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Metal Spraying by the Wire Process.

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Synopsis.
The process of metal spraying is comparatively new and some notes on its development are given. The basic principles of the wire-spraying pistol are described. The use of the metallic films produced as a means of protection against corrosion is described and reference is made to the aluminising process for protection against oxidation at elevated temperatures. Particular notice is given to the use of aluminium coatings. The theory underlying the use of deposits of the harder metals for reclamation of worn parts is discussed. Suggestions are made with regard to the issue of specifications for sprayed coatings. The methods used in the preparation of surfaces for receiving the spray, including shotblasting and rough turning, are described. Some details of the mechanical properties of the deposits with a discussion of their structure are added. Notes on methods of finishing are included and the paper then gives descriptions of the use of the process in connection with specific problems in marine engineering, including reclamation and protection of propellers, building up of propeller shafts, bracket bushes, rudders, turbine shafts and rotors, crankshafts, main bearings, cylinder liners, piston valves and rods, gudgeon pins, boiler valves, steam joints, pump parts and armature shafts. The protection of hulls, water tanks, winches and boiler mountings is discussed.

METAL SPRAYING BY THE WIRE PROCESS.

It is perhaps unfortunate that a paper on metal spraying should be submitted to The Institute during war-time because, while the process is contributing greatly to the war effort, obviously no description can be given of the precise nature of the work done during the period of hostilities. A paper such as this must, therefore, be mainly a statement of past achievements with some speculations for the future. Many engineers have had personal contact with the process and will be able to judge for themselves its possibilities, while those who have not yet made use of metal spraying will undoubtedly meet it in the future. It is hoped that this paper will give to both classes some information of value, and maybe increase the contribution of sprayed metal to the national effort.

The process is of Swiss origin and is comparatively new, dating back over a period of thirty years only. When first published, the invention was hailed as revolutionary, and many sweeping claims were made for it. As usual in such cases, a process needs not only invention but development, and it was not until 1922 that a real commercial start was made in Great Britain, when appreciation of its advantages and limitations became better known.

The original patents covered three methods, namely:—(*a*) the spraying of molten metal, (*b*) of metallic powders and (*c*) of solid metal in wire form. The wire process is the most generally adaptable, and the modern development of metal spraying is due to its success. The vast majority of spraying is still carried out by the wire method, although modern adaptations of the first-named methods have been commercialised, but they are more restricted in their applicability. This paper therefore refers only to coatings produced by the wire system, as they are equally effective for tinning a small vessel or reclaiming the steel surface of a worn shaft of great diameter. This general claim is made with the condition that the process is in the hands of a technician who has some experience. Despite the claims made by some, the process of metal spraying is not foolproof, and thought and skill are necessary to obtain the best results, these results not always being gained by maximum deposition speed and low first cost.

The aim of the metal-spraying process is to obtain a deposit of metal on a surface in order to protect the original surface against corrosive conditions, or in order to build it up to a given dimension. This aim is achieved by melting a wire of the desired metal in a blowpipe flame and spraying the resulting liquid as it is formed by means of a gaseous propellant. It will be seen that this necessitates certain arrangements which may be stated as follows: (i) the maintenance of a steady flame to melt the metal, (ii) the presentation of the metal to the hot zone of the flame continuously at the correct speed, (iii) the splitting of the droplets of molten metal as formed by a gaseous propellant, and (iv) the direction of the spray so formed onto the object to be coated.

These functions are all performed by a small tool known as the pistol, which weighs about 3½lb. It is not proposed to give a complete detailed description of this tool here, as it has been described so many times in the technical press, and those interested may easily refer to existing *literature.

A general idea of the arrangement is as follows:—A metallic wire, usually of 1 mm. to 3 mm. in diameter, is caused to pass through a nozzle at a steady speed. Around the nozzle is arranged a series of gas ducts usually equi-spaced. These ducts carry a

*"Metal Spraying". E. C. Rollason, M.Sc. 2nd Edition. Chas. Griffin & Co., Ltd.
"A New Metal Spraying Pistol". "The Engineer", Feb. 3rd, 1939.

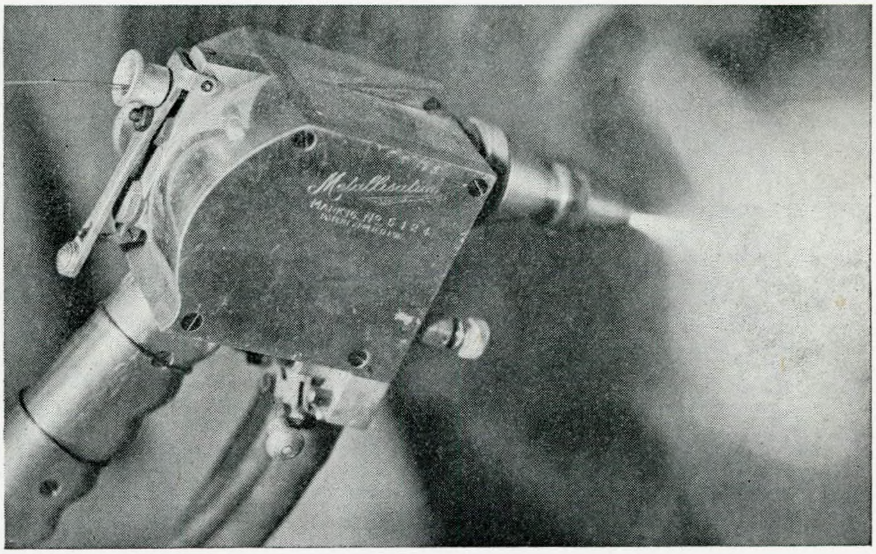


Fig. 1.—*A modern type of pistol spraying steel, which is one of the few metals giving a visible spray.*

mixture of a combustible gas at a pressure of 15 to 35lb. per sq. inch, and oxygen at a similar pressure. The combustible gas supply may be of hydrogen, coal gas, propane or acetylene from cylinders, or in the case of coal gas compressed from the town main by a small compressor. The amount of gas used will depend on its nature and the particular metal being sprayed, but may range from 15 to 60lb. cu. ft. per hour, with a similar range of oxygen volume. When the gas is ignited, the wire will melt at the hot zone of the flame. Around the gas nozzle is a similar series of ports carrying compressed air at 40 to 60lb. per sq. inch pressure, and taking from 15 to 30 cu. ft. of free air per minute. The parts are so arranged that the compressed air cuts the flame immediately in front of the melting wire and breaks the molten metal into particles about 1/100 mm. in diameter. These particles are projected at high speed onto any surface within a few inches of the nozzle. The wire is drawn into the pistol by means of rollers actuated by a small air turbine located in the pistol casing. The gases and air are led to the tool by means of pressure hose and all the feeds are regulated by one valve, or rather a combination of three valves connected together. The flow of gases produced by the nozzle is so large that the particles are chilled and at a few inches from the nozzle the residual heat is so small that to all intents and purposes, the process is cold. It will also be seen that the tool is very mobile and can therefore be used to carry out deposition on site. The deposition speed varies with the diameter of the wire used and the melting point of the wire. A pistol set to spray 10lb. of zinc per hour will spray only 2lb. of steel.

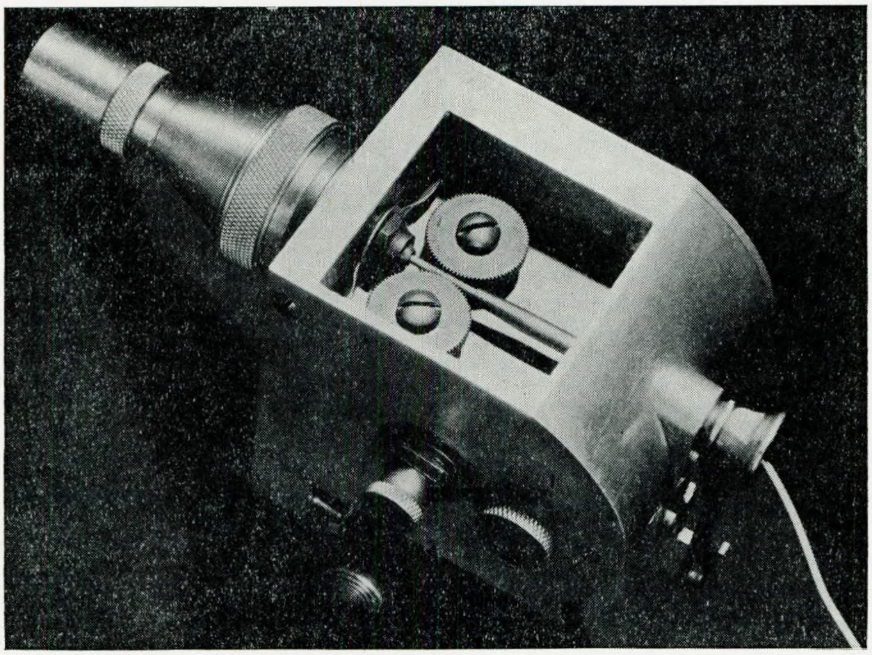


FIG. 2.—*The pistol with lid removed, showing the wire rollers.*

For some years the commercial development of the process was confined almost entirely to the production of protective coatings and some notes on these may not be out of place. Metallic structures used in marine engineering are particularly prone to corrosion, due to the action of salt air and water. The most common form of metallic protection is hot galvanising, which is merely a coating of metallic zinc in a more or less pure form. It is now recognised that zinc protects steel by sacrificial action of an electrochemical *type. The zinc is slowly dissolved away, but while zinc remains the underlying steel will not be attacked, as zinc is widely separated from iron in the electrochemical series, and becomes the anode of the electrolytic couple. It is also established, as seems obvious, that the protection given by zinc in any set of circumstances will be a function of the weight of zinc present, or in the case of coatings, of the thickness of the deposit. It is clear also that the higher the purity of the zinc, the better able it is to give protection, and in this particular, galvanising has sometimes fallen short of demand because hot galvanising gives a coating that is alloyed to the steel surface underneath, and a large proportion of the coating is an alloy of iron and zinc, and is not therefore so protective as the pure metal. Pure zinc coatings are somewhat soft, and it has been suggested that better life might be obtained by a zinc coating containing a hard inert substance such as a silicate. On reflection it will be seen that this is not theoretically sound, as thickness for thickness, the purer the zinc the more protection will be given from corrosion.

The protective quality of zinc has, of course, been fully realised by the shipping industry generally, as it is quite normal to have light fittings galvanised, to galvanise small boats, and to attach plates of zinc to the hulls of ocean-going vessels. The use of zinc to a greater extent has probably been cramped by the fact that hot galvanising and electro-deposition are not suitable for the coating of large and awkward surfaces such as are common in the shipping world. As will be explained later in the paper, metal spraying does offer a means of obtaining a pure zinc coating of any desired thickness no matter how large or unwieldly are the surfaces.

While on the subject of zinc coatings, it is generally realized that zinc, when subject to the attack of sea air or sea-water, gives rise to a white florescence of basic zinc-chloride, which is apt to be unsightly and would not be very effective as a finish for ships on passenger service. On the other hand, the coating of galvanised articles with paint is far from effective, as it is extremely difficult to paint galvanised articles successfully. A coating of zinc applied by metal spraying has, however, the distinct advantage that it is an extremely good base for paint owing to its matt surface, and this has been proved from time to time by scientific *investigation and has been reported in the technical press. Before the war it was a common sight in any repair yard to see large thicknesses of white paint being chipped from the surfaces of ocean-going vessels, and despite the thickness of paint that had been used, layer by layer, it was still normal to see brown rust coming through from the steel underneath. There could be no doubt whatever that had the surfaces been sprayed with zinc before painting, this rust would have been totally avoided, and the painting would have only been necessary at infrequent intervals when the paint became dirty through exposure to smoke, etc. There can also be no doubt that a zinc coating under paint could have saved many examples of the pitting through deck fittings of ocean-going liners. In certain circumstances coatings of cadmium are preferred by some and these coatings can also be produced by metal spraying.

It is felt that most engineers will agree with the foregoing paragraphs with regard to zinc coatings, but it is quite possible that many will be rather surprised at the suggestion that even better protection is given in many circumstances of marine exposure by a comparatively thin coating of aluminium. The use of aluminium and its alloys as permanent structures on ships has been in the past in many cases fraught with disaster. Many cases are known to the authors of this paper where solid aluminium articles have deteriorated so much as to become useless in the course of one voyage, and some aluminium tanks, which had been immersed through enemy action for a period of three weeks, have completely perforated. Is it therefore reasonable to suppose that a thin coating of aluminium applied to a steel surface can give any protection at all? Maybe at first sight it appears that the answer is definitely in the negative. Largely due to the work of Evans and his †collaborators at Cambridge, it was found some years ago that aluminium was very effective as a protection, in many cases more effective than zinc, and it is therefore necessary to state the reasons why this should be so. There seems some evidence again that the purity of the aluminium is a matter of some importance, and if it is used as a protective coating the aluminium deposit should not be too thick. If it is too heavy, the deposit takes on the nature of a solid aluminium article, and pitting will occur. On the other hand, a coating from 0·003 to 0·005in. in thickness can be applied by metal spraying to steel, and the surface produced is matt and somewhat porous. It appears that during the first period of life of the coating corrosion is somewhat intense, but the products of corrosion of

*R. Lecoeuvre Metaux, 1934, 9, 525.

*"Enamel and Paint Finishes over Sprayed Metal". Halls, "Metal Treatment", Summer, 1941.

†S. C. Britton and U. R. Evans, *J. Soc. Chem. Ind., 1932, 51, 217T, 1936, and 55 340T.*

aluminium, that is the basic chlorides, are extremely insoluble and the result is that each particle of aluminium takes to itself a coating which becomes hard and insoluble. The result is that a very fine protective coating is obtained, and corrosion slows down until it is negligible. In this case paint can be applied to the surface, but will not largely increase the protective value, and in fact the paint must be chosen with care as some of the synthetic paints seem to have a deleterious effect on the protective films of corrosion product.

Later in this paper a discussion is given on the use of aluminium coatings on cast-iron propellers, but at this juncture it can be mentioned that the use of aluminium coatings on parts of seaplanes, especially those planes operating in tropical waters, has been of the utmost service, and the metal-sprayed coating of pure aluminium has even been found to be protective to articles made of wrought aluminium alloys.

The story of aluminium coatings cannot be completed from the marine aspect without reference to the process known as aluminising. An aluminium coating, as sprayed, will protect steel from oxidation to temperatures of about 500° C. But if this aluminium coating is heat treated, and the aluminium is allowed to penetrate into the steel base, the final surface will be that of an aluminium iron alloy. At temperatures exceeding 500° C. and up to 950° C., the effect of oxidation is to cause the aluminium iron alloy to take on a film of aluminium oxide, which is very strong and prevents further oxidation. The aluminising process is, therefore, a means of preventing high temperature oxidation up to temperatures of 950° C. It is quite obvious that such a coating will have its uses in the furnaces of ships whether steam or oil fired. Many thousands of deflector cones on oil-fired ships have been treated by this method.

The discussion on protective coatings cannot be closed without reference to the use of tin for tanks containing water and food generally, or the use of lead to prevent the attack of foaming seawater. Unfortunately, lead is a soft coating and cannot always be used where it is most needed. For very high temperature work, coatings of nichrome have been extremely successful, but these have been used mostly in connection with industrial furnaces rather than marine engineering. There must, however, be some scope for these coatings in ship work. It will be obvious to the reader that if metal spraying is able to produce coatings of such widely different metals as lead and nichrome, it can also be used for the spraying of copper, brass, nickel and cupro-nickel, and while these coatings, except for special circumstances, cannot be regarded as protective coatings to steel, they have their uses in obtaining decorative effects —particularly coatings of copper and its alloys have been used in the saloons of passenger liners for producing decorative effects, especially when they have been subjected afterwards to a metallic colouring process such as is used for the solid articles. Only passing reference is made to this aspect, as the decorative effects are not usually in the hands of marine engineers, but coatings of copper and zinc have also been found to be of great use in the screening of radio sets and the lesser known devices which are now used on ships and which make use of high-frequency currents.

So far, these notes on the use of metallic coatings have dealt with the matter from the angle of corrosion protection, which was the first development of the spraying processes, but some years ago it became obvious that a sprayed coating of steel or other hard metal might well be used as a means of reclaiming worn parts. There appeared to be some difficulties with regard to this matter, largely due to the peculiar structure of metal-sprayed deposits which will be discussed later. It was, however, quickly realised that these deposits of metals melting at high temperatures were porous throughout to the extent of 2 or 3 per cent., and as such it was visualised that in contact with oil they would become saturated, and that the surface of such a deposit in use should retain the oil film better than any other metallic surface yet known.

It had been realized over the past decade or so that bearing surfaces relied for their properties not so much on the surface which was presented as to the ability of that surface to retain an unbroken oil film. Mr. Harry Shaw, who had developed special machines for examining metallic surfaces and their lubricating properties, was struck by the possibilities of sprayed metal, and made an exhaustive series of tests on their properties which have resulted in the publication of two *papers. He found that tests on steel shafts rotating in white-metal bearings at high speed proved that if they were surfaced with sprayed metal, the wear over a considerable period was very much less, both on the shaft and on the bearing. Furthermore, he experimented with oil "cut-off" tests in which, after a certain length of time, the supply of oil to the journals was stopped. In one set of tests he found that a hardened steel shaft under these conditions seized-up completely in 3½ hours, whereas a shaft sprayed with steel ran under similar conditions for 22½ hours and then the seizure was not complete. Shaw was not content only with laboratory experiments, but put the result of his work into practice by treating crankshafts of petrol engines of buses, private cars and lorries, and also some tests were done on Diesel buses and lorries. In every case it was found that the sprayed shaft had considerable advantages over unsprayed shafts. He then investigated the property of sprayed white metal for bearings, and in this case also similar results were achieved. The results of his work on steel shafts gave more impetus to the use of sprayed metal for the reclamation of steel parts and some success had also been achieved on bearing surfaces before the war, but since then the work on bearings has been somewhat scanty owing to the stress of abnormal conditions. Before the war, the building-up by metal spraying of steel parts had grown to a considerable industry, and it is obvious now that the matter has become one of national importance. Specific cases of its use in marine engineering will be mentioned later.

*Metal Sprayed Surfaces in relation to Lubrication. Harry Shaw. Association of Metal Sprayers, 1937.

Metal Sprayed Bearings for High Speed Operation. Harry Shaw. Association of Metal Sprayers, 1939.

It will be seen from what has already been said that the metallising plant is quite portable, but of course there arises the question of preparation of surfaces, and this preparation can be divided into two classes. It is obvious that any metal coating must be put on to a clean surface, free from grease and rust, and as metal spraying is comparatively cold, there is no alloying of the metal deposit to the surface unless some after-treatment is given. Such after-treatment is only demanded in the case of the aluminising process to which reference has already been made; normally, protective coatings are left as sprayed, and it is necessary to prepare a surface which shall be roughened as well as cleaned, and the roughness of the surface should be in the same order as the diameter of the particles to be received. It is usual, therefore, in the case of protective coatings, to prepare the surface by shot-blasting or, in the case of site work, by sandblasting. There are, of course, difficulties in the use of sand as an abrasive owing to the fact that there are restrictions due to the likelihood of setting up silicosis among the operators. There are, however, types of work on site where it is impossible to recover the abrasive and where it becomes uneconomical to use the more expensive steel grit. Therefore, if the work can be done in the open, it is usually sandblasted with black flint sand of a very angular nature. Where possible angular steel grit is used of a grade which will pass through a 20 mesh sieve, and the air pressure may vary from 30 to 60lb. per sq. inch. It need hardly be said that the shotblasting apparatus is quite portable, usually being in the form of a cylinder about 1ft. 6in. dia. and 3ft. high. Unfortunately, shotblasting takes a considerable volume of air; a 5/16in. nozzle requires 100 cu. ft. of free air per minute. This means that the compressor for driving a sandblast and metal-spraying pistol will require to have a capacity of about 120 cu. ft. of free air per minute at a minimum, though usually plenty of compressed air is available at shipyards. Blasted surfaces must be immediately covered by the metal in order that they shall not get dirty, and the metal-spraying pistol is used in a similar way to a paint-spraying gun.

Largely due to American influence, there has arisen lately an idea of specifying the thickness of deposit as so many coatings. It is unnecessary to explain to an engineering institution that this means absolutely nothing, and the thickness of a coating applied by a spraying pistol depends on the rapidity with which the operator moves the pistol over the surface to be coated. It cannot be too greatly stressed that specifications should demand a thickness of deposit of so many thousandths of an inch, or alternatively so many ounces to the square foot. This can be arranged in two ways. The first way is by the method of averages, which is as follows. An area of say 10 sq. ft. is marked out by the metal spraying pistol, and the spool of wire is weighed. The amount of metal to be deposited is worked out, and after the 10 sq. ft. are covered, the spool of wire is again weighed. Calculation will give the average thickness of metal which should be applied. In the hands of a skilled operator this average thickness is usually found to be very near the truth. In recent years, however, there has come on the market the *Tait electric magnetic thickness tester which is used in conjunction with an alternating current, and can be used for all non-magnetic coatings on a magnetic base. It depends for its working on the measurement

*"Physical Examination of Metals". Bruce Chalmers and A. G. Quarrell. Edward Arnold & Co. Vol. II, p. 67.

of imperfect magnetic linkage in a small transformer in the testing head, balanced against a perfect linkage in a small transformer in the instrument itself. The instrument gives a direct reading of thickness, and the test is non-destructive to the coating. The apparatus has been used successfully on many large Government contracts, and gives the thickness applied easily and within reasonable limits of accuracy. There is, therefore, no reason why definite thicknesses should not be specified and obtained by the customer.

