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Propelling Machinery for Small Craft.

By ALLAN CALDWELL (Member).

Some twenty-five years ago the question of the type of propelling machinery for small craft scarcely arose. The prospective owner or designer required to give thought to the power needed to meet the conditions of the vessel's intended service, but the means by which that power was to be generated was, more or less, taken for granted. Propulsion and steam were almost synonomous terms. Whether the vessel was a coaster, tug, lighter, water boat, dredger or hopper barge mattered not—if it was self-propelled the prime mover was a vertical inverted-cylinder direct-acting surface-condensing engine, with a marine return-tube boiler, the latter ninety-nine times out of a hundred coal-fired. Comparatively higher boiler pressures were being used then, and consideration might be given to whether the engine should be compound or triple-expansion, but generally compounds were still favoured.

And looking back to, shall we say, these good old days, one can only do so with mixed feelings. On the one hand we think of the comparative crudeness of the machinery arrangement, the low efficiency and the resulting high fuel consumption and running cost; but at the same time we cannot help but recollect the almost absolute reliability and freedom from trouble experienced. Although hulls in those days were most "well and truly" built—the author says this with all due respect to present-day shipbuilding practice, but nevertheless with conviction—the machinery could generally be relied upon to outlast the ships. Machinery in many tugs, for instance, was still giving excellent service after forty years of really hard work and not a great deal of attention. The author has known vessels change hands and start a new lease of life under fresh ownership at even riper years.

It is true that before then a number of small craft had appeared, fitted with internal-combustion engines. Except perhaps for some of the smaller fishing craft, however, they did not inspire confidence. Certain of the early motor-driven coasters made all too frequent appearances in the casualty lists, and experiments in motor propulsion for trawlers proved very costly and unsuccessful for more than one firm of builders.

The author does not think that the hot-bulb or so-called semi-Diesel engine would ever have become a serious competitor of steam, but with the development of the compression-ignition or Diesel engine and its adaptation to marine service, there came a revolution in small craft propulsion. This revolution, like some of the early engines, was slow to start and this is not surprising. For the small craft owner is, paradoxically, enterprising whilst conservative and cautious. He will struggle and take great risks to secure fresh markets, but, generally speaking has ingrained ideas in regard to plant and takes a great deal of convincing that a class of tool that has served well for generations may not be best suited for his particular job. In addition to this conservatism, the question of personnel caused hesitation. In small steam craft the engineer in many cases simply developed from a greaser into a fireman; and when it is remembered that the majority of small craft work three shifts, the problem of finding suitable engineers on the adoption of any serious change can be appreciated. Also, it did not require much skill to maintain the steam plant in serviceable condition, but this new engine apparently demanded highly-skilled attention and refused to work unless and until it got it. Because of these and other considerations, it will be seen that the early users of internal-combustion engines in small craft were not only heroes, but in some cases martyrs. It will also be appreciated that Diesel-engine makers who wished to develop a new market and consultants who felt that there might be some advantage to their clients by the adoption of the internal-combustion engine, had an almost impregnable barrier of prejudice to break down. Bearing this in mind, the enormous change over from steam to some form of Diesel propulsion that has manifested itself during the past twenty years, would seem to suggest that the internal-combustion engine, in spite of prejudice, has proved itself to be definitely advantageous from the owners' point of view, and that the steam engine has, in an extraordinarily short period of time, fallen from grace with little likelihood of recovery.

All sorts and conditions of small craft are at present under construction, but generally speaking the choice of prime mover employed for their propulsion is not governed by its economy or even its suitability, but rather by speed of production or grade of priority afforded to the particular class of vessel, so that when the war is happily over and the building of craft for private ownership begins again, the question of the most suitable type of machinery for particular services will have to be faced afresh and we ought to be in a position, when that time comes, to give owners some lead in the matter.

The author has designed hundreds of steam-propelled vessels and was fortunate enough to be entrusted with the design of some of the earliest Diesel and Diesel-electric tugs built in this country, but unfortunately the trial and service data collected has been destroyed. As, however, a considerable amount of it has already been published in various directions, the author's inability to reproduce actual results need not affect a general consideration of the subject. We are apt to become overloaded with statistics and it may be salutary, for once, to endeavour to state only general impressions.

So far as running costs are concerned, the governing factor will be the comparative cost of the fuels concerned, and as no one can say with any degree of accuracy what the relationship will be after the war, we must assume that it will be in proportion to that which obtained in pre-war days. On this assumption, there can be no doubt whatsoever that if running costs only are considered, the choice in order of economic priority will be Diesel, Diesel-electric, steam (oil burning) and steam (coal burning).

But as running costs are not the only consideration, it may be useful to summarize shortly what the author considers to be the pros and cons relating to the various systems. As tugs are the author's particular interest, it may be excused if his views are based on this class of vessel.

In the author's opinion, the thing that matters most in the propulsive mechanism of a screw-propelled vessel, is the screw propeller. All attempts to increase mechanical and hull efficiency can easily and effectively be rendered null and void by fitting an unsuitable propeller, and the author is reasonably sure that there are many small craft afloat to-day which have been running inefficiently for years because the propeller is of faulty design and not best suited to the ship and the power delivered to it. Further, in the author's opinion, the thing that matters most in the case of the propeller is the diameter. Taylor's curves confirm this view. B_p value should vary directly as r.p.m. so that a glance at the curves makes it apparent that efficiency must drop as r.p.m. increases. Also a considerable proportion of the gain in thrust claimed for the Kort nozzle is due to the fact that, owing to the form of the nozzle, the race does not contract behind the propeller, so that a propeller of a given diameter working in a nozzle has the same effect as a propeller of considerably larger diameter working in the open. So important has the author considered ample diameter, that he has from time to time done outrageous things with stern frames in order to avoid restricting this dimension.

This is necessarily associated with revolutions and when there are no legitimate restrictions such as draught of water, the author considers that best results are obtained from a propeller designed to absorb the required power at not less than 110 or more than 125 r.p.m. This suits steam admirably, as this range of revolutions covers a series of standard proportion steam engines from, say, 300 to 1,500 i.h.p. All too often the naval architect is asked to design a vessel for which the dimensions, draught and machinery are pre-ordained, and propeller scope is circumscribed before suitable proportions have been considered. So the propeller design is based not on maximum efficiency but to suit a restricted aperture.

If the author's contention in regard to propeller diameter and r.p.m. is sound, then direct-Diesel drive is necessarily inefficient compared with steam. The average r.p.m. of low-powered Diesels is about 300, and many are rated considerably higher. Apart from propulsive efficiency, a propeller suitable for such a speed does not give the high qualities of manœuvrability inherent in the large blade area and pitch associated with slow-running screws.

Steam machinery, however, as we know it, has certain disadvantages. In the first place the time taken to get under way from cold or even from banked fires is costly both in time and money, and may frequently result in the loss of an important job. And more trouble arises from efforts to reduce this time than perhaps from any other cause. When coal is burned the necessity for regular and frequent cleaning of fires is another drawback. Especially when a two-furnace boiler is fitted the loss of speed resulting from pressure drop brings down the service average to a very appreciable extent. The comparatively small quantity of fuel that can be carried restricts the vessel's range and involves further loss of time for frequent bunkering. The Diesel engine, on the other hand, can be started up from cold and the ship got under way immediately, in addition to which the power developed is constant. Not only are the pounds of fuel per hour consumed a fraction of that of coal, but owing to the saving in weight of the machinery installation and easier stowage of the oil, a great deal more fuel can be carried on equal draught. The vessel's range is therefore greatly increased and the number of stoppages for bunkering reduced and time taken for the operation very much less. The seriousness of this aspect of the problem can be best appreciated by making a rough estimate.

Assume that a tug say 140ft. long indicates 1,250 h.p., *i.e.* 1,000 i.h.p. towing. Coal bunkers could probably be arranged to carry about 170 tons; but there would be no difficulty in carrying 300 tons of oil fuel. Coal consumption would be about 17 tons per day giving 10 days steaming, or at 100 miles per day, a range of 1,000 miles. If oil were burned in the furnaces instead of coal, consumption would be about 12 tons per day, giving 25 days steaming or at 100 miles per day, a range of 2,500 miles.

With internal-combustion engines and making due allowance for loss in towing efficiency due to fast-running propeller or alternatively for transmission losses due to the introduction of some form of reduction gear, consumption would be about 6 tons per day plus, say, 1 ton per day for auxiliaries, giving 45 days steaming or, at 100 miles per day, a range of 4,500 miles.

In terms of range, therefore, the ratio of possibility would appear to be in the neighbourhood of 1 : 2½ : 4½ and this in conditions most favourable to the steam vessel, the comparative consumption of which is less when engaged in continuous than when in spasmodic work. In harbour service for instance, where there is a great deal of stand-by time, the steam vessel is always burning a certain amount of fuel, whereas the Diesel uses none when not under way.

In terms of fuel cost, assuming Diesel fuel to be double the cost of coal, the saving in favour of Diesel would be roughly 20 per cent. This would be partly offset by the higher cost of lubricating oil and maintenance. Actual comparative costs are difficult to ascertain owing to the differences in the services in which these craft are employed, but the author thinks it may be safely assumed that in terms of overall running and maintenance costs the ratio of coal-burning steam to Diesel would be about 1 : 1·15.

The comparative inefficiency of the high-speed propeller, although perhaps not generally admitted, is in many cases appreciated: hence the various methods devised for coupling the Diesel, which is essentially a high-speed engine, to a slow-running propeller. For vessels engaged in long runs, ordinary single or double mechanical reduction gear may be found suitable. Although this has been the source of many troubles in the past, most of these have been eliminated by increasing tooth width and surface and by more accurate cutting.

But for small craft whose service entails only short runs and a great deal of manœuvring and for tugs in particular, which are necessarily changing propeller direction almost constantly, mechanical gearing cannot be considered satisfactory. The Burn reduction gear is extremely reliable, but the limit of 2/1 reduction inherent in its design greatly restricts its usefulness. For the lower ranges of powers at any rate, oil-operated gears such as the S.L.M. have proved most reliable and when reverse and reduction gear is combined leave little to be desired. They lend themselves to simple remote control giving direct and immediate response to bridge orders, and the main engines being uni-directional are simpler than the direct-reversing type and run under most favourable conditions. Such gears have been examined after a long term of service in the worst possible conditions and no signs of wear observed. Although the author has no record of a failure of the oil pump, this is a potential weakness, as failure would put the propulsive mechanism out of action. It may be considered advisable, therefore, where this type of gear is incorporated, to provide a stand-by oil pump for emergency use.

The only present alternative to oil-operated gear of which the author has any experience is electric drive. There is no limit to the power or to the engine/propeller speed ratio where they are coupled electrically. It has the advantages of a uni-directional engine or engines, positive and instantaneous bridge control, and has a particular and important advantage in respect to tug propulsion.

If the propeller of a steam or direct-Diesel tug is designed to absorb full power when the vessel is running light, then full power is unobtainable when towing. A normal tow will reduce propeller revolutions and so the power developed by approximately 20 per cent., so that at the time when maximum power is required it is not available. If on the other hand, the propeller is arranged to absorb full power in average towing conditions, the engine will race when running light and must be checked by either governor or throttle.

An electric propulsion motor, however, can be designed to develop full power over a considerable range of revolutions, so that full power can be delivered to the propeller in any condition of load. Another feature of electric drive is that the power being developed is always known, so that there is never excuse for running on overload. Owners may tend to be nervous of adopting electric propulsion, but there has never seemed to the author to be any justification for their fears. After all, trams, tubes and an increasingly large number of trains are operated electrically and one seldom hears of a breakdown due to electrical causes. It may be that their fears are grounded in the apparent complication of the system and their lack of technical knowledge of its operation. Few things are more complicated than wireless and not one of us in a thousand has any technical knowledge of its operation; nevertheless we all make full use of it with perfect confidence. Up to a point, however, the author is in sympathy with such owners. Knowing the vigorous conditions under which machinery in small craft operate and the stir that is caused at "topsides" when a vessel has to be taken off for a few days for repair or overhaul after months of almost non-stop work, and also being aware of the lack of technical qualifications of the men who in many cases drive these craft, the author has always felt that the keynote of the machinery arrangement must be robust simplicity. And the author feels very strongly that this simplicity of arrangement must be maintained in whatever system of propulsion adopted. The tendency to-day, especially in the United States of America, seems to be towards various forms of electric drive or gearing with electric couplings. And developments seem to be on the lines of increasingly large batteries of small generating engines running at ever increasing speeds. This may be sound from a mass-production point of view, or it may be leading towards a higher standard of general efficiency. This latter the author doubts, but is open to conviction. It all seems to be leading away from the simplicity of arrangement which small craft demand, and to obtain which the author would even be prepared to sacrifice a little efficiency.

Anyone going aboard the "Framfield" would be inclined to point out that she was far from being an example of simplicity. But it must be remembered that she was one of the earliest tugs of her class to be built in this country and that little or no working experience was then available. Her owners were taking a revolutionary step, more or less in the dark, and rightly required some sort of assurance that the vessel would be reliable. It was necessary, therefore, to visualize every possible eventuality and to make such provision as seemed desirable to meet, as far as was practicable, all imaginable contingencies. The fact that most of these contingencies never arose was all to the good and reflected credit on the thought given to the general installation, but in the circumstances the precautions taken were nevertheless justified at that time. As a result of experience gained since, the author would not now hesitate to recommend a less complicated arrangement.

The Diesel-electric system has at least all the advantages of the direct-Diesel with none of the disadvantages. It permits practically the same range, lends itself to any propeller and engine speed desired with bridge control, and gives visual protection against overload. Initial cost would be a little higher but not a great deal, as the faster-running engine and deletion of reversing mechanism would represent a considerable saving to set against electrical equipment. Running costs would be a little higher and maintenance costs and running time probably about the same. Overall working costs would certainly be less than with oil burning, and considerably less than with a coal-burning plant.

It would appear, therefore, that Diesel, either direct or geared, or Diesel-electric propulsion are likely to present more attractions to the small craft owner than steam after the war, and although the author may be considered old-fashioned, this seems to be a very great pity. Apart from the fact that we are a coal-producing country and it is therefore our natural fuel, there is something very comforting and soothing in the rhythm of a reciprocating engine, and a sense of latent energy in the sound of a safety valve blowing. But the shipowner is hard and heartless and lacking in romantic sense when costs are involved, so that those of us—unless the author is the only one—who would be greatly disturbed to witness the total eclipse of steam propulsion for small craft, are faced with a very serious problem. It ought to be possible to go some way towards greater economy and efficiency, as generally speaking steam machinery in the low power range is practically the same to-day as it was when we first knew it.

In recent years very considerable progress has been made in regard to improving efficiency and economy in larger-powered reciprocating engines with coal-fired boilers. This has been achieved to a very large extent by superheat, reheating poppet valves and by the introduction of an exhaust-steam turbine between the l.p. cylinder and the condenser. But none of these modifications is, in the author's opinion, suitable for application to machinery in the class of craft under consideration, although the Bauer-Wach system has been adopted in some of the larger trawlers.

If the author is given the opportunity, when conditions become more normal, he would like to build a steam tug which he had suggested just before the outbreak of hostilities. Roughly what the author has in mind is a vessel fitted with a totally-enclosed forced-lubrication, non-reversing steam engine running at say 375 r.p.m. driving a propeller through an oil-operated reverse-reduction gear with 3/1 ratio. Steam would be supplied by a Lewis single-drum boiler, burning preferably coal, but if necessary oil fuel. This boiler would give higher efficiency and its weight would be less than one-third that of a Scotch boiler. It could be accommodated in a very much smaller space, so that bunker capacity could be at least doubled on the same displacement. The permissible water level drop is at least four times that of a Scotch boiler and steam could be safely raised in one hour instead of twenty-four. Circulating, air, feed and bilge pumps would be independent and an exhaust steam feed heater fitted. The author would arrange for the most efficient form of lagging and insulation at every point throughout the whole installation where heat was likely to be lost and fit baffles on all cold-air inlets. If Mr. Shoosmith's or some other means of mechanical stoking were practicable it would be a very great advantage, but the necessary gravity feed seems to the author to rule this out except, perhaps, for a very restricted class of work. A vessel developed somewhat on these lines would have a greatly increased range, bridge control and constant readiness for almost immediate service. Alternatively, one might substitute for the engine and reduction gear suggested, a similar type of engine, but running at 600/700 r.p.m. driving a generator operating a slow-running propulsion motor, in which case auxiliaries could be either steam or electrically driven. Compared with the normal steam vessel, overall efficiency would be higher and running costs lower, but to what extent the author would not care to say without further investigation.

But the author is reasonably sure that one would still have some distance to go to get down to direct-Diesel running costs. Burning oil fuel instead of coal would certainly get a great deal closer to it, but to reach parity with the internal-combustion engine would require an approach from another angle, the direction of which the author is unable at present to visualize.

If therefore, an owner wishes a vessel, reasonably reliable, but above all economical in operation, the author would have to recommend direct-Diesel drive. And if the intended service involves, generally, comparatively short runs, the author would propose a two-stroke engine. If normal runs were long a four-stroke would be advised, provided head room permitted. It is not suggested that the two-stroke engine is incapable of a long run. The author had a little tug built on the East Coast a few years ago which was fitted with a two-stroke engine. Her maiden voyage was from the Humber to the Mexican Gulf and she made an excellent non-stop run with only one qualified Diesel engineer on board. But when long runs are the rule and not the exception, four-stroke is probably more reliable. An engine which developed the required power at the lowest possible revolutions would be chosen, subject always to the draught being available for proper propeller immersion and to the nearest major critical to rated r.p.m. being at least 30 per cent. of that r.p.m. below the rated speed. Irrespective of the make or type of engine, every effort would be made to arrange for a closed cooling system with thermostatically controlled cooler. Means would be provided for easily and quickly observing exhaust temperatures preferably by Bimetal thermometers with large dials fitted in the exhaust of each cylinder as close to the cylinder as possible and with full load temperatures clearly marked.

Ample storage space would be provided for starting air, according to the maximum amount of manœuvring the vessel was likely to be called upon to do, bearing in mind that, when most air is being used, the main compressor is probably only recharging at a fraction of its capacity. The auxiliary air compressor would have the same output as the main compressor and be driven by an auxiliary Diesel engine running at not more than 1,000 r.p.m. This engine would also be coupled to a general service pump and possibly be arranged to drive a dynamo and must have ample power to drive all three at once. If, however, the electrical load were not too great a 12-volt A.E.C. or similar type generator would be incorporated in the main engine coupled to a battery of accumulators of sufficient capacity to carry, say, half the ship's lighting for 48 hours. The general service pump must be self-priming and have sufficient suction head to deal with bilges, and should have connections to enable it to be used for main engine cooling in emergency.

Particular attention would be given to the design and capacity of the exhaust silencer which must silence efficiently without retarding the flow of the exhaust. Unless it is designed to suit the engine, back pressure may be built up which would quickly reduce engine efficiency. The only time when back pressure serves a useful purpose is when starting up on a cold morning. It would be useful if a really foolproof arrangement could be devised for this purpose. The normal method is to place a piece of wood over the exhaust outlet and get someone to volunteer to sit on it. Although usually effective, such an operation is rather crude and a volunteer not always forthcoming.

Should a slower-running propeller or a faster-running engine be permitted and reduction gear introduced, the above remarks would apply; but if reverse/reduction gear were fitted, then the compressor and air storage capacity could be greatly reduced, and if electric starting were adopted, could be altogether dispensed with. It is suggested, however, that in this case a stand-by oil pump be arranged on the main engine for use with the gear in case of emergency.

To facilitate maintenance in good running condition a spare fuel pump unit should always be available, and in the case of four-stroke engines, a spare cylinder head should be kept. Working heads can then be taken off, one at a time and reconditioned without stopping the ship for any length of time. A pressure pump should be carried and fuel sprayers regularly tested.

