship.

Our trusted friend, the water-ballast double-bottom has disappeared and this will call for a considerable redistribution of material in the midship section to preserve adequate strength. Longitudinal bending stresses in the light condition may also require investigation.

So far as the propulsion angle is concerned it would be better if the bow propeller was normally designed to run and add its quota of thrust, as this propeller fixed in position at the bow would develop a fair amount of resistance.

The aft propeller is straightforward and to absorb 12,500 b.h.p. at 100 r.p.m. should be about 21ft. diameter. If the revolutions are higher than this the overall propulsive efficiency would be lowered in about the following manner.

R.p.m.	*Relative Efficiency.*
100	Basis 100
125	96
150	92½
175	89½

At 175 r.p.m. the propeller would be about 16ft. diameter, and should have a larger disc area ratio than the 100 r.p.m. propeller, so that adequate area is given to the blades for manœuvring and heavy-weather conditions.

Whilst a certain amount of sympathy will be given to the author's views on state control, the writer still believes that the future of British shipbuilding and engineering will lie in encouraging the engineer to design what he wants to design, the builder to make what he wants to make, and the owner to choose what he wants to choose, all of course, with what sound advice the state can offer. If the state demands for war contingencies a higher average speed than the commercially prudent speed for the Merchant Navy as a whole, the state must also offer financial assistance in addition to advice.

Further, if in pre-war days there had been state assistance for each ship capable of 15 knots loaded on trial in fine weather—the total annual cost of which would probably not have equalled a few hours of our wartime expenditure—we would not have heard to-day of 5 and 6 knot convoys with all that that implies.

Mr. C. T. Adams (Member) wrote: The author assumes that the fast cargo warship would not be convoyed, whereas Admiralty policy is to convoy all ships, regardless of their speed, whilst carrying valuable cargoes. The Admiralty alone being in possession of all the facts about sinkings, convoyed or otherwise, are in a position to build the most suitable type of ship, and the answer was given in the British merchant shipbuilding programme in North America, where considerations of existing building berth limitations did not arise. There are few, if any, berths available in this country to-day for cargo warships, and it is doubtful whether the first of such ships could be put in service in less than three years, during which time the berth might have launched six or more "Ocean" class ships—the first of which would have been usefully employed for two years or more.

Should a cargo warship, in spite of all the author's precautions, happen to be sunk, we lose at one blow the equivalent of six or more "Ocean" class ships. In view of naval experience with modern torpedoes, the author's ships would not be immune, although their chances of limping home would be greater provided the enemy did not use a second or third torpedo.

Increased subdivision on a tanker basis and watertight and explosion-tight hatches are sound, but the provision of only ten cranes for twelve holds will not facilitate the desired rapid handling of cargo.

The cubic capacity of the cargo warship for bale cargo is apparently about 450,000 cubic feet—*i.e.* some 15,000 cubic feet less than that of a single "Ocean" ship, and war cargoes are by no means all deadweight cargoes.

It is doubtful whether the crew of this ship would appreciate being housed below deck right forward and right aft, and those on watch in the control room would have to face some dirty weather and the exhaust from the forward engine room when in use.

The author would have strengthened his case if he had proposed the well-tried steam turbine and water-tube boiler powering, instead of an experimental type of highly-rated oil engine, as he must be aware of the time required to bring a marine engine design to the production stage. The argument in favour of the lower oil-engine fuel consumption must, in wartime, be subordinated to those of reliability and rapidity of production. One wonders what proportion of vessels sunk after falling out of convoy by breakdown were oil-engined ships.

Messrs. William Doxford & Son will no doubt study with interest the proposal to increase the output of one of their three-cylinder engines to 7,000 i.h.p. which might transform a relatively inexpensive reliable engine into a costly and complicated installation. Even so, 7,000 i.h.p. is a long way short of the desired 12,500 b.h.p.

unless the author hopes to persuade the Admiralty to let him use twin screws.

The failure of British designs of oil engine, apart from the Doxford engine, is easily explained. During the prolonged era of the reciprocating steam engine, British builders sank into an abyss of "marked up" designs, out of which they are having great difficulty in climbing. Many marine drawing offices have, until recently, preferred to make use of a design dating from say 1900, rather than modernise in the light of up-to-date knowledge of science and materials. Consequently, when buying a new ship, the shipowner frequently purchased a new but out of date engine with it. Under the stress of competition design offices have been reduced to the function of determining the size of engine necessary to drive a certain ship at a certain speed, and real machinery designers, suitably paid as such, have been compelled to look elsewhere for employment. The writer well remembers the consternation when it was discovered that for one reciprocating engine contract there was no drawing in existence for the specified cylinder sizes, despite a thorough search of the dusty archives dating back to the beginning of the triple-expansion era. Under such conditions, it is apparent why the introduction of a new principle of marine propulsion found British builders sadly lacking in fruitful enterprise and initiative, compelling them to pay heavy royalties to their foreign competitor builders of successful designs. Again, shop practice suitable for building steam reciprocating engines is useless for building successful oil engines, and it is of interest to note that when Messrs. Doxford commenced building oil engines, they stopped building steam reciprocating engines.

Building under licence discourages enterprise, for when a defect in service arises the trouble is referred to the licensors and they may or may not be particularly interested in the troubles of the client of another firm. The writer knows of a series of oil-engine piston head failures which threatened to become very serious indeed some years ago. Consultations with both builders and designers led to no improvement, and finally the shipowner's superintendent produced a design which is proving successful in service to-day. Such a state of affairs does the British marine oil engine industry no credit.

A plea for the standardization of ships' auxiliary machinery is welcomed, if only on the grounds of spare gear simplification. Would it not be possible to reduce to, say, three standard sizes, the many sizes and types of electric motor found in a ship's engine room, and the same principle might be applied to pumps in many cases.

Surely the proposed national oil engine development station must wait until after the war, as those best fitted to undertake this work are fully engaged on production and maintenance problems.

There are, perhaps, three factors which influence the shipowners choice of machinery builder:—

(1) Superior competitive design and hence lower running costs.
(2) Superior shop methods and hence lower first cost.
(3) After sale service reputation.

Building under licence, British or Continental, rules out No. 1 and possibly influences No. 3.

The proposed elimination of the double bottom in way of the cargo warship's main engine recalls to mind not a few ships which suffered bottom damage here, and yet managed to get home with a dry engine room, thanks to the double bottom.

The method proposed for engine overhauling has the drawback of exposing machinery parts to the weather.

The author's picture of the future oil engine is stimulating, but it is as well to remember that for powers of 8,000 s.h.p. upwards, a modern turbine installation is closely rivalling the oil engine in fuel costs, it is more reliable, requires less maintenance, and can be fitted in a smaller space, if comparisons are made between designs actually in production.

Mr. W. Muckle, B.Sc. (Department of Naval Architecture, King's College) wrote: The writer is in agreement with the author's ideas covering the subdivision of such vessels. In a paper which the writer read recently before the North-East Coast Institution of Engineers and Shipbuilders the increased safety to be obtained by means of a watertight deck has been fully investigated. One criticism which may be made with regard to the subdivision in the author's design is the fitting of the lower watertight deck below water. Although this is protected to some extent by the internal bulges, one cannot neglect the fact that in the event of damage by torpedo attack there is a great possibility of the deck being damaged by being placed in such a vulnerable position. Another point is that in the event of damage of the side above the lower deck only there will be loss of stability, although looking at the author's design it would appear that the vessel will have considerable initial stability. In arranging watertight decks in cargo vessels the major difficulty is undoubtedly the question of hatch openings. There seems to be some difference of opinion as to whether it is possible to maintain a watertight hatch cover of sufficient size to be useful. The writer is of the opinion that it is possible and there is some practical evidence to support this opinion. In certain cases where vessels have been damaged, steel watertight hatch covers have kept them afloat for considerable periods. The author's suggestion to prevent the rise of water in the holds by compressed air is not considered altogether desirable. A free surface effect is bound to be present in that case, resulting in loss of initial stability.

The longitudinal strength of the vessel is certainly going to be a difficult problem. It is noted that the length/depth ratio is 15·5, considerably above Lloyd's limit. The concentration of the cargo amidships will tend to large bending moments in the sagging condition, which will be very considerably increased in the event of damage. The necessary strengthening had to be got into a very shallow section and, further, the second deck will contribute little or nothing to the $I/_y$ of the midship section. Heavy scantlings for the upper deck will therefore be necessary and the whole question of the strength of the vessel would have to be very carefully considered. There is another reason why a heavy upper deck would be necessary. Due to the low freeboard, lack of sheer and forecastle and the fact that there are no erections to prevent seas sweeping the weather deck from end to end, the deck would be subjected to continual battering from the waves.

There is little doubt that the weather deck of a vessel of this type will almost be completely awash in rough weather due to the low freeboard, and on that account the vessel is likely to be a bad sea boat. In this connection it should be pointed out that the stability of the vessel would be practically that of a totally submerged body. Again, the range of transverse stability is not likely to be large due to the low freeboard. It is significant that certain vessels of apparently similar design to the author's (the so-called "Sea Otters") have been built during the present war but have since been discontinued, for what reason the writer is unable to say.

With regard to the method of propulsion of this type of vessel, that proposed by the author seems to be the most suitable. The saving in weight by the use of a high-speed engine more than offsets the loss of propulsive efficiency of the high-speed propeller.

Mr. J. E. Church (Member) wrote: The subject matter of the paper is undoubtedly one of paramount importance to-day and had such a scheme been adopted in the early stages of the war, there is little doubt that many fine seamen and valuable cargo would be with us still and not resting on the ocean beds of our trade routes.

The fundamental idea of a cargo vessel specially designed and built, not simply to suit the needs of war, but to survive them, is very sound, and worthy of the closest attention of all concerned. That such a vessel's chance of survival would be immeasurably enhanced by equipping it with superior speed, manœuvrability, ability to resist all forms of attack and resistance to explosion, giving a fair chance of making port if hit, cannot be doubted, and probably the greatest of these is speed. The author is to be complimented on his method of attacking the problem, having with courage swept away practically all that has gone before. What are the possibilities of going still further and developing a cargo submarine?

In the present proposal it is noted that provision is made for aircraft to return to the ship after being catapulted off, a landing deck of some 400ft. being arranged for this purpose. Would this be sufficiently long for the faster types of fighter machines to land in safety, since the writer understands that to do so on the twisting and heaving deck of aircraft carriers is a feat of considerable skill on the part of the pilot, who, occasionally, after first touching down, finds things not just right, compelling him quickly to fly off again over the fore deck in order to circle for another attempt. If this is so, the flight deck would have to be continuous fore and aft the vessel without obstruction as in the case of all aircraft carriers.

The arrangement of accommodation as shown has evidently been laid out on the assumption that the vessel would be classed as a warship and in consequence existing rules applicable to merchant ships could be swept away. Is this likely to be permitted, however, in view of the fact that such vessels would presumably have to be manned by merchant seamen and their living quarters in consequence arranged in accordance with present rules governing crew spaces in merchant vessels, which will not permit of any living quarters at the fore end of the ship and which stipulate that all spaces appropriated to the use of the crew must be adequately lighted by natural light? In a vessel such as the cargo warship, skylights to deck could not be fitted if this is required for aircraft landings, and the only alternative would be for accommodation to be arranged adjacent to the shipside with side scuttles in the usual way in order to give the cabins access to light and air, and the side alleyways—in themselves an admirable feature—discontinued in way of accommodation, the whole of which would then be arranged either aft or amidships. This would mean that the crew were given space which, as the author points out, is the best part of the ship for cargo purposes. It is also the best space for accommodation and as it is cargo which is being sacrificed, not safety, it is felt that the men who sail the seas in wartime, or at any time for that matter, should be given the benefit of it, their comfort being of first importance and having been neglected for too long already. If this were done, there is no reason why all should not be housed between decks in view of the additional protection afforded by so doing, providing an adequate system of controllable forced ventilation were installed and a system of ejector tanks fitted for disposal of sewage, etc., made necessary by the low level of the accommodation relative to the load water line.

The use of such vessels after the cessation of hostilities may not be so attractive as might at first appear, due to the increased weight of such a vessel brought about by numerous additional bulkheads, explosion blisters and increased thickness of steel employed for defensive purposes, which would result in loss of cargo lifting capacity compared with similar purely commercial designs, whilst the carriage both of oil and general cargo in the same ship, though useful in time of war, would present operational difficulties in normal times to owners who desired only to trade in one or the other. The solution would appear to be for such vessels to be subsidized as cargo warships and maintained in peace time as other defensive vessels must be, as a precaution against future wars, in order that they could run in fair competition with commercial tonnage.

One point which is considered worthy of notice is the fact that the silhouette of the author's design is such that when first picked up in the distance at sea, it will closely resemble that of a submarine. Since in time of war all such vessels are attacked by friend and foe alike immediately sighted, it being the duty of all submarine commanders to expect this and keep out of sight, such vessels might attract trouble to themselves from friendly warships. Therefore, on the face of it, some distinctive alteration in outline such as a further deck erection at the side aft may be deemed advisable.

In conclusion it is felt that the policy of producing large numbers of ordinary cargo vessels in a feverish attempt to keep pace with sinkings is not the best method of maintaining our supplies—surely the correct procedure must be to produce fewer numbers of a type such as the author visualizes, his principal objective being to ensure that the ship when built must have a real chance of making port, voyage after voyage, and not merely to replace another unfortunate vessel, the loss of which has thereby been accepted as inevitable.

Mr. E. A. Beavin (Associate) wrote: In the proposed vessel it seems that much protection has been afforded against side and under-water explosion, and less against aerial attack. Whilst admitting that the former is more deadly in effect, on average, than the latter, the writer feels that a disproportionate amount of protection has been afforded to the sides of the vessel.

No doubt the Admiralty have figures for comparative losses by U-boat and aerial attack, but for a vessel as proposed by the author, not sailing in convoy, and with a fairly high speed, the writer imagines bombing by aeroplane to be a greater hazard than U-boat attack. Speed would undoubtedly help in the avoidance of bombs, but in an attack on four destroyers in the eastern Mediterranean in May, 1942, three vessels—H.M.S. "Lively", "Jackal", and "Kipling" were sunk by aerial bombing. These ships must have put up a heavy A.A. barrage (each had six 4·8-in. guns) and in view of their speed—36 knots—the suggested cargo-warship would not bear favourable comparison. The two guns indicated on the proposed ship would not provide a sufficient deterrent and one fighter aeroplane against a well-armed flying boat is not to be regarded as offering greatly superior protection.

Heavy deck plating or better still light armoured deck over each end of the vessel should be provided, of sufficient thickness to resist any of the smaller type of demolition bombs. This heavy weight would mean considerable risk of breaking the vessel's back on hogging or sagging especially as the vessel is fine at the ends, and additional longitudinal stiffening might be needed.

A point not mentioned by the author is that the vessel would stand a much better chance of evasion of surface raiders, and a smoke-screen apparatus might be a useful accessory.

The writer has enjoyed reading and considering the author's thought-provoking proposals and they have much to commend them, more especially as they might be a considerable factor towards victory.

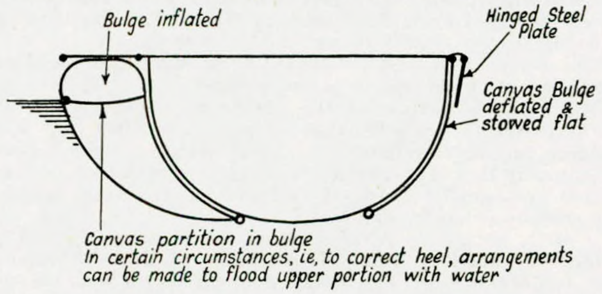
Mr. J. L. Kent (Superintendent, The William Froude Laboratory) wrote: The author considers that the altered tactics in modern sea warfare, caused bv the extended use of the submarine and aeroplane, call for the re-introduction of cargo-warships which were so successfully employed by the English in Elizabethan times. To be completely successful such vessels must be capable of eluding or beating off the attacks of either submarine or warplane without assistance from other surface warships, and then convoys become unnecessary. If such vessels can be designed their wartime advantages are obvious.

One essential of the cargo warship emphasized by the author is speed, which is particularly desired in foiling submarine attack. The speed suggested by the author is 18 knots, which the vessel should at least be capable of attaining in moderate weather at sea. To do this a vessel of 525ft. length and 18,700 tons displacement proposed by the author would probably need at least 14,500 brake horse power, and then only if driven by an efficient screw of large diameter turning at, say, 110 revolutions per minute. But such a screw would inevitably leave a well-marked race which was one of the major things the author particularly wished to avoid in his effort to elude reconnaisance planes. Well buried screws of smaller diameter offer the best chance of undetectable race, so that a twin-screw design would seem to be needed. To obtain the advantage of less vulnerability to complete loss of speed which would result from a torpedo hitting the stern in the usual twin-screw design, the author suggests a single bow propeller and a single stern propeller arrangement. For maximum efficiency with invisible race, a more equal distribution of total power between these two screws than that proposed by the author would be necessary. Smaller diameter propellers would result in somewhat less screw efficiency and probably the brake horse power would rise to 15,000 before a completely satisfactory solution was found.

Another point raised by the author is that the type of bow wave created by the vessel should be one which would not advertise itself to reconnaisance aircraft. To obtain this is not so much a matter of flaring the bow lines above water, but of keeping the bow wave low in height and broad, so that its breaking length is small. For the required speed a fine angle bow line is required and this will result in a high, narrow breaking bow wave unless the stem is heavily raked and the underwater portion of the ship forward very much cut away. To place one of the two screws forward as proposed by the author rather tends to defeat the reduction in the size of the bow wave.

Mr. W. F. Spanner, R.C.N.C. (Graduate) wrote: In attempting to design the vessel to resist torpedo and bomb attack the author has proposed the incorporation of blisters in the design together with a lower watertight deck and an upper watertight and airtight deck. This results in considerable complication and to a certain extent waste of space due to the blisters; it would also increase the amount of time and labour spent in production. The effectiveness of this construction would also appear doubtful since splinters would almost certainly destroy the watertightness and airtightness of the lower and upper decks.

It might be preferable to omit the blisters and allow flooding



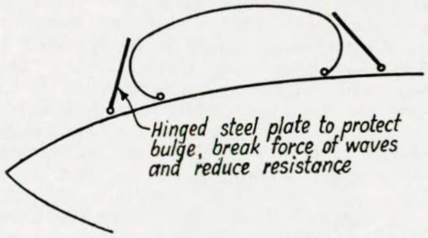


FIG. 10.

to occur over the full width of the ship, fitting more transverse bulkheads, the vessel being given sufficient metacentric height initially to allow of, say, two or three main transverse compartments being flooded right across, and a small positive metacentric height resulting

FIG. 11.—*Bulges normally stowed flat.*

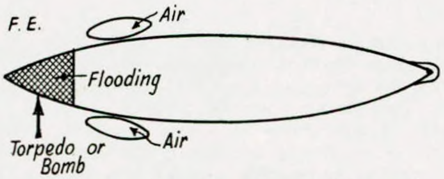


FIG. 12.—*Flooding at fore end.*

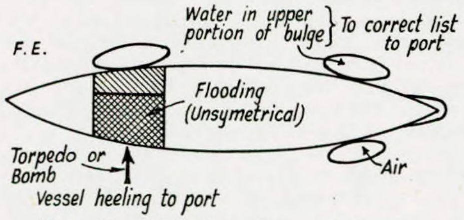


FIG. 13.—*Flooding abreast bulge.*

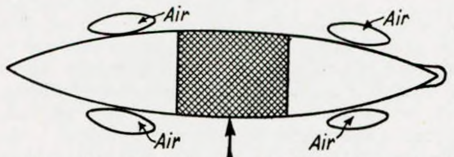


FIG. 14.—*Flooding amidships (large hold).*

in this connection. No doubt this would make a very stiff ship, but this defect could be overcome by arranging large valves in the longitudinal centre-line bulkheads in oil fuel tanks at the ends of the vessel. Normally the valves would be kept open and there would be a large free surface correction for the oil fuel, giving a normal *GM*. In the event of damage occurring, the valves in the centre-line bulkheads would be shut, thus reducing the free surface correction for the oil fuel to a small value.

By allowing the vessel to flood right across, heel would be avoided; with the low freeboard it would be highly desirable to restrict heel to a minimum. By the above means it is suggested *GM* could be preserved.

This is of course only one half of the problem, the second half being how to preserve buoyancy. To do this oil fuel could be pumped overboard. There is, however, a preferable alternative to this which would also partially assist in solving problem one, namely the provision of canvas bulges attached at suitable positions on the sides of the vessel which could be inflated by an L.P. blower to provide additional buoyancy. So far as the writer's knowledge goes, no attempt has ever been made to develop such bulges, but provided technical difficulties could be overcome they would appear to offer very considerable advantages and could be used in conjunction with existing tonnage.

The problem of how to save a torpedoed merchantman is a difficult one, but this idea is put forward in the hope that it might suggest to abler and more mature minds the lines upon which this problem could be solved. Fig. 10 shows a proposed canvas bulge. In a simple case if four canvas bulges were fitted to the sides of a vessel (Fig. 11) various kinds of damage could be controlled as indicated. (See also Figs. 12, 13 and 14).

With regard to the author's proposals for propulsion it is suggested that the following might be worthy of consideration. To fit a large number of high-speed Diesel-electric generators in units (say 24 at 600 h.p.) well distributed about the ship to ensure a greater degree of invulnerability in the event of damage; the generators would supply current to the main motors which it is suggested could be made of a submersible type so that there would be a good probability of the main motor continuing to function even if the engine room was completely flooded. The provision of a generating plant made up of a large number of separate units would ensure, as far as is possible, a supply of power to all auxiliaries in the event of an emergency, and would enable the auxiliary means of propulsion at the fore end to be driven.

Mr. D. W. Gelling (Member) wrote: The extreme breadth at 80ft. would restrict this pattern of cargo vessel to certain ports, which would be ambushed by U-boats; total war requires ships to follow armies to small harbours and enemy action at arrival and departure does not allow small margins in beam, besides which it has to be proved that a vessel of these proportions would zig-zag easily if attacked from the air.

Two lifeboats do not allow risks to be spread and if the vessel was hit in the deep-tanks below, the resulting explosion and fire would destroy the crew's chances.

With 12 per cent. of the propelling power at the bow, the author must be optimistic if he expects "over half the normal speed" with only the forward propeller and, again, abnormal care would be needed manœuvring in narrow waters, among tugs, small craft, barges and escort-vessels, during black-out and with pilots accustomed only to stern screws; any damage forward would mean excessive helm for the rest of the voyage, increased consumption and loss of speed.

Where ship-side valves are fitted, it is suggested that the larger injections and discharges should in future be replaced by smaller ones, spaced two or three frames apart, with the chests connected by corrugated bends, the weight being taken by strong-backs to the deck, ⅛th the ship's breadth from the side. For instance, a 14-in. main discharge would be replaced by eight 5-in. welded chests. They would probably fail by tearing and could be clipped around the necks, while the present casting would fail instantly and fill the engine room; besides, to follow the author's reasoning, these small fittings could be produced up and down the country and the massive casting requires an already overworked foundry to produce it. The ship-side valves should be in compartments, with only the valve spindles and glands protruding through the bolted covers, rendering the valves and seats accessible in dry-dock for overhaul. The sides of the compartments would be corrugated, to give to a "near miss", and if the boats are to be so far from all discharges, as suggested, the latter could be carried high enough to miss all the sudden force transmitted from under-water explosion, thus ruling out one chance of flooding.

In place of the "light hatch relief valves", why not revert to the old system in the days of cold-air machines and use white-metal-lined nuts on the cofferdam hatch covers? On a deck which the author expects to see awash, the small springs of relief valves would soon be salted-up and unreliable. It is not proved that a gyro compass would be any aid on the tortuous courses set in wartime, although it is an aid on the long, straight tracks of peace.

Evidently the two bow rudders would be independent, as the author suggests them closing the aperture, but this envisages complications not to be lightly added to the deck officer's other worries just now. If the crane posts are down to present a small target, how can they act as inlets and outlets?

Will the lifeboat compartment doors not be jammed in the event of enemy action? The idea of replacing worn-out engines, as in car practice, was put forward by Mr. Ricardo some years ago, and would be the logical outcome of the author's proposals. Once fitters at outports became accustomed to the routine of this, the ships could be off at sea again, with their standard but defective engines *en route* to any large garage away from the congested ports.

Altogether the author has given the shipping community food for serious, constructive thought, which will be certainly accorded across the Atlantic!

Mr. W. J. Middleton (Member) wrote: Although many of the author's suggestions may appear revolutionary to the naval architect and marine engineer, there is not one suggestion in the paper that can be regarded as impracticable from the technical point of view.

Published a few years ago the value of the paper would have been inestimable, but now it would mean starting from scratch with unproved designs in the middle of a conflict when speed of production is of primary importance.

The author himself agrees that most British shipyards are fundamentally unsuited for the immediate adaptation of economic welding construction and welding is one of the least revolutionary of his suggestions, so that were the design agreed upon forthwith the chances are that hostilities will have ceased before production on a large scale could commence.

The paper will no doubt provoke considerable discussion over certain technical considerations. The writer would suggest that Loeffler or La Mont boilers or high-pressure natural-circulation boilers with geared turbines would give better and more reliable service than the Diesel engines proposed by the author. The writer would also be strongly against a vessel with cast-steel crankshaft pins and journals, having recently had the unhappy experience of replacing two such shafts that fractured after only a very short period in service. Reliability must be the first consideration in war time, and experience with built-up cast-steel shafts does not justify the use of cast steel for marine-engine shafts of the horse power required for the propulsion of a vessel of 12,000 tons at 18 knots. However, except for the use of cast-steel crankshaft components, the writer would be prepared to accept the author's design in its entirety, because it is as a whole a remarkable advance in the science of cargo-carrying construction for war requirements. A vessel designed in accordance with the author's recommendations is literally a warship, constructed to carry war cargoes and if necessary take considerable punishment without sinking. It provides a reasonable chance of a vessel remaining afloat and under control after receiving a torpedo or heavy bomb hit, and it has as an important feature the provision of protection for the ship's crew from enemy action—a consideration that up till now has been almost non-existent.

The writer would say that all naval architects are agreed that underwater damage should cause deeper immersion and not affect the trim, and a practical attempt has been made to secure these conditions in the design proposed.

The vessel proposed by the author has one serious draw-back; this is not technical, but economical. Apart from the possibility of whether or not production could be secured in time to influence the present conflict, there is the view of the shipowner to be considered. The proposed new design must represent a considerable increase in initial cost and whilst the writer agrees with the author that so far as possible repairs and upkeep should be done ashore and the automobile and aero practice followed of replacing defective parts rather than repair or overhaul as at present, this will add to the maintenance costs as compared with existing designs. The writer doubts if such a ship could compete successfully in peace time with a ship designed for peace-time conditions and that, the writer is afraid, is how the shipowner would receive the author's proposal, for it is only reasonable that even when designing a ship for cargo-carrying in war time, the shipowner has an eye to conditions that he anticipates will be in operation after the war. In war time, however, one does what is expedient to bring about the desired result and commercial returns are not the primary consideration. Nobody expects the battleship, cruiser, mine-sweeper or any other vessel attached to the Royal Navy to yield returns other than what can be measured in terms of national security. Then, since successful and safe cargo-carrying is vital to our security, post-war commercial considerations should not be permitted. The job of cargo-carrying in war time is mainly that of munitions and the absolute necessities of the armed forces and the civil population, a large majority of whom are engaged in activities closely associated with the war effort, and so the writer suggests that the Navy should enlarge its outlook and embark on its own construction programme of cargo warships.

The author's paper might well be regarded as the basis of the specification for the Admiralty's cargo fleet, where the primary considerations would be suitable protection against enemy action so that cargoes could be delivered as safely and quickly as possible and affording that measure of protection from enemy action that the ship's company might reasonably expect to receive.

The use of existing pre-war tonnage cannot, of course, be dispensed with, and the Royal Navy has adopted the convoy system as offering the best protection to peace-time designed cargo vessels engaged on war-time pursuits, and despite the obvious disadvantages, the results have been better than might reasonably have been expected. Therefore, so far as this present conflict is concerned, it looks as though construction will continue on normal lines with only those modifications to war requirements that can be expeditiously carried out, bearing in mind that a convoy organization has already been built up and the Admiralty's claim to have figures indicating that the losses with ships of 15 knots and over out of convoy are just as high as for 8-knot ships in convoy.

Mr. H. J. Fountain wrote: As might be expected, the writer is particularly interested in the suggestions for utilizing the heat in the exhaust gases by means of a waste-heat boiler.

The writer endorses the author's proposal to install a light-weight water-tube waste-heat recovery unit close to the main Diesel engine, instead of the normal heavy exhaust boiler, but would go further by suggesting that similar units should be fitted to each auxiliary Diesel engine, and the circulating pump to which the author refers should circulate the water at high pressure, through these three water-tube heaters, and a steam and water cylinder fitted at any convenient place in the engine room, at any level.

This steam and water cylinder would have its own normal water level, and make-up would only be required to replace water lost at the safety valve. Steam would not be used as such, and the steam pressure would not rise because the heat would be dissipated at the rate generated, by circulating the water for heating the cargo and accommodation space, as suggested. The steam merely provides a cushion for the hot-water system, which would circulate at the temperature of steam at 50lb. pressure.

In a ship of this design, with a 12,500-h.p. main engine and two 500-h.p. auxiliary engines with a good load factor, the problem would rather be to use profitably the heat which can so easily be recovered. Experience has shown that cargo and accommodation heating do not need to absorb the full quantity of heat available, consistently throughout the 24 hours, particularly in warmer weather. The writer suggests therefore that the surplus heat should be used to operate distilling plant, by circulating the high-pressure hot water at about 300° F., through evaporators.

The high-pressure hot-water circulating system referred to above has several advantages, such as:—

(1) Positive circulation.
(2) No steam traps and drains required.
(3) Clean water surfaces in the waste-heat recovery units.
(4) No air troubles, as the system is closed to atmosphere.
(5) Small radiators or unit heaters may be used.

If the author considers that at times he could use even more heat than is obtained from the exhaust gases, this could very simply be provided by installing electric immersion heaters into the water space of the steam and water drum, and controlling these automatically by a pressure switch fitted into the steam space. The large sea generators would be thus easily capable of providing more heat when required. This suggestion might be very useful for port use, when the main engine is not running—and incidentally would improve the load factor on the auxiliaries, which in turn, would produce more waste heat in the exhaust gases to be turned to good account through the medium of the waste-heat boiler.

The writer could suggest several other methods of utilizing the available heat which is so often wasted at present, but trusts enough has been said to set superintendent engineers thinking on how they might further improve the thermal efficiency of Diesel-engined ships.

Mr. F. A. Hunter (Member) wrote: The author's design of ship would undoubtedly be a great improvement on peace-time types, to suit conditions of the present war, and it would certainly seem to be a step in the right direction to avoid many delays in building ships and their machinery under the conditions which now prevail.

On the face of it it seems ridiculous to continue building large reciprocating steam engines of around 2,200 h.p. for driving 10-knot ships, and is an uneconomic use of material. However, it should be borne in mind that most of this material is not of a special nature and can easily be produced from the raw products available in this country. Furthermore, with such engines it is comparatively easy to repair them and make spare parts in the remote ports of the world, whereas with specialized oil engines, there is considerable difficulty in repairing them and replacing parts in many foreign ports.

With regard to the main propulsion engines, the author appears to have made out a good case for special production of single-screw machinery of around 12,500 h.p. direct drive, and special designs and production methods would be essential to turn this out in considerable quantities.

With reference to the auxiliary engines, surely the same conditions do not apply, as there are a number of experienced oil-engine makers in this country, who can offer proved designs of auxiliary oil engines of around 600 b.h.p. at 450/500 r.p.m. Presumably four such units will be sufficient to supply current for the forward propulsion motor and leave an adequate margin for supplying other auxiliary and ship services.

By utilizing standard designs of auxiliary oil engines for this purpose a considerable saving in man-hours would be achieved, as drawings, patterns, jigs, etc., are already in existence, and a great deal of additional work is avoided. Probably some small changes would be required.

From the outline drawings of the vessel shown it would appear that three of these 600-h.p. sets could be installed in the forward engine room, and one set in the after engine room. In the event of torpedo or mine damage to the latter, the three sets forward would be almost sufficient to supply the 1,500-b.h.p. emergency propelling motor, and conversely, if the forward engine room were damaged there would be a large set aft to supply current for the ship's services.

In addition to these four auxiliary units, presumably it would be necessary to have two small hand-starting high-speed oil-engine-driven air compressors of about 50 h.p. for use in the event of all compressed air being lost, one set forward and one aft.

The accommodation for the engineers has all been allocated to one part of the ship, but it is suggested that their cabins should be equally distributed between the forward and after accommodation, so that in the event of damage by enemy action there would be a greater chance of survivors.

The design of ship suggested would not only have many advantages in war time, but it also lends itself to easy conversion for peace-time trading, by removal of every other bulkhead, enlarging the hatches, fitting ordinary-type cargo derricks if required, constructing a deck house aft, and enlarging the forward deck house.

By making such comparatively small alterations, this country would acquire, soon after the end of the war, a fleet of 18-knot cargo vessels to compete with foreign ships and so reap the benefit of the good freights which we assume will be offering to and from all parts of the world.

Eng. Com'r. H. F. Harold (Member) wrote: It is to be hoped the author's proposals will not be looked at askance by the orthodox naval architect, and that every effort will be made to assist in providing vessels of a speed greater than 9 knots which plays into the hands of enemy submarines.

Four of the essentials are there:—

(1)) Speed.

(2) Low freeboard, small target.

(3) Loading and discharging in the minimum of time.

(4) Absence of heavy list when ship is damaged and holds flooded, a heavy list having been responsible for the loss of so many lives when it has been necessary to abandon ship.

We have to spend on what is considered best to win the war, and in regard to the question raised as to the use of such vessels when hostilities cease, it has been shown that a Diesel-engined ship of 12,500 h.p. will use no more fuel than a lower-powered steam turbine ship of lower speed. The comparison should be made with a lower-powered Diesel-engined ship of about 12 knots, which would carry more cargo and be a serious competitor of the 18-knot ship. There seems only one way out, and that is that we as a nation look upon the expense of these ships as the cost of victory and that they be sold to shipowners at a low price in order that their low capital cost may help to outbalance the higher operational costs and enable them to compete in the world's trade.

The writer is glad to see that the author refers to the reliability and minimum of technical skill necessary to operate the old reciprocating engine and marine return-tube boiler and to its lower fuel efficiency. The writer inclines to the view that reliability is one of the main essentials and is worth paying for. The author may be referred to as a "crank" by some—it is a remark often used when one introduces something outstandingly novel As a boy on holiday at Ramsgate about 50 years ago the writer bought a book by Jules Verne, the title of which, as far as he can remember, was "Underwater and Overwater Ships". On the paper cover were pictures of a submarine and an aeroplane, and it has always been of interest to the writer to observe, as time went on, how the appearance of aircraft more nearly approached the picture on the cover of this book, until at the present time the big passenger planes seem to be identical with Jules Verne's prophesy.

Bearing this in mind, the writer feels that the author has made a great leap in an endeavour to solve the war-time sea transport problem, and sincerely hopes that the response will be favourable and that the vast amount of work that Mr. Burn has done will not be in vain.

Mr. John H. Narbeth, C.B., C.B.E., M.V.O., R.C.N.C., M.I.N.A., late Assistant Director of Naval Construction, wrote:—The Government reminds us that "Shipping is the key to Victory", "The Lifeline of the Empire", etc. The writer wishes to acknowledge the brave and splendid services of members of the Institute of Marine Engineers who are taking such a splendid part in the production and operation of our shipping, and to pay a tribute to the memory of that long list of members whose heroic and devoted services have ended on the sea in the faithful performance of duty.

It is very fitting that a distinguished member of the Institute should devote so much time, thought and skill to means for increasing the efficiency of shipping, and to the preparation of practical, detailed proposals for the production of "Cargo Ships and Propelling Machinery adapted to War Conditions".

It will certainly be a fine achievement if cargo ships can by any means be produced which can perform lone ocean voyages with risks which are no greater than those of ships in convoy. The author makes proposals which may well form a basis for the evolution of such ships. Any remarks made hereafter will it is hoped be accepted as practical and helpful, even if variations are suggested in some portions of the scheme.

Ships are liable in war to greater risks due to weather, grounding and collision than they are in peace time, and it is very gratifying that the war losses from these three causes have not actually become noticeably aggravated. The war losses calling for special consideration are those due to the explosion of torpedoes, mines, bombs and shells. The author calls attention to the lack of information as to the results of such explosions on ships' structures. Members of the Institute who are now serving afloat and keeping diaries and photographic records will be able to provide much useful information, and presently they will perhaps be able to supply a symposium of information of great national value..

Meanwhile designers have to depend very much on "the process of thought" and "common knowledge", even though they are bewildered by paradoxes in the effects of explosions. When a charge is detonated (exploded) immense pressures and high velocities of materials are almost instantly produced. These may have a general shock effect on the whole structure at the same time as a terrible local pulverizing, destructive effect in which the energy of explosion is expended. The problem is how to dispose of all this energy with a minimum of damage to the ship. Let us make a little inquiry.

Suppose that when a charge explodes it forms a globe of gas at high temperature one foot in diameter at, say, a pressure of 1,000 atmospheres. When that suddenly expands to a diameter of 10ft. the volume has increased to 1,000 cubic feet, and during the process great damage may be caused. In expanding a great deal of work has been done against atmospheric pressure; this results in rapid cooling, and sudden contraction of volume, giving negative pressure. This changes the character of the explosion to that of a violent wave action. Hence doors and windows are pulled out of their seats by distant bomb explosions.

While the gas is expanding the path of least resistance is followed, and the explosion often becomes a directive force. If there is no path of diminished resistance and the explosion is restricted, as in a shell or in a bore hole in a stone quarry, the violence of the explosion is gravely intensified and local destruction exaggerated. In H.M.S. "Veronica", a torpedo struck the stern. .The explosions wrenched off 50 feet of the stern, but the main engine room bulkhead remained intact, and deck fittings just forward of it were very little disturbed. In H.M.S. "Begonia", the torpedo explosion expended itself in crushing coal in the starboard bunker. The hole made in the side was so big that the coal fell out and the ship took a list of 30° to port, but the fore and aft coal bunker bulkhead remained effective. In H.M.S. "Hunter" great areas of plating were destroyed by a mine explosion and masses of flaming oil were hurled all over the ship. When shells exploded on the armed merchant cruiser "Rawalpindi" it was reported that every shell that hit the ship caused a fire. Men were actually rewarded for extinguishing fires of wooden ammunition boxes which had readily burst into flame. When bombs were dropped from stern to bow on the armed merchant cruiser "Jervis Bay", it was reported that "every bomb was a bull's eye", and almost instantaneously the ship was a mass of flames. Such things as these conflagrations of wood must be made impossible in future by the general use of timber fireproofed by the process used by the Admiralty with great success for the last 20 years, and which proved of immense value in restricting fire and salving of H.M.S. "Hunter".