It will be seen that the preparation and spraying processes are such that very large structures can be sprayed; for instance the whole hull of a ship could be sprayed if it was thought necessary with very little more difficulty that it could be painted. This is one of the main advantages of metal spraying considered against such processes as hot galvanising, electro-deposition, etc. There are however some difficulties, as for instance difficulties of treating ships' decks after some of the machinery has been installed, the difficulty being that the abrasive is likely to blow about and get into parts where it is likely to be dangerous. Considerable practice has been obtained in this direction, and it has been found possible to limit the shotblasted area by shotblasting in a portable box, which is moved from place to place on the deck and avoids the spread of the abrasive.

While shotblasting is quite a successful method of preparation, it has its difficulties when the question of reclamation of worn parts has to be considered, because sometimes those worn parts have to be built up *in situ* in the engine-room of ships. There is, in this case, an alternative method of surface preparation, and this is rough cutting. The principle is that the shaft, or part to be reclaimed, is given a surface similar to that of a rough screw thread. This is managed on a lathe in the case of shafts, or by allowing the part to be turned *in situ* against a screw-cutting tool. The threads should be from fifteen to twenty per inch, should be about 0·025in. depth, and should be made as jagged as possible. In the case of flat surfaces, similar preparation should be done by means of chippers of electric or pneumatic type. It will perhaps be thought that this method of preparing a surface is liable to cause trouble in the case of highly stressed parts, due to the setting up of fatigue cracks, and it was this possibility that held back for some time the use of metal spraying for the reclamation of worn parts. After some years of careful test, it was found that this difficulty did not arise, and now, after a long commercial use, there has not been a single case where fatigue cracks have been set up by this method of preparation. Considering that the parts treated have, among other things, consisted of thousands of crankshafts for commercial vehicles, it can be definitely stated that the possibility of the setting up of fatigue cracks can be dismissed.

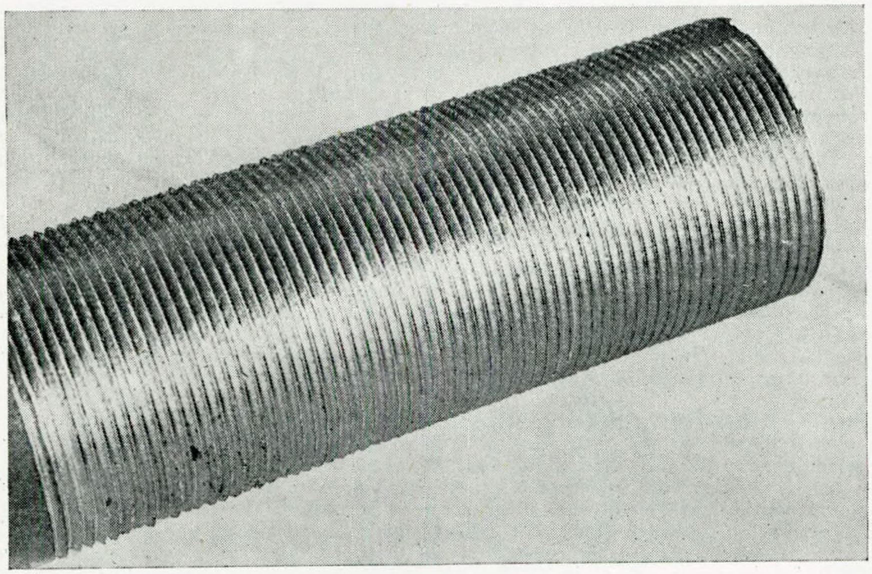


FIG. 3.—*A shaft prepared for spraying by a rough thread.*

Having dealt with the preparation of surfaces, it is desirable that some mention be made of the properties of the sprayed metal. All metals and alloys which can be drawn into wire and can be melted in the oxy-acetylene flame can be sprayed. Chromium cannot be used as the wire of this metal is not obtainable. From its method of deposit it will be obvious to all that the structure of sprayed metal will not be comparable with the structure obtained by casting or rolling; in fact sprayed-metal deposits have a peculiar structure of their own. They are built up of millions of small particles which may be likened within themselves to a pressure die casting, and these are held together by microscopic mechanical interlocking. Each particle will be oxidised to some extent on its surface, and there will be a certain amount of porosity where the particles do not entirely fit together. This porosity is very small in the case of the low melting point metals, but increases in the case of steel and the high melting point metals. It will be seen that a structure built up in this way cannot be expected to be very strong within itself, and in fact the tensile strength of sprayed metal is only comparable with that of cast metal, and the elongation is very small indeed. Owing to its structure, its compressive strength is comparatively high. Due to the fact that there are inclusions of oxide, the sprayed metal is somewhat harder than the metal as cast. In view of all that has been said, it will be appreciated that metal spraying is not suitable for covering a part that has to be worked and formed afterwards. Metal spraying must be applied as the last process.

Having made these general remarks, it may be stated that the amount of oxygen picked up during spraying varies from 0·2 to 0·9 per cent. according to the metal sprayed and the conditions of spraying. The majority of the oxidation occurs at the moment that the metal strikes the surface and not, as might be expected, in the flame.

*Rollason has shown that the interconnected porosity of a sample of sprayed mild steel is equal to 2·3 per cent., and a sample of 0·7 per cent. carbon steel gave a porosity of 3·4 per cent. It is this porosity of sprayed steel which is of the highest commercial importance, and gives the metal its bearing surface and its possibility of maintaining the oil film. The hardness of sprayed metal has been determined by †Fassbinder and Soulary, and the following figures indicate the range:—

	Brinell Number.	*Hardness of Cast Metal.*
Brass 70/30	103	58
Mild steel	226	118
Rustless steel 18/8 ...	187	160

All properties of sprayed metal may be varied considerably by the conditions of spraying, and many ‡investigators have given this matter their attention. It is, however, quite impossible in a paper of this type to give the conclusions reached, but the original work can be consulted.

In order to demonstrate the strength of the bond and the metal as sprayed, collars of sprayed metal $\frac{3}{16}$in. thick and 1in. wide were built up on 1in. dia. steel shafts. The rods were passed through a hole in a steel plate, and pulled in a tensile machine until the collars burst. With a collar of sprayed 0·8 per cent. carbon steel a pull of 22·45 tons was required, 18·8 stainless steel required 20·95 tons, and phosphor bronze 9·37 tons. A torsional test was made by building up a collar $1\frac{1}{16}$in. long on a $\frac{3}{4}$in. diameter steel shaft. The collar was $1\frac{1}{4}$in. external diameter corresponding to a deposit of $\frac{1}{4}$in. thickness. Two keyways $\frac{1}{8}$in. deep were cut in the collar to allow of it being fitted in a testing machine. The specimen appeared to fail at first by partial slipping of the collar, and then the shaft itself sheared just inside the sprayed coating. The torque was 4,600-inch-pounds and the total twist 310°. The stress was 24·8 tons per sq. in.

Sprayed metal can be turned and ground, and where possible, grinding to size is preferable. The wheel should not be too large in diameter compared with the work. It should be at high speed with comparatively light pressure. A medium hard vitreous bonded bauxite wheel is quite suitable. Where grinding is impossible, one of the authors has shown that turning will give a very satisfactory finish if a tungsten carbide tool is used with a low speed of about 70ft. per minute. The tool should be rigid and the

*"Metal Spraying". E. C. Rollason. *J. Inst. Metals, 1937, 60, 35.*

†Fassbinder & Soulary. "A Contribution to the Study of Metal Coatings". 12th Internat. Congress, Acet. Oxy-Acet. Welding and Allied Ind., 1936.

‡Thorman. Untersuchungen uber das Metallspritzverfahren nach Schoop. 1933. Karlsruhe. Badische Technische Hochschule Fredericiana.

cut light. It is needless to remark here that deposits of sprayed metal may be buffed to a high polish by the usual methods.

Having described quite briefly the process of metal spraying and its field of usefulness, it is desirable to consider some of the work which has been done in the marine industry. It must be stated, however, that the cases which are cited are merely examples, and the list is by no means complete. Engineers having before them a description of what has been done already, can visualise in how far the process can be of service to them. In many cases photographic records were made of the work, but these unfortunately have been destroyed by enemy action.

Propellers.

The cavitation of propellers on the suction side has long been a source of trouble to the marine engineer and a field of discussion for scientific societies. The causes of this phenomenon are outside the scope of this paper, but it is of interest to describe the incidence of spraying as a help to its solution.

Take first the case of cast-iron propellers on deep-sea trawlers where the average life is about eighteen months. One of the authors has been carrying out experiments over the last seven years mainly in the Humber district. At first a zinc coating was applied to the tips only, using a heavier coating on the suction side. This was unsuccessful as there appeared to be some galvanic action. Coatings of lead were next tried and gave good results from the corrosion point of view, but lead is very soft and will not stand up to conditions in shallow waters where the lead is destroyed by the abrasive action of sand. The coating was sometimes removed by the propellers fouling the trawl warps.

Commercial aluminium was next tried as a coating and was encouraging, but the use of pure aluminium (above 98 per cent.) was an achievement. One case, for example, was that of a trawler, the propeller of which was sprayed all over with this aluminium and lasted four years, and was still quite good when the ship was taken over for war purposes. When this ship was put on the slip and the propeller was examined, it was sometimes found necessary to respray a part of the blades, but even the cost of this was small compared with the cost of a propeller. A new screw used to cost approximately £40 and the cost of fitting added £10 to £14. The propeller sprayed in the shop before the ship was launched cost £10 and the cost of respraying a part on the slip was usually £7, care being taken to protect all rudder pintles during blasting. It will be seen that over four years the method used was commercially sound, and before the war one superintendent had all his propellers so treated. The re-spraying of the tips at overhauls is, however, necessary.

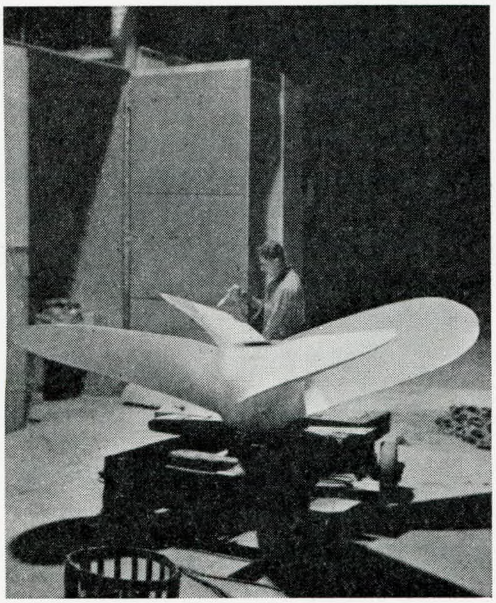


FIG. 4.—*Aluminium spraying a propeller in the shop. The shot-blasting chamber is seen in the background.*

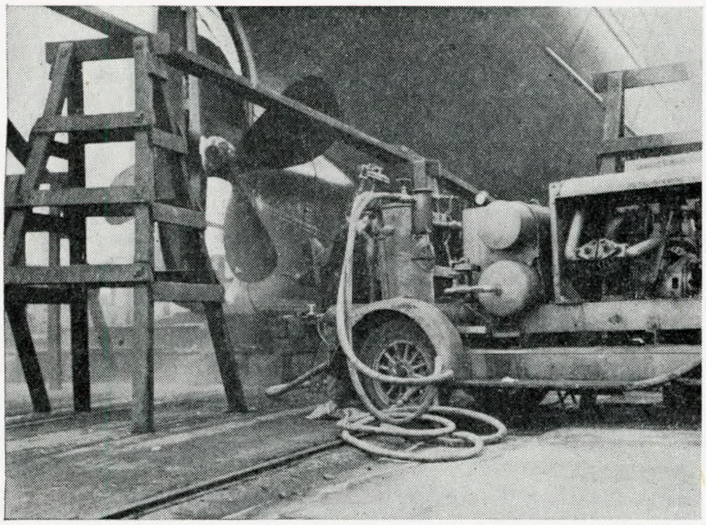


FIG. 5.—*Set up for spraying propeller tips on the slip. Compressor in foreground.*

With bronze propellers some successes have been achieved in the repair of cavitation holes. A Portuguese destroyer had one blade sprayed with lead and another with bronze. After eighteen months the repair was still in perfect condition. One of the three-bladed propellers of another ship was sprayed with phosphor bronze in August, 1939, to give, after grinding, the original contour of the blades on an area of about half their length from the tips, this area having been generally cavitated. After eighteen months, inspection showed very satisfactory results, but existing conditions made a follow up impossible. Two of the four blades of the propeller of a further ship, after being repaired with sprayed bronze and painted with bakelite varnish, showed the repaired portion unchanged after eighteen months' service. This propeller was, unfortunately, lost. These results prove that in some cases cavitated areas can be treated by spraying of bronze and the method would be of great commercial value. It is not suggested that in all cases of cavitation such repair would be effective as in one case involving the repair of the screw of a very large and fast liner, further cavitation occurred round the repaired portions and caused the added metal to be lifted out of position. Even in this case, several trips were made before breakdown, and in view of the fact that the repair was carried out in dry dock without removing the propeller, this may have been a commercial proposition.

Propeller Shafts.

No experience is claimed by the authors of the spraying of shaft liners of large ships, but as this has been successful with motor and small vessels, there is no reason why it should not be successful. The gland bearing surfaces of shafts on picket boats are being sprayed regularly with gun metal, bronze or Monel to give new bearing surfaces on bronze shafts. In the case of a 3,500-ton vessel it was found that a new propeller had been bored out approximately 0·020in. large in the big end of the taper. The tail shaft cone was built with sprayed mild steel and machined to the new taper. This was carried out by permission of Lloyd's who placed a letter aboard for the benefit of the surveyor who next examined the propeller. About two years later a report from Lloyd's, New York, stated that the shaft had been withdrawn and the work was perfect, and we understand that the propeller was refitted. The time taken for spraying and machining was twenty-four hours so that the saving of dock dues was considerable.

Propeller Shaft "A" Bracket Bushes.

These have been sprayed externally with bronze to increase the diameter to fit the rebored "A" bracket. The process being comparatively cold, the white-metal lining internally in the bush is not affected. In the case of one vessel four bushes between 12 and 14in. in diameter were built up to a maximum thickness of ⅜in. The cost is fairly high, but is not comparable with the cost of new bushes and dock dues, and so this type of repair has been used in many naval and merchant vessels.

Rudders.

The rudder tiller of a 6,000-ton merchant ship was found to be slack and working on the keys only. The yoke was sprayed in the bore with mild steel, machined and refitted. The cost was around £17 while a new rudder yoke was valued round £200. After two deep-sea voyages, this job is perfect.

Slack rudder pintles have been reclaimed and stocks have been built up to take the wear in the deck bushings.

Turbine Shafts and Rotors.

There are several instances of the successful building up of journals on turbine shafts and also of building up blade ring landings on rotors. In May, 1940, the main turbine rotor of one of H.M. cruisers was built up on eight ring landings and machined to leave a finished thickness of $^5/_{64}$in. of sprayed mild steel. The built-up rings were then pressed on and the complete assembly of the blades made. The rotor was balanced and the rings removed for re-assembly on board. The treatment was successful and a similar job was reclaimed in November, 1941.

Crankshafts.

These shafts for heavy auxiliary engines have been reclaimed by building up. A built-up crankshaft that has become loose or twisted in the webs may be reconditioned, thus saving new webs or forgings. A crank pin which was loose was removed, sprayed, ground and fitted to the re-bored web, and the whole shaft rebuilt in the usual manner. The amount bored out on the web was only a matter of 0·010in. to true up the hole.

Marine Bearings.

When the white metal in main bearings cracks and becomes loose, the pieces may be removed and replaced by sprayed babbitt metal. Bearings which have become loose on the pockets are also being sprayed with steel or bronze and refitted to the pocket. In one example the cost was about £1. Another case was the building up to a template with sprayed metal $\frac{1}{32}$in. to $\frac{1}{16}$in. in thickness, of the seven main bearing shells of a certain ship. Sprayed tin can also be used as a base for the ordinary white-metalling process of casting bearings, providing that the white metalling is carefully controlled. In one works this method has become standard—no failure having been recorded.

Cylinder Liners.

Owing to a mistake a cylinder liner some 4ft. in diameter for a marine engine was turned on the outside a slack fit in the cylinder, the mistake not being found out until the liner was aboard. The liner was sprayed with steel on the fitting strips and refitted to the cylinder and has been in service for some years.

Piston Valves and Rods.

Slack valve cages may be sprayed and refitted, and if grinding is possible, the bore of the cages can be treated. Solid type valves are being built up with high carbon steel to fit rebored valve cages as a routine job. Rods are reclaimed with mild steel or stainless steel so that standard packing can be used.

Gudgeon and Cross Head Pins.

Slack pins on Diesels are sprayed with high carbon steel and ground to size. This type of work has been common practice over a period of three years.

Main Engine and Boiler Valves.

Seats made of steel, bronze or Monel that have become slack are being reclaimed by spraying of the appropriate metal, and in some cases the actual face of the valve eroded by steam has been repaired. Another routine repair is that of Diesel valve inserts of bronze or steel.

Steam Joints.

When these have become grooved by escaping superheated steam, they may be sprayed and refaced with steel, giving a perfect job. Recently the process has been tried on copper discharge pipes which had pitted. The pipes were blasted and sprayed with copper internally and externally. The work appears to have been very successful.

Pumps.

Pump rods sprayed with stainless steel to bring back to original size are commonplace in repair work, and a rod from a Worthington pump has just been resprayed after a repair executed five years ago.

Naval bronze or Muntz metal rods are repaired similarly with brass.

The impeller shafts of centrifugal pumps are also being treated daily. Air pump buckets are sprayed either with phosphor bronze or stainless steel to fit rebored liners, with every success.

Armature Shafts.

This type of repair is now general and it is proving a great saving, as they can again be made a perfect fit for the ball races.

The above examples are taken in order to show the possibilities of repair or reclamation work by means of metal spraying. It is obvious that this type of work should be undertaken only by those with engineering experience, as sprayed metal does not add to the strength of a worn part, so that the detail in itself must have sufficient strength for further service.

With regard to the use of spraying as a protective coating, a few examples may be cited.

Hulls.

A great many launches used by the Services are being sprayed with zinc before painting. From what has been said, the advantage is obvious, as frequent painting is obviated and the results obtained have fully justified the proceeding.

Water Tanks.

These are sprayed with tin 0·008in. in thickness and are giving excellent service.

Winches.

The fittings of deck winches subject to attack from sea spray are sprayed with zinc 0·004in. thickness. In one extreme case violent corrosion occurred after a single voyage to the Orient—after spraying no corrosion was discernible after three such voyages.

Boiler Mountings.

Very good results are obtained by spraying with aluminium 0·004in. in thickness.

Zinc coatings applied by spraying are now commonplace on radio chassis, aerial mountings, transformer cases, petrol tanks, gun and searchlight mountings.

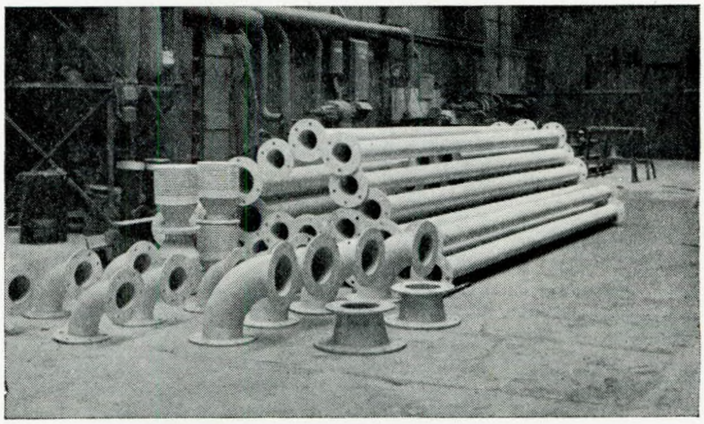


FIG. 6.—*Salvage pipes sprayed inside and out with zinc.*

The authors hope that this paper will serve to show the scope of the metal spraying process and to stimulate interest in its further use. Many corrosion problems can be solved if the correct metallic covering is applied, but many yet remain. So far, spraying cannot give the answer to the corrosion taking place inside tanks of tankers used for crude oil, and using sea water as ballast on the outward trip. The process offers in many cases the long desired "putting-on tool" but again this is not so in every case of wear. Parts subject to heavy shock loads are not in general ideal subjects for spraying. It is only by close co-operation between the engineers and the metal sprayers that progress can be made, and if this paper contributes to this union of effort, it will have served its purpose.

DISCUSSION

Contributions by correspondence, not exceeding 1,000 words in length, are invited to the discussion on this paper. Such contributions will be published, with the authors' reply, in a subsequent issue of the TRANSACTIONS.

JUNIOR SECTION.

Naval Architecture and Ship Construction (Chapter XIV).

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

Trim.

Trim is the difference of draught forward and aft.