In the event of an economical form of Diesel-electric propulsion being decided upon, the author would propose a four-stroke engine running at, say, 500 r.p.m. driving a main generator, auxiliary generator and controller coils on the same shaft. The auxiliary generator would have sufficient capacity to provide current for all auxiliaries and lighting, as well as for excitation. A cooling-water pump could be incorporated in the main engine operated by chain drive, say, from the timing shaft. The main engine could be started either electrically or by air. The former method would require a battery of accumulators and might therefore involve more maintenance cost than the latter, but it would enable air compressors and receivers, etc., to be dispensed with. The propulsion motor would be designed to develop the required power through a range of, say, 95 to 115 r.p.m. The switchboard and controller would be of the simplest possible design. The voltmeter, ammeter and tachometer indicating propeller r.p.m. and direction, together with fingertip operation of controller might be placed in the wheelhouse, control operation being duplicated on port and starboard wings and aft if desired. The only engine-room auxiliaries necessary would be an electrically driven general service pump and, if the main engines were arranged for air starting, an auxiliary air compressor. In addition, although not essential, it would be useful to fit an auxiliary Diesel-driven generator of sufficient capacity for lighting and to drive either general service pump or auxiliary compressor. As already indicated, main engine cooling should be by closed circuit, thermostatically controlled and flow indicators fitted where easily visible. With Diesel-electric drive the governing of the engine must be quick and reliable. Propulsion control is so instantaneous that the resulting changes of load on the engine are most severe, so that the governor should be such as will maintain perfect control.

But in what seems to be developing into a contemplation of the demise of the steam engine, there is surely something we have overlooked. The author seems to recollect that, some years ago, a competent authority warned us that the world's oil resources, at the then rate of consumption, were unlikely to last more than twenty years. The enormous increase in consumption that has taken place in the past three years could never have been anticipated, so that the period indicated must be considerably reduced. If then, this estimate was sound and no fresh sources of oil have been discovered, our problem would seem to be well on the way to natural solution.

This, however, is perhaps wishful thinking and the author hopes that efforts to revive the attractions of coal-burning steam plant will not be shelved on the off-chance that *force majeure* may save us the trouble.

*Cargo Ships and Propelling Machinery adapted to War Conditions

Discussion (continued).

Mr. D. Rebbeck, M.A. (Associate Member): The author's paper covers such an enormously wide field of matter suitable for discussion that the writer would first deal with points raised in connection with the propelling machinery. The writer heartily agrees with the suggestion that experimental work by engine builders should be encouraged, but who is to pay for it and where is it to be carried out? Most marine engineering firms have no facilities at present for plunging into experimental work. There are always keen and intelligent men in every firm who would eagerly and ably carry out experimental work, but unfortunately that is not enough. The universities and technical schools lend themselves to experimental work, but most of their engineering equipment is hopelessly out of date—especially in the heat engine sections.

The availability of coal in this country has tended to be a serious deterrent factor as far as the Diesel engine is concerned. How about more experimental work in producing oil from coal?

Why is it that "most British marine engineering firms were initially content, and have remained content, to pay licence fees and royalties in payment for foreign designs and developments?" The blame for the lack of initial development of British heavy-oil engines for marine propulsion lies at the door of the British shipowner, and not the British marine engineering firms. Because of this lack of vision and daring on the part of our shipowners some thirty-five years ago, our technical men, who are as good as any Continental designers, were never given the opportunities to develop their own ideas and plans. When some brave company endeavoured to produce a British heavy-oil marine engine, it generally failed, due to lack of experience and experiment prior to going into production. Much of the success of the Burmeister & Wain marine Diesel engine was due to the foresight and courage of the directors of the East Asiatic Company, closely followed by the Axel Axelson Johnson Line of Stockholm; A/S Det Forenede Dampskibs-Selskab of Copenhagen; Fred. Olsen of Oslo; Wilh. Wilhelmsen of Oslo; A/S Dampskibsselskabet "Norden" of Copenhagen; and A/B Svenska Ostasiatiska Kompagniet of Gothenburg. Who were their counterparts in Great Britain?

In spite of the appeal of a national or all-British oil engine, the writer feels that for the duration it would be wiser to concentrate on a well-established type already in production, than to experiment on the high seas. Let the shops produce a standard version of the best-known and reliable Diesel engine of to-day and at the same time let the designers work hard at a new engine, ably supported in their work by substantial Government financial assistance. Some form of "special financial encouragement" as the author calls it, is just what is wanted to assist our designers. If this could be arranged there would be no more *"reluctance"* on the part of British firms to engage on research and development work.

It would seem sensible that small and moderate sized marine engineering firms should not manufacture their own fuel injection equipment, and the standardizing of engine service pumps and motors also makes a strong appeal. In fact, standardization would appear to be even more attractive in war time than in the keenly competitive days of peace, when standardization and its accompaniment, low cost, etc., had proved its value in the open markets. The most correct construction for single-acting internal-combustion engines would appear to be the trunk type rather than the crosshead, although in four-cycle engines some manufacturers use the crosshead engine to introduce such improvements as under-piston scavenging. For higher piston speeds the lead bronze bearing rings have been used with success in many trunk-piston two-cycle engines and the lubrication of the cylinder has apparently been improved in consequence, as well as giving a reduction in clearance. The writer agrees with the suggestion of replacing engine-driven reciprocating blowers by turbo blowers electrically driven; these latter have already been fitted in some very powerful marine Diesel engine installations such as those in the large Union Castle liners, and have given excellent results. These are of British Thomson-Houston manufacture, and have a capacity of 31,000 cubic feet per minute at 2,200 r.p.m. and are rated at 590 b.h.p. Engine-driven rotary-vane type blowers have also proved themselves efficient and reliable.

From the writer's experience the production bottleneck in shipbuilding would appear to be engines, not hulls. The machine shops are terribly overloaded, and this is only to be expected when so many various items have to be manufactured somehow or other in the same shops.

Finally some general points:—

(1) Is the aircraft really necessary? The greatest danger to ships at sea is at dawn and dusk when aircraft are of no value.

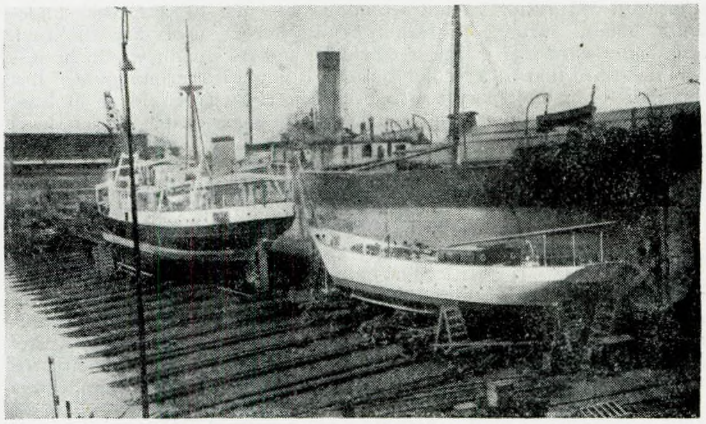

FIG. 27.

The raising of the flight deck to a suitable height above the waterline would destroy one of the chief claims of the design, *i.e.* the reduced visibility.

(2) Fire-fighting equipment—is this adequate? Could the cargo warship deal effectively with fires?

(3) A double bottom should certainly be incorporated—it has proved its value.

(4) Lifeboats—the latest design of cargo warship with four lifeboats is a great improvement in this respect. They are certainly safer if carried inboard, but could they be made simple and foolproof to launch?

(5) Shortage of adequate drydock facilities for cargo warships has been mentioned in the paper. This raises a most important point. With so many small ships such as corvettes, minesweepers, etc., as well as coastal shipping, needing dry-docking facilities, our drydocks are terribly overloaded. The writer recently saw four minesweepers together in one dry dock, but though this was a brave effort to overcome the shortage, it meant that large ships were kept waiting. Fig. 27 shows an attractive patent slip in P. Smit's

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shipyard at Rotterdam. Surely such slips could be quickly and cheaply built in our ports to deal with the smaller ships and release our existing dry docks for the larger ships?

THE AUTHOR'S REPLY.

Mr. D. Rebbeck. Mr. Rebbeck's contribution strikes a progressive note and the author is glad to have the engine development problem further discussed. The author agrees that neither marine engine works nor universities have adequate and modern testing equipment.

The lack of first-class experimental and research equipment for engine work at our universities is a serious national defect, and is all part and parcel of the lack of appreciation in Britain of the part technique can play in the national wellbeing in times of peace and the striking power it provides in times of war. Bearing in mind the need for new equipment and financial assistance, the author believes that the only immediate solution is to provide new national experimental stations for the use of the various internal-combustion engine industries. Various firms or individuals or government departments can then have designs tested out authoritatively and independently with the best equipment and by experienced testing specialists. The latter are just as rare as the equipment, and therefore must be garnered together for the common national good.

Who can deny that the Teddington Tank has been of great value to the shipbuilding industry? The author believes, however, that had there been three or more test tanks in various parts of the country, all under separate technical control, the benefit would have been even greater. The author does not believe that the centre of research and development should be at the local university; quite separate regional establishments for commercial and private utility use, but under central government control, should be provided.

Such establishments would not exist to discourage the individual efforts of firms to engage on private research but on the contrary to encourage both firms or individuals with small resources but good ideas.

Ships and ships' engines mean so much to the nation's existence that some organized national technical assistance must be given. The object of building marine engines is not just to provide a means for small sections of the community to make a profit, but also to fulfil a real national requirement. From a national point of view, the present independent private-firm system has proven quite inadequate, and has caused great national loss and much human suffering. Inasmuch as the nation at large must "pay the piper", so must it have a measure of control in peace as in war.

It would be unsafe to leave technical development unorganized from a national point of view, as the heads of marine-engine firms have tended for many years to be chiefly of the commercial or salesman type and incapable of making highly-technical decisions *until a design has been proven and demonstrated*. Some means must be found of encouraging invention and design, as well as organized research and development, as a national safeguard to ensure our survival in a world growing more and more technological. When men and women are called upon to make supreme sacrifices they must also have the right to demand that industry must be well organized on a national basis to give the fullest material support. Before production can be made effective, the most careful organization of invention, designing and experimental development capacity must be arranged, to ensure that only the best possible articles are produced.

Granted that we must now make the best of existing designs, simultaneously some vigorous development of more advanced designs is required. Surely most designers and experimenters will prefer to work at present for direct national utility rather than private interests.

It is not enough to develop engines in laboratories; they should be given full practical development at sea under proper observation. The author has had the personal experience with a firm of moderate size of designing large engines from a clean sheet of paper, building them, developing them experimentally, building commercial units and developing them at sea with shipowners, and he is satisfied that such individual efforts are completely inefficient except in giving the perpetrator a remarkably varied experience.

By the time an engine is developed in this individual manner it is already out of date, when compared with world developments.

Criticism has been made of the author's idea that new marine engines could be produced to be of use in the war, but a really co-ordinated effort by specialists to produce such engines has never yet been tried. A carefully organized effort may well produce astounding results. Admittedly it may make many existing commercial designs of reduced value after the war and is therefore not popular in certain quarters, but viewed nationally the benefit could be enormous.

The technological possibilities of using a combination of specialists cannot but be of value. The author, himself an engine designer, only too well appreciates that so many other engineers know so much more of certain aspects of the art and science of engine designing that he realizes the potentialities of such men, could they apply to a given engine that which they can do best, instead of each separately evolving individual complete engine types.

Mr. Rebbeck suggests that shipowners are to blame for the present deplorable engine position, but with that the author cannot agree; the fact is that British marine-engine builders for years have been technically and productively backward.

Mr. Rebbeck mentions the real reason for the failure of so many British marine oil engines—"the lack of experience and experiment before going into production". The idea of nationally supported experimental stations and ships is to relieve the shipowner of an unfair responsibility.

In the case of large combines consisting of shipyards, engine works and shipping firms no facilities should be needed.

The example of the U.S.A. with the American Maritime Shipping Board must be fully appreciated, and the author believes we shall never be able to compete without a similar central organization to give the equivalent of a technical subsidy to all concerned to ensure that both engines and ships are efficient and reliable before going into production. The aircraft industry has shown the way in this country.

Many British shipowners have been let down by British designs. In this connection the author would like to pay tribute to at least one progressive shipowner who has always been ready to help new marine-engine developments—namely, Mr. Stanley Thompson of the Silver Line, who aided greatly in the development of the author's design of engine. If the author had been a shipowner before the war he frankly admits that he would have preferred to get Diesel engines not only of foreign design but of foreign manufacture; this applies to German, Swiss, Danish or Swedish makes. This would not apply to auxiliary machinery or engines, as these would have been British on the score of efficiency. When famous Lines such as Messrs. Alfred Holt & Co. sometimes went abroad for their engines, it was for sound commercial reasons after giving British firms a chance.

Let us face the facts. So far there has been no all-British large Diesel engine which is a technical and commercial success. The nearest is the Doxford, which incidentally was first tried out in Swedish ships.

British marine engine technicians are relatively ill-trained, enjoy a relatively poor social position, are ill paid and unless one really likes the work, as a profession it has little to recommend it.

This situation must be altered, as the relative well-being of any country, now and in the future, will largely depend on its capacity to organize technologically and productively on a national basis. The day of individual exploitation is passing and only insomuch as individuals consider the national utility of their endeavours will a nation prosper as a whole.

The author is glad to have Mr. Rebbeck's agreement on many technical points.

Coming to cargo warship features, the author believes an aircraft is really necessary. The danger exists chiefly at dawn or dusk because the U-boats are already in the vicinity and merely awaiting a safe opportunity to close in.

Provided trailing U-boats could be dealt with before dusk, the chance of contact during the night or at dawn is reduced. Trailing submarines, however, are associated with slow convoys and would have no chance with a fast cargo warship. The function of a ship-based aircraft would be to explore the seas and ensure the complete absence of submarines in a given sea lane through which the vessel would traverse at night. The raising of the flight deck to that proposed still gives reduced visibility compared with existing ships, due to the elimination of deck structure.

Coming to fire-fighting equipment, the longitudinal trunk alleys will enable really good fire mains and equipment to be provided.

On the question of slips for small craft, the author fully concurs in Mr. Rebbeck's views on this subject. In this country there is a very fine slip equipment for trawlers at Fleetwood, which with advantage could be emulated all over the country. The possibility of using slips for medium sized ships must not be dismissed as impracticable.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on Tuesday, 30th March, 1943.

Members.

Charles William Armstrong, Lt.-Com'r.(E.), R.N.V.R.
Ralph Beal.
Robert Sidney Blackledge.
Joseph Sydney Bell, Lt.-Com'r(E.)., R.N.R.
Edgar Charles Evans.
Fergus Ferguson.
Herbert Christopher Fothergill.
Luke David Francis Fraser.
William Jack Fox.
Denys Gamlen.
George Rochfort Grange.
John Hall.
Sidney Bertram Jackson.
James Love.
Charles Macpherson.
John Mackay Manson.
Stephen Thatcher Pigott.
Hector Shannon.
George Arthur Skelton.
A. Murray Wilson.
John Wyld, D.S.O.

Associates.

George Charles Henry Back.
George Curphey.
William Dickson White Gillies.
William McQuillan.
James Millar.
William Edward Postlethwaite.
Sidney Arthur Read.
Geoffrey Thorpe-Smith.
Arthur Woodbridge.

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

The following British Standard Specifications:—

B.S. 1109-1943. Cold Forged Mild Steel Rivets for Cold Closing.

B.S. 1114-1943. Wartime Finish of Machinery and Plant.

Gears. By H. E. Merritt, D.Sc. Sir Isaac Pitman & Sons, Ltd., 420pp., copiously illus., 30s. net.

The author is well known by virtue of his authoritative position in the sphere of gear production, and he has drawn on his wide experience in producing what he describes in a sub-title as "A Book of Reference for Engineers, concerned with the Design, Manufacture, Application or Maintenance of Gear Drives".

His aim has been to present the whole field of gear problems, so that any particular portion can be seen in its proper relation to the whole, and he does so with a very large measure of success. To this end the fundamentals of gear types are discussed and a nomenclature covering all forms of gearing is proposed.

The chapters on the geometry of gear teeth are characterized by lucidity of expression and fullness of treatment, though it might be suggested that the chapter on tooth generation could have been profitably extended, especially with reference to the actual operation and arrangement of gear-cutting machines.

The involute tooth merits and receives adequate treatment, its properties and peculiarities being fully discussed and analysed, with special attention to gear generating cutters for use with gear-shaping and hob machines.

Gear materials and the types of tooth ailments generally encountered are briefly considered, the symptoms and causes of each being described.

There are nineteen chapters in all, attention being given to surface loading of teeth, strength of teeth with methods of calculating stresses, design factors and gear lubrication; tooth proportions are fully discussed, and there is an important chapter on the accuracy of gears, and the allowable tolerances in manufacture. An important feature of the work is the candour with which the various assumptions used are stressed, and the clear indication of empirical rules and formulæ as such, since the author realizes there are many gear problems still requiring elucidation and experimental definition.

The work is very comprehensive and it is difficult to indicate the immense field covered by the author. Throughout, there are numerous useful and helpful charts, curves and tables which contribute largely to the value of the volume as a book of reference.

Students, designers and users of gear drives, will all find much to interest them in this work, and the author can be congratulated on having written a concise, yet comprehensive, treatise on a very difficult subject.

Modern Oil Engine Practice. Edited by E. Molloy. George Newnes, Ltd., 636 pp., copiously illus., 30s. net.

This book provides a comprehensive survey of the Diesel engine in all its fields of application. It can be roughly divided into two parts, the first dealing with special subjects of technical and practical interest and the second giving useful descriptions of the products of several of the leading oil-engine builders. The first part largely consists of contributions by specialists under a variety of headings.

It is difficult to pick out for special mention any particular chapter in a book of this size, where each subject is dealt with with care and accuracy, but a few brief comments are worth recording.

The chapter on testing and type testing gives a description of up-to-date methods and also systems of tabulation and the significance of results obtained. This is followed by chapters on fuel injection and C.A.V. equipment, which contain a great deal of useful technical information. Then comes a description of the development of the high-speed Diesel engine, passing through its history to the design of the present-day engine and its accessories. In the next chapter there is a very interesting description of the development of the marine engine. This covers high- and low-speed engines for both propulsion and auxiliary duty, the former including direct drive, gear drive, Diesel-electric drive and the various types of transmission in use at the present time.

Next follows a valuable chapter on the gas Diesel engine, a subject about which very little has hitherto been written. One can visualize a potential market where the supplies of oil are limited but where gas and other alternative fuels are available. The first half of the book ends with a short description of the Büchi exhaust-turbo pressure charger, followed by a few pages devoted to torsional vibration with suitable diagrams.

In the second half of the book we find complete descriptions of some of the leading makes and types of Diesel engine, embracing heavy and light engines, high speed, low speed, horizontal and vertical, two-stroke and four-stroke, etc., together with notes on operation. These give a clear picture of modern design and practice in this country. The book closes with a chapter on routine inspection and maintenance.

The whole book can be summed up as an excellently planned and illustrated work. A big book in more senses than one, which should prove useful to all engineers and Diesel-engine users.

Abstracts of the Technical Press

Fabrication Methods Applied to Repairs.