Referring now to the practical proposals in the paper, it would be well to carry the side bulkhead in a curve to the weather deck and provide venting plates as indicated in Fig. 15.

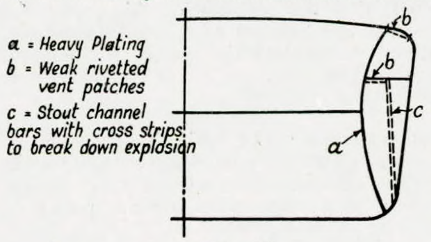


Fig. 15.

It will be necessary to work out carefully the stability of the ship, and results of loading and of flooding due to varying degrees of damage. Such calculations will probably indicate the need for *more* freeboard. When H.M.S. "Dreadnought" was steaming at 19 knots, in waves of about the same length as the ship, the crest of the seas rose to 2 or 3ft. above the head of the stem, which was 28ft. above still water, and as the waves passed aft more than 100ft. of the upper deck aft, about 18ft. above water, was submerged. Thus the proposed engine vents will need consideration. A greater freeboard will also be necessary to permit aircraft to alight at sea and to take off even with the aid of a catapult. The catapult should also be mounted on a turntable. The airmen will also require the cranes to be stored below the weather deck level. The whole of the conning arrangements, etc., should be transferred to the *starboard* side of the ship, and moved to a greater distance from the bow.

The round over of the sheer strake, the complete separation of the navigating party (forward) and the engine room staff (aft) are concurred in. All were very satisfactorily done in H.M.S. "Attendant". Low visibility was secured in the P-Boats of the last war, but even then the freeboard was substantial compared with the draught.

The proposal to fit two watertight steel decks is concurred in but the lower deck should be 5ft. above water instead of 5ft. below it. When H.M.S. "Camperdown" rammed H.M.S. "Victoria" the bow compartment of the former gradually filled, the ship trimmed by the head, and water crept along the main deck causing very serious, almost fatal, loss of metacentric height. It is considered to be very doubtful whether the upper deck and the ship's sides above water could be expected to be airtight. Some of the gain due to decreased visibility must be sacrificed for more freeboard.

The author's remarks as to the failure of torpedo nets, etc., to give protection without loss of mobility are concurred in. They proved a dangerous encumbrance.

The proposed bow propeller and rudders might be of great value in some circumstances, but the fitting of such rudders together with an efficient propeller appears to involve some practical difficulties.

The general proposal to give increased safety by increased transverse sub-division is fully concurred in. Tankers have another advantage beyond this if they go to sea with their main compartments already flooded with oil.

The proposal to use internal-combustion engines is justfied by their low fuel consumption. It has been reported that whereas Germany obtained 1,000,000 tons of light fuel oil from coal before the war, 6,000,000 tons were produced in 1940. Here is a great lesson for British coal owners, who seem hitherto to have failed to realize the importance of a national effort in that direction. The use of Diesel engines with electric drive gives much greater opportunity for good sub-division. The almost romantic suggestion to use aero-type engines is well within the range of practical politics. Eight or ten such groups of engines and dynamos could be widely spaced in the ship, and would give increased facilities for maintaining pumping, lighting, etc., in emergencies. Three propellers might well be fitted aft with well separated motor engine rooms.

The author's remarks on opposed-piston engines are fully concurred in, but more evidence seems needed as to the advisability of adopting doubt-acting engines. In those engines heat problems are intensified, and oil-fuel valves and scavenging arrangements must be duplicated, making such engines far more complicated than the opposed-piston engine. The duplication of connecting rods and cranks in opposed-piston engines is by comparison a very simple alternative.

The author refers to the difficulties in Diesel engine production in this country. This was very early recognized by the Admiralty and orders were placed for three 1,000-ton tankers, Carol type, two 2,000-ton tankers. Trefoil type, and one 8,000-ton tanker (H.M.S. "Olympia") for the express purpose of providing British engineers with the opportunity of obtaining experience in the manufacture of Diesel engines. Orders were also placed for small tankers with Bolinder engines.

The writer sincerely trusts, that the outcome of this paper and the discussion thereon will be the appointment of a small committee, including official representatives, to consider the matter further and make definite proposals for building, say, six experimental vessels at an early date.

Mr. A. M. Riddell (Member) wrote: The author's proposals, by breaking away from convention, offer the possibility of minimizing the serious losses of merchant vessels. The scheme deserves the most earnest consideration of those responsible for the policy of merchant-ship design.

All the very bitter experience of the last war and of the present war up to date, has utterly failed to evolve any radical changes in anti-submarine measures of merchant-ship design. This, despite the enormous increase in deadliness, cruising range, speed and number of enemy submarines now operating, including those of Italy and Japan.

Little or nothing has been done to minimize the effect of underwater explosions in merchant ships. So far as evasive action is concerned any increase in speed since the last war, has been dictated by commercial policy and is not sufficient to render escorts unnecessary. No radical changes have been made in manœuvring ability. Merchant ships are now being built almost similar to those in which the writer served during the last war.

The author states that building in this country cannot keep pace with losses. A long-term policy before, or at least at, the outbreak of war, with revolutionary changes in design, might by now have resulted in such immunity as to have corrected this deficit with the additional benefit that if ships of such higher speed not calling for escort had been built, a worthwhile proportion of our building capacity could have been diverted to the building of offensive capital ships.

The author has overstressed the importance of man/hours. Assuming, say 15 per cent. increase in man/hours to result in such immunity as to save a vessel which would otherwise have been lost, then the saving of the vessel both actually and potentially as well as the saving of the crew and the man/hours and material represented in the cargo, would return an altogether disproportionate dividend on the additional, say. 15 per cent. man/hours required. Furthermore, the safe arrival of the cargo or cargoes might make the difference between losing or winning a campaign.

In the scheme as put forward, the propeller loading and tip speed of the after propeller would, the writer thinks, be unsatisfactory and the writer questions the ability of the forward propeller to obtain a speed of 10 knots; 8·5 knots would be nearer the mark.

In view of the revolutionary suggestions embodied in the paper, the writer is surprised that the author has not "gone the whole hog" and made a double-ended ship, that is, with both ends similar, preferably with electric propulsion.

A summary is appended showing the assessed reduction in horsepower with a double-ended ship as compared to the scheme put forward, although this is a minor point in relation to the other advantages available. The "eggs would be equally divided between the baskets" as remote from each other as possible. If the electric complications are not too great, cross connections would permit of one propeller being worked by either of the engines, a speed of nearly 15 knots being obtained. Furthermore, one propeller, in case of emergency, could absorb the power of both engines. This would call for motors capable of about 60 per cent. more torque, the revolutions would be increased by about 25 per cent. with a temporary loss in efficiency.

The "fifty-fifty" double-ended arrangement would give manœuvring ability for evasive action vastly superior to that obtainable in the proposed scheme, since the lateral force of the equal size rudders would be equal and opposite to each other; therefore, for a given angle of heel much more rapid steering circles would be possible. A further advantage would be that if the vessel had to use a harbour where tugs were not available, greater manœuvring ability would be possible under all conditions, including the ability to obtain evasive action if the harbour were under air attack.

Visible wake is, in part, due to the kinetic energy of the race. The summary shows the reduction possible by fitting larger propellers. This aspect could be studied in tank trials.

The race from the forward propeller would increase skin friction and wave-making resistance and would affect the wake factor of the after propeller. In the summary it has been assumed that the author's stated 6 per cent. loss of efficiency for forward propellers covers these points.

If Diesel-electric were to be considered, high-speed engines of any suitable existing type of from, say, 500 to 2,000 s.h.p. direct coupled to a.c. generators, would launch the scheme pending the evolution of a special type of engine or modification of such existing type, if necessary. Multiplicity of engines would permit of just

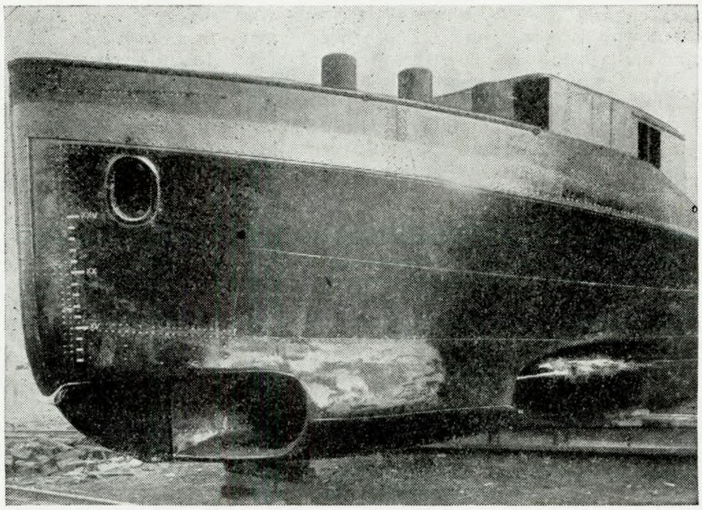


Fig. 16.

sufficient of them being used to ensure the highest thermal efficiency when full speed was not required. A service of replacement by reconditioned engines could be evolved.

A point which the author might consider is that if the draught were increased to, say, 30ft. the cargo capacity would be increased by about 30 per cent. for an increase in power of about only 10 per cent.

If the scheme or a modification of it is considered, the writer presumes the tank trials would be carried out, in which case, it is suggested that the Kort nozzle be tested.

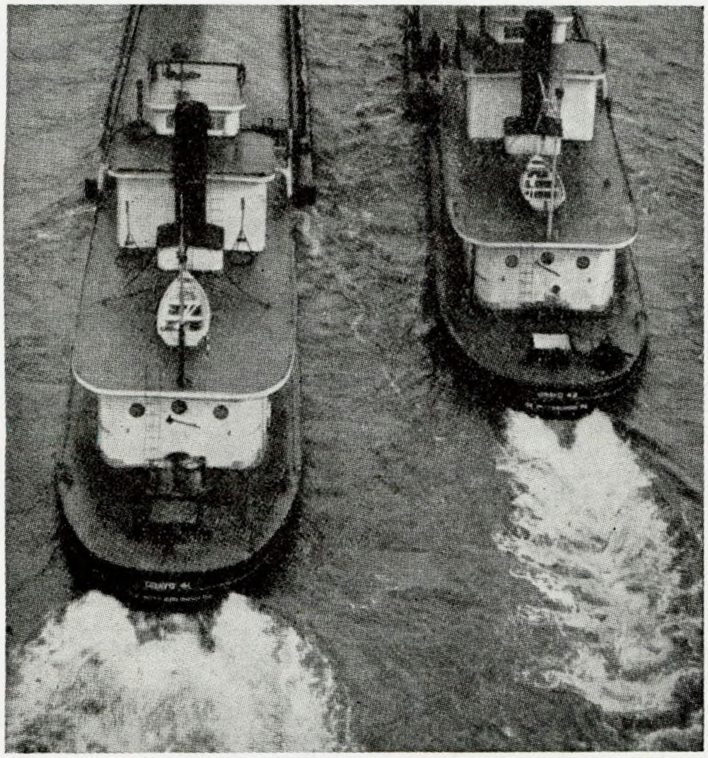


FIG. 17.—*Controlled and more effective wake from the Kort nozzle on the right compared to the wasted energy in the turbulent wake of the ordinary propeller on the left.*

There is a current misapprehension that nozzles are useful only for tugs. Prior to the war the Hamburg Tank Authorities carried out trials with models of free-running vessels where the overall efficiency with the open propeller was 73·5 per cent., which was increased to 85 per cent. by the fitting of a nozzle. Particular attention is drawn to the high efficiency in the case of the open propeller. Tank trials and results in practice prove a greater gain with nozzle under bad-weather conditions than under fine weather.

The most serious objection to the forward propeller is its vulnerability, especially to damage from the anchor and cable and from paravane gear. Nozzles would overcome this objection and give ample protection to the after propeller, sternframe and rudder, which from the drawing appear to be vulnerable. Fig. 16 shows nozzles fitted to forward propellers.

The inherent directional stability of nozzles would permit of less deadwood than as shown and the elimination of forefoot; the latter would help to give a "green bow".

The nozzles could be deflected downwards to give better immersion to the propeller races, and since the kinetic energy with nozzle is less than with open propeller these two factors would both reduce visible wake. Fig. 17 illustrates this.

It is possible that if nozzles are filled with sound-deadening material, this would minimize the risk from acoustic mines and detection by under-water listening-in devices.

It can be proved that nozzles tend to reduce not only pitching, but what is more important, vertical lift. This would make the launching and recovery of the envisaged aircraft very much safer in bad weather .

Mr. E. W. Blocksidge wrote : It is obvious to the technician that there is very little in the design of modern cargo ships to suggest that considered forethought has been exercised to meet the conditions at sea created by the present war. We have been concerned, mainly, with the general question of the safety of life should a vessel become a casualty, in preference to bold initiative or daring innovation, with a view to devising means which can be incorporated in the hulls of vessels to limit the damage from torpedo or aerial attack.

Some of the suggestions in respect to hull construction made by the author are not entirely new, but the paper does show how dilatory we have been to utilize the accumulation of suggestions and evidence from many available sources.

The time has almost gone for the Government to initiate a research department for the purpose of reporting quickly on the whole subject; a department that will be free from the trammels of tradition, owner's pet theories, and Merchant Shipping Acts.

The characteristics of the design suggested by the author make

Speed, knots.	Propeller dia. and location.	S.h.p.	S.h.p./sq. ft. disc. area.	Theoretical jet efficiency. η	Approx. actual efficiency.	% relative theoretical kinetic energy.	Tip speed ft./sec.	R.p.m.	Approx. P/D ratio.	Theoretical acqd. velocity ft./sec.	% Theor. slip.	Approx. E.h.p. and remarks.
18	16ft. aft.	12,500	62·5	0·826	0·66	100	147	175	0·89	12·8	29·7	8,250
18	6ft. 6in. f'wd.	1,500	45·2	0·857	*0·645		85	250	1·54	10	24·8	970
		14,000										9,220 (about correct for 18 knots).
18	16ft. f'wd.	6,500	32·5	0·885	0·73	62·5	118	140	0·95	7·9	20·6	4,750
18	16ft. aft.	6,500	32·5	0·885	*0·685		118	140	1·05	7·9	20·6	4,450
		13,000										9,200 = 7% saving in power.
18	18ft. f'wd.	6,300	24·7	0·907	0·775	49	100	106	1·09	6·2	17	4,760
18	18ft. aft.	6,300	24·7	0·907	*0·706		100	106	1·2	6·2	17	4,455
		12,600										9,215 = 10% saving in power. R.p.m. might suit direct Diesel.
†8·5	6ft. 6in. f'wd.	1,500	45·2	0·58	*0·43		76	220	1·54	20·5	59	645 E.h.p. (about correct for 8·5 knots) Note: torque increased 14%.

* Assumes forward propeller 6% less efficient than similar propeller if fitted aft.

Theoretical jet efficiency η by Froude's Actuator theory where acquired velocity is difference between speed of advance and ultimate speed of race through contracted jet abaft propeller disc. Final area of race equals area propeller disc/2-η

† Forward propeller alone, neglects resistance of stationary(?) after propeller.

it essential to consider specially the facilities which must be provided for the last line of defence should the vessel become a casualty. The objective in the mind of the author appears to be as follows :—

(1) To provide adequate protection to the lifeboats from the weather and sea, and in particular to afford a measure of safety from the effects of machine gun attack, bomb explosions, burning oil, etc.

(2) With this measure of protection, to install a system of launching apparatus which can operate and launch successfully large steel motor-driven lifeboats which are stowed reasonably near the load-water line, with proper facilities for the embarkation of the crew.

The necessity for steel lifeboats on cargo and passenger ships, as a war measure, and the installation of such boats in oil tankers, have been recognized by the Ministry of War Transport and measures taken for their supply.

It is not a good policy to provide "all your eggs in one basket" by limiting the accommodation to one lifeboat on each side of the ship. If the only superstructure on the proposed ship is damaged the available resources are nullified. Compensation can be made, however, by the provision of suitable buoyant apparatus along the ship's upper deck, without interfering with the available space for operating the derricks or the movement of aircraft.

Large lifeboats are desirable when efficient launching apparatus can be fitted and the crew are available, but the writer suggests to the author that, in the case of a cargo ship, it would be preferable to duplicate the boatage by erecting an installation in way of the after accommodation, in addition to that already provided in way of the control towers forward.

A scheme was adopted some twenty-five years ago in a German passenger liner, if memory serves correctly, whereby the lifeboats were stowed on the lower deck under the protection of an upper deck and, consequently, were nearer the load-water line than in normal circumstances. The lifeboats were launched overboard by means of swing davits, hand operated by mechanical gearing supplied by the Welin Davit Company. This arrangement did not, apparently, become popular and was not repeated in later passenger ships.

With an efficient arrangement of gravity davits, or rails operated by gravity and controlled by automatic blocks, the inherent difficulties would disappear.

The proposals suggested by the author in respect of the life-saving equipment are worthy of helpful consideration, for the writer feels that a satisfactory arrangement can be developed which will prove of effective value.

Mr. J. MacGregor, M.B.E., wrote : The author's general idea is excellent but with regard to the proposed internal blisters, these would be of little use at the depth at which a torpedo strikes, as both shells being so close would be perforated at once, and the effect of the extra beam in ordinary passage conditions would be to give excessive *GM* with all its evils. Would it not be better to retain the inner shell only and reduce the weather-deck breadth somewhat, as by making the change suggested later for derrick posts as good a plane deck breadth can be retained, and then one can still rely on two W.T. decks and close-spaced transverse bulkheads to keep ship afloat in case of damage?

From the writer's experience, which mainly embraces war damage with air- and water-tight steel hatch covers supplied by his firm for a far more vulnerable type of craft than the one proposed, *viz.* screw colliers, there is no need to fit relief hatches. Oil tankers are misleading as a guide to what actually takes place in the ordinary cargo carrier. The tank lid of very small area and closely bolted down gives sufficient resistance to an internal explosion to do considerable damage before blowing off, but with the much larger area of the ordinary cargo hatch, combined with the wide-spaced fasteners, sufficient to hold the cover against air pressure of a few feet only, the covers are blown open quite easily and no more damage occurs than without the steel covers, and this is quite localized. The hatches might be better longer and not so broad, say 35ft. long×20ft. broad, which would allow of double hinging in two halves up to transverse bulkheads in tween decks and allow the covers to rise and drop back in case of explosion. Those on the weather deck would be of same size in four pieces in length rolling fore and aft to one end only. These could be kept both air and watertight and absolutely flush on this deck.

With the short compartments proposed, the double bulkheads do not seem necessary, as the cargo will hold them in loaded condition and little danger exists in light condition.

Is the outfit of 10 cranes of 25 tons each with their projecting posts necessary, or would not shore discharge take care of heavy weights and the ordinary 5-ton lift suffice for the ship? and if these are on one side only instead of both, it would allow for shore discharge on one side and barge discharge on the other, which is all that is needful in war-time.

It would be quite feasible to fit telescoping derrick posts in vertical trunks with derricks triced up to vertical when stowed and ordinary electric winches where the crane motor gear is shown. This would give a flush deck with plenty of breadth for the planes, etc., without obstruction. The writer considers no good purpose would be served in specially trying to resist the effects of explosion in second deck, as the covers would be unnecessarily heavy. The lighter covers being intact elsewhere will preserve the ship through W.T. second deck and transverse division.

Would the tween deck height shown not be excessive? If this were reduced to 10ft. at most, it would greatly reduce the loading on beams, etc., whilst at the same time affording a sufficient blanket against upward pressure in loaded condition.

The air and watertight ventilator question has already got a satisfactory solution which has worked well in practice, that is a steel cover fitted up in same way as hatches, replacing the usual wooden plug.

Mr. H. Mackegg (Member) wrote : The writer desires to submit for consideration a few points relating to the application of centrifugal oil purifiers in both Diesel- and turbine-propelled vessels.

It is an accepted fact that the centrifugal oil purifier is an essential auxiliary, and considerable economies can be effected if more careful consideration be given to the capacity of the equipments fitted. It does not seem to be generally appreciated that the initial cost, power consumption and weight of the largest capacity centrifuge which is manufactured under present conditions is very little greater than the medium capacity equipments which are usually called for. For instance, the comparison between a lubricating or fuel oil purifying equipment having a capacity of 2 tons per hour and that of a similar equipment having a capacity of 5 tons per hour shows that the power consumption increase is only 1½ h.p., the weight increase 20 per cent., and the price increase 22 per cent., but the capacity increase is 250 per cent. and of course the separating efficiency at full capacity and below is relatively higher.

The space taken up by the larger equipment is only slightly greater, and the ancillary equipment, such as the pumps which are incorporated in the equipment, are of greater value because, due to their higher capacity, they can be used as fuel or lubricating oil transfer pumps, thus eliminating separate motor-driven pump sets. At the same time, these larger equipments are adequate also to deal with the Diesel or turbine auxiliaries without any additional plant.

From the manufacturing point of view, the production of the 5-tons-per-hour equipment does not present any difficulty, and the man-hours involved in production are not much greater than those needed in the production of the medium and smaller equipment, and the installation time is much the same in each instance.

The man-hours involved in the actual operation of the equipments is less than that with the medium and smaller capacity equipments, because considerably longer running periods without stoppages are obtained.

The facts stated herein are amply proved by certain owners who have carefully investigated these points, and by fitting these larger equipments they have obtained remarkably good results, both as regards purifying efficiency and reduction in engine wear and overhaul.

There are a very large number of people who do not realize that the installation of these large units on the lubricating and fuel oil systems in motor ships, and on the lubricating-oil systems of turbine ships will go a very long way towards solving lubrication, bearing, liner, and gear wear problems, plus injection equipment troubles which have been worrying them for many years.

In the higher-powered vessels with which the author deals in his paper the writer would very strongly advocate that the adoption of the highest capacity centrifuges should receive serious consideration; also in the case of the lowered-powered ships, centrifuges comparable with the size of the power unit with which they have to work should always be fitted.

Mr. Robert Welch wrote : It will be agreed that the prime function of the ship under consideration is not to seek out and fight the enemy, but if possible to evade him ; it follows therefore that all matters dealing with the ability to evade the enemy should take precedence. Chief among these are speed and manœuvring power. The speed of 18 to 19 knots mentioned in the paper seems to be a wise one, as it would enable the ship to outdistance the submarine, while as regards the other two methods of attack—by surface raider or by air bomber—the former will be rarely met with, and the speed of the airplane is such that in no circumstances could the ship evade attack by means of her own power alone.

It is desired to draw attention to the proposal to fit a propulsive unit and rudder forward as well as aft. In this respect the writer would suggest that it might be advisable to go even further than the author proposes. No doubt a certain reduction in efficiency must be expected in the forward unit, but in a ship of this size with the coefficient mentioned, *viz.* about 0·6, this should not be prohibitive, and a reliable guide could be obtained from the model tests which would necessarily be carried out. Would it not be advisable to try out a model of a "double-sterned" ship with a full-sized engine and a full-sized rudder and steering gear at each end? The propelling units could be of equal power, independent of one another, and together give the designed speed. Should one be put out of action the remaining one would still be capable of giving a speed of 13/14 knots alone. The two steering engines should be separate units, capable of both combined and individual control. In service the combined control should be used, but if one end is put out of action the ship could still be controlled from the other end.

The advantages of this arrangement are obvious. While both sets are intact a degree of manœuvrability can be obtained which may mean the preservation of the ship under frequent or constant air attack. The writer has knowledge of a case where a 16-knot ship survived almost continuous air bombing for three days, and although the ship was finally lost not one of the crew was even hurt. The ship also might have been saved had she been fitted out as described above.

Very important also are the advantages which such an arrangement affords in port in wartime, when it would be possible by manipulating the engines and rudders to get the ship away from the quay, or turn her in a confined space without the assistance of tugs. If caught in an air raid in port the ability to manœuvre as described may mean the preservation of the ship, cargo and all on board. This scheme also gets rid of one of the ship master's principal bugbears in a single-screw ship—the difficulty of steering astern.

The second point to which it is desired to draw attention is with regard to the manœuvring qualities of the rudder or rudders, which represents the last chance the ship has of escaping by her own efforts, especially when attacked at close quarters. More consideration should be given to this in the design of all ships for wartime service than has hitherto been the case. It is essential that the rudder adopted should be capable of giving quick and even violent avoiding action with the least possible diminution of speed, and should also have the maximum possible turning moment per unit of area. The partially balanced rudder mentioned in the paper fulfils neither of these desiderata. Even when streamlined the flow of water round the back of a balanced rudder breaks down at a very moderate angle, and the diminution of the ship's speed is excessive without any extra compensatory turning effect. The "two-part" streamlined type of rudder, with the forward part fixed and the after part rotative, gives not only a better turning moment per unit of area at large angles, but also causes much less loss of speed when turning. This type has become general during the past twenty years. Recently however another rudder, known as the Hydrogap rudder has been developed which has proved to be much more efficient than any of its predecessors. Exhaustive comparative tests carried out at the N.P.L. in 1937/1938 on rudder models "in open", and also behind actual ship models showed that the Hydrogap develops about 68 per cent. more turning moment than the Oertz type per unit of area, with practically the same torque. Trials with ships fitted with the Hydrogap rudder have since confirmed the results of the tank tests. These ship trials also showed that the ship responds immediately to the rudder without any perceptible delay whatever. The cost and weight involved are no greater than is the case for the ordinary type of double-plate rudder of equal area, and are less than those of the Oertz rudder.

Mr. E. Sutton, B.Sc., wrote: In passing comment on the paper, while not agreeing with all the suggestions put forward by the author, one is very conscious that one's remarks might be considerably different if all the relative facts of war experience were available to the general observer.

The author's main thesis appears to be that a vessel of 12,000-tons deadweight and of 18 knots speed, specially designed, closely subdivided, provided with suitable armament and a protective aeroplane which could take off or return again at will, would have little to fear from submarine or air attack, that such a vessel could therefore sail unconvoyed and would be able to carry, in a given period, three times the weight of cargo carried by an ordinary vessel of the same deadweight proceeding in convoy.

Immunity from submarine attack, it is claimed, would be given by the speed, reduced visibility and silent running machinery; from air attack, by some measure of reduced visibility from the air and the protecting aeroplane carried. If the vessel were unfortunately attacked, she could actively defend herself, while the chance of survival from torpedo hits or near bomb misses would be considerable by virtue of the special subdivision, or from bomb hits by virtue of the thickness of the deck provided.

Does experience justify the assumption that 18 knots speed would be the principal factor in giving immunity? Many fine vessels of about this speed on "lone" voyages have been intercepted and sunk. The author's own remarks in the section "Speed as a Measure of Defence", paragraph 5, supply the answer. He makes out a case for running convoys at higher speeds, but not a convincing one for taking the risk generally of "lone" voyages by 18-knot vessels. The chances of a fast vessel getting through a submarine pack alone are more than those of a slow vessel alone, but whether more than those of the slow vessel in slow convoy is doubtful. They are much less than those of the fast vessel in a fast convoy.

Again, speed is a useful factor in taking avoiding action during air attack, but whether 18 knots is likely to be of much more use than, say, 15 knots is a moot point. In the proposed design, the target represented by a deck of about 40 per cent. to 45 per cent. greater area than the normal vessel of the same deadweight would appear considerably to increase the chances of being hit in spite of extra speed.

The author's statement that the proposed vessel would carry three times that of an ordinary convoyed vessel needs more justification than is supplied in the paper. It appears to leave out of account the time spent in loading and unloading which is not a factor of the ship's speed.

An ordinary 12,000-tons d.w. vessel having an average convoy speed of 8 knots from U.S.A. would take about 17 days. Routing and delays might increase this to say 22 days. The time spent in loading and unloading would be about 14 days for each, *i.e.* 50 days in all from beginning of loading to completion of discharge. At 18 knots the voyage would take 7¾ days. Routing and diversions might increase this to say 9 days which with 28 days in port gives 37 days total. This would mean that over a given period the 18-knot vessel would carry 35 per cent. more total deadweight instead of three times. This would be reduced to about 33 per cent. more useful cargo when differences of fuel consumption were accounted for. To carry three times the deadweight the 18-knot vessel must reduce time in port to a week at each end and then cross the Atlantic in 2¾ days, or conversely the convoyed vessel must take 12 weeks to cross from U.S.A.

If in the preceding figures, the time in port could be reduced to a week at each end for both vessels the 18-knot vessel would carry about 56 per cent. more total deadweight.

Another way of putting it would be that two convoyed vessels each of about 8,000-tons deadweight would carry the same cargo as the 18-knot unconvoyed vessel in a given period and might even do better by a quicker turn round at the ports. These considerations would make the 18-knot project considerably less attractive.

Apart from the question of speed and working with or without convoy, the author's design and suggestions afford many interesting points, some of which might be touched upon.

Reduced visibility is generally desirable, but does not appear of such importance as to render necessary the acceptance of undesirable proportions. The low freeboard proposed is presumably to reduce visibility and there is very little sheer and no forecastle. The wide beam and shallow depth will result in an abnormally large metacentric height and produce heavy rolling. A roll of 11° would put the gunwale awash and the fore end would be very wet; the bridge appears relatively too near the stem for weatherly qualities and the hangar door would probably get a lot of heavy punishment.

The length-depth ratio of 15·4 and the 40ft. wide deck openings would require heavy scantlings of upper deck and bottom, rather wasteful of steel, but going part of the way to meet the author's idea of deck protection from bombs. The defensive armament provided appears much below present standards and additional armament positions would have to be found.

Regarding stowage of cargo, the author suggests a series of short holds in the midship body and a series of tanks towards each end for the carriage of oil, grain or bale cargoes of weight one third of the total deadweight. There is no provision, however, for getting grain or bale cargo into these spaces, and as arranged they could only be used for liquids. The general policy of carrying a mixed general and oil cargo under war conditions is very questionable. These vessels would doubtless be used mainly to and from America.

Munitions of war would not be shipped at oil ports so that oil brought in this vessel must be transhipped. It is surely better to carry oil direct in tankers from the oil-producing regions. The general cargo spaces amidships are of limited capacity, barely large enough to carry the balance of deadweight after allowing for oil cargo, fuel oil, water, stores, etc. The stowage rate would be somewhere about 65 cubic feet per ton, which it is suggested is too low. For two reasons oil cargo is economically essential in this design, for the tanks must be full to get the deadweight into the vessel and also should be full of liquid to avoid the possibility of heavy list resulting from damage in the region of empty tanks on one side of the ship.

In addition to the short holds amidships with double transverse bulkheads, the author proposes narrow side compartments and horizontal subdivision by a watertight deck, although the latter appears to be discarded in a later section of the paper in favour of explosion-resisting decks and hatches. The side compartments are indicated about 8ft. maximum width, returning to the ship's side at the bilge and at about a foot below the waterline.

Having seen on certain vessels the extent of damage resulting from torpedo hits one feels these narrow side compartments would be of little use. The author does not say what thickness he contemplates for the inner skin though he does visualize something "immensely strong", but even if very thick plating were provided the connections at the shell would probably fail. Extensive and deeply penetrating damage with consequent flooding of lower and upper holds and of the fore and aft passage would be a very probable result of a torpedo hit or hits. The probability of damage of fore and aft extent sufficient to flood three holds could not be ruled out.

With two midship holds flooded the freeboard would be reduced to about 4ft.; with three holds flooded to about 2ft. If the holds were the forward or after ones there would be also considerable trim putting one end of the weather deck under water. Whether trimming or not, the almost certain flooding of the fore and aft passage would afford a convenient channel for water to flow along and flood the lower deck accommodation and probably find its way into the engine rooms at one end or the other, still further imperilling the ship. These things would happen quickly and give little time for pumping out the end oil tanks even if the pump rooms themselves were still accessible. These possibilities should not be accepted for the sake of reduced visibility.

One agrees with the author about the desirability of providing better transverse subdivision than was normal in cargo vessels but one would prefer to effect this by suitably proportioning the vessel, giving ample freeboard and making the most of it by carrying the bulkheads up to the weather deck, and spacing them further apart.

There is some confusion in the paper about decks, *e.g.* whether the lower deck is to be watertight or not, as mentioned above. The upper deck and hatches are to be air and watertight but pressure relief valves or hatches are to be fitted between the double bulkheads. Hence when a bulkhead fails the adjacent hold would be open to atmosphere and the contemplated air cushion could not be maintained. Also the hold ventilators would require closing by someone when explosion occurs, but is this likely to be done quickly enough in the resulting confusion? The value of immediate gas pressure release is stressed and venting arrangements are to be fitted for this purpose to the lower deck in each oil tank, but the lower deck amidships is to be pressure-resisting.

Among other features which would demand considerable attention are:—

The strength of the shallow bottom framing which is indicated.

The details of the 20ft.×40ft. explosion-resisting lower-deck hatches.

The details of the 20ft.×40ft. flush air and watertight upper-deck hatches.

The method of working heavy lifts from holds and overside by cranes of the type indicated.

The practicability of reassembled planes taking off aft from the short available run in a vessel of some 10-14 knots astern speed.

The particular virtue of a trapezoidal form of midship section and whether this type of section carried fore and aft would give a suitable form for 18 knots.

Access to and lighting and ventilation of accommodation, etc.

Regarding propulsion, the author proposes a small engine forward to lessen the chances of complete disablement. Apart from the general question of the propulsive efficiency to be expected from a bow "pulling" propeller, it does seem from the illustration that the propeller would be badly handicapped in this case. It is apparently to be placed in a tunnel with something like a blank wall immediately behind it. What sternward flow may result is to be deflected downwards to emerge at the keel where only what is left, in the horizontal direction, of the initial energy would be usefully employed.

For the main propelling machinery, the author is wholeheartedly in favour of Diesel engines and suggests that a body of selected Diesel-engine designers should produce a design of a new, light type of high-speed engine for direct drive and also of a lighter, faster type for Diesel-electric drive. These are to be brought into mass production for war use and for future post-war purposes.

There is much to be said for a real concerted attempt to make the best of the Diesel engine by drawing on the widely accumulated experience available and to get away from the huge machines hitherto necessary for large power production. Whatever might be produced in this way would, however, be a new untried type, and how many responsible engineers will support the proposition to pin the national faith to it?

If such an effort could be developed and tried out in time to be of use in this war, well and good, but it could not be allowed to interfere with established programmes of war effort, though the ground might well be prepared for post-war development.

Mr. W. F. McDermid wrote: One deplores what appears to be a state of mental inertia, which stunts and retards the development of cargo vessels along lines comparable with the progressive improvement of the submarines which menace their usefulness on the sea.

Broadly speaking, present-day cargo vessels are just as slow and conspicuous as those conceived at about the same time as the Army's "thin red line", and, in war time, they present to the personnel much the same chance of survival.

It may be that the commercial economy standards of the pre-submarine period did indicate 10 knots or less as the optimum speed in the matter of fuel consumption, and, of course, hulls and cargoes in transit could be fully insured; meanwhile, the safety of crews could go-hang—but no such ruling is acceptable to-day, it would not scan as sound national economics.

After three years experience of the second war in one generation, and when during each war the submarine has taken such toll of our shipping, the simple fact that the lack of some protective improvement in ship construction must be reviewed, is in itself a scathing indictment of any and all coteries in control of such matters.

Apparently the 1914-1918 experience was well over the heads of the powers controlling mercantile shipping and taught them next to nothing; however, the experience of the man in the street is that aggressive wars are and will be recurrent and epidemic as a national disease, so long as perfidious rulers are tolerated.

If an improvised and expensive palliative was the only "remedy" which the official doctors could visualize during the first epidemic of some dread disease, and later, after three years stress of another outbreak in a more virulent form (which followed about twenty years immunity), these doctors, for want of initiative, could suggest and would accept nothing but the same old palliative, it may be assumed that the wish to appoint fresh "medicine-men" would be pretty general; particularly if possible remedies suggested by other qualified doctors had been pidgeon-holed by the delinquents as uninteresting criticism.

While expounding what appears to be a well-reasoned and sound practicable proposition, the author mentions that convoy work absorbs "a very high proportion of Allied Naval Forces". He might also have cited as a fair addition to that Naval "on-cost", the extra cost of shore-staffs working at high pressure loading and/or unloading the convoy. This work has to be done in gusts, followed by idle hours waiting for the next arrivals, also there is the ship-time wasted waiting for a berth, etc. The aggregate cost of these conditions must be colossal, and should be assessed and allowed for when estimating the relative costs of conveyance by present methods as against the more expeditious and regular delivery to be expected if fast self-protecting vessels such as the author proposes are to be used.

The author's opinion on "over-engining" his proposed vessel would be interesting. The idea which the writer wishes to convey is, in place of the proposed allocations of 12 and 88 per cent. at the respective ends, put engines of power equivalent to 88 per cent. at both ends. This arrangement would in effect mean, in peace time, that the vessel carried a complete set of "engine spares" disposed for instant use if necessary, and, in war-time, if the extra power available avoided disaster only once, the additional capital cost would be amply justified.

The author should be duly thanked for having made his comprehensive survey of the possibilities of improving mercantile shipping, not only in the matter of rendering it less vulnerable to attack, but, as offering a better commercial proposition for transporting goods, etc., than the old slow boats. What might be called "the engineering part" of his general scheme appears to be very sound and unlikely to be challenged except, perhaps, in minor matters. Personally, the writer would not venture criticism of hull construction one way or the other.

As a pioneer, the author is certain to have ruffled orthodoxy perhaps to the same extent as did Plimsoll, who had to wait years for universal acclamation. In the present case, however, considering the urgent need for some constructive result, it is to be hoped that the author and the team of experts he has asked to help him will have an early success.

Mr. Victor Dover, F.C.I.I., wrote: Many things advocated in this paper appeal to one's common sense. If it is important to mobilize technical and scientific knowledge for the successful prosecution of the war, so it would seem wise to pool such knowledge to meet the problems of post-war reconstruction. British shipbuilding technique has always been in the forefront; it is to be hoped it will maintain itself in this position in the future.