For example a vessel drawing 26ft. aft and 24ft. forward is said to be trimming 2ft. by the stern. If a weight already on board be moved in such a way as to cause a change of trim of say 1ft., there would be an increase of approximately 6in. one end and a decrease of 6in. the other. It is important to note that a change of trim of *"h"* inches does not mean an alteration of this amount at each end of the ship, but only one-half thereof. The point should be made clear in subsequent examples.

It has already been recorded in this work that a vessel *trims* about her *centre of flotation,* which is the centre of gravity of the waterplane, and as this point is usually a few feet abaft amidships (in the loaded condition) it follows that the change aft is rather less than the change forward. As an example take a vessel 400ft. long having its centre of flotation 10ft. abaft amidships, and suppose there to be a change of trim of 1ft. by the head. Referring to Fig. 161

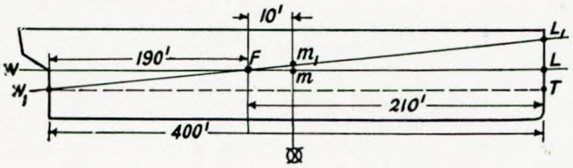


FIG. 161.

$$\text{it is clear that } \frac{WW_1}{WF}=\frac{LL_1}{LF}=\frac{L_1T}{W_1T}=\frac{1}{400}$$

also $WF=190$ft., $LF=210$ft.

$$\text{Hence } WW_1=\frac{190\times 1}{400}=0{\cdot}475\text{ft.}$$

$$LL_1=\frac{210\times 1}{400}=0{\cdot}525\text{ft.}$$

If in this case the original draught had been 24ft. even keel, the new draughts would be $\left\{\begin{array}{l}\text{Fd. } 24{\cdot}525\text{ft.}\\ \text{Aft. } 23{\cdot}525\text{ft.}\end{array}\right\}$ the mean of which is 24·025ft. Since there has been no change of weight on board, the mean draught after trimming should have been the same as that before trimming, but there appears to be a discrepancy of 0·025ft. The explanation is that mean draught should always be measured at the centre of flotation, not amidships as is done in practice, and as is implied when the forward and after draughts are added together and divided by 2. The error involved is represented in the figure by the quantity mm_1.

$$\text{Now } \frac{mm_1}{10}=\frac{\text{change of trim } (L_1T)}{\text{length } (400)}$$

For small amounts out of designed trim the refinement is of little value, but consider a case where the amount out of designed trim is say 6ft. Then

$$\frac{mm_1}{10}=\frac{6}{400}$$

$$\text{or } mm_1=\frac{60}{400}=0{\cdot}15\text{ft., which is nearly 2in.}$$

If the tons per inch immersion was about 45, the error in estimating displacement would be $45\times 0{\cdot}15\times 12=81$ tons. In the case of a vessel down by the head, as illustrated, the value obtained in the ordinary way by referring to the displacement scale would be in excess of the true value and the 81 tons would have to be deducted. When down by the stern the correction should be added. Bearing in mind that the load-line markings are amidships, it will be seen that for a vessel trimming heavily by the stern, overloading will occur unless the centre of the disc is kept an inch or two clear of the water. When down by the head it should be permissible to submerge the centre of the disc slightly.

The moment to change trim 1in. is as the name implies that moment of force which would give rise to a change in trim of 1in. It may be abbreviated M.C.T. 1 in. or I.T.M. (Inch Trim Moment).

Suppose a weight w tons to be moved d feet from aft to forward (Fig. 162) such that the vessel trims 1in. by the bow.

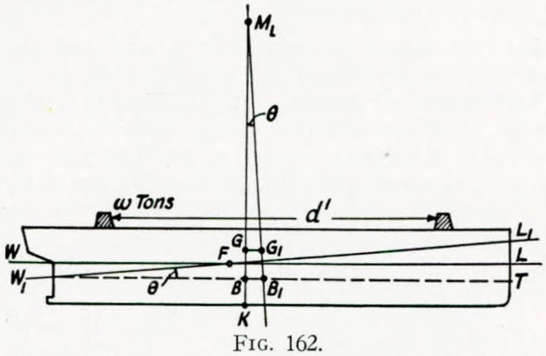


FIG. 162.

Then $(w\times d)$ tons-feet is the moment which trims the ship 1in.

If the centre of gravity of the ship moves from G to G_1 where GG_1 is parallel to the shift of weight,

$$GG_1=\frac{w\times d}{W} \quad (W=\text{displacement in tons})$$

i.e. $w\times d=W\times GG_1$ ... ... (1)

$$\text{Again } \frac{GG_1}{GM_L}=\text{the circular measure of } \theta\text{, where } \theta \text{ is}$$

the angle of trim,

i.e. $GG_1=GM_L.\theta$

Hence $w\times d=W\times GM_L.\theta$ ... ... (2)

The condition of the problem is that the vessel should trim 1in. Therefore

$$L_1T=1\text{in and since } \theta=\frac{L_1T}{W_1T}=\frac{\frac{1}{12}}{L}=\frac{1}{12L}$$

it follows by substitution in (2)

$$w\times d=W\times GM_L\times\frac{1}{12L}$$

$$\text{Whence M.C.T. 1in.}=\frac{W\times GM_L}{12L} \quad \dots \quad \dots \quad \dots (3)$$

The quantity GM_L is termed the *longitudinal metacentric height,* where M_L is the longitudinal metacentre.

The *longitudinal metacentre* is the intersection of a vertical line drawn through the centre of buoyancy in the initial position with a vertical line drawn through the centre of buoyancy in a slightly trimmed position.

It is now possible to employ Simpson's Rules to determine the position of M_L relative to the keel, and reference to Fig. 162 will indicate

$$KM_L=KB+BM_L$$
$$GM_L=KM_L-KG$$

The method of getting KB has been dealt with already; it remains to show how BM_L may be obtained. Once more, much of what follows must be taken for granted, for in the interests of brevity and simplicity mathematical deduction has been eliminated wherever possible.

It can be proved that $BM_L=\frac{I_{CF}}{V}$ where I_{CF} is the moment of inertia of the waterplane about a transverse axis passing through the centre of flotation; V=underwater volume of the ship.

To obtain I_{CF} it is the practice to calculate I about a transverse axis amidships, at the same time calculate the position of the centre of flotation relative to amidships, and finally make the necessary correction to the moment of inertia by employing the Theorem of Parallel Axes.

The Theorem of Parallel Axes.

This theorem is so important in engineering work that no apology is offered for stating it here.

The moment of inertia of a plane surface about an axis in its plane but external to the centroid, is equal to the moment of inertia about a parallel axis passing through the centroid, plus the area of the surface multiplied by the square of the distance between the centroid and the specified axis.

In Fig. 163 suppose the axis XX_1 is at a distance h from C, where C is the centroid of the surface. Let PP_1 be an axis through C parallel to XX_1 and let the area of the surface be A.

Then $I_{XX1} = I_{P'P1} + Ah^2$

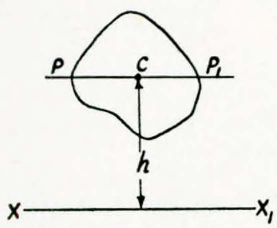


FIG. 163.

Now referring to the ship's waterplane in Fig. 164

Let A = area of plane

h = distance of centre of flotation abaft amidships.

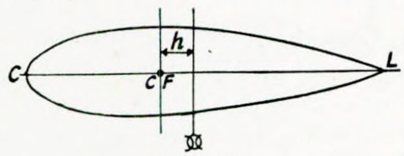


FIG. 164.

The required moment of inertia about the centre of flotation $= I_{CF}$

Moment of inertia about amidships $= I_{\text{amidships}}$

Then by the Theorem of Parallel Axes $I_{\text{amidships}}$
$= I_{CF} + Ah^2$ or $I_{CF} = I_{\text{amidships}} - Ah^2$

This is very important.

To obtain $I_{\text{amidships}}$ the following table is used.

½ ord.	S.M.	Product for Area.	Lever.	Product for Moment.	Lever.	Product for Moment of Inertia.
y_1	1	y_1	5	$5y_1$	5	$25y_1$
y_2	4	$4y_2$	4	$16y_2$	4	$64y_2$
y_3	2	$2y_3$	3	$6y_3$	3	$18y_3$
y_4	4	etc.	2	etc.	2	etc.
y_5	2		1		1	
y_6	4		0	m_1	0	
y_7	2		1		1	
y_8	4		2		2	
y_9	2		3		3	
y_{10}	4		4		4	
y_{11}	1		5		5	
		S		m_2		Z

Area of plane $= 2 \times \frac{1}{3} \times$ common interval $\times S = A$ sq. ft.

$C.F.$ from amidships $= \dfrac{\text{common interval } (m_1 \backsim m_2)}{S} = h$ ft.

$I_{\text{amidships}} = \frac{2}{3} \times (\text{common interval})^3 \times Z = I_{\text{amidships}}$ ft.⁴ units,

and finally $I_{CF} = I_{\text{amidships}} - Ah^2$

Certain complications arise when the waterplane has what is called a stern appendage, but it will not be necessary to make further reference to the matter here.

Example 43.

The half ordinates of the waterplane of a vessel whose displacement is 8,000 tons are spaced 35ft. apart and measure 3·0, 16·6, 25·5, 28·6, 29·8, 30, 29·8, 29·5, 28·5, 24·2 and ·8 feet respectively, starting from forward. Find (1) the area of the waterplane, (2) the position of the centre of flotation, (3) the distance between the centre of buoyancy and the longitudinal metacentre.

½ ord.	S.M.	Product for Area.	Lever.	Product for Moment.	Lever.	Product for Moment of Inertia.
Fd. 3·0	1	3·0	5	15·0	5	75·0
16·6	4	66·4	4	265·6	4	1,062·4
25·5	2	51·0	3	153·0	3	459·0
28·6	4	114·4	2	228·8	2	457·6
29·8	2	59·6	1	59·6	1	59·6
30·0	4	120·0	0	722·0	0	0
29·8	2	59·6	1	59·6	1	59·6
29·5	4	118·0	2	236·0	2	472·0
28·5	2	57·0	3	171·0	3	513·0
24·2	4	96·8	4	387·2	4	1,548·8
·8	1	·8	5	4·0	5	20·0
		746·6		857·8		4,727·0

(1) Area $= \frac{2}{3} \times 35 \times 746{\cdot}6 = 17{,}420$ sq. ft.

(2) CF abaft amidships $= \dfrac{35(857{\cdot}2 - 722{\cdot}0)}{746{\cdot}6} = 6{\cdot}36$ft.

(3) $I_{\text{amidships}} = \frac{2}{3} \times 35^3 \times 4{,}727 = 135{,}100{,}000$ft.⁴ units.

$I_{CF} = I_{\text{amidships}} - Ah^2 = 135{,}100{,}000 - 17{,}420 \times 6{\cdot}36^2$
$= 135{,}100{,}000 - 706{,}000 = 134{,}394{,}000$ft.⁴ units.

$$BM_L = \frac{I_{CF}}{V} = \frac{I_{CF}}{35W} = \frac{134{,}394{,}000}{35 \times 8{,}000} = 480\text{ft.}$$

N.B.—All the quantities in Column 7 have to be added. Do *not* take differences as in Column 5.

Example 44.

In the vessel in the previous question the centre of buoyancy was 14ft. above keel, and the centre of gravity was 24ft. above keel. Calculate the moment to change trim 1in.

$KB = 14$ft.
$BM_L = 480$ft.

$KM_L = 494$ft.
$KG = 24$ft.

$GM_L = 470$ft.

$$\text{M.C.T. 1in.} = \frac{W \times GM_L}{12L} = \frac{8{,}000 \times 470}{12 \times 350} = 895 \text{ tons ft.}$$

The effect of shifting a weight already on board.

This will be understood from the following example.

Example 45.

A weight of 50 tons already on board is moved a distance of 180ft. from aft to forward. The moment to change trim 1in. is 900 tons ft. The original draughts were 25ft. aft, 23ft. forward. Estimate the new draughts assuming the centre of flotation amidships.

$$\text{Change of trim (in inches)} = \frac{\text{Moment Causing Trim (in tons feet)}}{\text{M.C.T. 1in.}}$$

$$= \frac{50 \times 180}{900} = 10\text{in. by the head.}$$

New draughts { Fd. 23′ 0″ + 5″ = 23′ 5″ ; Aft. 25′ 0″ − 5″ = 24′ 7″ }

Change of Trim due to the Addition of Weight.

When weight is added to a ship there will be an addition to the mean draught as well as an alteration in trim, and the final draughts are obtained by considering both of these effects.

Let T = tons per inch immersion, W = added weight

N = number of inches change of trim say by the head then the alterations will be

$$\left.\begin{aligned} &\text{Fd.} \quad +\frac{W}{T}+\frac{N}{2} \\ &\text{Aft.} \quad +\frac{W}{T}-\frac{N}{2} \end{aligned}\right\} \text{approximately.}$$

Example 46.

A vessel whose original draught is 24ft. even keel and displacement 8,000 tons has its centre of flotation amidships. The tons per inch immersion is 45 tons and a weight of 90 tons is placed on board 100ft. forward of amidships. If the M.C.T. 1in. is 900 tons ft., estimate the new draughts.

$$\text{Bodily sinkage} = \frac{\text{added weight}}{\text{T.P.I.}} = \frac{90}{45} = 2\text{in.}$$

$$\text{Change of trim} = \frac{\text{added weight} \times \text{distance from } C.F.}{\text{M.C.T. 1in.}}$$

$$= \frac{90 \times 100}{900} = 10\text{in. by the head.}$$

$$\text{New draughts}: \left\{\begin{aligned} &\text{Fd.} \quad 24'\,0'' + 2'' + 5'' = 24'\,7'' \\ &\text{Aft.} \quad 24'\,0'' + 2'' - 5'' = 23'\,9'' \end{aligned}\right\}$$

Example on the Box Form.

Example 47.

A box form 300ft. long, 42ft. beam, 16ft. even keel draught has a weight of 40 tons already on board moved a distance 80ft. aft. Find the new draughts. The centre of gravity is 14ft. above keel.

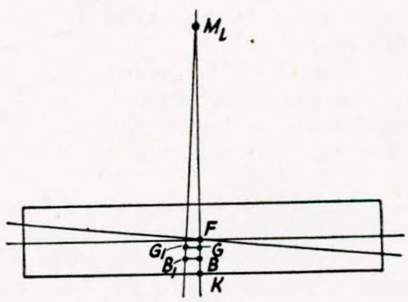


Fig. 165.

The waterplane is a rectangle of length L and breadth B; so that its moment of inertia about a transverse axis amidships is $\dfrac{L^3 \times B}{12}$.

Since the centre of flotation in this case is also amidships no correction to the moment of inertia is necessary.

If the mean draught be d feet the underwater volume $V = L \times B \times d$ cu. ft.

$$BM_L = \frac{I_{CF}}{V} = \frac{L^3 \times B}{12} \times \frac{1}{L \times B \times d} = \frac{L^2}{12d}$$

$$\text{Whence } BM_L = \frac{300 \times 300}{12 \times 16} = 468{\cdot}75\text{ft.}$$

$$KB = \frac{d}{2} = \frac{16}{2} = \quad 8{\cdot}00\text{ft.}$$

$$KM_L = KB + BM_L = 476{\cdot}75\text{ft.}$$

$$GM_L = KM_L - KG = 476{\cdot}75 - 14 = 462{\cdot}75\text{ft.}$$

$$\text{M.C.T. 1in.} = \frac{W \times GM_L}{12L} = \frac{300 \times 42 \times 16}{35} \times \frac{462{\cdot}75}{12 \times 300}$$

$$= 840{\cdot}4 \text{ tons ft.}$$

Change of trim in inches =

$$\frac{\text{moment changing trim}}{\text{moment to change trim 1in.}} = \frac{40 \times 80}{840} = 7{\cdot}6\text{in.}$$

$$\text{New draughts}: \left\{\begin{aligned} &\text{Fd.} \quad 16'\,0'' - 3\tfrac{3}{4}'' = 15'\,8\tfrac{1}{4}'' \\ &\text{Aft.} \quad 16'\,0'' + 3\tfrac{3}{4}'' = 16'\,3\tfrac{3}{4}'' \end{aligned}\right\} \text{approx.}$$

The Position where a Weight must be added in order to Keep the After Draught Constant.

Occasionally a vessel may have to pass through a channel where the depth of water is restricted. In the particular case of a vessel trimming by the stern, where the after draught is the maximum which can be allowed, it may nevertheless be possible to add weight, provided there be no change aft, and provided the increase forward is limited to the amount which will bring her on to an even keel.

The amount which can be added is derived approximately as follows:—

Let d_1 = draught aft

d_2 = „ forward.

$$\text{Mean} = \frac{d_1 + d_2}{2}$$

If on an even keel at draught d_1

$$\text{the permissible sinkage} = d_1 - \frac{d_1 + d_2}{2}$$

$$= \frac{d_1 - d_2}{2} \text{ ft.}$$

Example 48.

For a certain vessel the after draught is 24ft. and the forward draught 22ft. The tons per inch is 45. What weight must be added to bring the vessel to an even keel draught of 24ft.?

$$\text{Weight to be added} = 12 \times \frac{d_1 - d_2}{2} \times \text{T.P.I.}$$

$$= 12 \times \frac{(24 - 22)}{2} \times 45 = 540 \text{ tons.}$$

It now remains to find where the centre of gravity of the added weight should be situated if the after draught is to remain constant.

For simplicity assume the centre of flotation to be amidships, and let a weight w tons be added d ft. forward of amidships.

The bodily sinkage $= \dfrac{w}{T}$ in. where T is the tons per inch.

The change of trim $= \dfrac{w \times d}{M}$ where M is moment to change trim 1in.

Hence the change of draught aft $= \dfrac{w}{T} - \dfrac{wd}{2M}$

If this is to equal zero,

$$\text{then } \frac{w}{T} - \frac{wd}{2M} = 0$$

$$\frac{w}{T} = \frac{wd}{2M}$$

$$d = \frac{2M}{T}$$

This expression would be somewhat inaccurate in the special case where the centre of flotation is well removed from amidships, but in general it gives quite satisfactory results.

Example 49.

A certain vessel has a moment to change trim 1in. of 900 tons ft., and a tons per inch immersion of 45.

Assuming the centre of flotation amidships, where must a weight be added in order to keep the after draught constant?

Let d = distance of weight forward of amidships

then $d = \frac{2M}{T} = \frac{2 \times 900}{45} = 40\text{ft.}$

The Effect of Density on Trim.

When a vessel passes from river to sea there is a small reduction in draught, and that portion of the upthrust which in river water would represent a layer in the region of the waterline, and which could be considered as acting upwards through the centre of flotation, is now transferred to the centre of buoyancy. The centre of flotation in the loaded condition is usually a few feet abaft amidships, whereas the centre of buoyancy would be a foot or so forward. The transference involved therefore is the equivalent of moving an upward force a short distance forward. Its effect is to produce a small trim by the stern. It does not amount to more than an inch or two, and as the effect is relatively negligible it has not been thought necessary to introduce formulæ for its evaluation.

Approximate Formulæ for Moment to Change Trim 1in.

In an average cargo steamer the longitudinal metacentric height (GM_L) is approximately 1·0 to 1·2 times the length of the ship (for the loaded condition). If this be so, M.C.T. 1in. $= \frac{W \times GM_L}{12L} = \frac{W \times L}{12L} = \frac{W}{12}$ tons ft.

or for a fine-lined ship M.C.T. 1in. $= \frac{W \times 1{\cdot}2L}{12L} = \frac{W}{10}$ tons ft.

where W = displacement in tons.

Example 50.

What would be the effect of adding a weight of 90 tons in the after hold of a ship of 10,800 tons displacement, if the tons per inch immersion is 45, and the centre of gravity of the hold space is 130ft. abaft amidships?

Assume M.C.T. 1in. $= \frac{W}{12}$

$= \frac{10{,}800}{12} = 900$ tons ft.

Change of trim $= \frac{90 \times 130}{900} = 13\text{in.}$

Bodily sinkage $= \frac{90}{45} = 2\text{in.}$

Increase aft $= 2 + 6\frac{1}{2} = 8\frac{1}{2}$in.
Decrease forward $= 2 - 6\frac{1}{2} = -4\frac{1}{2}$in. } roughly.

Another approximate formula which is in fairly common use is M.C.T. 1in. $= \frac{31T^2}{B}$, where

T = tons per inch immersion

B = breadth of ship in ft.

It should be used with caution, since both T and B alter with changes in draught. The constant 31 would also vary with draught.

Example 51.

Find the moment to change trim 1in. in a vessel 60 ft. beam and tons per inch immersion 45.

M.C.T. 1in. $= \frac{31 \times 45^2}{60} = 1{,}046$ tons ft.

It is usual for the builders to provide the ship with trim data in some form or another. Sometimes this consists of a profile drawing on which is depicted the effects of loading certain compartments, or a tabulated statement may be supplied setting out information of a similar character. The object of such data is to relieve the ship personnel from the responsibility of making calculations. The methods lack generality, and it is suggested that the best procedure would be to provide the ship with a table of moment to change trim 1in. values at, say, intervals of 2ft. of draught, together with a profile drawing indicating the positions of the centres of gravity of the various compartments when homogeneously loaded. If the officer responsible for loading can claim a sound knowledge of the principles involved, there should be no difficulty in estimating changes of trim of moderate amount. When large alterations of draught and trim are involved the procedure is rather more complicated than can be dealt with here, although there is no inherent difficulty.