There is a general impression that so-called fabrication methods are only useful in building, whereas they can, in actual fact, be employed with equal advantage for large ship repairs. In one instance the side of a large cargo liner which had been in a broadside collision was driven in from the bridge deck to the margin plates over a length of 50 to 60ft. Two plate lengths of 25-26ft. were renewed or taken out, faired and replaced in each strake, the strakes averaging 7ft. in width and ⅞in. in thickness, with side frames of channel section 12in. × 4in. × 4in., part of which had to be renewed, while the remainder were taken out, faired and replaced. The work was carried out in the following manner: The exact lengths between the undisturbed shell butts—the plates to be removed, faired and replaced being considered as undisturbed—the positions of the frames, deck angles, stringers, etc., and the widths of the shell strakes were all taken from the ship on battens to permit of the damaged part of the shell being reconstituted on the mould-loft floor, the sheer being taken from a level line. The spacing of the riveting in the undisturbed shell plating, extended as far as necessary, was taken up on battens, as well as the spacing in the frames which were to be taken out, faired and replaced, and marked in on the reconstituted shell expansion on the mould-loft floor. Similarly, the riveting in the undisturbed butts and seams was taken up on battens and transferred to the mould-loft floor, and, finally, the holes in the butts, seams and frames of the part to be renewed were marked in on the floor expansion to correspond with those taken from the undisturbed parts, and the plates and frames which were to be taken out, faired and replaced. There was then, on the mould-loft floor, a complete detailed expansion of the shell damage, showing the riveting in the new plates and frames (which could then be taken up on battens), the new shell plates and frames marked off, the new frames having, in the meantime, been bent and those to be refitted, faired and replaced. By the time the new and faired frames had been bent, marked off, machined and erected in place on board, the new and faired shell plates were lying on the dock side ready to go on. This might appear to be a somewhat lengthy process, but the different operations had all been carried out concurrently and the entire job, which involved handling over 50 tons of new and refitted steel material, was completed in eight days, working two shifts and including all the incidental work, removals and replacements. A considerable saving in time was effected by carrying out the different operations simultaneously instead of in the usual sequence. The reconstituted mould-loft shell expansion was, of course, only a skeleton affair. A similar procedure was adopted in the case of an extensive bottom damage, involving a considerable renewal of floors, intercostals and bottom shell plating. A partial scrieve of the double bottom was reconstituted from measurements taken on board, and all the materials prepared from it as for a new ship. Another instance was the fitting of 'tween decks to a series of 9,000-ton d.w. vessels, to adapt them for another service without taking them out of operation for a too lengthy period, a condition of the contract being that the transformation should be carried out in a minimum of time. The ships were successively discharged and put at the disposal of the yard for a very few days to take off the necessary information. The vessels then proceeded to sea for a period of about five weeks, and on their return the whole of the materials, including hatchways, hatch beams, etc., were ready to be fitted on board after the necessary holes had been drilled in the frames for the beam knees, as also in the shell and end bulkheads. Had the ships been fabricated and their respective scrieve boards available, the work could have been prepared independently of the ship, as all the different members would necessarily have been in their correct relative positions, whereas in these cases the frame spacings varied by as much as 1½in. on opposite sides of the ship, and in one particular vessel one of the holds was 3in. longer on one side than on the other; nor were the half-breadths of the ship the same on both sides. The following procedure was adopted in each hold: The centre line was fixed at each end bulkhead, and a wire was stretched from end to end at the height of the beam side line. In this particular instance the 'tween deck line was kept parallel to the sheer of the upper deck to avoid crossing a seam of the shell, although it would have been simpler to have made the 'tween deck parallel to the waterline. The squareness of the end bulkheads was tested from the centre-line wire by means of large squares, and any errors noted, sufficient half-breadths being taken at different spots, with steel tape measures, to enable the outline of the new deck to be established on the mould-loft floor. All differences between the port and starboard half-breadths were noted, so that the plan of the new deck could be reproduced exactly, with the necessary allowances for these irregularities. A batten was then bent round the inside of the frames on board—both sides independently—the ends of the battens being correctly pitched, and the actual frame spacings were marked thereon. These battens were then bent round the ship-side line on the mould-loft floor, the ends of the battens being correctly pitched and the positions of the frames marked. Lines were struck across the floor from side to side to give the lines of the beam holes across the ship —due to the irregular spacing of the frame they were not always parallel, as they would have been for a fabricated ship—and the slatting out of the stringer plates for the frames to pass through. The hatches, plate edges and butts were then drawn in on the plan, and the requisite information for marking off the materials was taken up on battens. Bevels were taken on board at a sufficient number of frames at the ship's side for the beam brackets, and these were marked off by a template and pitched from the beam side line in the same manner as for a new ship under construction. The brackets were also prepared in advance. When the ship arrived the holes were marked off and drilled in the frames by means of the template used for the brackets themselves, pitched from the beam side line which had been necked in on board at the same time as the information was taken up. The beam brackets were then bolted into place and the beams lifted in. Meanwhile the holes in the shell plating between the frames, for the connection of the deck to the ship's side, were marked off at the required height above the beam side line and drilled, as were also the holes in the end bulkheads. The deck plates were then put in on board and bolted in place. As in this particular case the deck was only required to be nominally watertight, with cement chocks between the frames, the bulkhead stiffeners were not cut, but a light angle was worked on the inside of the stiffeners and cement chocks were fitted as for the ship's side. Had the yard in question had a sufficiently large welding plant available at the time, it would, of course, have been cheaper to have welded the new deck to the ship's side and bulkheads instead of carrying out the drilling and riveting required for angle-bar connection. A similar procedure was adopted in another ship in which an oil-tight deck had to be built. The lower hold was divided into tanks for the carriage of palm oil, whilst the 'tween deck was utilised for general cargo. In this instance the frames were cut at the height of the 'tween deck and bracketed.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,819, 26th November, 1942, p. 1.*

Shortage of Ship Material in U.S.

Under constant pressure to produce more and more ships, American shipyards are having to contend with the increasingly difficult problem caused by the frequent shortages of vital materials and by delays in the distribution of available supplies. While a slight improvement in the supply of steel plate and shapes has been noted recently, shortages of electrical equipment, pumps and other parts containing copper and other scarce metals continue to be acute. One large shipyard maintains a special staff for expediting supplies, and a large part of its work is concerned with sub-contractors' orders rather than with those placed by the shipyard itself. Thus, if the yard cannot obtain delivery of pumps from a sub-contractor because the latter cannot get the necessary motors, the makers of the motors are held up by a shortage of gears and the gear manufacturers complain that they are experiencing difficulty in getting castings, the shipyard staff referred to have, in the first instance, to make every endeavour to hasten the supply of these castings by the foundries concerned. It has, in some cases, been found necessary to launch ships with their pumps installed in place without driving motors and to utilise one motor for testing three or four pumps pending delivery of the remaining motors. Delays in the deliveries of boiler feed pumps have, in other cases, made it necessary to use portable donkey engines and pumps for testing feed systems, etc., on board ships fitting out. Such sporadic shortages of equipment are liable to give rise to the problem of temporarily idle labour in the shipyards, and as labour is one of the heaviest items in the cost of ship construction, idle labour on the pay roll can easily double the cost of a vessel. One yard has made a practice of discharging its personnel when no materials are available, re-employing them when deliveries are made. This method, however, undermines the morale of the workers, according to the unions, and also forces some of them into other industries.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,819, 26th November, 1942, p. 5.*

Refrigerating Condensers for Marine Service.

In the course of his paper on "Recent Developments in Refrigeration", which formed the subject of the 29th Thomas Hawksley Lecture presented to the Institution of Mechanical Engineers, Lord Dudley Gordon, D.S.O., referred to improvements which have taken place in the last few years in the design and construction of refrigerating condensers for marine installations. The amount of cooling surface provided in the early days was much greater than is now the practice with the present-day necessity for economy in expenditure and material. Fig. 8 shows a section through a type of

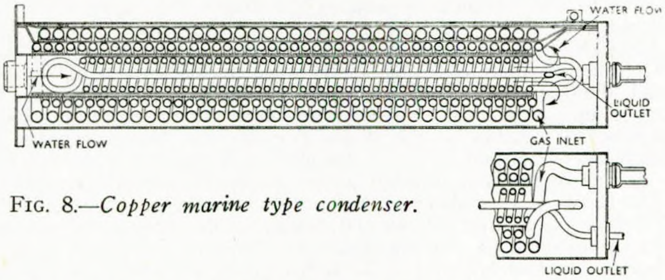


FIG. 8.—*Copper marine type condenser.*

condenser specially suited for CO_2 as the refrigerant, for use on board ship. For this reason both casings and coils are of copper. The CO_2 passes in series through three spiral coils arranged concentrically in outer and inner casings, the diameter of the piping being reduced in each successive coil as condensation takes place. In the final coil where the CO_2 assumes the liquid state the velocity is maintained, so giving an improvement in heat transfer compared with a circuit having the same bore of piping throughout. The inlet and outlet terminals for the CO_2 are at the same end, the cooling water being introduced at the opposite end. After being circulated around the inner casing containing the final stage of the CO_2 circuit, the water passes back along the annular space containing the first and second stages, thereby producing a "contra-flow" effect which increases the efficiency of the condenser. The velocity of the circulating water is great enough to prevent any accumulation of sludge. The unit described can be used singly or in parallel with a number of similar units (as shown in Fig. 9) to form a complete condenser of any desired capacity. The assembly illustrated occupies 117 cu. ft. and weighs 3½ tons, including the sea water passing through it. A condenser of the same capacity as that illustrated, but built of copper coils with a cast-iron casing, in accordance with earlier practice, would occupy 173 cu. ft. and weigh 8 tons with its water. It would also require far more space when it had to be dismantled. The arrangement shown is most suitable for carbon dioxide because in the case of that refrigerant so great a proportion of the condenser duty is performed with the refrigerant in the superheat region.—*"Mechanical World", Vol. CXII, No. 2,920, 18th December, 1942, pp. 588-591.*

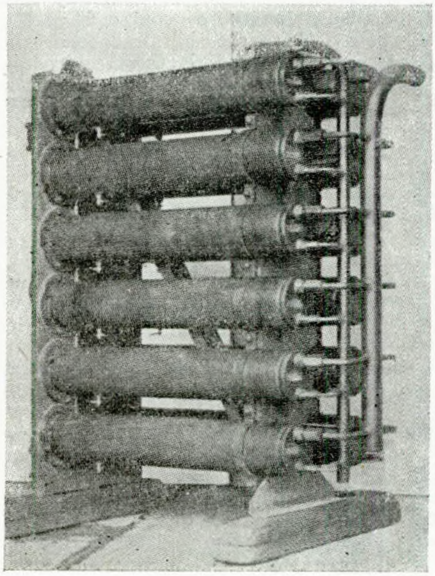


FIG. 9.—*Carbon dioxide condenser.*

Ship Prefabrication on the Clyde.

It has recently been reported that the adoption of prefabrication methods in a Clyde shipyard has proved very successful. The vessels concerned are light craft and the yard in which they are built is one which had been closed for a considerable period. It has now been brought back into use and in less than two years is breaking all established records for the construction of this particular type of ship, despite the handicaps involved by the use of old-type yard plant. It is claimed that the ships in question are being turned out at a higher rate than at any other yard building similar vessels, and that the output is twice as great as that of yards which have not adopted the prefabrication system.—*"Mechanical World", Vol. CXII, No. 2,911, 16th October, 1942, pp. 368-369.*

Revision of Tonnage Regulations.

The rationalisation and co-ordination of the various tonnage regulations is a matter which should receive attention after the war. The basis for tonnage measurement is that laid down by the different Merchant Shipping Acts, the general principles of which are accepted internationally, although there are variations in detail. Thus, special tonnage certificates are required for the Suez and Panama Canals, whilst the American regulations differ in some slight particulars from the British standards. One of the regulations which is overdue for revision is the one which deals with the exemption of certain spaces from tonnage measurement. The difference between a measured and an exempted space is, to a great extent, dependent on the nature of the so-called closing appliances of the openings at the ends of the erections, or, in a shelter-decker, of the bulkheads in the tonnage well. For instance, if these openings are closed by plates bolted to the bulkhead, the space is included in the tonnage, whereas if the securing bolts are merely hooked to the door frame and do not pierce the bulkhead, the space is exempted. It is this circumstance which, in normal times, compels shipowners to make the 'tween deck bulkheads of shelter-deckers non-watertight. Furthermore, the freeboard which is assigned to a ship likewise depends on these closing appliances, and, to make matters worse, an arrangement which is favourable from the point of view of tonnage measurement, may affect the draught of the vessel adversely or otherwise. Another regulation which is in urgent need of revision is that which deals with the allowance made for propelling-power space. In screw ships, if the engine-room capacity is between 13 and 20 per cent. of the gross tonnage, the allowance granted is 32 per cent. of the gross tonnage, but, if the E.R. space is either greater or less than the above percentages, the allowance made is 1¾ times the tonnage of the actual space. In the past this rule worked fairly satisfactorily because E.R. space was usually within the limits mentioned, but modern developments in propelling machinery have made it possible to decrease the size of engine rooms, and the time is approaching when it will be possible to have an engine room which takes up less space than 13 per cent. of the gross tonnage. There are already cases, especially in oil tankers, where it has been found necessary to increase the size of the engine room artificially in order to take advantage of the 32 per cent. reduction allowed. It is possible that the lower limit of 13 per cent. was originally fixed to ensure that the ship had sufficient engine power to make her seaworthy, but this consideration is inapplicable to modern conditions, and the sooner the matter is reviewed the better.—*"Fairplay", Vol. CLIX, No. 3,107, 26th November, 1942, p. 632.*

The Clyde Steamer "Lucy Ashton".

A remarkably fine performance stands to the credit of the 54-year-old L.N.E.R. Clyde paddle steamer "Lucy Ashton", which has for the past three years maintained the company's Clyde coast service all by herself and during that period has not missed a single sailing through any machinery or hull defects—a wonderful tribute to Scottish marine engineers and shipbuilders. The vessel leaves her home port at Craigendoran at 6.30 every morning and runs each weekday almost continually until 7.45 p.m., the longest break being one of 1¼ hours for the purpose of coaling and taking in stores.

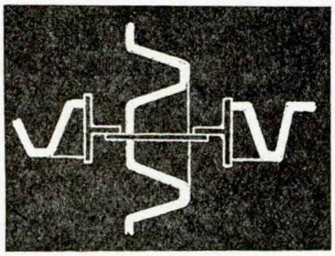
In setting up this record, the ship has steamed over 94,000 sea miles and made 10,000 calls at the various piers. She was built in 1888, by T. B. Seath & Co., Rutherglen, for the North British Steam Packet Company, and during her long service has carried some millions of holidaymakers and regular travellers to and fro across the Firth of Clyde. For many years she provided the regular service between Craigendoran, the Gareloch Piers and Greenock. The master, Captain D. Campbell, and chief engineer, Mr. C. McLean, together with the crew, take a great pride in maintaining their ship in good trim. Their duties are not confined to the sailings on weekdays, but extend to every Sunday, when they carry out all the maintenance work, painting, and the many other little jobs which require attention. Mr. McLean was serving as chief engineer in the L.N.E.R. Clyde steamer "Waverley" when she was lost at Dunkirk. *—"The Engineer", Vol. CLXXIV, No. 4,533, 27th November, 1942, p. 450.*

All-welded Danish Salvage Tug.

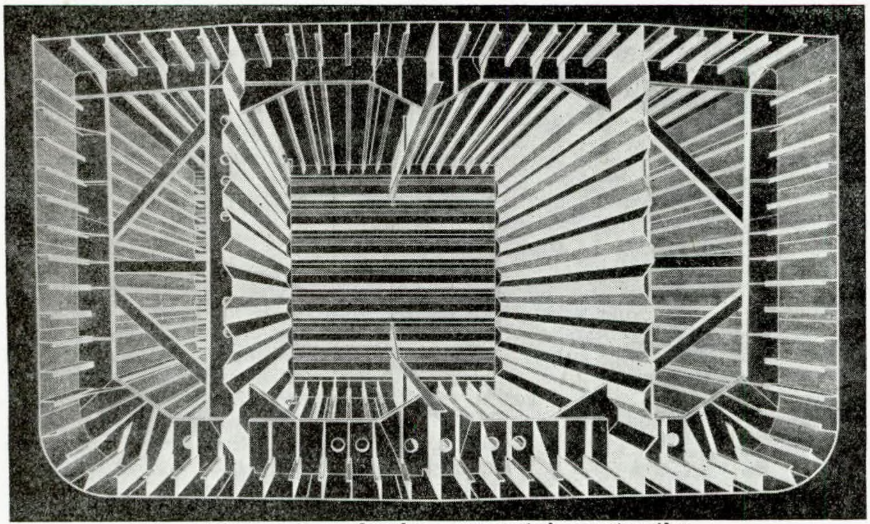
The salvage tug "Ymer", recently built at the Aalborg Shipyard for a Copenhagen salvage company, is the first all-welded vessel to be constructed in Denmark. Her main dimensions are 82ft. 5in.× 20ft.×10ft., and she is designed for use as an icebreaker as well as a salvage tug. The propelling machinery consists of a single-acting two-stroke Diesel engine of 500 h.p. The tug is equipped with a telescopic funnel instead of the usual hinged funnel utilised for vessels which have to pass under low bridges. The "Ymer" attained a speed of 10½ knots on her trials and has proved to be exceptionally manœuvrable.*—"Lloyd's List and Shipping Gazette", No. 39,938, 18th November, 1942, p. 6.*

Corrugated Bulkheads.

Although the use of corrugated bulkheads and decks under the Isherwood patents (*see abstracts on pp. 121 and 136 of* TRANSACTIONS, *September and November, 1941*) has only been developed within the past 18 months, it is reported that nearly 2½ million d.w. tons of shipping constructed on this principle are now building or on order, and that corrugated bulkheads have already been adopted as standard practice by many shipyards, especially in the U.S.A. For the subdivisional bulkheads, standard rolled corrugated steel plates are used in the manner shown in the accompanying illustration of a full midship section of a ship, while the simple method of connection adopted for the intersection of the longitudinal and transverse bulkheads (when I-beams are not used) may be seen in the upper diagram. The advantages claimed for this form of construction are lighter weight with increased strength, accompanied by lower cost of production and accelerated building by pre-fabrication, to which the design satisfactorily lends itself. Furthermore this form of internal subdivision imparts inherent strength to the whole structure, so that the provision of additional horizontal stiffeners is unnecessary and this makes it possible to build the hull of lighter material than would otherwise be permissible, and all-welded construction can be adopted, if desired. The corrugated sections are easy to clean, especially in oil tankers, and although it might be claimed that the corrugations would reduce the stowage space available for cased cargo, this apparent disadvantage is offset by the elimination of the space occupied by the stiffening which has to be provided in other cargo vessels.*—"The Syren", Vol. CLXXXV, No. 2,415, 9th December, 1942, p. 266.*



Connecting method.



Midship section showing corrugated construction.

Water Lancing.

The problem of the effect of high-temperature deposits on the external heating surfaces of boilers has been accentuated by wartime fuel supplies. One means of dealing with such deposits, particularly on superheaters, is by "water lancing". This process involves subjecting the slag, while the boiler is under steam, to repeated quenchings with cold water, and it is claimed that even the most obdurate deposit treated in this manner becomes loose and falls away, leaving the tube surfaces in a satisfactorily clean condition. The process was developed at the Barking Power Station of the County of London Electric Supply Company, where the Babcock & Wilcox boilers of 256,000-lb./hr. capacity were having to be withdrawn from service, due to superheater fouling, after about 800-1,000 hours' working. After some preliminary experiments, water lancing as now practised was begun on two boilers in October and November, 1939, and as a result of the complete effectiveness of this method, the two boilers steamed respectively 15,953 hours and 16,076 hours up to the 31st August, 1942, without any hand cleaning whatever and at rates considerably in excess of normal for long periods at a time. Following this experience at Barking, other important power stations adopted the process, and the results are stated to be promising. The equipment necessary for water lancing is all of a very simple nature, and can for the most part be improvised where normal facilities are available.*—"Boiler House Review", Vol. 56, No. 7, November, 1942, pp. 203-204.*

"Fans—Their Types, Characteristics and Application".