The question is often raised as to the attitude of the marine insurance market towards new developments in shipping design and construction. In the past it has been the practice for marine insurance rates to follow experience, not to anticipate it. That is to say, that the marine underwriter rates each risk on his estimate of the hazard and he makes this estimate on the basis of recorded statistics of past experience. If new developments in ship design and construction are to be fostered, where these give additional safety it would appear to be reasonable for marine insurance premiums to be adjusted accordingly. A discount from normal premiums has in fire insurance proved the most efficacious method of encouraging the installation of safety devices.

This theme could be developed in relation to marine war risks insurance. Should it be demonstrated that vessels constructed on the lines propounded by Mr. Burn were a better risk than vessels built on more orthodox lines, there would be a clear case for differential rating for war risks insurance purposes. It is to be hoped that this aspect of the subject has not been overlooked, especially as in this war it is advisable to take a long term view.

Captain T. S. Morgan wrote: From experience at sea in two wars, the writer would say that the author has designed the ideal ship for war transport. The writer has always advocated faster ships even in peace time, and learned with astonishment that the Government were building small and slow ships again in this war after what was experienced in the last war.

The writer feels sure that had the author's ship been put on mass production at the beginning of this war, using as much prefabricated material as possible in the hulls and more welded joints, the extra building time (if any) would have been offset by fewer ships being sunk.

The writer realizes that the engines necessary to drive this large vessel at 18-19 knots would be a big job, but by mass production (and assuming for argument's sake, that the fast individual ship has, say, a five-to-one chance against being torpedoed compared with the slow convoyed ship) the man power needed to build the fast engine would be offset by the man power needed to build five slow engines. Besides, if the engine were standardized, more unskilled labour could be absorbed than at present, when various types of engines are put into standard hulls.

The multiple compartments with airtight hatch covers as designed are, in the writer's opinion, the best method to prevent sinking after a vessel has been torpedoed, and the extra longitudinal strength provided by the internal blister practically nullifies the danger of a vessel breaking her back when torpedoed amidships.

In a recent convoy the writer saw three torpedoes explode on striking the ships; in each case the top deck plates were blown off to within two or three feet of the hatch combing. In each instance the vessel when struck listed heavily to the side struck, and the writer imagines the inrush of water would flow along the upper deck and into other holds. This would not happen where the vertical bulkheads were continued to the upper deck.

The elimination of the cellular double bottom, if practicable, will certainly reduce weight, but the writer is conservative in feeling that a vessel needs something in her bottom when she is empty of cargo.

In the design there are three cargo oil tanks forward and one aft. In loading or discharging, these tanks would have to be worked at the same port as the dry cargo, also these tanks being at extreme ends of the vessel would not be suitable for ballast on a sea voyage.

In the writer's opinion the overside door to the lifeboat compartment could be eliminated, for the door would surely be jammed if the vessel was torpedoed in that part of the hull.

From what the writer has seen of vessels torpedoed he feels sure that a vessel of this design could receive two torpedoes and still make port, and no reason is seen why this vessel could not easily be converted for express cargo service in peace time.

Mr. S. H. Dunlop (Member) wrote: The author has expressed in argumentative terms the propositions for war-time ship production. War-time conditions create national problems and the suggestion to compile from experience and ingenuity a national type of Diesel engine, suitable for a fast cargo vessel, would be to the advantage of the marine Diesel engine manufacturers and supply them with a national research unit. The many suggestions made by the author are theoretically sound but, in order to produce a reliable engine, the practical problems would be numerous, and a long period might elapse before a thoroughly reliable unit could be produced. Reliability is most essential when operating under war conditions, and in order to reap the full benefit from fast voyages, upkeep and overhaul would have to be a minimum. Moderate repairs and reliability appear to be the chief arguments for or against certain propulsion types, and would exert influence for the extensive development of the high-speed Diesel multiple units with electric propulsion. With this type of installation, engine failure would seldom cause a complete shut down, and when major overhauls were necessary, the complete engine could be removed for overhaul and a new unit installed, thereby avoiding delaying the vessel.

Rather than commence to design and erect a new type of direct-drive two-stroke double-acting Diesel engine of required horse power and weight ratio, the reverse cycle seems as practical, *i.e.* that of acknowledging an existing well-tried and reliable two-stroke engine, of which there are several, although the majority are of foreign origin. The hull could be designed to accommodate this engine and to give the required speed for non-convoying voyages, also attempts could be made to incorporate the sub-division as suggested by the author.

The standardisation of a hull suitable for various types of Diesel engines and the standardisation of the engine types would result in the obtaining of a very favourable production figure. By accepting the production of existing plant, present needs could be catered for and the research department permitted to devote all their energies to the perfecting of a reliable high-speed Diesel unit for incorporating in the electric propulsion or geared propulsion systems, although the adoption of high-speed units would greatly increase the number of engines to be manufactured and delivery difficulties may be encountered. However, the number of manufacturers of this type of engine would not be as limited as those of the large direct-drive Diesel engine. The author's proposal for the building of such a high-speed Diesel engine supplies a basis for further research in the field of high-speed Diesels, and provided every source is tapped, an engine with the characteristics, efficiency, simplicity and easy production, could be developed to compare favourably with a similar engine of Continental design and prove that British marine engineering was alive to the possibilities of high-speed Diesel units.

It would be interesting to have the author's opinion of the prospects of developing the internal-combustion turbine. Research in this direction would probably produce a propulsion unit to satisfy war-time requirements for speed in production, efficiency, reliability and low maintenance.

Captain F. G. Spriddell, C.B.E., R.D., R.N.R., wrote: The writer agrees that the tanker design of cargo ship is desirable to minimize damage by bomb, torpedo or mine, and to minimize broadside damage, and that the internal "blister" or skin gives great protection coupled with the proposed sub-division; the use of the fine ends or below-tunnel spaces for oil or bulk cargo such as grain, which can be pumped out, has already been adopted in some new vessels, both general cargo and meat cargo ships. Generalising on stowage such as steel plates and bars near bottoms and sides with a yielding and compressible, and thus presumably light, cargo at top or centres is wishful dreaming, and may in practice make the ship unseaworthy due to heavy rolling. The provision of so much cubic at fore end of ship for oil cargo limits the trade to which the ship can be allotted, and as there are no access hatches to allow these six tanks to be used for bulk grains, it would follow that occasions would arise when ballast water would be needed for trim purposes.

The writer does not like the description of cargo-warship, as the two types are not interchangeable. Is the vessel to be a cargo carrier or an aircraft carrier? Presumably the former is considered the prime reason for building the type; then after provision has been made to launch and possibly recover her scouting plane plus one or two planes in reserve, the design could be, the writer considers, vastly cheapened by building the usual type of hatchway closed by steel hatch covers. The proposal to make the upper deck air- and water-tight with a considerable number of 20ft.×40ft. hatches is, the writer thinks, Utopian. Most superintendents have experienced the difficulties in maintaining watertight joints on bulkhead doors which are used frequently for cargo purposes, and some have had experience with steel hatch covers depending on rubber and realize how such covers, even when treated ever so gently, usually get distorted and fail to make a watertight join without frequent and continual repairs and adjusting. The provision of a fore and aft below-deck alleyway should be unnecessary, the top of the internal blisters being brought above the load line to give torpedo protection; the upper deck should have usual camber with guard rails and, as in tankers, a raised fore and aft gangway from navigating bridge to aft end.

The writer does not agree that there is no fundamental reason why all accommodation should be berthed at the ends of the ship. In the sketch, all officers might be destroyed by one mine in the fore end, excepting any on watch. The captain should certainly not be berthed below decks off the galley and pantry alleyways, nor the chief engineer off the saloon; also the assumption that the position of accommodation as being well away from likely torpedo effects is not justified by experience.

There appears to be no reason why one ordinary control platform should not be built; the idea may be that if one is knocked out the other can be taken into service.

Unless the vessel is to be wholeheartedly a naval or military auxiliary and to carry tanks and similar heavy material, the large number of 25-ton cranes (incidentally one hatch according to sketch will have no cranes if all hatches are working) is excessive waste of heavy plant. One 25-ton crane per pair of hatches, *i.e.* three in all, the writer suggests, is sufficient; such cranes with their hoisting and slewing machinery would be very heavy and bulky and would take far more space than that allotted on plan; three 3-ton cranes to be of 10 tons, with the remainder fast-working 3-ton cranes.

Armament on upper deck would be considerably larger than that shown, also the launching gear for a 35- to 40-feet steel Diesel lifeboat from such a compartment as depicted would need much elaboration, and the writer would suspect more height than has been allotted; the doors to same would not be approved by the Ministry of War Transport, and quite rightly as they might be jammed in closed position after an explosion; also the position in ship is not good due to the fining away of the hull to the bow and centre line.

The author is not asking too much in the way of speed for such valuable ships as proposed, but whether machinery is available in such quantities is another matter. The proposal to have a 12 per cent. propelling or puller engine forward has a lot to be said for it as a stand-by should main engines be destroyed, but an unmitigated nuisance in conjunction with paravane gear, and the naval authorities would probably prefer the ship to be fitted with the minesweeping gear.

The beam of 80ft. should be seriously reconsidered, as there are very few docks in this country able to take such a ship, and there is already a severe demand for such drydocks for large troopships as well as heavy warships, due to certain mercantile and naval ports which have such beamy docks not being available.

The writer is of the opinion that such a design is not likely to be authorized for any large numbers, but there are, he ventures to say, many interesting and useful hints which could be adopted with considerable advantage to war-time construction.

With regard to the derogatory remarks on "greenhouse" contraptions, these are preferred generally both by officers, crew and passengers. Open, windswept, unsheltered spaces are mostly anathema to all travellers.

Dr. S. F. Dorey (Vice-President), wrote: The author has presented such a mass of rather novel and, indeed, ingenious suggestions, that it is difficult to contribute except at great length. The writer, however, proposes to confine his remarks to one specific aspect, namely, engine balance.

In the fast-running steam reciprocating jobs of the past, engine balance presented a real problem to engineers and naval architects alike. On the other hand, whilst the advent of the oil engine brought many troubles in its trail, the possibilities for perfect balance inherent in the oil engine brought many advantages. Although this appears a small point, it is in fact one of major importance because a great deal of damage to the hull can be caused by relatively small forces and couples under resonant conditions with the natural frequencies of the hull. The author rightly points out in his concluding remarks on page 141 of the November, 1942 TRANSACTIONS that the 10-cylinder Vee double-acting engine will give an almost completely smooth torque. On the other hand, this engine gives both primary and secondary unbalanced couples in both vertical and horizontal planes. It is commonly considered that only unbalanced forces need be taken into consideration; such conclusions, however, are dangerous and emanated from experience where engines are fitted amidships and have primary unbalanced couples. In such circumstances, undoubtedly, unbalanced couples have not created undue vibration.

However, with the faster running engines listed under proposal (4) on page 141 of the paper, and further considering the position of these engines in the vessel as shown by Plate 1, unbalanced couples would require to be eliminated as well as forces. For the engine proposed by the author in proposal (4), both primary and secondary forces would be completely balanced, but the following unbalanced couples would remain, *viz:*—

Primary couple.
Vertical plane ... ... 295·5 tons-feet.
Horizontal plane ... ... 112·8 „ „
Secondary couple.
Vertical plane ... ... 452 „ „
Horizontal plane ... ... 317 „ „

Furthermore, with the banks at 90° instead of 54°, the forces would again be balanced, but there would be present the following unbalanced couples, *viz.:*—

Primary couple.
Vertical plane ... ... 204·2 tons-feet.
Horizontal plane ... ... 204·2 „ „
Secondary couple.
Vertical plane ... ... 0 „ „
Horizontal plane ... ... 610 „ „

For the purpose of comparison between "in-line" and Vee type engines having the same number of cranks, the accompanying table is of interest and shows generally an increase in the magnitude of the out-of-balance couples with the Vee arrangement. In some cases, the increase in the unbalanced couple is very marked.

The writer is, therefore, of the opinion that if the Vee type of engine were to be adopted, at least six cranks should be used so as to obtain perfect primary and secondary balance.

Type of Engine.	Primary. Reciprocating. Force (Tons). Vertical.	Horiz'l.	Couple (T-Ft.) Vertical.	Horiz'l.	Rotating. Force (Tons). Vertical.	Horiz'l.	Couple (T-Ft.) Vertical.	Horiz'l.	Reciprocating+Rotating. Force (Tons). Vertical.	Horiz'l.	Couple (T-Ft.) Vertical.	Horiz'l.	Secondary. Reciprocating. Force (Tons). Vertical.	Horiz'l.	Couple (T-Ft.) Vertical.	Horiz'l.
5-cyl. "In-line"...	0	0	120·3	0	0	0	−15·5	15·5	0	0	104·8	15·5	0	0	334	0
10-cyl. "Vee" 54°	0	0	246·8	64·1	0	0	48·7	48·7	0	0	295·5	112·8	0	0	452	317
10-cyl. "Vee" 90°	0	0	155·5	155·5	0	0	48·7	48·7	0	0	204·2	204·2	0	0	0	610
3-cyl. "In-line"...	0	0	464	0	0	0	−59·7	59·7	0	0	404·3	59·7	0	0	116	0
6-cyl. "Vee" 30°	0	0	1,118	80·4	0	0	188	188	0	0	1198·4	268·4	0	0	251	38·9
6-cyl. "Vee" 90°	0	0	599	599	0	0	188	188	0	0	787	787	0	0	0	212

Mr. H. A. J. Silley (Member), wrote: That Mr. Burn's paper deals with one of the most important aspects of the war is in no doubt whatever, for the continued sinking of our ships is still the gravest matter with which we have to contend, and whereas it may well be said "we must win the war on land by an assault on Germany" that we can lose at sea is undoubted truth. The paper, therefore, and all papers dealing with this grave danger to our country, demand both respect and careful study.

That the author is advocating an increase in speed of merchant ships to 18 knots will find support in many quarters, and in fact since the paper was written, this has already been the subject of a newspaper article by Admiral Sir Hugh J. Tweedie.

It is, however, in the details of construction and lay-out that this proposed war cargo-ship will be the subject of much controversy in technical quarters. It seems to the writer that the proposal is based on a great number of assumptions, for which the author produces little proof that they are right in fact. The contention that the proposed ship will be more immune from attack when travelling singly in comparison with the present slow-speed convoys, is surely an assumption that can only be proved right by those who have access to the details of actual damage and sinkings.

There are also many factors in the ship construction which may be novel in a merchant ship, but which could be picked to pieces by those competent to do so. One wonders whether the proposal for anti-torpedo blisters is sound, when one considers the sacrifice in cargo space which this would involve. That there is a great increase in the explosive power of the modern torpedo compared with that used in the last war is common knowledge, and the sinking of the *Prince of Wales* and the *Repulse* was an event which surely casts some doubt on the efficacy of what would be much lighter construction on a merchant ship.

The proposals for additional subdivision in the form of oil cargo tanks and numerous short holds would not necessarily afford additional protection against attack, and the argument that something in the nature of a tanker's subdivision is required will only carry weight if oil tankers have been relatively luckier than ordinary cargo vessels after torpedo or air attack. Whether or not this is a fact, it is certainly not common knowledge, and it would be a dangerous assumption unless supported by fact.

The proposal, too, that a watertight deck will provide further protection, is another matter which is open to debate. The writer believes that experience has shown that the deck is no more immune from danger, and probably less so, than the tranverse bulkheads, and it might well be that the proposed gastight hatchcovers would tend to aggravate rather than lessen deck damage.

With regard to the propulsion side of the proposed war cargo-ship, there are many points which will undoubtedly give rise to controversy. One point which definitely invites criticism is the author's suggestion of three different speeds of engine. This will involve rather special personnel and necessitate considerable specialized training, particularly of ship's engineers, before full efficiency can be assured.

Regarding the type of engine itself, it should, the writer thinks, be conceded that the author is working on the right lines when he advocates the opposed-piston engine, which is borne out by the latest Harland & Wolff design and also Sulzer's development, mentioned on page 138. The idea, too, of a basis national marine oil engine undoubtedly calls for careful consideration, but here again the time factor at this stage of the war is surely the most important one. The unavoidable delay of changing over existing marine engine plant and the necessary alteration in tooling, would inevitably cause delay which might be most serious at a time when a constant uninterrupted flow of new ships is so urgently required, but there is no doubt that this matter should be looked into by a committee of experts to see just what would be involved, and what would be the cost in terms of delay or dislocation. Taking a long view, again, might well be worth while.

If such a committee were set up, they should concern themselves with questions such as an engine design giving a compact and simple lay-out and all important features involving mean effective pressures, stresses in the mechanical parts—such as crankshafts, connecting rods —piston speeds and the revolutionary speed; all should conform to the proven design of the existing engine. The adoption of the Diesel-electric drive would, to a considerable degree, remove the necessity for too much variation in size of engine and would enable a greater degree of standardization to be put into practice. This type of drive, too, would leave room for any stepping up of speed in vessels specially built for war service if the changing conditions of the war call for a greater speed. Cargo space could, if necessary, be utilized and this point could be taken into consideration in the original framing of the ship's bottom to carry additional weight.

Speaking as a ship-repairer, the writer can see difficulties arising with regard to the availability of suitable drydocks and other ship-repair facilities to deal with vessels of these dimensions. The author's proposal would inevitably restrict the repair of such vessels to certain ports and would mean that a large number of private firms having drydocks up to 400ft. in length would be unable to play their part in the repair of these ships, and this would be bound to bring with it complications with labour, involving transfer, and would tend to bring about more congestion at certain terminal ports.

In conclusion, the author is to be congratulated for a paper which has obviously required a great deal of careful work and investigation to produce, but he must realize that to advocate the scrapping of our present building programme in favour of his proposal would involve enormous delay and dislocation in marine engine works and shipyards, and this at a time when a steady stream of vessels from the stocks is essential for the successful prosecution of the war. If it could be proved that the faster ship will in fact lessen the danger of attack, and so save precious lives of our seamen, in this fact alone the author will have justified his paper; but it is with regard to the detailed proposals of his ship that he will find support lacking in many quarters.

Mr. A. E. Crighton (Vice-President) wrote: The proposed design of cargo warship appears to give a decided lead in the opposite direction to standard practice and is an important contribution towards a practical solution of making ships less vulnerable to attack. There are, however, several features in the design on which the writer would like the author's comment. These may be summarized as follows:—

General Arrangement.

The small amount of freeboard appears to indicate that a fore and aft flight deck is required over existing weather deck in order to give greater security to hangar house and airplane on rails by raising these a deck higher. This extra deck would also enable the crew to be berthed on deck higher and clear of the crown of oil tanks. It would also improve the mooring arrangements at bow and stern and avoid the crane post recesses in cargo tween deck or upper holds.

Stability.

The author does not state the estimated *GM* in light or loaded conditions. The excessive ratio of beam to length and depth indicates that an additional deck is necessary to lower the metacentric height to comfortable conditions.

Lifeboats.

The two large motor lifeboats are placed in a vulnerable position, *i.e.* around the bridge. The writer would suggest that the lifeboats be raised a deck higher and so be further removed from head seas. For lifesaving, it may be considered a mistake to place "all the eggs in only two baskets" and a larger number of lifeboat positions would therefore be desirable.

Construction.—Girdering and Pillaring.

This is not indicated on design and it appears that the cantilever system of girdering would lend itself well in conjunction with wide hatchways. From the design or description of the cargo warship is is not clear as to whether or not a double bottom is intended. Double bottoms have proved to be invaluable in reducing the amount of damage resulting from magnetic or acoustic mines.

Prefabrication.

The shape of the internal blisters is not conducive to rapid construction or prefabrication. A simpler design appears essential. Has the author considered the normal inner skin in conjunction with air escapes to reduce explosive effects? The author states that external blisters proved highly successful in the last war. Can he state if the water space between blisters and the inside hull contributed to the success he mentions?

Crew Accommodation, etc.

Naval architects to-day endeavour to arrange the accommodation away from the forward end. With the proposed flight deck, this would appear to be feasible. The crew space seems inadequate, understanding the increase of personnel in wartime. The storerooms also appear to be insufficient and too close to the galley, particularly the refrigerated store.

Compartmentation.

The introduction of double bulkheads introduces additional bilge piping, sounding, ventilation, etc. In view of the short length of holds, it would appear that the additional bulkheads could be eliminated and still maintain a "safe margin" of stability in the event of damage to single bulkhead. Will the author indicate his proposals for pumping, draining, sounding, etc. for the upper holds and will he also give his ideas for a suitable run of bilge pipes.

So far as the machinery section of the paper is concerned, the writer considers any remarks can be safely left to engine designers, whose criticisms, or otherwise, would naturally be of more value at this stage.

In conclusion, the writer hopes that the author will in no way consider that this criticism is destructive, because the reverse is intended. In other words, it is with enthusiasm that the writer gives support to such advanced ideas, which are conspicuous by their absence in these days. Every effort at this time to improve upon the last war in ship design and subdivision is obviously refreshing and essential.

The Author's Reply to the Discussion.

GENERAL REMARKS.

One of the advantages an author has in replying to the discussion is that it gives him an opportunity of expressing his "second thoughts", extricating himself from difficulties and, above all, benefiting from the advice of his critics. The author proposes to avail himself of all these opportunities.

The discussion has been very helpful and, in the main, in favour of the broad scheme. It is regretted that actual shipbuilders and marine-engine builders have remained completely silent, although a number have written helpful letters. Bearing in mind contributions the author has had to previous papers—not nearly so important in subject matter—this is disappointing, but doubtless builders are all so busy replacing lost vessels that the author can well believe that every minute is only too fully occupied.

Indirect questioning reveals that the subject matter of this paper has not been received as one would have hoped by many ship and engine builders, therefore one can assume that a reason for the lack of co-operation is the lack of full appreciation of what happens to our ships and men at sea in war conditions. One suggestion is that all designers, craftsmen, managers and directors should spend in turn a voyage at sea in war-time, subject to the full rigours of enemy activity so as to get first hand information. Certainly direct practical experience must be obtained by those dictating policy, and this suggests that the responsibility for even merchant ships should be more shared by professional Naval circles who are more war conscious.

It will be found that the fundamentals of ship construction in relation to known enemy action with torpedo or bomb has not been seriously considered by shipbuilding interests. For example the most important aspect of welding for war purposes is its merit relative to explosion resistance, but it will be found that shipbuilding interests have been more concerned with justifying British adherence to riveting from a man-hours point of view and have not considered the war utility point of view.

In addition to the absence of explosion-mindedness, British war-time shipbuilding appears to have been concerned more with economy of man-hours by simplification than by solution of the problem to remove the need for feverish building; in other words the intellectual aspect has been left far too much in the background.

Nevertheless, the author trusts that in the future it may be possible to persuade the "powers that be" to ensure that full information on the technical side of sinkings will be available to responsible designers all over the country, to ensure the fullest use is made of the designing genius and inventive capacity lying at present dormant, one might say under steel hatch covers well battened down.

Contact with a wide cross-section of persons interested in ships has revealed a keen desire for better ships, and if the spirit of the democracy is allowed free play in technical as in political affairs one cannot but have faith that the U-boat menace will be got under full control chiefly by the actual cargo-carrying vessels.

It is proposed to deal with each contribution seriatum and end with a general summing up, including a modified design of ship evolved as a result of the impact of other minds which have been brought to bear on this vital matter.

Mr. H. J. Wheadon. The author is glad the question of the beam and drydock facilities has been raised. A survey of the docks available was made at the outset and the author recently had an opportunity of a visit to most of the principal docks. Greatly improved dry dock and repair facilities are desirable in this country, and it is only because such a small proportion of torpedoed vessels get the opportunity of ever reaching port again that a crisis in the repair facilities has not already arisen. Simultaneously with a building programme of cargo warships a programme of new or enlarged drydocks and repair establishments would require to be embarked upon—if only to bring our facilities in line with the modern continental repair establishments which have for some years been taking more and more work from British establishments because of superior equipment and facilities.

The repair establishments should make use of the proposed regional prefabrication works so that damaged portions may be cut away and new standard prefabrication parts in large portions welded in place.

As new cargo liners and oil tankers are as much as 72ft. wide, even these are debarred from a large number of docks and more docks of up to 100ft. wide must be considered.

The inadequacy of the cargo-handling gear is realized and the number of holds and cranes has been since increased. The author is now proposing twenty holds instead of twelve, and twenty derricks instead of ten cranes.

The suggestion that the electric propulsion motor should be submersible seems to be a practical possibility, especially if the motor is suspended from the lower deck and the air-cooling equipment arranged above on the lower deck. At any rate the covers of the motors should be designed by a mechanical engineer and not the usual flimsy type, so that a measure of explosive effect can be withstood. A single screw motor could be placed in a small watertight compartment well away from the ship's sides and bottom.

Mr. J. Calderwood. The author is glad to have Mr. Calderwood's general approbation of the possible elimination of the bedplate. With regard to the boring out, etc., it was intended to consider the engine room portion of the ship's bottom as the bedplate and bore out and fit up as in normal practice, afterwards welding in this "engine room bottom" to the ship. The intention was to have a flexible coupling to ensure alignment; incidentally such a device would cause an appreciable ultimate saving in fitting-on-board time.

The whole question of the connection between the engine and the propeller to suit war conditions needs investigation, much more lateral and axial flexibility is required to permit even considerable ship distortion without causing the shafting to be immovable. Many fine ships have been lost by being rendered helpless by "frozen" shafting.

The author agrees on the general noise problem of the turbo blowers, but it was intended to have a relatively low-speed (4,000 r.p.m.) two-stage blower, the first stage delivery at about 1·5lb. per sq. in. and the second at about 3·0lb. per sq. in. The author is assured by blower experts that a silent job can be made. For the large power contemplated, turbo blowers and distributed air are an attractive proposition in size and weight.

The author agrees completely with all Mr. Calderwood's remarks on silence and engine type; that is why a single acting two-stroke engine is shown on Plate 1.

The author notes that Mr. Calderwood prefers the full double-ended ship; the author did not put this in the Paper as it seemed too revolutionary, but he is gratified to note the surprising acceptance of a greater or lesser measure of bow propulsion, as a war measure.

When it comes to weight the double actor has advantages at a given speed, but on the score of simplicity, fewness of different parts, fundamental silence and freedom from vibration, the author believes the single-acting two stroke has it. The best type of two stroke for crank silence is the opposed piston of the side rod type which is the only type with an almost self-supporting crankshaft. Three cylinders with this type are all that is required, especially if associated with a three-bladed propeller and twin screws to co-relate screw and engine variations in torque. The author is not sure that one cannot work in the main elements of the identical type of Doxford engine used in the present shipping programme in a multi-screw scheme, if his remarks on page 138 are applied to the smaller engine and the specific power increased.

If a very high powered engine is required he thinks there is no doubt that the Vee double actor is the best economic type and that he was right to investigate this type fully. Once one comes to, say, four screws the engine problem becomes much easier and many more engine types become available. Whilst the author believes it is desirable to use the large direct drive engine industry to the full, in the National interests the indirect drive with virtually aero engines appears to have overwhelming advantages for such vessels as cargo warships. We should not consider Federation demarkations in wartime, and any possible manufacturers should be brought in.

Regarding submarine engines the Navy have experience of Sulzer submarine engines and should be in a position to give valuable experience. Such a type could be immediately used in the multi-screw scheme at 200-300 r.p.m. and allotted to auxiliary oil engine makers for production.

Whilst the author agrees that no new or revolutionary designs should be put into mass production without the fullest tests, he believes most definitely that wartime, as no other time, demands experiment and development of new instruments of war, and that includes ships and engines as well as guns and tanks. He submits that our merchant shipbuilding policy requires complete revision in this respect. The object of this paper is to sow the seeds of such a technical revolution and stimulate the vitality.

Mr. C. Wallace Saunders. Mr. Saunders suggests that a turbo electric installation "will save frame spaces". Compared with Plate 2 this is possible. The engine room on Plate 2 was evolved over a year ago—not without much thought, to give the minimum volume of engine room on more or less conventional engine lines. An in-line engine of the type available demanded a long engine room, but every endeavour was made to keep it narrow to give the greatest side protection; the author considers it now out of date.

The engine room with Vee single acting engines shown in Plate 1 is preferable with the auxiliary engines and equipment aft and here the engine room length is only 40ft. against the 68ft. of Plate 2.

By using the six cylinder Vee double actor, and limiting the power to 7,500 b.h.p. in a single engine it is possible to reduce the main engine room to the astounding figure of 24ft.—no more than the bow engine room of Plate 1 or the new hold width.

To the author's knowledge this represents the smallest, lightest, and most economical engine room possible for *direct drive* cargo warship machinery to-day, and is well worth considering in any National development. The control platform can be between the cylinders on the top platform and all possible auxiliaries can be on the same level, but aft in a central flat which will even include the steering gear and will be all exceptionally well protected from possible enemy underwater action. This is a new conception of engine room but the author maintains it is a correct one. The total weight of machinery of each engine room (of 7,500 b.h.p.) need not exceed 250 tons and the "marine engineer" man hours could be made not to exceed that of a 2,500 i.h.p. steam installation by careful utilisation of available external contractors for auxiliary machinery, fuel injection, scavenging and air starting equipment. As an immediate aid to production, reconditioned and derated Merlin aero engines, using petrol of an available octave number, could be used for generating purposes and looked after by the mechanics attending the aircraft maintenance.

The balance of a three cylinder double actor is not perfect but with balance weights can be made adequate—the first double action engine the author designed (cyls. 21½in. × 38in.)—for m.v. "Irania"—ran very smoothly, but the Vee arrangement will be worse than an equivalent powered in line three cylinder. Given great care to reduce the weight of the reciprocating parts, the author sees no reason why the reciprocating parts of a new 24in. engine should not be less than half the weight of an old type 27½in. bore engine.

If four screws are used the experimental nature of the direct drive disappears and the stage is set for a battle royal of the types.

The criticisms of the integral bedplate have been dealt with in replies to other speakers.

Separate pump rooms are, the author believes, essential to security, but there is no need for the piping to be excessive; interconnecting piping should be an absolute minimum. Many a good ship has been lost through water leaking into a sound hold through pump lines.

Whilst the freedom of cyclic variation is a strong feature of the electric motor, the great developments in non-metallic flexible couplings must be kept in mind, not to mention the common or garden flywheel.

The chief problem is to prevent cylinder knocks being transmitted to the bedplate, and in that respect certain opposed single-acting cylinders or opposed pistons with side rods are necessary, but it is possible to use certain horizontal double-acting types. To what extent knock and noise could be reduced compared with propeller noises is a matter for investigation and experiment; usually the propeller noise is the greater.

To suggest that we should not experiment in war-time is to suggest that our technique before the war was good enough to win the war—the author does not believe it was.

Turbo-electric propulsion has all the virtues *except low fuel consumption,* and as powers increase this becomes increasingly important.

As other than marine engineers will see this discussion, it is thought fitting to point out that the Diesel electric proposals are not greatly beyond that recently proposed by Herr Bleicken, the superintendent engineer of the Hamburg American Line, who, together with other German shipping firms, already have several fine Diesel electric ships; we have none. Hr. Bleicken also suggests machinery at the extreme stern with generating engines above in the tween deck above the motor. British developments in this section of marine engineering are urgently required.

Mr. E. C. Warne. The author's excursion into the realms of Vee engines was not only to save man-hours but to ease certain production difficulties. In single acting engines this type can have definite advantages: for instance the Rolls aero engine, the General Motors locomotive two-stroke oil engines and the latest Deutz submarine engines, have eliminated any novelty; in fact we are well into the Era of Vee opposed or radial engines. In the case of the double acting engine the main difficulty is that one has not a straight lift; fundamentally the author believes the advantages could be made to far outweigh the disadvantages. It can be admitted that a small engine of advanced aero engine size, say 7½in dia. × 9in. stroke, would not have these straight lift disadvantages.

A 16 cyl. Vee or horizontally opposed engine (with perfect balance) at 1,000 r.p.m. and 100 b.m.e.p. would develop about 3,000 b.h.p.; six such engines would be required for power purposes and with two spare engines, say four in each engine room, the total weight could not exceed 30 tons. Such engines cannot be deemed impractical until they are built and tried; the manufacture, development and maintenance could be simply arranged, only the designing would require a courageous outlook and a wide net.

The real point at issue regarding large engines is as to whether there is a large simple double flow double acting engine sufficiently developed and reliable to which to apply the Vee principle. The author does not think there is.

In the author's incursions into the Vee type of engine it may be thought that he stresses the importance of a short engine-room, but he has a very good reason for this. *In fact the present 13% volume ruling is a complete menace in war-time, and the figure should be altered to not exceeding half this figure forthwith.*

There is a good case however—which the author had not initially contemplated—for using four simple three cylinder double-acting two-stroke engines if four screws can be used. But the indirect drive with the smallest practical high speed double-acting engine made in aero engine factories offers a much greater potential reliability with vast economy in weight and space if this type is to be considered, and time will be saved by short circuiting the large engines for the present.

The intention is not to have a large amount of piping; on the contrary the forward and aft engine rooms are intended to be completely independent. In the modified scheme a protected duct keel is provided to deal with the bottom oil tank piping.

Regarding the built-in bed plate, the author believes it is possible to accommodate all engine stresses as in a normal ship's bottom. The forward engine in Plate 1 was made Diesel electric to give perfect manœuvrability, as the intention was not to use the direct drive main engine for astern running. Marine oil engines at 250 r.p.m. are not so easy to obtain.

A defect of the turbine, both geared and electric, is the inability to change speed rapidly; the presence of a bow propeller opens up great possibilities in avoidance action if the engines can be made to respond immediately to bridge requirements.

Either the direct drive double-acting two-stroke or Diesel electric machinery would respond perfectly in this respect.

Mr. W. A. Christianson. It is hardly correct to say, as Mr. Christianson suggests, that the whole basis of the proposals relates to oil engines; it is rather that no technical problem exists in the case of the steam turbine and oil fired boilers except the fundamental one of excessive consumption of fuel compared to that of oil engines. As the chief objection to high powers is high fuel consumption in times of fuel shortage, it is desirable to use that type of engine which uses least fuel. For high powers there are however great technical problems associated with oil engines; in normal types the weight and man-hours are excessive and *some better solution must be found.* The man-hours to build a normal 14,000 b.h.p. oil engine installation are not much less than the stated man hours to build a standard 10,000 tons d.w. ship; the man hours for a geared turbine are, however, nearly half this figure. Whatever propelling proposals are immediately adopted, the layout should be such as to permit switching over to oil engines when they can be developed without necessitating change to the hull.

Vee single-acting engines and multiple screws suggest one means of reaching the high power required without undue novelty. Any suitable engine proposals would have so many exhaust impulses as not to create problems of exhaust silence. Regarding the use of auxiliary engines to supplement the propulsive power, the author thinks the complication would make it hardly worth while, especially in a large installation with a relatively small spare auxiliary power.

Mr. H. O. Farmer. Whilst the author is in full agreement with Mr. Farmer regarding the use of relatively small high-speed engines, he thinks the use of engines of not less than 1,000 b.h.p. each should be considered; this implies an engine of aeronautical rather than of

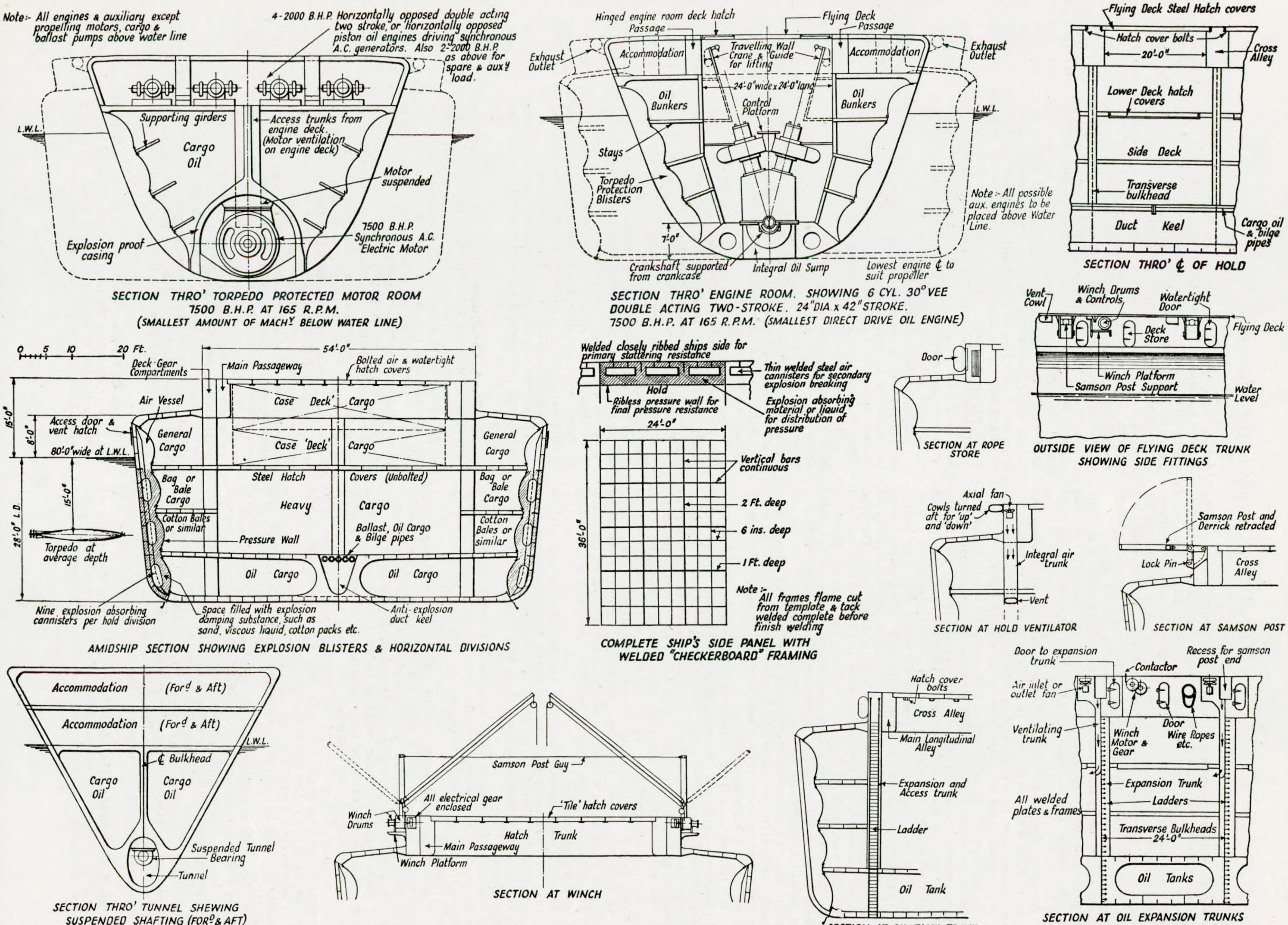


FIG. 18.—*Various sections and details of cargo warship (January, 1943, design).*

automobile characteristics. Geared oil engines were not proposed because of the very limited gear cutting equipment in this country; in the future it may be possible to import gears from the new American gear factories, in which case the position may change. A fundamental objection is the gearing noise—a well defined characteristic on hydrophones; it also entails having the engines below instead of in the tween decks.