Docking with a Large Trim by the Stern.

As the vessel reaches the blocks aft a certain amount of support is offered at the point of contact. The water falls away from the ship and the upthrust exerted by the water is correspondingly reduced. This goes on until all the water has left the ship, and all the weight is taken by the blocks. It is not necessary to pursue the enquiry, however, beyond the point where the vessel just takes the blocks all fore and aft; for it is then that the breast shores are set, and thereafter the ship may be considered safe.

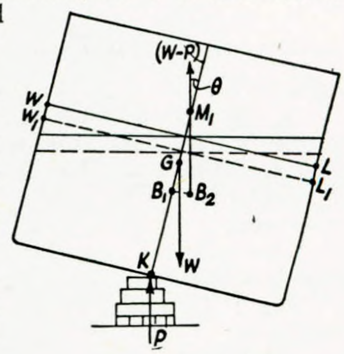


FIG. 166.

Referring to Fig. 166, WL is the water line for the afloat condition and W_1L_1 for the condition after a weight P tons has been taken by the after blocks.

Let B_1 be the centre of buoyancy corresponding to the upright condition for the water line W_1L_1.

Let B_2 be the centre of buoyancy for the inclined position of the water line W_1L_1.

Upwards through B_2 there will be a force $(W-P)$ tons, where W equals the displacement of the ship.

Downwards through G will be a force of W tons. Take moments about K.

Then if θ is the angle of transverse inclination of the ship, the

restoring couple $= (W-P)\ KM_1 \sin\theta - W.KG \sin\theta$
$= [(W-P)\ KM_1 - W.KG] \sin\theta$
$= [W.KM_1 - W.KG - P.KM_1] \sin\theta$
$= [W.GM_1 - P.KM_1] \sin\theta$ tons ft.

This statement is correct and complete in itself, but for the guidance of those who like to picture a change in stability in terms of a change in the metacentric height, the following procedure is permissible:—

Suppose the new moment of stability to be expressed in the conventional form $W.GM_2 \sin\theta$, where GM_2 is some virtual metacentric height.

Then $W.GM_2 \sin\theta = W[GM_1 - \frac{P}{W}.KM_1] \sin\theta$,

$$\text{or } GM_2 = [GM_1 - \frac{P}{W}.KM_1] \text{ ft.}$$

If the value of P is known, the position of M_1 can be found by reference to the metacentric diagram, and hence GM_2 can be evaluated.

As a rough approximation the loss of metacentric height due to grounding may be taken as $\frac{P}{W}.KM_1$. This is true if the metacentric curve is horizontal in the region of the draughts considered.

To find the value of P (the load on the after block just as the vessel grounds all fore and aft)

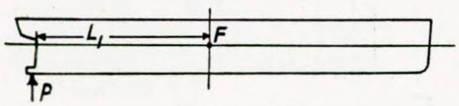


FIG. 167.

Suppose i to be the number of inches trim by the stern when the keel first touches aft;

Let l_1 be the distance of the point of contact from the centre of flotation (measured horizontally);

Let M be the moment to change trim 1in.;

$$\text{then } P \times l_1 = M \times i$$

$$P = \frac{Mi}{l_1}$$

If $l_1 = \frac{L}{2}$ where L = length of ship,

$$\text{then } P = \frac{2Mi}{L}$$

Example 52.

A vessel 400ft. long has a displacement of 10,000 tons, and a M.C.T. 1in. of 1,000 tons ft. Her metacentric height is 1ft. 6in. Her metacentre is 25ft. above keel, and the curve of metacentres is horizontal in the region of the draughts considered. It is proposed to dock this vessel with a trim of 4ft. by the stern. What will be the virtual metacentric height at the instant of grounding all fore and aft? Take the centre of flotation amidships.

$$P = \frac{2Mi}{L} = \frac{2 \times 1{,}000 \times 48}{400} = 240 \text{ tons}$$

$$GM_2 = GM_1 - \frac{P}{W}.\ KM_1$$

$$= 1{\cdot}5 - \frac{240}{10{,}000} \times 25 = 1{\cdot}5 - {\cdot}6 = {\cdot}9\text{ft.}$$

NOTE.—Should a vessel tend to develop negative metacentric height during the operation, it would be desirable to set the after pair of breast shores immediately she grounds aft. Further, if P becomes excessive the after blocks might tend to crush and collapse. They should therefore be reinforced.

The Flooding of an End Compartment.

The argument involved in this investigation may prove troublesome to a beginner, who would be well advised perhaps to pass it over for the time being.

For the purposes of illustration a box form has been employed, although with minor modifications the

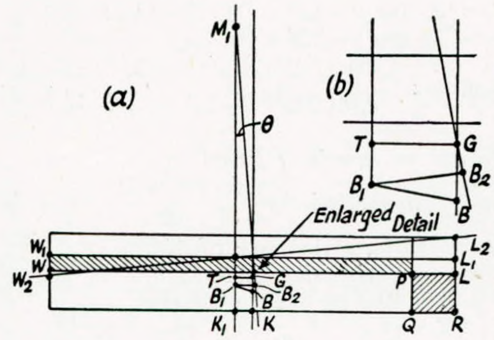


FIG. 168.

method is equally applicable to a ship form.

If the compartment $PQRL$ be flooded, first assume the vessel to sink to the line W_1L_1 where the shaded volume W_1P equals the volume of buoyancy destroyed PR. This supposes no trim, and the centre of buoyancy will have moved from B to B_1. The vessel is not in equilibrium, however, as the lines of action of buoyancy and weight are separated horizontally by the distance TG. Trimming must now take place on to the line W_2L_2 such that the centre of buoyancy moves from B_1 to B_2, the latter point being in the same vertical as G, and in the line containing M_1. In other words B_2, G and M_1 are in the same line, and this line is perpendicular to W_2L_2.

Let the angle of trim be θ.

Draw GT horizontally to meet B_1M_1 in T.

$$\text{then } \frac{GT}{TM_1} = \tan\theta.$$

GT is the horizontal distance between B_1 and G.

$TM_1 = K_1M_1 - K_1T = K_1M_1 - KG$.

Hence if KG is known, and K_1M_1 and GT can be found, $\tan\theta$ can be evaluated.

$K_1M_1 = K_1B_1 + B_1M_1$

$$B_1M_1 = \frac{\text{moment of inertia of intact plane about } C.F.}{\text{underwater volume}}$$

K_1B_1 is readily determined.

The following example will make the process clear.

Example 53.

A box form 300ft. × 40ft. × 16ft. draught has its centre of gravity 14ft. above the keel. Find the new draughts when an end compartment 50ft. long is bilged.

Bodily sinkage $= x$, where

$x \times$ area of intact plane = volume of buoyancy destroyed;

$$x \times 250 \times 40 = 50 \times 40 \times 16$$

$$x = 3{\cdot}2\text{ft.}$$

Hence for an even keel condition the draught at $W_1L_1 = 16 + 3{\cdot}2 = 19{\cdot}2$ft.

$$\therefore\ K_1B_1 = \frac{19{\cdot}2}{2} = 9{\cdot}6\text{ft.}$$

$$B_1M_1 = \frac{I \text{ of intact plane}}{V} = \frac{40 \times 250^3}{12} \times \frac{1}{300 \times 40 \times 16}$$

$$= 271{\cdot}3\text{ft.}$$

$K_1M_1 = K_1B_1 + B_1M_1 = 9{\cdot}6 + 271{\cdot}3 = 280{\cdot}9$ft.

$TM_1 = K_1M_1 - KG = 280{\cdot}9 - 14 = 266{\cdot}9$ft.

$$\text{Clearly } B_1 = \frac{250}{2} + 50 = 175\text{ft. from F.E.}$$

$$G = \frac{300}{2} = 150 \text{ ,, ,, ,,}$$

$$\text{Hence } TG = 25\text{ft.,}$$

$$\text{and } \tan\theta = \frac{TG}{TM_1} = \frac{25}{266{\cdot}9} = {\cdot}09365$$

$$\theta = 5^\circ\ 21'$$

Now $W_1W_2 = 125 \tan\theta = 125 \times \cdot09365 = 11\cdot7$ft.

$L_1L_2 = 175 \tan\theta = 175 \times \cdot09365 = 16\cdot39$ft.

$$\therefore \text{ new draughts: } \begin{cases} \text{Fd.} & 19\cdot2 + 16\cdot39 = 35\cdot59\text{ft.} \\ \text{Aft} & 19\cdot2 - 11\cdot7 = 7\cdot5 \text{ ft.} \end{cases}$$

Alternative Solution to Previous Problem.

An upthrust represented by $\frac{50 \times 40 \times 16}{35}$ tons is transferred from P to b_1, a distance of 150ft.

This gives rise to a trimming moment of

$$\frac{50 \times 40 \times 16}{35} \times 150 = \frac{960{,}000}{7} \text{tons ft.}$$

The actual change of trim will be found by dividing this quantity by the M.C.T. 1in. for the damaged condition.

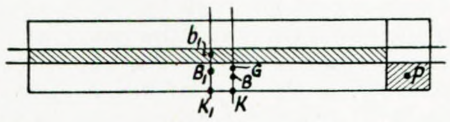


FIG. 169.

$$I \text{ of intact portion of plane} = \frac{250^3 \times 40}{12}$$

$$B_1M_1 = \frac{I}{V} = \frac{250^3 \times 40}{12} \times \frac{1}{300 \times 40 \times 16} \quad \text{[NOTE.—There is no change in volume.]}$$

$$= 271\cdot3\text{ft.}$$

$$KM_1 = K_1B_1 + B_1M_1 = 9\cdot6 + 271\cdot3 = 281\text{ft.}$$

$$GM_1 = KM_1 - KG = 281 - 14 = 267\text{ft.}$$

$$\text{M.C.T. 1in.} = \frac{W.GM_L}{12L} = \frac{300 \times 40 \times 16}{35} \times \frac{267}{12 \times 300}$$

$$= 406\cdot7 \text{ tons-ft.}$$

$$\text{Change of trim} = \frac{960{,}000}{7} \times \frac{1}{406\cdot7} = 337\text{in.}$$

$$\text{Increase forward} = 337 \times \frac{175}{300} = 16'\ 4\tfrac{1}{2}''$$

$$\text{Decrease aft} = 337 \times \frac{125}{300} = 11'\ 8\tfrac{1}{2}''$$

$$\text{New draughts: } \begin{cases} \text{Fd.} & 19'\ 2\tfrac{1}{2}'' + 16'\ 4\tfrac{1}{2}'' = 35'\ 7'' \\ \text{Aft.} & 19'\ 2\tfrac{1}{2}'' - 11'\ 8\tfrac{1}{2}'' = 7'\ 6'' \end{cases}$$

A New Pump Suction Strainer.

By E. GOODSON (Member).

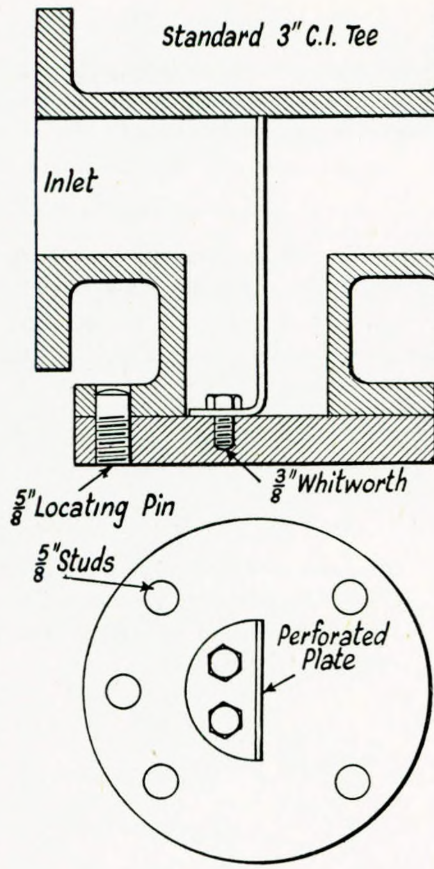
Certain alterations have to be made to most ships when they are required to transport large bodies of men, and not least of the problems which arise is to provide sufficient fresh water.

This is usually achieved by the utilization of the existing ballast tanks to supply a special washing water system, the cemented fresh-water tanks being retained for drinking and culinary purposes.

A few judiciously placed blank flanges and new pipes enable the spare fresh-water pump to be used, but if this is of the high-speed centrifugal type, trouble may be experienced due to choking of the impeller by debris overlooked by the cleaners. To clear the impellers in the case of a vertical pump entails lifting the whole pump, a very inconvenient operation when, as in convoy, it is necessary for the watch-keeper to remain on the control platform.

The strainer described below was designed to prevent this trouble, and has a number of advantages over the more orthodox weed traps. The body may be adapted from a standard tee piece as illustrated, or may be a branch welded in the suction pipe at any convenient position, both types having proved perfectly satisfactory in practice over a period of two years.

A strainer plate is mounted on the blind flange and slides freely up to the top of the pipe bore, with a clearance of not more than $\frac{1}{16}$in. It is made from $\frac{1}{8}$in. Muntz metal perforated with $\frac{1}{4}$in. holes to give an area of about twice the pipe bore. Two $\frac{5}{8}$in. Whitworth steel tap bolts secure it to the base flange and the sides of the branch support it if any forward movement takes place due to choking. These bolts being on the inlet side require no locking device. A locating pin is fitted between two of the stud holes to prevent the strainer being fitted incorrectly, and where the base flange is sufficiently thick two lifting studs may be fitted. It will be seen that the cost of the strainer is little more than that of the standard tee, fitting it in the suction line being the highest charge.



The top of the pipe retains its continuous run, so is easily flooded after cleaning and any dirt lying in the pipe tends to flush out when the strainer is withdrawn. As the joint is submerged any leakage is detected immediately on flooding the line. The lower branch of the tee forms an appendix into which small pieces of dirt will fall and the strainer will choke almost solid before the water flow is noticeably affected. A similar strainer fitted to the fresh-water tank suction has given equally good results. It has been found that cleaners at some ports have evolved new and better methods of hiding their brushes, shovels and buckets, as well as piles of cement scrapings and even clothes, from the not always experienced person whose duty it is to inspect the tank before it is closed up.

ELECTION OF MEMBERS.

List of those elected by the Council during the period 13th November to 31st December, 1941.

Members.

Thomas Tarleton Brandreth.
Frederick Cavill Lloyd.
George McAllister.
William Albert Nevin.
William Nithsdale.
John Brundrit Sankey.
Robert Lyon Scott.
Edward Stephenson.
William Lyle Stevenson.
James Adam Barbour-Caldwell.
Harry Edgar Durrant.
Norton Howarth.
George Robert Lister.
Charles William Thomas Saunders.

Associate Members.

George Hamilton Crosby.
Denis Rebbeck, M.A.

Associates.

Alfred Norman Gibson Aadahl.
James Charles Bunn.
Richard Francis Dillon.

Graduate.

Thomas Lea.

Student.

Peter James Humphreys.

Transfer from Associate to Member.

John Guthrie.
Charles Lawrie.
Christopher John Parnaby.

ADDITIONS TO THE LIBRARY.

Purchased.

War-time Guides to British Sources of Specilised Information, No. 1, Fuel and Allied Interests (excluding Electricity). Association of Special Libraries and Information Bureaux, 3s. including postage.

Presented by the Publishers.

Memorandum on the replacement of drop forgings and pressings by welded parts. Advisory Service on Welding, Ministry of Supply.

The following British Standard Specifications:—
No. 949-1941. Screw Taps.
No. 994-1941. Centrifugal and Axial Flow Pump Specifications, and Data required for Estimates and Orders.
No. 367-1941. Ceiling-type Electric Fans.

Blueprint Reading Simplified. By A. C. Parkinson, A.C.P., F.Coll.H. Sir Isaac Pitman & Sons, Ltd., 91 pp., 183 illus., 6s. net.

A new book on his own subject by so able a writer as A. C. Parkinson is naturally opened with eagerness, and it may be stated at the outset that one's hopes are not disappointed. In the short space at his disposal the author covers the essentials of a vital branch of production with clarity and a surprising amount of detail. This book should be of great value to all engaged in the training of "operatives".

Such criticisms as can be levelled are of minor importance. The making-up of the book inevitably separates drawings and diagrams from the relevant notes, often by several pages, necessitating a constant turning back and forth, while the same reason no doubt accounts for the upsetting of the order of Figs. 62-66. Two misprints are noticed; on page 67 line 24, item 7 should read 17, and in Fig. 76 the right-hand end of the stud is either not to scale or misprinted. In Fig. 62 on page 26, a "supplied" drawing shows thin webs section-lined solid, contradicting a previous recommendation on page 24; and one doubts the value of devoting nearly half a page to examples of symbolic hatching in order to condemn their use overleaf.

These are all minor points, however, and as an offset, one can acclaim some brief notes on foundry practice, welding, jigs and fixtures, and a clear summary of the principles of American or Third Angle Projection which should be most valuable in these days of collaboration.

Another valuable feature is the constant reference to workshop practice and technique, so that the trainee is stimulated to link up these flat drawings with his solid jobs.

The general standard of clarity in letterpress and diagrams alike is well up to the publishers' usual standard. The cover is printed as a facsimile of a blue print and a parting suggestion is that if some of the illustrations could have been similarly printed, the value of the book would have been still further enhanced.

Annual Reviews of Petroleum Technology, Vol. 6 (Petroleum Technology in 1940). The Institute of Petroleum, 318 pp., illus., 11s. post free.

The complete record of research and development in the petroleum industry since 1939 is as yet unpublished and must necessarily remain so under existing circumstances. Nevertheless, the record in this volume is as full as possible and is one of substantial progress in the application of science to a world-wide industry. The following aspects of the petroleum industry have been reviewed by experts in this volume, viz.:—petroleum geology, regional geology and development in the United States; drilling and development in U.S.A. fields; production engineering; production; transportation and storage; natural gas, liquefied petroleum gases, and natural gasoline; chemical and physical refining; cracking; alternative fuels (*a*) low and medium temperature carbonization and (*b*) fuels produced by hydrogenation and synthetic processes; motor benzole; analysis and testing; gas, Diesel and fuel oils; asphaltic bitumen and road materials; special products; petroleum literature in 1940; petroleum statistics; and lubricants and lubrication.

Fuel Saving Charts. (Second Series). By W. Goldstern. John D. Troup, Ltd., 90/91, High Holborn, London, W.C.1, 4s. net, post free.

The first series of twelve fuel saving charts prepared by the author were published as a reprint from "The Steam Engineer" in 1940, and, in general, dealt with various aspects of boiler operation. During the past year the author has contributed a further series of twelve charts, which are now made available as a reprint. In this series the wider field of steam and power generation is included, as may be inferred from the titles to the twelve charts which are given below: steam loss by reduced vacuum, fuel loss by condensate, fuel and heat loss in boiler ash, fuel saving by economiser, steam loss by reduced superheat, loss in exhaust steam or condensation, loss by steam jets or leakage, economic thickness of insulation, heat loss of open hot-water vessels, steam requirements of feed pump, pressure loss in steam pipes, and equivalent pipe length.

Turbines, Condensers and Associated Equipment. Edison Electric Institute, 420, Lexington Avenue, New York, 47pp., 52 illus., $2.10 post free.

This work is a report by the Turbine-Condenser Sub-Committee of the Prime Movers Committee of the Edison Electric Institute. The Sub-Committee issued a questionnaire comprising 35 items covering operating problems and experiences and also questions related to design and equipment selection, and this report has been compiled from the answers. Manufacturers were asked to comment on the problems associated with the design and operation of some particular equipment and others have submitted statements covering new developments. The report comprises seven sections, each accompanied by a committee statement, arranged as follows: (1) turbines, (2) condensers, including condensate pumps, (3) heaters, (4) evaporators, (5) elimination of occluded gases, (6) instruments, (7) turbine operating and outage data.

The Turbine-Sub-Committee has continued the work of compiling and assembling operating and outage data on turbines over 20,000kW. or over 1,000 psi operating pressure, and this report covers 370 turbines of which 31 operate at 1,000 psi or higher.

Data on the elimination of occluded gases (oxygen, carbon dioxide and ammonia) which normally would be a part of the Chemistry Sub-Committee work, has been included due to the numerous problems attributable to these gases and the direct association of these problems with the equipment discussed in this report.

Researches on the Structure of Alloys. By W. Hume-Rothery, M.A., D.Sc., F.R.S. British Non-Ferrous Metals Research Association's Report, No. 562. Published by the Association at 2s. 6d. post free.

During more than fifteen years Dr. W. Hume-Rothery has been responsible for a remarkable series of researches on metallic alloys carried out in the laboratories of the University of Oxford. This work has been directed mainly to the establishment of the general principles which decide (1) whether and in what proportions two or more metals are capable of forming solid solutions, (2) the structural and equilibrium characteristics of alloy systems, and (3) the properties of alloys. These are in fact the general principles of physical metallury. In the course of the large amount of delicate and accurate experimental work involved, new and improved techniques of various kinds have been developed. The investigations so far completed have been published in more than thirty papers in the *Proceedings of the Royal Society*, the *Journal of the Institute of Metals* and elsewhere. The practical importance of the work, apart from its great scientific interest, lies in its promise of providing means for forecasting the properties of alloys from the atomic characteristics of the constituent metals and thus permitting the building up of alloys of desired properties.