A fan is defined by the British Standards Institution as "a machine which propels air continuously, the total fan head never exceeding 1lb./in.^{2}". When the pressure is above this limit the field of blowers is entered. The paper deals descriptively with modern fans and their applications under the following three main types: (*a*) propeller fans, (*b*) centrifugal fans, (*c*) axial-flow fans. The differences in their characteristics and construction appear to justify the classification of (*a*) and (*c*) as different types. After giving a short summary of the fundamental formulæ used for assessing the output, power requirements and efficiencies of centrifugal fans, the author discusses various test results on actual installations, with some of which he was personally concerned. Axial-flow fans are considered both from manufacturing and from aerodynamical aspects, and test results are given, together with curves showing the power absorbed and the efficiency achieved. In the latter part of the paper the author deals with various applications of fans: to the ventilation of buildings, ships and mines; as a method for supplying draught to boiler installations by mechanical means; and in the operation of dust-extracting plant. The control of fan speed and output by hydraulic couplings is compared with methods of adjusting the inlet vanes, in order to achieve the same result. The section of the paper devoted to marine applications deals with the "Thermotank", "Punkah louvre" and "Thermo-Reg" louvre systems of ventilating passenger accommodation. Air-conditioning plant for passenger vessels is briefly discussed and modern practice in E.R. ventilation is considered. The author points out that axial-flow fans are displacing centrifugal fans in this field, as it is frequently possible to instal units large enough to show a considerable saving, whilst the resistance to the flow of air may be reduced to 1in. w.g. by making the ducts as straight and easy as possible. At this pressure an axial flow fan is reasonably quiet, as is evidenced by the fact that torpedo fans of this type were fitted on the sports deck of the "Queen Elizabeth" to supply air to the engine room. The "Queen Mary" is equipped with eight centrifugal E.R. fans having a total output of 50,000 cu. ft./min. at

2in. w.g. and absorbing 280 h.p., whereas the "Queen Elizabeth" has eight axial-flow fans giving the same output with only 128 h.p. at $1\frac{1}{2}$ w.g. Although the air pressures in the two ships differ, the straight-through ducts fitted for the axial-flow fans make is possible to reduce the pressure required, so that the two performances just cited are strictly comparable. The "Queen Elizabeth's" ventilating equipment comprises a total of 291 motor-driven fans with a total of 1,318 b.h.p. There are also 24 forced-draught fans of the backward-inclined-blade centrifugal type, driven in pairs by 12 motors each of 358 b.h.p., making a total of 4,296 b.h.p. The total fan power in this ship is thus 5,614 b.h.p., *i.e.* more than double that of the main engines of the average cargo vessel Axial-flow fans have been applied to forced-draught work in only one special case, but there appears to be no reason why they should not be more widely adopted for the sake of the saving in power. The increasing use of the battery system of refrigeration, in which large quantities of air are blown over a compact battery of brine pipes and through the refrigerated hold or 'tween decks, makes matters affecting the fans of considerable importance. The power taken by the fan has a double significance, first as a direct load on the ship's generators, second as a load on the refrigeration system, as the heat equivalent of the kW. input tends to raise the air temperature. In some instances the motor is located outside the refrigerated space and drives the fan through an extended shaft, in which case the heat equivalent of the b.h.p. is added to the air. Both as regards the load on the ship's generators and on its refrigerating plant, any reduction in the power absorbed by the fans represents a considerable saving, and for that reason high-efficiency axial-flow fans possess a special advantage for this work. Moreover, an axial-flow fan fits easily into the ducts and can be directly reversed, so that by changing the direction of the air flow the formation of "hot spots" in stagnant corners may be avoided. The author cites the case of three Clan liners with refrigerated holds which were equipped throughout with axial-flow fans. Very satisfactory results were obtained in these ships, and axial-flow fans have now completely displaced centrifugal fans in this important application.—*Paper by C. G. Ferguson, B.Sc.(Eng.), "Proceedings of the Institution of Mechanical Engineers", Vol. 148, No. 1, November, 1942, pp. 1-19.*

Gas Turbines.

Since a 4,000-kW. constant-combustion turbo-alternator was put into service on the Neuchâtel electricity supply system, nearly two years ago, the practicable size of this type of gas turbine has risen to 10,000 kW., while the thermal efficiency has increased from 18 to 22 per cent. This result is not enough to enable the gas turbine to compete with good steam or Diesel installations for normal running, but it possesses the considerable advantages of low capital cost, a greater degree of independence of site conditions (since it needs little water) and an ability to carry full load very quickly after being started up from cold. For the present the chief function of the gas turbine would appear to be to provide stand-by or emergency supplies.—*"Electrical Review", Vol. CXXXI, No. 3,391, 20th November, 1942, p. 640.*

English Electric Company's Auxiliary Diesel Engine.

An improved type of pressure-charged high-speed Diesel engine for marine auxiliary and other services, is now being produced by the English Electric Company. The new engine, which has six cylinders of 6in. bore and 8in. stroke, is a development of an earlier non-pressure-charged design, and has a power rating of 300 b.h.p. at 1,500 r.p.m., the b.m.e.p. being 117lb./in.^{2} A Richardson's Westgarth-Büchi-type exhaust-driven turbo-blower is mounted at the flywheel end of the unit, the total length of which is 7ft. 2in., with a width of 3ft. 5in. and a height of 5ft. 3in. When mounted on a standard C.I. bedplate, the weight is $3\frac{3}{4}$ tons, or 28lb./b.h.p., but for some marine installations and for certain industrial and transport services, there is provision for three-point mounting and the bedplate is of Meehanite. A triple chain drive from the crankshaft next to the flywheel is employed for the fuel pump on the front of the engine and for the water pump and governor at the back of it, as well as for the camshaft. Each of the six cylinders has two inlet and two exhaust valves, and the valve timing is arranged to give a large overlap for scavenging purposes, according to the usual Büchi turbo-charging system. A feature of the combustion process of this engine is the shortness of the delay period. Air is supplied by the blower which normally runs at 22,000 r.p.m. and has a maximum speed of 26,000 r.p.m. The pistons are of aluminium alloy and are lubricated by oil mist. The main lubricating-oil circuit has a working pressure of 40 to 50lb./in.^{2}, whilst the valve gear is supplied at a pressure of 3 to 5lb./in.^{2}. An air motor taking effect on a gear ring on the flywheel is normally fitted for starting purposes. On a panel on the front of the engine are mounted the starting-air control valve, the air-pressure gauge, and a hand-wheel giving "start", "run", and "stop" positions. This control not only cuts out the fuel when desired, but also limits the quantity of fuel injected per stroke of the pump during the starting process, so that when firing begins the engine runs steadily, with no tendency to race until checked by the governor. At the back of the panel is a lubricating-oil-pressure safety device which cuts out the fuel-injection pump if the lubricating-oil pressure should fail. This safety mechanism is tripped out of action for starting purposes.—*"The Motor Ship", Vol. XXIII, No. 274, November, 1942, pp. 246-247.*

Insulated Doors for Ships' Refrigerated Chambers.

An improved method of removing and suspending the insulated doors of ships' refrigerated chambers has recently been patented in this country, and is illustrated in Fig. 3. The door *(10)* is of the single-unit plug type and serves as a closure to the doorway *(11)* formed in the wall *(12)* of the chamber. The bevelled edges *(13)* of the door are made to fit the seating *(16)* of the doorway, and a packing strip *(17)* ensures the effectiveness of the sealing action. When the door is opened it is supported by a rigid overhead structure which guides its movements. This structure consists of a single track *(31)* parallel to the chamber wall and perpendicular side tracks *(32)*. The door is suspended from these tracks on rollers *(33)*, a swivel bracket *(34)* turning about a pivot *(35)* connecting the bracket to one of two door brackets *(36)*. Rollers *(37)* are provided to bear on opposite sides of the tracks. The door is opened by moving it bodily outwards in a direction perpendicular to the chamber wall until it is clear of the latter and the rollers reach the single track; the door is then moved sideways clear of the doorway in a direction parallel to the chamber wall. Arrangements are also made to guide the bottom of the door.—*"The Motor Ship", Vol XXIII, No. 275, December, 1942, p. 302.*

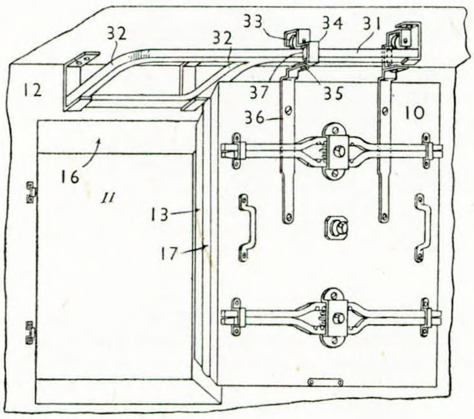


FIG. 3.

Merchant Shipbuilding and Repairs.

The 17th report from the Select Committee on National Expenditure, which was recently issued, is devoted to merchant shipbuilding and repairs. After examining various problems connected with the industry, the Committee make a number of recommendations, most of which concern labour and the wider employment of female labour. Other recommendations made are that: (1) Training schools for riveters should be set up in the main shipbuilding areas under the management either of the Ministry of Labour or of private shipbuilders in their own yards. (7) If workers are not doing satisfactorily the work for which they have been reserved, reservations should be withdrawn, and the yard committees should be given power to recommend dereservation to the National Service Officer. (11) The Admiralty should specifically examine the problems and organisation of the slower and more costly shipyards. (12) Prefabrication of hull portions should be carefully examined from the point of view of economy of labour. (13) Standardisation of sections and fittings should be carried further. (14) Further simplification should be attempted from the point of view of eliminating non-essentials. (15) The British Classification Societies should be asked to review their rules in order to ascertain how far it may be possible to assist production without lowering standards of safety. (16) Shipbuilders should be instructed that the National Physical Laboratory be brought into consultation at the appropriate stages in the design of all proposed new types of hull, and the Admiralty should make the arrangements necessary to secure that full technical liaison is maintained between themselves and the Laboratory. (17) The Admiralty should establish an organisation with the specific responsibility for directing and co-ordinating all development and research in respect of merchant shipbuilding.

(18) A technical intelligence staff should be appointed in close association with the recommended organisation for directing research and development. (19) Where a number of firms are building similar vessels, one of them should act as "leader" for each part of the completed ship and machinery and should be responsible for development and improvement in production technique of that part. (20) A review should be made of all yards engaged exclusively on naval work to ascertain whether a small admixture of merchant shipbuilding could be made without substantially interfering with naval work. (21) The allocation of building programmes should be reviewed with the object of reducing the number of types of merchant ships built in the same yard. (22) A survey should be made of all the shipyards not now in use for shipbuilding, and those should be selected for re-opening which could be brought into use in the shortest time. (23) The possibility of turning over a proportion of repair capacity to shipbuilding should be examined.—*"Shipbuilding and Shipping Record", Vol. LX, No. 21, 19th November, 1942, pp. 487-490.*

Securing Timber to Damaged Hulls.

The device shown in Fig. 4 relates to a recently-patented method of securing timber to sunken ships in order to patch the structure or to build a cofferdam round a damaged part. Securing bolts (*4*) are exploded into the hull by means of a special gun and the timber (*1*) is drilled to take the necessary number of bolts for securing the patch to the sound part of the hull plating (*9*). The holes (*2*) are drilled to take the barrel (*3*) of the bolt-driving gun, and the bolts (*4*) are driven into the plating through the drilled timber. An extension piece (*5*) is then screwed on to each bolt, the outer end having a screw thread cut on it to take a wing nut (*8*). A tapered wooden ferrule (*6*) is threaded over the end of the hole (*2*), and when the wing nut is screwed down this ferrule is crushed into the space (*2*) and seals the cavity formed by the bore.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, p. 302.*

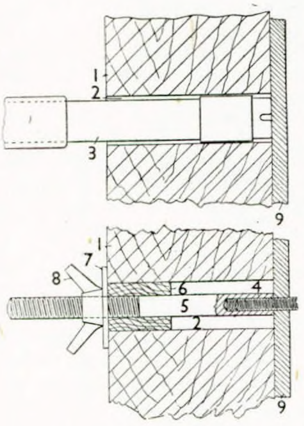


FIG. 4.

New Designs Developed by U.S. Maritime Commission.

New ship designs developed by the Maritime Commission were announced by Admiral E. S. Land, Chairman of the Commission and War Shipping Administrator, when he addressed the 50th general meeting of the Society of Naval Architects and Marine Engineers in New York. During the year ended 1st October, 1942, contracts were placed for 1,139 EC-2 cargo vessels and 712 long-range programme ships, whilst 329 EC-2 ships and 74 long-range programme vessels were delivered. Building periods for all types of ships had been substantially reduced, and during the past year destroyers had been completed in as little as 6½ months, whilst submarines, which formerly took 16 to 17 months to build, were now being delivered in little more than 12 months after keel-laying. Several submarines had, in fact, been completed in just over eight months. Admiral Land also stated that during the past year, designs had been developed and construction initiated for two large high-speed types of ship, one of a special naval type and the other an improved standard type of cargo vessel. In some tankers, propelling machinery of 10,000 h.p. is being installed in lieu of the 6,000 h.p. originally used. The Commission is designing a vessel to replace the present Liberty type of cargo ship, which will have a greater length, slightly more beam, and a somewhat greater carrying capacity. It is also proposed to increase the power/volume ratio, which, together with a better hull form, will result in higher speed. This increased speed should be sufficient to make the improved Liberty ship less vulnerable to submarine attack.—*"The Journal of Commerce", (Shipbuilding and Engineering Edition), No. 35,813, 19th November, 1942, p. 2.*

Tramp Steamers as Meat Carriers.

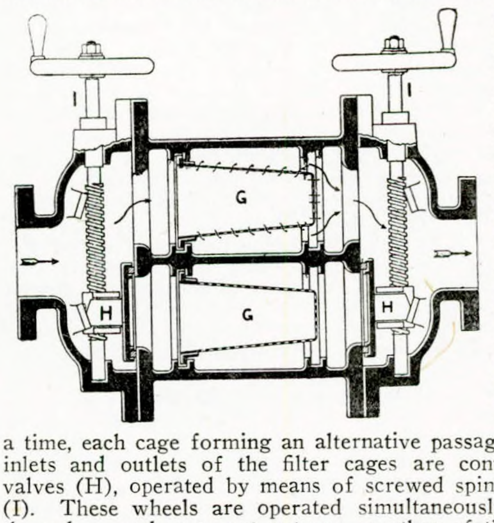
It was recently stated that in order to meet the shortage of refrigerated tonnage due to war conditions, special measures had had to be adopted. Ships specially designed as refrigerated-cargo carriers take a long time to build and present-day conditions tend to lengthen the construction period still further. It happened that there was more refrigerating machinery available than was required for fully-refrigerated cargo liners and so the conversion of ordinary tramp cargo steamers of 10,000 tons d.w. in the course of completion was decided upon. They were given a capacity of from 250,000 to 300,000 cu. ft. of refrigerated cargo space, as compared with the 400,000 to 500,000 cu. ft. of such space provided in a modern ship specially designed for the meat trade. The ships were equipped with boilers of larger capacity than they would otherwise have had in order to supply the additional steam required to drive the refrigerated machinery, and the holds were insulated and converted into refrigerated compartments. The conversion has proved highly successful, and the first ship to be adapted for the meat trade in this manner has now completed her first round voyage and has landed her cargo in this country in good condition.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,807, 12th November, 1942, p. 2.*

"The Watertight Subdivision of Merchant Ships with Special Reference to the Use of a Watertight Deck".

The object of the paper is to investigate the possibility of using a watertight deck in ships, and particularly in those of the shelter-deck cargo type. After discussing the assumptions made in determining the subdivision by the ordinary method and the standard of subdivision attainable by the employment of transverse bulkheads as laid down by the classification societies, the author compares this standard with that which can be attained by the use of a watertight deck below the weather deck. The question of possible damage to the W.T. deck is considered, as well as that of the necessary strengthening of the deck to enable it to withstand water pressure from beneath. The author then goes on to discuss suitable means of closing the various deck openings, such as hatches, and points out that the efficiency of the proposed arrangement depends upon the effectiveness with which water can be prevented from finding access from below. The general seaworthiness of a damaged ship is then considered under the headings of stability, longitudinal strength and ability to withstand heavy weather. The general effect of the proposed modifications on the design of the ship is also considered, and the author arrives at the following conclusions: (*1*) Provided the deck is not damaged, a two-compartment standard can be attained by the use of a watertight deck; (*2*) watertight hatch covers are feasible by utilising a light alloy; (*3*) the modified arrangement involves only a small increase in the weight of the hull structure; and (*4*) only slight modifications to the design of a ship need be made, such as reduction of sheer and camber on the second deck, increase of sheer on the upper deck, and adjustment of the position of the transverse bulkheads. The method of making the necessary calculations is described in an appendix.—*Paper by W. Muckle, B.Sc., read at a general meeting of the N.-E. Coast Institution of Engineers and Shipbuilders, on the 16th November, 1942.*

Filtration of Cooling Water.

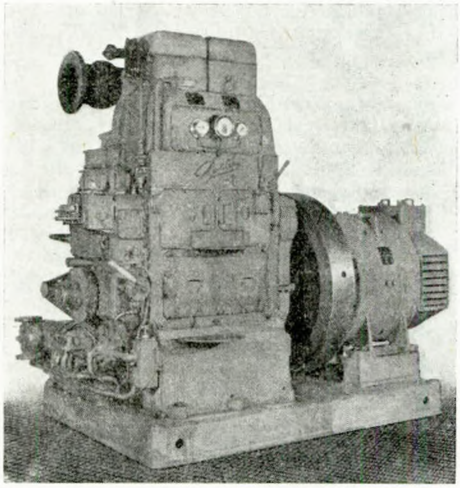
The accompanying illustration is a longitudinal section of a filter for use in the cooling-water system of an oil engine. A feature of the device is that it can be cleaned without stopping the engine and that it can be employed in any circulating-water system irrespective of whether the cooling water is passed directly through the cylinder jackets or through a heat exchanger. The body of the filter, which is usually of cast iron, forms a part of the water-inlet pipe line and contains two filter cages (G), which, by opening side doors, can be withdrawn for cleaning one at a time, each cage forming an alternative passage to the other. The inlets and outlets of the filter cages are controlled by two slide valves (H), operated by means of screwed spindles and handwheels (I). These wheels are operated simultaneously to raise or lower the valves, and so to cut out one or other of the cages preparatory to cleaning. In the larger sizes of filter the screwed spindles are interconnected to ensure simultaneous operation of the valves.



Where hot water is concerned, the slide valves have whitemetal rings for the jointing faces. The doors which give access to the cages for cleaning are secured by means of bars and set-screws. The filters are available in sizes from 2in. to 16in. (diameter of inlet and outlet passages) and are manufactured by a well-known Manchester engineering firm. Where sea water is used the cages are made of brass instead of cast iron.—*"The Oil Engine", Vol. X, No. 116, December, 1942, p. 211.*

Petter Auxiliary Superscavenge Engines.

The accompanying illustration shows one of two Petter superscavenge engines recently installed on board a British oil tanker. Each engine, which runs at 500 r.p.m., is coupled to a Brush 75-kW. compound-wound dynamo generating direct current at 110 volts. The two sets replace three single-cylinder Diesel-engined dynamos with a total output of 96kW. which were originally installed about 15 years ago and were damaged beyond repair by enemy action. Up to that time these machines had been running well and there had been no question of replacement. It is stated that the principal item of upkeep was the blast-injection air compressor, in each instance.—*"The Motor Ship", Vol. XXIII, No. 274, November, 1942, p. 248.*



Petter superscavenge engine coupled to 75-kW. dynamo.

Operating Results with Götaverken Turbo-compressor.

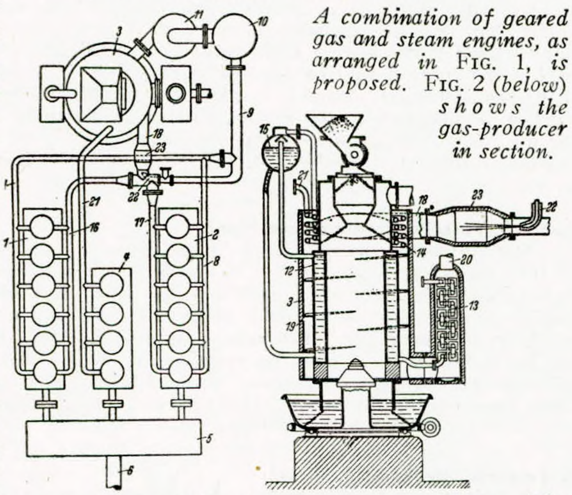
One of the earliest Götaverken turbo-compressors to be installed in a steamship was fitted in August, 1934 in the Swedish steamer "Hektor", a vessel of 8,200 tons d.w. built in 1921. The turbine and compressor were opened up last June for the first time, and the shipowners recently sent to the Götaverken a detailed report on their working. The ship was undergoing extensive repairs to her rudder and the opportunity was taken to examine the turbine and compressor because during the past year the lubricating oil had shown a higher temperature than usual. The turbine blades were found to be almost free from deposit and foreign matter; the blades of the compressor were likewise free from deposit, but their surfaces were dull. The wear in the radial bearing could not be measured, but the shaft bearing was found to have a clearance of 0·024in., which was adjusted to the original 0·012in. The oil channels in the bearing and the smaller oil pipes were partly choked with oil carbon. The cause of this and of the rise in temperature of the lubricating oil was found to be that the dividing wall in the water-jacket cover of the oil cooler had been damaged, so that the cooling water did not run through the cooler tubes and the lubricating oil was not cooled. The entire forced-lubrication system was thoroughly cleaned out and a new cover was fitted to the oil cooler. The temperature of the lubricating oil has since been normal. Several changes in the E.R. staff of the ship took place during the last two years, but the new engineers quickly became used to the working and care of the turbine. A record of the working results of the latter was compiled from engineers' reports covering a period of five years and two months, during which the vessel steamed 281,000 sea miles in 28,977 hours, corresponding to 237 days per year. Prior to the installation of the turbo-compressor the mean speed of the ship was 9·2 knots, but this was increased to 9·7 knots after the turbo-compressor was fitted. There was also a saving of 8,700 tons in coal consumption, in addition to an economy of Kr. 50,000 (about £3,000) in respect of the wages and victualling of three firemen. The owners' report gives full details of the manner in which the various savings have been calculated. They include the increase in freight earned by the increased cargo capacity due to the reduced coal consumption (Kr. 144,000) and the increase in freight earned due to the increased speed (Kr. 225,000). The total saving in operating costs during the period under review is assessed at Kr. 593,000 (about £35,000).—*"Lloyd's List and Shipping Gazette", No. 39,938, 18th November, 1942, p. 6.*

The Oxy-hydrogen Cycle and Submarine Propulsion.