Mr. H. D. Adam. Mr. Adam asks why we should not develop the submarine engine with generators; why not indeed. Sulzer single-acting two-stroke submarine engines have been built under licence in this country which would form an excellent basis type, so would the German M.A.N., especially as 16-cyl. vee engines and fitted with standard fuel injection equipment and turbo blowers. Such engines could be built in most of the auxiliary oil-engine works throughout the country in an efficient manner, with the minimum of novelty and experiment. Smaller engines with similar cylinders could serve as auxiliaries.

Mr. E. F. Spanner. One realizes onlv too well with Mr. Spanner that the breadth-depth ratio is large, but here the author would appeal to shipbuilding technicians to try and solve this problem, as it is a main feature of the design. The author did not give details of the type of framing but originally envisaged the use of longitudinal box frames—either pressed or fabricated and then welded —and transverse frames of inverted tee bars. The general idea was to depend more on framing and less on a stressed skin, so that large sections of plating could be blown away without serious effect. The use of welded joints and box sections opens up a completely new field and the author would recommend naval architects and ship draughtsmen to study air frame technique to make the best use of material.

Just as welding has made the German submarine a much more difficult proposition to sink, so should we use the same weapon against the submarine.

The idea of having oil of an inflammable nature adjacent to the side plating appears to me as a barbarous expedient of the first order, a mixture of viscous oil and sand may have possibilities, but the whole matter could be simply tested out in specially constructed test ships and torpedoes experimentally fired at sides with various internal constructions.

One advantage of the trapezoidal ship section is that explosion blast effects will tend to be kept off the deck.

There does seem to be evidence that oil gives support to shell plating in the case of tankers, and one would like to know how much better viscous oils (say, boiler oil) are than petrol or water or molasses or solids of fluid character like sand or grain. Centre division tanks appear better than wing tank construction indicating how the forces are transmitted.

Then the construction of the outer plating is important. It would appear that tranverse framing or transverse bulkheads tend to restrict or localize the longitudinal damage; certainly welding gives improved resistance. The author questioned the captain of a torpedoed Fort (Canadian) type of vessel recently which had butt welds, riveted seams and riveted frames; the amount of tearing was in the reverse order given, but the resistance of the welds was particularly commented upon. Important also is the evenness of the supporting frames and a sort of chequerboard secondary framing perhaps worth consideration is that shown in Fig. 18. This, of course, is only suitable to welded construction. This box framing will give a locking effect to the side chamber filling material or liquid, which should aid the supporting and damping effect and transmit a less violent pressure to the inner plating design to withstand high pressures. Personally the author believes that in the long run it will pay not to try to use the side protection spaces for bunkers or cargo purposes, but to concentrate on the most efficient permanent side protection even at the cost of space and deadweight.

In case of developments in this direction and to give an immediate protected place for either oil cargo or ballast, as well as giving greater bottom protection, strength of ship and vastly superior longitudinal distribution of cargo, the author proposes to revert to an earlier scheme which he evolved of using deep bottom tanks, not a double bottom but actual tanks some 8ft. deep with a central division. The expansion trunks are embodied in the vertical side bulkheads and the hatches are readily accommodated on the amidships side decks, reminiscent of tanker construction. A central upward supported duct keel will be advantageous to give protection to pipes. This construction is only made possible by the use of welded joints.

All practical experience seems to show that riveted joints are vastly inferior to welded joints, and on this count alone *a cargo warship should be all-welded.* Comparative experience of explosion effects on American-built welded vessels and British-built riveted vessels with similar hold sizes and cargoes is urgently needed. Generally speaking the author feels sure that down welding will show superior results to side or overhead welding, and machine welding will be best of all. *All of which supports the American policy of the maximum possible prefabrication and welding under the correct conditions.* The author's own engine experience of welded fatigue and impact tests fully confirms this.

The author hopes that Mr. Spanner's remarks on the need for improved steering will be noted. The author believes there are certain practical difficulties regarding Kort rotatable nozzles but this design does seem worthy of close investigation and drawing-board development.

The author has no knowledge of the Kort propulsion nozzle, other than that gleaned from the technical press and a paper on this subject in the current Transactions of the Institution of Naval Architects. On approaching the Kort organisation in London, they stated that the swivelling type of nozzle has, so far, only been used on vessels of small horse power and that they would not be prepared to put forward this type for the large powers proposed. Apparently, the fixed type of nozzle is much superior because of its strong attachment to the hull, thus affording an excellent guard to the forward propellers in particular.

The author is taking much of Mr. Spanner's advice regarding increased hold subdivision, the length of the holds is being reduced and means provided for pressure relief against anything but residual explosion effects.

The problem of the suggested deflated balloons doubtless will be the rubber shortage and the difficulty of preventing puncture following explosion effects. The author still prefers the airtight upper hatch and the use of compressed air to make good minor air leaks. The experience with certain tankers has been definitely promising in this respect. Regarding waste-heat utilization, as indicated elsewhere, lightweight schemes with forced circulation are required, whether steam or hot water is used.

The author expresses his thanks for Mr. Spanner's very helpful contribution to some of which the reply to Mr. Narbeth also applies.

Dr. G. S. Baker. Whilst there is no need for Dr. Baker to accept the author's assumptions or conclusions on details, there is a great need, a pressing need, for a practical scientist of Dr. Baker's renown to make his own investigations, unofficial or official, of the suitability of the design of the present cargo ships and constructions to withstand enemy action. The author's opinion, based on a fair knowledge of the facts, is that it is lamentable, however suitable the ships may be naval architecturally, to carry a given weight of cargo with a given weight of steel and quantity of propelling power in peace time.

The author wonders if Dr. Baker is aware that whilst a U-boat will be content to deliver a single torpedo at a cargo vessel it will invariably deliver three torpedoes practically simultaneously at an oil tanker.

The author is afraid a lot of naval architectural habits will have to be discarded; some of the vessels at this very moment being sunk doubtless representing the acme of tank tests and inherent stability, are sinking due to inherent capacity to sink when holed. All the author is suggesting is that more attention should be given to the prevention of ships sinking in war-time, and that the peace-time design considerations be put completely to one side for the present.

A Canadian minister was quoted in the press as having stated that twice as many ships have been sunk as have been replaced since the war started. The author suggests that that is a good enough reason to design cargo ships *specifically* to suit war conditions, just as one would design a gun or a tank *for war,* not peace. With regard to the unusual dimensions of the ship, a wide ship is to allow for the fitting of internal "blisters", the real "strength width" is nearer 65ft.; a wide ship is necessary to provide a suitable flying deck. The fine coefficient seems essential to reduce visible wake or bow-waves, but at present the author is more concerned with the capacity of the ship to survive than to agree with a peace-time ruling of ship proportions. On investigation a slightly bluffer ship may conceivably be possible, but it is doubtful. Certainly there are large differences in the visibility of the water disturbances of different ships from the air—this from my own air observation. As a matter of interest Fig. 19 is included; this shows water disturbance in smooth clear Mediterranean water; in disturbed Northern waters the "white" water is much more distinctive.

The author is very glad to have Dr. Baker's confirmation of the British engine position and is hopeful that something will be done to ensure—to use Dr. Baker's own excellent words—*a development effort proportional to the problem and its urgency.*

Mr. R. S. Blackledge. In view of the common marine practice of playing for safety in this country regarding marine auxiliaries, Mr. Blackledge's warning on over-motoring is timely for the high-duty war-time vessels.

Although it may not be possible to take marine motors from industrial stock shelves it is suggested that efficient industrial motor production should be utilized to avoid disturbing the customary "marine electrical firms" and in any case the former are frequently more used to standardized mass production methods.

For war purposes it would appear that a uniform voltage of 230-250 should be used as in land practice for lighting and auxiliary power purposes, and, as indicated, wherever possible single-speed squirrel and cage motors should be used.

With regard to ventilation fans the advantage of axial-flow fans with induction motors should be noted.

Although no mention was made of shock loads, the intention was to have the greatest amount of electrical equipment *above* the lower deck. In the case of many auxiliaries there is no need to adhere to the conventional system of locating most of the auxiliaries on the bottom platform level; some auxiliaries, starting air, jacket water, fuel separators and all generators are better situated above the water level.

If electric mean drive is used, the motors should be *suspended* from a deck and *not supported* from the ship's bottom.

The presence of the two longitudinal ship's alleyways for power wiring and piping should be attractive from an electrical point of view and this may facilitate the use of a cheaper form of insulation.

Two completely separated generating sets should make the all-electric ship attractive from a war reliability point of view.

Mr. A. E. L. Chorlton. The type of engine Mr. Chorlton developed for railway purposes is in fact a type which would be of great service. This engine was before its time and it is tragic that it was not continuously developed.

The author's reason for proposing an engine of aero-engine dimensions is quite definite and clear cut. The author wants to make use of the greatest internal-combustion engine producing industry with immeasurably the greatest capacity for technical research and development as well as having a mass production mental outlook.

For the power in question six of Mr. Chorlton's engines would be required in each engine room. By allowing for a mild supercharge there would be ample power even if one or two engines were continuously under overhaul. This is a type which should receive full consideration in view of the large amount of development work already put into it.

Eng. Lt.-Comdr. A. J. Elderton. The author agrees with Com'r. Elderton's remarks on the need for high-speed ships after the war to make good the deficiencies created by the war. The proposed ships could be designed with a view to rapid adaptation to carry say 50 passengers and by preparing a deck structure, prefabricated on American lines, the ship passenger service will be capable of rapid augmentation. Whether air transport will make this commercially worth while is another matter.

The author does not agree that because of detail technical difficulties the proposal to carry one or more aircraft should be dropped, and is confident a full solution can be found by using the available technical skill and knowledge. Not only is great experience available from aircraft carrier design but aircraft themselves are being rapidly adapted to meet specific marine requirements. Special bilge keels will require development to prevent rolling, and it seems that the addition of forward propulsion will reduce pitching to an appreciable extent. The control of pitching in particular suggests a new line for the application of fins and all existing knowledge should be garnered. Every care is needed in hull form design to ensure a steady platform.

The author agrees with Com'r. Elderton that the "Buy British" policy can be carried too far, but that generally speaking we want a minimum of trade; provided we get the article, trade and transportation are not in themselves productive. British workmen are better employed on articles requiring great skill with a large number of man-hours per ton than hewing vast quantities of say coal of a low rate per ton, and in that respect the development of the internal-combustion engine provides great utility, high-grade employment and the minimum use of raw materials. National encouragement is therefore needed.

The author is glad to have Com'r. Elderton's specialist remarks on economic exhaust utilization.

Mr. F. McAlister. In view of the paramount importance of finding a solution to the U-boat menace the author considers that all who feel they can contribute constructively to the development of a cargo warship should do so even though busy; now is not the time to stand on ceremony and better late than never. The author is glad to have Mr. McAlister's authoritative figures relating to propeller efficiencies at different speeds on record.

The author is sorry that Mr. McAlister should consider he favours state control. God forbid! We are suffering to-day from excess of semi-technical dictatorship in the subject under consideration; we shall have to progress a long way further in the mechanism of selectivity to positions of technical control before one would consider such a thing.

National *assistance* is suggested. The author uses the terms *support, foster* and *encourage,* to aid a wide variety of designers of ship and engine types. Whilst the Government can well limit easily earned war profits, it should simultaneously foster "the geese that lay the golden eggs", whoever may consume them.

The author also mentions *regional* establishments and development *stations*. Technicians as well as politicians can be dictators and competition should be encouraged. One would like to see far more "vertical" and less horizontal control of establishments. The fact that a man may excel at amassing "bawbees" or be particularly skilled at one branch of the art, industrial politics or science of engineering is no reason why he should be allowed to control more than the branches in which he is most knowledgable.

Mr. C. T. Adams. The fact that the Admiralty is in full possession of the facts about sinkings does not imply that a fair idea of the situation is not known to others, nor does it imply that the best use is made of such knowledge and records, or even that all necessary records are kept. There are such things as departments; moreover recording staffs are seldom designing staffs. The author has attended many ship casualty meetings, but confesses that he has never known a ship designer to be present or for that matter a marine-engine designer.

The suggestion that six ocean-class vessels could be built instead of one cargo warship is surely wide of the mark, especially when no such welded ship has yet been built in a British yard.

With regard to the use of steam turbines and water-tube boilers, the author certainly suggests they should be used but would like simultaneously attention to be given to oil engine designs. More than eighteen months ago the author got out a design of steam turbine installation with a well-known firm and established that on weight, man-hours and space it was superior to normal oil-engine types—hence the suggestions to encourage new oil-engine developments so as not to lose the great fuel savings possible. Since that time the fuel situation makes fuel economy an even more important consideration, *but certainly not more important than having a special war-time ship.* Mr. Adams's explanation of the failure of British marine-engine builders to adapt or better still to innovate is not far from the truth. The fact must be admitted that technologically —however good our craftsman—the British merchant shipbuilding and marine-engine industry is backward and lacks vigour, initiative and imagination.

Mr. Muckle. After attending innumerable enquiries on vessels sunk by torpedo action the author is convinced, as is Mr. Muckle, that the problem of making the weather-deck hatches airtight is not serious, as the explosion force is frequently largely spent. The deck is usually completely undamaged and often only some of the wooden hatch covers are blown in to the air. This depends on the draught and cargo. The author feels confident that given proper side protection and with protective explosion breaking lower decks, the air-tight main deck problem is not insurmountable. The author postulates simultaneously side as well as deck protection.

The degree of subdivision by strong transverse bulkheads would appear to make serious loss of stability due to the flooding of the lower decks extremely improbable, especially when the presence of ample oil tankage makes adjustment of trim a relatively simple matter.

As indicated elsewhere, further thought has caused the author to abandon bolted-down lower-deck hatches and to consider only simple lightly-bolted flying deck hatches which can lift to give pressure relief to serious explosions and yet be made adequately watertight and airtight in most cases.

The problem of the longitudinal strength is eased by the new arrangement of the decks, but the intention was and is to use welded longitudinal box girders both for hatch coamings and along the ship's bottom.

There is now *ample* evidence that the present design of raised hatch coaming is quite unsuitable to war conditions as it forms a stress raiser of the first magnitude; a ship torpedoed in say No. 2 hold will often crack immediately abaft No. 2 hatch coaming and so on. Therefore the flush flying deck proposed is not so odd as may be supposed. As for the gunwale the normal construction constitutes a shocking stress raiser which simply is not suited to war conditions and the common German warship practice of a rounded gunwale must be followed. The modern engine or aircraft designer's attitude to stress concentrations must be applied to ship construction; this eliminates anything but a stream-lined construction; the rivet hole and the patchy construction riveting necessitates have no place in cargo warship construction.

A war-time cargo boat must be able to stand a volley of three torpedoes and survive. The author believes this can be done by the application of dynamic lessons to ship constructions.

By the fullest use of welding, with careful design the light weight of the vessel will be little more than that of a present day riveted tanker as the use of welding itself contributes a saving of 15 per cent. to work on.

The modifications to the orginal design will meet most of Mr. Muckle's criticisms, but any further co-operation will be greatly welcomed. One of the very first things to do is to take the out of date Tonnage Rules, bury them, forget them, and start with a clean sheet of paper.

Mr. J. E. Church. Mr. Church suggests a cargo submarine; undoubtedly for special purposes, for example supplies to Malta, or similar difficult ports, the use of cargo submarines is an obvious solution and in various forms are no doubt used by the Germans, but for the bulk of traffic the author feels a thoroughly adapted but much larger surface vessel will suffice. The technical difficulties of a submarine increase with size.

Is the 400ft. enough for landing aircraft? It is believed so provided the aircraft is adapted with extra flaps and a retarding wire pickup; there is, however, a type becoming available which has unique advantages for this special duty.

Mr. Church suggests the flying deck should be continuous and as a result of further investigation the author now suggests a rather important change to the method of airplane take-off. Instead of using a catapult forward the latest proposal is to fit a turntable in the hangar to enable the aircraft to be turned round 180° to take-off towards aft. In view of the long run available (425ft.) and recent developments in sea fighters, this is considered practical for take-off. The ship will preferably turn out of the wind and may reduce speed somewhat or it may even reverse into the wind. The bow propeller and rudder giving full control astern.

Instead of the two control towers a single low "U" shaped streamlined bridge structure is proposed, the centre serving as the hangar. The A.A. and A.S. guns are now placed at each end of the side decks well out of the way.

The structure is low enough for aircraft to fly over if a false landing is made and the silhouette of the bridge is curved and sloped to reduce the visibility, all sharp perpendicular outlines being eliminated. In spite of the increased freeboard of the flying deck the surface visibility is reduced rather than increased. This construction gives a perfect central control room and makes the fore part of the vessel much more ship-shape.

A central telescopic periscope will give range of vision—to the man in control. During landing the periscope would be lowered.

It is believed that the air stream can be controlled by proper shape of the bridge structure and if necessary, any degree of synthetic wind from electric fans or scoops in the bridge structure can be made to concentrate and stabilize the air stream over the flying deck.

This construction eliminates the mechanical objections to the former hangar door and nozzle, and will, it is believed, make a greater appeal to seamen in view of the spacious bridge with reasonable vision. The influence of aircraft design will be apparent.

The author is indebted to Mr. Church for constructive suggestions regarding the crew accommodation. This has been moved further away from the ends of the ship as he suggests. The author has also moved it towards the centre of the ship and the alleyways are now less likely to be flooded and are better protected. For war conditions side scuttles would appear to be unsuitable and the author suggests should be completely dispensed with for the present. After the war, deck skylights can easily be fitted to give ample natural light. Two accommodation decks will be an improvement, officers above and men below, deck and engine-room crew being mixed for'd and aft. The author agrees completely on the need for radical improvement of sailors "sea homes". The American C-class of ship gives a precedent for first-class crew accommodation which is also fireproof to a unique extent. The men's accommodation on new Swedish ships should be a guide.

Mr. E. A. Beavin. The protection against air attack has been considered and in fact that is the major reason for carrying fighter protection. This is considered far more effective than the provision of a heavy A.A. barrage, as Mr. Beavin's instance of the four destroyers fully substantiates.

If these vessels sailed in small convoys of, say, six vessels, a protective escort of six fighter aircraft would not be taken lightly. The object of the flying deck is to permit these fighters to re-alight and refuel at will. The author believes great improvements have been made in the capacity of certain new Allied types to take off and land and that further improvements in future will be made in this direction. If, however, increased lengths or widths are needed for a cargo warship they must be provided.

Certainly the deck should be lightly armoured forward and aft, especially in way of the accommodation and the machinery.

The author is glad Mr. Beavin emphasized the improved surface-raider immunity of the cargo warship. The aircraft would be able to deal with all smaller surface vessels and daylight trailing submarines would have a "thin" time. The essence of the scheme is to provide such a ship design as will enable the fullest use to be made of high performance fighter-bomber aircraft as a routine protective measure without making too great demands on the courage of our airmen or the technical quality of the aircraft.

Mr. J. L. Kent. The author is glad Mr. Kent has made the historic reference to the use of cargo warships in Elizabethan times —that glorious era of British marine power.

Regarding the vessel's displacement, the author had hoped this would not exceed 18,000 tons by using a welded structure and high-duty engines, and therefore ensuring a moderate light weight; this with the fine coefficient proposed suggested a power of about 14,000 s.h.p., but in deference to Mr. Kent's specialized knowledge let us assume that a service power of 15,000 s.h.p. will be required to give a speed of 18 knots for a ship of this type.

To ensure an undetected race let us also assume two equal small-diameter medium-speed well-buried screws situated no more than half the propeller diameter from the ship's bottom.

To give security of mobility the author feels that some bow propulsion is essential. Mr. Kent suggests a more equal distribution of power forward and aft. Bearing in mind his remarks on the need for a bow wave low in height and broad, this suggests a fine bow line and to obtain this twin forward screws may be required or an open single screw. Here there appears to be definite possibilities of controlling the bow wave not only by giving the optimum bow form but by direct suction effect of the side screws by placing them in the correct axial location on the ship's side.

Once one adopts electric propulsion one has great geometric, and to a large extent economic, freedom of action. This confirms the author's deep impression that the future lies in electric propulsion to give the requisite flexibility of design.

In the revised ship arrangement drawings (Plate 3) the author is showing the combination of spade rudder and propeller boss fairings which has always been his particular favourite as a result of considerable model making. To the eye it looks good with the bow propeller, as it makes a sort of hydrodynamic bulbous bow and clipper prow combined. No doubt it could be made very efficient. The spade propeller confers more work on the engineer, but with welded construction a beautiful underwater form could be obtained. The reduced forefront will have manœuvrability merits.

Mr. W. F. Spanner. The question of increased subdivision has already been dealt with, but Mr. Spanner's suggestions regarding the use of free surface correction of the fuel oil to give a normal *GM*, if a number of holds are flooded is interesting, especially when considered with very novel ancillary "buoyancy lifebelts". A defect would be that speed would require to be reduced, and it does seem desirable for our cargo warship always to be capable of running away; it is however a new line of attack which needs consideration, especially for existing vessels.

The use of distributed power units is bound to come. The author started with two sets of machinery, now it looks as if four sets are both possible and desirable, until air attack becomes much more dangerous. The author would suggest that if one has as many power units as screws this should be reasonable and four units will give immense security compared with the present single-screw "thumper".

Reduction in propeller and machinery noise can be effected by running each propeller and its operating generator out of step. The governing of Diesel-electric units can be made as simple as turbo-electric by feeding each motor with a separate generator.

Mr. D. W. Gelling. It is agreed with Mr. Gelling that the dimensions of the proposed cargo warship will impose a restriction on the number of ports that can be used without alteration, but as long as the draught does not exceed 28ft. this restriction will not be serious.

It is also agreed that more than two lifeboats are desirable, although it is pointed out that each lifeboat could accommodate the entire crew. It is also apparent that there should be no oil tanks immediately below either the lifeboats or for that matter the accommodation.

Surely 1,500-s.h.p. is considerable for 9 knots for a ship of the proposed size and lines when one considers the customary powers of tramps; as will be seen from replies to other speakers it is proposed to augment the bow propulsion to 7,500 s.h.p.

The need for duplication and flexibility of ships' side valves is now apparent and the suggestions made are noted for future consideration; has Mr. Gelling considered cast steel chests welded to the plating? The suggestion of white-metal lined nuts for use with the main hatch covers is also well worthy of consideration, instead of spring devices. The crane posts were to serve as *forced* outlets only; the latest proposal is to fit the mechanical ventilating inlets and outlets further inboard incorporated with the main trunk longitudinals.

Will the lifeboat protruding doors become jammed? Sometimes certainly, but the author thinks not often with careful design, whereas the present system of exposed lifeboats has a very high casualty rate.

Mr. Gelling's last remark may be prophetic.

Meantime as a means of giving greater immediate security and also increased speed the author suggests that the latest American Liberty ships should be fitted with a bow Diesel electric unit. Careful prefabrication in a unit would make it simple to fit.

The author also suggests side protection is also an urgent matter for our American allies to take up as existing welded vessels could be readily adapted to blisters.

Mr. W. J. Middleton. The example of American production has demonstrated what can be done in the way of building shipyards if the will is there behind it, and the author suggests to Mr. Middleton that there is no objection to getting Americans to aid us in this respect in view of their proven capacity. As in America, it must be conceived and executed nationally with national finance; when all is said and done the Treasury has already agreed to build special national shipyards *in America;* why not in Britain, why not on the Thames?

On the subject of commercial suitability of the use of small engines and maintenance rather than repair and overhaul by the ship's engineers, this is a world tendency; it occurs with the London buses, the Diesel trains of America and is the rule with aircraft. Personally, the author thinks there will be a surplus of small engine building capacity after the war and works overhauls and replacements will be cheap and good. At any rate it should be noted that Germany was rapidly leaving the mammoth oil engine in favour of the smaller multiple unit system before the war and Germany has always had a prominent place in Diesel developments.

Not only new shipyards are wanted but new national engine works—unless we use existing nationally-financed aero engine shadow factories with an existing organisation and mentality for mass production.

There is much to recommend the use of forced-circulation boilers; the La Mont boilers for example could be arranged in the after tween deck very satisfactorily, but the author would prefer electric to geared drive for reasons stated elsewhere.

The experience with cast steel crankshafts is noted, but a lot depends on the design. The pin or journals should be plain and hollow and not integral with webs. There are castings and castings, but fundamentally there is no objection.

Mr. Middleton's remarks on post-war conditions are noted but the author thinks a Government subsidy could make up any deficiency. It is of course vital that even in war-time the vessels should be efficient cargo carriers, and it also must be remembered that post-war conditions will not be pre-war conditions even in shipping; the vast national interest America has taken in shipping has completely altered the centre of gravity of shipping, and the author suggests we shall require "all our buttons on" after the war.

Mr. F. A. Hunter. A fundamental point is raised. Should we have large engines of low ratio per unit weight constructed of easily obtained materials to enable repairs to be effected all over the world, *i.e.* large marine main and auxiliary engine practice as exemplified in Plate 2, or should we have small highly-rated engines of specialized material and workmanship which must be replaced rather than repaired. If one contemplates the ubiquitous V8-Ford with its superlative crankshaft and main working parts and its distribution over the earth's crust, or the aero engine with its highly specialized parts, the answer for the future lies in the smaller specialized engine with organisation for replacement and *only one size of engine cylinder throughout the ship.*

Large engines are too laborious to repair. The engine in Plate 2 would have a bottom-end bolt over 3ft. long and 6in. in diameter; the split pin makes an excellent poker: the small double-acting engine with a 7½-in. bore would have a bottom-end bolt 1½-in. in diameter. The author asks any practical engineer which he would rather handle?

The author agrees with Mr. Hunter's suggestion regarding the allocation of the crew between the forward and aft accommodation.

Eng. Com'r. H. F. Harold. The 12-knot ship with *Diesel* engines would use little more than a quarter of the amount of fuel oil. After the war it would be a simple matter to fit smaller engines to the cargo warship built up of parts of the more powerful war-time engines and have a splendid supply of spares to draw upon.

The author agrees that reliability is a first essential, hence the attractiveness of the multiple-unit scheme and electric drive. Then any speed can be made economical and alteration after the war would be the absolute minimum. This is where the oil engine has peculiar advantages over the steam turbine.

After the war there will be a surplus of high-grade precision factories to supply all engine parts for such installations.

If cargo warships were sold after the war to shipowners at a low price it would be at any rate a more economic proposition than the disposal of say tanks and guns to the scrap merchant.

Mr. J. H. Narbeth. Mr. Narbeth's tribute to the memory of those of our members lost on active service is fully appreciated. His extremely helpful contribution will serve to awaken greater technical interest, to cause engineers to think as well as to serve.

There has been too much tendency to rely on the "Government" to solve our problems instead of all making our own individual contribution, and the suggestion of a symposium of information contributed to by members regarding the effect of enemy action on ships will most certainly be considered by the Council.

The explanation given of the physical action of an explosion is informative and graphic, likewise the effects of these on various naval vessels. The need for the elimination of ordinary wood is demonstrated and it is here worth commenting on the excellent steel and asbestos panelling used on American Maritime Shipping Board vessels which combines beauty with utility, a combination which has always been so appealing to Mr. Narbeth.

In the case of the cargo warship the author hopes the accommodation partitioning will be an integral part of the ship's structure and well away from torpedo or mine action.

The suggestion is made that the inner shell or side bulkhead be continued to the weather deck and in the modified design this is done. The author has, however, given further thought to the optimum shape of the side bulkhead and is reminded of an incident concerning his late chief, Mr. D. B. Morison, when he was perfecting the corrugations of Scotch boiler furnaces. The scene was the courtyard of a well-known hostelry in the upper Tyne valley, the action was doubtless the quaffing of ale. In the line of vision were hanging chains, mentally inspirated he connected catenary curves and constant loads per unit length and the optimum shape of a corrugation in a boiler furnace. The result was the well-known Morison furnace. The problem of the inner side bulkhead is one associated with external pressure and strength and elasticity and freedom from stress concentrations, and can best be obtained by giving the plates a natural form. The author is therefore proposing four supports and three corrugations of suitable curved formation to suit semi-radial pressure loadings.

The lower deck has been raised and a further bottom tank deck added. These light decks will support the sides and cross bulkheads and protect the weather deck and hatches as well as facilitating war cargo stowage.

Mr. Narbeth remarks on the supporting effect of oil cargoes and the value of coal in damping explosions. This suggests the use of a specially suitable "filler" in the side explosion chambers. A material that suggests itself is sand; grain size, type, whether loam or sea sand, to be a matter of experiment. This will enable the side chambers to be made much smaller. Sand would absorb energy, distribute the pressure and absorb the shattering effects of the outer skin.

The effect of different cargoes on the damage to the shell plating is interesting, bulk cargoes like oil, grain and the like, seem to be the worst, bale and box cargoes are better, and best of all are well-packed bales of cotton or sisal. The relative ineffectiveness of oil is demonstrated by the fact that whilst wing bulkheads in oil tankers are burst asunder, centre bulkheads often are not. Oil, from this point of view, is too efficient a transmitter of pressure waves.

The more efficient the blister "filler" the smaller the blister and the more cargo can be carried.

A cargo of cotton bales below the main deck is known to be beneficial in preventing deck damage, and a hold packed with cotton bales—as would be expected—causes the extent of the side damage to be greatly minimised. In fact a 12,000 ton ship with holds say *24ft.* long and air tight hatches would be almost unsinkable if loaded completely with bales of cotton.

Alternative suggestions of materials for filling the blisters are, air-tight iron canisters, canisters filled with cotton or sawdust, bundles of wood branches, cotton in small bales which will "fit" the chamber walls, small round wood pit props. The latter seems a practical suggestion as the space could be tightly packed thus giving support, air spaces are formed and the wood itself has good damping properties which would take the brunt of the explosion.

These and other alternatives have been considered by the author and a solution evolved which is shown in Fig. 18, which makes use of a light welded "chequerboard" outer shell, a corrugated inner shell supported on girders which has no framing whatever, *i.e.* it has the absolute minimum of stress concentrations so as to withstand very high bursting gas pressures.

In the centre of area of each bulge is fitted a welded light steel airtight canister, strapped to the outer plating. In the intervening spaces is sand cotton. The expected operation is as follows:—

An exploding torpedo is resisted by the sand supported ribbed outer plate, the plate is forced inwards, bursting the air cannister, and the reduced pressure transmitted via the sand to the flexible corrugations which are designed to stand uniform straining action.

Because of the fundamentally correct shape of the inner skin quite high pressure of the order of hundreds of pounds per sq. inch should be withstood by plates of normal thickness as considerable plastic strains can be withstood *provided* the conventional stiff but weak structures with rivet holes, angles or bars are eliminated.

Even the top and the bottom of the corrugated side plate are free of connection with any ribs or beams.

Whilst the width of the hold is about 24ft. the explosion chamber is divided into nine transverse compartments or divisions.

All these new constructions are only possible with welded-plate joints.

When an *explosion occurred a few yards away* from the side of an ocean boat which has welded butts and seams the effect was just to "billow" the plates about the frames in a manner *never seen with a riveted ship.* The author is confident that a welded chequer board framing would have given even better results. In the above case the outer wall was analogous to the author's proposed inner wall, but with water as a medium and the incident support the suggested inner blister wall.

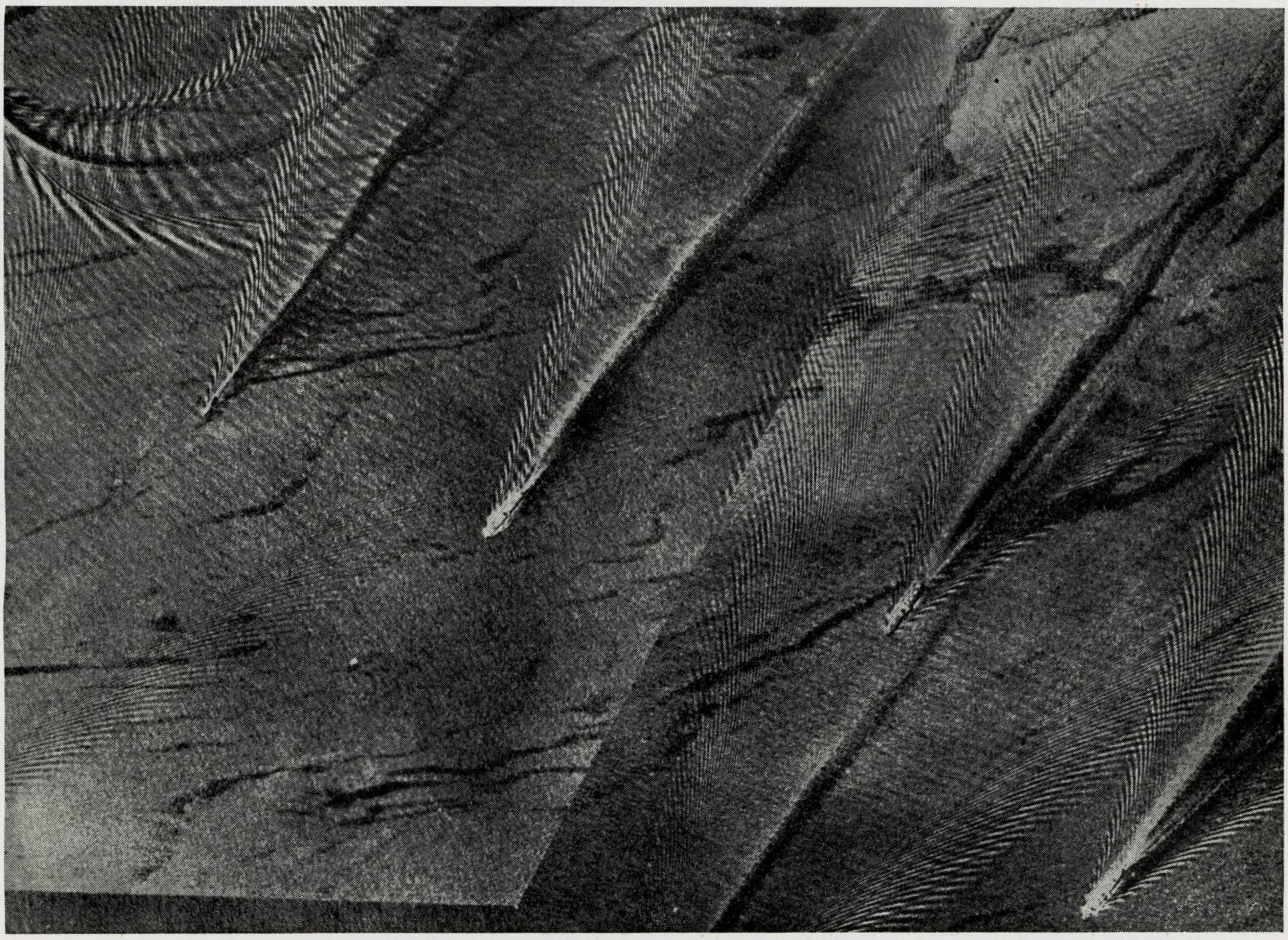


FIG. 19.—*Aerial photograph of bow waves made by ships in convoy.*

The author thinks there is evidence that longitudinal framing tends to elongate the torpedo explosion apertures and must be associated with strong and close transverse bulkheads to prevent this. On the other hand with transverse framing in the case of a well-laden ship the explosion can cause the explosion rip to extend up the topside and round the deck. Longitudinal strength below the gunwale and above the bilge keel seems desirable to limit the tear. Again, however, the "chequer board welded on framing" seems to be the ideal "tear" localiser.

The freeboard has been increased, the conning towers moved further forward, the cranes are retractable and at sea are below the central trunk flying deck which is not unlike the R.F.A. "Attendant".

As far as this country is concerned the author firmly believes in the aero-engine type and is glad to have Mr. Narbeth's support.

There is much to be said for Mr. Narbeth's suggestion of three screws aft like the "Ark Royal", the centre screw to give rudder control and side screws to give rapid turning. Given electric propulsion with control of the relative propeller speeds from the bridge we have the ideal solution for rapid swerving. The author, however, does wish to retain a forward propeller and simplicity suggests two single screws to start with.

Criticism has been made of the height of the cranes above the flight deck, but it should be borne in mind that a high-wing aircraft was intended which, moreover, the author still believes is the correct type for ship-based aircraft. However, an alternative proposal is being made for hinged derricks which will make possible the use of low-wing aircraft.

It would be a pity to sacrifice the cargo-carrying part of the ship by having an amidship side structure as in most aircraft carriers, as the *raison d'être* of the vessel, the carriage of cargo, must be given first preference.

Many alternative solutions of the landing, take-off and the storage of the ship-based aircraft have been considered. Advice has been received that not less than 150ft. is required for catapulting instead of the 100ft. allowed in Plate 1.

The vulnerability to sea and weather action of the forward hangar door is admitted, as is the desirability for high freeboard forward to facilitate take off in Atlantic weathers—stated by one high authority to be not less than 30ft. This seems to indicate that it may be better to abandon the forward take-off altogether and take-off astern along the flight deck. Once a decision is taken in this direction it is possible to move the bridge structure forward, and thus increase the length of the flight deck to 425ft. It is also possible to give greater protection to the flight deck without undue aerodynamic interference, and to protect a lift and turntable arranged in the centre of the bridge structure, whilst at the same time maintaining a low visibility and making no encroachment on the cargo space.

This alternative construction will give many good features from a ship point of view.

Mr. Riddell. The author is glad to have Mr. Riddell's interest in bow propulsion and is particularly pleased he has suggested the possibilities of the Kort nozzle. The author may have overstressed the importance of man-hours, but the problem of man-hours is hurled back at one whenever an innovation is suggested, and therefore it has a real significance apart from any fundamental issue.

