The

INSTITUTE of MARINE ENGINEERS

Founded 1889. Incorporated by Royal Charter, 1933.

Patron: HIS MAJESTY THE KING.

SESSION 1941.

Vol. LIII. Part 6.

President: SIR PERCY E. BATES, BT., G.B.E.

Appendix and Discussion: *The Lewis Single-Drum Water-Tube Boiler for General Marine and other Service.

Appendix.

In the above paper the suitability of the Lewis boiler for ordinary cargo ships under adverse conditions was proved by citing, amongst other evidence, the successful use of its predecessor—the Niclausse boiler.

Marine engineers and naval architects of this generation will be surprised by the ubiquity of that boiler and its long period of service. Beginning in 1894 with the pioneer equipment of 20 boilers in the 10,000-h.p. 19-knot French cruiser "Friant" (which was in service until after the last war, when her boilers were installed for shore service at Toulon), it was extensively adopted in 17 navies and by numerous steamship companies. Up to 1923, Niclausse boilers totalling over 1,000,000 h.p. were installed in naval and merchant ships—these included battleships, cruisers, gunboats, sloops, yachts, tugboats, river steamers, trawlers, cargo ships and large liners. In latter years its use has been less common, due to the development of lighter small-tube boilers, but the Rhone tugboats, built in 1931, continue to show its suitability for heavy work, involving sudden changes in load, etc.

Some examples of satisfactory service by Niclausse boilers under adverse conditions, using salt water and river water for feed, were given in the paper itself. In the reply to the discussion mention is made of the satisfactory experience with Chinese-owned cargo steamers manned entirely by Chinese crews. Its use in yachts, pinnaces, trawlers, drifters, and other small craft shows its ability to work satisfactorily even when subject to violent tossing about, pitching and rolling, using mixed quality of feed water, and when handled by the roughest type of sea-going engineer.

The fact thus illustrated, that boilers employing the Perkins-type tubes can be relied on to give good service at sea, is of first-class importance to-day, when the Lewis boiler, employing such tubes, yet improving them and simplifying their application far beyond anything achieved hitherto, offers the means for making an important step forward in steam navigation. What has definitely been achieved by the Niclausse is well within the ability of the Lewis boiler, so that the need for trials, in the generally accepted sense of trying out something entirely new hardly arises, except as a confirmation of facts already established.

* This paper, by W. Yorath Lewis, M.I.Mech.E., A.M.I.E.E. and Struan A. Robertson, B.Sc., Assoc.M.Inst.C.E., A.M.I.Mech.E., was published in the March, 1941 issue of the TRANSACTIONS, Vol. LIII, pp. 15-37.

In the paper, Fig. 1A (the title of which was inadvertently omitted) illustrates the experimental apparatus used for demonstrating the nature of steam formation in the tubes of a water-tube boiler, and the circulation in the tubes. A full description of this and of the research work done with it was given in the authors' paper to the Institution of Mechanical Engineers published in the June, 1940 and February, 1941 proceedings of that Institution. The apparatus consists of two glass-sided tanks connected by three glass tubes of 1¼in. diameter and about 6ft. long. Within these, water and steam circulate at atmospheric pressure. Centrally in two of the glass tubes are ⅜in. diameter steel tubes containing high pressure steam, whose temperature is sufficient to cause violent ebullition in the surrounding water. With this apparatus, the effect of heating the downcomer tube in stopping circulation, the stagnation possible when one downcomer feeds several steaming tubes, and the turbulence caused in the upper drum by discharging steam below water level are all clearly seen. The excellence of the circulation, when supplying water through an unheated downcomer to a single steaming tube discharging above water level in the drum is also obvious. These are the features secured in the Lewis boiler by the special design of the tubes, which ensures that the circulation is always satisfactory.

DISCUSSION.

Major W. Gregson, M.Sc. (Marine Manager, Babcock & Wilcox, Ltd.) wrote: I entirely agree with the authors that the time has come when the heavy Scotch boiler should, on economic grounds, be replaced in most types of tonnage by suitable water-tube designs: in fact, this change-over has already started in all classes of ship except the British trampship, which is still the stronghold of the Scotch boiler, and here it looks as if a sturdy and simple type of water-tube boiler will eventually be acceptable to owners. To underrate the Scotch boiler, as the authors have done by assessing its performance as 5lb. per sq. ft. of heating surface per hour, is not the way to combat it. A modern Scotch boiler, operating with forced draught and preheated air, is capable of much better than this.

I agree with the authors regarding the necessity for positive and directional circulation; no water-tube boiler will operate successfully at high ratings without these factors being inherent to the design, but surely the suggestion made by the authors that the designers of all existing and established types of marine water-tube boilers have left this vital matter to chance is entirely erroneous. Evidently, the authors are not aware of the experimental and research work which has been carried out on full scale experimental boilers by leading firms in this country, in the United States and on the Continent. As the result of these experiments, boiler types have been evolved, fulfilling requirements of weight and space and establishing satisfactory circulatory characteristics for these designs. The authors have stated on page 17 that the Admiralty type boiler when pressed has practically no circulation at all, but this is not borne out by the wonderful endurance of H. M. ships at full power during the present war.

The authors have laid great stress on the merits of the Niclausse boiler: as a junior engineer the writer had experience with these boilers, and they certainly were free steamers at the hand-coal-fired rates to which we then worked. However, a successful boiler must be sound in three essential points, *viz.* circulation, freedom from mechanical breakdown, and ease of maintenance. From the experience gained with these boilers in H.M. ships, the Naval Boiler Commission decided in the early part of this century that, compared with contemporary designs, the Niclausse boiler was not of sufficient merit to warrant its further development.

Operating experience with the Lewis boiler appears to be limited at the time the paper was written to a miniature oil-fired unit, which has worked for some years at a technical college, and a recent small coal-fired portable boiler, both at ratings well within the limits of pretty well any modern type of boiler; when the authors have experience with a design at sea operating at ratings round about the 20lb. per sq. ft. of heating surface per hour mark, we shall be in a better position to assess the merits and demerits of the design compared with water-tube boilers which have withstood the test of many years' service afloat.

Boilers established at high naval ratings are the best proof that similar designs are suitable for the steadier operation required at lower ratings for the Merchant Service; in fact, we get the simile here between racing car design and its effect on that of the normal car of every-day life.

Mr. A. G. Pemberton (Member) wrote: I compliment the authors on their courage, for in some respects they have surely trodden on dangerous ground in their efforts to convince the marine engineer of the superiority of the Lewis boiler. However, it is only by courageous efforts that real progress can be made, and if the advantages claimed for the Lewis water-tube boiler can be fully substantiated, it appears to be a proposition worthy of adoption.

The writer supports the view that a boiler with efficient natural circulation is generally to be preferred for marine service, and theoretically at least the Lewis tube appears to be an ideal natural circulator. However, from a practical point of view it seems that some difficulty may easily arise which will upset the positive flow of water in accordance with design. The writer has in mind the leakage of water through joints which the authors describe as "sufficiently watertight".

It is generally accepted that it is most important to ensure the purity of feed water, particularly for the successful operation of water-tube boilers, and it does not seem wise to suggest that this requirement can be relaxed, even though the authors feel that it may appeal to the marine engineer to be able to run with a high density in the boiler on occasion.

With regard to constructional design, particular difficulty may arise in connection with the withdrawal and refitting of evaporating tubes, due to the limited space available in a ship.

The authors' comparison between a Scotch boiler installation and their own design is very impressive, and appears to warrant no serious criticism. The reduction of weight and space should always enhance the value of claims in favour of the adoption of the Lewis boiler.

Mr. J. Hamilton Gibson, O.B.E., M.Eng. (Vice-President) wrote: Marine steam engineering is unique in one respect, and that is that every piece of machinery destined for ship propulsion must weigh as little as possible. Hence minimum weight and space for a given steam output are primary essentials in marine boiler design, and it will be noted that the authors have kept these essentials well to the fore in preparing their paper for the consideration of Members of The Institute, which is to be congratulated on publishing particulars of what, in years to come, will be regarded as one of the most outstanding improvements of recent years in steam generator design.

When the writer first came across the Lewis single-drum water-tube boiler he recognised its good points at once, having spent a large part of his working career in designing, constructing and installing marine boilers of every known type, including a set of Niclausse boilers in a foreign training ship over 40 years ago. The use of Field tubes, and the method of separation and isolation of generated steam in the Lewis boiler was reminiscent of the writer's Niclausse experience, and he was not surprised therefore to learn that Mr. Yorath Lewis had at one time been associated with Niclausse. It had always seemed strange to the writer that the Niclausse boiler, with its many advantages, had not made much headway in this country: but British prejudice is strong and, as the authors explain at the top of page 33 of the March, 1941, issue of the TRANSACTIONS, Niclausse himself was fully engaged in making and installing his boilers where they were better appreciated.

Now the Lewis boiler, starting off on the assumption that water drums were unnecessary and redundant, utilises the main features of the Niclausse design as above mentioned, besides several new features such as the U-tube and the better disposition of effective heating surfaces, which are set out clearly in the paper under review. Moreover, there is another important feature that should not be overlooked, *viz.* that altogether here is a design which in its entirety is quite novel, yet there are no freak ideas in the general arrangement or details. The Field tube principle is old and well-known; the segregation of steam, once it is generated, from the surrounding water, so that it has no need to fight its way into the steam reservoir, is also well-known and appreciated; the manufacture of spear-headed U-tubes in marine superheater installations has been successfully carried out for many years past; the use of water-tube walls to protect the refractories has long been common practice in land boilers, though usually associated with bottom water "headers" which in the new design are seen to be unnecessary. In other words it would appear that there is nothing in the Lewis design to cause the slightest perturbation or misgiving to the minds of boilermakers, nor indeed of users, for the robust nature of the construction of all essential parts and the scouring effect due to effective internal circulation should render it an ideal boiler for working under the severest conditions at sea.

But, as mentioned at the outset, what will appeal to the shipping community most—designers, builders and owners alike—is the immense saving in weight and material and water carried. Taking the authors' figures as correct, this saving is over 70 per cent. as compared with a Scotch boiler and 16½ per cent. as compared with a naval type three-drum boiler of the same overall dimensions. In the latter case the estimated evaporative output is 68 per cent. greater!—which may sound somewhat over-optimistic, but is explainable by the large increase in total heating surface and the higher rating. An actual comparative test of two such alternative water-tube boilers would be most interesting and some very useful data would be forthcoming, for there is no doubt that the possibilities of the small tube "express" type of water-tube boiler has not yet been fully exploited, and that there is no need to play about with entirely new types depending on artificial methods of forced combustion and forced circulation, until we are satisfied that the existing types, working under normal conditions, which have served so well up to now, have been "stretched" to their limit.

It is perhaps too much to expect that naval authorities should make any change in established practice during the present emergency; but the Ministry of Shipping, who are building numbers of cargo-carrying vessels with heavy Scotch boilers, and the Ministry of Supply, who are responsible for procuring thousands of tons of sheet plate for such construction, will no doubt be interested in the saving of weight and precious material and the increased cargo-carrying capacity thus gained. Meanwhile, much valuable experience would become available for larger and higher-powered vessels.

There is much more that could be said, but the writer has already said enough to convey his conviction that the Lewis boiler, as described in this valuable paper, is worthy of the most careful consideration by everyone concerned in improving and advancing that most important branch of marine steam engineering, the efficient production of the best quality of steam in the largest quantity for every type of propelling machinery; and in thanking the authors the writer expresses the hope that they will meet with all the success they deserve.

Mr. E. A. Flint (Member) wrote: It appears that the vital factor in the success of the boiler is that no scale deposits in the tubes due to the high velocity of the water circulation.

The writer is interested in a battery of water-tube boilers, the make-up for which is untreated well water which contains scale-forming matter. This does not give much trouble in the boilers, hence no treatment is carried out. It does, however, scale up the internal feed pipes which have occasionally to be cleared. The interesting point is that when these pipes are clear the velocity of the water is low, about 1½-ft. per second. When the pipes get scaled internally the diameter gets smaller and, since the same amount of water is pumped into the boilers, the velocity increases. It follows that a speed of 6 or 7ft. per second is reached, when no more scale should form. This is not the case, however, and in fact the internal feed pipes continue to scale up until they have to be cleared. It will be interesting to have the authors' comments on this point.

Mr. G. Davis (Associate Member) wrote: The problem of circulation has always occupied the attention of designers of water-tube boilers and it is obvious that considerable time, thought and trouble have been devoted to it in the development of the Lewis boiler. The abolition of lower drums by substituting a modification of the Perkins-Field tube is particularly ingenious.

Whilst reading through the paper I was always comparing the Lewis boiler with the Yarrow, presumably because of the similarity in design; consequently, I was constantly confounded because references were made to other types of boilers. For this reason I think it would have been preferable had the authors tabulated the comparative advantages and disadvantages with the three standard designs, *viz.*, marine, segmental-cum-steel drum-cum-economiser, and several drum-cum-small water-tube types, and thereafter refrained from comparisons in the text.

Admittedly, the Scotch or marine multi-tubular boiler has its disadvantages in weight and inherent defects, yet it should be remembered that it is a boiler which can safely be left in semi-skilled hands, very often native labour, provided the feed arrangements are satisfactory and that maintenance and supervision are exercised by a responsible person. With a water-tube boiler the rate of evaporation is very high and should difficulty be experienced with the feed a serious accident could occur (in the absence of a competent person) unless the attendant had the wit to extinguish the fires. This is, in my opinion, one reason why the marine type boiler should not be entirely eliminated. Regarding defects, I am definitely of the opinion that these are mainly due to faulty design in not providing for good circulation and adequate allowance for expansion and contraction.

As the authors have brushed aside all other forms of water-tube boilers except the Niclausse by cataloguing all their defects (and none of their virtues) in a single paragraph, it is only fair that some of these defects should be explained for the benefit of those less informed. My connection with watertube boilers ceased more than twenty years ago; therefore, I trust I shall be forgiven if my memory serves me falsely as I have no text book at hand to which to refer.

I think it is correct to say that the British Admiralty experimented with every type of water-tube boiler possible. The principal segmental-cum-steel drum types (I propose to ignore the economisers) were the Belleville, Babcock and Wilcox, and Niclausse. I regret that I had no practical experience of the last, but I understand it gave satisfactory results.

The Belleville boiler steamed at 300lb. per sq. in., which, for those days, was considered high. For those who are not familiar with the construction, the boiler consists essentially of a common lower feed collector to which are connected a number of segments which, in turn, are connected by headers to a transverse steam and water drum. A segment consists of a flat spiral of tubes about 3½-in. diameter joined at front and back by junction boxes. The feed enters the front lower box from the collector, passes through the bottom tube to the back end of the boiler, through its junction box back to the front of the boiler and so on until the steam and water are finally delivered to the steam drum. The bottom junction box at the feed collector is coned and a joint with the feed collector is made with a male cone and a suitably formed metallic ring, the joint being made tight by means of an anchor bolt (so called on account of its form) through a lug on the junction box and a pressure bar. The inclination of the tubes would be about 7 degrees to the horizontal. Expansion of the segments is provided for by allowing each segment to move towards the back end, movement being assisted by means of a roller placed under the back bottom junction box and resting on a suitable bracket. As frequently happened, the roller got choked with soot and also the space between the junction box and the refractory of the casing so that expansion was restrained. The obvious result of course, was hogging of the lower tube or tubes so that the conical joint at the feed collector strained and leaked. Efforts to prevent leakage sometimes resulted in serious accidents by the fracture of the anchor bolt due to excessive tightening. The tubes were screwed into the junction boxes and the joints would sometimes leak if the threads were worn or too slack. To guard against such leakage every segment was tested prior to being placed in the boiler. Even distribution of the feed water was uncertain as the water would naturally pass into the wing segments first (the feed entering the collector from both ends) and thus deprive the central segments of an adequate supply; this would be revealed by the melting of the fusible plugs which were fitted to the third and fifth row of junction boxes. There were two hand-hole doors to each junction box, one for each tube for examination and cleaning; these joints gave a certain amount of trouble if the doors or boxes were corroded or worn, as would any other door under similar conditions. I should hesitate to say that any of these defects were the outcome of racking strains set up by the ship as is suggested by the authors. The Admiralty fitted these boilers extensively to the older battleships and cruisers, the average number in the latter class of ship being 40 to 48, so that the trials and tribulations of the engineering staff can be well imagined.

The advent of the Babcock and Wilcox boiler sounded the death knell of the Belleville so far as the British Admiralty was concerned, much to the relief of the engineering personnel generally.

The Babcock and Wilcox boiler is, in effect, a considerably improved design of the Belleville, and is not subject to so many defects. Hogging of the lower tubes does take place and trouble can be experienced with the joints of the hand-hole doors in the headers, but again, these defects can hardly be attributed to ship stresses.

These boilers, as is well known, are in use all over the world, sometimes in the hands of native labour (of course under competent supervision) and as regards feed water, conditions are not always favourable; yet these boilers give reliable service and a good life. I remember examining one boiler of this type in the S.E. district of London some years ago, and found that the incrustation in the tubes was fully ¾-in. thick, yet the owners did not experience any tube trouble.

I do not think I shall be guilty of a misstatement of fact if I say that the several drum-cum-small water-tube boilers were all cradled in the destroyers and steam picket boats of the Royal Navy.

The standard design was a top drum connected to a lower water drum each side of the fire grate by means of small diameter tubes of various shapes. Although the tubes are, of necessity, rigidly held between their respective drums, expansion is allowed for, and, in the case of the lower drums, by means of sliding feet which, according to my experience, functioned with no trouble at all. I have not known any tube to leak under either steam or hydraulic test, neither have I seen a fractured tube plate as asserted by the authors, unless of course, they intend this assertion to apply only to the tube plates of marine type boilers.

Under "Construction Simplicity" it is stated that "the pressure within the boiler and the tubes tends to keep the expanded and bell-mouthed joint between the tube and the drum tight". Whilst this is true in principle, I very much question whether the amount of pressure exerted has any real influence, and I cannot help but feel that this is a case of attempting to gild the lily, because all tubes in this class of boiler are expanded and bell-mouthed. The bell-mouthing of tubes is to preclude the possibility of withdrawal from any cause. If I remember aright, the withdrawal force for a tube so fitted is over 20 tons, so that it is hardly likely that the tubes of a Lewis boiler will be blown out by any pressure exerted at the ends. Any tendency to leakage at the joint with the tube plate in a Lewis boiler would be caused more by the unsupported weight of the tube, but providing the tube plate is of sufficient thickness this is hardly likely to occur except in ships susceptible to violent rolling; in this case, one could safely say that the defect was set up by ship stresses and strains.

Regarding the facility for renewing any tube in any water-tube boiler without disturbing any of the others, the authors, in asserting that this is impossible, appear to have overlooked the White-Forster boiler. This is a three-drum boiler identical with the standard Yarrow, except that the tubes have a curvature; the top drum is made of sufficient diameter to allow any tube to be drawn and replaced without disturbing any of the others. It is highly probable though that, when tubes reach the stage when they show signs of wear, it will be found necessary to renew the whole of them, so that this point need hardly arise.

I suppose the most popular of this type of boiler is the Yarrow. The principal defect to which this boiler was liable was the longitudinal splitting of the wrapper plates of the lower drums at the overlap of the longitudinal seam of the tube plates, and in view of the design this is hardly surprising. It is to be regretted that one such failure occurred in one ship whilst under steam; as may be supposed, the results were terribly fatal. It so happened that the defect was revealed to me whilst putting one of these boilers to a hydraulic test. The fracture of the wrapper plate extended practically the whole length of the drum, and the cut was as clean as if it had been done in a shearing machine. Subsequent examination of other boilers disclosed the presence of a very fine marking immediately beneath the landing edge of the tube plate, and in the ordinary course of events this would, and did in fact, pass unnoticed. The theory put forward at the time was that the cause of the failure of these plates was due to the way they had been caulked, but with this I could not agree.

For the benefit of those not familiar with the construction it should be mentioned that as all the tubes were straight, it was necessary to have a very thick tube plate to allow sufficient depth for expanding the tubes, the tube plate being slightly curved and the sides, reduced in thickness, flanged over with a good radius to receive the wrapper plate, which was more or less circular. The flanged sides of the tube plate were, however, considerably thicker than the wrapper plate and here, in my opinion, lay the fault in design. The two plates combined formed a rough "D", the upright of the D being the tube plate, slightly curved outwards. Beyond this defect, the boilers gave every satisfaction and no trouble at 235lb. per sq. in. Steam could be quickly raised from cold, as it can be in all water-tube boilers, but it was customary to allow about 2½ hours. I understand that the lower drums of these boilers now have a circular form which, obviously, is the best.

Referring to troublesome joints, perhaps I should mention that these, through careful treatment, lasted a considerable time, but trouble would be experienced if the doors were not properly fitted before they left the manufacturers' hands. In this class of boiler the only manholes are one for each drum, situated at the ends.

The internal cleaning of these boilers was usually done in about twelve hours, including the overhaul of all the internal gear and of such fittings as required attention. The only evident corrosion would be a few minor pittings each side of the orifices for all fittings placed along the top line of the steam drum, caused no doubt by pumping up the boilers to full capacity as is the practice in the Royal Navy when boilers are not required for immediate use.

I regret to see that in dealing with the quality of feed water to be used in water-tube boilers the authors are guilty of contradicting themselves, because they say that "faulty circulation and design have compelled the use of pure feed" and then go on to say that "it is recognised that practically pure feed water should be the rule, hence the insignificance of the lower drum". In my opinion, pure distilled water should be the rule for all boilers, although there are natural waters which deposit but little sediment and have no harmful effects, except, curiously enough, on the non-ferrous fittings. In the Royal Navy pure distilled feed to which milk of lime was introduced was the rule; serving members can confirm if this practice obtains to-day.

Before leaving the question of feed, I suggest that owners of the average type of cargo vessel would do well to consider the question of utilizing the exhausts from the various auxiliaries. I may be under a false impression (or, perhaps, out of date) but I understand that these usually go to an auxiliary condenser, when they could be more usefully employed in an evaporator. Again, false economy in repairs often results in badly leaking glands, and judging from what I have seen whilst making surveys in this class of vessel, economy of coal and water does not appear to be of paramount importance; not only that, but it means that considerably more water has to be passed through the boiler, adding to the scale and increasing cleaning costs.

Regarding the heating of the feed, I understand the current practice in the Royal Navy is to heat the feed between the pump and the boiler. There can be no question that this is infinitely superior to the mercantile practice of having a heater sufficiently high up to give the requisite head to enable the feed pump to deal with feed at 240° F. I am not quite clear why, after making every effort to secure dry steam in the Lewis boiler, all these efforts should be nullified by spraying the feed into the steam in order to raise the temperature, should this be less than 180° F., when this might be better performed with a steam injector if heating cannot be effected between the pump and the boiler. I imagine either of these methods could be employed, even with the portable boiler the authors have described.

The authors have informed us that with good circulation no deposits or incrustation will be possible, also that the water circulates 24 times before final conversion into steam. I believe it is a fact that at full steaming, a water-tube boiler evaporates its initial supply of water in about 20 minutes (see paragraph 3) so that, according to this, the water circulates very rapidly and consequently leaves but little chance for sediment to settle except in places conducive to sluggishness. In a three-drum boiler the only places are the bottoms of the lower drums, and at these the blow-down valves are placed. This leads one to the conclusion that sediment encountered in other parts of these boilers is deposited after steaming has ceased and the boiler is cooling down.

I am sorry to see that the authors have succumbed to the "desirable egg-shell initial coating" theory, because, according to my experience, it can cover a multitude of defects. What is more preferable are perfectly clean surfaces. In this connection, I should like to ask if any experience has been obtained with bright polished surfaces. At first sight this might appear as adding unnecessarily to the initial cost of a boiler, but it might conceivably save considerably in repairs or renewals in the long run.

I notice that the authors have referred to heating any downcomer pipes which may be fitted. Every downcomer I have seen has been placed outside the boiler and not connected with the heating surfaces in any way. Surely the fact of heating downcomers defeats the very object for which they were intended. As to whether downcomers are necessary is another question.

The non-baffling of the heat gases leads me to suppose that the rate of combustion is fairly high, and I should have preferred a comparison with a boiler of its proto-type as well as a marine type boiler.

It is not stated whether Lewis boilers have been manufactured for pressures in excess of 200lb. per sq. in., but presumably this is possible. In any case, a solid-drawn tube would be preferable to a lap-welded one. I am pleased to see that the authors do not favour the fitting of screwed plugs to the ends of the tubes; in spite of their assurances to the contrary, I feel confident that these would lead to trouble in time. Searching of the tubes could be done with a suitable electric lamp after the inner tubes had been removed.

I am somewhat hazy as to the nature of the water level and its course in the top drum, though a brief examination of a boiler would soon explain this. Better diagrams of the internal gear and a photograph of the boiler taken from the firing end to complement Fig. 16 would have been very helpful.

Regarding the permissible drop in water level, I think the authors have been inclined to exaggerate when they state that this is only 4in. in a marine type boiler (see paragraph 3), and I take it that what they meant was 4in. after the water had disappeared below the bottom water gauge cock, which is an entirely different matter.