The examination of captured Nazi U-boats by Allied naval authorities has resulted in a report that "the usual electric motors, supplied with current from a large battery installation, have been discarded. Instead, the main Diesel engines intended for propulsion on the surface are designed to run also on a mixture of oxygen and hydrogen so that, operating with a closed exhaust, they can be used for driving the vessel when the latter is submerged". It is claimed that the Erren engine, as applied to submarines, increases the radius of action, the space available for armaments, and the speed and angle of submersion, in addition to which it eliminates the possible generation of poisonous fumes from the batteries. Moreover, it also provides the locomotive power for a trackless torpedo which, even if it misses, will give no visible indication to the enemy that it has been fired. Rudolph Erren, the inventor of the engine, is a German who came to this country in 1930 in order to develop his ideas regarding the internal-combustion engine and to acquire British nationality. His oxy-hydrogen generator was demonstrated to the Admiralty some years before the war, but was turned down. Erren was subsequently approached by representatives of the German Government who were desirous of applying his invention to the propulsion of German submarines. Despite attractive cash offers, Erren declined to entertain the German proposals, as he was strongly opposed to the Nazi régime. Subsequently, his London office was burgled and all his private correspondence stolen, and it was latter discovered, after Erren's internment by the Home Office, that a person who had been financially interested in his schemes had kept in this country a German assistant of Erren's working on his patents for a year after war broke out. This man was eventually interned by order of the Home Office. The Erren submarine is driven on the surface by alternative-fuel engines running on oil and driving a small high-speed dynamo which delivers its current to a high-pressure electrolyser by means of which water is broken up into hydrogen gas and oxygen gas in the ratio of 2 to 1 (H_2O) under a pressure of 3,000-5,000lb./in.^{2}. These gases are stored in separate lightweight high-pressure cylinders along the keel. When the submarine dives, the Erren engines are switched over to run on oxygen and hydrogen without any air or oil. The combustion product of these gases is steam, which is put back into the engine at a temperature slightly above the saturation point. Oxygen and hydrogen in the correct ratio and in an amount according to the power output required are injected into each working cylinder separately; the latter is thereupon filled up with the steam and the resultant mixture is fired by means of a spark. The heat generated then superheats the steam, which expands in the usual way and drives the piston. A considerable amount of experimental and research work in connection with the Erren system was carried out at the works of Wm. Beardmore & Co., Ltd., at Dalmuir. The test unit was a 10-year-old single-cylinder Beardmore engine in which the original compression ratio of 14·8 to 1 had been reduced to 10 to 1. Official tests attended by Government representatives included demonstrations of starting on air and hydrogen, changing over to oxy-hydrogen with closed exhaust, changing over to fuel oil and hydrogen and to fuel oil alone, and manœuvring at different speeds on various fuels. Demonstrations were also given of the Erren system applied to National single-cylinder Diesel engines and to a Beardmore engine in a Leyland 32-seater bus. A remarkable increase in efficiency aud output was a feature of these tests. It is claimed that the application of the Erren system to a submarine makes it possible to increase the radius of action to more than 15,000 miles, whilst the saving in weight allows the pressure hull to be strengthened to such an extent as to enable the boat to crash dive at a steep angle and to submerge with safety to a depth of 600ft., *i.e.* far below the depth at which the normal depth charge is effective. In the event of a disaster of the kind which overtook the "Thetis", the amount of oxygen stored would be sufficient to keep the crew alive for anything from two to four weeks, and the huge amount of compressed hydrogen would be more than ample to blow out the water from the ballast tanks and trimming tanks, and to clear any of the inner compartments which might be flooded by sea water. The resulting buoyancy would cause the submarine to rise to the surface automatically. It is suggested that small submarines for coastal defence, or of a type which could be carried aboard large warships, might be equipped with an Erren engine and separate cylinders for oxygen and hydrogen gas. These cylinders could be charged either ashore or on board the parent ship, thereby eliminating the high-pressure electrolyser in the submarine. As regards the trackless torpedo, the Erren oxy-hydrogen propelling unit can be run without any lubricating oil in the cylinders. The former owner of a fleet of trawlers operating from La Rochelle stated recently in London that after his vessels had been equipped with Erren oxy-hydrogen engines they were able to remain at sea for eight weeks instead of only two to three weeks when fitted with ordinary Diesel engines. It is reported that between 3,000 and 4,000 commercial motor vehicles in Germany are now operating on hydrogen, and that the well-known Berlin-Hanover express has, for some years past, been drawn by an Erren hydrogen engine. There is a plant in Munich which can produce 600,000 cu. ft. of hydrogen per day at the right pressure for operational purposes. The same thing could, no doubt, be done in this country.—*"Shipbuilding and Shipping Record", Vol. LX, No. 21, 19th November, 1942, p. 495.*

Gas Producer Plant for Ship Propulsion.

A gas-producer installation with non-reversible gas engines for ahead running and a reversible waste-heat-boilered reciprocating steam engine for manœuvring and astern running, has been patented by a Cologne engineer and was described in the March issue of *Werft*Reederei*Hafen*. The steam engine also provides auxiliary power for ahead running and is supplied with steam by the waste-heat boiler. When the steam consumption is high, the output of the latter can be increased by additional oil firing. Referring to the accompanying diagrams, Fig. 1 shows the general lay-out, while Fig. 2 is a vertical section of the gas producer. There are two non-reversible gas engines (*1* and *2*), a gas producer (*3*), and a reversible reciprocating steam engine (*4*). All three engines drive the propeller shaft (*6*) through gearing (*5*). The pipes (*7*, *8* and *9*) are the separate and common gas mains from the gas cleaners (*10* and *11*) to the gas engines. The gas producer has a steam-generating jacket (*12*), and there is a feed-water heater (*13*), a superheater (*14*), and a steam separator (*15*). The steam-generating jacket (*12*) is heated by the exhaust of the gas engines through the exhaust pipes (*16*, *17* and *18*), the exhaust gases traversing the jacket from top to bottom past the spiral guides (*19*) after passing through the superheater (*14*). After leaving the steam-generating jacket the exhaust gases pass through the feed heater (*13*) and thence to the atmosphere through the funnel (*20*). The steam produced in the jacket is led to the steam engine by the pipe (*21*). An oil burner (*22*) in the combustion chamber (*23*) of the waste-heat boiler is used to supply the extra heat required to produce the additional steam necessary for manœuvring.—*"The Marine Engineer", Vol. 65, No. 785, December, 1942, p. 277.*



A combination of geared gas and steam engines, as arranged in FIG. 1, *is proposed.* FIG. 2 *(below) shows the gas-producer in section.*

Air Screw Propulsion for Barges.

A well-known Hungarian engineer, Mr. Oskar v. Asboth, recently demonstrated to a number of experts an air-screw-driven barge which should prove useful on the inland waterways of Hungary. Although not very fast, this craft will carry up to 150 tons of cargo along waterways having a depth of only 3ft. The experimental vessel was built in the workshops of the Hungarian Ministry of Agriculture and has a length of about 79ft. and a breadth of 17ft. 9in. She draws about 24in. of water, and a petrol engine mounted on a steel tubular frame at the stern drives an air screw about 10ft. in diameter. The vessel carried 60 tons of ballast on the tests, and with the engine developing 30 h.p. the barge maintained a speed of over 4·3 m.p.h. on a petrol consumption of 0·56 gall./mile. Tests have shown that a motor barge with an ordinary propeller would require 60 h.p. to obtain the same effect. The experimental vessel is steered by a hand rudder and boat hooks. Although astern movement is technically possible, it is not considered that it would be necessary in practice. The vessel makes no wash. A Diesel engine could be used instead of a petrol engine, if desired. As many Hungarian rivers and canals become so shallow towards the end of summer as to be unusable, on these waterways air-screw-driven barges of the kind described above should prove invaluable.—*"Lloyd's List and Shipping Gazette", No. 39,926, 4th November, 1942, p. 9.*

Welding v. Riveting for Cargo Ships.

A well-known Cardiff shipowner and underwriter, whose firm is managing some of the American-built cargo ships delivered to the Ministry of War Transport, recently gave a Press representative his views on the main advantages which a welded ship is claimed to possess as compared with a riveted vessel. After pointing out that the time has not yet come for forming any definite conclusions on this matter, he expressed the opinion that the smooth hull which is a feature of all-welded construction offers less resistance to propulsion and that a welded hull is as strong, if not stronger, than a riveted hull. Referring to the collision in which one of the ships, the "Ocean Vanguard", was involved on her maiden voyage, the shipowner declared that the impact had been so severe that in a vessel of ordinary riveted construction the landings and butts would have failed and the forward compartments would have filled with water. The riveting of internals would also have failed. As things were, no welded joints were started despite severe distortion of the hull structure, and the only water which entered the ship was through an actual hole in one plate caused by an anchor fluke and by loosened frame rivets. A riveted joint of even the best design, he went on to say, could only express a percentage strength of a solid plate, whereas a welded joint properly made appeared to possess practically the same strength as solid plate. The confidence of the American designers is such that they disregard the conventional "shift of butts" in the deck plating which is usually adopted in riveted hulls to distribute the weakening due to this type of joint, and make the athwartship welds of the deck plates continuous over the width of the ship. The life of the average cargo vessel—20 to 25 years—makes the question of repairs to damage caused either by marine casualty or enemy action a vital one. Repairs can be carried out effectively on these welded ships in the U.K., but not as expeditiously as in America, as we have neither a sufficiency of trained welders nor the necessary plant available in all parts of this country. Repairs to bottom plating in dry dock are more difficult owing to the "overhead" welding involved, and the great size of the plates in the American-built ships is a feature to which our men have not yet become accustomed. The shipowner also stated that his firm had received most favourable reports from the masters and chief engineers who were at sea in these welded ships. The amount of leakage via welded seams had been nil.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,801, 5th November, 1942, p. 8.*

Fabricated Engine Parts.

Apart from the use of the process of fabrication as an alternative to riveting, which is being so extensively employed in ship construction at the present time, it is now recognised that mild steel plates welded together provide a very satisfactory alternative to iron castings. Thus, the bedplates and frames of Diesel engines have long been fabricated in this manner, thereby effecting a substantial saving in weight without any sacrifice of strength. Apart from its inability to withstand the effects of suddenly applied loads and shocks, cast iron has the disadvantage of suffering from the effects of growth and creep when subjected to steam at even moderate temperatures. Fabricated construction, on the other hand, has proved very successful in withstanding such conditions, and even L.P. turbine casings are now being built in this way. Engine parts built up in this manner should, if possible, be annealed after fabrication if a furnace of adequate size is available, although it is probable that any stress concentrations would gradually be eliminated in service.—*"Shipbuilding and Shipping Record", Vol. LX, No. 19, 5th November, 1942, p. 435.*

The Electric Drive.

The author deals with the contentions put forward by a well-known consulting naval architect regarding the merits of electric transmission for ocean-going motorships, a form of drive which is viewed with disfavour by the writer. After referring to the popularity of electric transmission in the U.S.A., and to the enthusiasm displayed for it by the superintendent engineer of the Hamburg-America Line, the naval architect states that by locating the machinery right aft and above the electric motors on the main shaft, the length of the engine is reduced to a minimum, thereby achieving a large gain in capacity and deadweight. The cost per ton d.w. is therefore much less than with any form of slow-running direct drive and the machinery is also far more accessible for overhaul. The author's reply is to the effect that reliability is by far the most important qualification for propelling machinery, with fuel cost as a good second; while capital charges on the first cost cannot be ignored. No doubt reliability *can* be achieved with electric transmission by multiple generating sets, by duplicating the electrical accessories and by providing twin screws—at a cost. In a paper entitled "Marine Engines from a Superintendent Engineer's Point of View", read before Lloyd's Register Staff in 1935, Mr. S. B. Freeman, C.B.E., M.Eng., gave comparative prices for various types of machinery of about 8,000 s.h.p. Taking a steam engine and Scotch boiler as 1, he gave direct-coupled oil engines with twin screws as 1·33 and oil engines with electric transmission as 1·66 to 2·1. In addition to the capital charges on the higher first cost, the loss of power by the double conversion and the accompanying increase in fuel cost, is a serious item in the running costs of ships that make long voyages. The author concludes his article by expressing doubts concerning the wisdom of placing heavy machinery right aft, and quotes his personal experience while serving as an engineer in a Western Ocean tanker which had her engine and boilers aft. This vessel was always liable to poop big following seas, and had to be turned off her course sometimes due to this risk. She pooped one while the author was serving in her, sustaining considerable damage on deck and almost being lost.—*W. O. Horsnaill, "Shipping", Vol. XXXI, No. 364, November, 1942,, pp. 28 and 30.*

Submarine Cable Repairs.

A paper entitled "Salvaging, Relaying and Jointing Submarine Power Cables", by J. C. Fraser, mains engineer to the Sydney County Council, which has been published in the *Journal of the Institution of Engineers, Australia,* describes a method adopted to joint and replace in its original position a 33-kV. submarine cable which had been fouled by a ship's anchor. The cable, an important one in Sydney Harbour, was dragged some 220ft. upstream and severed at about 540ft. from one end and 1,260ft. from the other. It was not feasible to insert a length of new cable with two joints owing to the danger of the cable in its new position being fouled by anchors, in addition to which it was impracticable to anchor a jointing lighter over the cable in such a heavy traffic area. It was also considered inadvisable to attempt to move the cable back to its original position by underrunning it, because of its weight (the longer section weighed 14 tons) and the possibility of damage to it and other cables. The only other method that presented itself was to salvage the cable in good condition and relay it along its original route. Of the various means considered for salvaging the cable the one which offered the best prospects of speed and simplicity consisted of utilising a power-driven cable drum to raise the cable and roll it on the drum in one operation. A flush-deck lighter was available equipped with a steam winch with two warping heads to provide the motive power for driving the cable drum. It was decided, therefore, to effect the drive by means of ropes fleeted over these warping heads and "warping rings" bolted to the cheeks of the drums. As the cable was brought aboard, the lighter was warped slowly ahead by means of hand winches. The direction of the lighter over the cable was controlled by the relative speeds of the forward hand winches and the rate at which the stern anchor rope was paid out. The average rate at which the cable was recovered, excluding the time for placing anchors, etc., was a little over 300ft./hr. It was decided to relay the cable by warping the lighter on anchors in a similar manner except that the steam winch was employed to provide the power for the warping operation. The paying out of the cable was controlled by means of a drum brake.—*"Electrical Review", Vol. CXXXI, No. 3,392, 27th November, 1942, p. 678.*

Alternating Current for Ships' Auxiliaries.

It was recently stated that 105 of the 128 oil tankers on order for the U.S. Maritime Commission are to have their auxiliary machinery driven by a.c. motors. The current for the auxiliaries is not usually taken from the main propulsion generators of vessels with turbo-electric drive, but is supplied from independent auxiliary generators. In addition to the above tankers, over 50 motorships now building in America are to have their auxiliaries driven by a.c. motors. As regards the tankers referred to above, each ship is being fitted with two 550-kVA alternators generating 60-cycle current at 440 volts. There are approximately 50 auxiliary motors of from 0·5 h.p. to 200 h.p. in each tanker, and with the exception of the shaft-turning-gear motor, all these are of the direct-starting squirrel-cage type. The main cargo oil pump motors are also arranged to take current supplied by the main propulsion generators at 2,300 volts through step-down transformers which reduce it to 440 volts. All the motors with the exception of those driving the turning gear, the oil-fuel transfer pump, the oil-fuel service pump and the forced-draught fan, are of the constant-speed type, the others having resistances in series with insulated squirrel-cage windings as a means for varying the speed. All these motors are machines of ordinary standard types which have been in production in large numbers for various industrial purposes in the U.S., and their simplicity, reliability and ability to withstand the effects of moisture and condensation have been fully established. There are obvious advantages in favour of the use of alternating current on board ship, despite the fact that the motors take a very high starting current in relation to their full-load current. Most of the a.c. motors are arranged for "across the line" starting, which involves starting currents about seven times as great as those taken under full-load running conditions, although the large cargo oil pump motors as well as those driving the main circulating-water pumps are equipped with compensator type starters. In other respects, however, the control gear is simpler and considerably less expensive to manufacture than the corresponding d.c. equipment. Recognising the fact that starting currents are undoubtedly high—although in some of the more recent designs of squirrel-cage motor it is claimed that the starting current is only about four times the full-load current—the suggestion has been put forward that a higher temperature rise than that now permitted by Lloyd's rules should be allowed, particularly in view of the fact that organic non-inflammable insulating materials are now available. Such a modification of the regulations might do much to encourage the use of a.c. for all auxiliary purposes on board ship.—*"Shipbuilding and Shipping Record", Vol. LX, No. 22, 26th November, 1942, p. 508.*

Swedish Vessel's Producer-gas Plant.

The auxiliary sailing vessel "Elsa" recently completed at the Holms Shipyard, Raa, Sweden, has now run her trials. Her main dimensions are about 89ft. by 22½ft. by 10ft., and her propelling machinery consists of a two-cylinder 130-h.p. engine designed to work on producer gas. The vessel attained a speed of nine knots on her trials with a gas consumption of about 10·6 cu. ft./hr., whereas the corresponding speed obtained with an oil engine would have been only eight knots.—*"Lloyd's List and Shipping Gazette", No. 39,944, 25th November, 1942, p. 5.*

A Portable Mechanical Shovel.

A British engineering firm have developed a portable mechanical shovel which is designed to reduce the amount of labour involved in filling the hoppers of mechanical stokers. Two types are manufactured, one being operated by an electric motor and the other being worked by hand and weighing only 140lb. Coal hoppers are usually about 6ft. above floor level, and with this shovel it is claimed that the task of filling the hoppers with coal is considerably lightened.—*"The Steam Engineer", Vol. XII, No. 135, December, 1942, p. 86.*

Cox Water Heaters.

An improved form of water heater which is claimed to be silent in operation has been put on the market by a Sheffield firm under the trade name of the "Cox" water heater. The general design embodies the use of a chamber filled with hard porcelain balls over which cold water flows, through an inlet at the side of the chamber. Steam enters at the top and passes through a series of tubes surrounded by the cold water before being discharged into the chamber containing the porcelain balls, where a very thorough mixing takes place due to the large amount of heating surface provided by the spherical surfaces of the balls. Various arrangements of design are available, including one fitted with an interlocking device which prevents the steam valve from being opened until the water is flowing. The reverse occurs when shutting off. The apparatus is made in three sizes, the first of which supplies 130 gall./hr. of water with a temperature increase of 90° F. The second size is capable of heating from 150 to 1,800 gall./hr. of water up to 212° F., whilst the largest size has a maximum capacity of 24,000 gall./hr. based on a temperature rise of 150° F.—*"The Steam Engineer", Vol. XII, No. 135, December, 1942, p. 86.*

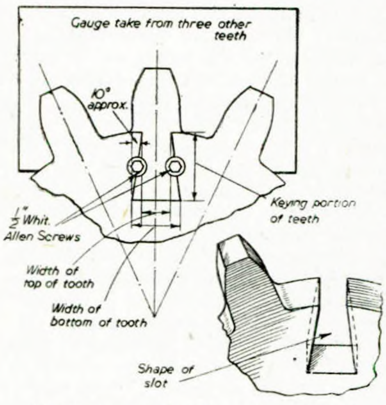
Abstracts of the Technical Press

Electric Propulsion.