It can be readily established that the number of merchant shipbuilding man-hours is quite an unreasonable proportion of the total man-power effort, and no real expansion as in other war industries has taken place. No new shipbuilding or mass production schemes have been permitted in this country as in America, where in one new shipyard as many men are employed as are employed on the whole of British merchant shipbuilding, according to a broadcast to America by the Controller of the Navy.

Status quo and proportional increments in the productivity of existing yards appears to have been the order of the day, rather than the national interest first.

The figure of 15 per cent. increase for the cost of a cargo warship hull compared with a tanker of equal displacement is perhaps not far wrong after a number have been built, but the high power of the engines does introduce a very real addition in man-hours, unless mass-produced engines are considered.

A really up-to-date geared turbine installation of 14,000 s.h.p. whilst weighing no more than existing 2,200 s.h.p. reciprocating steam engines will absorb four times the man-hours. The turbo-electric would require five times as much and the direct-drive oil engines six times as much, assuming a conventional but efficient arrangement.

In fact the man-hours of the oil-engine installation would be a substantial part of that required to build an entire ship, and the author thinks if one said a cargo warship would require twice the man-hours it would be nearer the mark, without machinery innovations.

The number of man-hours required, however, entirely depends on the *design* of the article and the *production organisation.* For example, the author imagines the difference in man-hours to build a standard ship throughout the shipyards in America is very considerable and the lowest will be a *vast* improvement on pre-war figures of a vessel of similar size. In this country the author imagines production man-hours of a standard aero engine has been reduced to a fraction of that required in pre-war days. An analysis of the relative improvement in man-hours made for aero-engine and marine engines would be, the author imagines, *politically illuminating.*

Mr. Riddell's analysis of the propulsion problem does not take into account the need for high propeller revolutions to reduce man-hours and if one is limited to a given propeller speed it will be found that the scheme proposed is the most efficient from a propulsive point of view, apart from the actual design of the forward propeller. The author does think, however, that the forward power should be increased to 7,500 s.h.p., *i.e.* about that of a standard cargo liner, and that this power should be continuously in use to bring the total power to 15,000 s.h.p.

The use of a Kort nozzle for this bow unit would appear to be well worth full investigation.

As to whether the powers at bow and stern should be equal or not should, the author thinks, be settled by tank tests. A year ago the author got out a completely double-ended ship, as from the machinery point of view it has many advantages especially if oil engines are used. If turbines are used then the scheme as proposed has advantages, especially when using the single-reduction non-reversing geared turbines aft and Diesel-electric forward, all manœuvring being done by the forward propeller, the Diesel-electric also providing the port power requirements. Such a scheme has many good features, the elimination of a reversing turbine being one, and the spreading of engine types another.

The possibility of more rapid steering with reduced heel, directional stability and the possibilities of reduced pitching and vertical lift all encourage bow propulsion. One point the author would stress is that the bow and stern propulsion units should be entirely separate and so should be pumping units; cross connections will lead to complication and risk of both being put out of action.

An ideal application of the Kort nozzle would be in connection with the lifeboats; "ring" propellers are now being fitted to avoid injury to men in the water and the rotating nozzle would appear to offer definite advantages for this vital purpose.

Mr. Riddell suggests inclining the nozzle downwards to avoid wake effects. This would apply equally to the bow and could in fact be made to reduce materially the effect of the slip stream from the forward propeller on the hull.

In view of the great experience our American allies have of building Kort nozzles for river craft and also the great experience they have of large double-ended ferries, the author strongly commends them to consider the possibilities of bow propulsion. As they have available the ideal vee two-stroke engines for Diesel-electric propulsion of such a forward propeller of say 3,000-4,000 s.h.p. in two or three units, there should be a minimum of delay in the application.

After further thought about the draft the author has decided to increase this to 28ft., that is to a tanker draft rather than that of a cargo boat, as it will always be invariably possible to discharge oil cargo first. The increased draft improves the propeller immersion.

Mr. E. W. Blocksidge. The author is glad to have a contribution from Mr. Blocksidge to focus attention on a matter which concerns members of this Institute so very actutely, namely the need for lifeboats to be adapted to war conditions and not merely to B.O.T requirements based primarily on peace-time marine risks. The general design of Plate 1 made the inclusion of more than two lifeboats difficult, but with the elevation of the flying deck it is now possible to adopt Mr. Blocksidge's suggestion and fit in two additional boats, all four boats being arranged as high as possible above the side decks on sloping launching rails. As the lifeboat housings are nearer amidships, sea conditions will be better. A point to bear in mind is that no oil cargo will be allowed near the boats or the accommodation, and the later two are now adjacent in all cases.

The author is glad to have a confirmation regarding the need for larger lifeboats with suitable launching gear. Most present davits are *most* unsuited to war conditions, and the practice of having the boats outboard results in a large proportion of boats being hopelessly damaged by torpedo blast before being used. The revised design of lifeboat accommodation is shown in Plate 3.

Mr. J. MacGregor. Whilst it is not anticipated that the internal wall of the blister will be undamaged, it certainly will be damaged to a much less extent than the outer shell plating and will prevent major effects in the holds and the usual havoc with bulkheads and hatches. The author looks on the blister as the first line of defence to restrict hold damage. Further thought on this subject even suggests increase in the ship side protection as indicated elsewhere.

Coming to the problem of hatch-cover construction, Mr. MacGregor's suggested hinged lid construction is very neat, and although for the present the author is retaining plain sectional "tile" steel hatches, he is glad to have this further confirmation of possibilities from a hatch specialist. In the modified design of ship the author is showing the hatch covers on the main deck bolted down, and in the case of lower deck hatch covers these are of similar construction held loose. No fixings are suggested to the lower hatches as the weight of the cargo in the upper holds will weigh down the lower hatches to "break" the blast effect. The main deck hatches are free to lift slightly and return and by means of rubber "sausage" joints they can be made air- and water-tight, the lands being steel to steel to ensure the flush fitting required for the airplane runway.

The author agrees with the suggested reduced height of upper hold and does not use the term 'tween deck, as the length is only that of the lower holds. The additional deck and the vertical bulkhead trunks made the double bulkheads unnecessary, especially as the hold length is reduced to 24ft.

Regarding the use of telescopic samson posts the reproductions in Fig. 20, by Gordon Nicholls, the artist shows such a construction in a design got out some two years ago. The design the author now prefers adheres to the use of derricks, but the mechanism is located in the flying trunk sides and the same on posts hinged from the central trunks above the side decks. The proposed raised flying deck makes all this possible and the hold is much clearer of crane rooms and alleyways.

Second thoughts suggest that the ventilators should be separate trunks built into the transverse bulkheads and likewise the expansion trunks of the bottom cargo oil holds.

Mr. H. Mackegg. This is precisely the sort of constructive suggestion desired from a specialist on oil purification. Here is a case of how it is possible to get an increase in capacity of 250 per cent. for a weight and man-hours increase of about 20 per cent. The author believes the same feature will become apparent with many other rotary auxiliaries, such as turbo blowers and centrifugal pumps for jacket water, ballast and cargo oil.

The same thought was in the author's mind when he reckoned the direct-drive oil-engine to be as large as customary machining and handling equipment would permit with efficiency.

The author completely agrees with Mr. Mackegg's ideas on high-capacity centrifuges.

Mr. Robert Welch. The author is grateful to Mr. Welch for his constructive contribution on steering; all he says is concurred in and the author trusts that his suggestion that models of double-sterned ships be tested out exhaustively at the N.P.L. will be noted by the authorities and acted on without delay. By all means let us have some practical evidence as soon as possible.

It is noted that Mr. Welch favours equal powers at both ends and the author trusts the advantages of the Hydrogap rudder will be applicable to a fine lined twin screw ship as well as single screw.

One reason for the fixed bow in Plate 1 was to allow the normal minesweeping gear to operate and this also caused the author to try to find a solution to an "enclosed" bow propeller. Such an enclosed design is worth expert investigation, but this must be left to specialists in such matters; the logical development is no doubt the "Kort" nozzle if closed propellers are considered.

The use of electric propulsion motors and twin screws would enable a large measure of directional control to be effected by instantaneous control of the speed of revolution of each screw.

Mr. E. Sutton. Mr. Sutton asks if speed is a principal factor of immunity. The author thinks that if the evidence of sinkings is carefully sifted the answer will be yes, but it will be doubly so if the vessel has low visibility, is difficult to detect from under water and yet fitted with good means of submarine detection so that our vessel can show a "clean pair of heels" to the submarine ascertained to be in the vicinity.

Not so many ships capable of 18 knots have been lost *whilst travelling at this speed,* most cargo liners having speeds much below this.

A point which must always be borne in mind is the great on-cost of naval escort, and the vast shipbuilding effort absorbed in providing ships of no direct cargo carrying capability.

The target area is certainly not 40-45 per cent. greater than that of a standard vessel; a projection of the vessel must be made in line with the direction of the bomb. It is the dive bombing or low bombing attacks which are dangerous, when the bomb has a considerable component of horizontal velocity; low freeboard and rounded gunwales help to reduce the target area. The author would say there is little or no increase—the modern cargo liners 72ft. wide will have a greater target area. In any case the control and power units are duplicated in the cargo warship and will therefore be difficult to put out of action.

Coming now to the question of speed and cargoes carried, the *reductio ad absurdum* is of course that given a long enough period in port high voyage speed has only a minute effect. One must, however, assume rapid and urgent loading and unloading and that is why the author suggests the fitting of high speed cranes and clear hatches and the greatest use of the "belly" of the ship.

Given an adequate system of engine maintenance and preferably a number of indirectly connected engines, to ensure that cargo handling *solely* dictates the time in port, the author suggests that a reasonable time in port for a vessel of the cargo capacity (bearing in mind at least one-third of the cargo can be pumped out) is five days and not a day longer. He knows of several cases of 7,000 ton general cargoes being discharged in Glasgow in five days. The smaller holds could facilitate a measure of simultaneous unloading and loading. One of the great advantages of either "lone" vessels or small convoys is that they do not cause congestion of the ports. The author has observed the port cyclic operation with the convoy system with interest. Another point—it will be possible to use many ports now almost unused. Yet another point—who would suggest that British ports do not need overhaul in the way of unloading and loading equipment? This is where we can learn from our friends on the other side of the Atlantic just as much as in modern methods of ship and engine building, and during the next year or so considerable improvements can be reckoned upon; already during the past year improvements have been effected. Mr. Sutton's time of 17 days to cross the Atlantic is a reasonable but good figure for to-day, but the author thinks his figure of five days for assembly and other delays is on the low side taking the average. Convoys to other parts of the world are not so good and the author thinks an average speed of 5 knots loading to unloading would be quite good. As the length of the voyage increases so the value of high speeds becomes more apparent. The effect of time in port does emphasize the importance of reliability of machinery and indicates electric propulsion with multiple units that can be overhauled at sea. All this supports either turbo or Diesel-electric and any extra man-hours needed for their manufacture will be fully justified subsequently.

Regarding many of the constructional points raised, these have been in the main dealt with in replies to other contributors, but the author would like to emphasize the need for low visibility; he thinks it will be found that submarine commanders will fully support this aspect; a submarine itself is a tricky bit of work just for this very purpose, and this elemental fact must be well and truly appreciated.

A number of criticisms have been made regarding the abnormal ratio of breadth to depth of the proposed vessel from a structural point of view. To such critics the author would say, what about the structure of an aeroplane's wing? There is no reason whatever why by using welded joints and special framing, only possible with welding construction, a strong and yet light structure should not be evolved far superior to the present riveted structures.

At any rate the author cannot imagine anything so lamentably unsuited to war conditions as the present design of cargo vessel, as proven by the thousands of sunken ships.

Regarding the cubic capacity, etc., the author has no doubt that as the design develops this will be made all that can be desired for war requirements.

Oil cargo is considered primarily as a means of controlling buoyancy. The author is quite certain that it will be possible to give 95 per cent. immunity from sinking by three torpedoes; the present cargo vessel does not enjoy a 5 per cent. immunity from one torpedo.

The lower decks would not be watertight, merely explosion damping.

Regarding the main propelling machinery, in the author's opinion the logical thing to do would be to start with turbo-electric machinery and follow on with Diesel-electric machinery, but development for the latter should be immediate. The U.S.A. can provide valuable technical assistance on both systems, but for real ultimate production the author would "put his money" on the aero engine and electrical industries, and any time lost in preliminary development would be soon made up and moreover the normal marine industry can be left almost undisturbed on present production. The author cannot see any other alternative, except to leave America to produce vast numbers of merchant vessels and ourselves to produce escorting warships, particularly as our present contribution of cargo carrying vessels is rapidly receding to a minor fraction of the total allied output. Whatever the ultimate production there is every argument in favour of building a number of experimental ships as soon as designs can be evolved, and starting at long last on *solving* instead of *shelving* the U-boat menace.

The author is particularly glad that Mr. Sutton has called attention to the need for reducing the total port time to the absolute minimum; this has a vital effect on the design of a cargo warship.

Mr. McDermid. The contribution of Mr. McDermid is interesting as giving the reactions to the Paper of a technician associated with an industry other than shipping, to whom the author can well imagine the British shipping position must appear very baffling, especially when related to American effort.

His suggestion of over-engining will be good when we can get the engines and the author has no doubt that with development of the cargo warship type the powers and speeds will greatly increase, and no doubt an economy unit will also be provided, say the aft engine. The Diesel-electric proposals are ideal in this respect.

Mr. Victor Dover. One of the significant features of the wartime shipping situation has been the insignificant effort or at any rate ineffective effort of shipowners to adapt existing ships or to

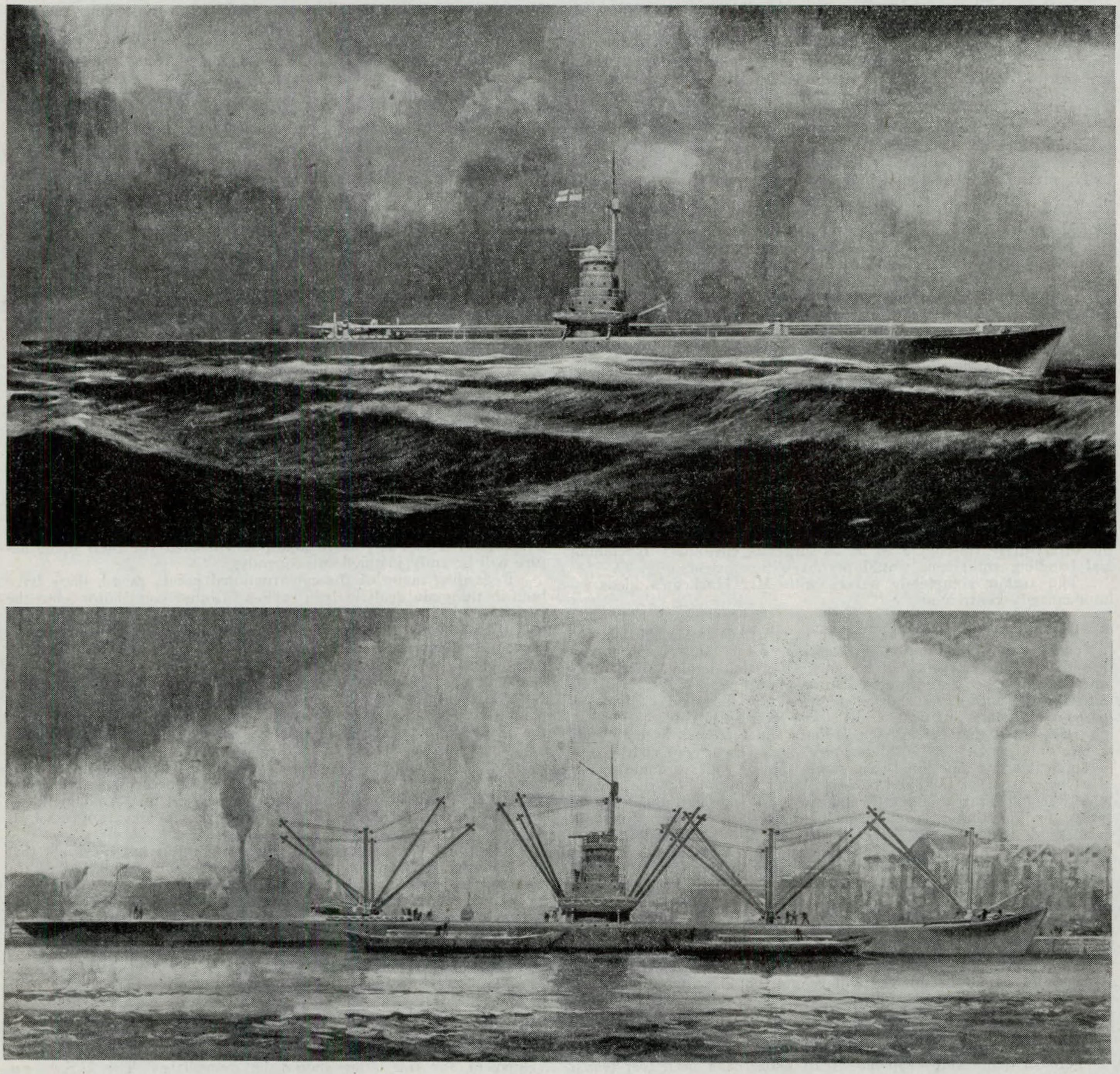


FIG. 20.—*The well-known artist Gordon Nicholl's impression of the cargo warship as depicted by the author's designs in 1941. (Top) Cargo warship at sea; (lower) cargo warship in port.*

build new ships more suited to war conditions, and perhaps one reason why they have not interested themselves has been the lack of financial incentive in view of there not being a differential war risk premium which would encourage expenditure on protective devices. The author is therefore glad to have Mr. Dover's comments on this aspect.

The exception to the above statement has been the universal demand from shipowners and master mariners for more speed, a demand which, as is well known, was resisted for long by the department in control who must be held responsible for the complete lack of success in producing a suitable type of cargo vessel without requiring vast and costly naval protection. In other words, they "passed the buck" to the Royal Navy, whose magnificent response cannot be over-estimated.

Mr. Dover says British shipbuilding technique has always been in the forefront; until the American programme it certainly was in quantity but not for some years in technique. The author thought he had made the position clear as regards *marine engines,* but with regard to *shipbuilding technique* the author would like to mention a recent motion which was put by Dr. Baker and carried at a meeting of the North East Coast Institution of Engineers and Shipbuilders in which the lack of scientific research and development in naval architecture was deprecated.

This did not make the position appear exactly rosy for British naval architecture. Coming to actual *production methods,* the author does not think that British ship and engine methods are precisely in the forefront to say the least and it is a remarkable tribute to British workmen that their efforts have offset the lack of modern equipment and technique to such an extent.

At the present moment there is a great import of ships to this country from U.S.A. and it looks as if this will continue after the war.

Captain T. S. Morgan. The author's special thanks are due to Captain Morgan for a contribution from a practical seaman. His experiences of the torpedoed ships are just what the author has heard recounted until sick at heart. *If only shipbuilders, ship designers, naval architects and marine engineers will attune their minds to war conditions, they will soon alleviate this terrible destruction.*

The author appeals to every technician in the shipbuilding industry to think for himself and to study naval construction and the effects of explosions in ships and their possible remedy. The author hopes Captain Morgan will approve of the return to an earlier design with bottom tanks and a more even ballast loading.

It is believed that the overside door to the lifeboat compartment can be made a really practical job, but an endeavour is being made to find a solution without requiring a door. It would of course be counterpoised and should be supported from the centre and not from the ends as shown in Plate 1. The author's object is that the lifeboats, if inside, can be kept in perfect trim with engine always warm and ready to start. The lifeboats, davits, etc., would be a specialist's job designed by specialists and fitted by the shipbuilders.

Mr. Dunlop. Mr. Dunlop's contribution is particularly interesting as coming from an engine designer, and the author finds himself in agreement with most of his remarks. The author believes, however, that for the amount of effort required to produce new engine types the reward would be great—if a real co-ordinated effort is made. The author definitely does not think we should consider foreign engines except as a further string to our bow, but first full scope should be given to a wide variety of British engine designers—not only marine. There can be no monopoly of endeavour in such a total war as that now being waged.

Many firms and designers have a developed theory and practice. By all means give them a chance, but also give young men a chance such as the author had himself seventeen years ago. But give them decent manufacturing facilities and above all give them all the scientific help they need; give them established good testing conditions and facilities and a nice fat purse to draw upon. The nation would get good value for the war and the peace.

The author has looked into the possibilities of the internal-combustion turbine with electric reduction. The weight, and even man-hours are definitely attractive, but the fuel consumption is not as good as the steam turbine. Unfortunately, the development of the large units is Swiss, and it is doubted whether the necessary technical co-operation would be possible to arrange. It would be extremely interesting for the certain sections of our aero-engine industry to have a crack at such a proposal with multiple units and it is hoped this suggestion will fall on fertile soil.

To ensure reliability in new engine units developed at such a time and for such a purpose, a small multiple type which can be replaced with ease offers the least risk and experiment.

Stalin is quoted by Beaverbrook as having said: "This war is a war of engines". Stalin knew his stuff. When we pinned our faith for nearly three years of the war on the obsolete coal-burning marine steam engine, we certainly showed we had not then attained *(nor have we yet awakened nationally) to the full realization of the meaning of engine power and its significance relative to the speed of propulsion of vehicles of war.*

Captain Spriddell. There is no reason why the fine ends of the vessel could not with advantage be used for grain cargoes. The fact that hatches are not shown is purely due to the need to omit detail. Naturally, expansion trunks would be needed in the case of oil. As the author has had to be his own draughtsman, he pleads for some leniency in such matters. These points are shown in the new drawings. The idea of carrying grain under the crew accommodation is attractive.

Considerable doubts have been raised as to the suggested use of steel airtight hatches. The author fully realizes the difficulties as many designs and pictorial constructions have been studied, but one thing the author feels certain about is that the present use of wooden hatch covers and tarpaulins is criminal, as the sinking time due to the inrush of water and loss of buoyancy is so rapid.

Some measure of delaying time is *absolutely* essential to give the crew a chance to get away from the ship. Consideration of our merchant sailors is surely a matter of prime importance. Boats may be difficult to lower and undue hurry must be avoided when days or weeks in open boats are in prospect.

Some measure of airtightness is simple to arrange—absolute airtightness difficult. But as long as the compartmentation and the means for discharging part of the liquid cargo or ballast are adequate, all that is wanted is a delaying action to give time to make up the loss of buoyancy due to the entry of the sea.

Fundamentally, therefore, as long as the means to discharge are greater than the leakage of air in cubic capacity, buoyancy control is effective. There are plenty of hatch cover "brains" in this country not being used to help to solve this vital war problem.

Attention should be drawn to the fact that it is the combination of shell plating design, torpedo blister, hold subdivision, cargo arrangement and strong hatch covers which is vital and not any one feature taken by itself. The main ultimate aim is to maintain airtightness of the greatest possible proportion of the upper portion of the ship to maintain buoyancy.

The author has examined many published designs of internal compartmentation to resist torpedo action, and any engineer used to explosive forces (say an internal-combustion engine) cannot but be struck by the comparative crudeness of the designs, admittedly due in a large measure to the use of riveted joints which impose such serious design limitations.

From many interviews with torpedoed ships' captains, the author is convinced that a vast improvement in the design of a ship is possible, and it must be realized by everybody that the normal ship is quite unsuited to withstand torpedo action, as has been only too tragically demonstrated.

The author believes that a large amount of valuable information could be obtained from small-scale experiments, which should be instituted with the utmost dispatch, to be followed by full-scale experiments on an unprecedented scale. It is believed that not many ships need be sacrificed to give the desired information and portions of existing ships should be adapted immediately and subjected to torpedo action under various conditions.

Such experiments should include hatch cover alternatives. *It is hoped those in the highest authority will ascertain precisely the extent of experiments and developments on such matters since the war started.*

Coming to Captain Spriddell's other points, the author would very much like shipping firms in general to consider the cargo space and accommodation and to offer suggestions as to how these can be made to suit particular trades. Suggestions regarding the capstan and warping gear are also wanted from those more competent to deal with such matters than the author.

The new trunk design of deck will perhaps appeal more to Captain Spriddell.

The author realizes the enormity of his crime regarding the captain's accommodation, but what about the accommodation in a submarine? The author is afraid only war-time accommodation is possible. Afterwards something really first class can be put above deck. The new arrangement of accommodation is improved, but these are specialists' problems.

The suggestion that the cranes of varying lifting capacity should be used appears sound, and this is shown on the new drawing. As the swing is smaller than usual the saving in weight may not be so great.

Captain Spriddell's other remarks are dealt with in replies to other speakers.

Dr. S. F. Dorey. Dr. Dorey's contribution is very realistic and very valuable. He shows the need for perfect dynamic balance which, unfortunately, means more cylinders. This in turn, is incompatible with lowest production costs. For example the Vee six-cylinder would have a simple crankshaft, very similar to a triple-expansion steam engine and the crankcase would be short and simple and easily handled. No inner joins of crankshaft or crankcase would be necessary.

Referring to the table, it will be noticed that it would be possible to improve the primary vertical couple at the expense of the horizontal couple by larger balance weights.

In view of the prime need for a vibrationless vessel it may well be that any idea of saving in weight and man-hours by using the fewest number of cylinders should be abandoned, and a much smaller engine with as many as six cranks and twelve cylinders (two banks at 30°) considered. For a power of 7,500 s.h.p. at 175 r.p.m. the cylinder size would be only 18in. dia. with 36in. stroke, with a b.m.e.p. of 82lb. per sq. in. and a moderate piston speed of 1,050ft./min. The length of such an engine would be only 27ft., thus permitting an engine-room length of only 33ft.

Such an engine could be assembled at marine engine works, but most of detail parts, such as liners, covers, cylinders, etc., could be readily manufactured at auxiliary oil engine works throughout the length and breadth of the country. There is knowledge and experience available to design and produce such an engine very quickly by using proven fuel injection and turbo-blower pump equipment. The size would ensure freedom from heat stresses. It is believed that the greater manufacturing capacity available for such a moderate-sized engine will much more than compensate for the greater complication. The weight should not exceed 40lb. per s.h.p. for a bedplateless and all-welded engine.

Referring to the proposals on page 146, it would appear that instead of the 27in., 24in. and 14in. engines, the development could well be compressed into one engine of 18in. dia. to cover any direct-drive schemes.

The "aero engine"' size would provide both the indirect-drive engine and the auxiliary engines for the direct-drive scheme.

Thus, only two engine sizes are required to utilize all marine oil engine production.

Initially, development contracts could well be placed with, say, twelve main firms, six to auxiliary engine makers and six to marine engine makers, and the final designs accepted for mass production—the result of tested performance.

Only variations in cylinders and details would be needed. The author believes there are immense possibilities in such national developments. A condition should be that all patents and designs should be the property of the Government and all firms would be free to use all such patents and designs. Means for any personal recognition could be simply arranged as in any form of national service.

Mr. H. A. J. Silley. As Mr. Silley remarks, the paper is based on a number of assumptions for which the author has satisfied himself that proof could be given if it were permitted, and this suggests that if the fullest technical statistics of enemy action on merchant ships were made available to all responsible members of the industry ways and means would be evolved to solve the U-boat menace.

Regarding the sinking of the *Prince of Wales* and the *Repulse,* whilst these vessels received many torpedo attacks the outstanding resistance of the *Bismarck* is also an object lesson. In the last war light blisters were fitted to ships having heavy armour showing that mere strength is not enough. The differential effect of torpedoes on merchant vessels has suggested there is great scope; can the merchant shipbuilding section bring proof that various torpedo explosion resisting integral constructions have been tried in merchant vessels and proved ineffective?—have *any* been tried? Has any scientific data been collected of the effect of explosions on merchant vessels and used to evolve new designs?

What real experimental work has been carried out? I trust these questions will be asked by those in control.

Is a tanker more immune than a cargo vessel from torpedo action? there seems no doubt on this score; a tanker is greatly superior.

The behaviour of the decks depends on the loading, the cargo, the ship's structure, and the weather, and is again very variable, showing the scope in design. Protection of the decks can best be given by control of the explosion at the ship's sides. Once the explosion is allowed to enter the holds then the relief afforded by loose hatch covers may be necessary to avoid greater damage.

With regard to any delay likely in changing over to new designs of engines, this would surely be a matter of careful organisation and the development of types of engines to suit the three major kinds of engine works, that is marine, marine auxiliary and aero engine works. Already in this country a number of new types of turbine machinery and oil engines have been commenced in works which have not previously built such engines.

In the author's opinion there is not nearly enough standardisation of engine types, whether turbine, oil engine, or steam engine to suit war conditions, and America with its central design control could teach us much in this respect. Greater standardisation would greatly assist engine repairing as well as production.

The author is glad the question of repairing has been raised by a ship repairer. The intention is that present repair establishments would continue to deal with present ship types, but for dealing with ships of the new welded type, special new repair facilities would be required to be put down on the new American plan, which depends on prefabrication. The author has gathered that our repair yards have not as yet been able to deal very effectively with repairs to American welded ships on these lines.

On a visit to a C2 vessel which had previously been in a collision which destroyed 60ft. of bow, the author was informed that the damage was wirelessed to a suitable port, a complete prefabricated bow intended for a new ship got ready, and the actual repair took only two to three weeks. It may well be that the construction of shipbuilding docks with the prefabrication system could work side by side with ship repairing. If for example a yard with six such docks were laid down, one dock could be used continuously for repairs and more used as required. At any rate the building and repairing of vessels like all welded cargo warships must be treated as one problem. No doubt British repair yards would be required in the U.S.A., and just as logically American ships should have American ship-repairing establishments in this country. It is believed that much repairing time on American ships damaged en route to this country could be saved by this latter suggestion.

Mr. A. E. Crighton. Mr. Crighton's remarks are all very pertinent and therefore will be dealt with seriatim.

General Arrangement.—Much as the author would like to retain the lowest silhouette there is no doubt a higher flight deck is needed and this will give the greater freeboard and the various other advantages cited by Mr. Crighton.

Stability.—This will need fuller investigation than the author is able to deal with as there are a number of new features, not the least being the weight of the "blisters".

The raising of the lower deck proposed will aid matters and so will the raising of the flight deck and the increase in the draft from 26ft. to 28ft. makes for normality.

It may even be necessary to sacrifice comfort for security. On the basis of the latest design it is hoped that naval architects themselves will go a step further and apply known data to the new ship type.

Lifeboats.—Mr. Crighton's views are concurred in and four lifeboats are now to be provided.

Construction and Pillaring.—As indicated elsewhere the intention was to use welded box girders and pillar construction where possible and this has been developed further in Fig. 18, which is self-explanatory. It is agreed that a double bottom, if specially designed, will be invaluable from a mine protection point of view, and bottom tanks are now proposed in the revised design.

Prefabrication.—Provided the inner wall of the blister is free of framing of any description, the author believes it will be possible to provide a corrugated wall which will be simple to produce and require the minimum of welding man-hours. The new design is an improvement on that proposed in the Paper.

Normal inner skins as used in naval craft have been considered, but it is considered that the complication for a given strength is great and the real explosion resistance greatly reduced by the number of stress raisers inevitably caused. One does not rib the outside of a Scotch boiler shell! and the pressures involved in the blister may be higher.

Furthermore the inner and outer walls should be non-rigidly connected to allow of the action of damping materials.

The water space in the blisters used in the last war do appear to have contributed to the strength, but it must be remembered that the inner wall often consisted of armour plate and was immensely strong. Personally the author feels that flexibility and damping alone can solve the problem of explosion effects which have not impact.

Crew Accommodation.—It is agreed that the crew space is inadequate and a second accommodation deck is being provided so that officers are above and men below to give greatly improved living conditions; some of the accommodation forward is being dispensed with. Stores and refrigerated space also need greatly increasing in size and improving in position.

Compartmentation.—With reduced length of hold, depth of lower hold, and the improved support of the bulkheads by the three box trunks, the author agrees that the double bulkhead can be dispensed with in favour of single plating with "chequer board" stiffening. The intention had been to use the double bulkheads for accommodating the bilge pipes and the bilge pumps, the latter being separate for each hold and located near the crane rooms, hence the author's remarks on page 146.

In the modified design a duct keel is provided and a duplicate bilge system for the lower holds is arranged therein. The floor of the lower hold is especially sloped towards the ship centre line to aid draining for this purpose. In the case of the upper holds the bilge pipes are taken up the central box trunks to the offside of the lower hatch coaming beam and the lower deck is sloped down to this beam to afford drainage. In a war-time ship all piping should be towards the centre of the ship and away from the sides. It is believed that the proposed special duct keel will enable a "common" bilge pumping system to be used.

The author appreciates Mr. Crighton's response.

SUMMARISED NOTES ON THE REVISED DESIGN REQUIREMENTS OF THE CARGO WARSHIP.

Cargo Carrying Efficiency.

High efficiency as a cargo carrier will be obtained by using the best middle portion of the ship for cargo and delegating the machinery to the fine ends. The use of light and efficient oil engines will ensure minimum machinery and fuel weights. The saving in engine weight and the use of welding will make the vessel lightweight comparable to commercial types.

Speed of Cargo Carrying in a Given Ship.

The high speed at sea of 18 knots when fully loaded needs ample reliable power; high speed when light requires sufficient ballast and clean watertight decks; high speed of loading and unloading requires first class holds and cranes. High speed of turnover in port means no engine delays and hence a modern engine replace and maintenance system. High average port to port speed means no routing delays and hence small convoys or no convoys.

It is believed that provision can be made to obtain the above requisites to such an extent as to give a carrying capacity three times that of the present slow convoyed ship.

High Speed Loading and Unloading.

Provision should be made for:—

Ten hatches 42ft.×20ft. which can be easily opened and closed. Twenty immediately available rapid derricks capable of heavy and small lifts at suitable lift speeds to enable simultaneous working at each side of the ship. Deep tween decks and shallow lower holds which facilitate the stowage of vehicles, tanks, guns and general munitions. Means for easy trimming of the ship to facilitate storage.

Cargo Stowage.

The stowage should be made to a specific plan, based on experiments, to give the greatest explosion resistance.

Normal deck cargo (large cases) can be placed in the space between lower and flying deck hatches.

Visibility.

Whilst the height of the flying deck has been raised to 15ft. above the water line, no cranes are now visible and the overall height of the bridge is reduced. The height of the control room is reduced to the absolute minimum and a telescopic periscope is considered more efficient than crows' nests to give more perfect bridge control in avoidance action.

From an aircraft point of view, all above deck structure would be better dispensed with altogether, and this must be done as far as possible by reduction in height of the bridge structure, so that an aircraft making a false landing can take off again with a slight "bank".

It is regretted that the visibility of the deck line is increased, but the reasons for so doing are strong when the need for the regular use of ship based aircraft is considered. The overall visibility is reduced.

Protection Against the Submarine.

High speed, low visibility, minimum self underwater noise but maximum capacity of underwater detection, an airscout plane capable of frequent flights, capacity to withstand up to three torpedo hits and yet maintain safe speed, instantaneous ship control and high degree of manœuvrability to take avoidance action, are all necessary.

Duplicate multi-bore gun armament on each side decks. Capacity to take punishment, thus causing submarine to "watch his step" and "keep his distance" is good defence.

Protection Against Torpedoes.

The side protection must be given the greatest transverse division (24ft.) with scientifically correct corrugations in the pressure wall having four point suspension. The "blisters" should contain a shock absorbing material in the blisters below water, the upper blister serving as an air vessel.

The hold bottoms should be protected from all types of torpedoes or mines by deep bottom tanks which are always filled with oil cargo or water which have release hatches. Air spaces should be allowed between ceiling and the oil or ballast which the chequer construction provides.

The entire cargo space is compartmented into no less than twenty holds or ten completely separate transverse subdivisions; the effect of torpedo action is therefore localised to an unprecedented extent.

The lower holds should have strong steel hatch covers for a measure of explosion resistance, but be held down by the cargo only. The flying deck hatch covers should be both air and water-tight and consist of plain steel box type covers in sections laid on the "tile" principle and lightly bolted down from *inside* the transverse cross beams.

The transverse bulkheads should be strong in structure but with flexible plates. The supporting trunks are used for functional purposes.

All oil tanks should have a centre division to facilitate trim correction with duplicate pumps of large capacity easily controlled.

There are two completely separate engine rooms spaced as widely apart as possible, each having the minimum target length and area and the smallest volume below the water line.

Protection Against Bombing Action.

Relative immunity to near misses will be given by the protected sides and clean decks.

Strong side decks resistant to light bombs. Two layers of strong steel hatch covers. Adequate hold subdivision both transverse and horizontal, the upper holds serving as explosion chambers with lightly held flying deck hatches to release pressure effects. Bombs must penetrate three horizontal decks to hole the ship's bottom. Strong steel hatch covers are essential to bomb protection.

Protection Against Aircraft.

The availability of a fast fighter aircraft based on board. High manœuvrability control for avoidance action. Quadruple multi-bore gun armament. Capacity to take punishment, ensuring that several heavy bombs would be needed to sink or immobilise the vessel.

Protection Against Mines.

The side blisters, bottom oil tanks hold subdivision and end tankage and backbone construction will all act as effective protection. The bow propeller will aid the early explosion of acoustic mines. As the lower part of the stem is dispensed with, some modification of the paravane gear must be devised.

Armament.

Speed and capacity to take knocks while maintaining speed, are the chief protection from enemy seacraft. The principal air armament is the fighter aircraft. Fixed artillery on the vessel is considered of a secondary nature for both purposes and preferably one type of gun should be used for all purposes.

Control of Speed and Direction.

A basic requirement is that precise and instantaneous control of the ship must be in the hands of the man at the controls, not only as to rudder control but also the speed of revolution of each propeller so as to give complete avoidance action against torpedoes or bombs. This requirement can be best met by some form of electric drive.

The steering must have the greatest efficiency with the minimum of heel; efficient rudders at each end of the ship will give this.

Buoyancy Control.

For preserving buoyancy and to give rapid trim correction after torpedo action, it would appear that the blowing out system as used in submarines would require development for this application, with some system of control from the control room.

The intention is to have two pump rooms, one at each end of the duct keel, with a water-tight separating door amidships.

Trim will be readily controllable from either the end or the bottom tanks, the capacity of which together will amount to 5,000 tons.

Underwater Hull Form.

The desiderata here are:—

(1) Minimum resistance to economize in power and fuel.

(2) Minimum water disturbance whether from bow wave or wake to reduce aerial visibility.

(3) Greatest volume above water with the minimum height of deck or freeboard to reduce surface visibility.