For some years past the British Non-Ferrous Metals Research Association has made a contribution towards the cost of these investigations, and Dr. Hume-Rothery has now written a concise account of the work done since this support began.

In this clear review of 20 pages' length Dr. Hume-Rothery has been more concerned to set out the plan, aims and main conclusions of his work than to give the detailed results which are published elsewhere. Nevertheless, he has found it possible to indicate broadly the experimental results obtained and the evidence on which his conclusions rest. A list of the published papers mentioned is appended to the report.

Dr. Hume-Rothery's work is of fundamental importance to metallurgists, physicists and chemists, and the present report should be useful as a summary to those who have read the original papers and to all others who are interested in the scientific study of metals and alloys.

Test Code for Steam Turbines. American Society of Mechanical Engineers, 29, West 39th Street, New York, 92pp., illus., $2.50.

The Test Code for Steam Turbines was one of the group of ten forming the 1915 edition of the A.S.M.E. Power Test Codes. A revision of these Codes was begun in 1918, and the Test Code for Steam Turbines was re-issued in revised form in 1928. In 1932 a decision was reached to undertake a complete revision of the 1928 edition. Two developments contributed to the making of this decision. First, increasing use of extraction, mixed-pressure and other types of turbines made it desirable to enlarge the scope of the Code to include these types; and second, a broader concept of test codes had been gained as a result of international conferences.

The 1941 edition of the Code which has resulted from this decision contains six sections as follows: (1) Object and scope; (2) description and definition of terms; (3) guiding principles; (4) instruments and methods of measurement; (5) computation of results; (6) report of tests.

The Code provides for the testing of all types and applications of steam turbines. It is necessarily voluminous to embrace rules for all turbine types, including instructions for the correction of test results for deviations of the test conditions from those specified. Only relevant portions of the Code need apply to any individual case; for a simple turbine the test procedure is simple, and not different from what is familiar and customary; for complex turbine types or modes of operation, the procedure and calculation of test results are necessarily more complicated and require the more involved provisions which have properly been included.

The revised Code has been approved and adopted as a standard practice of the Society by the Council of the American Society of Mechanical Engineers.

Heroes of the Atlantic. By Ivor Halstead. Lindsay Drummond, 235 pp., 39 illus., 7s. 6d. net.

The author, although he calls himself a landbound spectator, shows in his preface an insight into the subject which betrays long acquaintance with the sea and those who go down to it, and it is to these that the book is dedicated. It is very necessary that such a record should be made to ensure that the story of the sea struggle should have a more permanent memorial than the pages of the press.

After a passing reference in his dedication to the shameful record of the fatuous "statesmen" (some of whom are still enjoying the "sweets of office") who thought that the festering spirit of envy, hatred, malice, and all uncharitableness which filled the breasts of those who hungered to usurp our place, could be appeased by a display of supine and facile acquiesence, and by abstention from any course of action which might offend them, even to the closing down of our shipyards, the decay of our craft, the starvation of our agriculture and the emasculation of our Navy, the author deals briefly in his opening chapter with the origin and development of our sea power.

There is a carefully compiled presentation of the sea story, condensed to a readable form, tracing the account from the beginning of the war, and touching upon the high spots; the "Athenia", "Dunkirk", "Graf Spee", "Altmark" and "Bismarck" episodes are retold in vivid and authentic language. These alone will be very acceptable to those at sea who did not get the original accounts.

There is throughout the following chapters a statistical element which gives the book a special value for reference, and the chapters which deal with incidents in the convoys and the recital of individual acts of heroism make stirring reading for those afloat and will provide those who abide ashore, "dwelling safely all of them", with the material for a deeper understanding of the work of those upon the ramparts of the waves.

The photographs are excellent both in subject and in quality, and two chapters on "The Welfare of Merchant Sailors" and "A Cradle of the Merchant Navy" are happily chosen and presented.

The references to the Ministry of Shipping are in order until May 9th, 1941, from which date the affairs of Merchant Shipping have been under the administration of the Ministry of War Transport which combines the functions of the former Ministry of Transport with those of the erstwhile Ministry of Shipping, into which the old Mercantile Marine Department of the Board of Trade was transformed in circumstances which the author records for the astonishment of his readers.

This most interesting volume is commended as a suitable gift alike to those who have seen and shared the episodes it describes and to those who, remote from the scene, like to have authentic intelligence of affairs at sea.

The Merchant Service To-day. By Leslie Howe. Oxford University Press, 159 pp., illus., 4s. 6d. net.

The title of this book alone is intriguing, particularly when we recall what the Merchant Service to-day is doing.

The book itself is one of a series entitled "The Pageant of Progress" which the Oxford University Press has published. The series covers the whole realm of modern activity. From Flight to Cinemas; from Electricity to Military Science, and even to Police and Crime Detection.

Mr. Leslie Howe really gives a lively, helpful exposition of the many sides of modern shipping and shipbuilding. To deal with any question of merchant shipping is to undertake a problem in selection —what to put in and what to omit. With these thoughts in mind, it is interesting that Mr. Howe introduces his subjects by dealing with types of merchant ships and the vexed question of tonnage. He also has something to say on propulsion.

Perhaps he might have devoted somewhat more attention to this controversial matter, particularly insofar as its effect upon shipping economics to-day is concerned. People are apt to forget that although propulsion was once the servant of the shipowner, the shipowner's policy to-day is being guided very largely by the researches of the marine engineer. Trade routes and cargoes, the types of ships operating on them, are dealt with in considerable and erudite detail. After this, the author deals with navigation, and has much to say on modern methods, including the echo-sounder.

Then he discusses loading and discharging, and has some excellent photographs of the various methods of handling cargo. Chartering organisation and administration, a subject which can almost occupy a book in itself, is succinctly handled, as also the questions of bunkering and fuel supply, and even of building new tonnage. Docks and harbours, insurance, personnel, also come within the author's purview, and the book finishes with an interesting chapter on the Merchant Service at war, in which life-saving devices are dealt with.

Mr. Howe has done a good job with this book. It is helpful, without being too detailed; informative without being too technical. He covers a very large ground, missing few of the essentials.

Steering Telemotor. MacTaggart Scott & Co., Ltd., Loanhead, 28 pp., illus., no stated price.

This booklet describes the steering telemotor installation produced by the publishers. Following a general description of the gear, there are sections on erection instructions, charging fluids, washing-out instructions, as well as on charging, testing and working instructions. The work concludes with sections on maintenance and spare parts. Copies of the booklet, which is usefully illustrated with coloured and line diagrams, are available to Members of The Institute without charge, on application to the Secretary.

Rubber as an Engineering Material. The British Tyre & Rubber Co., Ltd., 30 pp., illus., no stated price.

The purpose of this handbook is to present concise information about rubber as a material—its various forms, properties and limitations. Excellently produced and illustrated, the handbook contains chapters on: Forms of manufactured rubber; properties; resistance to corrosion; resistance to abrasion, cutting, tearing and impact; elasticity; the insulation of shock, vibration and noise; heat resistance and insulation; resistance to oils and solvents; rubber hydraulics; and testing rubber products.

The Journal of Commerce Annual Review of Shipping, Shipbuilding and Marine Engineering. Charles Birchall & Sons, Ltd., 260pp., illus., 2s. 6d. net.

Of special interest to marine engineer readers of this admirable annual are the chapters "Marine Steam Engineering—The Next Phase", by J. Hamilton Gibson, and "Thoughts on the Power Plant of To-morrow", by A. C. Hardy. There are many other articles that Members will find of outstanding interest, notably "The Future of British Shipping", by Lord Rotherwick, "Re-creating and Protecting our Merchant Navy", "Reducing the Risks which Seamen Run", "Replacing Losses and Repairing Damage", by H. E. Hancock, "Prospects for Ships with Electric Drive", and "Latest Progress in Metallurgy".

Past readers of this annual who have become accustomed to its opulent appearance and (for its price) astonishing value, will not be disappointed by the present issue.

Munro's Engineer's Annual, 1942. James Munro & Co., Ltd., 143pp., illus., 3s. net.

Many of the features for which this Annual is noted have been retained, though some restriction of the valuable data it usually contains has been necessary. In addition to many tidal and mathematical tables there are articles on "Arc, Flame and Metal", by Butler, "A Review of Systems of Training and Grading of Marine Engineers in Great Britain and Foreign Maritime Countries", by Smith, "Marine Engineers' Examinations", by Martin and Barr, "Research at the William Froude Laboratory", by Baker, "Centrifugal Pump Drive", "Chlorinated Rubber in Marine Work", "Centrifugal Pumps for Marine Work", "Cooling Water and Steam Control", "Hand Fire Extinguishers", "Modern Steel Doors", "The Rototherm Rotostat", "Removal of Suspended Matter from Water", "Steam Reducing Valves", and "Welding Progress in Marine Work", by Brett.

Abstracts of the Technical Press

Propelling Machinery of American Merchant Ships.

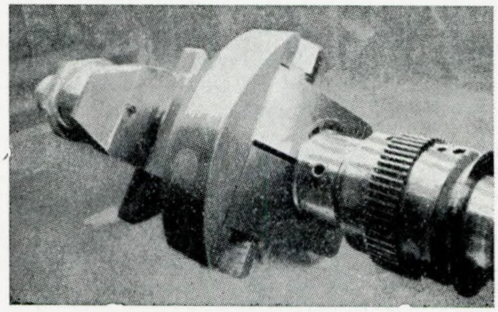
An article in the current issue of the *Bulletin Technique du Bureau Veritas* gives some interesting statistics concerning the various types of propelling-machinery installations of the new merchant fleet now in process of construction in America. Of 183 vessels representing a total gross tonnage of 1,533,000 tons and a total horse-power of 1,228,800 h.p., no fewer than 137, with a gross tonnage of 1,160,000 tons and developing 950,000 h.p., are equipped with turbines, so that 76 per cent. of the new mercantile tonnage of the U.S.A. is turbine driven. Only two ships, with a gross tonnage of 23,000 tons and a horse-power of 10,000 h.p., are equipped with turbo-electric propelling machinery. The number of new motor vessels is 42, with a total gross tonnage of 340,000 tons and a horse-power of 259,000 h.p. The percentage of turbine-driven ships in the American merchant marine has always been high, and even before the present shipping programme was put in hand, the proportion of turbine-driven ships represented 4 per cent. of the total "steam" tonnage under the American flag. This proportion will be substantially increased when all the new ships are in service. The reason for this is not only the abundance of oil fuel available in the country, but also the specialised lines along which the marine engineering industry in the U.S. has been developed. The manufacture of marine oil engines has only been established for a relatively short time, whereas the production of mechanical gearing, more especially reduction gears for steam turbines, has been an outstanding feature of the industry for many years past.—*"Journal de la Marine Marchande", Vol. 23, No. 1,136, 18th September, 1941, p. 703.*

Steering Engines for American Emergency Ships.

It is reported that all but 60 of the 312 emergency-type ships under construction for the U.S. Maritime Commission are to be equipped with steering engines built in Seattle. A contract for 252 steering engines of the conventional two-cylinder type, to a total value of $2,252,000, has been awarded to the Webster Brinkley Company of Seattle, Wash., who are making use of a unique production line, 180ft. long and with 16 cars, to deal with the assembly of the engines as they roll along. Sixteen days will be required to build each engine, and one complete steering engine will be finish-assembled each day. This is the first occasion on which a production system of this nature is being utilised for steering-engine manufacture.—*"Marine Engineering and Shipping Record", Vol. XLVII, No. 10, October, 1941, p. 140.*

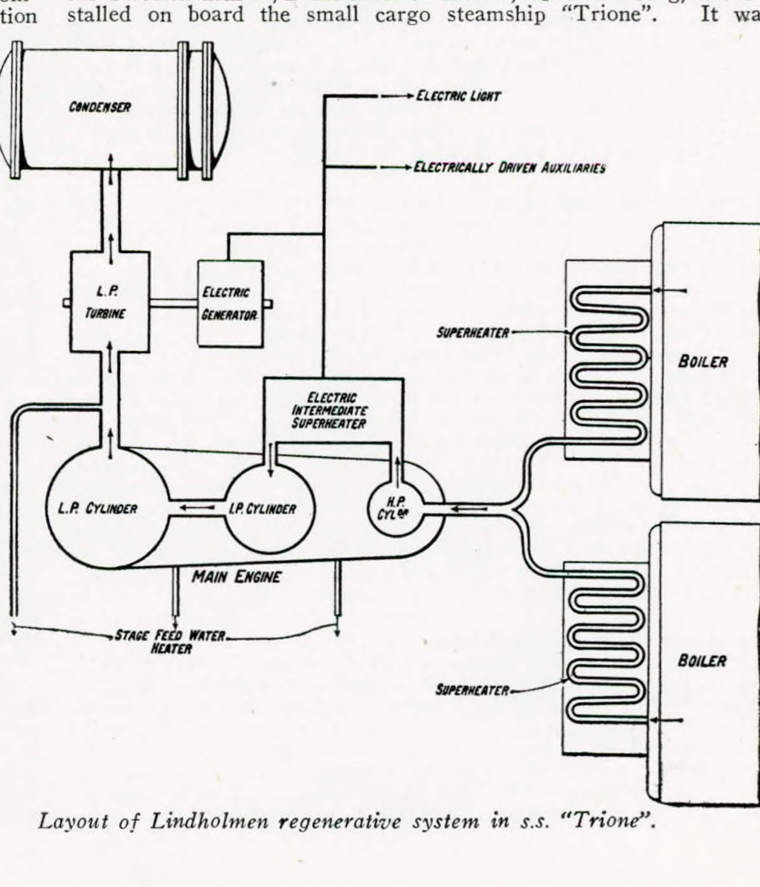
New Hungarian Danube Sea-going Motorship "Kassa".

A description of the 1,022-ton twin-screw motorship "Kassa", the latest addition to the Royal Hungarian Danube-Sea Navigation Company's fleet, appeared in the German technical periodical *Werft * Reederei * Hafen* a short time ago. She is by far the largest of the company's vessels, having an o.a. length of 254ft., a beam of 32ft., and a d.w. capacity of 1,267 tons at her maximum draught of 10·1ft. The frames, shell plating, decks, keel, deck beams and other important parts of the hull are of high-class chrome-copper Siemens Martin steel, and the vessel is largely of welded construction. A double bottom extends over most of the ship's length under the cargo holds and machinery space. There are four cargo holds with a total capacity of 60,800ft. and a deep water-ballast tank is located amidships under the bridge, between Nos. 2 and 3 holds. There is also a water-ballast tank forward, between the fore peak and No. 1 hold. The four cargo hatches are served by two 3-ton electric cranes. The captain's and deck officers' quarters are in a deckhouse under the bridge, the crew being berthed forward and the engineers aft. The twin streamlined built-up rudders behind each propeller are hung on ball bearings and steadied in a bronze bush; hand steering is the only method employed. The machinery space is located aft, immediately before the fuel-oil tanks, and contains two sets of 8-cylr. direct-reversing, 4-stroke Ganz-Jendrassek engines of the trunk-piston type. These have a total output of 800 b.h.p. at 700 r.p.m. and drive the twin propellers through 2·7 to 1 reduction gears. The designed service speed of the vessel is 10·6 knots. Bibby flexible couplings are fitted between the reduction gears and the thrust bearings, the latter being of the ball-bearing type. The crankshafts of the main engines are of an unusual built-up type and run in lead-bronze main bearings. The connection between the centre section of the shaft with the two end parts comprising each throw is by key and fine screw threads, the webs being split and clamped on the screwed shaft by means of bolts. The construction is shown in the accompanying illustration and is said to have proved satisfactory, as it facilitates replacements in case of breakdown. A Ferodo-lined frictional vibration damper is provided on the end of each crankshaft to reduce torsional vibration. The main engines are flexibly mounted on rubber pads. The engine auxiliaries include two 25-kW. Diesel-generator sets, in addition to a dynamo driven off the S. main engine, and a large electric battery. The "Kassa" was until recently employed on the company's service between Danubian ports and Alexandria.—*"Gas and Oil Power", Vol. XXXVI, No. 433, October, 1941, p. 205.*



Superheating by Electricity.

The accompanying diagram shows the arrangement of a somewhat unusual system of superheating developed some years ago by the Swedish firm A/B Lindholmen-Motala, of Gothenburg, and installed on board the small cargo steamship "Trione". It was



Layout of Lindholmen regenerative system in s.s. "Trione".

anticipated that a specific coal consumption of about 1lb./i.h.p.-hr. would be obtained with a triple-expansion engine incorporating this regenerative system, the current obtained from the generator driven by the exhaust turbine being used to dry and superheat the steam. The "Trione's" triple-expansion engines developed 1,000 i.h.p., and 168 kW. of the turbo-generator set's output was absorbed by the electrical superheater, this raising the steam temperature anything from 75° to 110° F., according to conditions. A small amount of current was also available for lighting and for driving one or two engine-room auxiliaries. Little has since been heard of this development, but by all account the results obtained in the "Trione" came up to expectations.—*G. R. Hutchinson, "The Marine Engineer", Vol. 64, No. 771, October, 1941, p. 216.*

Ship Repairs in the United States.

According to a recent announcement by Mr. J. E. Otterson, Co-ordinator of Ship Repair and Conversion of the U.S. Maritime Commission, 783 vessels, both American and foreign, were taken in hand for repair and alterations by U.S. ship-repair yards during July and August, 1941, in addition to the ships that were already in these yards on the 1st July. During the two months, 492 ships completed repairs, and of the 783 vessels taken in hand, 343 were completed in under a week, the remaining 440 taking longer. Among the various ships dealt with by the repair yards there were no fewer than 202 tankers. There are altogether some 2,000 repair yards in the U.S.A., including small yards, yacht basins and other establishments capable of undertaking small repair jobs. About 250 yards are directly concerned in the present emergency, and of these approximately 80 are classed as being of "first importance" for repair work. The co-ordinator's office is exclusively concerned with work carried out in private yards and does not deal with Navy Yards. The repair yards take ships as they are allotted—U.S.N. ships; ships of the Allies, both naval and merchant craft; Maritime Commission vessels for repair or conversion; and privately-owned ships. Vessels needing repairs, particularly foreign ships, usually arrive at an American port without notice and apply for repairs, advance notification by radio being prohibited. The owner or agent submits an application for allocation, describing the ship and giving particulars of the repairs required. The local staff of the co-ordinator are in possession of an up-to-date report on the repair facilities available in every yard. They know what berths are filled, what jobs are in hand or about to be dealt with, and when they are due to be completed. These reports are made out by every yard at 5.0 p.m. each day, and in addition the co-ordinator's inspectors visit the yards and keep themselves informed on the progress of repair work. The ship is then allocated to a yard and the yard manager is notified as well as the shipowner or agent, and the various Government departments concerned in Washington. The office of the Co-ordinator of Ship Repair and Conversion has a technical staff of 20 expert assistants and is expected to expand.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 10, October, 1941, p. 126.*

Steam Gun for Cleaning Operations.

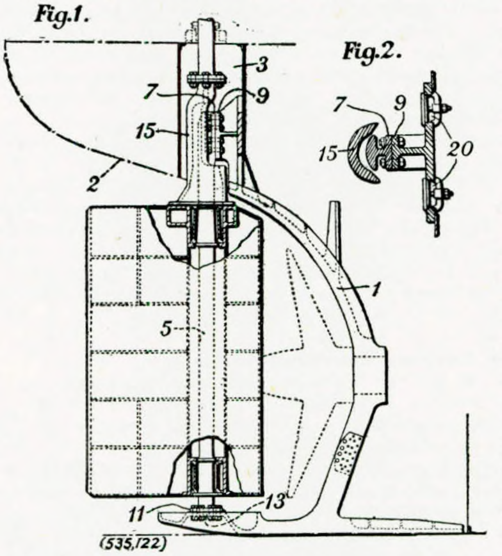
An improved form of steam gun has been developed by a New York engineering firm for the purpose of facilitating the various cleaning operations involved in the construction and repair of warships, oil tankers and merchant vessels. It is claimed that this device provides the triple combination of heat, mechanical force and effective detergent action to remove deposits or accumulations of oil, grease, chips and dirt from large machined parts between operations, or before inspection and assembly. The steam gun is said to lift the cleaning solution to a height of 12ft. above floor level without the aid of pumps, injectors or other accessories, all that is needed being a steam supply at a pressure of not less than 30lb./in.^{2}, hoses for the steam and solution, and an open-top container for the cleaning solution. Among the various applications of this apparatus are the cleaning of dismantled machinery before repair and overhaul; the steam-cleaning of holds, bilges, etc.; and the preparation of superstructures and other large surfaces for repainting.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 10, October, 1941, p. 98.*

Importance of Ships' Bilge Pumps.