The various systems available for the electric propulsion of ships are the turbo-electric a.c., the Diesel-electric a.c. and the Diesel-electric d.c. In addition, turbo-electric d.c. with geared d.c. generators may be utilised and also Diesel engines driving through electromagnetic couplings, but this latter system does not offer all the advantages of the others. Although no definite dividing lines can be drawn between the scopes of the three main systems, it may be stated that, generally speaking, turbo-electric a.c. propulsion is suitable for powers of 5,000 h.p. and over per turbine, whilst Diesel-electric a.c. propulsion can be employed up to the limits of engine output, several alternators being paralleled to supply one propulsion motor. The Diesel-electric d.c. and turbo-electric d.c. systems are suitable for installations of up to about 2,500 h.p. per screw, the output being limited by the currents in the commutators and switchgear, whilst magnetic slip couplings can be employed up to the limits of the output of the Diesel engines. With the turbo-electric a.c. system the prime mover is a steam turbine coupled direct to a 3-phase turbo-alternator. The speed is not limited by the standard frequency of 50 cycles as in land stations, as the frequency can be chosen at the best value to suit the designs of the alternator and propulsion motors. In the case of the "Normandie", the frequency was chosen at 81 cycles. The propulsion motors are of the synchronous type and are designed to suit the optimum speed of the propellers. The synchronous type is preferred to the induction type owing to the saving in the size of the alternators, cables and switchgear due to the improved power factor. The synchronous motors are operated at approximately unity power factor, whereas induction motors would have a considerably lower lagging power factor on account of the high number of poles necessary to obtain the propeller speed. The usual practice is to start the motors as induction motors, a squirrel-cage winding in the pole faces acting as the secondary winding and the field being unexcited. The alternator field is over-excited and the motors are synchronised by exciting their fields when up to speed, the alternator excitation being then reduced to normal. For reversal, the excitation is cut off from all machines, the stator connections interchanged and the alternator over-excited. The motors again act as induction motors and reverse their direction, whilst the rotation of the turbine remains unchanged. Intermediate propeller speeds are obtained by regulating the speed of the turbine. The governor is designed to give good inherent regulation at any speed down to quite a low level. Twin-screw ships usually have one turbo-alternator for each propulsion motor, and for cruising speeds or in case of a breakdown of one of the turbo-alternators, both propulsion motors can be supplied from one alternator. In quadruple-screw ships, two turbo-alternators can be arranged to supply the two pairs of propulsion motors, various groupings being thereby made possible. The alternator on one side can supply the two motors on that side, or else it can supply the outboard motors while the other alternator supplies the two inboard motors. One alternator can also supply all four motors at a reduced speed. Alternatively, as in the "Normandie", four turbo-alternators can be installed each supplying one propulsion motor. This again allows for various groupings and practically ensures that power will always be available for propulsion in any eventuality. With the Diesel-electric a.c. system slow-speed alternators direct-coupled to Diesel engines supply power to synchronous-type propulsion motors. This system has already been adopted in a small number of ships, but its development has been delayed by the war. It possesses several advantages and appears to have a promising future. The most economical size and speed of the engines are chosen and several alternators are connected in parallel to provide enough power for the propulsion motor. This parallel connection constitutes one of the principal differences between the Diesel-electric and turbo-electric a.c. systems. With the latter, there is no need to run alternators in parallel, since the turbines can be made large enough for the input of the propulsion motors. Another important difference between these two systems is the method of full-speed reversal. With the turbo-electric a.c. system, when the phases are reversed and the alternator re-excited, the propulsion motor acts as a brake while the speed is being reduced. During this time considerable energy is fed into the pole-face windings of the motor by the turbo-alternator and the turbine must supply this energy, in addition to the losses in the stator windings caused by the heavy currents. Fortunately, the turbine is able to do this as its torque increases as the speed falls. On the other hand, a Diesel engine can exert little more than full-load torque at any speed, so that when the losses absorb almost its entire output, very little power is left to supply the reversing torque. This difficulty is overcome by using the principle of dynamic braking. In one method the stator of the motor is disconnected from the alternators and is connected across a resistance, its field being excited. The motor then acts as a generator driven by the propeller, and its kinetic energy is dissipated in heat in the resistance. When the motor is nearly at rest, it is reconnected to the alternators. Instead of using a separate resistance, the energy may be dissipated in windings on the motor and several schemes have been devised for this purpose. There appears to be no justification for the assertion that provision for rapid reversal is unnecessary in cargo vessels; emergencies may arise when the safety of the ship may depend on being able to stop as quickly as possible. The simplest form of Diesel-electric d.c. is the Ward-Leonard system. Here the engine drives a shunt-wound propulsion motor. Speed control is obtained by varying the field of the generator, thus varying and reversing the voltage supplied to the motor. Several generators may be connected in series, thus allowing the most suitable choice of the speed and size of the engines. The regulation of the generator fields can be carried out by hand in the engine room in response to signals from the bridge, or else the controllers can be operated directly from the bridge, thus saving time in response. This arrangement is of special value for tugs and similar craft. An important advantage of the Diesel-electric d.c. system is that no regulation of the engine speed is required. The speed and direction of rotation of the propeller are controlled by manipulating the shunt regulator in the generator field. Full-speed reversal is readily carried out by reversing the generator field and it is found that the kinetic energy of the propulsion motors is absorbed by the friction losses in the engine without appreciable overspeed. There appears to be little scope for the turbo-electric d.c. system, in which the turbines are geared to the generators and the method of control is the same as for the Diesel-electric d.c. system. For a full-speed reversal, the friction losses in the turbine are not sufficient to absorb the kinetic energy of the propulsion motor, and it is necessary to provide some sort of loading device during reversal to absorb this energy. Some of the earlier motor vessels had two or more Diesel engines geared to the same gear-wheel on the propeller shaft, in order to enable higher engine speeds to be employed. This was found to produce excessive wear on the pinions and gear-wheels, and a hydraulic coupling was thereupon fitted between the gear wheel and propeller shaft. A later development was the magnetic slip coupling, one for each engine, which provides a transmission without any mechanical connection between the engine and the pinion. The coupling consists of two members with an air-gap between them, one member being a multi-polar field magnet excited with d.c., and the other a magnetic core carrying a squirrel-cage winding. The coupling exerts torque in the same way as an induction motor and the mechanical energy is transmitted from one member to the other by means of the magnetic energy in the air-gap. This form of coupling has proved highly satisfactory, and its complete flexibility renders the wear on the gear teeth negligible. The member coupled to the pinion always runs at a slightly slower speed than the engine. Speed regulation is obtained by varying the engine speed and reversal by reversing the engine. Where two or more engines are geared to one propeller shaft manœuvring can be simplified by running half the engines in one direction and the other half reversed. Whichever direction is required for the propeller can then be obtained by exciting the appropriate couplings, the others being unexcited. Proposals have also been made for reversible couplings which would permit the engines to run always in the same direction, reversal being obtained by manipulation of the fields of the couplings.—*R. G. Jakeman, D.Sc., "The Shipping World", Vol. CVII, No. 2,579, 18th November, 1942, pp. 431-435.*

Replacing a Broken Gear Tooth.

It recently became necessary to replace a broken tooth in a large gear-wheel, and as the time-honoured method of drilling-in a series of pegs and filing them to shape was not considered adequate, a tooth was keyed into the wheel in the manner shown in the accompanying sketch. After carefully marking out the pitch distance and the depth of the keyed portion of the proposed tooth on the wheel, this was machined out to the dimensions shown. The new tooth was marked and made out of a piece of mild steel flat section, machined roughly to the shape of the other teeth with the keyed portion added at the base. This was then driven into the wheel, in which it was a good driving fit. Both sides were then spotted, and Allen screws inserted at the joins, half in the wheel and half in the tooth. In order to check the depth, pitch and contour of the new tooth, a gauge was made to fit three of the other teeth along the circumference, and this gauge was then placed over the fitted tooth. The latter was subsequently filed to the correct shape and size in relation to the adjacent teeth. The fact that the wheel is now in daily operation would appear to indicate that this method of repair is satisfactory.—*N. W. King, "Practical Engineering", Vol. 6, No. 156, 15th January, 1943, p. 669.*



Replacing a broken gear tooth.

"The Post-War Training of Sea-going Engineers".

The author of the paper bearing the above title is more concerned with the problem of the *quality* of the sea-going engineers of the future than with that of their probable number. He expresses the view that the real difficulty is two-fold, *viz.* (1) the progressive increase in the variety and complexity of marine propelling machinery brought about by the search for increased economy and efficiency, and (2) the failure of the system of education and training available to the prospective sea-going engineer to keep pace with these developments. The theoretical knowledge and practical training expected of the present-day marine engineer cannot possibly be obtained by means of a five-years' apprenticeship primarily designed to train the apprentice as a *tradesman,* coupled with a concurrent night-school course during which (on, say, three nights a week) an attempt is made to "cram" an ever-increasing amount of highly technical knowledge under the adverse physical and mental conditions that follow a long day's work. The author advocates the creation of a "Training College for Engineer Officers of the Merchant Navy" in the form of a training ship and associated shore establishment specially built for the purpose. The initial capital cost of the scheme would be borne by the Government, while the running costs would be defrayed by nominal annual fees, a Board of Education grant and annual contributions by the shipowners. Admission to the college would be by entrance examination and/or scholarship at the age of 15½-16 years, and the course of study would extend over a period of three years, followed by about 18 months' apprenticeship. After this the "cadet" engineer officer would go to sea in the usual way. The author's proposals concerning the equipment and location of the training ship and shore establishment are set out in some detail, and he suggests that the curriculum for students at the college should be such as to enable them to pass the National Certificate examination for both Second and Chief Engineers' certificates. Nevertheless, the three-year course of training would be sufficiently practical to enable the B.O.T. to recognise the three years spent at the college as equivalent to three of the four years' apprenticeship to be served before going to sea. It is also suggested that shipowners might select young men graduating from the college for about 18 months' intensive service as apprentices with shipbuilding firms who might at the time be building or about to build one of their vessels, so that wherever possible the young engineer would make his first voyage in a ship which he had seen in the building.—*Paper by R. E. Mate, M.Eng. (Liverpool), "Bulletin of the Liverpool Engineering Society", Vol. XVI, No. 4, November, 1942, pp. 11-18.*

Cargo Ships and Propelling Machinery Adapted to War Conditions.

The paper contains proposals for the design and construction of an entirely novel type of motor vessel—described by the author as a "cargo warship"—which, he claims, is specifically designed to meet war conditions. He endeavours to show that the country's shipbuilding resources could be made more effective by adopting a higher sea speed, thereby increasing the amount of cargo carried with a given weight of steel, whilst the risk of loss by enemy action would be greatly reduced. Such a ship calls for more powerful engines of low weight, the manufacture of which must involve a minimum of man-power. This, the author suggests, is much easier of solution, in weight of material and in man-power, than the actual building of hulls. A carefully designed ship of 12,000 tons d.w. to run at 18 knots would require engines of 12,500 b.h.p., and it is suggested that such engines could be designed to be only slightly heavier and to consume only 25 per cent. more weight of fuel than the "Ocean" class ships' triple-expansion engines of 2,200 b.h.p. supplied with steam by coal-fired boilers. No less than three times the amount of cargo could then be carried in the unconvoyed vessel envisaged by the author at the cost of a relatively small increase in man-power per ship, such man-power having the virtue of being mainly of a non-shipbuilding character. In addition to high speed, the ship would have low visibility from a submarine—all crew accommodation being below deck—but a good "eye" in the form of a ship-based aircraft which could take-off or land on the deck with ease and safety. Centralised ship and gun control would give the vessel exceptional powers of defence, whilst a form of hull construction which embodies side explosion chambers or internal "blisters" would enable her to withstand the effects of torpedoes. Greater subdivision, especially horizontally, would be provided to localise explosion effects and the combined carriage of liquid as well as dry cargo would give a large measure of control over the buoyancy in the event of underwater damage. The author admits that the crux of the problem is the provision of special high-duty lightweight oil engines, but he considers that if this matter were dealt with on a national basis in order to evolve an engine for a specific war purpose, such an engine could be quickly designed and developed. Having explored the possibilities of its design, he suggests that fundamentally the most suitable engine type appears to be a moderate-speed direct-drive double-acting two-stroke oil engine with two banks of cylinders in vee formation, giving exceptionally low weights and sizes. Alternatively, a high-speed opposed-piston engine of almost aeronautical type might be evolved and used with electric reduction gear. Both of these types could with advantage, the author claims, be developed by a central national design and experimental department and a co-ordinated effort on the part of experienced oil-engine designers, making the best possible use of specialised design as well as manufacture. Such engine types would be of great subsequent value to the entire marine engine industry as basis engines from which to develop after the war.—*Paper by W. S. Burn, M.Sc., "Transactions of the Institute of Marine Enigneers", Vol. LIV, No. 10, November, 1942, pp. 129-146.*

American Yacht with Fuel-valve Boilers.

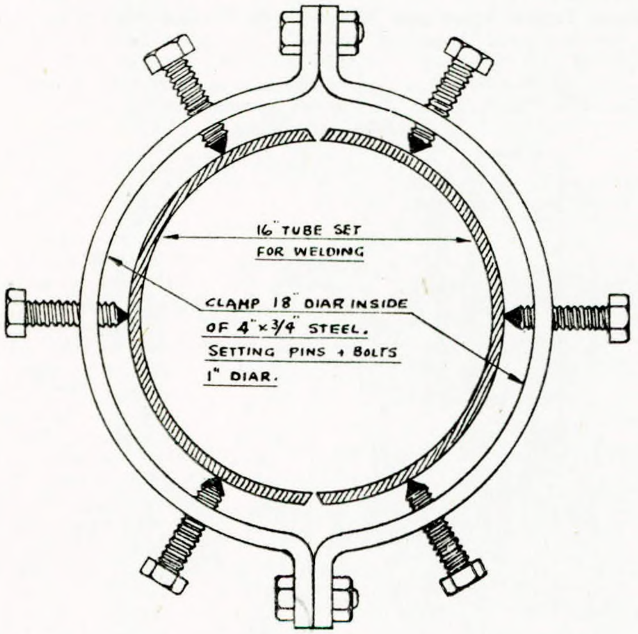
The Consolidated Shipbuilding Corporation, of Morris Heights, N.Y., well known as constructors of a special type of yacht, recently built a small, very fast, steam-driven yacht known as a commuter, the type of vessel which carries wealthy New York business men to Lower Manhattan from their Long Island homes. This commuter is only 100ft. long, with a beam of 16ft. and a draught of 4ft., but she is equipped with high-speed V-type reciprocating steam engines of 2,000 h.p. driving twin screws and giving her a speed of 35 m.p.h. The specific weight of these engines is stated to be only 3·5lb./h.p. and the total specific weight of the entire machinery installation, including the boilers, is only between 10 and 12lb./h.p. The two boilers are located abaft the engines and are of the so-called "fuel-valve" type, *i.e.*, of the forced-circulation flash type, supplying steam to the engines at a pressure of 1,500lb./in.^{2}. The boilers are tubular and have neither steam drums nor large water storage spaces, feed water being pumped into one end and steam taken out at the other. —*"Lloyd's List and Shipping Gazette", No. 39,944, 25th November, 1942, p. 11.*

A Lewis Boiler Installation.

A Clydeside representative of *The Marine Engineer* recently had occasion to inspect a Lewis single-drum watertube boiler at the works of Thos. Reid & Sons (Paisley) Ltd., where it is used to supply steam for carrying out the shop trials of marine auxiliary machinery. The boiler is oil-fired and is equipped with electrical automatic control. The single riveted drum is 5ft. 3in. long with a diameter of 2ft. 7½in. and is designed for a working pressure of 400lb./in.^{2}. The boiler has an output of 4,000lb./hr. and can raise steam at a pressure of 300lb./in.^{2} in under 15 minutes. It has been in operation for over a year, utilising local water for feed purposes without treatment of any kind. The tubes show no signs of corrosion, neither has any serious corrosion been observed in any other part of the boiler. The highly satisfactory results given by the boiler under peculiarly arduous working conditions would appear to indicate that many of the claims made for it by Mr. Wm. Yorath Lewis in his paper (*see p. 15 of* TRANSACTIONS *for March, 1941*), are substantiated.—*"The Marine Engineer", Vol. 65, No. 785, December, 1942, p. 266.*

A Welding Clamp.

The accompanying sketch shows the construction of a simple form of clamp for adjusting rolled plates into position for electric welding. The clamp is made of 4-in.×¾-in. flat steel of a suitable diameter for the work to be carried out, and is claimed to be particularly useful for the purpose of adjusting plates of different diameters for ships' masts and similar jobs. By screwing up the setting pins around the circumference of the clamp, the required gap for the welded joint is obtained.—*"Shipbuilding and Shipping Record", Vol. LXI, No. 1, 7th January, 1943, p. 17.*



Welding clamp.

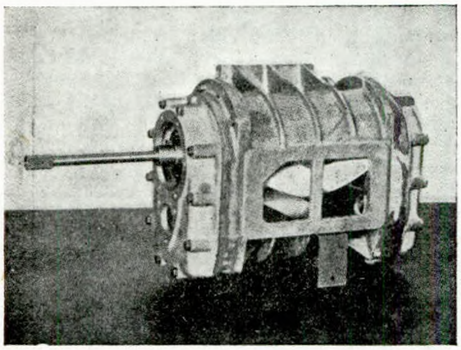
Building Liberty Ships in America.

Nearly half a million men are now employed in the U.S. shipbuilding industry—and of these, two-thirds were never inside a shipyard before 1940. The other third are skilled workers. However, over 60 per cent. of those now engaged in this work were familiar with trades that could be quickly adapted to shipyard procedure, they are mechanics, electricians, sheet-metal workers, plumbers, construction men, machine-tool operators, etc. The result is that the Liberty ships of 1942, built according to an original basic British design, are not the flimsy, ugly, floating boxcar types of the last war, but are vessels that can readily be modernised, have their power increased from 2,500 to 5,000 h.p., and become Diesel, or steam-turbine ships which will be suited to the post-war international trade routes. The average net cost is $1,800,000 per ship, but this price includes contractors' fees and amortization of the emergency shipyard costs spread over a very short term. As the average American shipyard worker earns $65 per week, and in view of the speed and volume of output attained, the cost of construction cannot be regarded as excessive. The Kaiser organisation controls six separate and complete shipyards on the West Coast, and so important is the handling of materials, that one of these establishments, the yard of the Oregon Shipbuilding Corporation, maintains a special Equipment Maintenance Department, complete with repair gangs, mobile equipment despatchers, lubrication and spare-parts crews. Its object is to keep the mobile equipment in operation and to have it available instantly, wherever and whenever it may be required. The covered and enclosed area of this particular yard has increased by 50 per cent. since May, 1942, and the mechanical equipment is as nearly perfect and complete as it can be made. All wiring, air, gas, oxygen and signal pipes are buried underground. Electric welding has almost entirely superseded riveting, and the array of gas-cutting machines and welding equipment for cutting and assembling steel plate is unparalleled as regards range and numbers of machines employed and the quantities of materials handled. Hand labour is eliminated wherever possible, and every department has its own battery of small hoists and cranes. The jig system is used throughout the yard, and the equipment includes exact replicas of the boiler-room and engine-room floors of a Liberty ship in a huge mould loft where all the requisite bilge piping is cut and welded, the flanges are fitted, the bends made for the ship, and the fabricated sections cut to the limit of portability and carried to the hull in the fitting-out basin, where there is a pipe-assembly shop containing an exact replica of a ship's engine room. Beneath it is the pipe shop, where pipes are passed through holes in the walls to save making detours through doorways; here the pipes are cut, bent, flanged and welded in long lengths before being taken upstairs for assembly on the large jigs there. Boilers are made in a boiler erection department half a mile from the slipways, where they are assembled, cleaned, pressure tested, steamed up and partially cased before being transported to the slips on 50-ton trailers. Only the brickwork and pipes require to be installed inside the ship. Uptake and funnel sections, already prefabricated, are lowered into place, the remainder of the boiler lagging is secured, the sheet-metal casing is completed, and the boilers are then ready for service. It takes one shift to finish the boiler work inside the ship after the two Whirley cranes have lowered them inside the hull. While this is going on, the boiler-room casings are fitted, whole deck sections being dropped in place at once and entire lengths of finished bulwark, deck-housing, ventilators and gratings hoisted aboard for the electric welders to secure in place before the painters spray on their quick-drying paint. They sometimes spray their paint while the ship is going down the ways! An ingenious travelling boiler-erection platform is now being devised on which eight boilers can be assembled at once. This relatively small department is already completing four boilers every two days. About 250,000 linear feet of electrically-welded seams go into each ship and barely 25,000 rivets. Unionmelt travelling welders, unreeling electrode from a large roll, weld the seams of the ship's bottom and deck plating in straight lines, automatically. Welding positioners, swinging 360° by means of ball-and-socket mountings, facilitate the down-hand welding of all special shapes and parts. Whereas it used to take one man eight hours to cut out gaskets by hand in the plumbing shop, a converted platen printing press, using hand-made dies, and devised by a young worker from England, now turns out gaskets at the rate of 800 per hour. Refrigeration manifolds are all made up on jigs and packed with wet asbestos before silver brazing, to avoid damage from heat. Funnels are built in the horizontal position with inside turnbuckle expanders; they are now completed in three shifts, whereas it formerly took 11 days. Among the short cuts and improvements in wiring devised by the electrical department is the pre-punching of holes in bulkheads instead of cutting or drilling them. Templates for each special hole are carried on a kind of giant key-ring, and every hole and shape is cut from a template to the exact size required. Instead of fitting lead sleeves in the bulkhead holes by hand, pre-cast lead collars made from salvaged scrap lead are now fitted and easily hammered into shape. Small, non-watertight junction boxes have been replaced by a single large watertight box made in the yard. Formerly, main wiring cables went through the shaft tunnel, but they are now carried on flat steel racks slung under the main deck, saving 1,500ft. of cable and one to four days' time and about $1,200 per completed ship. A machine was designed for die-punching all straps and hangers instead of making these by hand. It is also used in laying out and fitting piping. Improved plumbing and pipe-fitting practices are now saving $6,000 per vessel. Some 300 welds and 150 bends are done in the assembly shop on boiler-room piping alone, before placing these pipes on board the ship. Liners for pipe hangers are now cast at the rate of 220 per hour from scrap waste lead instead of from costly, scarce sheet lead. The salvage department reclaims and reworks $100,000 worth of shipyard waste per month, including re-threading all bolts, polishing them up to make them look like new ones. Over 500 tons of scrap plate are sent every week to the Oregon training schools for shipyard workers, while punchings are used to make gantry crane ballast up and down the Pacific Coast. Unsalvageable bolts are sent to the Columbia Steel

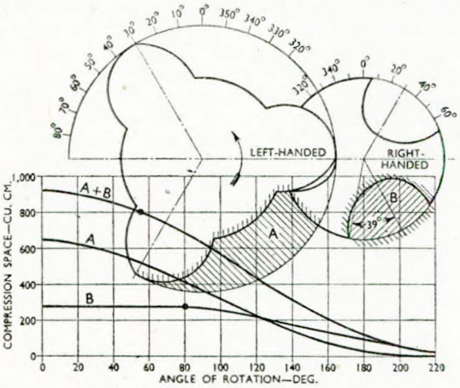
Company for making stern-frame castings. Cable lead is salvaged at the rate of three tons per week by burning off the lead and insulation, and even saving the pieces of copper wire. It is generally believed in America that Kaiser-built Liberty ships are as well built and cheap as any cargo ships of their class, and that they will survive the war for peace-time use.—*C. F. A. Mann, "The Motor Ship", Vol. XXIII, No. 275, December, 1942, pp. 280-285.*

A New Rotary Compressor.