Reference has been made to external cleaning of tubes by soot-blowers, apparently of the live steam variety. The apparatus which was used in the Royal Navy with Yarrow boilers was an air compressor operating at about 90lb. per sq. in., with a flexible copper hose and "swords". To my then youthful mind, this gave every satisfaction. I will not say that every atom of soot was removed, but the tubes were effectively cleaned whilst the boilers were under steam and without impairing their steaming efficiency; furthermore, no external corrosion resulted. It therefore passes my comprehension why people should want to use live steam, which is not only wasteful in fuel and water, but provocative of every external ailment which can beset a boiler.

I have only touched briefly on points which have occurred to me whilst reading through the paper, but I, for one, am very grateful to the designers for having introduced their boiler to the special notice of marine engineers. My only regret is that they should have trailed a few red-herrings across the path in their anxiety to prove that their boiler is "par excellence". I am convinced that the design is a forward step on previous designs of boilers of this type, and that it can be safely left in charge of most seafaring people, but it would be essential to fit reliable feed pumps and a highly efficient and reliable automatic feed in view of the evaporative rate, and they would have to be maintained in a high state of efficiency.

As America is building us a large number of merchant ships, may I point out that water-tube boilers of various designs are in common use in their own cargo vessels.

Mr. E. F. Spanner, R.C.N.C., retd. (Member) wrote: There are many points in the design of the Lewis boiler which are of particular interest to designers of thimble-tube boilers. These points of interest, and technical similarity, may be summarized as follows:—

Both types of boiler:—

(1) Utilize tubes held at one end only, and thus escape stress troubles common to tubes held at both ends.

(2) Are capable of working efficiently on less satisfactory water than is essential for ordinary water-tube boilers.

(3) Lend themselves easily to the securing of persistently high efficiency owing to the high and uniform gas velocities secured between entry to and exit from the tube nests. This results from their flexibility in design.

(4) Are easily cleaned on the gas side, and provide little lodgment for soot.

(5) Provide opportunity for securing large areas of tubular heating surface in a very small volume.

(6) Require much less accurate boiler-making work than is required with ordinary water-tube boilers.

(7) Are very simple of manufacture and repair.

(8) Are very economical of weight.

A certain amount of qualification is necessary as regards item (8), so far as it concerns thimble-tube boilers, the fact being that for pressures exceeding about 100lb./sq. in., and outputs exceeding about 1,000lb./hr., thimble-tube boilers tend to become heavier than fire-tube boilers—according to present standards adopted for design.

The Lewis boiler here provides a valuable extension of the range served by the thimble-tube boiler, since it enables very great economy of weight and space to be secured for large outputs and high pressures.

As a naval architect one can only express the very sincere hope that it will not be long before the Lewis boiler thoroughly satisfies those responsible for providing the steam-raising elements in merchant vessels that it is capable of giving trouble free service in marine work.

At a time when steel supplies are short, boiler-making plants working at high pressure, and every ton added to deadweight of many times its normal value, it might be expected that at any rate some of the new vessels being built would be fitted with Lewis boilers—even were some slight risk involved in so doing.

According to Mr. Lewis there is no risk whatever—and certainly he advances experience worth noting to justify this opinion.

The Authors' Reply to the Discussion.

In reply to Major Gregson, the fact remains that the recently improved Scotch boiler is still much too heavy, bulky, and costly. Its 25 per cent. increased output per ton is due to water-tubing, drybacking, and unifying the rear combustion chamber, whereby it has become a mongrel. Such a mixture of furnace tubes, water tubes, fire tubes, superheater tubes, stay tubes, stay bolts, gussets, heavy shell with large flat ends which are the worst possible things to have with high steam pressures, heavy brickwork, air heaters, air casings, etc., all thrashed a bit harder, cannot but add to the skill required and the worry experienced by the operating staff, especially as the range of water content is considerably less. The chief evidence it affords is not that the Scotch boiler has any good features, but that the ordinary sea-going engineer can now be trusted to operate this more complicated equipment. It goes to demolish the idea that the simpler water-tube boiler is beyond the ability of an ordinary engineer to manage. The authors have not under-rated the Scotch boiler which in its improved form appears to be good for about 6¼lb. per sq. ft. of heating surface. This incidentally approximately equals the rating of B. & W. boilers in the s.s. "Orion", as recorded in Eng. Rear-Admiral W. M. Whayman's paper read before the Institution of Naval Architects in 1936.

The government cargo ships now under construction both in this country and in America are being equipped with the crudest form of the old type Scotch boiler—not the improved type mentioned; hence the importance of the authors' comparison of the Lewis boiler with the old type. The policy under present conditions of adopting the simplest possible equipment in these ships has much to be said for it. The authors have given evidence to show that this policy will be realised more effectively by use of Lewis boilers than by any continuation of old-fashioned types.

The authors are not unaware of recent research work. In their paper read before the Institution of Mechanical Engineers (Proc. I.Mech.E., June, 1940) they gave a long list of references to recent technical papers from all over the world. One of the interesting things they found was that the firm with which Major Gregson is associated has not even yet, after 50 years, seen the errors in George Babcock's theory of circulation propounded to Cornell University in 1890. That theory, equating available head causing circulation (and even this available head is wrongly calculated) to the kinetic energy of the steam rising from the upcomer, is completely wrong, and shows that its author did not comprehend the most elementary principles of hydraulics and thermodynamics, whilst in addition, no allowance at all is made for the frictional resistance to flow. The continuance by the firm of their publication of this theory and the exposition of similar theories by Admiralty experts, entitles the present authors to doubt whether there is any general understanding even yet of boiler circulation.

The full-scale researches mentioned by Major Gregson seem to the authors to consist of firms such as that with which he is concerned making trial and error experiments in the dark with half a dozen totally different types, such as the WIF, CTM, SX, High Head, Stirling, Johnson, and now the Forster Wheeler, in the hope of finding one that can stand up to more than very moderate rates of heating notwithstanding their costly complexity. In view of such procedure resulting from inadequate understanding of the circulation question, it seems time that boilermakers got down to first principles, and studied the facts regarding circulation as stated correctly for the first time in history by the authors in the paper referred to.

Regarding Major Gregson's reliance for support of his views on what he calls the wonderful performance of the Admiralty three-drum boiler at full power, it must be pointed out that their maximum ratings are quite moderate in comparison with the possibilities indicated by the authors in Fig. 9 in the paper. It is true that there has been an advance from 17 to about 20lb. evaporation per sq. ft. of total heating surface per hour, thanks to the so called "augmentor", a device used by Niclausse 40 years previously. Even so, this rating is "from and at" per sq. ft. of total boiler and superheater surface, the efficiency is low, being only of the order of 75 per cent., and the boilers are certainly limited in output by violent fluctuations in water level due to steam formation in the rear tubes upsetting circulation. The occurrence of these fluctuations is vouchsafed by makers of feed water regulators who have had great difficulty in controlling the water level in these boilers.

The use of the so-called augmentor in increasing the possible output of the Admiralty boiler by some 20 per cent. shows what can be done by observance of one of the principles of good circulation, namely, that the steam should have a free discharge above the water level in the drum. If the authors' other two principles, the use of unheated downcomers, and the individual water supply to each steaming tube could also be observed, the output of the boiler could again be greatly increased. The only way of achieving this which the authors see is by use of the Lewis tube. The fact that the Admiralty boiler operates is no evidence that it is as perfect or as light and compact as it ought to be, and the example given in the paper of a Lewis boiler, occupying the same space, but capable of producing double the amount of steam, shows how far short of perfection the Admiralty boiler really is. The same example also shows that the requirements of weight and space mentioned by Major Gregson as having been fulfilled by the boiler types he describes are extremely modest, and far from being so exacting as such requirements will be in future, when steam engineers realize the possibilities of the Lewis design. The "wonderful" endurance of His Majesty's ships is probably in spite of, and not because of, their boilers and one shudders to think what is the state for instance of their unprotected refractory brickwork after a spell of full-power working, or what would happen if a little salt got into the feed water.

Major Gregson's youthful conception as to why the Niclausse boiler was not retained beyond the 120,000 h.p. installed during the battle of the boilers, is entirely erroneous. The Niclausse boiler undoubtedly satisfied the three conditions mentioned, namely good circulation, freedom from mechanical breakdown, and ease of maintenance. Much evidence was given in the paper, but to emphasize the ubiquity of the Niclausse boiler, which had replaced Scotch boilers in a large Greek warship in 1900, the authors submit the following list of ships as examples of its successful use:—

(1) French cruiser "Friant", 10,000 h.p., 19 knots, built in 1893, was the first of many other warships to have Niclausse boilers. It remained in service until about 1925, and even then the boilers were installed for shore service in Toulon.

(2) H.M.S. "New Zealand", 16,000-ton battleship of 18,000 h.p., 18·5 knots. "The Times" in April, 1905, reported that the steam trials of the New Zealand battleship were very satisfactory.

(3) H.M.S. "Berwick", 9,800 tons, 22,000 h.p. "Engineering" of 9th June, 1903, said: "On the full power trial the very high speed of 23·613 knots was attained, which is exceptionally satisfactory in view of the fact that earlier cruisers of this class have not quite attained their designed speed". "Berwick" equalled the "Drake", a much bigger ship, in a race from Sandy Hook to Gibraltar, arriving first of the County Class cruisers, and having burnt less coal. The "Naval and Military Record" of 24th December, 1903 said of the "Suffolk", a sister ship to the "Berwick", and also fitted with Niclausse boilers: "the 'Suffolk' proved an excellent sea boat, and at each run her engines exceeded expectations, while her mean speed at the full power trial was 24·7. She can be relied on as a good 23 knotter at a pinch when at sea".

(4) S.s. "Minnesota" and s.s. "Dakota", 30,000 tons, 15,000 h.p., 14·5 knots, Atlantic and Pacific liners, each with 16 Niclausse boilers of 350,000lb. per hour total capacity built by Cramps in U.S.A. The "Dakota" did a remarkable first run, using only 12 boilers from New York to Seattle, 15,879 miles, in 1905. "The running of this ship on her regular service since this maiden voyage is reported as very satisfactory, and the boilers are admitted a great success" ("The Steamship", 1906). She was probably the first large ship to be fitted with mechanical stokers with forced draught.

(5) Tramp steamer "Morbihan", 1,200-ton cargo boat, amongst several others.

(6) Inland river passenger boats, e.g. the thirty-five "Batteaux Parisiens".

(7) Yachts "Bacchante" and repeat orders "Almee" and "Julia", and many others which toured the oceans.

(8) Argentine naval training ship "Presidente Sarmiento". This is the ship referred to by Mr. Hamilton Gibson.

(9) Tug-boats "Menhir", "Hercules", "Travailleur", etc., 150-250 h.p. The first of these steamed for 30,000 hours from 1895 to 1900 without a single boiler defect or difficulty.

(10) "Le Rhone", the latest of several repeat orders from her owners during the last 45 years, built in 1931, for powerful Marseilles-River Rhone turbo-driven tug-boats. This boat demonstrates conclusively the outstanding advantages of Perkins tubes applied in the most modern Niclausse design, namely high economy, high superheat, high pressure, low maintenance, and great range of steam output in meeting heavy overloads without appreciable pressure drop.

(11) Many French and other battleships, e.g. the 36,000-h.p. 25,000-ton "Bearne". The high-duty Niclausse naval boilers, of which 21 were ordered in 1914 by the French Admiralty after a series of competitive trials for this ship, were fully described in a paper read to the Institution of Mechanical Engineers in July, 1914, and in "The Engineer" of 13th and 27th March, and 24th April, 1914. The boilers were arranged either for oil firing or hand-fired coal. The test results yielded efficiencies ranging from 90 per cent. at cruising rates to 78 per cent. at 100 per cent. full power overload. The coal was hand-fired at the high rate of 46lb. per sq. ft. of grate area, *i.e.* far above the rates of which Major Gregson had experience. These trials were extremely interesting, because even then, now 28 years ago, Niclausse heat releases per cubic foot of combustion chamber, and absorption per square foot of tube wall area and of boiler heating surface were of the same order as those only recently employed in our oil-fired Admiralty boilers at present-day full power ratings. Incidentally that paper gave, in the reply to the discussion by one of the present authors, the first disclosure of the analytical steps to be taken to establish properly the balance sheet for a boiler test, and challenged other firms to follow these steps when claiming efficiencies for their boilers.

Some examples of satisfactory service by Niclausse boilers under adverse conditions, using salt water and river water for feed, were given in the paper itself. To these may be added the satisfactory experience with Chinese-owned cargo steamers, manned entirely by Chinese crews, plying on the Yangtse River. Its use in yachts, pinnaces, tugs, trawlers, Lowestoft and other drifters, and various small craft, shows its ability to work satisfactorily even when subject to violent tossing about, pitching, and rolling, when handled by the toughest type of seagoing engineer, and with mixed quality of feed water.

In view of the satisfactory service of the Niclausse boilers in the British naval ships mentioned, it was certainly not lack of "merit" as Major Gregson suggests, which made the Naval Boiler Commission decide against its further adoption. There were of course some details which were disapproved, such as the use of malleable cast iron headers, the low height of the combustion chamber causing, when the firing skill was poor, CO to form which burned in the uptakes, in which Niclausse had stubbornly refused to apply feed heaters or economizers like his contemporary Belleville, and the use of machined cone joints at a time when improved expanded joints were coming into use, and when with improved feed water and better quality tubes, the need for easy tube withdrawal was becoming less important, but all these could have been and were later overcome. The real reason perhaps was that it was a French boiler, and at that time, when France was a possible enemy, no good word could be said in either country of each other.

Moreover there were good enough boilers available of English origin, *viz.* Yarrows and the like. Nevertheless, the Niclausse boiler continued to be extensively fitted and to give satisfaction in many other navies, and to the extent of about 66 per cent. in the French Navy right through the last War. Subsequently, following better understanding of feed water treatment and combustion, small-tube boilers came more into favour. The Lewis boiler combines all the advantages of the small-tube boiler, in splitting up the gas stream, and in presenting more valuable heating surface, with the excellent characteristics of the Perkins tube, so ably demonstrated by Niclausse.

It is well to point out again, that the claims for the Lewis boiler are not based solely on the existing small units, though these have done excellently in verifying expectations. The design is scientific, that is to say, the action and interaction of air, fuel, flue gases, water, and steam, at every point can be predicted accurately. There is nothing indeterminate about it. The gases have a straight path through the tube banks, and the heat transmission, and the draught losses, can be calculated very closely. The circulation in the tubes can be predetermined and proved ample. In no other boiler can these calculations be made reliably with the same facility and accuracy, whilst in most they are not possible at all. The effect of sudden changes in the direction of the gas flow, the effect of baffles and of areas of heating surface out of the gas stream, and the variable and indefinite angles at which the gases cross the tubes in all other boilers, can only be allowed for by using rough formulæ which are no more, in fact, than factors of ignorance. So far as circulation within the tubes is concerned, not only is it impossible to calculate the flow where there are banks of tubes in parallel between drums or headers, but it is also impossible to guarantee that there will be any flow at all. In the absence of scientific knowledge, their design must be based on trial and error, and costly trials are obviously necessary. The poor results to be obtained by this process have been illustrated above. The simple, straightforward reasoning which underlies the Lewis design renders such extravagant experimenting unnecessary and ridiculous.

Again, so far as operating experience is concerned, the long and varied experience of the Niclausse boiler shows that the Lewis boiler is robust and may be relied on to give sterling service. The Niclausse vindicated the ability of the Perkins tube to give good circulation when subject to the most intense heat, and to remain comparatively free from scale. An example was quoted of a Niclausse boiler in London remaining clean even with feed water which necessitated the periodic use of scruffing tools in boilers of the double header type alongside. The Lewis boiler, which forms the culminating development and application of the Perkins tube, adds to these excellent characteristics the utmost possible simplification in general and in detail design, making it the ideal boiler for general ship and other work.

The authors agree that experience with such boilers at sea is desirable, not only from the shipowners', shipbuilders' and marine engineers' viewpoints, but also in the public interest, and it is to be hoped that such trials will not be much longer delayed. The fact that the Lewis boiler can be steamed to full pressure and output within one hour as against a day for the Scotch boiler, should be sufficiently impressive alone to warrant its adoption, in view of the present need for quick turn round at ports.

In reply to Mr. Pemberton's interesting and pertinent point about possible leakage through the trough floor, there is in fact little reason to fear trouble. The bars composing the floor are machined to pitch and squeezed up tight prior to drilling the holes between them for the inner tubes. On subsequent assembly in their containing frame, they match and pinch up equally well, and after treatment against corrosion they make good surface joints. Even if there were a slight seepage between the bars, there would be little appreciable effect on the circulation, as the weight of wet steam circulating is much greater than the weight that could possibly leak through, and the seepage would be immediately returned to the trough under the cover.

Mr. Pemberton's remarks about feed water are important. In the present state of engineering science and experience regarding feed-water treatment, there is no excuse for bad feed water not receiving proper treatment, either outside or inside the drum, even aboard ship. Normally, with the Lewis boiler, good feed water would be of course desirable, but its ability to use inferior water in emergency, as was proved by the Niclausse boiler, is a valuable asset.

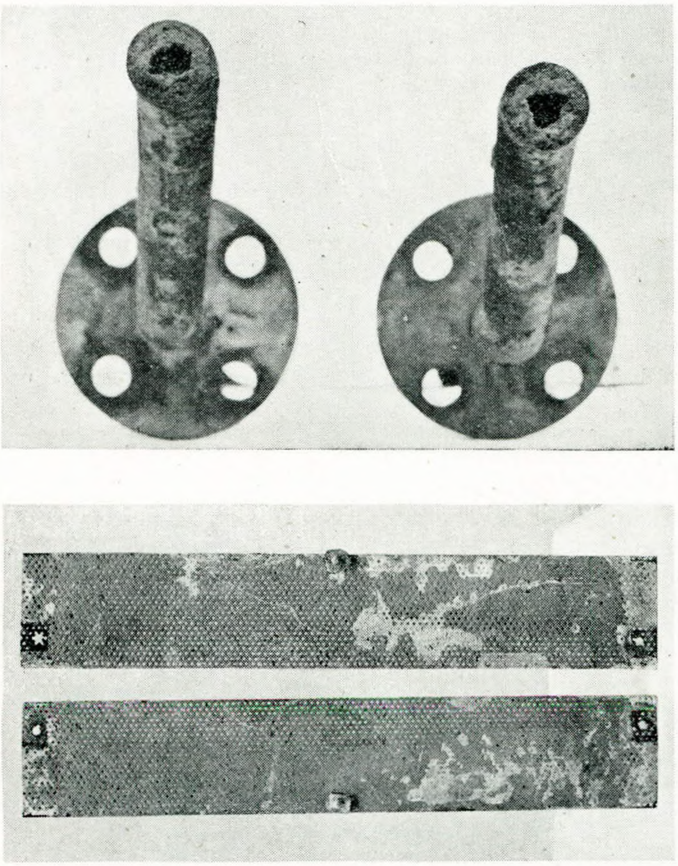
The withdrawal and refitting of the outer as in the case of the inner tubes is exceptionally easy, and ample space to do so is provided. Tubes in the front or fire rows and the end wall tubes, are handled from inside the combustion chamber. The superheater is withdrawable into the firing space in front of the boiler. The rear tubes, being relatively short, can be readily handled through the casing doors at their lower ends. This is shown in Fig. 7 in the paper, where there is an alleyway between the boilers available for this purpose, and clearance under the opposite boiler grate. The alleyway, incidentally, provides a means of access from the engine room to the stokehold which is often impossible with Scotch boilers. It is not necessary to have full length clearance in the direction of the tube bank angle, owing to the springiness of the tubes, which allows ample play to work the tubes in and out of position. Also it may be mentioned that any tube can be withdrawn and replaced without disturbing others—a very different procedure from that necessary in boilers having bottom drums, wherein sometimes several good tubes have to be cut out and destroyed to replace one defective. The absence of bottom drums in the Lewis boiler enables sighting of all the ligaments in the tube plate around the tubes, so that any leaky tube joint can be definitely located, instead of having to be guessed at, as in other boilers.

The authors are indebted to Mr. Hamilton Gibson for his useful contribution and good wishes. His remarks, based on long and wide experience in marine engineering, and on a far-seeing understanding of desirable future developments, express the conviction of many shipowers, shipbuilders, and sea-going engineers. Undoubtedly, straightforward and simple design, and reduced weight and space, are the most highly valuable features a boiler can have, ensuring not only lessened first cost, but the minimum of trouble and expense in firing and maintenance.

The high predicted output of the simplified naval boiler described in the paper is due, not only to the increased total heating surface and its higher rating, as mentioned by Mr. Gibson, but also to the more effective use of the heating surface. There is the "economiser effect" due to the separation of sensible and latent heating, though without the trouble, expense, weight, and space of the ordinary external economiser. There is the sufficient contraction of the gas passage areas, increasing gas speeds and heat transmission in the rear tubes, but without any baffles. There is the ease of keeping the tubes externally clean, without sootblowers, resulting in less complication and higher efficiency. In addition, the water walling, which is achieved with not one single extra complexity, drum, or joint, enables higher combustion chamber temperatures to be used safely, whilst still giving adequate protection to the refractories.

The authors do not accept the view that changes in marine practice cannot be contemplated during the present war emergency. The situation at present is so serious, making such demands on the country's shipbuilding steel producing capacity, that any development likely to reduce the amount of steel, labour, and machine tool requirements, and the time for construction, of any component of a ship, ought to be given first consideration, and immediate trial. As already shown, so far as the Lewis boiler is concerned, the need for trials in the generally accepted sense of experimenting with something entirely new, hardly arises. As Mr. Gibson has pointed out, although the design as a whole is new, yet every component idea and detail in it has been well tested in practice.

In reply to Mr. Flint, the formation of scale in drowned internal feed supply pipes is a common occurrence for which there are several explanations. For instance, there is the irregularity of manual operation of the regulating valve, or the cyclical action of the feedwater regulator controlling the supply of ill-conditioned feed. Depending on the sensitiveness of the regulator, there is a fluctuation in water level in the drum between two limits, and however close these limits may be, they show that the feed supply is intermittent. There are therefore considerable periods from this and several other causes during which the water in the pipe is stationary and receiving heat from the surrounding water at steam temperature, thus encouraging the formation of deposits which usually tend to build upon themselves where there is stagnation. The deposit in the internal feed pipe does not take place when the flow is at the good velocities Mr. Flint mentions. Probably most of it precipitates when the boilers are shut down at night time. It is then that the cooler water in the feed pipe is being steadily heated to cause the precipitation, and this happening every night for several weeks would gradually choke up the pipe. This is a feasible explanation in line with a similar case experienced with internal drowned feed pipes in one Lewis experimental boiler which has been working on and off for five years at various pressures up to 200lb./sq. in. and outputs. The photographs show the ends of the two feed drowned discharge pipes within the drum. It will be seen that they are severely choked with scale, although fed with softened M.W.B. water. The other photograph shows deposits of similar scale found on the screen plates and elsewhere within the drum wherever water could lie at all stagnant, or moving very slowly. Yet no such scale deposits have been found anywhere on the inner or within the outer Lewis tubes. Fig. 3b in the paper shows one of the inner tubes on withdrawal on the same occasion as when the other photographs were taken, indicating how the assured and ample circulation, with no stagnation, and the scouring effect at the reversal at the bottom of the tube, have prevented any trouble therein.



Photographs showing (top) interior feed distributing pipes, and (below) screens, from Lewis experimental boiler drum encrusted with scale. The photograph in Fig. 3b in the paper, taken on the same occasion, shows how the inner tubes remain clean and free from scale in spite of presence of scale-forming matter in the water.

Niclausse discovered in his earliest days the remedy for Mr. Flint's trouble by injecting the feed into the steam space, compartmenting it to lead down to his detartarizing trough when stagnation and settlement takes place, as shown in the actual drawing of Niclausse drum arrangements given in Fig. 13A of the paper. Such devices have been copied by others and will naturally be followed in the Lewis boiler. Thereby the internal feed pipe does not foul, and the precipitations are thrown down harmlessly whence they can be ejected or periodically removed. The enhancement of feed-water temperature by its admixture with the steam rather than with the water in the drum, not only ensures precipitation, but also deaerates the water. This has resulted in obviating any considerable corrosion in the Niclausse boiler tubes and their very thin inner tubes over periods of very many years of service in many thousands of boilers.

Mr. Davis, whose long and thoughtful contribution is welcome, seems to have made the common error of comparing the difficulty of feed regulation of water-tube boilers of large output, with that of cylindrical boilers of small output. For boilers of the same output, the figures in the paper show that the Lewis has a greater range of possible water supply fluctuation. The standard handbooks on Scotch boilers give 4 inches above the crown of the combustion chamber as the normal water level, so that a 4-inch drop would be the maximum permissible for safety. Mr. Davis's reasons why the Scotch boiler should not be altogether eliminated are unsound, as it is full of objectionable features and inherent defects, and in spite of the immense amount of steel used it is subject to unknown stresses as well as scale and corrosion. In the words of a leading consulting marine engineer the survey of the Scotch boiler is a bane to all concerned with a ship, at least after a few years.

Haircracks and even greater cracks in the tube plates of three-drum boilers are not uncommon. Illustrations were given in "Welding" of November, 1934, showing the repair of such cracks by electric welding. A recent visit to a shiprepairing yard gave abundant evidence of this trouble.