Although the bilge pumps which form part of every ship's equipment are normally designed to deal with the water admitted through a leak sustained by a marine casualty, they have recently succeeded in getting to port many a mined or torpedoed ship which had sustained much more than normal damage. However, many naval architects consider that the existing regulations concerning the design and location of bilge pumps are in need of revision, as the standards laid down are inadequate. In point of fact many British shipowners instal far more elaborate pumping arrangements in their vessels than is required by the regulations, the Blue Funnel liners in particular, being outstanding examples of this practice. Marine engineers, on the other hand, are not so much concerned with the idea of increasing the pumping capacity of the average ship, as with overcoming the old trouble—dating back to the earliest days of pumps—of the strum box at the suction pipe inlet getting choked up with dirt or cargo washed down into the bilges by the water entering the ship. The Ministry of War Transport require that non-return valves must be fitted in the bilge suction pipes to limit the flow of water inside the ship, which is a rule that cannot be evaded, but many engineers maintain that these N.R. valves prevent the strum boxes from being cleared and pumping made more efficient, by occasionally changing the direction of the flow for a few seconds.—*F. C. Bowen, "The Nautical Gazette", Vol. 131, No. 10, October, 1941, pp. 30-31.*

An Improved Stern Frame and Rudder.

Amongst the most recent British patents to be published is one relating to an improved stern frame and rudder assembly of the type having a backpost carrying a rudder and detachably coupled to the stern frame. Referring to the accompanying diagrams, the stern counter (2) is provided with a rudder trunk (3), whilst a backpost (5), detachable from the frame, is mounted between the upper and lower limbs and carries a balanced streamlined hollow rudder. The upper end of the backpost projects up into the trunk (3) and is fitted with an integral vertical coupling flange (7), bolted to a registering flange (9) of a bracket integral with the frame (1) and extending up within the trunk. The abutting faces of the flanges (7, 9) lie in a vertical athwart plane of the ship. The lower end of the backpost (5) has an integral flange (11) bolted to a seat (13) on the lower limb of the frame (1). The rudder is coupled to a rudder-operating stock by means of a hollow coupling sleeve (15), the lower end of which encloses the upper end of the backpost (5). This end of the sleeve terminates in a flange, which is bolted to the rudder forward and aft of the axis of the latter. The flange (7) of the backpost projects into the trunk through an opening in the forward wall of the coupling sleeve (15). The coupling (7, 9) is accessible through manholes (20), shown in Fig. 2, cut in the bracket and fitted with watertight covers. To facilitate shipment and unshipment of the rudder a removable distance piece is interposed between the flange (11) and the seat (13).—*"Engineering", Vol. 152, No. 3,954, 24th October, 1941, p. 340.*



Storage Batteries for Cargo Motorships.

The high state of development reached in the application of electric storage batteries in connection with intermittently-operated propelling machinery in Diesel-engined tugs suggests the desirability of their more extensive use in large motorships. Most marine engineers are familiar with the floating battery system and the continuous battery system that are now standard equipment for large tugs, the former being used in connection with the lead-acid type of battery and the latter with the nickel-alkali type. In both cases the battery serves to maintain the supply of current throughout the electric system when the main source of current is a dynamo driven off the propeller shaft which changes speed or stops, according to the movements of the main engines, and to smooth out the overload peaks resulting from the starting and stopping of various auxiliary motors. It has been noted that ammeter swings of 1,500 ampères or more frequently occur while cargo is being worked in some of the recent Maritime Commission motorships equipped with electric winches. In some cases it has even been found desirable to instal generators of greater capacity. Although it is not usual to run cargo winches at top speed, present-day conditions are abnormal and it is always possible that all the winches in operation may pick up their loads at the same instant. This means that the generator capacity available must be great enough to meet this maximum demand, although the auxiliary machinery may be running for most of the time with fractional load. or there may be periods during which the rapidity with which the load peaks and valleys alternate imposes a strain on the governors. Where two or more generating sets are employed the operating conditions could be improved and probably one generator set eliminated if a storage battery were used to cushion the peaks and carry momentary overloads. Furthermore, the use of a storage battery would provide an increased factor of safety. The average motorship requires only one dynamo, while under way, to supply current for the motor-driven auxiliary machinery and steering gear, but when manœuvring in narrow waters or in a congested harbour, it is usual to run a second generator, at almost no load, to ensure against any interruption of generator current, the consequences of which might be disastrous. With a battery installation of the kind referred to above, however, it would be perfectly safe to run only one generating set. In the unlikely event of a sudden stoppage of the generator engine the battery would pick up the load and there would be no interruption in the vitally important current supply. The care and maintenance of a modern storage battery is so simple that no additional duty would devolve on the E.R. staff, whilst the reliability of this type of equipment under severe operating conditions is amply demonstrated by its year in and year out service in various harbour craft.—*"Motorship and Diesel Boating", Vol. XXVI, No. 10, October, 1941, p. 602.*

Speed of Corvettes.

The First Lord of the Admiralty has been defending the corvettes vigorously against criticism of their comparatively low speed, in the House of Commons. Admittedly a higher speed for these ships would be an advantage in itself, but it would have to be paid for at an excessive price. More speed would demand a bigger ship, for the corvette's hulls are already packed full and any great increase in the power of the machinery would not only necessitate far bigger engine and boiler rooms, but also a far greater fuel capacity if the ships were not to be constantly running back to port to refuel when they wanted to be at sea hunting submarines or convoying merchantmen. Increased displacement would not be likely to make them any less lively in a seaway, since the additional weight of more powerful machinery and boilers placed very low in the ship would probably tend to increase their liveliness. A bigger ship would not only be at a disadvantage in reducing the extraordinary handiness of these corvettes, which is desirable both for attacking U-boats and dodging bombs from hostile aircraft, but would also cause a reduction in the number that could be built in a given time, whereas the Royal Navy needs numbers of anti-submarine craft above everything. The number would also be reduced because the higher speed and more intricate design would limit the number of yards which could turn out the ships. At present corvettes are being built at establishments both at home and in the Dominions, which have never attempted to construct warships before, and owing to the main features of the design these yards are producing remarkably satisfactory vessels.—*F. C. Bowen, "The Nautical Gazette", Vol. 131, No. 10, October, 1941, p. 31.*

The Liberty Ships.

Among the 14 vessels launched on Liberty Fleet Day—the 27th September—were three of the EC-2 type, now to be known as the "Liberty ships". The vessels in question, the "Patrick Henry", "John C. Fremont", and "Star of Oregon", were the first three units of the emergency fleet of 200 cargo ships of standard EC-2 design for the U.S. Maritime Commission, while 112 similar vessels are under construction for allocation to Britain under the provision of the Lease-Lend Act. The main features of their design are minimum cost, rapidity of construction and simplicity of operation. In addition to the particulars of these vessels already published (*see abstract on p. 137 of* TRANSACTIONS, *November, 1941*), it has now been disclosed that the hull has an overall length of 441ft. 6in. and is of the full-scantling type with a raked stem and cruiser stern. The cargo-handling gear is designed for simplicity of operation to meet the handling difficulties likely to be encountered in foreign ports. The normal complement will number 44 officers and men, all of whom are housed in the single deckhouse. The living accommodation, though less spacious than that provided in the ships of the Government's long-range programme, is roomy and well equipped, not more than four men being berthed in one room. The approximate average cost of the vessels (including contractors' fees) is stated to be $1,610,000.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 10, October, 1941, p. 72.*

Hull Design of American EC-2 Class Ships.

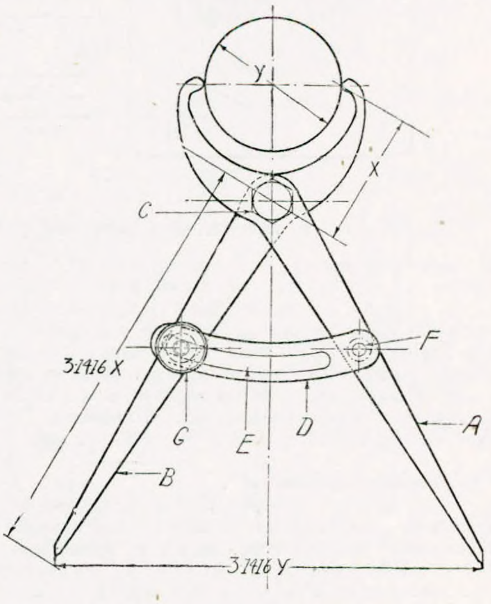
The hull design of the EC-2 type vessels is said to approximate very closely to the normal shelter-deck design adopted for tramp steamers built in this country before the war, although it has been suggested that a steel vessel with square bilges and straight frames would be very much cheaper to build. This principle, however, was tried in the "Z" type fabricated ships constructed during the last war, and did not commend itself either to shipbuilders or to owners. One ostensible objection to the straight frames was that the sections are not delivered in this condition by the steelworks, and have to be worked anyway. In America it is the practice to deliver frame bars cold straightened, and it is noted that in the EC-2 type of ship, as well as in British designs, the midship frames are so arranged that they are without curvature.—*"Fairplay", Vol. CLVII, No. 3,052, 6th November, 1941, pp. 459-460.*

"Further Experiments with Models of Cargo-carrying Coasters".

This paper concludes, for the time being, a series which have been given on the results of experiments made with models of coasters at the National Tank at Teddington. The main object of the research was to determine the effect of changes in block coefficient upon the resistance and power for propulsion, the principal dimensions of the ship being kept constant. The effect of change in engine revolutions upon the propulsive coefficient was also explored, the variation being obtained by altering the diameter or the pitch ratio of the propeller, or both. The work covered by this paper is concerned with cargo-carrying coasters of relatively high speed. Four models of 200-ft. vessels of varying fullness were used in the resistance experiments, the two extreme ones being utilised for the propulsion tests. These latter two hulls were tried with a variety of cruiser sterns and the after end was modified as necessary to suit the changes in propeller diameter.—*Paper by F. H. Todd, B.Sc., Ph.D., and J. Weedon, read at a general meeting of the N.-E. Institution of Engineers and Shipbuilders, on the 28th November, 1941.*

A Calliper Divided Instrument.

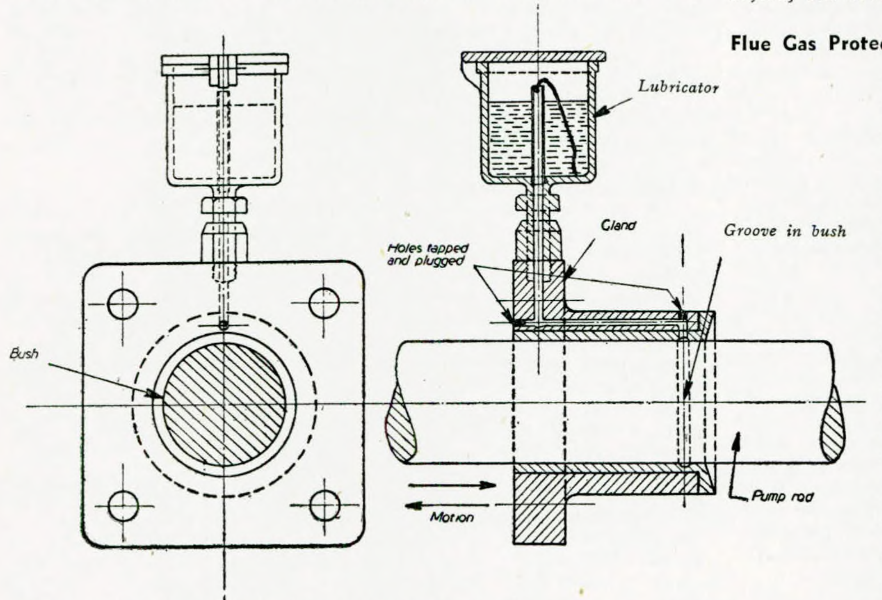
A considerable wastage of packing material is often incurred when repacking the glands of valve rods, piston rods and connecting rods, owing to the difficulty of estimating the actual length of packing strip likely to be required beforehand. The accompanying diagrammatic sketch shows a simple measuring instrument which, it is claimed, enables the exact length of packing required for a given diameter rod to be determined by applying the tool to the rod itself without any calculations. Referring to the sketch, it may be seen that the device is a combination of a pair of ordinary outside callipers and a set of dividers. *A* and *B* are the two legs of the latter and are pivoted to move fairly smoothly about the hexagon-headed fulcrum stud *C*, the shank of which passes through plain holes provided in the legs. The upper end of each leg is bent over as shown to form the jaws of the callipers, whilst the lower ends of the legs are straight and terminate in sharp points, which are well hardened to enable them to be used for scribing purposes. A simple-looking arrangement, comprising a shaped slotted arm *D* and nut *G*, is provided for fastening both legs securely together at any desired setting within the capacity of the instrument. The arm *D* is pivoted so as to swivel easily on the shoulder stud *F*,



which is riveted securely into the right-hand leg *A* of the tool. The parallel elongated slot *E* of the locking arm is made slightly wider than the diameter of the threaded shank of the knurled-headed locking screw *G* which is screwed into a tapped hole in the leg *B*. The fulcrum stud *C* is so located that the distance *X* from the centre of the stud to the top of each calliper jaw is exactly 3·1416 times less than the distance from the centre of the stud *C* to the tops of legs of the dividers. Thus, if the calliper jaws are set to calliper the diameter *Y* of a rod, the distance between the points of the dividers will be exactly 3·1416 times the diameter *Y*, *i.e.*, equal to the circumference of a circle of this diameter. In cutting lengths of packing to correspond to complete turns round the rod, etc., some slight allowance must be made for the thickness of the packing, as the length given by the tool will be that of the inner circumference of the packing ring when wrapped round the rod. If the ends of the packing are cut off dead square, the outer circumference of the ring wil be slightly short and fail to match up. To ensure a completely closed ring, it is desirable to cut the packing at a slight outward angle of 10°-15°. The size of tool here described was employed for the measurement of rods of up to 2in. diameter, but a similar instrument to deal with larger diameters may be fashioned as long as the ratio of 3·1416 referred to above is maintained. The saving in time and materials made possible by the use of such a tool will, it is claimed, quickly repay the small outlay involved in making the instrument.—*W. M. Halliday, "The Marine Engineer", Vol. 64, No. 772, November, 1941, pp. 230 and 233.*

Lubricating a Pump-rod Gland.

The accompanying sketch shows the method adopted by the writer for lubricating the pump-rod glands of a 3-throw hydraulic pump, working at a pressure of 1,500lb./in.². He claims that this



Method of lubricating a pump rod gland.

arrangement ensures the maintenance of a film of oil around the circumference of the rod at all times. There are no loose parts to be adjusted after the gland is tightened up, and dirt or foreign matter cannot be drawn into the oil system. If the lubricator is filled with oil, the oil level can be seen to rise and fall at each stroke of the pump. The writer states that after two years' service, the rams of the pump show no signs of wear, while the packing account has been astonishingly low.—*E. A. Harland, "Practical Engineering", Vol. 4, No. 97, 27th November, 1941, p. 509.*

"Engineering—Unlimited".

The author suggests that a great opportunity exists for an engineering organisation to take on maintenance work of *all* descriptions under the one roof, so far as organisation is concerned. The latter would have to be directed by an engineer in the true sense and meaning of the word, and would include a competent staff of specialists, each with his outside staff of engineers—electrical, mechanical, heating and ventilating, and structural. The big engineering insurance companies maintain large staffs of specialists who advise and act as consultants on any engineering service, but they will not do the actual work and do not employ what may be termed "industrial staffs". The author declares that the scope for a concern of the kind he envisages could be unlimited in these and post-war days.—*H. E. Johnson, "Electrical Review", Vol. XCCIV, No. 3,337, 7th November, 1941, p. 503.*

Bomb Damage to Cast-iron Valves.

Owing to the damage suffered by cast-iron valve boxes secured to the ship's side in merchant vessels through bomb explosions close by, the U.S. Government have ordered more ductile materials to be used for such fittings in all new ships. It is stated that British experience indicates that C.I. connections to the sides of vessels below the freeboard deck tend to fail as the result of concussion from bursting bombs, although the ships may not be actually struck. A fracture in such a connection may result in an inflow of water that is difficult or impossible to control. The U.S. Bureau of Marine Inspection and Navigation has accordingly decreed that cast iron is not to be used for such connections in any ship laid down on or after the 15th June, and that C.I. valves are not to be secured to sea chests. In the case of vessels of which the keels were laid prior to the above date, cast-iron underwater connections other than sea chests must be replaced by others of more ductile material at the time of the first overhaul or the first load-line renewal survey, unless excused for good reasons. C.I. sea chests that have been reinforced with concrete or other approved material need not be replaced in these vessels. Cast steel has proved to be much more suitable than cast iron for underwater fittings of this kind and is also preferable for sea chests connected directly to a ship's side. In some cases structural steel is being utilised for sea chests.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,492, 6th November, 1941, p. 7.*

Flue Gas Protection for Ships' Tanks.

The author explains how it is theoretically possible, and entirely practicable, to definitely protect the tanks of oil tankers at all times against the presence of explosive mixtures. In actual use, results may fall slightly short of the ideal, in that explosive mixtures may sometimes form for short periods during tank ventilation; but this is the result of failure to make proper use of the equipment, rather than a defect in the principle involved. The use of the flue gas as a means of excluding air from ships' tanks, thus preventing the formation of explosive mixtures, was first started about 10 years ago (*see abstract on p. 65 of* TRANSACTIONS, *April, 1939*), but certain minor changes in the equipment used for this purpose have recently been introduced. The gas is taken from a connection fitted below the air heaters of one of the ship's boilers, in order to avoid the possibility of contamination by air leakage. Care must be taken to have fires burning in all the furnaces of the boiler from which the gas is being obtained. Connections to more than one boiler are not fitted because the valves required to shut off the boiler not being used are liable to give trouble. The flue gas is cooled and washed with salt water in a bubble plate-washer having three plates. The washer operates under pressure, and the wash-water overflow is fitted with a liquid seal to prevent loss of pressure. In early installations, corrosion presented a problem, which has been partly solved by using galvanised C.I. parts. A steam-jet injector is employed to draw the flue gas from the uptake and force it through the washer and distributing pipes to the tanks. Centrifugal or displacement blowers have been found to be subject to clogging with soot and other troubles which make them unsatisfactory. Injectors have the advantage of low first cost and maintenance, but the steam consumption is fairly heavy and where distilled water is used for boiler feed purposes, their employment is open to an objection which has not yet been overcome. The flue gas is led from the washer to the tanks through a system of piping consisting of a header running the length of the ship, with branches to each tank. In the early installations shut-off valves were fitted in all the tank connections and individual tanks were equipped with pressure-relief valves, but in the newer systems a special combined tank relief and shut-off valve is provided. This is set to maintain a pressure of 3lb./in.² and discharges into the flue-gas line, which thus serves as a vapour-collecting system. The suction valve is set to draw in air at a vacuum of 3in. of water. The pressure valve has a lever to enable it to be held open to permit the flow of flue gas from the header to the tank. Vent pipes from the tanks are led up to a point well above the deck on one or more of the masts. Some method for gauging the tanks without opening them, is, of course, necessary with a flue-gas system, and enclosed float gauges are entirely satisfactory for this purpose, although a variety of other devices have been tried. As safeguards for the operation of the system, a few special appliances have been adopted. An automatic valve, which opens only when the steam pressure is turned on the injectors, prevents gases from the tanks from flowing back through the washer to the boiler uptake. Excess-pressure alarms are usually provided, and the latest installations include pressure connections from each tank to a central position, where a manifold system enables the pressure in any tank, as well as in the main header, to be read.—*Paper presented at a meeting of the Institute of Petroleum, London, by O. W. Johnson, Ph.D., and reproduced in "Shipbuilding and Shipping Record", Vol. LVIII, No. 22, 27th November, 1941, pp. 501-504.*

A Stepped-plunger Fuel-injection Pump.

A new British patent of Swedish origin concerns a stepped-plunger fuel-injection pump, shown in Fig. 3, in which a series of overflow ports in the plunger communicate with the pump pressure chamber as well as with one or more delivery ports, and co-operate in sequence with each overflow port in the cylinder. The regulation of the delivered quantity of fuel is effected by returning some of the liquid displaced by the plunger on the discharge stroke through a valve connected with the pump pressure chamber and communicating throughout the discharge stroke, with a region of lower pressure. The pump shown in the diagram is for a four-cylinder engine. In the pump casing (*1*) there is a barrel (*2*) with a plunger (*3*) and an operating tappet (*4*). The cam (*5*) is mounted on the camshaft (*6*). In the block (*7*) is an overflow channel (*30*), discharge channels (*10a, 10b, 10c, 10d*) and a pressure chamber (*23*). The openings are in different axial planes and are spaced apart to an extent corresponding with the distance traversed by the plunger between two consecutive injections. At a lower level than the delivery ports there is an overflow port (*20*). The edges of the recess (*19a*) co-operate with the delivery ports (*10aa, 10bb, 10cc and 10dd*) and the edges of the recess (*19b*) with the overflow port. In the plunger is a channel (*21*) which connects the pressure chamber (*23*) with the recesses (*19a, 19b*) through a channel (*22*). Fuel is supplied through a pipe (*8*) and a suction valve (*9*). During the suction stroke the plunger is actuated by the spring (*25*). To the foot (*3a*) of the plunger is fixed an arm (*3c*) which engages the slot (*32a*) of a segment (*32*) forming part of a device for rotating the plunger to regulate the quantity of injected fuel. The elongated recess (*19b*) in the plunger has four "island" portions (*33a, 33b, 33c, 33d*) with oblique control edges, and is thereby adapted to shut the overflow port (*20*) during certain periods of the discharge stroke. The lengths of these periods depend on the angular position taken up by the plunger, due to the adjustment of the regulating rod (*20*).—*"The Motor Ship", Vol. XXII, No. 262, November, 1941, p. 270.*

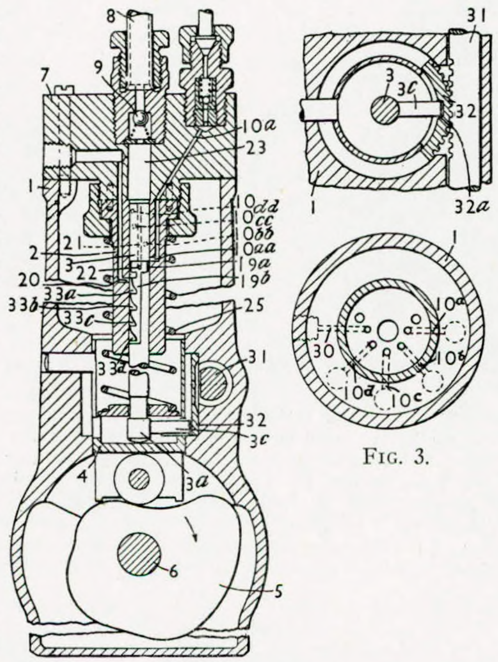


FIG. 3.