An improved design of rotary compressor developed by Mr. A. J. K. Lysholm, was described in a paper which he read before a meeting of the Institution of Mechanical Engineers on the 18th December. The compressor is claimed to be suitable for use as a scavenge pump or supercharger for I.C. engines, especially when high compression is required, and a Lysholm compressor for service as a scavenge pump for a two-stroke Diesel engine is shown in the accompanying illustration. It is a helical-lobe type, which combines the advantages of the gear and the usual screw design, has a positive compression between the lobes and may be run at a very high speed without large losses. The lead of the lobes varies between 146° and 217°. This design of compressor was evolved by the inventor in the course of his investigations of the construction of gas turbines. The largest unit yet built has a capacity of 10,000 cu. ft./min. at 3,000 r.p.m., the diameter of the male rotor being 500 mm. and that of the female rotor 450 mm. The rotor length is 750 mm. and the number of lobes 4 plus 6. A useful field for these compressors is for multi-stage machines delivering air at 80-120lb./in.² pressure, with interstage cooling, as the dimensions and weights are considerably less than those of reciprocating blowers.—*"The Motor Ship", Vol. XXIII, No. 276, January, 1943, p. 325.*



Lysholm compressor arranged as scavenge pump for a two-stroke Diesel engine.



A three-lobed compressor.

The Definition and Measurement of Power.

Ideas on the speed of a ship vary according to a point of view. Speed does not mean the same thing to the shipowner, the shipbuilder and the engineer. It may be the figure attained on trials, loaded, three-quarter loaded or light, or it may mean the speed at sea in average weather, with average loading, or with full cargo. Some may prefer to consider it in terms of what is obtained on an average in all weathers. So with engine power. A comprehensive definition of the output of propelling machinery is that given in Dr. G. S. Baker's new book *Ships' Efficiency and Economy*, in which he refers to it as a "mean value which can be held for prolonged periods with the normal fluctuations occurring in average working conditions". Even if this description be accepted, the measurement of power is itself elusive and uncertain. If, *e.g.*, it is based upon indicator diagrams under working conditions, one engineer may obtain a result differing by some 3 to 5 per cent. from that of another equally careful and able man, in precisely similar circumstances. The measurement is, moreover, affected by mechanical errors and is naturally dependent upon an accurate estimate of mechanical efficiency to attain the corresponding s.h.p., which is the only practical unit of consequence. Mechanical efficiency, again, is by no means constant even with similar engines, and varies a good deal according to engine speed within a moderate range of revolutions under normal conditions at sea. Again, what is the "rated" power of an engine as defined by the manufacturers? Should it correspond to Dr. Baker's definition, and thus represent the normal load of the engine day in and day out under ordinary sea-going conditions? If so, it involves a certain mean pressure which is frequently lower than that specified on the engine test bed under constant conditions of test runs, although it is on the basis of the latter that manufacturers usually rate their engines. In other words, if this system be adopted the engine runs below its rated power for the greater part of its service. These considerations and others must be ever present in the mind of a superintendent engineer responsible for purchasing large marine oil engines. He must also decide to what degree he is justified in permitting a higher m.e.p. to be adopted for the standard rating of certain engines than is allowed for others. Such variations are permissible, but the justification can only be decided on the basis of much experience. It does not matter so much if the ideas on power and its measurement differ, as that the factors on which they are based should be fully understood.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, p. 273.*

Crossley Engine Scavenging Blower with Vertical Mounting.

An improved form of vertical scavenging blower has been developed by the makers of Crossley engines and forms the subject of a recent British patent. The arrangement of such a blower is indicated in Fig. 1, which also shows a special feature of the design in the form of the thrust block (E) which is located inside the crank chamber, between the aftermost cylinder and the blower, thereby saving space. The rotors (F, G) of the blower have their shafts (H, I) geared together, one shaft (H) being driven by bevel wheels (K, M) from the crankshaft (C). The blower draws air from the inlet (N) past one or other of the two valves (O, P) and discharges the supply into the manifold (B) through the valve (R) or, alternatively, the valve (S). In one direction of rotation suction occurs in the space (T) where the valve (O) acts as the inlet and pressure is built up in the space (U) where the valve (S) acts as the outlet. In the other direction there is suction in the space (U) and pressure in the space (T). In order to avoid the employment of split gear-wheels for driving the blower, the bearing (V) and the shell are in halves, the cap (W) being removable in the usual way. The bearing is carried on the casing (A) which is spigoted and bolted into the main bedplate. By removing the casing (A) and the bearing (V), the wheel (M), which is solid, can be withdrawn along the crankshaft.—*"The Motor Ship", Vol. XXIII, No. 276, January, 1943, p. 348.*

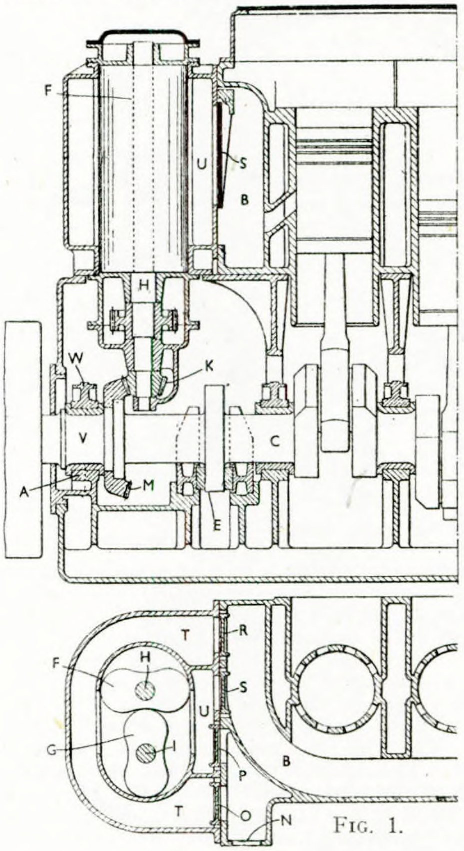


FIG. 1.

Lubricating Oil from Pine Tar.

Addressing the annual meeting in Stockholm of the Swedish Academy for Engineering Research, Professor Edy Velander stated that tests carried out in the laboratories of the State Material Testing Institute in connection with the distillation of lubricating oil from the tar extracted from old pine stumps had produced remarkably good results and that the quality of the oil had proved to be far better than had been anticipated. Pine tar is now regularly used as fuel by the large fishing craft operating off the west coast of Sweden.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,825, 3rd December, 1942, p. 5.*

Further Progress in Two-stroke Engine Design.

Although there is relatively little scope for improvements in the thermal efficiency of Diesel engines, designers are endeavouring to increase the specific output per cylinder of two-stroke engines either by raising the speed of revolution or by increasing the mean effective pressure. The latter course involves supercharging or improving scavenging and exhaust-pipe systems. In the latest design of Sulzer two-stroke engine brake mean pressures of up to about 142lb./in.^{2} are employed, apparently with complete success. The new Deutz engine operates with a brake m.e.p. of about 71·5lb./in.^{2}, whilst in the latest design of Polar engine the brake m.e.p. for continuous rating is 81lb./in.^{2}. These mean pressures are substantially higher than those which have hitherto been regarded as reasonable for continuous service at sea. In the case of the Sulzer engine a high degree of supercharging is resorted to, but with the Deutz and Polar engines centrifugal blowers combined with the use of special scavenging systems have rendered it possible to attain the higher pressures with satisfactory results. From what is known of the new Götaverken supercharged two-stroke engine it would also appear that increased m.e.p. has resulted, and although the means employed in the four cases mentioned differ, they are all based essentially on an increase of the mean effective pressure and the adoption of new systems of scavenging.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, pp. 269-270.*

Faster American Cargo Vessels.

The announcement that the U.S. Government are about to build a faster type of cargo vessel to succeed the present 11-knot EC-2 class of ship, has been hailed with satisfaction by the advocates of fast cargo ships for post-war service. However, despite all that has been said about the advantages of cargo vessels with a speed of round about 15 knots, the fact remains that a high-speed ship cannot transport cargo as cheaply as an 11-knotter. Comparisons have been made between a vessel built in the 1920's and burning, say, 1·8lb./i.h.p.-hr. of coal, and a modern ship of about the same deadweight, but with improved machinery and hull form, reducing the coal consumption per ton-mile to about half that of the older vessel. From these comparisons it can be shown that the economical speed of the new ship is perhaps one knot greater than that of the earlier one. What is not shown, however, is that the 12-knot vessel is as economical to run as an 11-knot ship of the same hull and engine efficiency. As regards a 15-knot ship, the discrepancy between the running costs of such a vessel and the slower ship are even greater. In the case of a 10,000-ton d.w. cargo vessel, the dimensions of the slow 11-knot ship would be about 415ft. by 57ft. by 37ft. to the upper deck, with a draught of some 27ft., whereas those of the 15-knot vessel would be 450ft. by 60ft. by 39ft., with a draught of some 26ft. In the first case the power required would be 2,200 s.h.p., whilst in the second it would be 6,000 s.h.p., or nearly three times as much. The first cost of the faster vessel would be fully 50 per cent. greater than that of the slower one and the running expenses would be correspondingly higher. Furthermore, at present-day rates, the minimum freight for the fast ship would have to be about 50 per cent. more than that for the slow one to avoid making a loss on a specific voyage.—*"Fairplay", Vol. CLIX, No. 3,109, 10th December, 1942, p. 684.*

Machinery and Service Speed of War-time Cargo Tonnage.

Various reasons have been put forward to justify the present policy of building slow-speed cargo ships, none of which will bear the test of expert examination, apart from the necessity, evidently overlooked, of providing such vessels with escort protection both by sea and air, which, when placed to the account of the slow-speed ship, makes the latter a very costly, slow and cumbersome proposition. A 10,000-ton d.w. standard cargo vessel with a designed speed of 11 knots takes 11·3 days to cover the 3,000 miles across the Atlantic and burns 40 tons of coal per 24 hours, *i.e.*, a total of 452 tons of coal. A 15-knot ship of the same d.w.. capacity could make the voyage in 8·3 days, burning 54 tons of coal per 24 hours, *i.e.*, a total of 448 tons of coal. Thus the 15-knot ship saves three days on each voyage on less fuel, and 10,000 tons of additional cargo would be transported every 34 steaming days, securing a very large increase in revenue by the extra cargo carried annually in addition to a substantial reduction in war risk and naval escort protection. A considerable increase in horse-power would admittedly be required for the 15-knot vessel, but the employment of really modern designs of watertube boilers and geared turbines would make it possible to reduce the total weight of the machinery installation below that of the Scotch boilers and triple-expansion engines of 2,500 i.h.p. with which the standard-type cargo ships are now equipped. The overall weight of a MacLeod double-reduction geared turbine unit, including the main thrust block and condenser, is not more than 28 tons as against the 155 tons of the reciprocating steam-engine installation of equivalent power. The fuel consumption of the turbine is about 30 per cent. lower and the overall length from the forward end of the turbines to the after end of the condenser is about half that of the equivalent triple-expansion engine, while the first cost of the former is less. In a high-powered water-tube-boiler installation of 7,000 to 10,000 s.h.p., employing the same principles of design, the main turbine machinery would weigh approximately 11·2lb./s.h.p. or 35 tons for a 7,000-s.h.p. installation and 40 tons for a 10,000-s.h.p. unit. These weights include those of the main thrust block, condenser, forced-lubrication pump, governor and control gear, and various instruments and turning gear. Such an installation, if supplied with steam by two modern watertube boilers, would weigh much less than a corresponding Diesel-engine installation, whilst the space taken up by the engine and boiler rooms would be less than that required for the Diesel engines. In point of fact, the space occupied by MacLeod geared turbines and modern watertube boilers for 10,000 s.h.p. would be about the same as that taken up by the triple-expansion engine and Scotch boilers of the ordinary standard war-time cargo ship of 2,500 i.h.p. now being built. Contrary to the general belief of those whose experience is confined to the operation of reciprocating steam engines and Scotch boilers, and who advocate such machinery for war-time cargo steamers largely because it is supposed to be the easiest to operate with mixed war-time engine- and boiler-room personnel, modern turbine installations with watertube boilers can be so designed and controlled by automatic regulation as to reduce the amount of skilled supervision and attention called for under service conditions to a minimum.—*Jas. MacLeod, "The Marine Engineer", Vol. 65, No. 785, December, 1942, pp. 275-276.*

The Sulzer High-pressure Forced-circulation Boiler.

The Sulzer high-pressure forced-circulation boiler consists of one or more single tubes into which feed water is forced at one end, while superheated steam is delivered at the other, the output of steam being dependent on the amount of feed water injected. Prior to the war, the only ship to be equipped with a Sulzer boiler was the cargo liner "Kertosono" of the Rotterdam Lloyd Co. This boiler replaced one of six cylindrical boilers and had a working pressure of 852lb./in.^{2}. It was used to supply steam to a special H.P. turbine which exhausted to the original H.P. turbine at the pressure of the steam supplied by the Scotch boilers. The addition of this special H.P. turbine increased the power of the machinery installation from 4,500 to 5,800 s.h.p. Automatic devices were fitted for regulating the steam supply from the Sulzer boiler to the H.P. turbine, and it was claimed that the propelling machinery could be reversed from full ahead to full astern in 15-20 seconds. The efficiency of this boiler, including its auxiliaries, was said to have been 90 per cent.—*W. O. Horsnaill, "Shipping", Vol. XXXI, No. 365, December, 1942, p. 18.*

Suitable Structures for Welding.

It has been stressed in various papers on the subject of welded ship construction that in order to secure maximum efficiency the structures should be designed to take advantage of the possibilities of the process, and not be merely adaptations of riveted structures. For instance, partly following tradition and partly no doubt on account of the limitations of riveted connections, it has been usual to arrange for what is known as "a good shift of butts" in the plating of ships—*i.e.*, the end connections of adjacent strakes of plating are staggered so that they do not come in the same line. This precaution is regarded as unnecessary with welded connections, and it is quite common to find a more or less complete ring of connections in the same transverse plane of a welded ship. This arrangement enables the fabrication of large units to be carried out much more easily in the case of a welded ship than in a riveted vessel. Modifications can also be made in the stiffening members of the plating; the flanges which are used in a riveted hull to connect the stiffeners to the plating are not required, and therefore the usual rolled sections which are provided with this flange are not well adapted for welded construction. So far, a certain amount of improvisation has been carried out. Ordinary angles are fitted with the toe of the broader flange welded to the plating, the stiffening effect of a channel section being attained in this manner, and, when a larger stiffener is required, it is usual to burn away one of the flanges from a rolled channel so that the web may be connected directly to the plating. Occasionally, too, structural I-sections are split down the middle to produce two T-sections. The T-type section is obviously the most suitable stiffener for welded construction, but unfortunately the present range of these sections is very limited, while those which are available are not entirely suitable. It is important, therefore, that rolled sections adapted for welding should be produced, and it is suggested that the matter is one which calls for the immediate attention of the British Engineering Standards Association. The type of section required is a modification of the old-fashioned bulb plate—*i.e.*, a symmetrical section with material concentrated where it is most required. Such sections would have to be rolled with various depths, thicknesses and sizes of bulb, and should be standardised in the same way as the angles, channels and bulb angles used in riveted work.—*"Fairplay", Vol. CLIX, No. 3,109, 10th December, 1942, pp. 684 and 686.*

Oil v. Coal.

Although coal may appear to be advantageous as a fuel for ships operating from British ports under war-time conditions because it is produced in this country and does not make any demands on valuable tanker tonnage, it must be borne in mind that this advantage may not be as real as it might seem. Bunkering for a round voyage of substantial length may not always be practicable and, in any case, must necessarily reduce the export cargo space available. Coaling at the other ports has also to be considered. These factors may tilt the scale in favour of the motorship with her large radius of action. On the other hand, the production of marine Diesel engines makes greater demands on the country's manufacturing facilities, more especially where these have had to be extemporised. During the last war, neutral countries which were partially deprived of British coal supplies and in a position to undertake oil-engine development work, established a lead over the U.K. in the production of Diesel-engined vessels, but there is little likelihood that a similar state of affairs will be experienced after this war.—*"Shipbuilding and Shipping Record", Vol. LX, No. 23, 3rd December, 1942, p. 531.*

Qualifications of a Refrigerating Engineer.

In a paper on "Recent Developments in Refrigeration" read at a recent meeting of the Institution of Mechanical Engineers by Lord Dudley Gordon, D.S.O., the qualifications of a refrigerating engineer were summed up as follows: He must have had sound engineering experience and possess a good knowledge of thermodynamics; he must have some knowledge of chemistry and be able to appreciate not only the properties of the various gases used as refrigerants, but also the many applications of refrigeration in the chemical industry; he must have some knowledge of biology and be able to deal with the different problems to be solved in the handling of dead meat and fresh fruit, besides providing for the comfort of human beings; he must have some knowledge of many industries, such as brewing, dairying and agriculture; he must be conversant with the different conditions to be provided for in the case of refrigerating plant designed to work on land or on board ship; and he must also be an engineer prepared not merely to supply such machinery but also to advise on and devise means for applying the effect it produces.—*"South African Engineering", Vol. LIII, No. 12, December, 1942, p. 240.*

Deck Fittings.