(4) Least difference between loaded and ballast condition and a flooded condition of two or three holds.

(5) The hull coefficients should be based on warship design and not on cargo-boat design, the disadvantage of the fine form from a cargo-carrying point of view being largely offset by using all the centre of the ship for solid cargo and the highly-shaped ends and bottom for liquid cargo.

(6) The use of a bow propeller and the need for minimum wake suggest the greatest practical immersion of the propellers and the elimination of forefront and deadwood.

Structural Strength.

A central backbone (the duct keel) which is largely protected from under bottom explosions serves as a basis. The lower hold bottom should not be rigidly connected to the ship's bottom as in present day double bottom practice.

The flying deck of necessity is greatly cut away, but heavy deck side plating and the main longitudinal box girders which are connected by trunk girders to the lower deck and the tank top can be made to fully compensate for this.

The bottom tanks must be well vented for explosion pressures through the trunk and deck hatches.

A basic design requirement of the war-time ship, that the outer hull should be much weaker than the inner is adhered to and a great proportion of strength comes from parts of the hull not directly subjected to explosion effects. As far as possible all plating should be stiffened by "chequer board" framing (so common in aircraft fuselages, *e.g.* Flying Fortress, Sunderland, etc.).

The new side pressure skin offers a basis of design to give longitudinal strength with capacity to resist great external pressures without great plate thickness and without frames of any kind.

Relative Bow and Stern Propulsion.

In view of the flexible nature of the electric drive, the precise relative power at the bow and the stern must be the result of tank tests and practical experience, but it would appear that the bow unit should be not less than 20 per cent. or more than 50 per cent.

It would appear that one screw aft and one open screw forward (or Kort) will give the most efficient solution and give the best rudder control at each end. By placing the propeller at the lowest position—6 to 7ft. from the ship's bottom—the bow wave and wake should be satisfactory and the efficiency high.

Propelling Machinery.

It can be considered that there is universal agreement that a high ship's speed is desirable and that only the restrictions of engine fuel consumption, constructional man-hours, weight and space, prevent such higher speeds being generally adopted. Low fuel consumption can only be obtained by using oil engines. Low man-hours, small weight and space can best be obtained by getting a large amount of power from a small engine which can be manufactured by mass production methods; this means using high-speed engines of the double-acting two-stroke type which theoretically has four times the number of working strokes of the usual four-cycle type of aero engine which, as a type, is a conservative type.

The definite conclusion the author has come to is that a high-speed double-acting oil engine for this specified purpose should be developed forthwith with the fullest Government resources.

The author, having had what would be generally admitted a unique experience, for an Englishman, of this type of engine, suggests this expression of opinion should carry some weight, particularly as he has given many years to the study of this specific, vastly difficult problem.

There is nothing experimental about the electric transmission, nor need there be anything experimental about the various air, water and oil pumps and other auxiliary equipment.

The speed of the engines would be 1,500 r.p.m. and that of the propeller 150 r.p.m. The normal full power available would be 15,000 s.h.p.

In the paper, the author tried to find a solution to the use of a large direct drive engine, and the best economic solution is a six-cylinder Vee engine of 7,500 b.h.p. at 165 r.p.m., but whilst two such engines will give the range of the requirements of cargo warship propulsion, it would appear that the engine with the greatest number of advantages will come from aero engine works, the fitting on board being done by modernised marine engine works.

Absolute continuity of operation at sea is a first essential. This implies multiplicity of units and spare units, so that a defective unit can be shut down and replaced by a spare unit, the defective unit being adjusted at leisure by maintenance personnel or removed for overhaul at the first convenient port. The size and weight of each unit must be such therefore that it can be easily handled at ports. A 2,000 b.h.p. double-acting, two-stroke unit could be made to weigh no more than 3 tons, and in size no larger than 8ft.×4ft.×3ft.; it would be therefore readily portable in ports.

Eight engines would be needed for normal operation and with two for auxiliary duties and two spare, a total of twelve engines per ship would be required. Such a unit could be made completely free from vibration and noise and could be accommodated right aft and right forward well above the water line. With two electric propelling motors the target length is a minimum and the below water engine room the physical minimum.

Lifeboats.

Four 35ft. lifeboats should be arranged on the amidship side decks and should be capable of being very simply launched.

Accommodation.

The accommodation is now arranged on two decks and is further removed from the ends. The deck officers and airmen will be mostly arranged forward.

Visibility from the Air.

As well as camouflage of the ship itself every known expedient must be used to reduce bow waves and visible wake, therefore an exceedingly fine form is essential in excess of that usually considered adequate for the speed of 18-19 knots. Ultimately the fine clipper lines may be found to be exceedingly efficient from a propulsion point of view.

Shape and Size of Vessel.

This is very largely influenced by the fact that a cargo warship must be an aircraft carrier as well as a cargo vessel, hence the minimum overall length should be 525ft. and the minimum beam 80ft., whereas the draft could be increased to the maximum of an average modern oil tanker, say 28ft. The minimum plane runway should be 50ft. wide. Every expedient is required to make the ship a steady platform of absolute minimum practical height above water with the minimum of deck projections. The need for as perfect an *above* water form as *below* is apparent, and it will be necessary to ensure that the introduction of the functional side deck recesses to accommodate the cranes, oil trunks and ventilators, rafts, etc., will not detract from the concentrated air stream along the flying deck.

Vessel as an Airdrome.

The long flying deck for take-off and landing, protected hangar with turntable forward will all give efficiency as an airdrome without detracting from the efficiency of the vessel as a cargo carrier.

Building Capacity.

Doubt has been expressed as to our capacity to build cargo warships with present naval commitments.

The entire shipbuilding effort is suffering from self-inflicted man-hour starvation. The author is certain that Mr. Bevin has been always willing to divert man-hours to shipbuilding, but British shipbuilders have not been able to assimilate so called unskilled labour such as America has done with such outstanding success. This is a matter demanding urgent and independent enquiry, the facts are plain and incontestible, and constructive action is needed.

It should also be more widely known that the shipbuilding and marine engine industry has introduced less new manufacturing facilities than any other. Who is responsible? The Treasury? The Unions? The Federation or The Admiralty?

The use of unskilled labour, welding and prefabrication go hand in hand. America has solved the problem successfully, why cannot we? A temporary suspension of workers' or employers' interests as in the Army or Navy or Air Force seems to be indicated and suggests that any new National works must be controlled and staffed on some new basis. As a Nation the author does not believe we have put our best foot forward with regard to sea transport.

Again the facts are incontestible and constructive action is needed.

We have in this country some of the most remarkable facilities for modern shipbuilding in the world, including tidal rivers and estuaries with immediately adjacent steel works—the Tees, Trent and South Wales for example, demand modern expansion. It may be necessary to move yards from the banks of narrow unsuitable rivers to places better geographically if not so historically, situated.

In Conclusion.

If built on American lines the extra man-hours required need not exceed the present slow vessels (with naval equipment) by more than 75 per cent. or would cost no more than a present 14 knot cargo liner. The man-hours saved by retaining the ships and cargo in service would be enormous, and the saving in human life and suffering well worth a terrific effort on the part of all ship and engine designers and all concerned with the manufacture and construction.

The hull weight need not exceed normal riveted figures for an oil tanker by more than 10 per cent. The propelling machinery weight would not exceed the present coal-burning standard steamers and the weight of fuel need be only 25 per cent. greater.

In conclusion the author feels more confident than ever as the result of the Paper that cargo warships could be designed and built which would carry three times the cargo with a given hull and crew and with a security approaching that of peace conditions.

An Appeal.

This paper has been given solely in the hope that it may cause specialists connected with marine engines, aero engines, naval architecture, ship drafting, electric propulsion, propellers, rudders, cranes or winches, welding, sea-aircraft, accommodation, lifeboats, ventilation, hatch covers, periscopes, aircraft landing gear and all the various pumps and compressors and innumerable parts which go to make up a war-time ship, to think objectively on the subject matter of this paper, and to offer any suggestions they may have to The Institute in the form of a continuous discussion.

It is hoped that all technicians will give of their help regardless of patent rights or any hope of personal reward, or even of appreciation.

ERRATA.

The following corrections should be made to the Paper as published in the November TRANSACTIONS, Vol. LIV, Part 10, 1942 :—

Page 137, line three, eighth paragraph, right-hand column: "seem good reasons" should read "seem no good reasons".

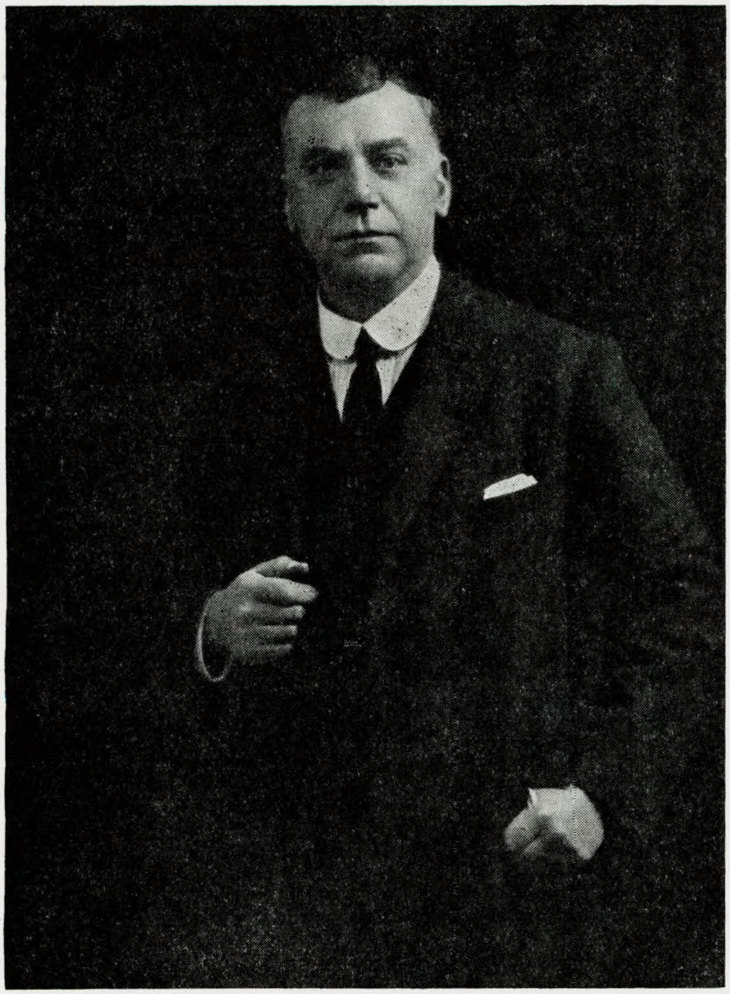
Page 138, line seven, first full paragraph, left-hand column: "12 knots" should read "18 knots".

Page 141, in item (3) under heading "Alternative Direct Drive Engines", second column : "44in." should read "42in.".

OBITUARY—Mr. W. E. FARENDEN.

It is with deep regret that we record the death of Mr. W. E. Farenden, which occurred on Monday, 21st December, 1942, at his home at Surbiton, Surrey, after a short illness.

Mr. Farenden was born at Southampton in 1869 and served his apprenticeship with Messrs. Day, Summers & Co., of Southampton. Mr. Farenden then entered the service of the P. & O. S.N. Co. with the object of going to sea, but showing a marked aptitude for draughtsmanship the Company offered him a position on the London Office technical staff, on which he remained throughout 38 years' service with the Company. During this time he occupied various positions and was principally connected with refrigerating machinery and insulation for the Company's ships. In 1926 he was promoted to the position of head of the drawing office, but in 1929 ill health compelled his retirement from the Company's service. In 1904 he was an assistant lecturer in engineering at Hackney Technical Institute.



THE LATE MR. W. E. FARENDEN.
Portrait by] [H. J. Whitlock & Sons.

In 1892, two years after the Institute was founded, Mr. Farenden was elected to Membership, his number being 555. He maintained a keen interest in the Institute's affairs and was elected a Member of Council for the period of office 1912-14. He was re-elected for 1922-23 and again for 1926-28. In 1928, his last year of office, he was appointed Chairman of Council, in which capacity he served with distinction.

Mr. Farenden's attractive personality endeared him to his colleagues on the Council, by whom he will be long remembered, and to the many friends he made among the Members of The Institute. On his retirement from business he took a great interest in bowls and was appointed captain of the Berrylands Bowling Club, a number of trophies which he won bearing witness to his skill at this game.

Mr. Farenden's funeral took place at Putney Vale Crematorium on Thursday, 24th December, at which the Secretary represented the Council.

CORRESPONDENCE.

THE TRAINING, GRADING, AND CONDITIONS OF SERVICE OF ENGINEERS IN THE MERCHANT NAVY.

53, Leadenhall Street,
London, E.C.3.
12th January, 1943.

MR. B. C. CURLING, *Secretary*,
THE INSTITUTE OF MARINE ENGINEERS,
73, AMERSHAM ROAD, HIGH WYCOMBE, BUCKS.

Dear Mr. Curling,—I was very interested to note in the TRANSACTIONS of The Institute of Marine Engineers for the month of December that the leading article deals with the training, grading and conditions of service of engineers of the Merchant Navy, as this is a matter in which I am very interested indeed and am in all questions relating to the training of sea-going personnel.

I notice with considerable surprise that in clause 3 of the fundamental principles given on page 147 it is stated :—

"That Marine Engineer Officers' service in the Merchant Navy should be made attractive and that the remuneration in the various grades of the Service should be such that it compares favourably with that applying to Engineer Officers in the Senior Service".

My surprise is the use of "Senior Service" in this connection. I presume the phrase is intended to refer to the Royal Navy, but the use of the term "Senior Service" is in my opinion entirely wrong in such a connection. On the question of seniority there can be no question as to which is the Senior Service as between the Merchant Navy and the Royal Navy. I believe I am perfectly correct in stating that there was no such thing as the King's Ship prior to the 14th century, and even at the time of the Spanish Armada I believe there were only four King's ships in the whole of the British Fleet that engaged the enemy: all the rest were Merchant Ships so there can be no question the Merchant Navy is by centuries the Senior Service, and in my opinion the words "Royal Navy" should have been used in clause 3 instead of the words "Senior Service".

My understanding of the matter is that it is quite correct to use the words "Senior Service" as a designation of the Royal Navy when one is referring to the Services of the Crown, Royal Navy, Army or Air Force.

I believe certain people attach considerable importance to the matter of seniority, and if they do, then I think that terms relating to it should be used in a correct manner.

I am sorry to take up your time with what is possibly in some people's opinion at any rate, a trivial point. I think it is well worth having the matter on record.—Yours faithfully,

B. Warwick.

ELECTION OF MEMBERS.

List of those elected by the Council at the Meeting held on Monday, 14th December, 1942.

Members.
Gilbert Manning Atkinson.
Fred Cooper.
John Alexander Eadie.
Charles Henry Jones.
Robert Spence Klottrup.
Ernest George Lashmar.
Ben Edward Leach.
Marinus de Vries, Capt. (E.), R.N.N.
Ernest McMaster.
Robert Stirling, Lt.(E.) R.N.R.
Hendrik Lambertus ten Cate, Lt.-Com'r.(E.), R.N.N.
Stephen John Thompson, Col., D.S.O.
Jack Tighe.
Frederick Rhodes West.
Geoffrey Bertram Wren.
Stanley Raymond Jones.
Peter Kennedy.
William Weir Love.
Walmar Martinson.
Hugh Ford Mouat.
Thomas George Pickering, Lt.(E.), R.N.
Edward James Phillips.
Stanley Rowland.
Arthur Francis Whiteley.

Associate Member.
William Ernest Parker.

Associates.
Alfred Colyer.
James Alexander Ferguson.
Walter Garriock.
Alfred Louis Giordan, D.S.C.
Edgar Albert Jackson, D.S.M.

Graduate.
Ferris Durnin Sturdy.

Students.
William Blacklock.
Eric Hall.
Charles Weir.

Transfer from Associate Member to Member.
Roland St. Clair Berlie.
James Tod Carnaghan, B.Sc.

Transfer from Associate to Member.
Frederick Mark Burgis.
Peter Arthur Montgomerie Simpson, Major, R.E.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

British Standard Specification No. 1081-1942 for Kilns for Heavy Clay Ware, including Refractory Materials.

An Introduction to Fluid Mechanics. By A. H. Jameson, M.Sc. Longmans, Green & Co. 245 pp., 115 illus., 12s. 6d. net.

This is an excellent work and is thoroughly up-to-date in the treatment of the subject. It presents on a sound scientific and practical basis the mathematical subjects which used to be studied under the names of hydrostatics and hydrodynamics and the empirical engineering subject of hydraulics.

The book has a fascination rarely possessed by this class of scientific text book, for the author leads the reader from one subject to another in a manner more like a connected tale than the enunciation of a series of scientific principles.

The helpfulness of the work is due to the author possessing a wider knowledge of the subject than is often revealed in similar books of an introductory character. For example, his explanation that the viscosity of gases increases with increase in temperature due to the molecules escaping from the faster to the slower moving layers, whereas the viscosity of liquids decreases with increase in temperature probably because it is more dependent on the cohesive forces between adjacent molecules, and these decrease with rise in temperature.

While Table III gives data on the viscosity of water and air from 0° C. to 100° C., its usefulness would be greatly enhanced if the range were extended to higher temperatures. In these days of forced-circulation high-pressure boilers, data on the viscosity of high temperature water is most useful. Again, with highly-preheated air and higher velocities in the boiler gas passages, the viscosity of hot air and flue gases is becoming an increasingly important consideration.

Some of the illustrations are too small, but this is a general failing of publishers for they do not fully appreciate that in technical literature the figures are as important as the text and should be reproduced to such a size that the letters on the figures are no smaller than the letters of the text.

The explanation, on page 104, of the flow past an isolated cylinder in a stream is too brief and is not in accordance with the whole of the known experimental evidence. This subject cannot be adequately treated without reference to the Reynolds' number representing the flow conditions.

It is suggested that for future editions a list of the symbols used, together with their dimensions, be given in the early part of the book. Where Greek letters are given in this list, the names of the Greek letters should also be included, for few engineering students in these days are taught the Greek alphabet!

It is difficult to say where an introduction to a subject should stop and where an advance course begin, but since, as soon as the flow of real fluids past solid boundaries is considered, the "boundary layer" becomes of great importance, a chapter on this subject would do much to make the work more complete.

Many references to the original more advanced works are given in the text and the theory of each subject is followed by practical examples which are worked out in detail.

The Journal of Commerce Annual Review of Shipping, Shipbuilding, Marine Engineering and Equipment. Charles Birchall & Sons, Ltd., 17, James Street, Liverpool. 310pp., copiously illus., 2s. 6d.

The new edition of this excellent annual is now on sale and will again impress readers by its amazing value at the relatively small price at which copies are available.

Preceded by an introductory survey by the editor and a foreword by Lord Leathers, there are excellent articles on shipping and private enterprise, problems of British liner companies, the position of the shipbroker during and after the war, the organisation of the Ministry of War Transport, the United Nations' Merchant Navy power, Merseyside dock labour problems, comforts for the Merchant Navy, greater safety of life at sea, keeping clear the ocean lines of communication, and a marine insurance survey.

The technical articles of special interest to marine engineers include British shipbuilding in 1943, United States shipbuilding, welding in shipbuilding and repairing (by Dr. J. Montgomerie, C.B.E., M.I.Mar.E.), progress of metallurgy, marine steam engineering, marine applications of electricity, trends in machinery space (by A. C. Hardy, B.Sc., A.M.I.Mar.E.) and "assembling" as applied to ship furnishing.

Munro's Engineers' Annual, 1943. James Munro & Co., Ltd., 151 pp., illus., 3s. net.

This year's annual has been completely revised and contains the usual tide and mathematical tables which users of past editions have found so valuable.

Many useful articles are also included, notably a lengthy review of world shipping and descriptions of oil-retaining bronze bearings, petrol engine driven launches, a remote water-level indicator for steam boilers, self-winding electric cable reels, strainers for pipe lines, turbine pump operation, and Tamperproof fire extinguishers.

Young marine engineers will find of special value the details given of the Ministry of War Transport Examination for Engineers in the Mercantile Marine, including War-time Regulations.

Abstracts of the Technical Press

Two Motor Lifeboats for Ships.

The Ministry of War Transport have adopted the resolutions of the Joint Maritime Commission of the International Labour Office concerning the provision of motor lifeboats for ocean-going ships. On the 10th August, 1942, a series of new requirements relating to life-saving appliances came into force, and under *Section C—New or Amended Requirements*—rule 9 states that "in every ship certified or permitted to carry more than 30 passengers, two motor lifeboats shall be fitted", while rule 33, concerning oil tankers, states that "one of the lifeboats on each side shall be a motorboat fitted with approved means of propulsion and one of them shall, where practicable, be carried amidships". The new rules are cited as *The Merchant Shipping (Life-saving Appliances) Emergency Rules, 1942*, and supplement those of 1938.—*"The Motor Ship", Vol. XXIII, No. 272, September, 1942, pp. 171-172.*

Alternating Current Machinery for Ships.

In their recently published review of the work carried out in 1941, Brown, Boveri & Co., Baden (Switzerland), state that the employment of alternating-current instead of direct-current motors for driving marine auxiliaries shows signs of becoming more general. Of the 120 ships' electrical machines ordered during the year, more than 40 per cent. were of the a.c. type. The increasing use of shaft-driven generators which supply all the current required while the ship is at sea is particularly notable. The frequency varies between 50 and 35, according to the speed of the vessel, and an automatic voltage regulator is fitted.—*"The Motor Ship", Vol. XXIII, No. 272, September, 1942, p. 191.*

Floating Power Barges.

In America, the total reserve of power supply is largely dependent on weather conditions, as the output of hydro-electric stations is liable to serious reductions because of drought. Labour and materials for war industries can be moved fairly easily wherever required and new munition factories may be built in about nine months, but it takes at least two years to construct and equip a new power station. Apart from arrangements for transferring power from one district to another by regulation of generation and transmission, emergency requirements can be met by the use of mobile power installations, and A. N. Wecksler, writing in *Mill and Factory*, states that as the result of experience gained by the U.S. Navy Department with mobile power plants, a plan has now been evolved for the construction of four shallow-draught barges for service on inland waterways, each vessel being between 250 and 280ft. in length, 40 to 50ft. in breadth and having a draught of 9ft. Each barge would be equipped with a 25,000-30,000-kW. turbo generator, boilers, fuel tanks and auxiliaries. It is estimated that the mobility of such a floating power unit would make it equivalent to at least double its kW.-capacity at a fixed location. It would be possible to connect the floating units to existing power systems, covering large parts of the chief industrial areas of the U.S.A.—*"The Power and Works Engineer", Vol. XXXVII, No. 435, September, 1942, p. 253.*

The Royal Electrical and Mechanical Engineers.

The recently created corps of Royal Electrical and Mechanical Engineers is to be formally inaugurated on the 1st October. In the main the R.E.M.E. includes all the engineering side of the R.A.O.C. and the maintenance staff of the R.A.S.C., along with a portion of the mechanical maintenance staff of the Royal Engineers. A former officer of the R.A.S.C. holding the rank of major-general, has been appointed Director of Mechanical Maintenance. The new R.E.M.E. headquarters, with extensive workshops and training centres, is now being used to train officers and artificers in specialised courses, the former according to their engineering qualifications and the latter according to their different trades. The courses so far arranged include the repair and recovery of armoured fighting vehicles, mechanical transport repair and recovery, and armament inspection, as well as a course for R.E.M.E. staff appointments in the field. Courses of instruction in other important subjects comprise those in electrical work, armour plate welding and general welding, and a special course in compression-ignition engines. At separate establishments other courses are given in field artillery equipment, A.A. artillery equipment, W/T equipment and fire control instruments. In all these courses intensive training is given under conditions which correspond as closely as possible to actual field work. This work, which includes rigorous infantry training, covers a very wide range. It embraces that of light detachments for the front line of battle, mobile brigade workshops, and work at base depôts and home bases, right up to the factories themselves. The repair and maintenance duties of the R.E.M.E. include tanks, guns, motor-cycles, searchlights, binoculars, typewriters and wrist watches. All tradesmen in the ranks will be given the new title of "craftsmen". The new badge of the corps is officially described as "a laurel wreath surmounted by a crown, four shields on the wreath bearing the letters R.E.M.E., and within the wreath a pair of calipers", these having been chosen as an indication of the accuracy which is demanded by the work of the new corps. The motto for the R.E.M.E. is to be chosen when the corps is inaugurated.—*"The Engineer", Vol. CLXXIV, No. 4,521, 4th September, 1942, p. 197.*

Possibilities of Gas Storage for Bananas.

Some hitherto unrecorded facts concerning the transport and storage of Jamaican bananas were mentioned in a paper by Professor C. W. Wardlow, Ph.D., D.Sc., read at a recent meeting of the Dominions and Colonies Section of the Royal Society of Arts. As the fruit can be stowed in the holds "naked", or in paper bags, the cost of packing and crating is obviated, and economy in hold space is effected. A "banana boat" may thus carry 90,000-100,000 bunches. Where the bananas are transported in cooled holds kept at 53° F., they are subsequently matured in ripening rooms ashore, in which a temperature of 65° to 70° F. is maintained. The essential feature of cold storage during transport is to delay the onset of ripening until the fruit is discharged from the holds at its destination. In the case of the relatively thin grades this can usually be achieved by refrigeration alone, but the heavier grades of bananas tend to ripen during a voyage of 15-17 days at the standard transport temperature of 53° F., and other means of retarding ripening must, therefore, be sought. Experiments with other fruits indicate that gas storage, *i.e.*, storage in an artificial atmosphere of high carbon dioxide and low oxygen content, in conjunction with refrigeration, might be efficacious in achieving the necessary retardation of ripening. It is probable, however, that the right concentrations of CO_2 and oxygen in the cooled holds will have to be maintained by means of a ventilating system incorporating a "scrubbing" installation which would remove the surplus CO_2 from the gas concentration in the holds. By these means it should be possible to maintain a concentration of 5 per cent. of carbon dioxide and 5 to 7 per cent. of oxygen in the storage spaces concerned. Certain technical difficulties connected with the practical application of this system of storage still remain to be overcome, but the general outlook is promising.—*"Modern Refrigeration", Vol. XLV, No. 534, September, 1942, pp. 161-162.*

Modified "Bennis" Sprinkler Stoker.

The makers of the "Bennis" mechanical stokers have developed a new stoker front-plate specially adapted for hand-firing conditions. This front-plate is embodied in the complete mechanical stoker with its self-cleaning forced-draught furnace, so that in the event of large coal having to be burned, a quick conversion can be made to hand firing and vice versa. The necessary hand-firing door and fittings are supplied with each stoker. It is claimed that this modified stoker arrangement secures that (*a*) the size of the fire-door aperture is larger than that usually provided with ordinary hand-firing equipment, that (*b*) users of the new appliance are independent of the size of the fuel supplied and that whenever suitable fuel again becomes available they can regulate the feeding mechanism and at once operate under the better mechanical conditions for combustion efficiency, and that (*c*) users are able to retain self-cleaning grates, thereby obviating the most laborious part of the fireman's work in the case of hand-fired boilers and the loss of steam output whilst the fires are being cleaned. It has been suggested that stationary grates should be fitted wherever possible in the interests of fuel economy, but it is pointed out that such a retrograde step is not good practice when, as at present, low-grade fuels, many with a high ash and clinker content, are frequently having to be utilised. Cleaning out through the fire doors, with any class of fuel, must involve loss of efficiency. In many instances the furnace doors are practically never closed, as either the fuel is being thrown on to the grates or the fires are being pushed on one side for cleaning. This disadvantage is obviated by the use of a self-cleaning grate on which the ash is gradually and automatically moved to the back, where it drops into the ashpit, whence it can be removed at regular intervals without opening the furnace doors or interfering with the fires in any way. With self-cleaning grates there is no struggling to get steam pressure back after cleaning fires, and they also mitigate the smoke nuisance. Where stationary grates with mechanical stokers are installed, the advantages of the latter are outweighed when burning low-grade fuels, by the losses and disadvantages incurred by the former.—*"The Power and Works Engineer", Vol. XXXVII, No. 435, September, 1942, pp. 249-250.*

Operating Results of American Tanker "Traverse City Socony".

The Socony-Vacuum Oil Company's twin-screw motor tanker "Traverse City Socony" is an all-welded vessel of 2,031 gross tons, completed by the Manitowoc Shipbuilding Company, Manitowoc, Wis., at the end of June, 1938. She was specially designed for the carriage of petrol on the Great Lakes, and her 12 cargo tanks have a total capacity of approximately 4,400 tons. Since leaving the builders' yard the ship has been engaged in delivering petrol to various ports on the Great Lakes throughout ten months of each year, and spends only six to eight hours in port on each voyage. Tugs are not used for docking the vessel at the various ports, and in the course of 3½ years' service, during which she covered over 150,000 miles, 2,016 hours were spent in manœuvring the main engines. The propelling machinery of the tanker consists of two 6-cylr. four-stroke Nordberg Diesel engines, each rated at 750 h.p. at 300 r.p.m. and directly connected to the twin propellers. The vessel has a service speed of 12½ m.p.h. (about 10·8 knots). The auxiliary machinery is driven by motors supplied with electric current by three Fairbanks-Morse Diesel-generator sets, two of these being 120-h.p. units and the third a 24-h.p. set. In January, 1942, the main engines were opened up for examination. Both crankcases were found to be perfectly clean, even up under the cylinder blocks. All the piston rings were found clean and free in the grooves. None of the original fuel, air-intake, exhaust or starting valves required renewal, and none of the crankpins, gudgeon pins or main bearings were found to show enough wear to require adjustment. The maximum wear in the 12 cylinder liners proved to be less than 0·018in., and the average wear did not exceed 0·011in. On the basis of 12,276 hours' running at full power and 2,016 hours' manœuvring, this works out at a maximum liner wear of less than 0·0013in. per 1,000 hours' running, and 0·00072in. per 1,000 hours. for the average wear for all liners. During the 3½ years' service of the vessel there was never any trouble with the machinery and not a single forced stop. The fuel oil used had a viscosity of between 32° and 36° Be, whilst the lubricating oil employed was Gargoyle D.T.E. No. 4. The average consumption of the latter was under 2 imp. gall. per 24 hours for the main engines, the oil being cleaned by centrifuging. A pressure of 18lb./in.^{2} was maintained in the forced-lubrication system. The exhaust valves were cleaned and reground after every 1,300-1,400 hours' running. The normally low temperature of the lake water makes it necessary to reverse the usual course of the cooling water through the Diesel engines of Great Lakes motor vessels. The circulating water is first passed around the exhaust manifolds and warmed up before going to the cylinder jackets. After the engines have been running for some time, the water temperature at the jacket outlets is maintained at 140° F., whilst when manœuvring in cold weather, the sea valve is kept closed and the same water is recirculated through the jackets. If the temperature of the water then tends to rise too high the sea valve is cracked enough to admit a little cold water.—*"Motorship and Diesel Boating", Vol. XXVII, No. 8, August, 1942, pp. 486-487.*

Arc Welding Applied to Steam Turbine Construction.

A Lincoln Foundation prize paper entitled "Repair of Machine Finished Castings by Welding" includes some interesting information concerning the employment of arc welding for assembling cast-steel sections of high-pressure steam-turbine casings. The author states that for many years he was frequently confronted with the loss of important and expensive steel castings by rejection, after the expenditure upon them of considerable time and labour. He gives particulars of some of these losses and describes attempts to make good defects in faulty castings by means of welding after gamma ray examination. The author states that in the end he became convinced that resort to welding as a repair or restoration process attacked the effect without seeking to cure the cause, so that when an opportunity presented itself to check the practicability of welded assembly of cast components by means of gamma ray examination as against the replacement of defective or questionable material by welding, he ventured to defy the widespread prejudice against welding steel castings intended for high-pressure, high-temperature service by a practical investigation of the possibilities of the welded assembly principle. For the location of prospective assembly welds during the preliminary design period, advantage was taken of the natural arrangement of H.P. compound turbines taking steam at a pressure of 400lb./in.^{2} and a superheat temperature of 700° F. For these steam conditions a considerable initial pressure drop occurs in the impulse stage, which is followed by several low reaction stages, an admission or "extraction" belt, the full-power or overload reaction stages, and the exhaust casing. Fig. 2 is a diagrammatic section of a turbine casing showing the relation of these

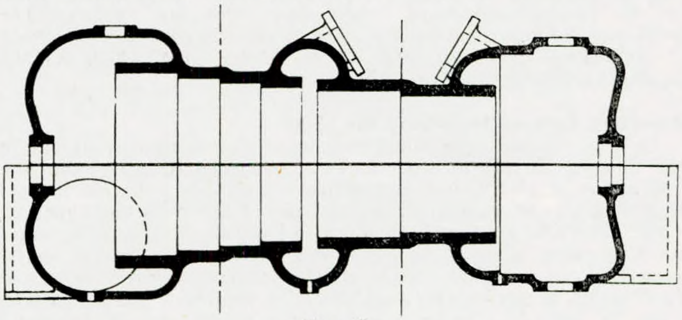


FIG. 2.

various stages. It was essential that the assembly welds should be made from both sides of the sections joined, but as may be seen from the diagram, the only regions which could be made fully accessible for welding from both sides were those between the impulse stage and admission belt and between the latter and the exhaust casing. These two regions were made accessible by abandoning a feature in previous designs in which steam passages from the impulse stage space to the admission belt were cast in the top half casings. Welded assembly as an alternative construction was thus anticipated in the original design by making practicable the casting of the half casings in three parts, as shown diagrammatically in Fig. 3. Such a division provided for shrinkage without damage in

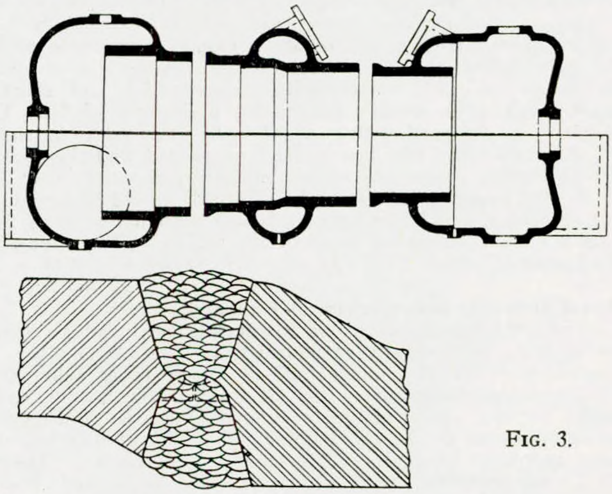


FIG. 3.

the solidification and cooling processes, the centre portion being free to shrink from both ends whilst the two end sections were open and free to shrink from one end. The rejection of a pair of top and bottom castings from an earlier shipment made available a set of castings for a development of the process. The two castings were carefully marked out, all critical dimensions being recorded for future use. Both castings were then flame cut into three pieces, as shown in Fig. 3, and the cut ends bevelled back to form an open

"U" for the assembly welds. Design requirements called for holding certain overall casing dimensions within close limits, and as no variation in the distances between gland seatings and between gland seatings and stator blading was admissible, the most serious problem to be solved was the complete elimination of shrinkage and distortion of the castings during the assembly welding and subsequent furnace annealing. In preparation for welding, each set of three castings was assembled upon a heavy platen, lined up, the alignment and overall dimensions checked with bench marks previously made, and then clamped to the platen for welding. Fleetweld electrodes of $\frac{3}{16}$in. diameter were used for most of the work, and as each bead of welding was laid on it it was immediately peened with an air hammer to counteract the tendency to shrink as well as to thoroughly remove the slag deposited by the coated rod. As welding progressed dimensions were checked from time to time from the bench marks, and any tendency to shrink or distort was immediately met by peening so adjusted as to correct this tendency. When the outside welds were completed, the assembly was released from the platen and turned over. The inside joints were then chipped out, exposing the bottom of the outside welds. Dimensions were again checked from the bench marks and the successive beads of the inside welds laid on and peened in the same manner as the outside welds. On completion of the assembly welds each half casing was checked for dimensions and placed in an annealing furnace for complete stress relief at a temperature of between 1,100° and 1,200° F., this temperature being maintained for eight hours and the casings then being left in the furnace to cool. The check of dimensions after welding and before annealing showed shrinkages of less than $\frac{1}{16}$in., and the precautions taken had so completely removed the welding strains that the change of dimensions during annealing was negligible. The completed casings were finally subjected to a water-pressure test of 1,200lb./in.^{2} to test the strength of the welds and adjacent material. As no water-joint material could be found which would withstand higher pressures on the water test, the original intention to test the casings to destruction could not be carried out. The author points out that for the project which his paper attempts to describe, comparisons of cost can only be approximate, but he appends the following figures showing the comparative costs of turbine castings only up to the point where the castings were ready for finish machining.

COST COMPARISONS.

Approximate costs, original project, 12 high-pressure turbines—24 castings £4,032
Lay-out, restoration welding, and machine work on 24 accepted castings at £600 each approx. £14,400
62 castings rejected, returned to foundry for credit... ... —
Lay-out, restoration welding and machine work, on 62 rejected castings up to point of rejection at £400 each, approx.... £24,800

Total cost, including loss on rejections of 24 accepted castings upon which machine work was completed £43,232

COST PER TURBINE CASING £43,232÷12... ... ... £3,602

Approximate costs, second project, four high-pressure turbines redesigned for assembly of three sections bolted together on flanged joints hand scraped for permanent tightness.
Eight half casings accepted £1,792
Lay-out, restoration welding, machine and handwork on eight accepted half casings at £800 each, approx. £6,400
Six castings rejected, returned to foundry for credit... ... —
Lay-out, restoration welding and machine work on six rejected castings up to point of rejection at £400 each, approx. £2,400

Total cost, including loss on rejections of eight accepted half casings upon which machine work was completed ... £10,592

COST PER TURBINE CASING £10,592÷4 ... ... £2,648

Approximate costs, third project, four high-pressure turbines, redesigned in anticipation of welded assembly as an alternative, purchased on the basis of rough machined castings subjected to gamma ray examination before delivery.
Eight castings accepted £3,136
Lay-out, restoration welding and machine work on eight attempted castings at £600 each, approx. £4,800
Three castings, rejected and returned to foundry for credit —
Lay-out, restoration welding and machine work on three rejected castings up to point of rejection at £400 each, approx. £1,200

Total cost, including loss on rejections of eight accepted castings upon which machine work was completed ... £9,136

COST PER TURBINE CASING £9,136÷4 ... ... £2,284

Estimated costs, fourth project, four high-pressure turbines, redesigned and cast in sections for welded assembly as described in this paper.
Eight half casings, accepted £1,792
Lay-out, assembly welding, annealing and machine work on eight accepted half casings at £600 each (rough machining of component parts is much simpler) £4,800
One half casing, rejected and returned to foundry for credit —
Lay-out, assembly welding, annealing and machine work on one rejected half casing up to point of rejection (anticipated) £600

Estimated total cost, including loss on rejection of eight half casings, assembled by welding with machine work completed £7,192

ESTIMATED COST PER TURBINE CASING £7,192÷4 ... ... £1,798

Comparison of Costs per Turbine Casing:—

	Original Project.	*Second Project.*	*Third Project.*	*Fourth Project.*
Cost per unit	£3,602	£2,648	£2,284	£1,798
Proposed saving per unit	£1,804	£850	£450	—
Proposed saving per cent.	50·1	32·1	21·3	—

—*"The Marine Engineer", Vol. 65, No. 783, October, 1942, pp. 213-216.*

Repairing a Leaky Pipe in Place by Welding.