In many boilers the tubes have to be beaded over as well as bell-mouthed. In the Lewis, only a slight bell-mouthing is required, thus saving the tubes much harsh treatment. Undoubtedly, immense force would be required to push or pull them out. The danger to the tubes during rolling of the ship, due to their being unsupported at their lower ends, is very slight, the additional stress on the joint at the tube plate being not more than one or two per cent., even with violent rolling. It must be remembered that the tube has only its own weight to support. There are no heavy drums resting on the tubes, or hanging from them, as in many three-drum boilers. In cases where long Lewis tubes are used, there is no difficulty in providing additional support to the tubes at their lower ends.

The White-Forster boiler undoubtedly provides the facility of withdrawal of any tube through the drum, without disturbing others, but it still retains the defects of other three-drum boilers in having heavy bulky bottom drums, tubes which cannot be sighted through, or cleaned externally from their lower ends, nor can the tube plates be properly examined.

Regarding feed water, there is no contradiction in the statements referred to. Pure feed water is most essential in Admiralty three-drum boilers, where circulation is known to be bad, hence there is no need of their lower drum for the purpose of catching sludge.

The spraying of the feed water in the drum is only done if it contains air, as it would do if at much less than 160° F., in order to expel the air and to precipitate any temporary hardness. This is done in a special compartment in the drum, so as to avoid any contaminating of the steam about to pass to the stop valve. In the Lewis portable boiler an injector is used as a standby to the Weir feed pump.

Slight initial scale is unavoidable when boilers are tested at their maker's works with 100 per cent. make-up of un-treated town's water. The bright polished surfaces which he suggests would not remain bright for long, unless possibly the parts were made of rustless steel.

The downcomer tubes referred to are not special external downcomers, but the rear rows of tubes connecting upper and lower drums in multi-drum boilers. These rear tubes are expected to act as downcomers, and possibly do so at low rates of heating, but when more than moderately heated, steam forms in them, and stops the circulation.

A Lewis boiler for 400lb. per sq. in. pressure is at present under construction. The advantages of the Lewis boiler, due to the simplicity of the pressure parts, is greatly increased at high pressures. Lap-welded tubes would not be used in any case. With regard to the fitting of screwed plugs at the bottom ends of the tubes, which the authors have never favoured, a leading boiler insurance company, and the engineers of a large water board, have recently decided that such plugs are unnecessary and undesirable, and have approved the use of tubes with permanently closed ends.

The question of permissible drop in water level has already been dealt with. The remarks on soot blowers savour of ancient history. Steam soot blowers involve much extra piping, valves, etc., and waste large amounts of steam, which causes corrosion, and they are not completely effective even then. In the Lewis boiler they are unnecessary, as mechanical means can be used in the direction of the tube length, removing the soot more completely and more economically than by blowing steam across the tubes.

Mr. Davis's graphic description of the tribulations attendant on the use of the types of boiler he mentions shows what the Lewis boiler is abolishing. These tribulations provide the reason why Scotch boilers have persisted so long in such a large proportion of our Merchant Service.

The authors welcome Mr. Spanner's comparisons and remarks, and trust that the publication of their paper and this discussion will help to overcome conservatism and awaken an interest in the great improvements in boiler design now shown to be possible. It may be mentioned that preliminary designs have been prepared for a Lewis waste-heat boiler of the composite type, in which either the waste heat from the Diesel engines or separate oil firing, or both together can be used. It forms a very compact unit, and should enable appreciable savings in space, weight and cost to be realised.

Discussion—" *The Computation of the Stresses in a Propeller Blade Section."

Mr. T. Robertson (Member) wrote: Mr. Smith's paper is a most careful and detailed computation of the stresses in the root section of a built propeller, based on certain assumptions justified by D. W. Taylor in his book on propellers.

In formula (2) Mr. Smith might have reduced it to the simpler form,

$$M_2 = \frac{5252\,P_1\,(d-d_1)}{N\,(d+d_1)}$$

With regard to the compressive stresses due to centrifugal force, Mr. Smith gives the compressive stress at Q Fig. 3, on line of maximum thickness, as 3,730lb. per sq. in. (page 45), whereas 1,365 appears to be a more correct estimate.

Assuming that the centrifugal force acts in a plane through the shaft axis and that the rake line passes through the centres of gravity of the blade sections, then approximately, as a single force may be equal to a parallel equal force applied at another point in the body together with a couple in a parallel plane, the couple being equal to the force multiplied by the distance between the lines of application, the centrifugal force of 126,400lb. is equivalent to a force of 126,400lb. applied at the centre of the root section together with a couple of $126{,}400 \times 5{\cdot}27 = 665{,}500$, where 5·27 is the distance between a line in the direction of the centrifugal force through the centre of gravity of the blade beyond the root section and a parallel line through the neutral axis of the root section (taken from Fig. 3).

* By S. A. Smith, M.Sc., April 1941 Trans., Vol. LIII, pp. 39-50.

The 126,400lb. is a tension and the couple 665,500 is resolved into a couple or moment of $665{,}500 \times \cos\theta = 665{,}500 \times {\cdot}729 = 484{,}600$ perpendicular to the blade face and $665{,}500 \times \sin\theta = 665{,}500 \times {\cdot}6845 = 455{,}000$ parallel to the blade face.

Compression at Q due to perpendicular moment

$$= \frac{y \times M}{I} = \frac{5{\cdot}35 \times 484{,}600}{1{,}900} = 1{,}365\text{lb. per sq. in.}$$

Compression at Q due to parallel moment

$$= \frac{5{\cdot}429 \times 455{,}000}{36{,}855} = 67\text{lb. per sq. in.}$$

This makes total stress at Q

$= 6{,}472 + 129 + 1{,}365 + 67 - 403 = 7{,}630$lb. per sq. in.

This, of course, is an approximation as it neglects the effect of any skew and the fact that the maximum thickness of the blade is not midway between the leading and following edges of the blade, etc.

The blade thickness fraction—0·0598—appears large for a manganese bronze propeller.

Mr. Smith gives 35 tons (=78,400lb. per sq. in.) as against 60,000lb. per sq. in. by D. W. Taylor for the tensile strength of manganese bronze. G. Simpson in his book "The Naval Constructor" on page 336 gives 71,200 for tension and 130,000 for compression as ultimate strength. The writer has been using 60,000 and 120,000 for tension and compression respectively, and would be glad of some guidance.

The paper should prove a valuable guide for assessing the stresses in a propeller blade.

The Author, in reply to Mr. Robertson, wrote: So far as the author is aware, none of the formulæ regarding stresses, etc., has been published before. This applies to equations 5 to 25 with the exception of equation 18, which is of standard form for the centrifugal force. Equations 1 to 4 were suitably acknowledged as due to the late Admiral D. W. Taylor. Formula 2 could have been reduced to the somewhat simpler form given by Mr. Robertson.

With regard to the computation of the centrifugal stresses, the author notes that Mr. Robertson considers that the substitution of equal and opposite forces at the centre of the root section is the more correct method of assessing the centrifugal moment stresses.

The ultimate tensile strength of manganese bronze was taken as 35 tons per sq. in. from a large number of tests of actual propeller blades carried out over the past seven years. The lowest of these tests was 33 tons and the highest 37·5 tons per sq. in., and in the paper, for the purpose of assessing the factor of safety, the average ultimate strength was used. The author has no test figures for the ultimate compressive strength of manganese bronze. The average of the tensile tests mentioned above was as follows:—

Ultimate breaking stress. Tons per sq. in.	*Elongation on 2in. %*
35·38	29·1

In addition to the tensile test a bend test was carried out in each case, a one-inch square bar being bent round a radius of 1½in. through an angle of 100 degrees without showing a sign of fracture.

ELECTION OF MEMBERS.

List of those elected by the Council during the period 5th April to 29th May, 1941.

Members.
Herbert Septimus Balmer.
Herbert Desmond Carter.
Percival Henry Simpson.

Associates.
Stephen Stanmore Crook.
Desmond Gerald Dymott.
George Launcelot Forster.
James Harkiss.
Brian Hill.

Graduate.
William Douglas McKay.

Transfer from Associate Member to Member.
James Craig Ferguson.

Transfer from Associate to Member.
John Allan Stewart.
Eric Christian John Volke.

JUNIOR SECTION.

Naval Architecture and Ship Construction (Chapter X).

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

Classification Societies, Tonnage and Freeboard.

The following definitions should prove helpful in connection with the study of tonnage and freeboard:—

Length between perpendiculars is the length as measured from the fore edge of stem to the after edge of sternpost at the level of the upper deck.

Lloyd's length and the International Load Line length is measured from fore edge of stem to after edge of sternpost at the *summer load line*.

Overall length is the greatest length of vessel from the extreme fore end to the extreme after end.

Tonnage length is measured from a point where a line drawn inside the frames or sparring cuts the centre line forward, to a similar point aft.

Moulded breadth is the greatest breadth of ship to the outside of frames.

Extreme breadth is the greatest breadth to the outside of plating.

Tonnage breadths are measured horizontally to the inside of frames or sparring (see later note).

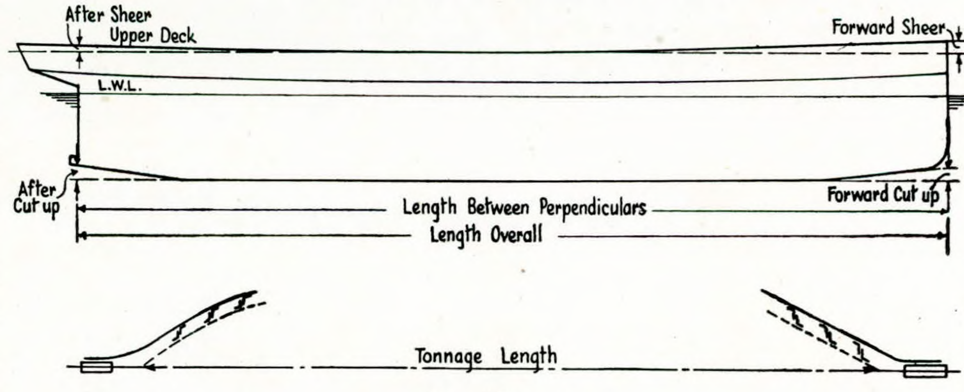


Fig. 106.

Moulded depth is measured from top of keel to top of uppermost continuous tier of beams at side at the middle of the length.

Lloyd's depth is measured from top of keel to top

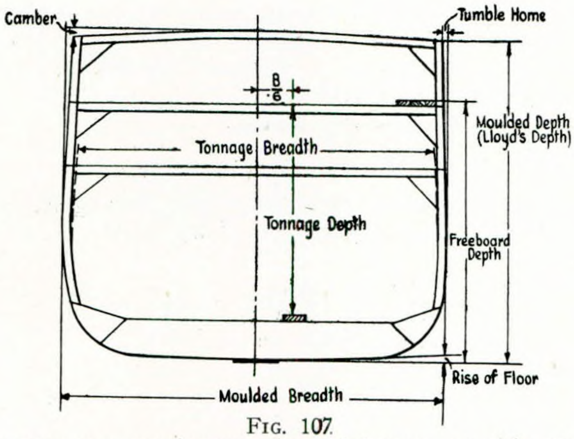


FIG. 107

of uppermost continuous tier of beams at side at the middle of the length, except when there are two or more complete tiers of super-structures, when it is to be taken to the deck next above that from which freeboard is to be assigned. For the purpose of the regulations it is to be designated the upper deck and strength deck.

(The actual wording in Lloyd's Scantling Tables suggests certain modifications in respect of length of vessel, but these refinements need not be set out here).

Tonnage depth is measured from the top of tank to the under side of tonnage deck at centre line, afterwards allowing one third of the camber and a reasonable amount for ceiling (about one inch).

The *tonnage deck* is the second continuous deck from below.

Ceiling is the closed planking covering portions of the tank top.

Sheer is the rise of the deck forward and aft as compared with amidships. Generally speaking the forward sheer will equal twice the after sheer.

$$\text{actual mean sheer} = \frac{\text{forward sheer} + \text{after sheer}}{6}$$

The sheer curve is presumed to be a parabola, and the area between it and a tangent line amidships would be $\frac{1}{3} L \frac{(\text{forward sheer} + \text{after sheer})}{2}$; from which it is clear that the height of the rectangle of the same length and equivalent area would be given by $\frac{\text{forward sheer} + \text{after sheer.}}{6}$ Hence the definition of mean sheer.

Standard mean sheer is not the same as above. It is derived from a formula involving the use of Simson's Rules and is set out in the International Load Line Regulations. Departure from the *standard* mean sheer incurs a modification of the freeboard assessment and will be referred to in the notes on freeboard.

Camber is the round down of the deck transversely. The standard camber of the 'midship beam is one-fiftieth of the breadth of the ship. Only the weather deck beams are required to be cambered by law. In the case of other decks it is optional. It is doubtful whether cambering adds much to the strength of the deck, but it undoubtedly prevents it from falling hollow, and thus lodging small quantities of water.

A beam round mould is made to the shape of the 'midship beam, which is taken to be an arc of a circle. All the other beams of the deck are shaped to the same mould, and are therefore arcs of the same circle.

Tumble home is the fall in of the sides amidships. Vessels of the sailing ship era had excessive tumble home, but modern practice is very varied. The effect of tumble home is to flatten out the stability curve, due to the fact that the wedges of immersion and emersion do not increase very rapidly as the vessel heels over. In sailing ships it was hoped that the result of this would be to counteract the effect of excessive metacentric height, and thus ease the rolling of the ship.

Rise of floor is the run up of the bottom plating measured transversely amidships. In a modern tramp steamer with a 'midship section coefficient of perhaps ·98 there could only be a few inches rise of floor, and it would always be preferable to sacrifice this so as to retain a good rounded bilge.

Cut up is the run up of the keel at the ends. Its primary object is to improve steering, but professional opinion is not standardized on this. Many recent ships whose steering properties are good, have little or no forward cut up.

Flare or flam is the fall out of the forward sections of the vessel. It is hoped that flared forward sections will throw off the seas and thus secure a reasonably dry ship.

The first set of drawings prepared for a new ship is known as the *sheer draft* and consists of three views :—

(*a*) *The profile* which shows the general appearance of the ship, giving the contour of the stem and stern, the arrangement of superstructures, position of bulkheads, extent of double bottom and position of decks.

(*b*) *The half breadth plan* which shows the shapes of decks and waterlines in plan.

(*c*) *The body plan* which shows the shapes of equidistantly spaced vertical sections of the ship.

In this plan it is not felt necessary to draw both sides of the ship. The sections in the fore body are drawn on the right-hand side, and the sections in the after body are drawn on the left. In the case of large vessels *twenty-one* sections will be employed, but with small vessels eleven is deemed sufficient. The Admiralty make No. 1 section the fore perpendicular, but in the Mercantile Marine this practice is frequently reversed, and the after perpendicular is No. 1 section.

These plans jointly give a complete and, with care, an accurate geometrical delineation of the ship. They are usually prepared on a scale of ¼in. per foot.

It is not proposed to deal at any length with the *geometry of shipbuilding* known technically as *laying off,* but in connection with the process of *fairing the body plan* two interesting definitions arise, viz. :—

A diagonal plane is one inclined to the vertical fore and aft middle line plane, but perpendicular to the transverse plane. The *trace* of this plane is its intersection with the curved surface of the ship. It appears as a

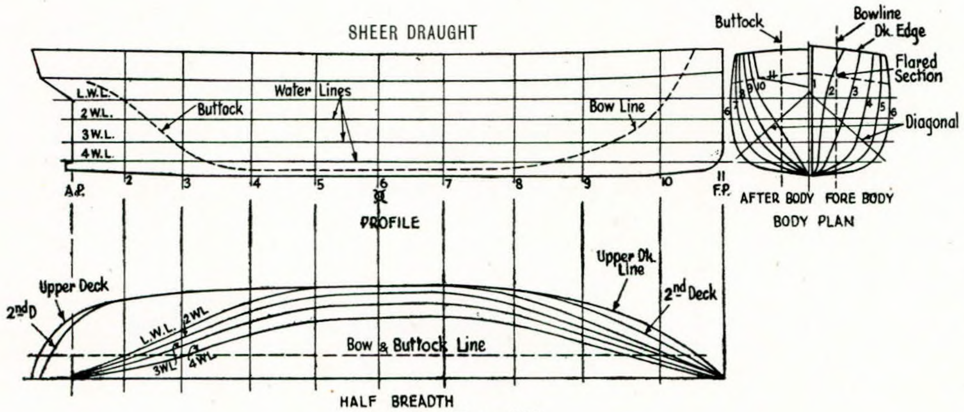


FIG. 108.

straight line in the body plan, but should be a fair curve in the profile and in the half breadth plans.

A bow and buttock plane is a vertical fore and aft plane parallel to the principal centre line plane. It appears as a straight line on both the body plan and the half breadth, but is a curve in the profile.

All three *sheer draught* plans are set out full size on the *laying off (mould loft) floor* where they are cut in and chalked over. When the "body" has been "faired", all frame lines are drawn in on it and it is then copied in its entirety on the *scrieve board,* which is a large level wood surface adjacent to the *bending slab.* The shapes of the various frames are taken off by bending a soft iron rod to the form of the respective frame line. This is laid on the slab and transferred in chalk. A *sett iron* is now bent to the curve, dogged down to the slab, and the frame is then heated and bent to the form of the sett iron, against which it is secured until cold.

The Classification Societies.

The primary function of a classification society is to furnish a guarantee to the insurance underwriters and to the shipowners as to the seaworthiness of the vessel. Their cumulative experience is also of very material assistance to the shipbuilder in matters of design.

There are three recognised classification societies in this country: (i) Lloyd's Register of Shipping; (ii) The British Corporation Register of Shipping and Aircraft; (iii) The Bureau Veritas. It should be pointed out that the Ministry of Shipping is not a classification society, but a governmental body whose *duty it is to protect the interest and safety of passengers and crew. It is in no sense concerned with the vessel's capacity to carry cargoes safely or to earn profits. Both the Ministry of Shipping and the three classification societies are authorized to administer the Load Line Act, and it should be pointed out that as questions of watertight subdivision, bulkhead design, life-saving appliances, as well as freeboard, are matters subject to the law of the country, regulations in respect of them are identical in the rules of all the above bodies. There may of course be recommendations suggested over and above the legal requirements.

A vessel is not required to be surveyed and classified by any of the societies by law, but in the event of this not being so the Ministry of Shipping will carry out its own survey upon the completion of the ship, and the assessment of freeboard will be affected by the results of this survey. Although not attempting to differentiate in the matter of the efficiency of one classification society as compared with another, it will be convenient to give a brief description of the work of one of them only, and for this purpose Lloyd's Register of Shipping has been chosen. When it has been decided that a vessel shall be classified and placed upon the register, preliminary plans are prepared and forwarded to the society. These plans show the principal dimensions and proposed scantlings of the vessel. The surveyors check this data to see that it is in accordance with the rules of the society, and if satisfactory they will give instructions for the work to proceed. There will be surveyors present both at the works where the materials are produced, and at the shipyard where they are fashioned and built into the ship. When it is said that a vessel has been built under survey it means that a surveyor has kept a supervisory eye on the proceedings from the earliest stage of production up to the date of completion.

Periodic special surveys are held at intervals of four years, and are known respectively as the Nos. 1, 2 and 3 special surveys. The date at which the No. 1 survey becomes due is four years after the "date of build", which is the day on which the surveyor certifies the ship as complete and ready for sea. The Nos. 1 and 2 surveys may, at the discretion of the owners, be carried out at any time during the twelve months previous to the date at which they become due. A No. 3 survey may be carried out *any time previous* to the official date. It should be borne in mind, however, that subsequent surveys will be dated from the day of completion of the previous survey. In all cases it is the duty of the shipowner or his accredited representative to advise the classification society when a survey is due. The No. 3 survey is particularly severe, and must be carried out under the supervision of a full-time servant of the society. In the case of Nos. 1 and 2 the society may, if convenient, appoint a private surveyor to conduct the work. A No. 3 is intended to be a complete overhaul, and to this end it is permissible to remove planking, break insulation, hammer cemented surfaces, drill plates, in fact take any steps deemed necessary to ensure that the structure is in a satisfactory condition, or can be made so.

The regulations also make provision for a thorough examination of main and auxiliary engines and boilers, windlass, capstan, steering engine and so forth. The complete details are set out in the published regulations of the society.

Although legally the surveyor of a classification society cannot order the detention of a vessel, he can in his capacity as an authorized administrator of the Load

* No attempt is made to discuss the war-time function of the Ministry of Shipping.

Line Act, withdraw the Load Line Certificate, on the score of unseaworthiness. It is then illegal for the ship to sail, so that in practice the decision of the surveyor is always respected.

The meaning of 100AI ✠ with freeboard.

100A means: Scantlings in accordance with the requirements of society.

I Equipment (anchors and cables and ropes) in accordance with requirements of the Society.

✠ Built under survey.

With freeboard. This means that the freeboard is that which can be assigned in accordance with the scantling standard of the ship.

Lloyd's Scantling Numerals.

The term *scantling* is used to denote dimensions when referring to some structural element of the ship. The *scantling numerals* are numbers based upon the ship's dimensions and may be regarded as criteria of the appropriate scantlings.

The numerals are as follows:—

(1) $L \times D$.
(2) $L \times (B+D)$.
(3) $\frac{L.}{D.}$
(4) D.
(5) (d).

(d) Is the unsupported length of frame and is measured from the top of the lowest tier of beams at side amidships to the top of double bottom at side. The other quantities have already been defined.

Tables are drawn up in which may be read the proposed scantlings against the appropriate value of the numeral. It is not necessary to deal with these tables comprehensively, but to convey some idea, the following brief summary may be useful:—

$(L \times D)$ regulates the scantlings of bottom plating, side plating, inner bottom plating and girder work inside the double bottom.

$L \times (B+D)$ regulates thickness of lower deck plating.

$L \times (B+D)$ together with $\frac{L}{D}$ regulate breadth and thickness of sheer strake, upper deck stringer and topside plating in general.

D regulates frame spacings.

D with (d) regulates frame scantlings.

Special numerals cover other parts of the structure, and it is necessary to make a careful study of the rules and their application before any confidence could be felt in their use. One other point of interest which may be mentioned is the equipment number. This is $L \times (B+D)$ to which must be added a prescribed allowance depending upon the volume of superstructures.

The equipment number, which is also designated by a *letter,* governs the weight of anchors, size and length of cables, size and length of steel wire and hemp ropes to be carried.

Tonnage Regulations.

On no subject is there more controversy than on the tonnage measurement of ships. The first English Law on the subject dates back to 1422, and applied to coaling vessels only. Another act was passed in 1694, but was short-lived. A system known as the Builders' Old Measurement (B.O.M.) came into being in 1773 and held the field until 1835. The quantity obtained by this measurement attempted to express the volume of the ship in terms of an artificial unit of 94 cu. ft. to the ton. It has been suggested that the origin of the term "tonnage" came from some early system of measurement in which the unit of capacity was the space occupied by a tun of wine.

The modern system of measurement is based on the Merchant Shiping Act of 1854, and the unit known as *the register ton* is the volume of 100 cu. ft. When the Merchant Shipping Act was revised in 1894, the tonnage laws also suffered some modification, to enable the shipowner to take advantage of the exemption for what were classified as open deck spaces—and it might be hinted, to soften the blow which had been delivered in the shape of the then comparatively new freeboard regulations.

Great controversy rages over the question as to whether a shipowner should pay dues (a) according to his indebtedness or (b) according to his capacity to pay. *Gross tonnage* would seem to be a criterion of indebtedness and *nett tonnage* is a travestied criterion of ability to pay. In point of fact he will pay just sufficient to enable the port authority to continue in business, and rather less than would be sufficient to cause him to go out of business. When it is borne in mind that designers have so well digested the regulations that the $\frac{nett}{gross}$ ratio for a pure cargo steamer is practically constant (*viz.* 62·5 to 63 per cent.), the advantages of a complex system of measurement would appear to have been nullified.

The present system of measurement was originally known as the *Moorsom System.*

Method of measuring up the ship.—The *tonnage deck* is the second continuous deck from below when there are two or more complete decks. Tonnage length, breadth and depth have been defined already. The length of the ship is divided into twelve equal portions, giving thirteen sections. The area of each of these sections is found between the tonnage deck and the tank top. The standard method of application of Simson's Rules may now be employed in order to find the enclosed volume in cu. ft. The result divided by 100 is called the *under deck tonnage.* To this must now be added all the measured up spaces above the tonnage deck, and the resultant figure is termed the *gross tonnage.*

The *nett tonnage* upon which dues are levied is derived by *deducting* from the gross certain spaces designated as unearning spaces.

It is now necessary to differentiate very clearly between the terms *Exemption* and *Deduction.*

An *exemption* is a space which is not included in any tonnage measurement whatever, *e.g.,* double bottom space, shelter deck space and bridge space, etc., when approved tonnage openings are fitted, space between frames, and spaces enclosed by hatch coamings and trunks, provided these latter do not exceed ½ per cent. of the gross.

A *deduction* is a space which is included in the gross but deducted in arriving at the nett, *e.g.* machinery spaces, crew spaces, peak tanks and ballast tanks, navigating bridge and certain store rooms. The most important of these deductions is that in connection with the machinery space. In the first instance the authorities allowed $1\frac{3}{4}$ of the actual measured up space to be deducted as an encouragement to shipowners to introduce mechanical means of propulsion into their ships. Later, in order to emphasize the important connection between adequate driving power and seaworthiness an allowance of 32 per cent. of the gross was offered in the case of vessels whose machinery space actually measured more than 13 per cent. of the gross. With the progress of time, high speed vessels made their appearance, and in such cases the space allocated to machinery amounted to more than 20 per cent. of the gross; consequently the earlier rule of $1\frac{3}{4} \times$ actual measurement would be more advantageous than the 32 per cent. constant value. It was agreed therefore that when the machinery space measured more than 20 per cent. of the gross the old rule could be used. Summarized, the position is as follows :—

When machinery space measures less than 13 per cent. or more than 20 per cent. of the gross, deduct $1\frac{3}{4} \times$ actual measurement.