"The Regenerative Cycle: An Efficiency Basis Having Special Reference to the Number of Feed-water Heating Stages".

The efficiency of the regenerative cycle may be defined as the ratio of the heat converted into work (in B.Th.U./lb. of steam) to the heat supplied to 1lb. of steam in the boiler plant. Where feed heating is employed, however, the heat converted into work is less than the adiabatic heat drop as calculated from the initial and final states of expansion. The difference between these quantities is termed "unavailable heat" in the paper, and the efficiency is therefore given as the ratio of the adiabatic heat drop *less* the unavailable heat, to the heat supplied to 1lb. of steam in the boiler plant. The object of the paper is to illustrate the advantage derived from working in terms of unavailable heat. Values of this quantity are given, and the author provides a worked example showing their use. The conditions for ideal efficiency would require an infinitely great number of feed-heating stages, and are investigated by the author in Appendixes I and II, in which he also indicates the relationship of the ideal efficiency to other efficiencies corresponding to various finite numbers of feed-heating stages.—*Paper by H. S. Horsman, "Journal and Proceedings of the Institution of Mechanical Engineers", Vol. 146, No. 1, November, 1941, pp. 5-19.*

Saving Effected by Feed Heating.

In earlier marine installations with boiler pressures of the order of 200lb./in.^{2}, it was generally estimated that where auxiliary exhaust steam was employed for feed-water heating purposes, the saving effected was about 1 per cent. for every 10° F. of feed heating. In modern installations with higher steam pressures, superheat and other refinements, and where bled steam instead of auxiliary exhaust is used, the percentage of saving is usually lower, but it should generally be possible to make a saving of from 8 to 12 per cent. by feed heating. Where multi-stage feed heating by auxiliary and waste steam as well as bled steam is used, the feed water can be heated to about 350° F. Under the old rule of 1 per cent. this should represent a saving of about 25 per cent., but in actual practice the saving in recent installations may be less than half this amount, owing to the fact that there is little or no waste steam available. As the engine economy increases, the per cent. of gain due to feed heating is reduced. If the feed water is heated to a temperature $=T_2$, the hotwell temperature $=T_1$, the temperature of the steam leaving the boilers $=T_s$, and $L=$ the latent of steam at boiler pressure, then the per cent. saving $= \frac{T_2 - T_1}{T_s - T_1 \times L} \times 100$. For example, in an installation with a boiler pressure of 200lb./in.^{2} and steam temperature of 500° F., a feed-water temperature of 250° F. and a hotwell temperature of 100° F., the saving would be $\frac{250-100}{500-100\times 832} \times 100 = 12{\cdot}2$ per cent. This formula and the rule of 1 per cent. for each 10° F. of heating are based on the assumption that the heating steam is waste steam. Where bled steam is used, however, this is not the case, and, depending upon the point of bleeding, the saving may be reduced to as little as one-third, since the live steam bled from the engine for feed heating has to be replaced by additional steam from the boilers. Thus the saving due to feed heating may only amount to from about 0·3 per cent. to 1 per cent. for each 10° F. rise in feed-water temperature, according to the source of the heat used for feed heating. It may be assumed that in an average modern three-stage feed-heating installation one-half of the heating is done by waste steam, and in that case the saving is about 0·6 per cent. per 10° F., so that with a total rise of 200° F. the saving may amount to about 12 per cent. When the source and the amount of steam used from each source is known, the saving can be calculated more exactly.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 11, November, 1941, p. 164.*

Rapid Construction of S/M Chasers for U.S. Navy.

The submarine chaser PC-490, which was launched on the 18th October from the Neville Island yard of the Dravo Corporation, is the first sea-going vessel to be built at Pittsburgh for a century and the first warship to be constructed there since the war of 1812. The PC-490 is the first of 20 similar craft being built by the firm. These S/M chasers are in many respects like the torpedo-boat destroyers of 40 to 50 years ago. They are of all-welded construction, 165ft. in length and carry a crew of about 60. A production line method of building the vessels has been evolved by the builders. The hull sections are constructed in special jigs, in an inverted position and, contrary to the usual shipyard practice, the deck is laid first instead of the keel. As the sections are completed, they are turned over by means of cranes and placed on the launching line. Immediately after the PC-490 was launched, the next hull was moved on a series of transfer carriages into the launching berth just vacated; the third hull was then moved into the second position, and the work of placing the sections for the fourth hull in the third berth was taken in hand. This method of dealing with the hulls was adopted in order to reduce the length of the waterfront space required. It is necessary to dredge the Ohio River opposite the launching berth to accommodate these ships, for which reason it is essential to use the waterfront space available in the most efficient manner possible. The time required to build and fit out each S/M chaser is about 300 days, and the interval between consecutive launches will, it is hoped, not exceed two months. PC-490 will be fully equipped for service before she leaves her builders' yard on the 2,000-mile journey to the Atlantic.—*"The Nautical Gazette", Vol. 131, No. 11, November, 1941, pp. 35-36.*

A Hyland Radial-cylinder Pump.

Illustrated in Fig. 2 is a Hyland radial-cylinder pump in which the pistons reciprocate and also function as rotary valves by a partial rotation near each reversal of the stroke. The casing *(1)* has cylinders *(2)* fitted with plungers *(3)* controlled by a compound eccentric made up of inner and outer elements *(4, 5)* the latter being integral with the main shaft *(6)*. Arcuate shoes *(8)* engage a ring *(9)* and have stems *(10)* with ball ends *(11)*. Sleeves *(3ˣ)* form extensions of the pistons and the ports *(13)* register as required with the inlet and outlet ports *(14)*, which have annular grooves *(2ˣ)* to equalise the lateral pressure. As each piston *(3)* is partially rotated, one of its ports moves out of register with one cylinder port *(14)*

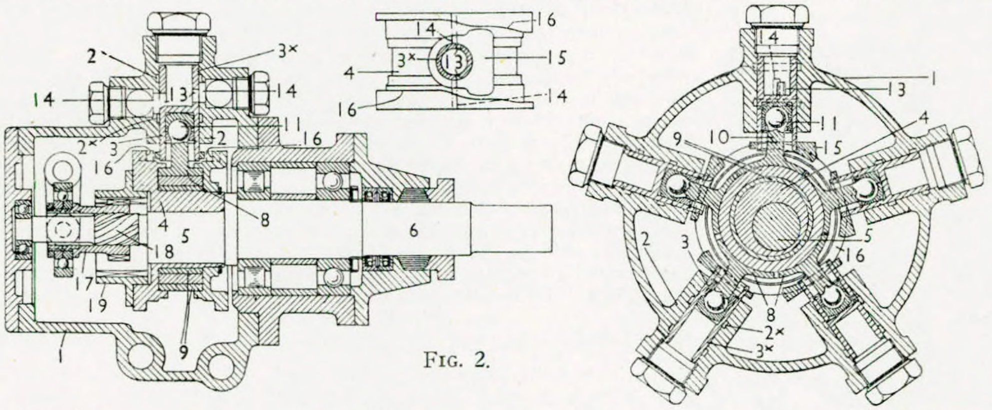
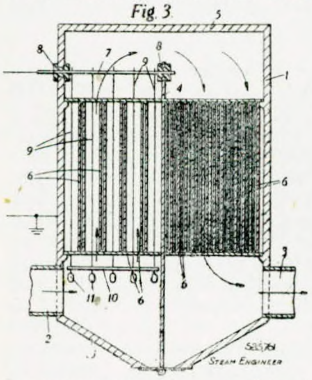


FIG. 2.

and the other moves into register with its own corresponding port. The reversal of the port connections from the inlet to the outlet, or *vice versa*, is obtained by means of a cam follower on each piston engaging a cam track on the eccentric. The cam follower comprises a radial cam *(15)* engaged by face cams *(16)* secured to the outer eccentric *(4)*. The two eccentric elements *(4, 5)* are connected by an adjustable sleeve *(17)* engaging a spiral extension *(18)* on the inner eccentric *(5)* and a sliding drive *(19)* secured to the eccentric *(4)*. When the sleeve *(17)* is moved axially, it is rotated relatively to the inner eccentric *(5)*, and this rotation is imparted to the floating eccentric *(4)*, thereby varying the effective throw of the compound eccentric. This alters the stroke of the pistons and thus increases the output of the pump while the driving speed remains constant.—*"The Motor Ship", Vol. XXII, No. 262, November, 1941, p. 270.*

Heat Exchanger for Flue Gases.



Improvements in combined gas-cleaning and fluid-heating apparatus.

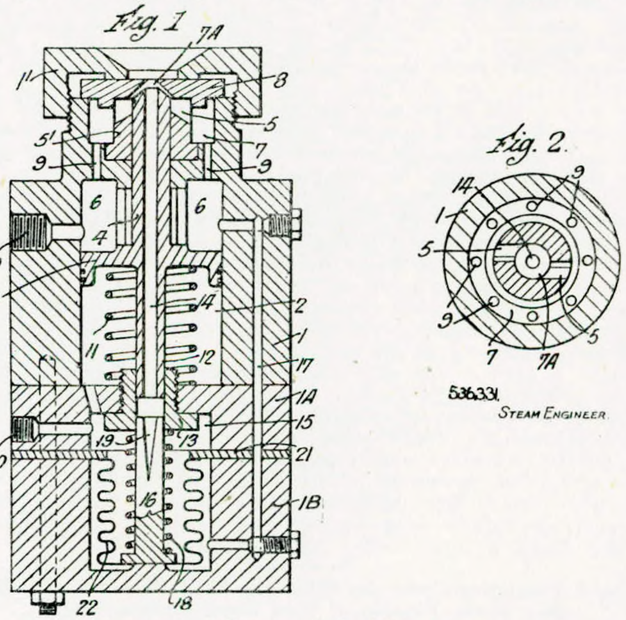
A British patent has been granted to the B.F. Sturtevant Company, of America, for a combined gas-cleaning and fluid-heating apparatus in which hot flue gases are cleaned electrostatically and used to heat air or other fluid by the process of heat exchange. Referring to the accompanying sectional drawing (Fig. 3), the device comprises a casing *(1)*, provided with an inlet *(2)* for initially hot gas that is to be cleaned (such as flue gases), and an outlet *(3)* for the cleaned gas. A central vertical wall *(4)* is arranged inside the casing and extends from the bottom to a point near the top of the casing. As a result, the gas entering the casing through the inlet *(2)* flows upwards in the space to the left of the wall *(4)*, is deflected by the top plate *(5)* of the casing, and then passes downwards in the space to the right of the wall *(4)* before escaping through the outlet *(5)*. Vertical air chambers *(6)* are arranged, as shown, in two groups located on opposite sides of the wall *(4)*. Those in the left-hand group are spaced about 6in. apart, whilst those on the right of the wall *(4)* are only about 1in. apart. These clearances apply to the use of the device for cleaning the flue gases in a steam power plant, but they may be varied to suit other requirements.—*"The Steam Engineer", Vol. XI, No. 122, November, 1941, p. 53.*

Increasing Use of Welding in U.S. Shipbuilding Industry.

According to Mr. David Arnott, Chief Surveyor of the American Bureau of Shipping, the growth of welding in the U.S. shipbuilding industry during the last 10 years has been remarkable. In 1929, of the vessels building to class with the American Bureau, only one small oil barge, 100ft. long and fittingly named the "Pioneer", was of welded construction. On the 1st October, 1941, there were 1,009 ships building or on order to American Bureau class. Of these ships 293 are under 300ft. in length and these are all welded with the exception of one small surveying vessel. Of the 711 larger ocean-going ships, no fewer than 207 are of all-welded construction, whilst in the remaining 504 vessels welding is being employed to a very large extent. It may in fact be said that 50 per cent. of all the merchant ships at present building in American yards are of all-welded construction.—*"The Nautical Gazette", Vol. 131, No. 11, November, 1941, p. 46.*

A New Liquid-fuel Burner.

A British patent has been granted to the Anglo-Saxon Petroleum Co., Ltd., for a liquid-fuel burner with a pressure nozzle of the forced vortex type, the nozzle having a "swirling" groove or grooves through which liquid fuel passes to a vortex chamber. The burner is capable of covering a wide range of consumption for a comparatively narrow pressure range. Referring to Fig. 1, the nozzle body *(1)* contains a chamber *(2)* having within it a piston *(3)*, which at its upper end is formed as a plunger *(4)*, the end of which is caused by the motion of the piston *(3)* to cover or uncover more or less (and so change the effective area of) one or more tangential swirling-grooves *(5)* through which the liquid fuel passes under pressure from a fuel supply chamber *(6)*, through an annular chamber *(7)* forward in the body, to a vortex chamber *(7A)*, at the end of the plunger *(4)* and just below the usual final orifice plate *(8)*, these grooves imparting a swirling motion to the liquid fuel in



A new and improved liquid-fuel burner.

the vortex chamber (*7A*). The chamber (*7*) is fed through apertures (*9*) from the chamber (*6*), which is itself connected with a fuel supply through the connection (*10*). It can be seen that the piston (*3*) is thus subjected on one side to the pressure of the liquid fuel supplied to the swirling grooves. The piston (*3*) is spring-loaded by a spring (*11*) against the fuel pressure, so that the position of this piston in the chamber (*2*) varies according to the fuel pressure and thereby causes the plunger (*4*) to regulate the effective area of the swirling grooves (*5*), a rise in the pressure increasing the effective area or opening of the grooves. At the same time the end of the plunger (*4*) will be obturated more or less into the vortex chamber (*7A*), the obturation decreasing with an increase in the pressure of the fuel supply. The vortex chamber (*7A*) may be of any desired shape, *e.g.*, conical or cylindrical, or a combination of both. This arrangement provides a first control by means of the fuel pressure, the control causing variation of the effective area of the swirling grooves (*5*) and also of the vortex chamber (*7A*). A second or "spill" control is obtained by means of an extension (*12*) of the plunger (*4*) beyond the piston (*3*), the extension being made to slide in an aperture—or bush (*13*)—in the cover (*1B, 1A*) of the nozzle body (*1*) and providing a passage (*14*) throughout the length of the plunger. The upper end of this passage communicates with a second chamber (*15*) formed in the body or the body covers (*1, 1A, 1B*) below the chamber (*2*), and provides a spill passage through which liquid fuel can spill from the vortex chamber. In this second chamber (*15*) is another plunger (*16*) connected in an oil-tight manner to a division plate (*21*) in the second chamber (*15*) by a flexible bellows (*22*). This piston bellows arrangement is open on one side, through a passage (*17*), to the fuel supply chamber (*6*), and the plunger (*16*) is spring-loaded by a spring (*18*) against the pressure of the fuel supply. A portion of the plunger (*16*) projects into the bush (*13*) and in the end of this portion is formed a spill port or V-notch (*19*). As the plunger (*16*) moves in response to a variation in the fuel pressure, the V-notch increases or decreases the extent to which it places the spill passage (*14*) in the first plunger (*4, 8, 12*) open to the chamber (*15*), a rise in the pressure causing a decrease in the opening of the V-notch. In this way the spill of liquid fuel from the vortex chamber (*7A*) to the second chamber (*15*) can be regulated in accordance with the fuel pressure, the fuel passing into this second chamber being returned, through a connection (*20*), to the pump suction or fuel tank.—*"The Steam Engineer", Vol. XI, No. 122, November, 1941, p. 54.*

Cylindrical Marine Boiler of Modern Design.

The accompanying sectional drawing (Fig. 2) shows the arrangement of a Howden-Johnson marine boiler, in which the weight and length of the boiler proper are very much reduced. The design incorporates a water-wall combustion chamber, combustion-space superheater, gilled-tube type economiser and an air heater. The results of a test made with a boiler of this kind were as follows:—

Weight of gas per hour	35,000lb.
„ „ fuel „ „	2,000lb.
Air temperature at heater inlet	80° F.
„ „ „ „ outlet	210° F.
Water „ „ economiser inlet	230° F.
„ „ „ „ outlet	318° F.
Gas „ „ „ inlet	580° F.
„ „ „ „ outlet	374° F.
Funnel temperature	250° F.
Heating surface of economiser	2,624ft.²
„ „ „ air heater	1,800ft.²
Weight of economiser	11·45 tons
„ „ air heater	5·0 tons

The economiser used in this boiler is of the Green-Foster patented type, made up of plain steel tubes with cast-iron gilled sleeves shrunk on. These sleeves have machined spigot-and-socket joints. Asbestos-packed gland rings at the tube places and end bends are also a feature of this design. The gilled surface is said to protect the steel tubes from external corrosion and erosion, while at the same time increasing the heating surface to about six times that of a plain tube.—*C. S. Darling, Wh.Ex., "The Power and Works Engineer", Vol. XXXVI, No. 425, November, 1941, pp. 262-265.*

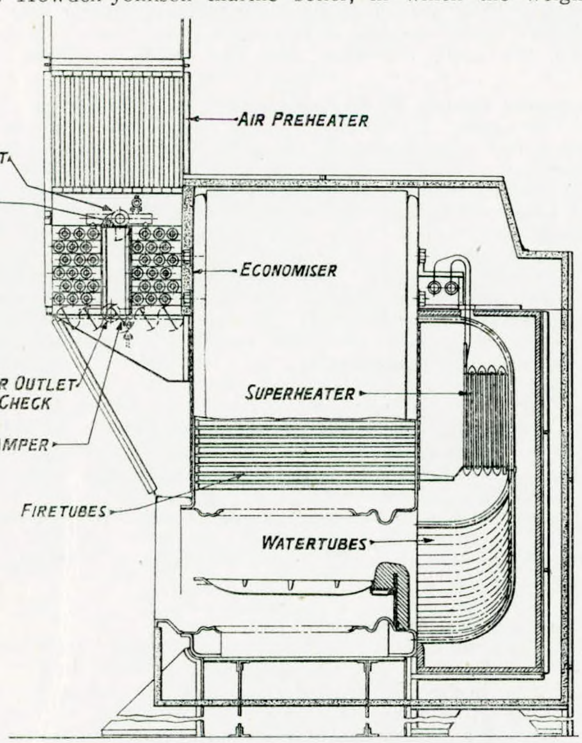
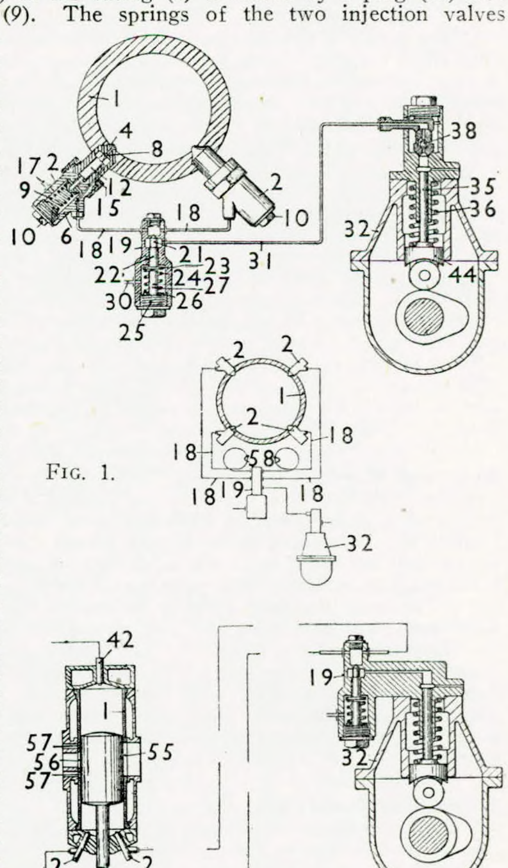


FIG. 2.—*Howden-Johnson boiler.*

Control Valve for Sulzer Fuel Systems.