It has been suggested that the various eyeplates and forged or plate lugs fitted on ships' decks in connection with the rigging or cargo gear frequently possess more than an ample strength margin and are made unnecessarily heavy. Strength estimation for pin-jointed or similar deck fittings follows closely on the corresponding calculations for ordinary riveted joints, the principles of which are sufficiently well known; actually, the calculations are somewhat simpler, since only a single pin or bolt is involved, but it is still essential to exhaust the possibilities of failure in various ways by considering in turn tension across the diameter of the hole, bearing in the hole, and shear or bursting between the hole and the end of the lug. For a ductile material like mild steel both bearing and shear strengths are in a fairly definite relation to the tensile strength, the permissible shear stress being 60 to 70 per cent. of the tensile, and the bearing stress, where there is no relative motion of the parts, substantially greater. An economical design should make full use of the available strength of the material for each type of failure, even if this should involve the use of a pin of harder material. Designs may be based on ultimate stresses with a factor of safety in the usual way, or perhaps better on the proof load to produce a small distortion of the part, in which case the 0·1 per cent. proof stress of the material is the appropriate and relevant property.—*"Shipbuilding and Shipping Record", Vol. LX, No. 23, 3rd December, 1942, p. 531.*

Sulzer Propulsion System with Reversible and Irreversible Engines.

A British patent recently granted to Sulzer Bros., Winterthur, covers an arrangement in which two or more Diesel engines having turbo-blower scavenging are employed for propulsive purposes in the manner illustrated in Fig. 3. One of the engines is reversible, while the other, of somewhat greater power, is irreversible and supplies both engines with air until the exhaust gases are available in sufficient quantities to drive the turbo-blowers of both. The engines are of the two-stroke type and can therefore only be started when the cylinders are supplied with combustion air from a blower. Both engines (*1, 2*) drive the propeller shaft (*4*) through a permanent coupling (*6*), and the irreversible engine (*2*) has a clutch (*7*) which is disconnected when the order to go astern is received. Air is supplied to each engine by two-stage blowers (*11, 12*) having coolers (*13*) between the stages, with two twin sets of exhaust-gas turbines (*14*) revolving in one direction only. The turbo-blower sets (*11, 12, 14*) of the irreversible engine (*2*) are also driven by gearing (*5*) from the crankshaft in order to start the plant and increase the power necessary for air compression. The air-delivery pipes (*9*) of the two engines are connected by a pipe having a stop valve (*15*). When the plant is being started, a non-return valve (*17*) prevents the air from the blowers of the irreversible engine (*2*) from escaping back through the blowers of the reversible engine (*1*). The engine (*2*) supplies combustion air to the engine (*1*) while the latter is being started up to run astern, and if necessary, while the ship is going astern, the blowers of the engine (*2*) can also supply additional air to the reversible engine.—*"The Motor Ship", Vol. XXIII, No. 276, January, 1943, p. 348.*

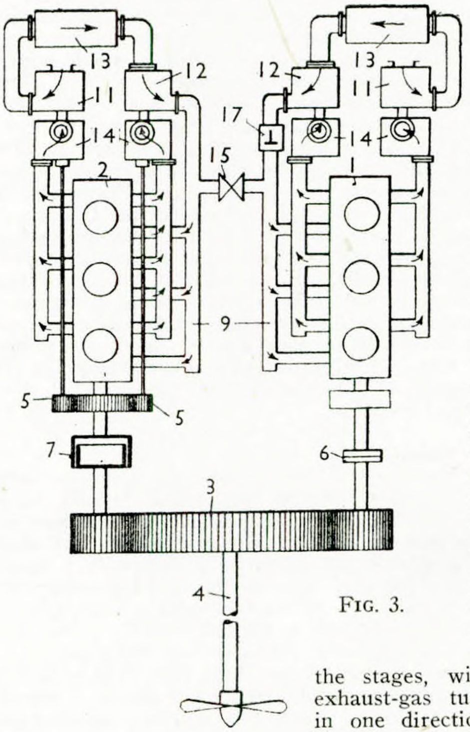


FIG. 3.

Water Leakage from I.C. Engine Cooling Systems.

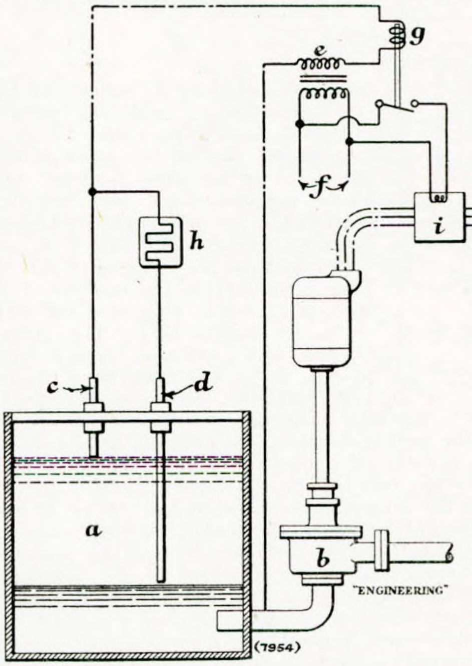
Leakage from the cooling-water system of an I.C. engine is liable to become a serious matter if it results in any water getting into the cylinders, because that impairs efficiency of the piston lubrication and may lead to piston seizure. Furthermore, if such leakage occurs while the engine is stopped, the combustion chamber may eventually become filled with water, so that when the engine is started up the piston will come into contact with an unyielding mass, incurring risk of a fracture. In some cases water has leaked into a cylinder past a plug used for filling up the core hole of a water-cooled exhaust valve, or in others, past a faulty liner joint. A leaky plug can be made tight by welding, while a faulty joint may require re-making with a more suitable packing. In one instance, trouble was experienced with the pistons of an 8-cylr. 670-b.h.p. vertical tandem gas engine owing to their seizure in the top cylinders. As the cause of the trouble appeared to be insufficient clearance, a new piston and a new cylinder were fitted, and some of the liners were also renewed. Subsequently, trouble was experienced owing to leakage of water into the cylinders past the valve-core-hole filling plugs of the water-cooled exhaust valves. Two lines of cylinders with solid valves were thereupon fitted, and one line of pistons eased. The engine then ran satisfactorily for a short time, after which the liners of several cylinders were found to be cracked and scored as the result of another piston seizure, although the piston clearance provided should have been ample. Investigation showed that water leakage had been taking place not only from the valve plugs, but also from the joints between the cylinder liners and cylinder heads, with the result that water had found its way into the cylinders and prevented efficient lubrication. The liner joints had been made with paper, which had charred under the effects of the heat. New joints were made with $\frac{1}{32}$-in. copper rings, and the leaky exhaust-valve plugs were welded up. As three top pistons and cylinders, three bottom cylinders, one bottom piston, one combustion chamber, and other parts had to be renewed, the effects of the water leakage proved to be extremely costly. In another instance, leakage of water past the joint between the liner and breech-end of one of the cylinders of a twin-cylinder horizontal oil engine caused the breech-end to fracture all round the circumference. The joint had been made with a copper ring, but a portion of it, about $1\frac{1}{4}$in. long, had been missing, and water trickled into the combustion chamber through the gap during an eight hours' stoppage of the engine. When the latter was re-started, the water was trapped between the piston and the combustion-chamber wall, and the breech-end fractured with a loud report. Leakage of cooling water will, of course, take place should a fracture develop in the cylinder jacket, or in any of the water-cooled metal walls. Such cracks are often very fine and only a few inches long, so that the amount of water leaking through them is insignificant; however, there is the possibility that such a small fracture may extend suddenly into a long and open one, necessitating an immediate shutdown. In many cases, an effective and comparatively inexpensive remedy for a water leak through a fracture is iron cement forced in between the severed faces, so that when it expands in hardening, it presses firmly against the edges and stops the leakage. Cement of the right kind can be forced into the finest cracks, but if there is any tendency for the crack to open wider owing to the pressure or temperature, this tendency must be resisted by means of cover strips secured across the fracture or by a cover plate placed over the opening and screwed firmly on to the casting. Extensive fractures can sometimes be remedied by the aid of anchors or brackets and draw-bolts arranged so that the screwing up of the nuts will draw the faces firmly together. Although cement might not be necessary with such a repair, its use would increase the probability of a cure. A case of this kind occurred with a 5-in. crack—of old standing—in the outer wall of a cylinder water jacket, immediately below the exhaust branch. The crack was repaired by a steel-plate patch, but two years later it suddenly extended until it reached the opening for the exhaust-valve-spindle guide, and a serious water leakage resulted. As the defect was entirely confined to the outside metal—which, fortunately, is often the case—it was considered that a sound and satisfactory repair could be made. Two cast-iron brackets were accurately bedded and firmly secured to the breech and casting, cement was worked into the fracture, and the brackets were then pulled together by draw-bolts, thereby effectively closing the crack and stopping the leak. Another method of stopping leaks in fractured water-cooled castings is by welding. It must, however, be remembered that the application of the welding flame is liable to distort and ruin the casting unless special precautions are taken to prevent dangerous heat stresses. It may be necessary to pre-heat the part for a long period prior to the welding; and afterwards the greatest care must be taken to cool down the casting very slowly and uniformly and to avoid cold draughts. The welding itself must be done by a highly skilled operator after independent expert advice has been obtained regarding the suitability of a welded repair. In many cases a leaky shut-off cock for controlling the flow of water into the jacket has been responsible for the fracture of the latter. This has been brought about in the following way: The jacket has been drained of water to prevent freezing, but the leaky shut-off cock has allowed water to dribble into the jacket during stoppage of the engine. The drain cock has been sealed by ice, and the water accumulated in the jacket has frozen solid.—*"The Oil Engine", Vol. X, No. 116, December, 1942, p. 201.*

The Electrical Equipment of Shipyards.

The author discusses the relative merits of a.c. and d.c. from the consumer's point of view, and the problems to be dealt with when planning a new sub-station or an extension to existing plant. Distribution cables and switchboards are briefly discussed, together with the ratings of the fuses to be employed. Both squirrel-cage and slip-ring a.c. motors are considered, as well as their ratings, enclosures and applications. The starting and control of a.c. motors used for driving the various machines commonly found in shipyards is discussed, and electrical equipment for special duties such as cranes, hydraulic plant, planing machines, small tools and fans is briefly reviewed. The advantages of electric rivet heating for hydraulic riveting are explained. Both a.c. and d.c. welding are discussed, together with the distribution problems involved. The importance of power factors and methods of correction are among the points dealt with by the author. Standardisation of electrical equipment to facilitate replacements and maintenance is regarded as important. The special needs of shipyards in regard to electric lighting are considered, and the author concludes with some notes on the general maintenance of electrical equipment and plant.—*Paper by H. M. Coatsworth, B.Sc., read at a meeting of the N.-E. Coast Institution of Engineers and Shipbuilders, on the 11th December 1942.*

Floatless Electrical Liquid-level Controller.

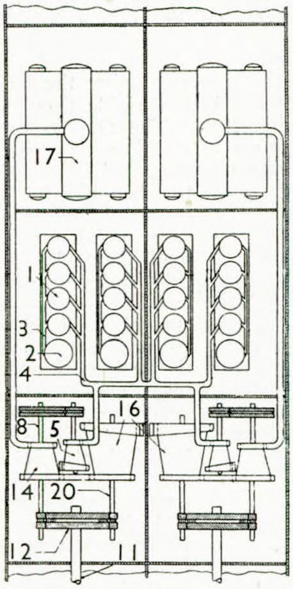
An electrically-operated control device for regulating the level of a liquid in a tank through which there is a variable flow has been developed by a London engineering firm. The arrangement, which is known as the "Lectralevel" system of floatless liquid-level control, is illustrated in the accompanying diagram, and is claimed

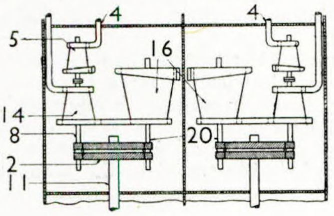


to be simple in operation and to ensure reliable automatic control. The substitution of electrical for mechanical control eliminates the need for a float, the action of which may, under certain conditions, become uncertain. Since the liquid itself forms part of the electrical circuit in the control device, a.c. at 25 volts is supplied from a transformer and the circuit is completed by two electrodes, a relay for the motor starter and a tuned resistance, as shown in the diagram. The tank (*a*) is emptied by a motor-driven centrifugal pump (*b*) having its suction pipe near the bottom, and the emptying operation starts automatically when the liquid reaches the level indicated by the dotted lines; it stops automatically at the level indicated by the full lines. The levels are determined by the position of the starting electrode (*c*) and the stopping electrode (*d*), to which current is supplied from the double-wound transformer (*e*), the primary of which is connected to the mains (*f*). It will be seen that the control circuit through the secondary of the transformer is completely through the liquid, the suction pipe being earthed and so forming a common electrode to the other two. The two electrodes do not require elaborate insulation and may consist of ordinary galvanized-iron piping. The starting electrode (*c*) is connected directly to the transformer through the relay (*g*) which contains a single mercury switch. The stopping electrode (*d*) is connected to this relay by the same lead through a tuned resistance (*h*) of only a few ohms. The relay (*g*) is fitted with a 25-volt coil and the switch is suitable for a.c. up to 440 volts and 20 amps. for the control of the motor starter (*i*). As soon as the level of the liquid reaches the electrode (*c*) the relay is energised and the pump motor starts up and continues to run even after the liquid level has fallen below the electrode, since sufficient current is passing through the relay from the stopping electrode (*d*) to hold the relay closed. When, however, the level of the liquid falls below the lower end of this electrode the current is interrupted and the motor is stopped. The motor is not re-started when the liquid level rises again and makes contact with the electrode (*d*) because the interposition of the resistance (*h*) serves to reduce the current below that necessary to pull the relay in. The liquid therefore continues to rise until it makes contact with the electrode (*c*), the circuit of which does not include the resistance. Thereupon the pump motor starts up and continues to run as the liquid level falls, since the current passing through the resistance is sufficient to hold the relay though not to close it. The holding current is only about one-quarter of that required to close the relay.—*"Engineering", Vol. 155, No. 4,016, 1st January, 1943, p. 17.*

Götaverken Propulsion Systems for Normal and Maximum Speeds.

The A.B. Götaverken, Gothenburg, have recently secured a British patent on systems of propelling machinery for dealing separately with normal and maximum speeds, three arrangements of which are shown diagrammatically in Fig. 2. Referring to the left-hand plan, there are two engine rooms and four 4-cylr. Diesel engines (*1*) each driving a compressor (*2*). The compressed air is supplied to





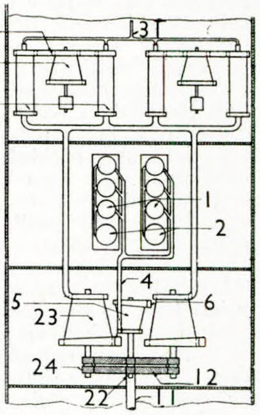


FIG. 2.

the engine cylinders through manifolds (*3*) and, together with the partly-expanded combustion gases, forms a compressed gas which passes into the turbines (*5*) through pipes (*4*). These turbines drive the propeller shafts (*11*) through double-reduction gearing. When full speed is required a steam plant is also employed. This comprises H.P. turbines (*14*) and L.P. turbines (*16*), supplied with steam by boilers (*17*). The rotors of the H.P. turbines are secured to the shafts (*8*) and those of the L.P. turbines to separate shafts (*20*) which carry pinions meshing with the gear-wheels (*12*) on the propeller shafts. In the centre diagram, the principle of operation of the plant is the same, except that instead of an arrangement with D.R. gearing there are only two turbine shafts in each set and S.R. gearing is employed. Thus, the outboard shafts are driven by the gas turbines (*5*) and the H.P. steam turbines (*14*), while the inboard shafts are driven by the L.P. steam turbines (*16*). The steam and gas connections are similar to those indicated in the left-hand diagram. The right-hand diagram shows a single-screw installation in which no steam is used. There are four combustion-gas chambers (*30*) supplied with fuel through a pipe (*31*), whilst a power-driven turbo-compressor (*28*) supplies compressed air to the chambers (*30*) through passages (*29*). The mixture from the chambers is delivered to the turbines (*23*) which drive the pinions (*24*); the turbine (*5*), which takes the combustion products from the engines (*1*) through a pipe (*4*), drives a pinion (*22*) which, together with the pinions (*24*) drives the propeller shaft (*11*) through the gear-wheel (*12*).—*"The Motor Ship", Vol. XXIII, No. 276, January, 1943, p. 348.*

The War Need for More Motorships and Fewer Steamers.

The output of marine engines in this country is in advance of the completion of hulls, and this applies more especially to oil engines. The policy adopted by the Ministry of War Transport and the Merchant Shipbuilding Department of the Admiralty has been based upon the fact that reciprocating engines could be produced more quickly than oil engines, and for that reason the great majority of the slow 10,000-ton d.w. cargo vessels now being constructed in this country are steamers, although the proportion of faster ships has latterly been increased. As things are to-day, a considerably larger number of oil engines might be built in some of the shops at present engaged in the manufacture of steam engines without decreasing the number of ships completed during a given period. These oil engines would take longer to build than the steam engines, but the completions of hulls and propelling machinery would, at the same time, be kept in step. The war-built type of slow cargo motorship is not only superior to the steamer under present conditions; it will, in addition, be more efficient commercially in times of peace. It cannot be denied that the motorship economises in coal and in labour, both of which are vital in present circumstances. With its machinery of 2,500 b.h.p. and fuel-oil consumption of about 0·36lb./b.h.p.-hr. for all purposes, the daily oil consumption is of the order of 9 tons, as against the 32 tons of coal per 24 hours which is the minimum consumed by the lower-powered steamers. The steamer burns some 1,200 tons of coal on a round voyage across the Atlantic, whereas the motorship uses under 400 tons of fuel oil under similar conditions. The saving in fuel, together with the reduced weight of machinery to the extent of 70 to 100 tons, means that more cargo can be carried per voyage. It is a significant fact that all the Government-built cargo motorships are readily taken up by shipowners as soon as they become available, whilst a considerable number of others are being constructed to private order. On the other hand, practically all the steamers are laid down to the account of the Ministry of War Transport. There will be a vast tonnage of slow steamers brought into service next year both here and in the U.S.A., and it is undesirable that further inefficient ships should be produced, if it can be avoided. Attention should therefore be concentrated on the building of the more efficient slow cargo motorships and such numbers of faster vessels as we are able to produce without diminishing the total output of tonnage.—*"The Motor Ship", Vol. XXIII, No. 275, December, 1942, p. 270.*

An American Record.

The Liberty cargo steamer "Robert E. Peary" has, it is stated, been completed by Mr. Hy. Kaiser's Richmond (Cal.) No. 2 Shipyard in 4 days, 15 hours, 26 minutes from the laying of her keel. The entire operation was accomplished in 97 lifts, and among the gangs employed were 12 woman welders. All those engaged were volunteers from among the ordinary employés, and the record was achieved without in any way interfering with the yard's scheduled output of one ship every two or three days. The machinery was installed on the tank tops in a matter of 12 hours, the fore and after peaks were water-pressure-tested before fitting, and the vessel was complete and ready for sea in every respect—even to filled inkwells on the table in the captain's cabin—in the time mentioned above. This yard has now been building ships for nine months, and it is worthy of note that the "Robert E. Peary" took 20 per cent. fewer man-hours to build than the first ten vessels constructed there and 6 per cent. fewer than the ten ships immediately preceding her. This fact, it is claimed, bears out Mr. Kaiser's contention that he is not indulging in "stunts", but that his methods, unorthodox though they may be, are based on ideas which may in time become normal practice.—*"The Syren", Vol. CLXXXV, No. 2,415, 9th December, 1942, p. 269.*

"The Application of Electric Welding to Merchant Shipbuilding".

An article bearing the above title, by P. Classen, appears in Vol. 40 of *Jahrbuch der Schiffbautechnischen Gesellschaft,* and describes the application of arc welding to the construction of the German Labour Front's holiday cruising ship "Wilhelm Gustloff". The ship was built by Blohm and Voss in 1936-37, and electric welding was utilised on a very extensive scale for the hull structure. The thickness of the hull plating varied from 6 mm. on the upper deck to 20 mm. in the keel, and it is estimated that over 1½ million rivets were eliminated by the use of electric welding, in addition to a saving in the amount of steel plate and scantlings, totalling about 1,300 tons, *i.e.,* 14 per cent. of the total weight of the hull. About 100 tons of electrodes was expended. The author considers that the chief difficulty in welded ship construction is the avoidance of internal stresses during the assembly of the prefabricated hull components, and suggests that a judicious combination of riveting and welding should provide a satisfactory and economic solution of this problem.—*Abstract in "The Journal of the Royal Aeronautical Society", Vol. XLVI, No. 384, December, 1942, p. 476.*