When the measurement is between 13 per cent. and 20 per cent. of the gross deduct 32 per cent. of gross.

Clearly a vessel having a machinery space measurement of 60 per cent. of the gross would show a negative nett tonnage, and so the port authority would have to pay this vessel every time it came into port—which is absurd. To remove this anomaly a limit of 55 per cent. of the tonnage remaining after all other deductions had been made, was introduced. In practice this means that the maximum deduction for machinery space is about $52\frac{1}{2}$ per cent. In a large passenger steamer the deductions for other spaces are not very large and a typical $\frac{\text{nett}}{\text{gross}}$ ratio is about 45 per cent. As already stated in a tramp steamer the ratio is about $62\frac{1}{2}$ per cent. It is not suggested that either the rules or the approximate values should be memorised, but an appreciation of the extraordinary complications involved in tonnage calculations will at least serve to increase the reader's respect for those who have to administer the regulations.

Not much can be written here concerning the special requirements when passing through the Suez or Panama Canals. The subject is very thoroughly treated in a book by Mr. E. W. Blocksidge entitled "The Register Tonnage of Merchant Ships". The reader will be well aware, however, that deck spaces which are exempted from English measurement may be included in Suez measurement, and he is no doubt familiar with the spectacle of cargo being moved out from the forecastle on to the open deck as the Canal is approached.

Another point of some importance is in connection with the carriage of fuel in the double bottom. When it can be argued that the fuel is essential for the driving of the ship the space which it occupies is not measured up. But if it can be shown that some of it is being carried for use on a subsequent or return voyage, it will be regarded as cargo and, as such, will be measured up. Most port authorities are fairly lenient on this point.

The peculiarities associated with the exemption of the shelter deck space have been touched on in the chapter dealing with hatchways. It will be sufficient to restate the position as follows. Shelter deck exemption is permitted only if an approved tonnage hatch having its after coaming $\frac{L}{20}$ from the sternpost is fitted. This hatch must not have permanent means of closing, and openings in bulkheads in the immediate 'tween deck can be closed by means of storm boards, but not watertight doors. Further, whatever the circumstances, whenever the space is used for the carriage of cargo, it must be measured up. This means that frequently the tonnage on the homeward-bound voyage exceeds that on the outward.

The tonnage measurement for Panama purposes does not vary, and when once the ship is measured up the value cannot be changed unless there is a change of ownership. This point must be carefully noted, because there is a case on record where due to the presence of one too many bolt holes in a plate used for closing a bulkhead opening, the whole of the 'tween deck space was included in the tonnage, the figure for the ship being increased by about 1,000 tons.

Freeboard.

Freeboard is the height of side as measured vertically amidships from the upper edge of the deck line at side to the upper edge of the load line.

The *deck line* is the intersection of the upper side of deck (whether wood or steel) with the outside of plating.

The freeboard deck is the deck from which freeboard is measured, and is the uppermost complete deck having permanent means of closing. It is the upper deck in flush deck vessels and on vessels with detached superstructures. In vessels of the shelter deck type it is the deck next below the shelter deck (see sketches in previous chapter).

All watertight bulkheads must be carried up at least to the freeboard deck.

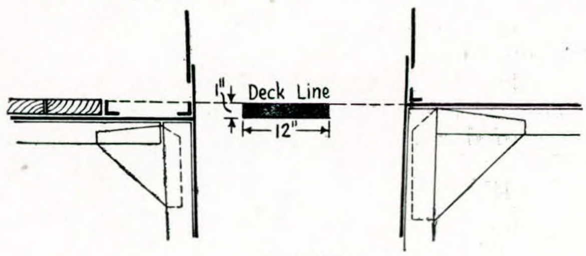


Fig. 109.

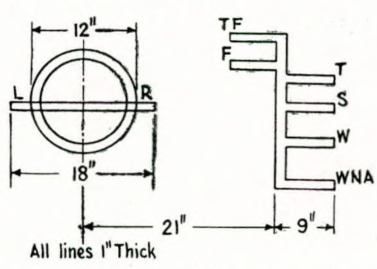


Fig. 110.

The load line disc is 12in. diameter, and is intersected by a horizontal line 18in. long 1in. wide, the upper edge passing through the centre of the disc. Alongside the disc lines are drawn to represent the permissible draughts under different seasonal conditions. They are each 9in. long and 1in. wide.

Broadly speaking freeboard is assessed on a basis of length, but the tabular values are for those vessels which comply with the standards of strength laid down by the classification societies, and whose $\frac{\text{length}}{\text{depth}}$ ratio is 15. Departure from the standard conditions of strength, $\frac{\text{length}}{\text{depth}}$ ratio and block coefficient, or where the sheer or camber differs from standard values, will incur penalties.

When a vessel is fitted with a full length (complete) superstructure with properly closed in deck and sides, the tabular freeboard will be reduced by 42in. For partial closed-in superstructures a proportionate allowance is given.

There are *two* sets of tables. One for *general cargo* and *passenger steamers,* and the other for *oil tankers.*

The *timber ship* freeboard is obtained by deducting $\frac{1}{3}$-in. per foot of draught from the tabular value for a general cargo ship of the same length and proportions. For *flush deck steamers* (full scantling type) deduct $1\frac{1}{2}$in. per 100ft. in length from the tabular values.

The following comparative values are of interest :—

Length.	*Standard freeboard. in.*	*Timber Ship. in.*	*Tanker. in.*
		assume 24ft. draught	
250	32·3	24·3	31·5
350	56·5	47·5	51·3
450	87·1	—	75·1
550	116·1	—	98·5

Referring to the markings alongside the disc it will be noticed that the summer load line (S) corresponds to the bar across the disc.

The winter line (W) is obtained by adding to the summer freeboard $\frac{1}{4}$in. per foot of draft.

Winter North Atlantic (W.N.A.) is winter freeboard + 2in.

Tropical (T) is summer freeboard less $\frac{1}{4}$in. per foot of draft.

Fresh water freeboard (F) is summer freeboard less $\frac{W}{40T}$ where W = displacement and T = tons per inch immersion.

Tropical fresh ($T.F.$) is fresh water freeboard less $\frac{1}{4}$in. per foot of draft.

In addition to the conditions set out in the foregoing notes there are numerous other regulations which must be strictly adhered to if the maximum freeboard for the type of ship is to be granted. These are set out in official "Instructions to Surveyors" under the heading "Conditions of Assignment". It may be worth while to mention a few of them. For example these instructions indicate the minimum scantlings for machinery casings, and they explain clearly how the latter are to be closed. Certain minimum requirements are set forth in regard to the closing of the ship side, and the strength of hatches. When bulwarks are fitted the following aggregate area of wash port per side is specified.

Length of well.	*Total area of wash port per side.*
15ft.	8 sq. ft. per side.
20 ,,	8·5 ,, ,,
30 ,,	9·5 ,, ,,
40 ,,	10·5 ,, ,,
50 ,,	11·5 ,, ,,
60 ,,	12·5 ,, ,,
65ft. and above	1 sq. ft. for every 5ft. in length of well.

It would not be fitting to close this chapter without some brief reference to the historical aspect of the freeboard problem. As far back as 1860 quite a number of shipbuilders and shipowners were interested in fixing a maximum draft for ships. They did not make a great deal of progress, if for no other reason than the obvious need for unanimity in such matters. One of the earliest politicians to lend his services to the cause was the late Mr. Joseph Chamberlain. It was some time later that a certain Mr. James Hall, of Palmer & Hall, shipbuilders, Jarrow-on-Tyne, drew the attention of the famous Mr. Samuel Plimsoll to the appalling condition of loading of vessels proceeding down the Tyne. In any reference to the great efforts of Plimsoll it should not be overlooked that Lloyd's were working more or less independently and had drawn up and put into practice a system of freeboard legislation which formed the pattern for the first set of rules authorized by the Government. Samuel Plimsoll who spent many months studying the position in the different ports before starting his agitation, had been elected Member of Parliament for the Mersey division of Liverpool. His first bill before Parliament was a private Members' bill. During its passage Mr. Plimsoll transgressed the rules of the House and was suspended. It is rather difficult to check up on all the facts, but it appears that he attributes his ultimate success to the assistance he received from a "Certain Noble Lady of the Land", to quote his book. At all events he was recalled to the House, and his bill passed through. This first enactment suffered from one peculiar blemish. Apparently the authority for fixing the load line was shared between the prospective owner and the builder, and it is recorded that one owner expressed his disapproval by having the Plimsoll disc painted on the side of the funnel. In due course Plimsoll and others pressed for a Royal Commission to be set up to investigate the subject thoroughly. The professional skill and integrity of its members was beyond all question, and they finally recommended the adoption of a set of rules which followed closely upon the lines of those which Lloyd's had already put into use. These rules remained in force from 1885 (approximately) until 1905, when recommendations were made for the reduction in freeboard in certain classes of vessel. Some criticism was offered at the time, but subsequent data showed that the deeper loading had not led to an increase in the yearly losses. If anything those losses were reduced. Improved structural design may have had something to do with this. The next milestone was the appointment of a body to establish international load line legislation. The work of this committee was proceeding more or less concurrently with that of the

"Bulkheads and Safety of Life at Sea" commission. Its deliberations were suspended during the last Great War, and although resumed very soon afterwards, final ratification and enactment did not come until 1932 under the aegis of Mr. Ramsay MacDonald's Government.

The first freeboard committee worked on the assumption that the object of freeboard was to provide reserve buoyancy, and in that sense the latter could be regarded as the basis of assessment. The principal technical advisor to the International Load Line Committee refused to take this view, however, and when asked what he regarded as the appropriate freeboard for a ship, replied somewhat upon the following lines :—

"The correct freeboard for a given vessel will be that height of side which in the opinion of a competent and courageous ship master would enable him to bring his vessel safely to port under heavy weather conditions".

The Guild of Benevolence.

TO THE EDITOR OF THE TRANSACTIONS.

Sir,—As a technical journalist and ex-member of the Papers and Transactions Committee, I take a closer interest in the TRANSACTIONS than most members, I think. Generally, I find the publication above criticism. I do wish to make an important criticism, however, and one which I trust will be acted upon. Your reference to the Guild of Benevolence is too modestly displayed and too briefly expressed.

I need not waste space by emphasizing the value of the Guild of Benevolence; at the present time, when we owe so much to the sea-going members of our profession, it is imperative that it should be strengthened substantially. I suggest, therefore, that a more prominent notice be placed in the TRANSACTIONS forthwith, embodying the timely reference to the Guild which appeared in the Annual Report.

Such a notice will serve to quicken interest—and consciences—but I think that one or two practical suggestions might be of some use.

(i) As a mark of the appreciation of the work of sea-going marine engineers (and those who are members in particular) I suggest that members in shore posts contribute one year's membership subscription to the Guild before the end of the year. This would be a small mark of appreciation for the winning of the Battle of the Atlantic, which will be "in the bag" by the close of 1941! Our annual subscription is lower than that of most similar bodies and I therefore make this suggestion with confidence. Most members would prefer, I am sure, that no published list of such contributions be given; a nice healthy round sum in the next statement of accounts would bring in the laggards fairly quickly.

(ii) Those firms who are benefiting most from the work of marine engineers, in the way of safe delivery of vital materials, should be approached for contributions. In many cases personal approach to high officials of such concerns could be authorized—I can think of a score of prominent members who could earn the Guild at least as many generous life subscriptions as easily as our Secretary could write, with similar result, to other firms outside the marine world, *e.g.* aircraft and aero engine producers, etc.

(iii) The technical press should be approached for publicity for the Guild, and the daily press might also assist. Much less deserving causes get regular publicity—and results—through these powerful media.

Other means of giving publicity and impetus to the Guild might occur to members, and I hope you will receive suggestions, publish them, and have them considered by the Executive Committee.

I intend giving practical expression to my views on this subject by giving the Guild early publicity in "The Marine Engineer" and readers and advertisers will be appealed to for subscriptions. I am also taking my own medicine and so is Whitehall Technical Press Ltd.—

Yours, etc.,

G. R. HUTCHINSON (Member).

[EDITORIAL NOTE.—*The Chairman of the General Committee of the Guild has expressed the Committee's appreciation of Mr. Hutchinson's letter and suggestions. Those in para.* 2 *and para.* 3(*ii*) *and* (*iii*) *are being adopted forthwith, while the suggestion in para.* 3(*i*) *is recommended to the consideration of those concerned.*

ADDITIONS TO THE LIBRARY.

Presented by the Publishers.

Boiler Operator's Guide. By H. M. Spring. McGraw-Hill Publishing Co., Ltd., 353 pp., 242 illus., 20s. net.

The purpose of this book is to supply a modern handbook specializing on boilers and boiler equipment. The first chapter deals with construction, and methods are given for calculating safe pressures for many types of boiler. Succeeding chapters describe installation, design and distinctive features of a wide variety of boiler from the common fire-tube types to the high-pressure steam generators in America and abroad.

A chapter on appliances and auxiliaries attempts to give the reader a picture of equipment necessary for safe, economical boiler operation. This is followed by a chapter on plant management, which includes personnel problems, wage incentives, and hourly shift schedules used in many plants. The concluding chapter covers many operating problems of a wide variety of equipment and their practical solutions.

The author has kept before him the object of making the text sufficiently non-technical to benefit the man starting at the foot of the ladder and yet contain information that will interest and be of value to the man at the top. Questions and answers are given at the end of many chapters and are based on each common type of boiler and the plant equipment described in the chapter. They are typical of those asked in examinations for firemen's, engineers' and boiler inspectors' licenses by various American States.

A useful list of abbreviations and symbols is given, and the book is excellently illustrated and indexed. The publishers, Messrs. McGraw-Hill Publishing Co., have been responsible for introducing to this country many valuable American technical books which have been entirely suitable for British readers. Occasionally it is necessary to emphasize that a particular American book, while containing much useful information, is of restricted value to a British reader. The present book comes within this class.

Marryat-Scott Lift Handbook. By L. J. Gooch. Marryat & Scott, Ltd., 75, Clerkenwell Road, London, E.C., 80 pp., 23 illus., 10s. 6d. net.

In the opening paragraph the author states that the purpose of the book is to deal with lift maintenance. Before touching maintenance he reviews principles and features of design in some 40 pages, so that it is probable the book will be of interest to others not directly engaged in lift maintenance.

A lift may be described as a simple machine with complicated controls. Control systems have been adequately treated by showing the evolution from a simple hand-rope and reversing switch to modern remote control systems in both a.c. and d.c.

In dealing with maintenance the necessity for performing the various duties in an orderly logical sequence is stressed, as is also the need for "Safety First". Many valuable hints are given which should save much time and trouble. The controversial subject of wear on ropes receives full consideration, but we believe that the rule quoted on page 57 as a Board of Trade regulation is taken from the Home Office Docks Regulations.

It is gratifying to see that the author draws attention to the possible danger in a floating car floor, where the floor short-circuits the car gate contact, and his warning should be seriously regarded by all connected with lifts. We regret that the scope of the book precluded the author from giving his views as a designer on this important matter.

The book is well produced and clearly printed. It is liberally illustrated with photographs, sketches and wiring diagrams. As its name implies it is a convenient size for the pocket, and this will enhance its value for the majority of its users. A novel and interesting feature is the inclusion of two charts constructed like a genealogical table intended to assist in the tracing of faults. The handbook should prove very useful to all connected in any way with lift inspection, installation and maintenance.

Abstracts of the Technical Press

Present-day Shipbuilding in the U.S.S.R.

Notwithstanding the vast improvement in output and standard of workmanship in the Soviet shipbuilding industry effected within the past 15 years, much remains to be done. The application of arc welding is not as general as it should be. The manufacture of screw propellers is still carried out in the primitive manner which was practised when the production of propellers was extremely small and is totally unsuitable for the large-scale output of the present day. The corrosion of hull plating constitutes a formidable problem which still awaits a satisfactory solution. The amount of research work carried out for this purpose has been very small indeed. Spoilt work continues to be the main curse of the foundries, the total value of defective castings amounting to a huge sum per annum. The internal organization of many engineering works is in urgent need of improvement and the specialised training of skilled operators requires more care and attention. Every effort must be made to attain the rate of output laid down and to make fuller use of adequate substitutes for non-ferrous metals and high-priced alloys wherever possible. The Soviet shipbuilding industry must spare no pains to reduce the period required for building ships now under construction, irrespective of whether these are warships or merchant vessels.—*I. J. Yakovlev, "Soudostroienie", Vol. 10, No. 11, November, 1940, pp. 497-502.*

A New British Coaster.

The single-screw motorship "Moray Coast" recently delivered to the Coast Lines, Ltd., by the Ardrossan Dockyard, is representative of the highest class of modern British coaster. She is a steel-built vessel of about 687 gross tons, 209ft. 7in.× 33ft.×21ft. 3in., with a d.w. capacity of 990 tons, and a raked bar stem and cruiser stern, the design lines having been taken from tank model experiments carried out at the N.P.L. The shelter deck extends the full length of the ship, and the main deck from the stem to the E.R. bulkhead. It continues clear of the engine casing to the stern, which houses the electro-hydraulic steering gear. The machinery is placed aft. The total cargo capacity of the two main holds and 'tween deck spaces is 68,420 cu. ft. (grain) or 66,452 cu. ft. (bales). The double bottom extends the full length of the ship, the fore peak, after peak and compartments below the cargo holds being designed to hold 295½ tons of water ballast, while the D.B. space under the engine room forms a fuel-oil tank. The ship has four transverse W.T. bulkheads extending to the main deck. The rudder is of the double-plate streamlined Oertz type and is operated from the wheel-house on the flying bridge by telemotor gear in conjunction with a motor-driven pump in the engine room. The two cargo hatches are served by four 3-ton electric winches and an electric anchor windlass is fitted on the forecastle deck, with a motor-driven capstan on the shelter deck aft. The captain's cabin is on the bridge deck, and below it are the quarters of the first and second officers. The engineers' accommodation is on the P. side aft, while the crew are berthed on the main deck abaft the machinery space. The ship is normally manned by a master, two mates, three engineers, three seamen, one seaman cook and one boy. The propelling machinery consists of a 7-cylr. British Polar Diesel engine, with cylinders of 300 mm. diameter and a piston stroke of 570 mm. The engine is of the standard 2-stroke direct-reversing type and drives a number of pumps. At the forward end is the horizontal plunger-type bilge pump at one side, and on the other the circulating pump driven from an eccentric on the crankshaft. The lubricating-oil pump, which is of the gearwheel type, is also mounted at the forward end and is driven from the crankshaft through gearing. Scavenge air is supplied by an engine-driven opposed-piston double-acting pump. The two outer cranks drive the bottom piston and the centre crank the upper piston through a connecting rod, also the piston of the two-stage compressor mounted over the scavenge pump unit. This compressor serves to charge the starting-air reservoirs to 350lb./in.^{2}, but when air is not needed for this purpose the compressor delivers air to the scavenge system at a pressure of about 1½lb./in.^{2}. At the after end of the engine room are two unpurified oil tanks and a purified oil tank, the fuel being delivered from the latter to the main-engine fuel pumps at a pressure of about 8lb./in.^{2} by a small pump driven by the engine. The average exhaust temperature is round about 520° F. and is recorded on separate dial thermometers for each cylinder. At the ship's normal sea speed the average consumption is about 39 gall./hr. for all purposes, *i.e.*, approximately four tons per 24 hours. There is no boiler or steam machinery in the engine room, the only steam used in the ship being that required for heating purposes, which is supplied by a coal-fired boiler under the bridge. Three 40-kW. generators driven at 1,000 r.p.m. by 6-cylr. Paxman-Ricardo engines are installed in the P. wing of the engine room. When the ship is at sea one generator set is sufficient, but two engines are required for working the cargo winches in port. Other auxiliary machinery in the engine room includes a motor-driven air compressor, a fuel transfer pump, a stand-by lubricating-oil and salt-water cooling pump, all these units being motor-driven. The generator engines are normally run on gas oil and a special gas-oil tank of 8½ tons' capacity is provided under the forward end of the engine room.—*"The Motor Ship", Vol. XXII, No. 255, April, 1941, pp. 6-12.*

Acceleration of Ship Repairs.

The Twenty-fourth Report of the Select Committee on National Expenditure contains a number of recommendations for accelerating ship repairs and increasing the supply of engine-room personnel for service in merchant ships. The report is based upon one made by the Committee's Sub-committee on Transport Services and is the tenth report of this session. The principal recommendations made are as follows:—First, that steps should be taken to comb out from every industry into which they may have drifted, all men of suitable age for service as engineers in mercantile vessels. Second, that careful consideration should be given by the Ministry of Shipping to the question of a further relaxation of their normal time requirements of the qualifications of marine engineers before they are granted the various grades of the Ministry's certificate. In time of war experience shows that many skilled engineering duties can be performed after a relatively short training, both by men and women. Similarly, it may be quite possible for mechanically-minded young men to be given short spells of training either ashore or afloat, or both, which in a few months would sufficiently qualify them to be entrusted with the responsibilities of third and fourth engineers in mercantile vessels. Every effort should be made to secure further labour of the class required wherever it may now be situate, so that it can be diverted from work which cannot possibly be of more urgent importance than that of repairing our maimed vessels. As an urgent, but temporary, measure, an appointment should be made of an engineer thoroughly experienced in shipbuilding management and repairs, and with knowledge of the latest mechanical practice, to visit the yards where repairs are, or may be, carried on, with the specific object of giving advice, where needed, regarding improvements in mechanical equipment for saving time and expense. Wherever practicable, more repairs to ships should be effected abroad. Although the salvage of ships is proceeding satisfactorily, such recovery of vessels is limited in its scope by the plant available. If by the provision of further equipment such recovery work can be expedited, all practicable steps should be taken to secure it.—*"The Journal of Commerce", (Shipbuilding and Engineering Edition), No. 35,313, 10th April, 1941, p. 2.*

Failure of a Lifting Block Pin.

During an inspection of a 30-ton electric overhead travelling crane an inspector found a fractured pin with unusual features. This was the sheave pin of the 5-ton auxiliary lifting block, and was $1\frac{7}{16}$in. diameter and about 9in. long. An axial hole through a portion of its length met a hole drilled radially to supply lubrication to the sheave. The crack spread from each side of this radial hole (see Fig. 1), and the pin was subsequently broken into two portions with one sharp blow of a 7-lb. hammer. Examination of the fractured surfaces showed that a crack had been in existence for some time, and also that the longitudinal oil hole was not central in the body of the pin. Moreover, no attempt had been made to countersink the holes or otherwise remove the sharp corners at which the crack originated. Fig. 2 is a photograph of the cross-section of the pin after final fracture. The material was wrought iron of normal quality, and there was no indication of inferior quality. The direction of propagation of the crack shows that it was caused by fluctuating stresses arising from bending of the pin under service conditions. The presence of the crack is evidence that the material had been overstressed locally. It is deduced that this overstressing was due (*a*) to the sharp corners at the top of the small radial oil hole, and (*b*) the out-of-centre position of the longitudinal oil hole at the mid-length of the pin. Overstressing at the origin of the fracture could have been avoided if the pin had been in a horizontal position, coinciding with the neutral axis of the section, since the bending stress on this plane is practically zero.—*"Industrial Power", Vol. XVII, No. 186, March, 1941, p. 45.*

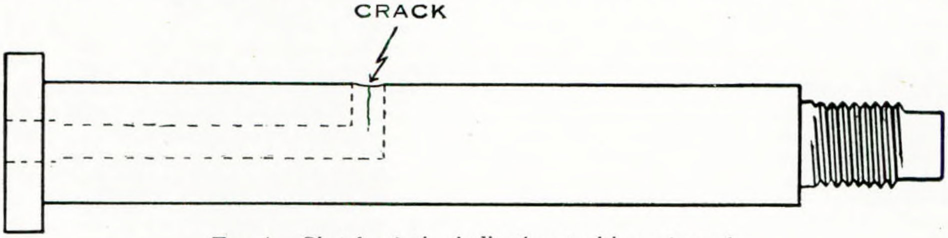


FIG. 1.—*Sketch of pin, indicating position of crack.*

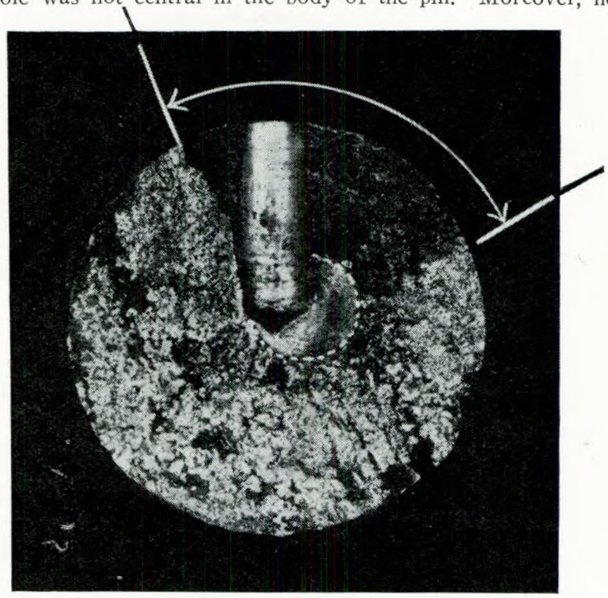


FIG. 2.—*Fractured surface of pin, showing extent of original crack. The photograph also shows the end of the longitudinal oil hole.*

Repairs to Captured German Freighter.