It is assumed that the defective pipe is not under pressure, but is full of water, which, for some reason or another, cannot be drained off. The proper procedure to follow is to drill a hole in the bottom of the pipe, or below the faulty section in the case of a vertical length of pipe, to permit the water to be drained from the defective portion of the pipe. The latter can then be welded in place without difficulty, and the drain hole can be tapped to take a screwed plug after the welding has been completed. In some cases the drilling of a drain hole can be dispensed with by using a fairly high heat and starting to weld about one inch away from the defective spot and continuing around the latter in a circle. This heats up the pipe section, generating steam which drives the water away and allows the leak to be sealed up. After the leak is stopped the section can be reinforced by additional weld metal without any difficulty.—*"Welding", Vol. X, No. 8, September, 1942, p. 182.*

Repairing Propeller Blades by Welding.

Most tugs and similar small vessels are fitted with cast-iron propellers, the blades of which will break if they strike a log or floating débris, thereby preventing serious damage to the propelling machinery. The breaking off of a large piece of blade, however, often makes it necessary to dry-dock the ship for repair. Frequently no spare propeller is available, and in this event it is usually possible to effect a satisfactory repair by bronze welding. After dry-docking the ship, the propeller is turned to bring the damaged blade to a horizontal position, and the bent or jagged edges of the latter are then trimmed off by drilling, chipping and sawing. Two methods of repair are common. The first is to cast a manganese bronze tip and weld it to the damaged blade, whilst the second method, considered better by most maintenance engineers, is to bronze weld a scrap cast-iron propeller blade to the damaged one. Many foundries, making a speciality of cast-iron propellers, have discarded ones lying around, and it is quite likely that the repair yard concerned may have some available. A propeller blade of approximately the same shape as those of the damaged propeller should be selected, and the blade is then chipped and filed to the correct shape and length. Both the repair part and the damaged blades' edges are Ve'ed on both sides. Holes are then drilled in the damaged blade stump and new tip, to take bolts for the attachment of steel straps for securing the tip in place for welding. The blade sections are fitted together with the points of the Ve'ed edges touching, and the V's are cleaned to remove all dirt and grease. They are then heated slowly to about 450° C. by means of an oxy-acetylene torch and filled in on both sides by bronze welding, using a bronze electrode and an electric arc welding machine. The straps and bolts are then removed, and any excess metal at the joint is ground off.—*"Welding", Vol. X, No. 8, September, 1942, p. 183.*

Glass Lathes for Turning Turbine Shafts.

The Plate Glass Company, Pittsburgh, have secured a sub-contract from the steam division of the Westinghouse Electric and Manufacturing Company for turning turbine rotor shafts for naval ships. The glass company's normal production of flat glass of various kinds involves the use of large-sized lathes to keep huge forming rollers in working condition, and these lathes have now been adapted for machining intricately-shaped rotor spindles to the requisite close tolerances. In order to speed up the production of naval machinery, the Westinghouse Company are reported to have placed out sub-contracts to the value of over fifteen million dollars.—*"Canadian Shipping and Marine Engineering News", Vol. 14, No. 2, September, 1942, p. 64.*

The Present-day Design of the Velox Boiler.

An article in the *Brown-Boveri Review* describes the slight changes in the design of the Velox high-pressure boiler which have taken place during the last ten years. These changes chiefly affect the evaporator and superheater. Whereas the evaporator elements were formerly made up of a water tube containing from three to seven fire tubes, present-day practice favours "single-tube" evaporator units in which each evaporator tube has only one fire tube. One to three pairs of such tubes are combined to form an evaporator element having a common outlet for the mixture of steam and water. The stuffing-boxes for sealing off the water inlet pipes which protruded outwards from the interior of the combustion chamber have now been eliminated, and the latest practice is to bolt the water inlet pipes to the lower water collector inside the combustion chamber. In the earliest Velox boilers the combustion gas collector, the duct to the superheater, and the casing of the latter were provided with a liner of heat-proof metal sheeting generally carried on some cooling tubes or refractory brickwork. To-day the liner consists of groups of tubes through which the circulating water flows, and which form effective evaporation heating surfaces. As the hot gases are ejected at high velocity from the evaporator tubes and eddy round actively in the gas collector chamber and duct between it and the superheater, the coefficient of heat transmission (k) and therefore the heat transferred through the heating surface is very high, although the temperature of the gas has already dropped to something below 1,700° F. By turning the insulating liner of the superheater into an evaporation heating surface, the amount of heat converted is increased by 25 to 35 per cent., and the temperature of the heating gases at the inlet of the superheater casing can therefore be made as much as 200° F. higher, without affecting the gas temperature at the superheater outlet. This rise in temperature permits an increase to be made in the diameter of the fire tubes of the evaporator elements and the heating surface of the superheater can be correspondingly reduced. Originally, the only protection against temperature rise provided for the wall of the combustion chamber was that formed by the evaporator elements which lined it, but in the latest Velox design a protective mantle of heat-proof metal sheeting is provided, leaving a gap of 1in. between it and the casing of the combustion chamber. This space forms a duct through which part of the air to be used in the combustion process flows, exercising a cooling action. As formerly, the superheaters consist of several elements grouped together in bundles of about six to ten pipe lengths slung in such a way that they are free to expand, being supported by sleeves and pins welded on the tubes. The pipe connections, or bends, are formed either by pressing and welding the tube ends themselves, or by using cast-steel end pieces. From the point of view of flow properties cast-steel ends are better than pressed ends. There are two economiser designs: the water-tube type, in which the feed water flows through the tubes, the latter forming separate elements built into the economiser sheet-metal housing with a cover over its whole length; and the gas-tube economiser, in which the gases flow through the tubes and the latter are welded into the end plates of the economiser. The tendency of the circulating-pump shaft gland to leak has now been overcome. The trouble was mainly due to the shaft running out of truth, owing to defective assembly, unequal forces on the wheel periphery, or different expansions of the housing and bearings under the influence of the water, which is practically at boiling point. The out-of-truth running caused unequal wear of the gland packing, to remedy which the gland neck ring was usually made tighter and tighter. This, however, gave rise to undue wear of the packing and the shaft and rendered the gland cooling less effective. Special attention is now devoted to accessibility, interchangeability, and effective cooling of the stuffing-box glands. In order to eliminate cavitation phenomena and, above all, to prevent the pump from ceasing to deliver when the pressure in the boiler drops suddenly, the pump is connected directly to the separator by means of a branch designed like a diffuser; this allows a part of the speed of rotation of the water ring to be transformed into pressure. The speeds of inflow to the pump are kept low. The layout of a modern Velox boiler installation is shown diagrammatically in Fig. 4. Apart from the scale, the illustration is valid for any Velox boiler of from 10 to 50 tons/hr. capacity. In boilers of over 50 tons/hr., two superheater casings instead of one can be used. For boilers of less than 20 tons/hr. the single-tube evaporator elements can be arranged in a single row along the inner boiler wall. Above 20 tons/hr. two rows are necessary. The pitch varies according to the number of tubes, but the arrangement is always such that the tubes on the inner pitch circle fill up the space between two tubes on the outer pitch circle. Another special design of Velox boiler has been evolved for torpedo-boat destroyers and other craft in which boiler-room space is very restricted. It differs from the standard design in that not only the superheater, but also the major part of the evaporator heating surfaces are lodged in separate casings located horizontally below the boiler-room floor. The combustion chamber only contains the necessary wall lining and is made as small as is compatible with the maximum combustion-chamber load. The first boiler of this type was put into service about the middle of 1941.—*"The Engineer", Vol. CLXXIV, No. 4,529, 30th October, 1942, pp. 364-366.*

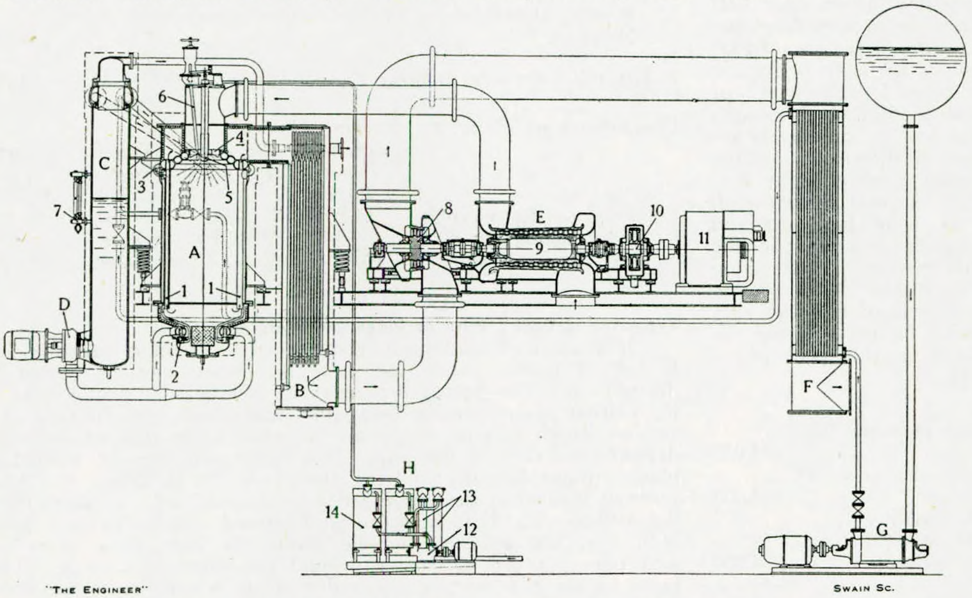


FIG. 4.—*Standard Velox Boiler for Outputs of 10-150 tons/hr.*

A. Combustion chamber:—
1. Evaporator tube.
2. Circulating water inlet.
3. Steam-water outlet.
4. Air nozzle ring.
5. Burner.
6. Igniter.
B. Superheater.
C. Water-steam separator.
7. Water gauge.
D. Circulating pump.
E. Charging set:—
8. Gas turbine.
9. Compressor.
10. Reduction gear.
11. Starting and regulating motor.
F. Economiser.
G. Feed-water pump.
H. Fuel supply:—
12. Fuel pump.
13. Filter.
14. Economiser.

"Recent Welded Repairs of Marine Machinery".

The paper comprises a number of brief but well-illustrated descriptions of repairs carried out by electric and gas welding to various items of propelling and auxiliary machinery and hull equipment. Amongst the repair jobs referred to by the author are the welding of a cracked cylinder jacket of a Diesel engine; the replacement of a broken propeller blade; the welding of a badly fractured crank casing; the repair and alignment of a crankshaft with a fractured inner web; the repair of a broken condenser end plate in a period of three days without removing the condenser; the welding of a fractured crankshaft bearing housing of a deck winch; and welded repairs to six cylinder covers of a well-known make of marine Diesel engine, all of which had cracked water jackets. Several cases of welded repairs to the scavenge valve seats and exhaust valve cages of Diesel engines are cited, and there is also a brief reference to the replacement of broken-off teeth on gear wheels. The author describes a case in which the employment of welding made it possible to fit a new propelling engine in a motorship in a very short time. The original Diesel unit, which was of Continental origin, was so badly damaged that it was considered best to replace it with new British-built machinery which happened to be available at the time. By flame cutting the bulkhead between the engine room and the adjacent empty hold, jacking up the discarded machinery and rolling it out into the hold for removal through the cargo hatch, the engine seating was rendered accessible for the necessary modifications, carried out with the aid of welding. The new engine was likewise moved into position through the empty hold, after which the bulkhead was sealed up again by welding. The paper concludes with some remarks concerning the application of metal spraying—which the author considers to be an off-shoot of welding—to the building up afresh of worn machinery surfaces.—*Paper by C. W. Brett, "Transactions of the Institute of Marine Engineers", Vol. LIV, No. 8, September, 1942, pp. 99-107.*

Parsons Gas Turbine Propulsion System.

The Parsons Marine Steam Turbine Co., Ltd., have recently developed and patented a system of gas-turbine propulsion for ships, two arrangements of which are shown in Fig. 2. The mechanism includes a positive ahead clutch and a centrifugal hydraulic coupling comprising a rotor capable of being driven in either direction. In the upper sectional view, applying to a double-reduction gear in a ship's propelling installation, there is a pinion (*2*) free on the driving shaft (*A*), a plate clutch (*H*) being provided. The shaft carries one set of plates (*3*), as well as the primary members (*C, E*) of the ahead and astern hydraulic turbines (*D. F*) respectively. The driving elements (*C, E*) function as centrifugal pumps and the driven parts (*J. K*) act as hydraulic turbine wheels and are fixed on a sleeve (*B*) which is attached to the secondary pinion (*2*). One driven part (*K*), associated with the astern turbine (*F*), is formed to give the reverse drive. The sleeve (*B*) also carries a series of clutch plates (*6*) in a chamber (*4*), into which oil is forced from the space (*5*) to engage the clutch for a direct drive. A release valve (*G*) disengages the clutch. For going ahead, oil is admitted to bring the turbine (*D*) into operation, whilst for going astern, oil is admitted to the turbine (*F*), the release valve (*G*) being opened. To propel the ship at full power, the turbine (*D*) is operated so as to bring the two sets of clutches nearly to the same speed before engagement, whereupon the turbine is cut out of action by releasing the oil through a valve (*U*). With the arrangement shown in the lower view, a reversible hydraulic turbine (*Y*) is employed, *i.e.*, the guide vanes (*7, 8*) are reversed for ahead and astern operation. The ahead guide vanes (*7*) are in the operative position between the primary member (*E*) and the secondary part (*K*), the vanes of the latter being practically radial. For astern operation, the guide vanes are moved until the vanes (*8*) reach their operative point, whilst intermediate positions of the vanes (*7, 8*) give intermediate speeds with either direction of rotation of the rotor (*B*).—*"The Motor Ship", Vol. XXIII, No. 274, November, 1942, p. 267.*

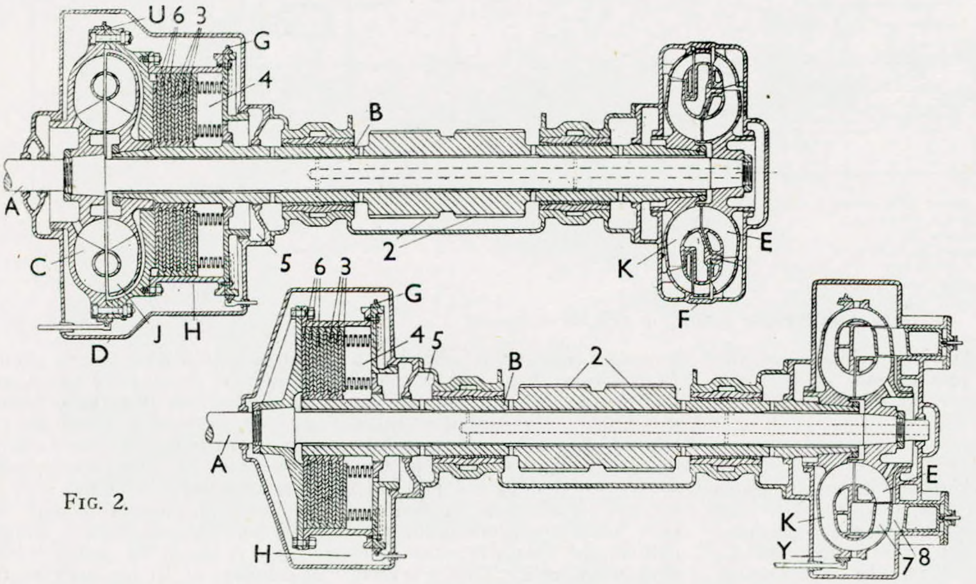


FIG. 2.

Technical Progress in Submarine Construction.

The chief constructor in charge of German submarine construction, Herr Schürer, recently gave journalists some interesting particulars of the technical improvements which have taken place in the submarine arm since the last war. Germany resumed the building of submarines in 1935, and during the present war their construction is being carried out in a large number of shipyards and engineering works scattered all over the country. The most important changes which have taken place in the design and construction of the German submarine craft since 1918, may be summarised as follows:—(*1*) The surface speed is substantially higher owing to the increased speed of present-day merchant vessels. (*2*) The weight of Diesel propelling machinery has been reduced by 50 per cent., and this makes it possible to employ higher-powered engines and to carry greater quantities of fuel oil. As a result, German submarines are now able to operate in distant waters for prolonged periods, as a matter of routine. (*3*) German submarines are, in general, smaller than those of other nations. In consequence of this, they are more manœuvrable and able to dive more rapidly. (*4*) During the last war the hulls of all submarines were riveted, whereas they are now electrically welded throughout. Apart from the saving in weight achieved by this form of construction, the strength of the hull structure is increased and the elimination of riveting has overcome the fractured rivet nuisance when exposed to depth-charge attacks. Broken rivets always weakened the hull structure and gave the crew constant trouble. Furthermore, leaky rivets in the fuel tanks caused tell-tale traces of oil to appear on the surface, thereby facilitating the work of anti-submarine craft. (*5*) Improvements in the speed, range and destructive effects of torpedoes, which are the main armament of a submarine, has caused it to become a more deadly weapon.—*"Journal de la Marine Marchande", Vol. 24. No. 1,187, 10th September, 1942, p. 1,076.*

Electronic Tubes to Eliminate Smoke.

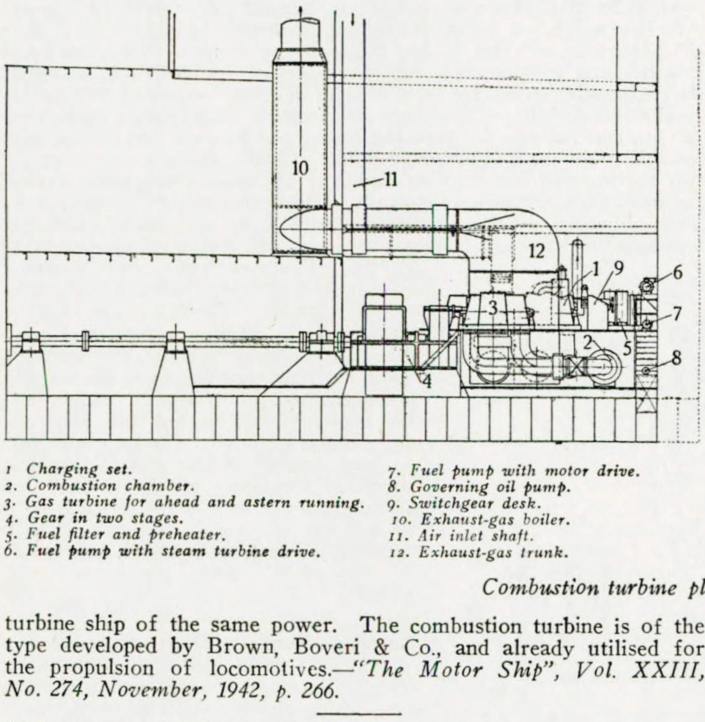
The General Electric Company (U.S.) have developed an electronic tube which enables ships' firemen to see at a glance whether any tell-tale smoke is passing into the uptake and funnel. Such electronic tubes are already in use in a number of industrial plants to prevent excessive smoke in chimneys and to save fuel. A beam of light is thrown across the smoke column in the uptake and is made to shine on a photo-tube. When the smoke becomes too thick the light is obscured and the photo-tube operates a relay which sounds a warning for the fireman, who is then able to take corrective measures to check the smoke. It is suggested that the use of such electronic smoke detectors in sea-going ships would help to reduce the sinking of Allied merchant shipping by enemy submarines.—*"Canadian Shipping and Marine Engineering News", Vol. 14, No. 2, September, 1942, p. 44.*

Plastics Used in Boat Construction.

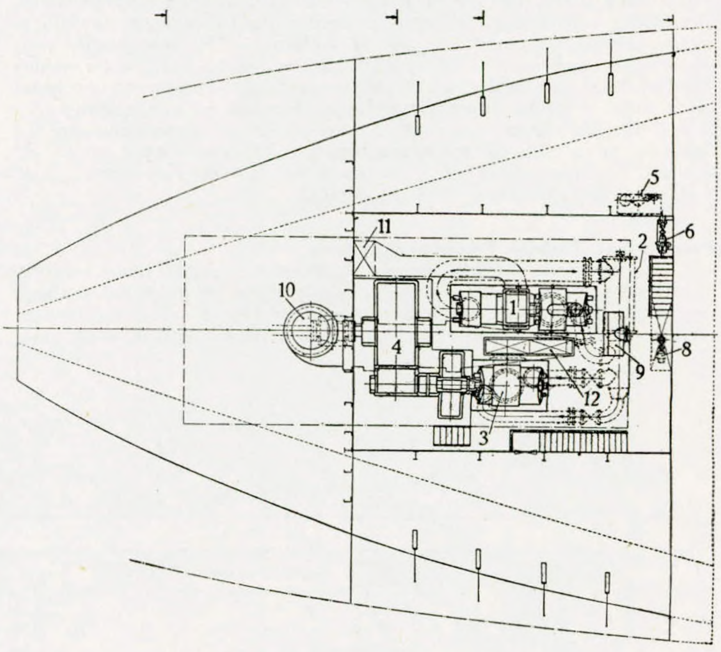
A New Orleans firm of boatbuilders are employing resin-bonded plywood in lieu of solid timbers for the construction of motor torpedo-boats and other small craft for the U.S. Navy. The technique developed for the use of plastic materials in aircraft construction is being very closely followed by the firm, and side panels, deck planks, bulkheads, partitions, etc., are being made of plastic-bonded plywood, whilst transparent acrylic sheet is used instead of glass for wind screens and scuttles. The entire sides of these boats, from the sheer to the chine, are single panels of plywood, the basic material being Honduras mahogany and the bonding agent a special phenolic resinoid. The laminated panels produced measure 84ft. by 8ft., and are stated to be the largest known to the industry. These sheets are cut according to templates and are applied directly to the sides of the boats. The transom, which has rounded corners, is moulded in one piece, as are also the machine-gun turrets, in which it is claimed it is almost impossible to detect a joint. The high-speed motor torpedo-boats constructed in this manner are triple-screw craft of 70 to 80ft. in length, capable of carrying four 21-in. torpedo tubes, two twin A.A. machine guns and eight depth charges. They are manned by a crew of ten men and can do up to 50 knots.—*"Canadian Shipping and Marine Engineering News", Vol. 14, No. 2, September, 1942, p. 54.*

4,000-s.h.p. Combustion Turbine Plant for a Tanker.

Several proposals have recently been put forward for the propulsion of fairly large ships by means of combustion turbines, and the accompanying illustrations show the lay-out for a proposed installation in a tanker. The plant is designed to develop 4,000 s.h.p. and drives the propeller shaft through reduction gearing at 75 r.p.m. The total weight of machinery is stated to be 44lb./s.h.p. and the fuel consumption (boiler oil) about the same as that of an oil-fired



1 Charging set.
2. Combustion chamber.
3. Gas turbine for ahead and astern running.
4. Gear in two stages.
5. Fuel filter and preheater.
6. Fuel pump with steam turbine drive.
7. Fuel pump with motor drive.
8. Governing oil pump.
9. Switchgear desk.
10. Exhaust-gas boiler.
11. Air inlet shaft.
12. Exhaust-gas trunk.



Combustion turbine plant for driving a tanker.

turbine ship of the same power. The combustion turbine is of the type developed by Brown, Boveri & Co., and already utilised for the propulsion of locomotives.—*"The Motor Ship", Vol. XXIII, No. 274, November, 1942, p. 266.*

Maintenance of Boiler Air Heaters.

The cleaning of air heaters under working conditions by steam soot blowers may not be entirely satisfactory owing to the increased amount of moisture in the gases during the blowing operation. Coal may normally contain up to 10 per cent. of moisture, but the amount of steam vapour in the flue gases may be considerably greater, due to the presence of hydrogen in the coal. Steam soot blowers are usually fitted only on the gas-inlet side of the heater, as the steam jets blowing in the same direction as that of the draught tend to raise the mean specific heat of the gases. Condensation of the vapour content of the gases generally occurs in an air heater when steam is being raised in the boiler, as the tubes and plates are then relatively cold. Especially is this the case when a forced-draught fan is employed for raising steam. Air heaters can be cleaned under working conditions by means of high-pressure air blowers, but this method is not so effective as that of steam. Whenever a boiler is taken out of service for periodic cleaning and overhaul, the air heaters should be washed and then blown through with compressed air. Where possible, the plates should also be taken out and cleaned with wire brushes. For washing through, it is advisable to use a centrifugal pump capable of producing a discharge pressure of at least 300lb./in.^{2} at the nozzle. The latter should be about ⅜in. in diameter to enable the jet to penetrate the space between the plates of a regenerative type air heater, which is about $\frac{3}{16}$in. It is essential to remove all soot deposits from the plates, otherwise rapid corrosion may be caused by the damp deposits. With regenerative type air heaters over 4ft. in depth it is advisable to remove the upper plates after washing, in order to give the lower plates a final washing to remove any remaining deposit. The washing method has the advantage of not creating the clouds of dust which are unavoidable where the compressed-air method is used. The latter should only be employed for tubular heaters or where the water method cannot be utilised. Compressed air will not remove damp soot deposits from the plates, and in the case of regenerative type air heaters, removing, wire brushing and replacing the plates is apt to be a laborious undertaking. After cleaning regenerative heaters, the seals should be carefuly adjusted to prevent air leakage into the flue-gas stream.—*H. Batley, "Mechanical World", Vol. CXII, No. 2,912, 23rd October, 1942, p. 393.*

Kort Nozzle Propulsion.

A recent article on this subject (*see abstract on p. 101 of* TRANSACTIONS, *October, 1942*) contained the statement that the increased pull at the bollard of a tug fitted with a Kort nozzle should range from 15 to 25 per cent., depending on the towing speed and hull form. A correspondent has now pointed out that these figures are liable to misinterpretation, since the expression "pull at the bollard" is generally considered to refer to the pull at a fixed bollard, the tug being stationary at the time, whereas the statement quoted above referred to the pull on the tow rope when the tug was in service. Tank tests carried out in America, in connection with the U.S. Maritime Commission's new 2,200-h.p. tugs, showed a bollard pull of 26¾ tons when the Kort nozzle was not fitted and 39¼ tons with the nozzle. This represents an increase of 46 per cent. at the bollard, or a *free pull* of 24·6 tons with the nozzle and of 20·6 tons without it, at a towing speed of six knots, thus showing an increase of 19·5 per cent. due to the nozzle. If this increase in pull is utilised to tow the same displacement as without the nozzle, the 19½ per cent. increase in pull would bring about an improvement in towing speed which, by reducing the slip, would produce a still further increase in efficiency. When towing the same displacement, the speed increase could be assessed at 7 per cent., the improvement in towing pull at 14 per cent., and that in the overall efficiency at 22 per cent.—*"Fairplay", Vol. CLIX, No. 3,095, 3rd September, 1942, pp. 290 and 292.*

Recent German Developments in Marine Watertube Boilers.

Two new patents described in recent issues of *Werft*Reederei* Hafen* concern improvements in marine watertube boilers effected by Dr. Gustav Bauer. The first of these patents covers a subsidiary automatic low-pressure boiler in the uptake of a watertube boiler, and is illustrated in Fig. 1. The various parts (*1, 2a, 2b,* and *3*) of this low-pressure boiler are arranged between the air preheater (*4*) and the accommodation round the uptake. Dr. Bauer claims that apart from saving space, the arrangement protects the surrounding accommodation from excessive heating. The second patent is an extension of an earlier one and is in the joint names of Dr. Gustav Bauer and Dipl. Ing. K. Reppel. The previous patent referred to covered an arrangement for natural-circulation boilers in which the circulation takes place through radiant-heat tubes connecting an upper drum and one or more lower drums and a set of downcomer tubes, the necessary temperature difference between the uprisers and downcomers being obtained by placing a superheater between the

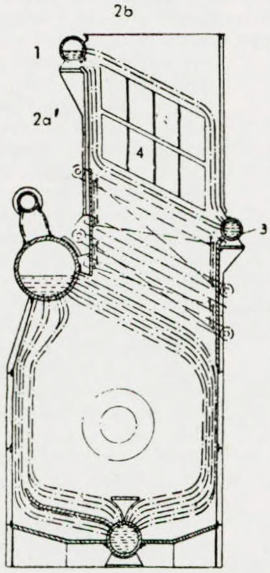


FIG. 1 (*left*).

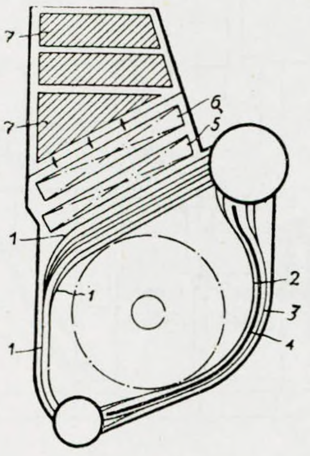


FIG. 2 (*right*).

two groups of tubes. This latest patent covers an arrangement for improving the circulation still further without restricting the freedom of boiler lay-out, as shown diagrammatically in Fig. 2. As before, the steam-generating tubes (*1* and *2*), completely encircle the combustion chamber. From the lowest point, however, of the upper drum, the downcomers (*3*) lead straight to the single lower drum and are protected from the combustion gases throughout their entire length by a row of radiant-heat tubes (*2*) or additionally, by a wall (*4*). The heating surface previously arranged in the downcomers is now replaced by an economiser (*6*) behind the superheater (*5*), the form and position of the economiser being chosen as desired. By this means the air preheater (*7*) is still protected from overheating and a wide control of temperature is made possible.—*"The Marine Engineer", Vol. 65, No. 784, November, 1942, pp. 250-251.*

Superheaters for Scotch Boilers.

There has been some criticism of the omission of superheaters in the majority of Government-built and licenced cargo vessels completed and under construction in British yards, despite the fact that this equipment was specified in the order placed by the British Admiralty in the U.S.A. for sixty 10,000-d.w. ton vessels, of which the "Ocean Vanguard" was the first ship to arrive at a British port. Smoke-tube superheaters are fitted to each of the three single-ended coal-fired Scotch boilers installed in these vessels, and steam is delivered to the triple-expansion engines at a pressure of 225lb./in.^{2} and 550° F. final steam temperature. As a result, the coal consumption is 15 per cent. less than in similar ships having engines using saturated steam. In some vessels in which the boilers had been forced and which were afterwards equipped with superheaters, an even greater saving in fuel consumption has been achieved. In a Scotch marine boiler without a superheater, an efficiency of 72·5 per cent. may be realised when burning 14,000 B.Th.U./lb. coal at 20lb./ft.^{2} of grate area per hr. with forced draught, a steam pressure of 200lb./in.^{2} and a feed-water temperature of 212° F. Under these conditions 10lb. of water will be evaporated per lb. of coal burned, and the steam will probably contain not less than 2 per cent. of moisture. The air pressure at the ashpits at the aforementioned firing rate will be 0·35in. w.g. If a superheater is fitted, an increase in efficiency will be obtained, while the amount of water evaporated will be lower than with saturated steam. The efficiency increases by reason of a larger proportion of heat being absorbed by the boiler and superheater, whereas the evaporation is decreased because a certain amount of heat from the flue gases is utilised for superheating the steam. A further gain is that with the employment of a superheater the 2 per cent. of moisture in the steam is also evaporated. The following figures are based upon a rate of combustion of 20lb. of coal per hr. per ft.^{2} of grate area with forced draught at the conditions mentioned above:—

Degrees of superheat.	*Lb. of water per lb. of coal.*	*Efficiency incl. superheater, %*	*Gross drop in evaporation, %*
Nil	10·0	72·5	Nil
100	9·7	75·0	3·0
200	9·25	75·0	7·5
300	8·85	75·0	11·5

The installation of smoke-tube superheaters in a number of steam trawlers for the purpose of raising the steam 200° F. above the saturated steam temperature, has resulted in an average saving in coal consumption of 1½-2 tons per day. As the larger trawlers average 300 days per year at sea, this means a saving of 450-600 tons of coal per annum.—*"The Shipping World", Vol. CVII, No. 2,576, 28th October, 1942, pp. 373-374.*

A New Danish High-pressure Reciprocating Engine.

It is reported that the Elsinore Shipbuilding and Engineering Company, of Copenhagen, have developed a high-pressure steam trawlers for the purpose of raising the steam 200° F. above the cheaper in operation. Details of the new engine have not been announced, but it is believed to be a development of the successful turbo-compound unit introduced by the same firm just before the war and installed in a number of small cargo vessels and fruit ships. The exhaust turbine was arranged alongside the engine on top of the condenser, and assisted to drive the propeller shaft through reduction gearing. Turbo-compound machinery of this type, built by the Copenhagen firm, was installed in the Danish steamship "Gerd," a fruit-carrying vessel of about 1,700 gross tons, in 1935. The engine had three cylinders, two of 400 mm. diameter and one of 1,000 mm., with a piston stroke of 950 mm. Steam at a moderate pressure was supplied by coal-burning Scotch boilers, and the total power output of the engine and turbine was about 1,800 h.p. at 119 r.p.m., the temperature of the sea water being 54° F., and that of the feed water 110° F. Under these conditions, and with 3,203 tons of cargo on board, the ship made a voyage from the Persian Gulf to New York at an average speed of 12½ knots, with a coal consumption of 17½ tons/24 hrs., or 0·95lb./i.h.p.-hr. In view of this excellent performance with steam at a moderate pressure, supplied by hand-fired coal-burning Scotch boilers, it is clear that even better results would be obtained with propelling machinery of this type in conjunction with high-pressure watertube boilers equipped with mechanical stokers.—*"Lloyd's List and Shipping Gazette", No. 39,884, 16th September, 1942, p. 6.*

Alloy Steels at High Temperatures.

In an article entitled "The Physical Properties of Metals for Steam Plants," appearing in the house journal of a well-known British firm of turbine engineers, reference is made to the fact that while certain alloy steels have improved creep properties at high temperatures, they tend to fail by intercrystalline cracking at much lower elongations than plain carbon steel. Thus, in the commonly used 0·5 per cent. molydenum steel, intercrystalline cracking has been detected with elongations between 1 and 2 per cent., so that it would be unsafe to employ this class of steel for any purpose where the total deformation exceeded a fraction of this figure during the life of the plant. If it were practicable, a plain carbon steel could be safely used with ten times the deflection allowed on an alloy steel.—*"Shipbuilding and Shipping Record", Vol. LX, No. 12, 17th September, 1942, p. 267.*

Chromium-plating the Top Part of I.C. Engine Cylinder Liners.

A recent development in the chromium-plating of I.C. engine cylinder liners concerns a proposal to utilise a chrome alloy cast-iron liner and to chromium-plate the combustion-chamber end only. For this purpose the liner bore is enlarged at the top, the chromium is deposited and the complete bore is then ground to size throughout. As wear takes place—or rather, as the surfaces take on their working texture—the chromium-plated part remains hard and acquires its maximum polish, while the chrome alloy cast-iron liner, having hard constituents which form excrescences, holds the oil film, and in this manner assists the general lubrication of the piston and rings. The cast-iron alloy for the liner contains about 0·5 per cent. chromium, 0·15 per cent. vanadium and 0·25 per cent. titanium, together with 1·25 per cent. manganese, the total carbon content being 3·4 per cent., and the combined carbon 0·9 per cent., while silicon and phosphorus are present to the extent of 1·5 per cent. and 0·3 per cent. respectively. A maximum of 0·15 per cent. sulphur is given in the analysis. The figures are, of course, subject to a certain amount of modification. The whole process forms the subject of a recently published British patent.—*"The Oil Engine", Vol. X, No. 113, September, 1942, p. 112.*

Prospects of Pulverised-coal Firing.