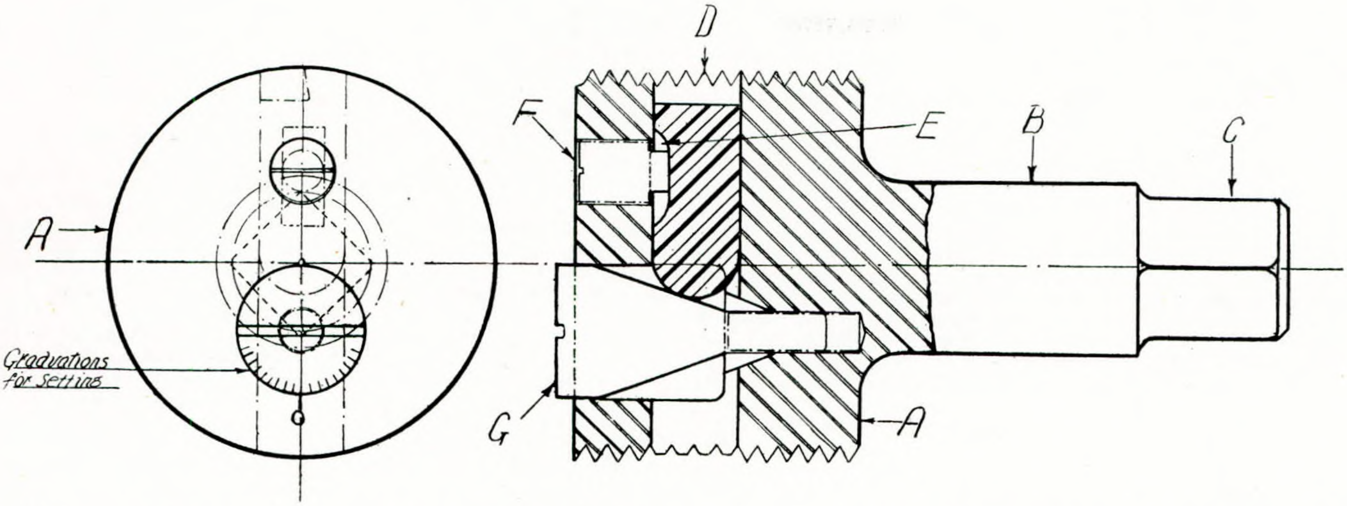
A reply given in the Canadian House of Commons in answer to a question concerning the cost of repairs carried out by the Canadian Government to the 9,200-ton German cargo motorship "Weser", captured by a Canadian auxiliary cruiser off the coast of Mexico last autumn, disclosed the fact that this amounted to $106,544 (about £24,000). Although the vessel's hull was undamaged, her prolonged stay in southern waters had resulted in the shell plating being badly covered with a marine growth of hard substances. It was considered essential to get the ship classed with Canadian Government regulations, as well as any commercial society for classification. After a preliminary survey of the hull and machinery, it was found that the latter had defects to the extent of 75 per cent. in the main engines, refrigerating machinery, tanks and steering gear. The necessary repairs and renewals were entrusted to the successful tenderers for the contract, Yarrow, Ltd., of Victoria, B.C., and as the opening up of the various parts progressed it was found that additional repairs and renewals were essential. This work had now been completed by the firm and the ship has been incorporated in the Canadian Government Merchant Marine. —*"Shipbuilding and Shipping Record", Vol. LVII, No. 15, 10th April, 1941, p. 354.*

Increasing Shelter-deckers' Capacity.

It is reported that the Ministry of Shipping have issued new regulations permitting the deeper loading of shelter-deck ships. As a special wartime measure, owners of such vessels have been requested to submit them to the competent authorities so that a new freeboard may be assigned. It is proposed to increase the draught of ships of this type to an extent depending on the structure of the vessel and the effect that reduction in freeboard would have on her seaworthiness, but in no case is the increase in draught to exceed 12in. It will, of course, be necessary to convert an "open" shelter-decker into the "closed" type by riveting up the tonnage openings before the increase in draught can be permitted, and in normal times this would mean a substantial increase in the gross tonnage of the vessel—(*e.g.,* the gross tonnage of a 9,500-ton d.w. ship would be increased from 4,900 to 5,500 tons—but it is understood that it is not proposed to amend the tonnages in this instance, so that the dues which will be charged will remain unaltered. The effect of this new rule will be that the deadweight carrying capacity of open shelter-deckers will be increased by about 5 per cent.—*"Fairplay", Vol. CLVI, No. 3,022, 10th April, 1941, p. 386.*

Adjustable Shaving Tap for Pipe Threads.

Considerable inconvenience is often experienced when assembling pipes, pipe-joints, flanged parts, etc., on locations where access to workshop appliances is not possible, because of the difficulty arising when fitting together threaded ends having thread variations. Ordinarily, it is not possible for the fitter to include in his kit a set of standard taps of all sizes likely to be needed. The result is that when a tight thread fit is encountered on a distant site, recourse is made to some doubtful dodge. Thus, the tap may be forced through the part together with strips of packing laid along the flutes, with the object of so jamming the tap in the threaded hole that the teeth are compelled to take a fine shaving off the hole thread. Or a large wrench mav be used in an endeavour to force or pull over the tap again to shave a slight amount out of the house. Both these common methods are apt to produce badly shaped holes which cannot be made water- or steam-tight without introduction of an excess of packing. A bad shape of thread, or an oval hole very often results from such treatment. To avoid these troubles, a set of adjustable taps, one for each size of hole covering the whole range of sizes, is likely to be required. One such tap is illustrated, views given being a partial sectioned one at the right, and an end view of the completely assembled tool. It will be noted that the tool consists of a cast-steel body A having a cylindrical shank of reduced diameter as at B, this latter terminating in a squared end



C, sized so as to be suitable for an ordinary tap wrench. The large-diametered end of this body is rough-turned to within 1/32nd inch of the finished size at the first stage, while the shanked end may be finished to size. A round hole is then drilled clean through the large end of the body, passing clean through the centre as shown. This hole should be reamered to produce a smooth finish and good size. The shaving tool D is made of good quality tool-steel, and is provided with a short keyway E, wide enough to permit fitting with the pip-end of the check screw F, which is located in a screwed hole machined in the front end of the body and passing through into the hole housing tool D. The pip portion of the screw F should be a sliding fit in keyway E as this serves for locating tool D radial. By screwing down screw F, it is caused to bottom against the keyway and so lock the tool in place within the body. It will be seen that the lower end of the shaving tool is balled over so as to bear against the tapered portion of the horizontally-located adjusting screw G. A tapped hole is machined in the left-hand end face of body A for taking this screw, the front portion of this hole being counterbored for a certain distance to the same diameter as the straight portion of the screw head, and for a suitable depth to permit a reasonable amount of travel to the screw. By screwing in the adjusting screw, the shaving tool is forced radially outwards or inwards according to requirements. With the shaving tool held in position and locked by the screw F, the outside of the body is finished turned, carefully threaded and finished, the threads being cut through the end of tool D, of course. This done, the latter is then removed from the body, the threaded end being reduced to almost half the diameter, edges off, as shown in the broken line in the left-hand view, then properly backed off to produce the requisite cutting edges, hardened and polished all over. Similarly, screw G should be case-hardened on its tapered portion. The method of using this tool will now be apparent. When it is desired to ease out an internal thread the body is screwed into the threads until the first thread of tool D is in contact with the thread in the work-piece. Then screw G is screwed inwards, thereby forcing out the shaver a small amount. Screw F is tightened and a trial made for a couple of threads. If the correct amount is being removed the tool is passed to proper depth. Usually, one or two trials will have to be made before the needed amount is obtained. To facilitate such adjustments the front face of screw G may be graduated and a setting zero mark scribed across the end face of the body as is shown in end view at left. A convenient scale of graduations is one which provides an ejection of the shaver of ·002in. per indication line. Thus the diameter is increased ·004in. for each movement of the indication lines. This form of shaving tap possesses several advantages, the chief of which are: (*a*) It can readily be adjusted to enlarge internal threads by any amount demanded by pipe thread; (*b*) it ensures a good thread and hole shape; (*c*) it enables considerable savings in fitting time to be made; and (*d*) from the angle of transit convenience, it will be found useful to supply the pipe fitter with a set of such taps to cover a whole range of sizes, thus avoiding the expense of a duplication of standard taps, as it would otherwise be necessary to provide. All the square shanks should, of course, be made the same size, thus rendering fitting to a single wrench.—*"Industrial Power", Vol. XVII, No. 186, March, 1941, pp. 39-40.*

Superheater Temperatures.

When a marine boiler is working at normal output under steady steaming conditions, the temperature of the steam leaving the superheater elements should remain fairly constant. These conditions cannot, however, be maintained for any length of time as, for example, when the amount of feed water entering the boiler is varied, and there is thus always the risk that an excessive rise of temperature may occur in the superheater. This, apart from its effect on the tubes themselves, may result in steam of excessive temperature passing to the main engines with the risk of damage due to unequal expansion and loss of mechanical strength of the various parts. It is, therefore, very desirable that means should be provided for controlling the temperature in the superheater. Two principal methods are available, the first of which regulates the quantity of hot flue gases passing over the superheater elements by means of dampers, and the second involving the use of a desuperheater so designed that the maximum steam temperature at any part of the superheater does not exceed the designed final outlet temperature. Automatic control is sometimes employed, but if due care is observed hand control can be relied upon to give satisfactory results.—*"Shipbuilding and Shipping Record", Vol. LVII, No. 16, 17th April, 1941, p. 362.*

M.L.S. Superheaters.

Two of the new cargo steamers constructed by the Burntisland Shipbuilding Co., Ltd., have M.L.S. superheaters fitted to their boilers. In the case of the s.s. "Suncrest", two of the three Scotch boilers have their smoke-tubes equipped with M.L.S. superheaters of the "R.B." marine type which give a final steam temperature of about 600° F. at the superheater outlet. This particular type of marine superheater consists of a number of solid-drawn mild steel pipes of special form which are placed inside the ordinary smoke-tubes of the boiler and are connected to the steam supply between the boiler stop valve and the engines, so that the steam is caused to traverse the whole of the piping which lies in the boiler tubes and, in its travel, circulates through a series of loops extending from the uptake end to within a few inches of the combustion chamber. Each superheater element consists of two, three or more U.-shaped bends connected in series, each U-bend being placed in a separate boiler tube. The saturated steam inlet and superheated steam outlet ends of the elements are connected to one or more headers or distributing boxes. Each header is divided into two chambers, one of which receives steam direct from the boiler and distributes it to the inlet ends of the superheating elements, while the other receives the superheated steam from the outlet ends of the elements. These headers are arranged vertically in the smoke-box, between the nests of tubes belonging to each furnace. In the case of a smaller vessel, the s.s. "Edencrag", the two main boilers are fitted with the "S" type of smoke-tube superheater supplied by the same makers, which is likewise designed to give about 600° F. at the superheater outlet. In principle it consists of a series of loops or elements of solid cold-drawn steel tubing from ⅞-in. to ⅞-in. external diameter inserted in horizontal planes in the smoke-tubes of a cylindrical boiler and connected to suitable headers or collectors placed in front of the boiler. The saturated steam from the boiler stop valve enters the saturated-steam heater, the steam circulating through the elements in parallel and returning superheated to the superheater steam collector from which it goes to the engines. The elements are, therefore, in the direct path of the flue gases flowing from the combustion chamber to the smoke box. A feature of all these superheaters is the forged return bend, which eliminates the need for acetylene welding.—*"The Syren", Vol. CLXXIX, No. 2,328, 9th April, 1941, p. 52.*

Simplifying Machinery.

Information recently released regarding two new cargo ships equipped with steam reciprocating machinery, states that their boilers are fitted with superheaters. The wisdom of installing such refinements, *at the present time,* may be open to question. The almost universal practice of fitting superheaters to the boilers of modern steamships may make all the difference to the vessel as a commercial proposition, but such a point of view cannot be accepted in wartime. The power of a reciprocating engine is not increased by the use of superheated steam, nor do any advantages beyond that of reduced fuel consumption follow, so that the correct procedure should surely be the provision of arrangements for the fitting of superheaters in new ships after the conclusion of hostilities. Apart from the labour and special alloy steel used for their manufacture—which could be diverted to more useful purposes—the simpler the machinery of a cargo ship in wartime the better, for it does not generally receive the same attention, nor are there the usual facilities for repairs. One of the ways of increasing the output of ships at the present time is by making small economies which in the aggregate may have a considerable effect on the time of construction of both the hull and machinery, and, so far as the engine room is concerned, perhaps the only auxiliary beyond what is absolutely necessary for the working of the propelling machinery is the forced-draught installation. The employment of forced draught increases the evaporative power of the boilers, and hence the speed of the ship, which in wartime is of great importance.—*"Fairplay", Vol. CLVI, No. 3,022, 10th April, 1941, p. 387.*

The Bleeder Turbine.

In most marine steam turbines it is the practice for the steam to be completely expanded from the highest economical boiler pressure down to the most perfect vacuum that can be economically produced in the condenser, but even then the maximum efficiency attainable with such turbines is only about 30 per cent. Of the 70 per cent. of the total heat of the steam received from the boilers which is not converted into mechanical work at the turbine shaft, the greater part is lost to the circulating water when the exhaust is condensed. At first it was only tentatively realised that by bleeding L.P. steam from a turbine at an appropriate stage of expansion and leading it to the feed-water heater, it was possible to raise the temperature of the feed on the suction side of the feed pumps to something like 212° F. Nowadays, however, it is not uncommon to find that steam bled from the main turbines at appropriate stages is used for three or sometimes four stages of feed heating, thereby producing a final feed temperature of 320° F. or even 400° F. The recognised economy of utilising bled steam in this way has led to its employment for other purposes besides feed-water heating and it is now the usual practice in modern steamships to install L.P. evaporators which are operated by steam taken from the main turbines. Other uses of bled steam include the driving of turbo-generators at sea, cabin heating, domestic water heating and various hotel services. In the 8,000-s.h.p. experimental steamship now under construction for the U.S. Maritime Commission, in which a reheat cycle with steam at an initial pressure of 1,235 lb./in.^{2} and a temperature of 750° F. is to be used, there are to be four stages of feed heating, and a large evaporating plant will be operated with steam bled from the main turbines at a pressure of 115lb./in.^{2}. The capacity of this plant will be great enough to enable fresh-water storage tanks to be dispensed with, thereby increasing the d.w. carrying capacity of the vessel. Furthermore the ship's two 350-kW. turbo-generators will also be run on bled steam at sea, the steam being taken from the I.P. turbine inlet at a pressure of 230lb./in.^{2} abs. and 740° F., immediately after reheating. In port the generator turbines will, of course, be supplied with steam direct from the boilers.—*"Shipbuilding and Shipping Record", Vol. LVII, No. 16, 17th April, 1941, p. 364.*

Sea Water as Boiler Feed.

An article in a contemporary technical publication states that recent scientific development has revealed that practically any kind of water can be rendered suitable for boiler feed purposes by a simple process which is a form of filtration. Thus, sea water has been successfully converted into drinking water, and the author suggests that this should make ocean-going ships independent of water supplies carried on board. This discovery was made accidentally, and merely involves the passing of the water through ten different types of synthetic resins, whereby not only acidic or alkaline salts but also small organisms are removed, leaving pure water similar to distilled water, but at about one-tenth of the cost of distillation. The synthetic resins do not, apparently, undergo any change, although after a while they become saturated and cease to function, but they can be readily regenerated for further use.—*"Shipbuilding and Shipping Record", Vol. LVII, No. 14, 3rd April, 1941, p. 315.*

An Axial Position Indicator of Hydraulic Type for Large Turbine Plants.

In a Metropolitan-Vickers turbine the axial thrust due to steam flow is carried by thrust pads of the Michell type acting on the face of a thrust collar secured to the shaft. Although wear on these pads is negligible in normal service, it is nevertheless

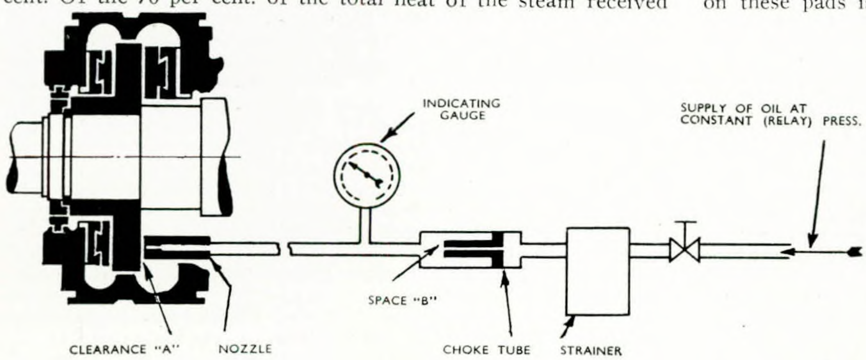


Fig. 1.—*Schematic diagram showing the operation of the Metrovick Axial Position Indicator for large turbine plants.*

desirable to keep it under observation as some abnormal operating condition might cause wear and so modify the axial setting of the rotor. The Metrovick hydraulic type position indicator provides a means of observing, while the turbine is in operation, whether or not such wear is taking place, without necessitating any actual contact between the stationary and rotating elements. The diagrammatic arrangement of the device is shown in Fig. 1. Oil at a constant pressure, derived from the turbine oil relay system, is fed through a choke tube of small bore to the space B, connected to which is a pressure indicator and a nozzle of small bore having the face at its open end registering, with clearance "A", against the face of the thrust collar on its pressure side. When this clearance is relatively large oil escapes freely, and the pressure in space "B", as indicated on the gauge, is correspondingly low, because the quantity of oil entering the space is limited by the choke tube. With wear of the thrust pads the clearance "A" would be reduced and, as less oil could then leave the nozzle, the gauge would show a proportionately higher reading, ultimately reaching the relay pressure when the clearance is reduced to zero. As the gauge reading depends on the ratio of the resistance of oil flow at the nozzle face to that at the choke tube, it is therefore independent of the viscosity of the oil. The ratio of the indicator pressure gauge reading to the relay oil pressure thus provides a sensitive index of the condition of the thrust pads, the needle of the former gauge, with the initial clearance "A" adopted, actually magnifying movement of the thrust collar some 300 times. In operation the nozzle clearance is to a small extent affected by the load which tends to decrease the oil film thickness at the pads and thus, at higher loads, the gauge pressures are somewhat higher than at low loads for any given thrust-pad setting. This variation, however, does not in any way detract from the utility of the device as these variations follow well defined lines and the necessary correction can easily be made. The principle of this device is based on the fact that in practice the wear, if any, occurs on the thrust pad faces and not on the hardened and polished thrust collar face. The construction is very simple. A pressure gauge, together with an oil strainer and stop valve, are formed into a compact unit and mounted in an accessible position on the turbine inlet end pedestal. *"The Metropolitan-Vickers Gazette", Vol. XIX, No. 332, April, 1941, p. 161.*

U.S. Coast Guard Cutters.

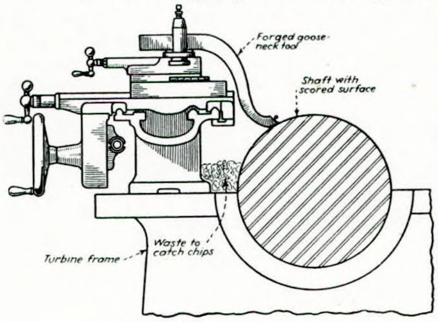
The U.S. Coast Guard authorities recently issued tender forms for the construction of 83-ft. wooden patrol cutters, firms being invited to bid for any number from two to forty. The boats are to be an improvement on the nine 80-ft. boats, numbered C.G.406 to C.G.414. built in 1937. and are to have a beam of 14ft. and a draught of about 4½ft. The contract speed is to be 20·5 knots, with two 600-h.p. petrol engines which will be furnished by the Service, together with the two generating sets. The hull is to be single planked, with combination steam-bent and web-framing, welded steel engine beds and girders, plywood bulkheads and decks, and a wheelhouse of welded metal. The boats are to have comfortable accommodation for two officers and eight ratings. — *"Shipbuilding and Shipping Record" Vol. LVII, No. 14, 3rd April, 1941, p. 315.*

Aluminium Condenser Tubes.

Aluminium brass and aluminium bronze condenser tubes have been used for about 15 years and have been progressively successful, more especially in tide-water power stations. They are cheaper than 70-30 copper-nickel tubes, but somewhat more expensive than Admiralty tubes. Although they have given excellent service in many marine installations, copper-nickel tubes are still favoured by shipowners as well as by the naval authorities. Aluminium brass tubes are usually made of an alloy consisting of about 76 per cent. copper, 22 per cent. zinc and 2 per cent. aluminium, while aluminium bronze tubes have 76 per cent. copper, 1·25 per cent. tin and 1·75 to 2·5 per cent. aluminium, the remainder being zinc. These proportions vary somewhat with different manufacturers, but may be considered more or less as an average. It is stated that the best aluminium tubes are equal or superior to the 70-30 copper nickel tubes and they are regarded as superior to Admiralty tubes. However, the definite superiority may be modified by the special condition of the circulating water and conditions of service, velocity of flow, turbulence, etc.— *"Marine Engineering and Shipping Review", Vol. XLVI, No. 3, March, 1941, p. 104.*

Truing Large Shafts in Position.

The device illustrated by the accompanying drawing from *Power* was used by the engineer of a power station in Hawaii to machine the badly scored bearing surfaces of the shaft of a 12,500-kVA steam turbine-generator without removing the shaft assembly from the turbine. The method consisted in removing the turbine bearing caps and bolting the bed and carriage of a 9-in. swing lathe to the turbine frame. The vee-ways of the lathe were aligned with the turbine shaft, and a goose-neck cutting tool forged specially to suit the job was mounted in the tool post. An old hoisting mechanism, driven by a 5-h.p. motor, was mounted on the floor and geared to the turbine shaft to drive it at a suitable speed. The tool was then fed along the scored journal by hand operation of the lathe carriage and an excellent finish was obtained quickly and at very moderate cost. A similar device may be applicable to the truing of other shafts *in situ*. In the present instance, the shaft assembly weighed 22 tons and apart from the time and trouble involved in removing it, there was no lathe in the neighbourhood capable of dealing with work of such size and weight. —*"The Power and Works Engineer", Vol. XXXVI, No. 418, April, 1941, p. 93.*



Rig of tool carrier.

Commutators and Brushgear.

Although commutation provides a very large proportion of the troubles experienced with d.c. motors and generators, there is no good reason, granted a reasonably balanced design and operation within the limits of good practice, why the functioning of this part of the machine should not be more or less trouble-free. In general, the first essential is that the commutator itself should be perfectly round. If it is not, no amount of attention to other parts will effect a cure. This cannot be too deeply stressed, and if the commutator surface is found to run untrue, immediate steps should be taken to remedy this. Filing should never be resorted to. Turning and/or grinding is the remedy. This can be done in a lathe or in the commutator's own bearings, using one of the special slide-rest or grinding attachments on the market. A lathe slide-rest is quite satisfactory, if room is available and if it can be mounted rigidly. The method used will depend upon the size of the commutator, and the facilities for handling. In certain circumstances the commutator can be ground under working conditions, provided that very light cuts are taken and that the terminal voltage of the machine does not exceed about 200. To turn a commutator in a lathe is not difficult, but certain points have to be watched. For copper only, it is usual to employ a fairly high speed, with a fair amount of rake on the tool, and if possible, to lubricate the cut. When turning a commutator composed of

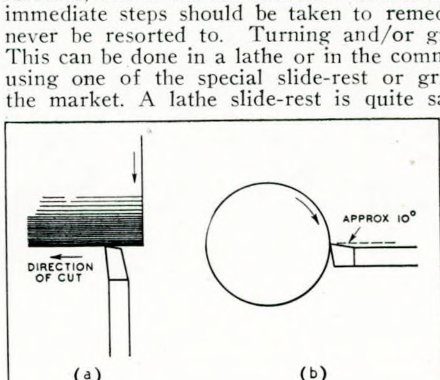


FIG. 1.—*Correct shape and angle of cutting tool.*

copper and mica in layers, however, the procedure is different. The speed should not be anything like so high, 100ft./minute is ample, nor should the tool have so much rake; 10° will be sufficient, and the tool must be hard (carbon steel will do) and kept dead sharp. A slightly blunt tool will cause the edges of the copper to drag and burr over. Cutting lubricant must never be used on a commutator of this type. Figs. 1 (a) and (b) illustrate the shape of the turning tool. The cutting point (not the edge!) should be *very slightly* rounded, and the clearance angle between the back edge of the tool and the commutator surface should be kept fairly small, to ensure a smooth cut. It is not difficult, by suitable adjustment of tool angle, to obtain a finishing cut which is reasonably smooth and only requires finishing off with fine glass-paper. The use of a file for this purpose is to be strongly discouraged. Undercutting of the mica has always provided matter for controversy. Admittedly in some cases it has been found in practice that undercutting is not essential, the deciding factors being the relative grades of hardness of mica, copper, and brushes. It has been found, however, especially in dealing with machines whose antecedents are unknown, as in general service and repair work, that it is desirable to undercut slightly all commutators. This is an operation requiring a considerable amount of care in ensuring that the undercutting is complete and for the full width of the bars. A section of the commutator should appear, as in Fig. 2 (a), which shows the full width of the mica recessed, and not as in Fig. 2 (b) where only the centre portion of the mica is recessed. The only reasonable way of achieving the correct result is to use a blade or cutter operating on the full width of the mica. No commutator - turning job is complete without a careful inspection to make sure that the edges of the segments have not been burred over anywhere to constitute a short-circuit between segments. If there is the slightest doubt, a drop-test should be made; indeed, it is good practice in every case. The copper dust and turnings should also be cleaned out from between the risers, and, prevention being better than cure, steps should be taken to keep them out during the turning by fitting a ring of cardboard or fibre closely against the risers. In practice, however, it has been found that this measure, although fairly effective, does not keep all the particles out and it is still desirable to go round the risers with a pair of bellows, or jet of air from the cleaning compressor, to complete the job. An irregular commutator surface may be due to a few loose segments, which may project above or be recessed below the remainder. In such a case, turning or grinding alone would not effect a cure, and the trouble would recur almost immediately. The commutator should first of all be heated, either by the application of external heat to the commutator only, or by stoving the whole armature. The heat should be sufficient to soften slightly the shellac with which the micanite end rings are bound. The clamping bolts or end ring should then be tightened and, after the copper has cooled, the turning or grinding process, followed by undercutting, should be carried out. If high micas only are the cause of bad commutation, a cure may be effected, if the trouble is not severe, by undercutting and polishing only. A commutator may be perfectly round, and run true, but grooves may be found of various widths and depths. If the surface of the copper, although grooved, is good and has a well-polished appearance, it is a mistake to turn it on account of the grooves alone. This grooving is hardly a fault and is due, where the grooves are of the full width of the brush, to the brushes on the various rocker arms having all been set dead in line. A point worth remembering after turning is to stagger the brushes on alternate arms, across the width of the commutator as shown in Fig. 3. The other chief causes of grooving are unsuitable brushes, and an accession of abrasive matter in the form of dust. Dust from external sources is one of the big worries of engineers. No general rules can be laid down, but periodic efficient cleaning will go a long way towards preventing trouble in all but the most acute cases. In the case of a machine having a number of brushes in box-type brush-holders on each rocker arm, it is important that each brush should be complete with its flexible lead or tag, and that the lead should be properly connected to its terminal. The brushes with faulty tags will burn at the sides and stick in the holders, thus causing bad sparking at the commutator. Owing to resulting unequal current distribution between the brushes, the previously sound brushes will be overloaded with consequent increased sparking and burning of the tags. If unequal current distribution is indicated, a careful inspection should be made. Some of the flexible leads may be loose at the point where they are moulded into the brushes, the spade ends on the leads may be oxidised, or the solder may have run out of the spade where the lead enters. As a result of any of these apparently trivial faults, the inner surface of the brush-holder will have to carry the current. There have been cases where most of the brush-holder has melted away as the result of a broken lead. Holders of the zinc-base white-metal type are found to be particularly prone to this trouble. Brush tension, too, plays an important part in the current distribution. The tension on the brushes in any one rocker arm should be the same. Inspection may reveal that owing to the failure of the tags, the springs have had to help to carry the current, with disastrous results. Box-type brush-holders should be quite satisfactory if mounted radially, that is, with brushes at right angles to the surface of contact with the commutator. Some makers, however, prefer to incline the holders at a small angle, but in these cases the machine will run perfectly, so far as commutation is concerned, in one direction only as indicated in Fig. 4. There are, however, very many cases where the reverse procedure has been used, which invariably results in a deep groove being worn in the brush at the point X. with consequent jamming in the holder. While the effect of this is not quite so marked if the holder is fairly long and the brush a good fit, nevertheless, it is there, and is a point worth watching. Another fault is incorrect alignment of brush-holders on any one rocker arm. With some types of holder, it is fairly easy for individual brushes to be set the width of a segment out of line, with the result that the brushes as a whole cover more segments than allowed for in the design, resulting again in bad commutation. The maximum tolerance should be the width of a mica segment, and the correct procedure is to set the brushes in line with one of the mica segments with the machine stationary. The brush spacing round the commutator should also be equal. Even if the brushes on each arm are in line, it is still possible, owing to the inclination of one arm, for the whole of one line to be out of place with respect to the others. If the radial setting is adopted, see that the brushes *are* set radially, and if the brushes are to be inclined, see that the inclination is the same on all arms. Normally, any departure from the grade of brush fitted originally by the manufacturers is to be deprecated. Where, however, abnormal working conditions demand such a change, it should only be done after due consideration of the disadvantages which may result. It will rarely be found that a better choice of brush can be made, having regard to all the points involved. In any case, the manufacturers should be consulted. Where in order to keep the plant going, temporary brushes have to be fitted, these should be as near as possible to the original grade. If they have to be used along with others of the original set, they should be divided among the rocker arms. On no account should they all be fitted to one arm. It must always be remembered that the expedient is only temporary and

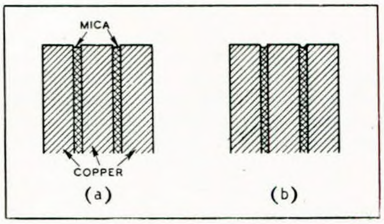


FIG. 2.—*The full width of the mica should be cut as in (a) not in part as in (b).*

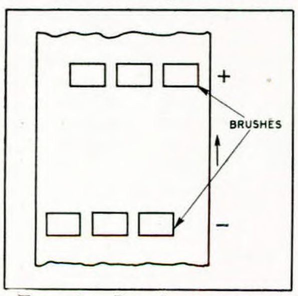


FIG. 3.—*Brushes staggered on alternate arms.*

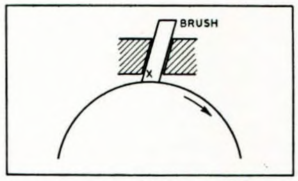


FIG. 4.—*Correct direction of rotation with brushes set at an angle.*

the performance of the machine must be carefully watched until the correct brushes are available. One final point: without going further into the relationship between winding faults and commutation, reference may be made to the effect of the interpole windings. It is not unknown for the interpole connections to have been reversed after an overhaul, or even on a new machine from the manufacturers. When sparking is very bad at all brushes as the load increases, everything else being fairly obviously in order, the interpole connections should be checked. Although it is not usually easy to confuse these connections, as they are of heavy section and fairly rigid, such cases have been known, and nothing should be taken for granted, least of all, electrical connections.—*J. E. Noble. "Electrical Review", Vol. CXXVIII, No. 3,308, 18th April, 1941, pp. 563-564.*

Repairing Gear Teeth.

Broken teeth can be replaced on grey iron and steel gears by oxy-acetylene fusion welding but not on automobile transmission gears except as an emergency repair. These wheels are generally made of alloy steel and specially heat-treated. If a suitable gear cutter is available, the preferable method is to build-in the broken teeth and adjacent tooth spaces solid with new metal and then cut two spaces. Obviously, if a gear cutter is not available considerable hand work is necessary. A method not so likely to produce a good job is to build in the tooth with carbon blocks alongside, and finish by filing to the shape of the other teeth. Hereunder is a brief description of another method which has been used to repair a broken tooth in a driving gear of a water pump. The tooth having been completely broken away and the wheel being found soft enough, four 9/64in. equally spaced holes were drilled along a centre line at the root of the tooth. These holes were then tapped 3/16in. Whitworth, and four pieces of 3/16in. diam. mild steel rod, ¼in. long, were screwed and fitted in position. The spaces between these pins were carefully filled by means of an oxy-acetylene flame, and the tooth was then filed up to shape and size.—*A. Selby, "The Machinist". Vol. 85, No. 3, 12th April, 1941, p. 25*E.

Building Up Bronze Propeller Shafts.

Two 3in. diameter bronze propeller shafts 12ft. 3in. long were found to have suffered considerable wear and grooving over a length of some 15 inches. In each case a groove ⅜in. in depth and approximately 2in. wide in addition to general wear varying from ¼in. in depth was discovered. The grooving had apparently taken place at the main bearing surface in the form of a series of deep ridges or grooves. 3/16in. Bronzotectic rods were used together with Bronzotectic flux. A United Service blowpipe with a No. 10 head was employed and the deposit was made systematically in order not to pull the shafts out of alignment. In view of the heat which it was necessary to put into these rather slender shafts, it was decided not to lightly hammer the deposit as is usually recommended when depositing Bronzotectic. The risk of distorting the shafts by such additional stress was considered to be too great, the deposits, therefore, were perfectly straightforward. Eight packets of 3/16in. Bronzotectic rods were consumed with ¾lb. of flux. Gas consumption worked out at oxygen 800ft., acetylene 700ft. The time taken for both shafts was 19 hours. This job was completed in January, 1940, and has since proved highly satisfactory.—*"Industrial Gases", Vol. 21, No. 3, April, 1941, p. 135.*

Performance of Sun-Doxford-engined Passenger Liner.

The "City of New York", built 11 years ago for the American-South African Line's service between New York and South African ports, has covered 600,000 nautical miles at an average speed of 13½ knots. She is equipped with two four-cylinder 2,700-b.h.p. Sun-Doxford engines and has proved remarkably successful. Not a single cylinder liner has been replaced in 600,000 miles and only routine repairs have been made. The engines were not even opened out for bearing examination until they had been in service 1½ years. The "City of New York" was placed in commission on 1st February, 1930, and made an average round trip of 18,000 miles in 97 days. It is stated that she has never been stopped at sea.—*"The Motor Ship", Vol. XXII, No. 255, April, 1941, p. 16.*

Interchangeability of Marine Motors.

The maintenance costs of high-speed compression ignition engines, as fitted to modern motor vehicles, are undeniably less, per hour run, than those of the lower-speed compression-ignition engines installed in fishing boats, notwithstanding the fact that the latter are not subjected to road shocks. A fundamental difference between the running of a lorry engine and a marine oil engine is that in the former the water temperature is kept high, whereas in the boat it is low. There being a definite temperature at which the best results are obtained, it is evident that the boat engine will suffer by reason of running well below that temperature. The remedy, of course, is to adopt the more correct plan of closed-circuit fresh-water cooling, with salt-water circulation to control the water temperature. This would enable a simple impeller to be used in the circulating pump, speeding up the flow of circulating water and simplifying the problems of strainers, and circulating pump glands and valves. The effect would be to make the marine engine virtually similar to the standard lorry engine, apart from problems connected with the reverse gear, and bilge and salt-water circulating pumps. It is obvious, however, that it would be all to the good to make the boat engine identical with the lorry engine, especially from the aspect of maintenance costs, so let us remove the reverse gear from the engine and drive the bilge pump from the reverse gear instead of from the engine. The higher speed of the lorry entails the use of a reducing gear, but that is becoming standard practice in any case, and therefore is no problem. Reverse-reduction gears of the S.L.M. type have certain definite advantages as regards durability, to say nothing of the way in which they facilitate the fitting of adequate engine bearers. The reverse gear could be mounted on a sub-base and would embody the bilge and water-circulating pumps, both of which would be arranged to draw from the bilge, if required. The connection from the reverse-gear input shaft to the engine would be through a flexible coupling, thereby simplifying the problem of alignment. The changing of a boat's engine should then become a matter of hours instead of several days, always provided that the skylight over the engine is made large enough to allow the engine to pass through it, if not horizontally, at any rate on end. Suitable eyebolts at the correct points would make the lifting of the engine a simple matter and the only connections which would have to be broken would be those between the engine and the cooling system, the fuel pipe from the service tank to the engine, and the engine exhaust. If the facings for these pipes could be arranged in the same position on all engines, the job would be a simple one. Furthermore, it should be possible to standardise certain dimensions for engines of all makes of similar powers and speeds. If the dimension from crankshaft centre to bottom of sump, the pitch and number of holding-down bolts, distance of holding-down bolts from crankshaft flange face, and the positions of the exhaust-pipe outlet facing, a circulating water inflow and return facings were the same for all engines, any engine of a given power and speed could be made to fit on any sub-base. At first sight, this might appear to be a big request to make to the engine builders. An alternative would be that any one firm adopting the system, and succeeding (as it undoubtedly would) in giving users better overhauling at lower prices, would collect a very large proportion of the business available. From the users' point of view, and from that of methodical improvement based on users' experience, it would be most advantageous if all the well-known engine builders made a standard model (say, 120 b.h.p. at 1,600 r.p.m.) embodying the special features of each make, but capable of being installed on a standard sub-base, and connected to a standard reverse-reduction gear. It is suggested that no provision should be made for driving a winch off the engine, this being a most improper way of driving a winch, bad both for the winch and the engine. The same principle could be followed, however, with the auxiliary engine, *i.e.*, its dimensions could be standardised, so that any make would fit any bed. By standardising the reverse-gear ratios, and the centres between the input and output shafts, makers could fit their gears to certain standard beds. The shipbuilder would tend to become the main contractor, fitting reverse gears and sub-bases to fishing craft, at any rate, and leaving the owner free to fit any of a certain number of engines, with ability to change his engine for another make at some future date without any modification to the boat or its fittings. The advantage to both owner and engine builder of the use of an absolutely standard lorry-type engine cannot be overstated. Reconditioning could be done on shore, under proper conditions, and there would be none of the exasperating delays accompanying repairs done in the boat; all too frequently hastily done under the stimulus of an impatient owner who wants to get to sea, and frequently resulting in further breakdown, loss of time and increase in bills. It seems abundantly clear that to get the best out of an engine it should be refitted systematically after so many hours' service. Good running is mainly a matter of clearances; if those clearances are maintained correct, running expenses will be low. Finally, by the method outlined, spare engines properly reconditioned, could be kept available all round the coast, and fitted as required, by the minimum of staff, with a maximum of expedition.—*K. W. Williams, "Engineering", Vol. 151, No. 3,297, 18th April, 1941, p. 316.*

The Computation of Stresses in a Propeller Blade Section.

After explaining the late Admiral D. W. Taylor's method of separating the fore-and-aft moment produced by the thrust and the transverse moment produced by the torque, the author describes how these moments can be used to determine the centrifugal and compressive stresses on the blade and root sections, as well as the tensile stresses on the face of a root section. He also shows how the size of the studs for securing the blades of built-up propellers may be computed.—*Paper by S. A. Smith, M.Sc.(Eng.) "Transactions of the Institute of Marine Engineers", Vol. LIII, No. 3, April, 1941, pp. 39-50.*

Noise and Hammering in Heating Systems.

Noise in a heating system is a nuisance; hammering is both a nuisance, because of the noise it creates, and an evil, because it may cause leakage at the pipe joints, and even fracture of pipes and radiators. It is common knowledge that a small volume of air imprisoned in any water circulating system, commonly described as an air lock or pocket, more or less checks the circulation, and impeded circulation has undoubtedly an important bearing on noise and hammering. Mr. H. H. Bruce, in a paper read before the East Midlands Branch of the Heating and Ventilating Engineers' Institution, described some interesting experiments made with ½-in. bore glass tubing to observe the behaviour of air and water in pipes. The tubing was arranged to represent a vertical drop at the lower end of a sloping pipe. The rate of water flow was adjusted until an air bubble about 3in. long was held stationary in the vertical pipe. Although the bubble seemed to occupy the whole bore of the pipe for a height of about 3in., a film of water could be seen flowing rapidly between the outside of the bubble and the inner surface of the pipe, and the velocity of this film must have been enormous. The lower end of the bubble was exceedingly agitated, and some of the air was detached and formed into very small bubbles, a portion of which were carried down and out of the vertical pipe (Fig. 1). It is pointed out that the vigorous behaviour of the air and water in the vertical pipe would explain why mysterious noises are emitted by heating and hot water supply systems. The velocity of water flow is an important factor in the production of noise, and noise may generally be expected if the velocity exceeds 5ft./sec. anywhere in the system. Velocities are kept down by using large pipes, and if the pipes are arranged to give a free flow to the water at all parts. *i.e.,* by avoiding contractions, sudden changes of direction, and dips or loops where air could collect, much will be done to guard against both noise and hammering troubles. As far as possible, air should be prevented from entering the system, and any places where air could collect should be suitably vented. The sectional area of the pipes is reduced, and the velocity of flow consequently increased, if scale is allowed to form in the pipes at any part; scale, therefore, may be responsible for faulty circulation, noise and hammering. If scale forms in the pipes of a hot-water heating system, or on the boiler heating surfaces, overheating may occur, with risk of cracking of cast-iron boilers, and the temperature of the water in the boiler may gradually rise until steam is formed. This steam, passing into the pipes and condensing there, may be responsible for heavy hammering. Most water hammer occurs when a quantity of water in a length of piping is driven violently forward by steam, or when water lying in a more or less horizontal length of piping is violently agitated by the admission of steam into the pipes. Such action sometimes occurs in steam heating systems because water of condensation is not effectively drained away from the pipes. The quantity of water formed by condensation when steam is first

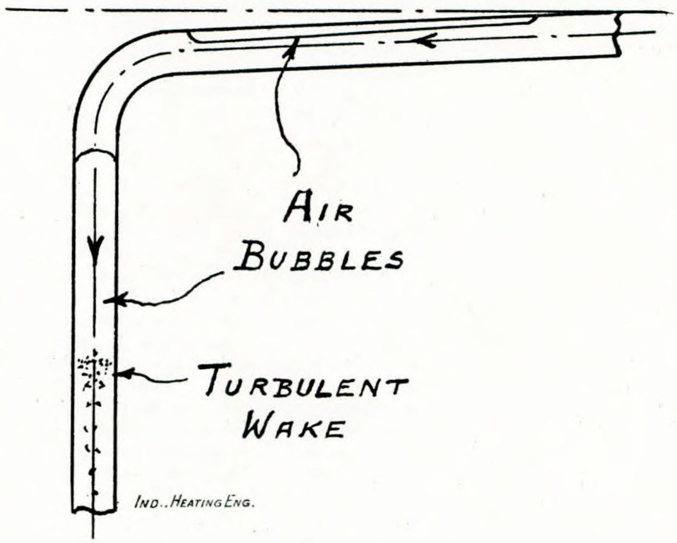


FIG. 1.

turned into comparatively cold pipes is considerable, and all drain pipes must, therefore, be kept quite clear, and taps, valves and traps maintained in good order. It is no uncommon thing for hammering to occur when steam is first turned into a heating system, and to persist for some time, and in such cases the cause is, more often than not, attributable to choked drains and faulty operation of traps. One cause of choked drains and faulty trap operation is want of care to keep dirt and foreign matter out of the pipes when or before the installation is erected, and the lavish use of jointing material in the making of the pipe joints. In one instance where loud and persistent water hammer was experienced after steam was turned on, the cause was traced to a scale-choked drain at the bottom of a receiving tank into which the boiler feed water, which contained considerable impurities, was delivered. In another instance, where water hammer occurred and smashed a cast-iron radiator, the cause was attributed to the valve of the trap having very little lift, so that it failed to remove fast enough the water of condensation which formed in the piping between the radiator and the trap. The valve was surrounded by small pieces of scale, a reminder that solid matter can be carried over from the boilers by the steam. With very extensive steam heating systems the quantity of water of condensation formed in the pipes when the steam is first turned into them may be so great that the traps cannot cope with it, so that water hammer takes place. To meet this difficulty, the traps can be fitted with by-passes, and if these be opened before the steam is admitted to the pipes, the water of condensation will be drained away as fast as it is formed, independently of the traps, and hammering thus avoided. A by-pass has the additional advantage that it enables the trap to be disconnected any time for overhaul or repair. Most people are familiar with the noise and hammering which often follow the quick opening or closing of a tap connected with a household water system. Quick opening sets the stationary water in the pipes suddenly in motion, under the pressure due to the head of water above the tap, and this may create a disturbance which is unpleasantly audible. Quick closing of a tap arrests the flowing water more or less suddenly, and is likely to produce more pronounced effects than is quick opening. Sometimes, the disturbance at the tap is transmitted back along the pipes to the ball tap in the supply system, and this is followed by a reactionary effect, and so on, the disturbance in some cases continuing for some time. Evidently, taps should be opened and closed very gradually if this trouble is to be prevented, and the taps should be maintained in easy working order so that there will be no difficulty in operating them very gradually.—*E. Ingham, "The Industrial Heating Engineer", Vol. III, No. 10, April, 1941, pp. 27-28.*

The Ventilation of Workshops.

Experiments have shown that the air in a room or building should be renewed completely about every ten minutes to provide

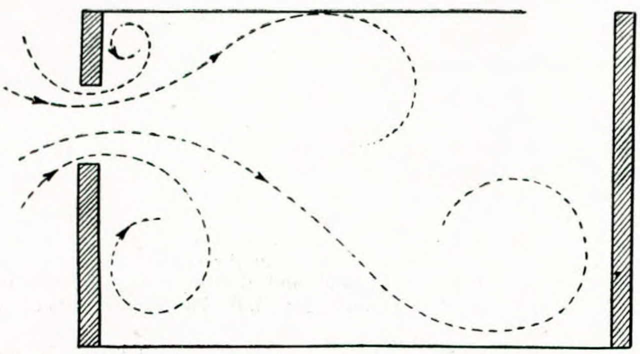


FIG. 1.—*Showing how the flow of air current is converted into swirls.*

fully healthy conditions for breathing. This figure varies slightly, according to the size of the room and the work of the occupants. There is an erroneous idea that the unhealthiness of a room is measured by the amount of carbon dioxide in the air,

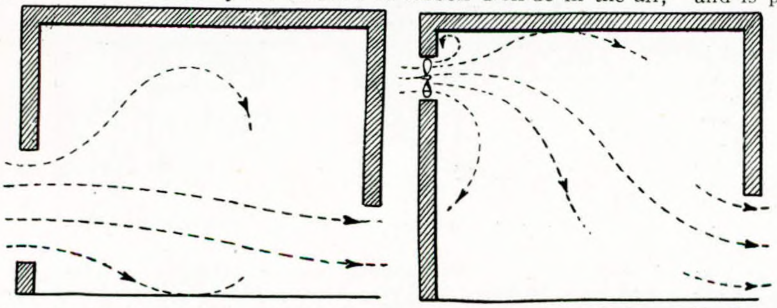


FIG. 2.—(*a*) *Room being fed with air by means of a window;* (*b*) *Room obtaining air by means of a fan.*

but researches have shown that the presence of organic impurities, such as those exhaled by the body, are more important in contributing to the unhealthiness. Then again, the humidity in the air is another factor, because this determines the rate of evaporation of perspiration from the human body, which, in turn, governs the general condition of the person. An adequate flow of air serves both to ventilate and cool; and the necessity of cooling a space containing a number of people will be readily appreciated when it is stated that an average man, when resting, radiates about 400 B.Th.U./hr., but that if he moves about or performs manual labour, this figure mav wel' be doubled. Generally speaking, twice the number of people can work in a ventilated workshop as in an unventilated one, and the quantity of fresh air to be supplied in the former case must not be less than 450 cu. ft. per person per hour. An air current does not mean a flow of air in a straight line. Fluids, including gases, flow in one of two states: the streamlined state and the turbulent. With air the latter is likely to predominate, the flow or air current being made up of a number of swirls, as shown in Fig. 1. The turbulent flow of the air enables it to penetrate to every corner of the room, sweeping out stale pockets of air. A turbulent flow of air, however, is *not* synonymous with a draught and it is precisely the absence of draughts in the ventilation of a space which indicates its efficiency. The problem is to get plenty of air through, to enable the atmosphere to be maintained at a constant temperature without any *localised* cooling or draught. With fans there is practically no limit to the amount of air that one can push into a room; one can also cool the air artificially, if desired, to bring down the temperature inside or to keep it level in hot weather. The art of ventilation, however, consists in keeping the air in a room fresh without causing discomfort to the occupants. The velocity of the air flow through a room is necessarily governed by the shape or size of the latter as well as by the pressure of the incoming air. The lower the pressure of the inlet air the greater should be the aperture through which it can enter and also leave. Fig. 2 illustrates this point, (*a*) being fed with air by means of a window, the pressure of air depending on the speed of the wind outside, while (*b*) gets its supply by means of a fan, which creates an artificial pressure. As may be seen, the aperture at the inlet and outlet of the latter room is much smaller than in the former case. Air flow can, of course, be controlled by the use of air-conditioning plant to such an extent as to eliminate draughts completely, the velocity of the inflowing air being kept to the minimum for full ventilation and air being admitted at locations where the stream can diffuse without obstruction. Although it may be possible to ventilate small workshops by natural means, such as windows, louvres and air shafts, it is customary to employ fans in large workshops. Three main types of fan are used for forced ventilation, *viz.:* centrifugal, cone and disc fans. The first-named resembles a water wheel, the cone type has blades of slightly conical shape, while the disc fan has blades with two planes of curvature. Fig. 3 (*a*) and (*b*) illustrate a centrifugal and disc fan respectively. The velocity of the air delivered by a fan must be equal to that of the blade tips and is proportional to the area of the fan outlet. The latter is sometimes referred to as the blast area and is, in effect, the area of outlet from the fan at which the air velocity equals the blade-tip speed. If D is the diameter of the fan and *w* its width of blade, then the blast area may be reckoned as $\frac{Dw}{3}$. Thus in the case of a 6-ft. dia. fan 2ft. wide at the circumference, with a rotational speed of 200 r.p.m., the blast area is $\frac{6\times 2}{3}=4$ft.², and the tip speed $200\times 6\times 3{\cdot}1416=$ 3,769ft./min. Therefore the *theoretical* amount of air delivered by the fan is $4\times 3{,}769=15{,}076$ cu. ft./min. Taking a renewal of air every ten minutes as a minimum health standard, such an air supply would serve a shop of about 200ft.×50ft.×15ft. The type of work done, however, would influence this figure and would probably reduce the size of the shop calculated. As regards the power required to supply a known volume of air to a building, if P is the discharge