Early experiences with pulverised-coal firing proved that the furnaces of cylindrical boilers are not suitable for this form of firing owing to the inadequate combustion space available in them. Water-tube boilers, however, offer an incomparably greater freedom in furnace lay-out, and are therefore better suited for pulverised-fuel firing. An important point to be considered in the lay-out of such a furnace is the combustion rate of the fuel, which is dependent upon the kind of coal fired (particularly upon the amount of volatile constituents), the fineness of the pulverised product, the temperature of combustion, and the amount of air supplied in excess of that theoretically required, etc. The speed of reaction can be assumed to double with every 20° F. of temperature increase. Assuming that fuel and air enter the combustion chamber at 300° to 400° F., it is clear that in the first stage of combustion the heat generated must be utilised for heating the combustion air, if a high combustion temperature and rapid combustion are to be achieved. This condition can be best attained by leaving the furnace uncooled in the zone corresponding to the first combustion stage, and providing furnace cooling only in those furnace regions in which the flame temperature has reached a satisfactory level. Undue wear of flame-exposed refractory furnace linings can be guarded against by the use of water walls, the heat-absorbing capacity of these in the region of commencing combustion being tempered by the employment of refractory-faced blocks. The furnace volume required to secure efficient combustion of the pulverised coal should be large enough to enable a rate of heat release of from 17,000 to 35,000 B.Th.U./cu. ft.-hr. to be maintained. This means that with pulverised-coal-fired marine boilers considerably larger furnaces are necessary than with oil-fired boilers, and this factor is a distinct disadvantage from the viewpoint of space requirements, more especially as additional boiler-room space for the installation of the pulverising plant must also be provided. As regards ash removal, the method of liquid slag removal now coming to the fore in American land boiler practice, is inapplicable to ships, and the more conservative system of dry ash removal in combination with a hearth screen over the furnace bottom must be adopted. The most effective way of ensuring dustless ash removal from the furnace is by means of a hydraulic system of ash removal, the ashes being pneumatically removed from the hopper bottoms of the boiler furnaces and sluiced overboard by water ejectors. Ash removal is carried out at fixed intervals, and gates are provided at the hopper outlets in order to seal the hoppers when the ash-removal system is in use. A German vessel in which equipment of this type was installed just before the war, was likewise fitted with an emergency ash-removal system of the vacuum type which could also be used for a general clean up of the boiler room. Because of the attendant risk of bunker fires, pulverised coal cannot be stored on board ship, and it is therefore necessary to employ pulveriser mills to supply the burners direct. The most suitable mills for use in a ship's boiler room are undoubtedly those of the pneumatic type favoured by Russian and German engineers. These mills have no revolving parts whatever and are almost silent in operation. About one-fifth of the combustion air required is supplied to the mill by a blower at a pressure of about 10in. w.g. This air is discharged into the working part of the mill through a nozzle at the bottom of the conical mill casing at a velocity of 600-650 ft./sec., and impinges upon the coal entering the bottom of the mill through the coal-supply connection at the side of the mill casing. A small air pipe is led into this connection, and serves to ensure a smooth, uninterrupted flow of coal into the mill. The coal pieces entrained into the jet of air from the nozzle are blown into an adjustable mixer tube just above it, the amount of their acceleration being determined by their size. Owing to the differences in velocity imparted to the individual coal pieces, a certain amount of attrition and impact between the fast-moving small particles and the slower-moving larger pieces takes place. An impact plate just over the top outlet of the mixer tube is impinged upon by the coal particles with great force, while the air stream is deflected from its straight-line motion. A classifier in the upper part of the mill enables the pulverisation of the discharged coal to be regulated to the required degree of fineness, the oversizes being returned to the lower part of the mill for renewed grinding. By using air preheated to a temperature of 430°-480° F., efficient drying of the coal during its passage through the mill can be achieved. In several Russian installations superheated steam is used instead of compressed air, but the considerable consumption of steam involved constitutes a serious disadvantage of this practice. Furthermore, it is by no means clear how the condensation of steam in the mills during the starting-up and shutting-down periods can be avoided. In the case of air-operated mills, the power absorbed amounts to about 20 kW.-hr. per ton of pulverised product with the mill adjusted to produce a fuel yielding a residue of 15 per cent. on Tyler No. 170 screen with 0·0035-in. apertures. The boiler-room lay-out of a German vessel equipped for pulverised-coal firing is shown in Fig. 3. There are

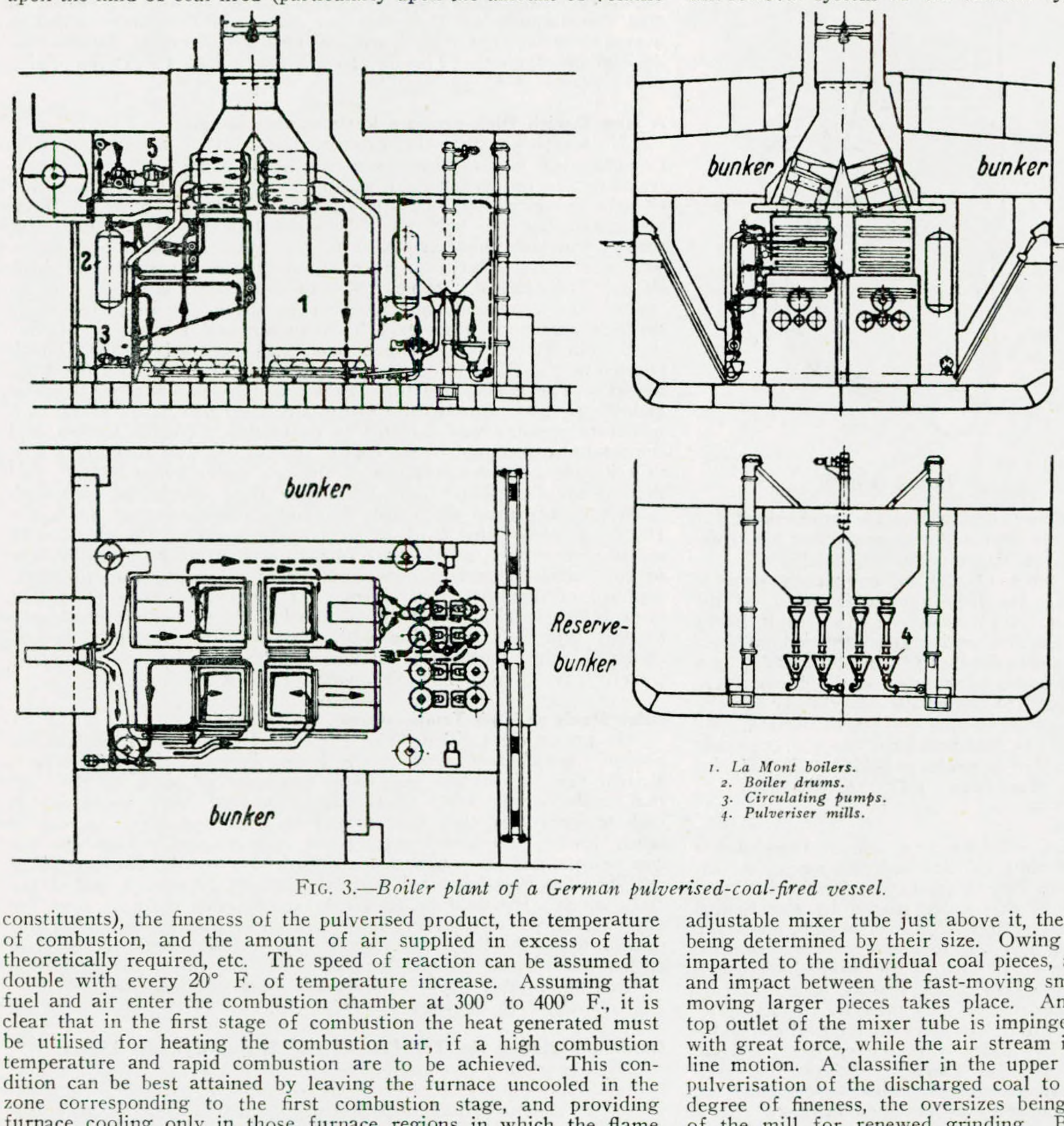


FIG. 3.—*Boiler plant of a German pulverised-coal-fired vessel.*

four La Mont boilers, each with a normal rate of evaporation of 22,000lb./hr. of steam at a pressure of 215lb./in.^{2} and final temperature of 617° F., at the superheater outlet. Each boiler is equipped with three pulverised-fuel burners, one of which has a discharge capacity of 1,100lb./hr. of pulverised coal, whilst the other two have each a capacity of 615lb./hr. To facilitate ignition, each furnace is also fitted with a small oil burner. As a short and very active flame is essential, burners of the turbulent type are used, and as each burner has a control range of 1 :3, the firing rate of the boiler furnaces can be varied in the wide range of 1 :12. The propelling machinery of this ship is a 1,750-s.h.p. turbine. There are two pneumatic pulveriser mills per boiler, and the air required for the operation of the eight mills and the 12 burners is supplied by a centrifugal blower which discharges into the individual air preheaters of the boilers. An axial-flow fan arranged in the funnel provides the necessary furnace draught. Two conveyor belts, each of 3 tons/hr. capacity, arranged fore and aft between the bunkers and the boilers, pass the coal to a coal crusher of special dust-proof design in which the coal is broken up into pieces of approximately 1-1¼in. size. From the crusher, another conveyor passes the crushed coal into an overhead bunker arranged above the mill battery. This conveyor is likewise completely dustproof. As may be seen in the diagrams, there is also a reserve cross bunker, forward of the boiler room, which is served by a special athwartship conveyor. The discharge of fly-ash and cinders from the funnels of a ship equipped with a pulverised-coal-firing installation must be guarded against by adequate cinder-trapping devices. Centrifugal dust separators of the vortex type would appear to be particularly suitable for this purpose.—*"The Shipping World", Vol. CVII, No. 2,576, 28th October, 1942, pp. 367-371.*

Cockburns Self-closing Emergency Stop Valve.

An improved form of self-closing emergency stop valve has been developed and patented by Cockburns, Ltd., the well-known makers of steam valves. Referring to the accompanying sectional diagrams (Fig. 3), when the handwheel (*9*) is rotated so as to allow the main valve (*2*) to open under the pressure on the inlet side, the collar (*21*) engages the operating lever (*20*) of an auxiliary valve (*8*). While this auxiliary valve is held in the open position the fluid for which the valve is used is admitted under pressure to the chamber (*6*) above the piston (*4*). The rings of this piston have a certain amount of clearance, thereby allowing the fluid to pass slowly from the chamber (*6*) to the exhaust end (*7*) of the valve box. When the pressures on the opposite sides of the piston (*4*) are approximately equal, the main stop valve (*2*) moves slowly in the opening direction. The exhaust end (*7*) is provided with a passage controlled by a valve (*23*) which is operated manually, when it is desired, in an emergency, to effect the closing of the stop valve by power, under the action of the piston (*4*). In the event of a fall in the pressure (or a reversal of flow) at the inlet side of the main valve, the non-return valve (*10*) prevents a reflux flow from the chamber (*6*). The expansion of the fluid trapped within the chamber (*6*) thereby effects the self-closure of the main stop valve (*2*). The fluid in the chamber (*7*) leaks back into the valve chest past the guide (*5*). A handle (*22*) is fitted to the lever of the auxiliary valve, so that, prior to the opening of the main valve, the auxiliary valve may be opened to admit pressure to the chamber (*6*) in order to relieve the regulating screw (*11*) of some of the unbalanced load on the main stop valve.—*"The Motor Ship", Vol. XXIII, Vol. 274, November, 1942, p. 267.*

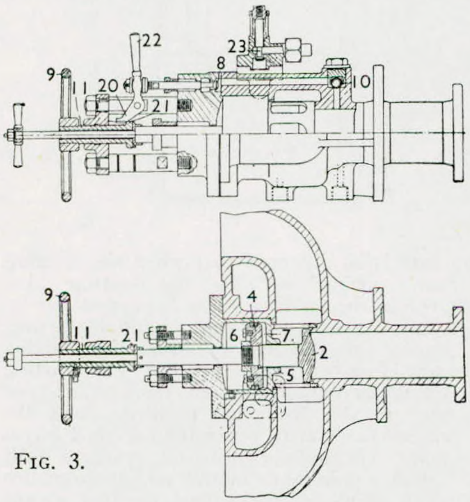


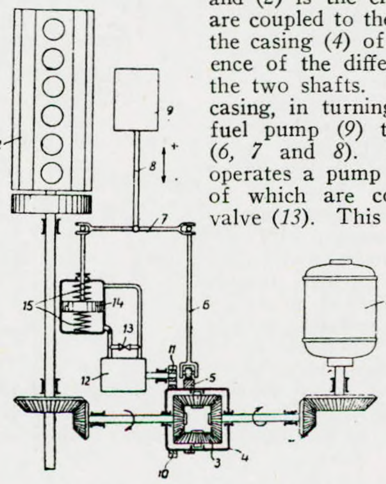
FIG. 3.

Hand-tool Inspection.

Hand tools such as hammers, files and spanners are so widely used in shipyards and marine engineering works that it is difficult to arrange for their regular inspection, although by keeping them in good condition it is possible to improve both the quantity and quality of production. The *Industrial Accident Prevention Bulletin* gives an account of one firm who make it a practice, every Saturday morning, about 15 minutes before knocking-off time, to have all the hand tools used in the fitting and erecting shops, etc., laid out for inspection, any that are not in proper condition being returned to the store and replaced. Every employee is provided with a locker and key in which these tools are kept to prevent pilfering or exchanging. When the scheme was first introduced there was some opposition from the production side, who visualised the loss of a quarter of an hour in all the departments affected, but it was subsequently found that the new routine led to a definite reduction in the number of accidents due to mushroom-headed tools, hammers with rounded heads, worn spanners and so on, while if it had been possible to make a check, it would probably have been found that there was an improvement in the standard of workmanship.—*"Shipbuilding and Shipping Record", Vol. LX, No. 11, 10th September, 1942, p. 243.*

Synchronising Gear for Multi-screw Ships.

A recent issue of *Werft*Reederei*Hafen* contains a description of a synchronising device for the propelling machinery of vessels having two or more propeller shafts, which has been developed and patented by Dr. Ing. W. Benz of the Klöckner-Humboldt-Deutz A.G. By means of this device, the relative displacement of the engine shaft and the shaft of the "pace-maker" is used to alter the output of the engine fuel pumps, and hunting of the engine speed is prevented by regulating the working of the fuel pumps to suit the relative difference in the speeds of the two shafts. Referring to the accompanying diagram, the electric motor (*1*) is the pace-maker and (*2*) is the engine to be controlled. Both are coupled to the differential balance gear (*3*), the casing (*4*) of which turns under the influence of the difference in speed and phase of the two shafts. By means of a cam (*5*), this casing, in turning, alters the working of the fuel pump (*9*) through the rods and levers (*6*, *7* and *8*). In turning the casing also operates a pump (*12*), the inlet and discharge of which are connected through a throttle valve (*13*). This pump is used to put pressure on the appropriate side of a piston (*14*) of a balance cylinder and spring (*15*) which is connected to the fuel pump (*9*) by the rod (*8*). The amount of movement of the piston (*14*) depends not on the relative angular displacement of the two shafts but on the relative difference of their respective speeds of rotation. Should the engine speed be slowed down, for example, because of a greater load, the cam (*5*) will increase the output of the fuel pump, in addition to which a further increase in the output of the latter will be effected by the action of the piston (*14*), thereby giving the engine a greater accelerating force according to the relative speed difference between the two shafts and thus bringing the speed of the engine up again before the shafts have time to get far out of phase. As soon as the two shafts are once more running in unison, the casing (*4*) stops turning, but is then at rest in a slightly different angular position which corresponds to the altered output of the fuel pump required by the increased engine load. The throttle valve (*13*) is adjustable and provides an additional means of controlling the temporary increments in fuel delivery to avoid any hunting of the gear.—*"The Marine Engineer", Vol. 65, No. 784, November, 1942, p. 250.*



Deutz synchronising gear.

Novel Design of Icebreaker.

The U.S. Coast Guard has placed an order with Peterson and Haecker, Ltd., of Blair, Nebr., for a small icebreaker of novel design. It will be a combination of a tug and an icebreaking plough, and will be used on the Illinois River linking the Lakes and Gulf waterway systems for ships of moderate draught. The new icebreaker will be unique in that three separate floating units will be variously combined to perform two distinct functions. To meet the special needs, the power plant will constitute a separate floating unit, so designed that it will be able to push a barge used for the servicing of navigational aids, or the icebreaking plough which is also a separate unit. The installation of the equipment for servicing the navigational aids on board a work barge to be pushed by the power unit will, it is claimed, not diminish the efficiency of the servicing arrangements. The vessel will have a welded steel hull 114½ft. in length, with a beam of 30ft., and a depth of 10ft., displacing 300 tons at a draught of 5½ft. The propelling machinery will consist of three 320-h.p. Diesel engines directly connected to triple screws. The ice plough, which will be attached to the ship whenever required, will be of welded steel, with a length of 59½ft., a beam of 49ft., a depth of 11ft. 10in., and a weight of 75 tons.—*"The Shipping World", Vol. CVII, No. 2,569, 9th September, 1942, p. 200.*

A New Deutz Engine.

The Klöckner-Humboldt-Deutz A.G., Cologne, who are by far the largest producers of Diesel engines in Germany, are now reported to have developed an entirely new design of V-type two-stroke engine for marine propulsion and auxiliary purposes for certain industrial requirements. The unit is to be manufactured in 12-, 16- and 8-cylr. form with a normal running speed of 700 r.p.m., and a rated output of 1,200, 1,600 and 800 b.h.p. respectively. Although no light alloys or special steels are used to any important extent in its construction and ordinary cast iron is utilised for the framework, cylinder covers and liners, the adoption of a high running speed and the V form of construction has made it possible to keep the weight of the engine and its auxiliaries below 13lb./b.h.p., the total weight of the 12-cylr. model being under nine tons. The cylinders, which are arranged in two banks at an angle of 36° to one another, have a diameter of 220 mm. and a piston stroke of 300 mm. The m.e.p. is stated to be about 72lb./in.² and the piston speed is 1,520ft./min. The engine is a self-contained unit and all auxiliaries are driven directly or indirectly from the shaft. They include the centrifugal scavenge blower, the fuel-injection pumps, F.L. pumps, circulating-water pumps and a general service pump, whilst the tank for lubricating oil and the cooler and filters for the F.L. and fuel-oil systems are attached to the engine, so that when it is to be installed it is merely necessary to make the various connections to the water, lubricating oil and fuel oil piping. The fuel-injection and scavenging systems are specially designed to permit the engine to run continuously at speeds as low as 100 r.p.m., if required. The overall length of the 12-cylr. engine is about 11ft., the extreme width 4ft. 9in., and the overall height 7ft. 11in. Fig. 5 shows a comparison in size between this engine and a normal four-stroke unit of equivalent speed (in full line) and a pressure-charged four-stroke engine of similar characteristics (dotted line). In a twin-screw ship the space required between the centre lines of the two propeller shafts is about 6ft. 6in. The makers claim that the m.e.p. of 72lb./in.² is equivalent to double this pressure in a four-stroke engine having an equivalent specific weight and that this mean pressure is not yet permissible even with the employment of Büchi pressure-charging. Fresh-water cooling is used and a small amount of anti-corrosion oil is employed, although any parts which are particularly liable to corrosion may be zinc sprayed for protective purposes. The pistons are of silicon aluminium and work in special C.I. liners which are free to expand downwards and contain the ports for the scavenging air and for the exhaust gases. Fig. 8 shows the control mechanism. The reversing lever moves from the "stop" through the "starting" to the "running" position, and the starting cam is so arranged that when the starting lever is brought back from "running" to "stop" the starting valve is not actuated. The control of the starting valve is carried out by means of a special cam-operated starting mechanism. When reversing, the starting cam is moved longitudinally. The starting lever can only be moved from the "starting" to the "running" position when the engine has started up in the specified direction. If the lubricating-oil pressure falls below a minimum figure, an oil-controlled valve shuts off the supply of fuel to the injection pumps. Pyrometers are provided for the measurement of the exhaust-gas temperatures with distance indicators on the control panel. Complete remote control of the engine from a sound-insulated control station overlooking the engine room may be arranged, in which case all the necessary gauges and instruments are concentrated at this point. Such an arrangement is usually adopted in German vessels with Diesel-electric propulsion. A 12-cylr. engine of this design underwent exhaustive shop trials, including a non-stop run of 400 hours, before production of the unit on a commercial scale was begun. The designed power of 1,200 b.h.p. was attained at a speed of between 410 and 480 r.p.m. with a fuel consumption of less than 0·35lb./b.h.p.-hr., a consumption of 0·36lb./b.h.p.-hr. being maintained over practically the whole running range of the engine. The wear on the cylinder liners and pistons, the crankshaft and crankpins, main bearings and big-end bearings was ascertained after the trials and proved to be negligible.—*"The Motor Ship", Vol. XXIII, No. 274, November, 1942, pp. 240-245.*

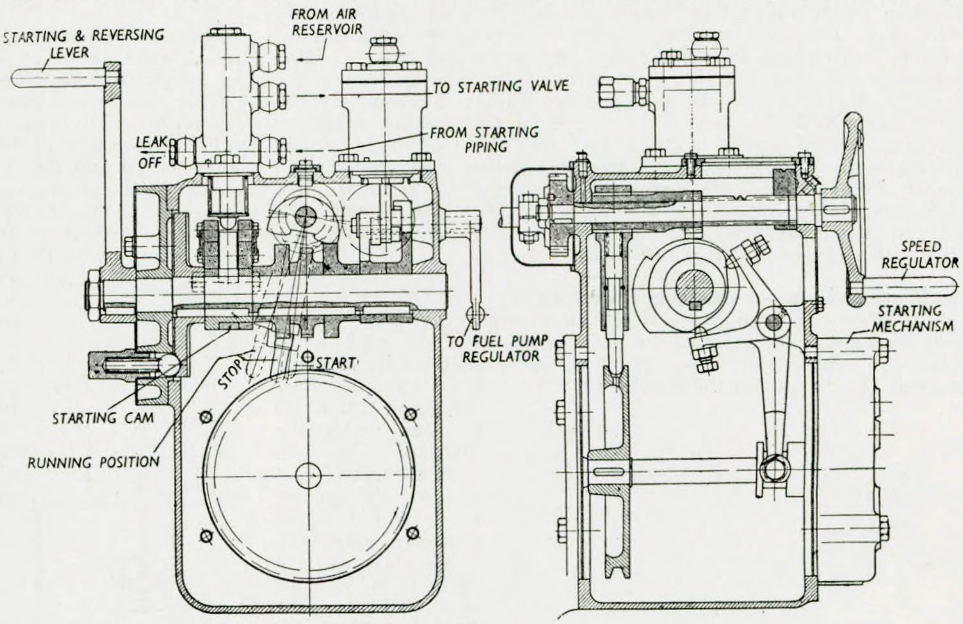


FIG. 8.

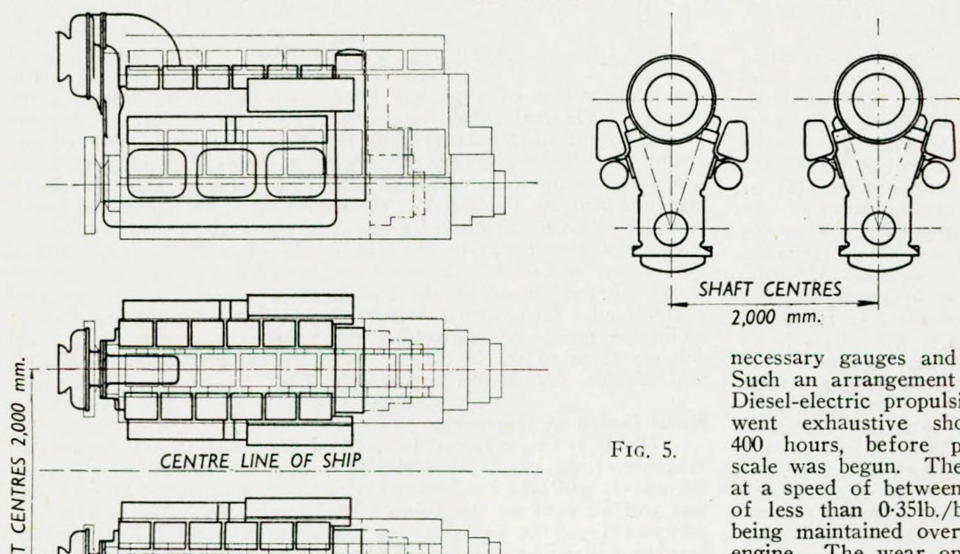


FIG. 5.

Producer Gas for Two-stroke Engines.

It is reported from Sweden, that after prolonged experiments and tests, the Bolinder Munktell Company have succeeded in eliminating the difficulties that have hitherto prevented a practical and economic use of producer gas in two-stroke heavy-oil engines. The principal feature of the system developed by the firm is that the gas has not to pass through the crankcase, but is led direct to the cylinder from the generator. During this circulation some of the compressed air from the crankcase is mixed with the gas. Improved fuel consumption and power output are claimed for producer-gas operation according to this new system.—*"Mechanical World", Vol. CXII, No. 2,906, 11th September, 1942, p. 249.*

Engineers Help Doctor.

A naval rating from a destroyer was brought to the sick bay of the battleship "Rodney" with a severe face injury. The medical officer decided to perform a new type of operation, for which a special instrument was necessary. He made a sketch of it and explained his requirements to the ship's engine-room artificers. The device resembled a miniature tyre lever and was forged from a steel bar, tinned and polished. The E.R.A.'s made two attempts before they got exactly what the medical officer wanted. The operation was completely successful and the injured man was able to return to his own ship two days later. The operation in question, which is quite new and as yet known to very few surgeons, was recently devised by Sir Harold Gillies, the famous plastic surgeon. The old operation for this particular injury used to leave a disfiguring scar on the face, while the new one leaves only a small scar hidden in the hair.—*"Lloyd's List and Shipping Gazette", No. 39,890, 23rd September, 1942, p. 9.*

Armstrong Whitworth Oil-cooling System for Pistons and Bearings.

An improved method of cooling the pistons and of lubricating the bearings of Diesel engines has been developed by Armstrong Whitworth & Co., Ltd., and forms the subject of a recent British patent. Two oil supply systems for the cooling of pistons and the lubrication of bearings are shown in the accompanying sectional drawing (Fig. 1). Both supplies may be at the same pressure, but if necessary, the piston-cooling-oil pressure can be increased separately. The crank web on the left has a hole (*A*) for allowing oil to pass to the crankpin, a second hole (*F*) taking cooling oil to the piston through an annulus surrounding a tube (*G*) which conveys lubricating oil to the gudgeon-pin bearing (*C*). The cooling oil for the piston passes up a hole (*L*) and is directed to the crown by a telescopic cylinder (*K*) which is spring-loaded and maintained in contact with the top of the connecting rod. It is to be understood that the top of the cylinder is provided with a number of slots or holes through which oil can escape to the interior of the piston and drain back through the small passages which are shown communicating with spaces between the gudgeon-pin bosses of the piston. The oil accordingly falls into the crankcase for recirculation. The supply from the oil pump is conveyed to a passage (*P*) and thence to the outside of the main-bearing shell. It will be observed that the hole (*F*) for the piston-cooling oil terminates at the sides of the main bearing and the big-end bearing respectively. In order to form a seal for the oil, a split ring (*M*), held in position by a spring (*N*), is fitted. If a single lubricating-oil pump is used to supply both systems, an adjustment is made on the delivery side of the pump to pass the required quantity and pressure of oil to each series of channels.—*"The Motor Ship", Vol. XXIII, No. 274, November, 1942, p. 267.*

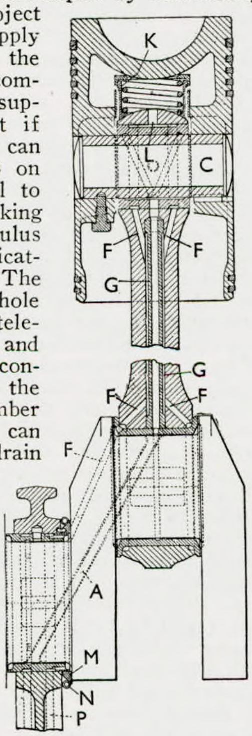


FIG. 1.

New Swedish Motor Schooner.

The auxiliary sailing vessel "Freja", which recently completed her trials, is the first of a group of five similar ships to be built at the Kalmar Shipyard for Swedish owners. The hull, which is of steel construction, specially strengthened for navigation in ice, has an o.a. length of some 132ft., a beam of 27½ft., and a depth of 12½ft., with a gross tonnage of 312 tons and a cargo capacity of 425 tons. Water ballast can be carried in the fore and after peaks, as well as in three compartments in the double bottom, where there are also two fuel-oil tanks with a total capacity of 15 tons. There are two cargo hatches, each served by a 2-ton electric winch; the forward winch motor also drives the windlass. The vessel is rigged as a three-masted schooner, the total sail area being 3,770ft.^{2}. The officers and crew are berthed aft. The propelling machinery consists of a two-cylinder Bolinder-Munktell engine developing 225 b.h.p. at 300 r.p.m. and driving a propeller with reversible blades, the hydraulic controls of which, like those of the main engine itself, are operated from the wheel-house. The engine room also contains a 10-h.p. Bolinder engine which drives a pump and a 1·2-kW. 24-volt generator. The vessel's equipment includes W/T and direction-finding gear.—*"Lloyd's List and Shipping Gazette", No. 39,896, 30th September, 1942, p. 11.*

New Swedish Steamer.

.. The cargo steamer "Arabritt", 2,840 tons d.w., built at the Oresund Shipyard, Landskrona, for Swedish owners, was delivered on June 16th. The vessel is of the single-deck type, with four holds, but has several unusual features. The engine room and bridge structure are between Nos. 3 and 4 holds; there are three pairs of derrick masts, one pair between the hatches of the two forward holds, one pair at the forward end of the bridge structure, and one pair aft; and the tank top in the after (No. 4) hold has been raised to the level of the top of the tunnel in order to enable cargo from this hold also to be discharged by means of grabs. The ship has an o.a. length of about 295ft., a beam of 42ft., and a draught of 18ft. on summer freeboard. The cargo-handling equipment comprises eight 5-ton derricks, each served by a steam winch. The propelling machinery consists of a triple-expansion engine, constructed by the shipbuilders, developing 1,300 i.h.p. at 85 r.p.m., and supplied with steam by two boilers equipped with superheaters, forced draught and air preheaters. The ship attained a speed of 14·15 knots on her trials.—*"Lloyd's List and Shipping Gazette", No. 39,896, 30th September, 1942, p. 9.*

Maintenance of Soot-blowing Equipment.

The following are some of the troubles which the writer has experienced with soot blowers of the element type: Elements placed in the region of a superheater, where the gas temperatures are high, very soon become either distorted or burnt. Calorised elements are a real danger to the boiler tubes, as the steam jets from them may impinge upon the tubes, causing erosion or punctures. Leaky glands are a common source of trouble, especially on blowers having a gland between the head and the boiler casing. Gland leakage may often be due to poor drainage and to the bending moment produced at the gland by the sagging of the element in its supports when rotating. Dust and grit from the top of the boiler are liable to be swept on to the soot-blower heads, filling the gear-wheel teeth and thus preventing the elements from being rotated. All gear should, therefore, be enclosed or provided with suitable guards to prevent such trouble. The choking of the drain pipes and the internal corrosion of the steam supply pipes are other causes of trouble. These effects are produced when the head valves are left open, so that after the master steam valve has been closed a partial vacuum is formed in the supply and drain pipes as the remaining steam condenses. This causes gas and dust to be drawn from the combustion spaces through the element nozzles and blower heads into the pipes, where the sulphurous gas quickly corrodes the metal and the dust eventually chokes the small drain pipes. Cases are known where badly corroded supply pipes have burst under steam pressure, causing injury to the boiler-room personnel. A vacuum-breaking device should be fitted to the supply pipes to prevent the above trouble. Soot blowers of the single-nozzle type sometimes give trouble through seizure or burning. Seizure, which may be partial or complete, may be attributed to lack of lubrication or to too fine a clearance between the moving and stationary parts, especially if the nozzle is left in the operating position too long, so that it overheats. Burning of the nozzle may be due to leaving it in the operating position or to the collapse of the protecting brickwork around the blower. Slight burning of the nozzle is generally due to the failure of the cooling steam supply.—*H. Batley, "Mechanical World", Vol. CXII, No. 2,908, 25th September, 1942, p. 296.*

"Sir Charles Parsons and Mechanical Gearing".

This Memorial Lecture deals with the pioneer work of the late Sir Charles Parsons in the development of mechanical gearing for marine propulsion. The initial success of the s.s. "Vespasian" in 1910 is mentioned and it is shown how this noteworthy achievement was followed by a very rapid change-over from direct-drive-turbine to geared-turbine propulsion, more particularly in naval vessels. Thus by 1916, all new naval ships, excepting those of special types, were equipped with mechanical gearing. The introduction of double-reduction gears for merchant vessels is mentioned, and there are references to the materials used in the construction of gears. A section of the lecture deals with gear noise and periodic errors, and it is shown how Parsons' invention of the "creep" machine has resulted in a reduction of gear noise. Parsons' insistence on accuracy in gear-cutting machines is mentioned, and it is shown how accuracy in the manufacture of hobs has developed. The lubrication of gears, gear loads and Parsons' introduction of the all-addendum gear are discussed, and the lecture concludes with a summary of Parsons' magnificent achievements in the introduction of mechanical gearing.—*The Parsons Memorial Lecture, 1942, by S. F. Dorey, D.Sc., Wh.Ex., "Transactions of the Institute of Marine Engineers", Vol. LIV, No. 9, October, 1942, pp. 111-126.*

U.S. Ship-repair Work.

According to the New York *Journal of Commerce,* the president of the National Council of American Shipbuilders, Mr. H. Gerrish Smith, has revealed that during the last 12 months American shipyards have completed repairs on 5,500 ocean-going ships of 2,000 tons or more, representing a total tonnage somewhat greater than one half that of the world's merchant fleets. Much of the war work carried out in these yards has been of a character quite different from the usual commercial repair work done in normal times, and has involved an increase in the numbers of shipyard workers of over 400 per cent. as compared with those of 1940. During the past year hundreds of ships have been armed with anti-submarine and anti-aircraft guns and have been provided with accommodation for the guns' crews. In addition, 31 sabotaged German and Italian vessels seized in U.S. ports have been repaired and equipped for war service at a cost of about ten million dollars, whilst 65 foreign ships that were requisitioned have likewise been armed and placed in good operating condition, as well as many of the 198 ships of the old laid-up World War fleet. Up to May 1st, the U.S. Army and Navy had acquired a total of 285 merchant vessels, aggregating more than three million tons deadweight. All of these had to be converted for service as Army transports or Navy auxiliaries, as well as 800 small craft, which have been armed and converted into Naval patrol craft.—*"Lloyd's List and Shipping Gazette", No. 39,908, 14th October, 1942, p. 4.*

Ingenious Repair to Broken Stern Frame.

An ingenious repair carried out recently in a British port enabled a ship to be quickly recommissioned without the delay that would otherwise have arisen due to the difficulty of obtaining castings under present conditions. The vessel in question is owned by the Lamport and Holt Line, Ltd., and returned to this country with the sole piece of the stern frame, below the propeller aperture, broken off. Had no alternative to a new casting been devised, it is probable she would have been out of service for several months while it was being made. The expedient adopted by the repairers was to cut three armour plates to the required shape, allowing for additional vertical welding at the rudder-post end of the stern frame to give an equal strength of weld to that on the forward break of the panel. The centre plate was first welded in position to both ends of the break, after which the plates on either side of this were similarly dealt with. The three plates were afterwards riveted together, and a covering plate was then slot-welded to this structure on either side and carried forward to the shell plating of the hull, to which it was secured by riveting. This ingenious makeshift repair was duly approved by the surveyors of the classification society concerned and of the Ministry of Transport, and the ship is again at sea.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,777, 8th October, 1942, p. 2.*

N.E. Coast Institution Presidential Address.

In the course of his address, the President referred to the part being played by Sunderland shipbuilders in the present-day programme of ship construction. After explaining the essential difference between the conditions which obtain in the British shipbuilding industry and those which prevail in the U.S.A., he pointed out the special advantages enjoyed by the U.S. yards on the Pacific Coast as regards climate, the absence of any "black-out" and the well-nigh unlimited supply of labour. The President took the opportunity of vindicating the past policy of National Shipbuilders Security, Ltd., in dealing with redundant shipyards, which has been the subject of a considerable amount of adverse criticism. He also replied to those critics of the Government's programme of cargo ship construction who maintain that the 11-12-knot vessels being built at the present time are too slow, and that ships with a speed of 15-16 knots would prove far more suitable for service under war conditions. Citing the case of one particular firm, who are now completing sixteen 11½-knot cargo vessels of 10,300 tons d.w. per annum, he declared that if that firm were directed to build instead 15-knot vessels of the same dimensions (and their berths will not permit of anything much bigger) then the power of the engines would require to be increased from 2,900 i.h.p. to over 7,000 i.h.p., with the result that the firm's annual output would be reduced to only ten of these faster ships, and these would carry only 8,300 tons of deadweight instead of 10,300 tons each. Moreover, the firm in question are producing a further eight 2,900-i.h.p. engines for other shipbuilders, but if they had to build 7,000-i.h.p. engines they could supply no engines at all to other yards. In other words, it is a case of either twenty-four 2,900-i.h.p. engines or ten 7,000-i.h.p. engines per annum. The President remarked that despite the adverse criticisms of the new cargo vessels' speed, the programme of fast ships is not so small as the critics think. As regards the people who advocate the adoption of new kinds of lay-outs for shipyards on the lines of the "production-belt", etc., he pointed out that apart from the very long time it would take to build such shipyards and the problem of where the additional labour involved could be found, the sponsors of these schemes would do well to ascertain how our existing shipyards in this country compare with the latest type of yards that have been established in the United States. If they would do this they would find that the existing type of yard has done things that are really meritorious so far as time is concerned, and that as regards the absorption of man power by the normal method of ship construction, our yards are well ahead of the best of the American yards having any such new kind of lay-out. It has also been said that all cargo shipyards in this country should be building exactly the same standard ship. This method was adopted in the last war, but, after a full experience of its working, it was deemed to be much better to permit each individual yard to concentrate on its own particular standard type as in production *before* the war, in order to utilise the different plant and facilities available in the various yards and the different methods of construction which they had perfected to the best advantage. The President then proceeded to dispel the popular illusion that all ships in America are constructed in parts far away from the yards and transported to them for assembly, and that the same method could be adopted here. If a yard has the space, labour and plant to fabricate the parts inside its own boundaries and close to the berths, there would be no point in fabricating them miles away and then burdening the railways and the roads with the transport of very large and unwieldly parts. In actual fact, those British yards which are able to erect and launch more steel than they can themselves prepare, have already been supplied with fabricated steel components such as masts, derrick posts, tanks, etc., to the extent of 50,000 tons by the structural engineering industry all over the country. The President called attention to the immense increase in the amount of work entailed in fitting out and finishing off a ship to-day, as compared with that in normal times, by reason of the defensive and offensive armament and other alterations and additions called for by war conditions, the extra weight due to defence measures in an ordinary cargo ship amounting to nearly 200 tons. After expressing the view that it will be futile to attempt to conduct the British shipbuilding industry after the war on the same lines as before, the President dealt with the function of provincial and national technical societies in general and with that of the N.-E. Coast Institution in particular. He then discussed shipbuilding education and the unreasonable prejudice which still appears to exist on the Tyne against University graduates in the engineering and shipbuilding industries. He concluded his address by recalling that the late Professor B. P. Haigh said shortly before his death: "War may be no time for deep reflection, but it offers notable opportunities for observation and leads in the long run to the advancement of engineering theory and practice.—*Presidential Address by J. Ramsay Gebbie, B.Sc., delivered at a general meeting of the N.-E. Coast Institution of Engineers and Shipbuilders, on the 16th October, 1942.*