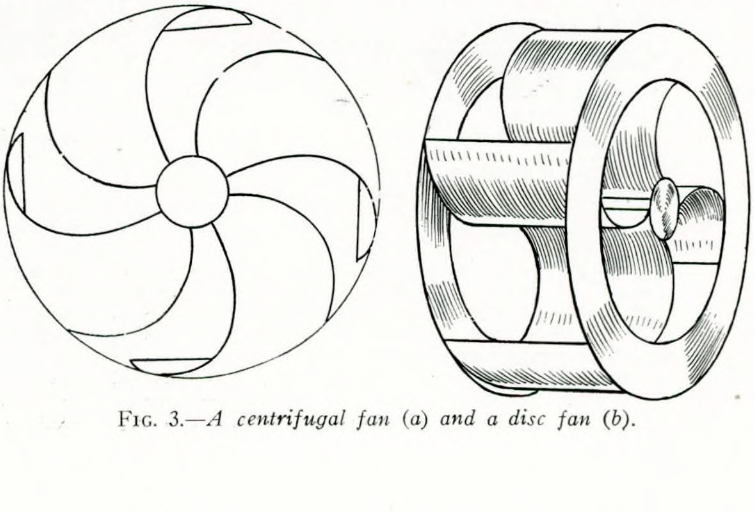
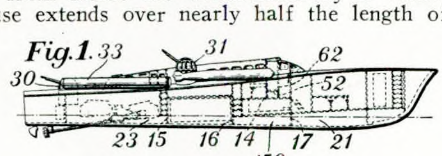


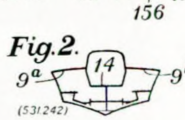
FIG. 3.—*A centrifugal fan* (*a*) *and a disc fan* (*b*).

pressure of the air from the fan in lb./ft.², V the air speed in ft./min., and A the area in sq. ft. over which P is exerted, then the relation W = PAV holds,, where W is expressed in ft. pounds/min. In order to determine the corresponding h.p. it is necessary to know the mass or weight of air which has to be driven forward by the fan. The power required is then given by the relation $\text{h.p.} = \frac{d\,a\,v^3}{5{,}100{,}480}$ where d = density of air at the particular temperature, a = area (effective) of outlet from the fan in sq. in., and v = speed of air flow in ft./sec. The pressure of an air current through a vent determines the amount of air flowing, whether or not a fan is used, so that the higher the pressure induced by a fan, the greater is the delivery of air. Certain practical aspects of workshop ventilation must also be taken into account, even where humidity or temperature need not be accurately controlled. For example, where a fan cannot be fitted in the wall of a building, it becomes necessary to employ air ducts of suitable design and proportions. If a fan is worked at too high a speed it not only loses power but tends to roar, and where air ducts are installed the noise may be carried along and amplified, producing an unpleasant, persistent noise throughout the ventilating system. It may be necessary to seek a compromise between air pressure in the system and the requiremnts for adequate ventilation. Too high a pressure may cause roaring, while too low a pressure may fail to offset the effect of a high wind outside the building.—*E. A. Smith, "Practical Engineering", Vol. 8, No. 63, 5th April, 1941, pp. 331-333.*

Improved Design of Motor Torpedo-boat.

A recently published British patent granted to H. Scott-Paine, of Hythe, is in respect of a motor torpedo-boat which he claims to be inconspicuous as a target, but which possesses good sea-keeping qualities in all weathers and is capable of high speeds in rough seas. The hull is of the hard-chine type and constructed so that the sheer lines of the gunwhale provide a smoothly-curved contour extending from a high-freeboard portion forward to a lower platform aft. The vessel illustrated in the accompanying diagrams is about 70ft. in length, the still water-line being shown chain-dotted. The freeboard between this line and the deck at the forward end of the boat is about 8ft. and approximately half this amount at the stern. The maximum headroom below the deck is just greater than the height of a man. The wheel-house floor (14) is below deck level, but of substantially less width than the beam, so that the wheel-house projects very little above the deck. Flattening of the camber combined with a downward slope of the deck in front of the wheel-house gives a low sight-line. The sides of the boat are flared outwards and the stem itself is flared forward to secure continuity of this feature. The wheel-house has a conning bridge constituted by a cockpit (62) which opens through the roof to command the whole of the boat, its floor (52) being above the level of the floor of the wheel-house. Access to the conning bridge is from inside the wheel-house by a W.T. door. The wheel-house extends over nearly half the length of the vessel

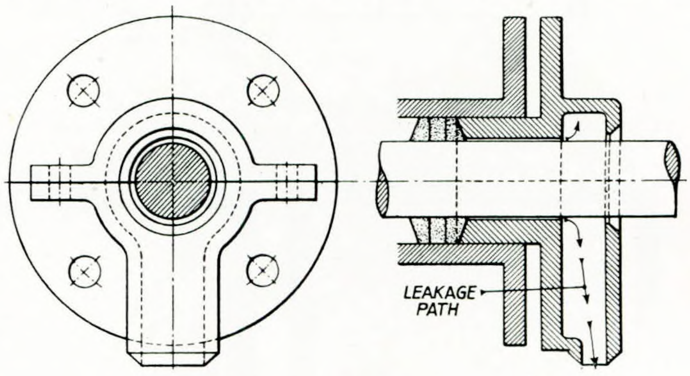




and is located approximately in the middle of it. Three water-tight bulkheads (15, 16 and 17) divide the boat into a compartment (21) with full headroom which accommodates the crew, a compartment (156) for the officers and the W/T equipment, a compartment containing fuel tanks and an engine room (23) containing three engines. Access to the crew's quarters is obtained from inside the wheel-house by a door forward of the cockpit. The officers' compartment (156) has the floor (14) of the wheel-house in it and sleeping berths are provided under this floor, the remainder of the space below the sides of the deck (9*a* and 9*b*) having full headroom. The wheel-house provides light and addditional headroom in the engine room, and also serves to provide communication under cover between all compartments, the inconspicuousness of the boat being enhanced by the smooth and unbroken silhouettte. The stern portion of the boat is long enough to accommodate two torpedo tubes (33), the torpedoes being stowed on deck, forward of the tubes. Automatic gun turrets (30 and 31) of the enclosed type used in aircraft are fitted amidships and aft. The mast, bollards, towing post, etc., are housed below deck level when not in use.—*"Engineering", Vol. 151, No. 3929, 2nd May, 1941, p. 360.*

Leaky Pump Glands.

The fact that it often pays to allow the glands of centrifugal pumps to weep rather than tighten them up to bone dry, affects, of course, pumps other than those handling pure water. In one particular instance the pumps were dealing with a 10 per cent. acid solution which was very corrosive, and although the pumps themselves were made of silicon iron and resisted the potential corrosion in a satisfactory manner, the bedplate, supports and pedestal, which were of cast iron or mild steel, were subject to attack by the solution that leaked from the glands. No provision was made by the makers to catch and dispose of this leakage and the first attempt to overcome the difficulty was to make up

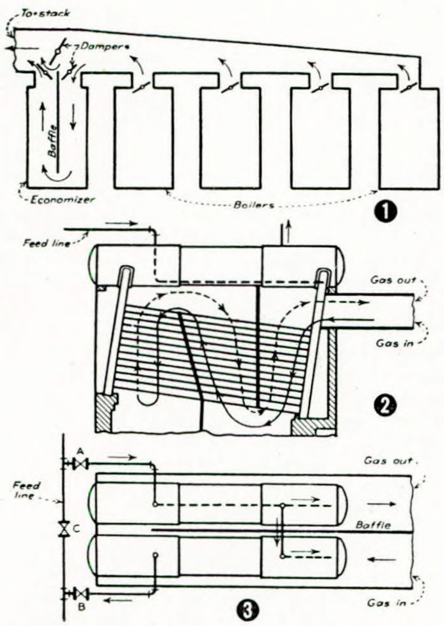


Special gland piece to trap corrosive leakage.

loose lead trays; these were designed to fit under the glands and each had an inverted U-shaped piece over the shaft to prevent the acid from being flung out. These trays, however, provided only a partial cure, and it finally became necessary to make new stuffing-box necks from castings as indicated in the accompanying sketch. The new stuffing-box sleeves are split and each has an external enclosure with a proper drain connection; leakage passing along the shaft is flung off in the annular space and runs down into the drain without splashing about. This new type of stuffing-box has proved satisfactory for a number of years.—*"The Power and Works Engineer", Vol. XXXVI, No. 419, May, 1941, p. 114.*

Water-tube Boiler Used as Economiser.

A saving of some £300 p.a. on the coal bill has been effected by converting a double-longitudinal-drum boiler for use as an economiser at a cost of £100. The installation comprises five boilers of which no more than three are ever in use at any one time, hence the decision to convert the one nearest the stack for use as an economiser. The tubes at the centre of the boiler were removed to permit of the insertion of a vertical longitudinal baffle, the origianl baffles being left unaltered. This provides for the flow of gases through the banks of tubes as shown at (2) and (3) in the accompanying illustration, three dampers enabling the gas flow to be directed through the economiser or passed straight to the stack as required. The feed-water connections enable cold feed to be admitted at the back ends of the drums as shown,



and the valves *A, B* and *C* allow the economiser to be put in or out of circuit at will. Normally, about 25 per cent. of the gases from the three boilers in service is passed through the economiser, the temperature of the gases being reduced by 180° F. and that of the feed water increased by 50° F.—*N. T. Pef (in "Power) summarised in "The Power and Works Engineer", Vol. XXXVI, No. 419, May, 1941, p. 118.*

Improved End Closure for Journal Bearings.

A novel form of end closure (in respect of which a patent has been applied for) has been developed by a well-known American firm of engineers. Known as the "Crown Ring" end closure for journal bearings, it is claimed to prevent oil leakage around any shaft which is not submerged in oil or flooded with it next to the closures. The complete closure consists of the crown ring itself and an outer adapter ring with internal "comb teeth" designed to prevent the entry of water or dirt. Oil is pushed back by this serrated inner edge and thrown off instead of following the shaft, only enough oil entering the crown ring to lubricate it. The latter is made in halves for assembling and loosely held in the adapter, so that it can follow slight radial movements of the shaft, such as take place with a self-aligning bearing. The comb has sufficient clearance to permit such movements and may have two or three rows of "teeth" (according to requirements), the last space between them draining to a sump. If much water is expected (*e.g.*, in a dredge pump) a thrower may be attached to the shaft and the adapter may form a shield around the thrower. This crown ring is claimed to be non-wearing and to require no attention. In combination with an adapter of suitable form, it makes an effective closure for ships' propeller bearings and heavy-duty bearings generally.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 4, April, 1941, p. 102.*

The American Steamship "Robin Locksley".

The 7,100-ton steamer "Robin Locksley", recently completed at Sparrows Point for the Seas Shipping Company at a cost of $2,250,000, is the first of six new vessels designed for the firm's cargo service, between New York, Baltimore and eleven ports of call in South and East Africa. The round trip involves a voyage of 20,300 nautical miles and includes a call at Trinidad on the homeward voyage, for oil fuel. The ship has an overall length of 479ft. 8in., a moulded breadth of 66ft., and a depth to shelter deck of 43ft. The displacement is just over 15,000 tons at the designed load draught of 27ft. and the corresponding d.w. capacity is 10,000 tons. There are three continuous and perfectly flat decks. The hull is divided into eight W.T. compartments and the continuous cellular double bottom is arranged for the carriage of fresh water (of which 613 tons are carried in the D.B. and separate tanks) and oil fuel (of which about 1,850 tons are carried in the D.B. and deep tanks). The peak tanks are used for salt water ballast. There are five cargo holds, three forward of the machinery space and two aft, with a total capacity of 608,670 cu. ft. (bale), including four refrigerated cargo spaces on the second deck with a capacity of 11,530 cu. ft. and two special cargo compartments of 3,485 cu. ft. on the shelter deck. The cargo-handling equipment comprises one 30-ton, one 10-ton and sixteen 5-ton derricks, served by sixteen electric winches. An unusual feature of the vessel is the provision of accommodation for 12 passengers in eight staterooms, each with a private bath or shower, grouped around two verandas, one port and one starboard, with a central lounge amidships which also serves as a dining saloon. It is claimed that there is no published record of any ship of comparable size carrying a limited number of passengers, which possesses accommodation of such luxury and comfort. The propelling machinery is of the standard design adopted by the U.S. Maritime Commission for all their steamships, and comprises a set of cross-compound turbines driving a single propeller at 85 r.p.m. through D.R. gearing and having a normal output of 6,300 s.h.p. Steam at 450lb./in.^{2} pressure and 750° F. total temperature is supplied by two oil-fired Babcock and Wilcox sectional-header boilers equipped with interdeck superheaters, water-cooled furnaces and horizontal tubular air heaters. The boilers are fitted with the Bailey automatic control system and are located at the forward end of the machinery space which, in addition to the main turbines and gears, contains two 300-kW. turbo-generators and a varied assortment of auxiliary machinery, much of which is electrically driven. Although the machinery compartment also contains a large engineers' workshop, an electrical storeroom and two large fresh-water tanks flanking the boilers, its total length is only 50ft. A 10-kW. Diesel-driven dynamo for emergency use is fitted in a compartment on the bridge deck. All the cargo holds except the refrigerated spaces are equipped with Cargocaire ventilation, while the living spaces for the passengers and crew are fitted with supply and exhaust fans of unusually high capacity. The "Robin Locksley" is manned by a complement of 47 officers and men, including six engineer officers and nine firemen, oilers and wipers. Although the designed service speed of the vessel is 16 knots, she attained a mean speed of 18·17 knots on her full-power trial, during which the fuel consumption was stated to be 0·59 lb./s.h.p.-hr for all purposes.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 4, April, 1941, pp. 64-87.*

American Cargo Motorship "Cape Alava".

The 6,839-ton motorship "Cape Alava" recently completed at Tacoma, Wash., is the first of the Maritime Commission's C1-B motor vessels to enter service. She is also the first of their ships to be equipped with Hamilton-M.A.N. Diesel engines. The "Cape Alava" is a full-scantling vessel with main and second decks extending from stem to stern and a third deck extending from the stem to the machinery space. Seven W.T. bulkheads extending to the main deck, which is the freeboard deck, ensure that the ship will remain afloat with any one compartment flooded. Deep tanks are located in Nos. 1, 4 and 5 holds, the one in the No. 4 hold being divided into four compartments. The tanks in No. 1 hold and the after tanks in No. 4 are intended for liquid cargo, the forward tanks in No. 4 being designed for either dry or liquid cargo, while the tank in No. 5 hold is for fuel oil or ballast. The overall length of the ship is 417ft. 9in., her moulded breadth is 60ft. and the depth moulded to main deck is 37ft. 6in. The displacement is 12,875 tons at the full load draught of 27ft. 6in., the total d.w. capacity being 9,113 tons. There are five cargo holds, three forward and two aft of the machinery space, with a total bale capacity of 452,303 cu. ft. or about 60 cu. ft. per ton of cargo carried, the total weight of the latter being 7,492 tons, including 734 tons of cargo oil in the deep tanks. The ship's cargo-handling equipment comprises sixteen 5-ton derricks served by 16 electric winches. A 30-ton derrick over No. 2 hold is a "national defence" feature and is not carried on board in normal service. All cargo holds are fitted with smoke-detection equipment and mechanical ventilation. The normal fuel capacity, contained in five D.B. tanks, settling tanks and deep tanks aft, is 1,233 tons, which gives the ship a cruising radius of 25,700 nautical miles. The amount of fresh water normally carried is 353 tons. The whole of the living accommodation is arranged in a central superstructure, the captain's and chief officer's quarters being on the bridge deck, those of the remaining deck officers and engineers on the cabin deck and those of the other members of the crew on the main deck. Eight passengers are accommodated in four double staterooms on the cabin deck. The complement of 43 includes an E.R. staff of 16, made up of five engineer officers, an electrician and ten oilers and wipers. The propelling machinery consists of two sets of 6-cylr. single-acting 2-stroke Hamilton-M.A.N. engines, having a cylinder diameter of 21¼in. and a piston stroke of 27½in. Each engine is rated at 2,080 h.p. at 240 r.p.m., and both drive a single propeller at 90 r.p.m. through a 2-pinion reduction gear. Each engine is connected to its pinion through a Westinghouse electric coupling with a full-load efficiency of 98 per cent. The pistons are oil-cooled while the cylinders and cylinder heads are fresh-water cooled. The engines drive their own fuel-injection pumps and rotary scavenge blowers. When operating at 4,000 s.h.p. under normal conditions, with an electrical load of 150 kW, the machinery is guaranteed not to exceed an overall fuel oil consumption of 0·42 lb./s.h.p.-hr., with fuel of 19,000 B.Th.U. heat value. The whole of the auxiliary and deck machinery is electrically driven, the necessary current being furnished by two 275-kW. d.c. generators driven at 450 r.p.m. by two 525-h.p. 6-cylr. Diesel engines. A 15-kW. Diesel-driven generator for emergency use is installed in a special compartment on the bridge deck. Steam at 50 lb./in.^{2} for the whistle, oil-fuel tank and cabin heating and other purposes, is furnished by a Foster-Wheeler combination waste-heat and oil-fired boiler through which the main engine exhausts are led. Steam from this boiler is also used to operate an evaporator and distiller having a capacity of 30 tons of fresh water per day. The designed service speed of the "Cape Alava" is 14 knots.—*"Motorship and Diesel Boating", Vol. XXVI, No. 4, April, 1941, pp. 232-244.*

Running Defects in Air Compressors.

Trouble was experienced with a new Broom and Wade compressor installed in a large foundry, due to "hunting" of the unloader, *i.e.,* constant cutting in and out at high frequency when the air pressure approached the maximum for which the governor was set. A defect of this nature may be caused by adjusting the governor too closely, so that it cuts out at 100lb./in.^{2} and in at, say, 99½lb./in.^{2}. The obvious remedy in such a case is simply to remove some of the adjusting washers on the governor. In the case quoted above, however, the trouble was found to be due to th fact that the connection for the air governor was taken direct from the compressor discharge pipe, with the result that a fluctuating pressure was acting on the governor valve and causing the latter to "hunt". In order to ensure a steady pressure on the governor, the connection should always be taken from the air receiver, where all pulsations are, of course, damped out. In this particular instance, however, it was not possible to do this, as the receiver was situated about 50ft. away from the compressor, so in order to get over the difficulty quickly, an auxiliary receiver was made from a short length of 6-in. diameter flanged pipe, the ends of which were fitted with blank flanges. Connections were then made from this auxiliary receiver to the discharge pipe and back to the air governor, with the result that the pulsations of pressure were damped out and the trouble entirely overcome. In another case trouble was experienced with a portable Diesel-engine-driven compressor of the same make due to clutch slip. An investigation of the cause showed that this was due to the engine not getting sufficient fuel, the attendant (who was new to the job) having omitted to clean the fuel-oil filter. Compressors of this type are fitted with a very simple and robust design of centrifugal clutch which allows the engine to be cranked for starting without rotating the air compressor. The clutch picks up the load when the engine speed approaches the working r.p.m. In the case being considered, however, the engine speed was sufficiently reduced by shortage of fuel to cause the centrifugal clutch to slip, and after the fuel filter had been cleaned, the trouble ceased. Another cause of reduced engine speed and consequent clutch slip would, of course, be a choked injector nozzle—this again being caused more often than not by failure to keep the fuel filter clean. The irregular note of the exhaust would indicate a choked nozzle and the particular one at fault should easily be found by feeling the small pin heads provided for the purpose. —*"Broomwade News Bulletin", Vol. 4, No. 2, April, 1941, pp.2-3.*

Plastic Theory—Its Application to Design.

The design of steel frame structures has always been carried out according to the well-known working-stress method in which it is tacitly assumed that the structure will become unsafe as soon as the stress at any point within it attains the yield value of the material. This is justified for a pin-jointed structure, since collapse takes place comparatively soon after yielding commences, but if the connections are rigid, the first signs of yield do not indicate imminent collapse of the structure; collapse is, in fact, considerably delayed. In order to develop more rational methods of design for steel frame structures with fixed connections, model beams and frames have been tested to determine their true strength, and the results of these tests indicate that a beam, restrained at its ends, is capable of supporting more load before collapse takes place than if it were in a simply supported condition. Moreover, with this restraint, the load for collapse will generally be considerably greater than that required to produce the first signs of yield. Hence, if design is based upon collapse load rather than on the first signs of yield, as is conventional, a marked economy of material should result.—*Paper by Prof. J. F. Baker, M.A., Sc.D., D.Sc., and J. W. Roderick, M.Sc., read at a general meeting of the N.E. Coast Institution of Engineers and*

Ball Joints for Superheaters.

Just prior to the outbreak of war the boilers of the steamships "Afghanistan", "Baluchistan" (both owned by F. C. Strick & Co.), "Rembrandt" and "Ribera" (both owned by the Bolton Steamship Co.), were equipped with Me-Le-Sco superheaters having metal-to-metal ball-joint connections between the superheater headers and elements in place of the usual spigot type attachments. These ball joints are designed for high pressures and temperatures and are similar to those already fitted in very large numbers of boilers, some of which are working at a pressure of 750lb./in. and steam temperature of over 800° F. The clamps and washers for securing the ball joints are of steel, the clamp studs being of special heat-treated high-tensile steel alloy. The ball-shaped ends on the superheater elements are formed in steps. The ends of the tubes first undergo a special upsetting or forging process, after which the ball ends are faced up in the lathe and ground to form true parts of a sphere, so that they will fit into the conical seats in the header. This type of joint is claimed to be much simpler to assemble than any form of joint, as no jointing material is used in it.—*"The Syren", Vol. CLXXIX, No. 2,330, 23rd April, 1941.*

Fine Cracks in Crankshafts and Other Machine Parts.

The detection of fine cracks is not easy. They usually show as fine "veins", only visible with a magnifying glass. The writer has found a number of simple expedients useful, and all save one have the merit of being quickly applied and afford equally quick results. Practically no apparatus is required. All except the last can be applied in emergency situations, mostly without removing the shaft from its bearings.

METHOD 1.

The shaft should be wiped clean of all lubricating oil and the suspected part well flooded with a thin penetrating oil. A thin lubricating oil, previously heated, will also serve. This should remain on the shaft for a few moments, and is then wiped away, leaving the surface of the shaft clean and dry. Next, the shaft should be given a few light taps round the spot where the crack is believed to be, using a copper hammer. This tapping usually produces a few oil or air bubbles along the mouth of the crack should one exist. The track of the flaw should, of course, be traced in pencil before the position of the bubbles has been lost. This is a quick test and often reveals a crack where it is not of too fine a nature.

METHOD 2.

Heat the suspected portion of the shaft to a state just short of discolouring, then wipe the surface dry and clean. Pour over the shaft a few drops of thin lubricating oil, and wipe away the surplus very quickly. Carefully watch around the area of the suspected crack for the emission of a light bluish vapour which will be seen to arise from a crack if present. If any oil has penetrated such opening, the heat of the shaft will partially vaporise the oil, so giving rise to its detection. This method requires rather longer to apply, but gives good results. The apparatus required is a blow-lamp to heat the shaft.

METHOD 3.

The surface of the shaft should be well cleaned and dried for an appreciable distance surrounding the supposed crack. The suspected area is then painted with a thin mixture of petrol and red lead of free-running consistency. It is not much use if made stiff. The shaft is left for a few minutes, then again cleaned, after which any crack or flaw will show plainly in the form of fine red lines. Other similar colouring materials may be used, while benzine, methylated spirits, etc., will also serve. A smooth free-running mixture should be made. This method has been found particularly satisfactory.

METHOD 4.

Very often, cracks occur at the point of the journal bearing portions and can often be discovered by slowly turning round the shaft after some of the weight has been removed, and watching closely for the development of slight air or oil bubbles exuded from any crack which may be present due to the easing of the load and pressure on the shaft. This method implies the movement of some of the members assembled on the shaft, or the fixing up of some arrangement for taking the bulk of their weight, etc., and for this reason is somewhat restricted in application.

METHOD 5.

Another method which rarely fails is to apply to the suspected surface of the shaft a very thin but even coating of a mixture made up of whiting and petrol, or benzine. This should be allowed to dry in a few minutes, and the shaft smartly tapped with a copper hammer. A crack will usually reveal itself by the formation of a tiny dark-coloured streak on the whitened surface. If the shaft has been out of action for some time, or operated in a damp atmosphere, a fine red line may show, this being due to rust within the crack. This method is the one most regularly used by the writer, and can be relied on to detect a very tiny crack.—*"Industrial Power", Vol. XVIII, No. 187, April, 1941, p. 52.*

Automatic Fault-detecting Device for Ships' Small Capacity Power Circuits.

In order to facilitate the detection of intermittent faults in the wiring of ships' small-capacity power circuits, such as those used for deck lighting, cabin lighting, galley power supply and similar purposes, the British Thomson-Houston Co., Ltd., have devised a simple fault-detecting system operated by means of relays and solenoid-actuated contactor switches, etc., which automatically and instantly puts into action a small motor-operated controller by which the circuits are isolated one at a time. The controller then tests the insulation of the circuit wiring of each pole and either reconnects the circuit to the power supply if satisfactory, or leaves it isolated if faulty. The object of the device, which is patented, is to provide a fault-detecting and circuit-isolating system which is always available and which is automatically brought into action by the fault current immediately a fault occurs anywhere in the system. The device does automatically exactly what an electrician would do manually when endeavouring to locate a faulty circuit by the tedious method of withdrawing the distribution switch and applying the test leads of a megger set to the various circuits in turn. Apart from the difficulty of keeping the earth indicator under constant observation, it is claimed that even with the most convenient hand-operated arrangement, a ship's electrician can only test out three circuits by hand in the time in which the B.T.H. system can deal with fourteen average circuits. In practice, this means that with the normal arrangement, intermittent defects are usually overlooked and allowed to develop to a dangerous condition, whereas with the automatic system the frequent isolation of a circuit with an intermittent defect would be an effective warning of danger. The B.T.H. automatic system is applicable to any number of circuits.—*"The Marine Engineer", Vol. 64, No. 765, April, 1941, pp. 73-74.*

A Simple Automatic Safety Device.

An automatic engine shut-down device evolved by the National Gas and Oil Engine Co., Ltd., is of purely mechanical type, and may be used to shut down the engine either in the event of low oil pressure or, if preferred, when low cooling-water pressure develops; it operates by cutting off the fuel supply to engine. The device, which is in the nature of a single-seat mushroom valve in the fuel-oil line to the engine, consists of a casing housing a plain spring-loaded mitre-seated valve, this being closed by a spring. When the engine is running the valve is kept open by the lubricating-oil pressure acting on a diaphragm which is located below the valve. In normal operation the valve is kept open and the fuel-oil supply to the engine passes through the valve box on its way to the injection pumps. Although we have referred in this brief description to the use of the valve in connection with lubricating oil, it can readily be operated off the cooling-water system if so desired, when coupled up to the pressure side of the cooling-water supply. Two diaphragms are provided, these being of a material which is resistant to the action of lubricating oil and fuel oil. A small hole is drilled through the body of the safety device between the two diaphragms so that should either be punctured a leakage of oil is immediately discerned by the engine attendant. Moreover, the use of two diaphragms ensures that neither liquid is contaminated by the other. Where the valve is to be used for water, the lower diaphragm is of rubber. In the event of a shut-down being effected by the device, when the valve automatically closes, it becomes necessary to re-open the mitre-seated valve before the engine can be started up again. For this purpose a screw fitted with a knurled wheel at the bottom of the device is provided. Once the fuel supply to the engine has been re-established, the valve is screwed back to its full extent.—*"Gas and Oil Power", Vol. XXXVI, No. 427, April, 1941, p. 74.*

Testing of Stainless Steel.

H. W. Russell, H. Pray and P. D. Miller, of the Battelle Memorial Institute of Columbus, Ohio, have described the development of a small electrolytic cell for attachment to a fabricated article of stainless steel to determine in 3 min. whether or not it will resist corrosion. The electrolytic cell solution acts on the surface, and by the appearance of the spot acted on, it is possible to determine whether or not the particular part is subject to corrosion. The test is non-destructive and can be applied to a completed structure.—*"Foundry Trade Journal", Vol. 64, No. 1289, 1st May, 1941, p. 295.*

New German Patents.

Among the new patents relating to hulls and ships' machinery recently taken out in Germany are the following: "Electric Propulsion", Dipl. Ing. Carl Meyer, Hamburg; "Control for Electrically Operated Rudders", Siemens-Schuckertwerke A.G.; "Tank Stabilizing Apparatus", Siemens Apparate und Maschinen G.m.b.H.; "Apparatus for Measuring Fuel Oil in Submarine Bunker Tanks", Fr. Krupp, Germaniawerft A.G.; "Vibration Resistance Thermometers for Marine Diesel Engines", Max Hertwig.—*"The Motor Ship", Vol. XXII, No. 256, May, 1941, p. 62.*

German Diesel Engine Research.

According to the recently published report of the Maschinenfabrik Augsburg-Nürnberg A.G., research work on Diesel engines is proceeding at their new experimental factory and investigations are being made into the possibility of bringing about a substantial reduction in fuel consumption. There is reason to believe that these investigations refer mainly to the problem in its application to high-speed engines, *i.e.,* to units of several thousand b.h.p. running at from 300-500 r.p.m. The efficiency of such engines has hitherto been substantially lower than that of the slow-running type, and if the fuel consumption of the former can be brought down to something like 0·35-0·36 lb./b.h.p.-hr., it will mean that a considerable improvement will have been effected. Other fields of possible development of the Diesel engine include the application of pressure-charging to two-stroke engines, silencing and reduction of vibration, and the employment of heavy, relatively cheap residual oils in fast and slow-running Diesel engines. It is known that special importance is attached to these problems in Germany.—*"The Motor Ship", Vol. XXII, No. 256, May, 1941, p. 40.*

The New Coaster "Coral Queen".

The recently completed motor coaster "Coral Queen" may be considered a typical example of the modern coaster of this class and size, designed to facilitate trade between British ports. She is the seventh vessel built at the Burntisland Shipyard for the British Channel Islands Shipping Company, her main dimensions being 132ft. × 24ft. 7½in. × 9ft. 6½in., with a gross tonnage of 303 tons and a d.w. capacity of 370 tons. The draught of the vessel when fully loaded is 9ft. 6in. The single cargo hold has a capacity of 20,130 cu.ft. and is served by two steel derricks on the mast between the two hatchways, operated by Diesel-driven winches. The propelling machinery is installed right aft and consists of a 6-cylr. two-stroke trunk-piston Crossley engine developing 330 b.h.p. at 300 r.p.m. The unit is of the direct-reversing type having the scavenge pump at the forward end, where are also located the controls and the fuel-injection pumps. A 15-h.p. two-cylinder vertical Diesel engine is used for driving an air compressor, a ballast and general service pump and a dynamo. A second dynamo is driven by an 18-h.p. Diesel engine. —*"The Motor Ship", Vol. XXII, No. 256, May, 1941, p. 65.*

Intercrystalline Cracking in Boiler Plates.

A report on "Intercrystalline Cracking in Boiler Plates", describing work done at the National Physical Laboratory, was presented at the Annual Meeting of the Iron and Steel Institute. The report is in five parts. Previous work having shown that, in the absence of corrosive attack, no cracks are formed in boiler-plate steel specimens kept under tension for five years, even when concentrations of stress are present, various combinations of stress and exposure to caustic solutions have been investigated. Part I is an introductory survey of the subject. Part II describes experiments in which specimens, with or without notches or drilled holes, were kept under tension in concentrated sodium hydroxide solution at 225° C. An electrically-heated pressure vessel was used, with special devices for maintaining constant temperature and stress, and for indicating the onset of cracking. The typical form of intercrystalline crack was not obtained, but in regions of concentrated stress breakdown was caused by the growth of non-metallic inclusions. Heavily cold-worked steel resisted better than annealed material. The black magnetic oxide formed had the composition Fe_2O_3. In Part III experiments under pressure at temperatures up to 470° C. are described. Using small pressure bombs, intercrystalline cracking was found in boiler-plate steel immersed in a solution of pure sodium hydroxide at 310° C. Decarburisation occurred, the carbon being removed as methane. In other experiments the steel specimens and the solution were enclosed in a steel pressure vessel lined with silver. Under these conditions, no intercrystalline cracks were formed in annealed material at 410° C., but if the steel were cold-worked, cracks similar to those produced by hydrogen at high temperatures were formed. With highly concentrated caustic solutions, intercrystalline cracks penetrating from the surface became filled with oxide. Experiments with powdered-silver filters showed that masses of oxide could be precipitated at a distance from the specimen, and this may contribute to the cracking of boilers, by sealing cavities and allowing a pressure of hydrogen to be built up. Pure iron developed cracks of the oxide type. Sodium sulphate in solution did not inhibit cracking. Some alloys of iron were also examined. In Part IV observations of strain-etching in acid open-hearth boiler-plate steel are described. Such markings are usually found only in basic steel. They were not produced in plates which had been deformed cold, but were found in material which had been bent at 100° C., and also in a rolled plate which had been presumably finished at a low temperature. They coincided with the stress lines found by magnetic testing, and with the directions of cracking in a marine boiler plate which had developed corrosion cracks in service. Part V describes the behaviour of specimens of boiler-plate steel and of both riveted and welded joints in the same material, when subjected to slow cycles of alternating bending stress while immersed in a boiling solution of sodium hydroxide. A machine taking plates 2ft 3in. long, ¾in. thick, and up to 12in. wide (for riveted joints) was constructed. When failure occurred, it was due to corrosion fatigue and the cracks were transcrystalline. The typical caustic cracking was thus not obtained, but the cracks observed closely resembled certain defects found in boilers as the result of service.—*"The Iron and Coal Trades Review", Vol. CXLII, No. 3,818, 2nd May, 1941, p. 497-499.*

Change in the Shipyard.

A proposal by Dr. J. Tutin, to build ships by what has been described as the "conveyor-belt system", suggests new methods of ship construction with the object of more rapid production. This proposal is to build ships in the water instead of on a slipway and move them along during the progress of the work to the place of manufacture and assembly of the various constituent parts. The scheme would necessitate the construction of a canal or waterway with the workshops on either side, and the ship would reach the end of the canal complete with its engines and almost ready for commissioning. The principal advantages claimed are speed of construction and the elimination of launching difficulties. Many of the obstacles to the widespread use of electrical gear aboard ship, and particularly the use of electrical propelling machinery, have been due to shipbuilding practice, which did not always fit in with the ideas of electrical engineers. For instance, many shipbuilders found it more convenient to build steamships of a more or less standardised pattern with auxiliary machinery, such as winches and steering gear driven by steam. They claimed that steam-driven gear was simpler, more robust and more reliable than electrical apparatus, and in addition they always pointed out that electrical machinery needed engineers with electrical training. The arguments against electrical machinery may be compared with those of earlier years against the Diesel engine for ship propulsion. The latter had to be adapted because British shipowners found that foreign competitors were beating them by running motor ships which, although more expensive in first cost, were far more economical on many services than coal- or oil-fired steamships. Demands of British shipowners forced many shipbuilders to alter their outlook and they took up licences for the manufacture of internal combustion engines in order to enable them to compete with Continental shipbuilders who were eagerly seeking contracts to build motorships for British owners. The increase in the number of motorships led to the wider use of electrically driven deck and engine-room auxiliaries, even for steamships where it was found that Diesel engine-driven generators enabled the boilers to be shut down in port. Thus developments in marine electrical gear had an effect on steamship equipment. Some shipbuilders have stated that they would be more favourably inclined towards large all-electric ships if they could themselves manufacture the main items of the turbo-alternators and propulsion motors to compensate them for the loss of work they would sustain by not supplying the main engines. This arrangement would be uneconomic, since the manufacturing capacity of the existing electrical works is sufficient for our requirements in normal times. Moreover, the existing electrical works are much more modern than most shipyards, where engine works are not laid out for manufacturing and testing electrical gear. A new method of constructing ships will naturally tend to modify the design of the ships themselves and in the method under discussion it seems that the present lay-out of shipyards will be radically altered. There will be arguments against the engine-building works forming part of the shipyard and, if these are valid, shipbuilders will be of a new type free to select any propelling machinery whether it be steam, Diesel or electric without worrying about the economic consequences to themselves. It is not only with the use of electricity aboard ship that the electrical engineer is concerned, for new methods of construction involve new handling devices and above all there will arise the question of electric welding. It is surprising that electric welding has not been used far more extensively in the shipbuilding industry to produce cheaper and lighter ships more quickly. A new type of shipyard will not need to make welding practice fit its production methods, for it can be laid out to utilise electric welding to the maximum and electrical engineers may legitimately look forward to the all-welded electrically-propelled ship as the normal product of our shipyards. An electric ship is not necessarily higher in first cost than other types, but even if it were, the operating advantages would offset the difference. At the present time we require ships capable of the utmost flexibility, suitable for any port irrespective of the handling facilities and able to give a quick turn round. Above all, we require these ships constructed quickly. The electric ship fulfils the requirements of flexibility; it is more easily manœuvred than any other ship and electric cargo-handling gear makes it independent of shore cranes. Where a straight drive is employed, the main engines are necessarily tied down to a definite position in the ship and this limits the design and disposition of the cargo space, but with the electric ship the engine room can be laid out to suit the cargo space and the cargo-handling facilities. This is an extremely important point when speed of loading and unloading is vital. As for rapid construction, it is obvious that a plant lay-out which enables component parts to be manufactured in specialised factories leads to speedier production than a lay-out which forces widely differing items to be made in relatively small quantities in the same factory. Other ships than electric ships could, of course, be built on the principle of making the engines in one factory and building the hulls in a yard entirely separate, but the very fact of separating the hull and main engines is in favour of electric ships, since designs have tended to be based on the assumption that hulls and main engines will be made in one yard. Looking at the matter from the commercial angle we see the shipping industry as an important market for electrical gear worthy of approach on organised scientific lines and, here again, the implication is the absence of any real plan in the past. The war has altered our attitude towards many things and we are now used to rapid changes of all kinds, but we have not yet acquired the habit of foreseeing the consequences of these changes. The electrical industry in its own interest must take advantage of changes wherever possible, ,and ship construction offers an opportunity since the urgent need for ships means that the necessity for rapid production will override many considerations previously though important.—*J. F. Amor, "Electrical Review", Vol. CXXVIII, No. 3,313, 23rd May, 1941, p. 677.*

Mechanical Mishaps.

A meeting took place on 25th April at the Institution of Mechanical Engineers, and the principal speaker was Mr. G. E. Windeler, president of the Diesel Engine Users Association. His subject was "Mechanical Mishaps", and his first example of oil engine interest was a chain wheel, numbers of which had worn out rapidly in a drive for an indicating appliance. It was found that the lubricator, which should have supplied drops of oil irectly on to the top run of the chain, was not doing so, but oil was being consumed. The shank of the lubricator was ¼in. shorter than the boss on the chain-case into which it screwed. As a result, oil flowed over the chaincase inner surfaces and never reached the chain. Reducing the depth of the boss so that the shank projected by a thread or so, from the bottom end, cured the trouble. In one engine the big-end bolts were well designed in every way, but frequently failed towards the ends where the nuts were applied. Investigation showed that the shoulders of the connecting rods with two-bolt caps were weak and tending to whip, so that the bolts were improperly stressed. A stiffer form of rod with a four-bolt cap cured this difficulty. Failure of oil circulation when the oil-pressure gauge reading was almost negligible, followed later by restoration of pressure, was found to be due to the use of felt-type filter elements in a full-flow strainer. Such a strainer is more intended to withhold from circulation relatively large foreign bodies, and should be of such a nature as will allow the passage of the smaller ones, which would tend to choke it up far too rapidly. It is best to use a by-pass filter to deal with the smaller impurities. If a single filter element be relied upon, it will soon choke up and cause a big pressure drop. Ultimately, the high pressure of a large volume will probably puncture the filter, when circulation will be restored, but filtration will be at an end and the damage will already have been occasioned. On a large gas engine with stainless-steel exhaust valves the fracture of a valve stem could not at first be accounted for. Examination showed that the stem had a number of small indentations in the zone of the fracture. It was found ultimately that the valve had been bent in the workshop, and the fitter had heated it up and hammered it straight. Stainless-steel valves will not withstand this treatment. Where such components are used, it would appear strongly advisable to warn operators of the danger. A connecting rod of a high-speed oil engine fractured midway along its length following a run-out big-end and bolt breakage. Examination showed that the oil-way from the big-end to the small-end had been drilled from each end; the two drills had not been exactly in line, with the result that at the meeting point one wall of the oil passage was exceptionally thin. In due course it failed, the big-end was starved of oil, and the white metal ran out. Continued running caused the cap bolts to loosen, one of them broke and in the consequential smash the connecting rod was broken. Mr. W. A. Tookey referred to a *vis-à-vis* engine suffering from repeated liner failures. These were traced to the fact that when the engine stopped, the attendant always barred it round to the starting position, shut off the cooling water and left the unit. In consequence, whenever the engine was stationary, the pistons were at the same position and the residual heat from the pistons was transferred from the gudgeon-pin masses to the same zones of the liners. After-cooling cured this. The same speaker gave two further instances. One concerned a two-stroke engine which was incapable of developing its full output. From each cylinder was a separate rigid exhaust pipe to the silencer, which, being placed against a wall, could not move to allow for pipe expansion. The result was a pressure against the cylinders which distorted the liners, tending to nip the pistons. Use of flexible exhaust pipes was the cure. The other breakdown referred to was a serious one. When stopped, an engine was found to have a bent valve push-rod; this was put right and the engine left ready for duty, but not started. When a start was made, there was an explosion. Investigation disclosed that a replacement exhaust valve was of a slightly different type from the original one, and when opening the valve spring closed up solid before the cam had reached the point of maximum lift. This caused the push-rod to bend. In succeeding cycles (after the bending of the rod), the exhaust had not opened and a number of injections of fuel had taken place without combustion occurring. Following the stop for correction of the rod trouble, the fuel remained in the cylinder, and when the start was effected later the excessive quantity in the cylinder was able to explode.—*"The Oil Engine", Vol. IX, No. 97, May, 1941, p. 10.*

Lining White Metal Bearings.

The old idea of making split bearings and soldering them together for machining in the bore and on the belts, etc., is now giving way to more modern methods of manufacture in which the aim is to machine the bearings on jigs so that any two halves will be interchangeable. Normally the white metal alloy is applied in the form of linings to shells of steel, bronze or other material. Popular belief is that all white metals can be bonded more satisfactorily to bronze shells than to steel, but tests prove that this is not so, and that the adhesion to a steel shell is always much stronger than to one of bronze. In many instances, steel-backed white-metal-lined shells have entirely superseded bronze bearings. The function of the bearing shell is to provide a rigid support for the comparatively weak white metal. In the case of cast-iron shell, mechanical anchorage is used to ensure the lining is firmly anchored to the shell. The shell is, of course, tinned, but with this metal tinning is generally a difficult matter. The use of mechanical anchorage to other metals, such as steel or bronze is not to be recommended. Where dove-tails or holes are present, tinning and subsequent lining is made far more difficult, and also the presence of sharp corners and varying thickness in section of the lining are likely to be the starting-point of cracks. Straight-through machined surfaces ensure more complete uninterrupted metallic contact between the white metal and its shell, and when the metalling is done properly it is possible to obtain a bond between the two which is stronger than the bearing metal itself. When the metalling is correctly carried out a bond of very high strength is obtained with cadmium-nickel and tin cadmium alloys. In the case of tin base alloys, it is usual to bond with pure tin prior to running the metal, but on no account must tin be used for this purpose in connection with a cadmium-nickel alloy. Lack of adhesion between lining and shell subjects the lining to excessive stresses, and adhesion depends upon maintaining a complete and continuous bond between the white-metal lining and the steel shell. Fluxing, tinning, and correct pouring temperature will ensure strong adhesion and will substantially improve the performance and reliability of this class of bearing. Preliminary preparation of the bearing shells is of vital importance to the eventual life of the white-metal lining, faulty work at this stage often causing the bearing metal to break up during service and to run hot. The bearing shell must be first thoroughly cleaned from grease before attempting the tinning operation; in the case of used shells this may be done by first boiling them in the usual caustic solution followed by thorough rinsing in running water. In the case of steel shells, pickle in sulphuric acid of about 25 per cent. strength, rinse, and then dip into a liquid flux. This should consist of a saturated solution of zinc chloride to which a small quantity of pure ammonium chloride may be added with advantage and which should be slightly acidified with hydrochloric acid. This refers to pressed steel shells or steel stampings, of which smaller types of bearings are made. Large cast-steel bearings, such as for marine machinery, should be heated to a high temperature in order to ensure all the oil which may be in the metal shell is burnt out. Degreasing with trichlorethylene or other solvent will not do, for, although this will remove surface oil, the pores of the metal shell become full of the solvent, which has then to be removed. The shell is then immersed in a bath of molten tinning metal, which can be the actual white metal, where it is held immersed until it attains the temperature of the bath, kept at about 280° C. On removal, the shell, if the cleaning operations have been adequate, will be completely tinned but if any places are observed where the tinning has not "taken" the surface should be swabbed with flux until the tinning is complete. Any excess of tinning may be shaken off. Precautions should be taken against injury by splashing when immersing shells in the tinning bath. Parts of the bearing which do not require tinning should be painted with a solution of common white distemper to which is added a little silicate of soda. The mixture should be allowed to dry on the bearing before it is fluxed and dipped in the tinning bath. The bearing shell, whether as a complete bush or split into halves, should be mounted vertically on an iron plate which has a smooth, level, clean surface and the mandrel and bearing clamped into their correct positions. The mandrel must be of a size to allow for subsequent machining and care taken to allow proper space for a bright steel feeding rod. In connection with the latter point, puddling is a very important operation, as it not only serves to dispel any air that may be trapped in the bearing beneath the level of molten white metal, but also helps the various constituents of the alloy to retain their uniformity, and any foreign matter that may have entered the mould is floated to the top. It is essential that the bearing shell and mandrel be heated before the pouring takes place, and they must be kept hot by means of the blowpipe until the metal is ready. The pouring ladle must be held as near to the pob as possible, and the ladle spout should be flat-nosed to pour in a wide stream. The use of top and bottom formers may be dispensed with in the smaller types of bearings as there will be little sinking in the head to follow up. When the lining alloy is almost frozen a blowpipe is sufficient to finish off the top end of the bearing to the correct level. Hammering the white metal surface after lining is not advised. This does not improve the lining or strengthen the bond to the shell, and, in some cases, may cause damage. The bearing may be lightly tapped to see if it rings true Hot bearings and cracked linings often result from imperfect adhesion between bearing shell and the lining. Temperature control during pouring is a factor which can play an important part in the active life of the bearing. Most bearing metals are heated too much, and this overheating is not only wasteful but impairs the anti-friction qualities of the alloy. White metal should be melted in an iron pot over a gas flame, ***not in a crucible in a pit fire***. In the absence of a thermometer a rough check may be kept on the temperature of the white metal by using a folded strip of dry writing paper. This should turn not more than a medium brown colour on being immersed in the white metal, and on no account should show signs of catching alight. Wood should not be used for this purpose. The temperature range will vary slightly with the brand of white metal used, and this should be checked repeatedly whilst molten. Trace alloying metals such as cadmium, nickel and silver, etc., when added to high tin base white metals undoubtedly impart additional advantageous properties, making the mixture superior to that of ordinary tin-antimony-copper-lead alloys. Cadmium in an unalloyed state is unsuitable as a bearing metal, and cadmium-nickel alloys are very susceptible to any trace of acidity in the lubricating oil, so that corrosion problems become acute. Additions of cadmium up to 3 per cent. cause an improvement in the strength and hardness and mechanical properties of tin-base white metals, but above this amount these advantages are offset by loss of ductility. The addition of 4 per cent. lead is slightly beneficial when cold, but is detrimental if the bearings are to work at elevated temperatues. A good white metal is made up by melting together 4lb. of melted, consisting of 76lb. of block tin, the hardening mixture This should be done under a thick layer of charcoal or commercial zinc chloride, and allowed to cool to a temperature at which it can be poured into a chill mould. Next the bulk metal can be melted, consisting of 76lb. of block tin, the hardening mixture added to it, and the whole well stirred. The mixture may now be cast into small ingots for use. This gives 1 cwt. of excellent Babbitt metal having 88·89 per cent. tin, 7·41 per cent. antimony, and 3·70 per cent. copper.—*H. Warburton, "Mechanical World", Vol. CIX, No. 2,837, 16th May, 1941, pp. 333-335.*

Difficult Welding Repairs in Ship's Boilers.

Some years ago a Greek steamer was sunk in coastal waters and remained submerged for some eighteen months. Finally salvage operations were undertaken and she was raised. At the time of foundering her two double-ended boilers were carrying a partial head of steam and went down hot. After survey numerous fractures were discovered in the combustion chamber backs and it was decided to fit butt-welded patchplates after cropping out the affected areas. In certain cases of short fracture, these were welded without doublers but here certain metallurgical phenomena intervened as the rapid chilling down had presumably embrittled the boiler plating and with the full contractional strain of the butt welds resisted by the riveted chamber flanges certain backs split with cannon-like reports. The cause was apparently the superior tensile strength of the butt welds as compared with the parent plate, for example the starboard furnace of the starboard boiler had originally a short fracture running vertically from a stay in the centre row. This was veed and welded, but during the cooling period, the butt split and the fracture extended vertically to the next stay. A second and third repetition of this coupled with the increase due to extension finally emphasised the importance of veeing open a butt in way of all stays affected, but even this was insufficient in some degree and fully satisfactory results were not achieved until specially manufactured electrodes were employed.—*J. K. Johannesen, "The Welding Industry", Vol. IX, No. 4, May, 1941, p. 91.*

Neither The Institute of Marine Engineers nor The Institution of Naval Architects is responsible for the statements made or the opinions expressed in the preceding pages.