An improved fuel system for Sulzer engines is shown in Fig. 1. The arrangement in general consists in providing a control valve for at least two fuel-injection valves operating simultaneously, fuel being supplied by a single pump. One of the diagrams relates specifically to a double-acting engine. In each of the arrangements shown, an injection valve (*2*)—of which four are indicated in the centre diagram—is fitted to the engine cylinder (*1*). Such a valve is shown sectionally in the top left-hand diagram. It comprises a fuel nozzle (*4*) and a needle (*8*) connected to a piston (*12*) subjected to the pressure of the fuel which enters through a passage (*15*). A leak-off pipe (*17*) in the casing (*6*) is closed by a plug (*10*) and contains a spring (*9*). The springs of the two injection valves shown in this diagram are set as accurately as possible to the same opening pressure and are connected to the control valve (*19*) by pipes (*18*). In the control-valve casing is a needle (*21*) together with an annular piston (*22*). The spring (*24*) bears on a plate (*23*) and on the plug (*25*), the disc (*26*) being of a suitable thickness to give the spring a sufficient loading; the lift of the piston is limited by a stop (*27*) which forms part of the plug (*25*). There is a leak-off pipe (*30*) in the control-valve casing. Fuel is delivered through a pipe (*31*) from a cam-operated pump (*32*) comprising a plunger (*35*) connected to a guide piston (*44*) loaded by a spring (*36*). Discharge of the fuel from the pump



takes place through a non-return valve (*38*) to the control valve (*19*) and hence to the injection valves (*2*), of which four are shown in the centre diagram. The pipes leading to these valves are all of the same length, loops (*58*) being provided on two of them to ensure this. In the case of the double-acting engine, which comprises a liner (*1*) having exhaust ports (*55*), scavenging ports (*56*) and supercharging ports (*57*), there is at the top a central fuel-injection valve (*42*). At the lower end two valves (*2*) are provided, and the control valve (*19*) for these is built into the fuel pump (*32*). This arrangement makes it possible for the control valve (*19*) to function as the delivery valve of the pump.—*"The Motor Ship", Vol. XXII, No. 262, November, 1941, p. 270.*

New All-welded American Trawlers.

The motor trawlers "Illinois" and "Maine", which are the latest additions to the New England fishing fleet, are the first all-welded trawlers to be built. They are 127ft. in o.a. length, with a beam of 24ft. and a moulded depth of 12½ft. They have a high flaring forecastle, a slightly raking stem and a cruiser stern. The accommodation for the officers and crew is greatly superior to that of the usual type of trawler. The main fish-hold has a capacity of nearly 134 tons, and is sheathed with cork covered with a 2½-in. lining of cypress made watertight. The main engine is a direct-reversing 6-cylr. Cooper-Bessemer Diesel developing 650 h.p. at 250 r.p.m. and designed to give the vessel a speed of 12 knots. The cylinders and valves are cooled by fresh water, whilst the pistons are oil-cooled. Electric current at sea is furnished by a 15-kW. 125-volt dynamo driven by a V-belt from the propeller shaft. A 115-volt storage battery of 56 cells with a total capacity of 279 amp.-hrs. is also provided. The auxiliary generating set comprises a generator directly driven by a 30-h.p. Lister Diesel engine. The whole of the vessel's auxiliary and deck machinery is motor-driven and includes a large trawl winch driven by a 100-h.p. motor. The current for the latter is furnished by a separate 80-kW. generator directly driven by a 135-h.p. Cooper-Bessemer Diesel engine. The trawl winch is controlled by a modified War Leonard system which regulates the armature windings of the motor.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 11, November, 1941, pp. 118.*

"Fretting Corrosion and Fatigue Strength, Brief Results of Preliminary Experiments".

The paper is devoted to a discussion of fretting corrosion, the conditions under which it occurs, and the possibility of its effect on fatigue strength. Fretting corrosion always appears in regions of unknown stress concentration, so that an accurate estimate of the weakening effect due to it cannot be made from combined fretting and fatigue tests. The author suggests that fatigue tests of previously fretted test pieces, analogous to determinations of the percentage loss of fatigue strength by prior stressless chemical corrosion, would be useful. He describes apparatus for making such tests, and gives preliminary results for a medium-carbon steel and for a nickel-chromium-molybdenum alloy steel. The losses of fatigue strength after fairly severe fretting, proved to be 13 per cent. and 18 per cent. respectively. Although these are not necessarily maximum values, the author considers that reductions of this order call for further investigations. He therefore examines the suitability of the apparatus and methods used in the tests.—*Paper by E. J. Warlow-Davies, B.A., B.Sc., D.Ph., "Journal and Proceedings of the Institution of Mechanical Engineers", Vol. 146, No. 1, November, 1941, pp. 32-38.*

Stress and Corrosion Resistance.

The American National Bureau's *Journal of Research* recently published a paper entitled "The Influence of Stress on Corrosion Pitting of Aluminium Bronze and Monel Metal", in which it is shown that for the alloys in question, stress, particularly if it is of a cyclic character, tends to accentuate the effects of corrosion. For the purpose of the investigation both well water and river water were used, and the form and size of the pits were correlated with the resultant lowering of the fatigue limit. With both metals there was an increase in the size of the pits, a sufficiently high combination of cyclic frequency and corrosion time causing the pits to develop into fissures. It was noted that steady stress has but little effect on the corrosion of Monel metal.—*"Shipbuilding and Shipping Record", Vol. LVIII, No. 22, 27th November, 1941, p. 495.*

Tightness of Double-beat Valves.

The expanding poppet valves used on Skinner Unaflow engines were formerly ground for a certain steam pressure and temperature, and were claimed to remain steamtight indefinitely provided the pressure and temperature were not allowed to vary. If the steam pressure and temperature did vary, the difference in the coefficients of expansion of the two metals forming the valve and the seat in the engine cylinder were liable to cause the one to expand more than the other, resulting in either the upper or the lower part of the valve not making contact with its seat in the cylinder. To prevent this leakage, the self-expanding poppet valve was designed. The upper part of this valve is not rigidly connected to the lower part, but allows an expanding and telescopic movement to take place, coming into contact with its seat shortly before the lower part. The result is that both seats make steamtight contact irrespectively of the difference in expansion of the cylinder and valve metal. The extent of the telescopic action is never more than 0·003 or 0·004in. and steam-tightness between the two elements of the valve itself is obtained by the form of construction of the steam-sprung metal packing rings.—*"Marine Engineering and Shipping Review", Vol. XLVI, No. 11, November, 1941, pp. 164 and 166.*

Canadian Shipyard Activities.

The cargo steamer "Fort Ville Marie", the first war-time Canadian-built merchant ship, was launched by Canadian Vickers, Ltd., Montreal, on the 9th October, and was followed within a week by her sister-ship "Fort St. James", which was put into the water at North Vancouver by the Burrard Dry Dock Co., Ltd. Mr. C. D. Howe, the Canadian Minister of Munitions and Supply, speaking on the occasion of the launch of the first-named vessel, stated that she and her sister-ship would be followed by a steady procession of cargo ships from 44 building berths in 14 individual shipyards. Material imported into Canada, he said, represented only about 5 per cent. of each ship. The propeller for this first vessel, manufactured on the shores of Lake Huron, was the largest bronze casting ever poured in the Dominion. Whereas two years ago Canada had practically no shipbuilding industry, there were now about 20,000 men employed in steel shipyards, and this number would soon reach 30,000. Mr. J. E. Labelle, president of Canadian Vickers, said that in a little more than four months their men had built the vessel's hull, machinery and boilers, and that in a few weeks' time the ship would be in service. The "Fort Ville Marie", which is being constructed to the order of Wartime Merchant Shipping, Ltd., a Government-owned concern, has a d.w. capacity of 10,000 tons, with a length of 427ft., a beam of 57ft. 2in., and a draught of 25ft. 6in. She has coal-burning Scotch boilers and triple-expansion engines designed to give her a service speed of 10 to 11 knots. Canadian shipyards have orders for 150 cargo vessels, all similar to the "Fort Ville Marie", apart from five which are to be of 5,000 tons. At the time of the launch keels had been laid for 24 of these ships, which are referred to as standardised "North Sands" type general cargo ships. They were designed at Sunderland, England, as ideal cargo carriers for war-time conditions.—*"The Syren", Vol. CLXXXI, No. 2,361, 26th November, 1941, pp. 239-240.*

Running Defects in Air Compressors.

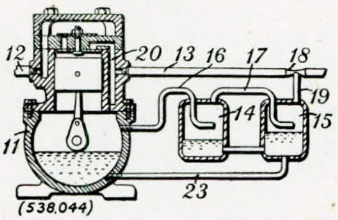
Difficulty is sometimes experienced with the automatic air governors of compressors owing to their action being upset by the presence of water in the air, more especially when the machine has to run in a humid atmosphere and is not fitted with an after-cooler. A simple method of overcoming the trouble is to fit a T-piece to the governor connection from the air receiver. The centre branch should point downwards, and be about 12in. or 18in. long, with a drain cock at the lower end. The water in the air will then collect in this vertical pipe, from which it can be drained, and the governor will be kept free from moisture. Failure of the valve plates in an air compressor usually manifests itself by overheating and loss of pressure. In single-stage machines, the delivery valve can easily be tested for leakage by lifting the suction valve (when the air receiver is full) either by means of the hand valve-lifting gear, if fitted, or by opening the governor, the compressor, of course, being stopped. If the delivery valve is leaking, air will be heard blowing back through the open suction valve. In two-stage machines, valve failure is indicated by the inter-cooler pressure gauge. If the cooler pressure is seen to be lower than usual, the L.P. cylr. valves are at fault, whereas a high inter-cooler pressure indicates trouble with the H.P. cylr. valves.—*"Broomwade News Bulletin", Vol. 4, No. 6, Nov.-Dec., 1941, p. 4.*

Floating Power Station.

Particulars of the operating results obtained from the generating plant on board the "Jacoma" during the 10 years since its installation, are given in the *Electrical World.* Originally built as a cargo steamer of 5,238 gross tons, 396ft. long by 53ft. beam, the ship was converted, at a cost about two-thirds of that of constructing a new land station, to supplement the output of the hydro-electric and steam plant of the Public Service Company, New Hampshire, U.S.A. The propelling machinery was removed to make room for two 10,000-kW. turbo-alternators and four 280,000lb./hr. oil-fired marine type boilers, working at a pressure of 425lb./in.^{2} and steam temperature of 700° F. During the 10 years the "Jacoma" has generated 564 million kW.-hrs. of the 2,361 million kW.-hrs. produced or purchased by the company, *i.e.*, about 23·9 per cent. of the total output. The floating power plant is normally run from Monday to Friday inclusive. The availability of the two units has been 85 per cent. and the average load factor 32 per cent. The hull is examined annually by a diver, whilst the boilers are examined and cleaned at intervals of from six to twelve months. Twice in the 10 years the vessel has been towed to dry dock, being away from her moorings for 10 days and out of commission for overhaul for about three weeks on each occasion. The operating problems have been generally similar to those of an equivalent shore station. A staff of 31 is employed.—*"Electrical Review", Vol. CXXIX, No. 3,340, 28th November, 1941, p. 596.*

Improved High Speed Air Compressor.

An improved design of high-speed air compressor employing splash lubrication has been developed and patented by the British Thomson-Houston Co., Ltd. Normally in such compressors it is difficult to provide for the return of lubricating oil to the crankcase after it has once passed the pistons, and there is a tendency to throw oil out of the crankcase and prevent its return from the inlet or suction side of the compressor. Referring to the accompanying sketch, the compressor has a crankcase (*11*), an exhaust line (*12*) and a suction line (*13*). A conduit (*16*) connects the crankcase with a first oil-separating chamber (*14*) above the oil level, and a second conduit (*17*) connects the chamber (*14*) with a second separating chamber (*15*) above the oil levels. In the suction line (*13*) is a Venturi contraction (*18*). A conduit (*19*) communicates between the low-pressure region of the Venturi (*18*) and the upper portion of the separating chamber (*15*) above the oil level. The suction (*13*) terminates in an inlet chamber (*2*), a restricted passage being provided between it and the crankcase for returning any oil which has leaked into the inlet chamber (*20*). The separating chambers are connected by a conduit below the oil level and the lower portion of the chamber (*15*) is connected to the crankcase (*11*) below the oil level of an oil return conduit (*23*). The operation of the compressor is as follows: Air, as well as oil, may pass from the inlet chamber (*20*) to the crankcase (*11*) through the restricted passage which connects them. The flow of air through the Venturi (*18*) in the suction line causes a reduction of pressure which tends to syphon the air from the crankcase through the chambers (*14, 15*) back into the suction line, thus producing a continual circulation of air through the circuit during normal operation of the system. If sufficient injector capacity is provided at the Venturi, and if the passages (*16, 17, 19*) are sufficiently large and the leakage past the piston is not excessive, there will be a reduction of pressure in the crankcase below that existing in the inlet chamber (*20*), and any oil deposited in the inlet chamber will be returned to the crankcase through the restricted passage. Due to the vigorous splashing of the oil in the crankcase a considerable quantity will pass through the conduit (*16*) into the chamber (*14*), where most of the oil is separated in the chamber (*15*). Whenever the amount of oil collected in the chambers (*14, 15*) is sufficient to overcome the pressure in the crankcase, any excess is returned to the crankcase by way of the conduit.—*"Engineering", Vol. 152, No. 3,959, 28th November, 1941, p. 440.*



Ice Damage to Shipping.

The transportation of war materials to North Russian ports is affected by the question of ice damage. Some ships, notably those which trade in the Baltic, are specially strengthened to resist such damage, and the classification societies have rules on the subject. The shell plating at the fore end of the vessel, at about the level of the water line, has to be increased in thickness, and additional frames must be introduced. The rudder, stern frame and propeller must also be protected against damage from ice. Ordinary cast-iron propellers appear to have no resilience if they come in contact with ice, and the tips or blades snap off. Cast-steel or bronze propellers are usually only distorted in these circumstances. Trouble often arises through inlet valves becoming choked with ice, and boiler connections have to be provided for cleaning them. In addition, such items as steam and water pipes, winches, windlasses and water tanks are affected by low temperatures, but an experienced and diligent crew can often keep these parts free from trouble.—*"Fairplay", Vol. CLVII, No. 3,055, 27th November, 1941, p. 540.*

A Non-metallic Substitute for Aluminium.

A new non-metallic material known as Formula C-102, one-third lighter than aluminium and intended to replace that metal, has been developed in the U.S.A. The new substance is made from fibrous and rubber-like ingredients, and, has, it is stated, been tested and approved by the U.S. army authorities. Under gunfire, for example, the new material does not rip or shatter, neither will it crystallise from vibration like metallic substances. It is also claimed to be immune from corrosion and pin-hole formation. The discovery of the substance was made in the course of research work in connection with self-sealing fuel tanks. Formula C-102 is slightly thicker than the $\frac{1}{8}$-in. aluminium sheets used for aircraft fuel tanks, but about one-third lighter. It permits penetration by gunfire with little tearing and with maximum support to the sealing compounds used. The makers expect the new material to find many applications in normal industry.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,510, 27th November, 1941, p. 6.*

Scheme for the Alleviation of Tanker Shortage.

A proposal put forward by Mr. D. C. Reid, a well-known American broker, in a recent issue of the New York *Daily Freight Record*, concerns a revival of the practice which obtained during the last war, of carrying low flash oil across the Atlantic in the double bottoms of ordinary cargo vessels in order to alleviate the shortage of tanker tonnage. He also suggests that the American EC-2 type ships, which are designed to burn oil, should be converted for burning either coal or oil, and use the former fuel during the present emergency. Such cargo steamers in the Atlantic trade could then bunker with coal in England for the round trip and thus make their double-bottom tanks available for the carriage of oil from the U.S. to this country. The present practice, it was stated, is for oil-burning steamships in that service to take in sufficient oil fuel for the round trip before leaving American ports. Although Mr. Reid's proposal may appear reasonable at first sight, it is not free from disadvantages. To take the case of a ship of about 8,000 tons d.w., which would burn about 300 tons of coal during an Atlantic passage, or a similar amount of oil on the round voyage; sailing from America the two ships would have the same useful d.w. capacity—*i.e.*, about 7,700 tons, but the oil-burning vessel could only carry about 900 tons of oil fuel in the remainder of the D.B. tanks, while the coal-burning ship could carry about 1,200 tons. The point is, however, that the deadweight for general cargo in the holds would be reduced in one case to 6,800 tons, and in the other to 6,000 tons, which is the aspect of the business that matters most at the present time. It is this which constitutes the main objection to Mr. Reid's scheme.—*"Fairplay", Vol. CLVII, No. 3,054, 20th November, 1941, p. 512.*

Concrete Ships.

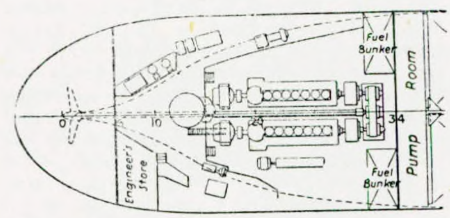
The New York *Journal of Commerce* reports that a new vacuum-dried concrete has been invented by Mr. K. P. Billner, which can be used in the construction of concrete ships. The inventor claims that hulls of 10,000-ton tankers could be built with this concrete in a period of four weeks or less and that they would have the same strength and lightness as hulls built of steel. In the course of a demonstration before the American Society of Mechanical Engineers, Mr. Billner applied a pressure of 12,500lb./in.^{2} to a concrete slab 12ft. long by $2\frac{1}{2}$in. thick; before it cracked. During this test the specially-prepared slab bent 5in. in the centre.—*"The Iron and Coal Trades Review", Vol. CXLIII, No. 3,848, 28th November, 1941, p. 499.*

Stability and Deck Cargoes.

In an address at the 30th National Safety Congress and Exposition held recently, Mr. J. F. McInnes, principal naval architect to the U.S. Maritime Commission, reviewed the development of safety measures on board American ships and discussed the additional safety features which are being introduced in these vessels. Means for the proper control of deep tanks under damaged conditions were, he said, provided in two ways: drain wells open to each tank to ensure symmetrical flooding, and a sluice valve in the division bulkhead operated from the deck above it. If deck loads were such as to call for increased stability, salt water could be admitted to the empty fuel tanks in the double bottom by means of the ballast pumps and pipes provided for the purpose. "We are considering", he added, "restrictions in respect of deck cargoes which, due to the addition of weights on the weather deck, raise the vessel's centre of gravity and thus reduce the stability of the ship". This was particularly important in the case of deck cargoes of timber, where one side of the latter might become waterlogged, causing the ship to list and thereby seriously reducing the already inadequate stability. It was of the utmost importance, he declared, to press up all tanks and to check up the vessel's stability before sailing with large deck loads. The proper control of damaged deep tanks and ballasting of the ship to counteract unequal loads on deck were matters of grave concern to the Commission. Although adequate means for dealing with emergencies of such a nature were provided, the personal element in times of danger was always an unknown factor, and improper handling of the facilities provided might increase the hazard. "Reports have been received". he declared, "that equalising pipes and sluice valves have been permanently blanked off by operating personnel, thereby defeating the object for which these safety measures were provided".—*"The Shipping World", Vol. CV, No. 2,529, 3rd December, 1941, p. 409.*

A Motor Tanker of the Future.

A study of the propelling-machinery installations of recent motor tankers constructed on the Continent and in America shows that the modern oil engines requires a good deal of fore-and-aft space when high powers are provided on a single screw. In this respect it does not compare too favourably with the compact machinery lay-out of the American steamships in which the water-tube boilers and their automatic combustion-control gear are arranged above and abaft the main turbines. This leads to the suggestion that the motor tanker of the future might well embody the arrangement shown in the accompanying sketch, whereby two engines drive pinions through electro-magnetic slip couplings at the forward end. These mesh with a common gear wheel which is attached to the propeller shaft running fore and aft between the two engines. At the scavenge-pump end of the engines, which are high-speed two-stroke units, are two generators with suitable couplings. By uncoupling the electro-magnetic units the full power of either main engine may be used for driving the generators when the vessel is in port, thereby securing ample current for the operation of the cargo oil pumps and any other auxiliary machinery that may be necessary. The main engines, therefore, operate as propulsion units at sea and as auxiliary engines in port, and whilst there may be certain disadvantages in this, there is, at the same time, an advantage in compactness, even when the space taken up by the couplings and gearing is taken into account.—*A. C. Hardy, B.Sc., "The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,522, 11th December, 1941, pp. 4-5.*



Twin engines driving single screw of 2,000 h.p. tanker; gears and couplings at forward end of engines and generators aft.

Strainers for Pipe-lines.

The makers of the Arkon Visible Flow Indicator (*see abstract on p. 164 of* Transactions, *October, 1940*) have developed a neat and efficient design of strainer for use in pipe-lines conveying oil, water, steam or air, and fluids for use in general. The device, which is illustrated in the accompanying sectional drawing, is known as the Arkon Type Y Strainer, and comprises a small fitting, generally screwed into the pipe-line, having a projecting portion at the bottom which contains a cylindrical screen inclined at an angle. The compressed air or other fluid passes through this screen, while the separated solid particles fall to the bottom by gravity. From time to time the end cover is unscrewed and the screen removed and cleaned. The fitting is intended for use in horizontal pipe-lines, and in the case of a vertical line, a short section of horizontal line must be included for this purpose. The strainers are enclosed in boxes constructed of cast or malleable iron for pressures of up to 150lb./in.², and for pipes of from ⅛in. to 8in. in diameter. The screens are usually of perforated phosphor-bronze metal sheet, but other materials are also used where necessary. The standard hole size for the screens is $^1/_{64}$-in. diameter, but this can be varied to suit users' requirements. Some typical applications of the Arkon strainers are in connection with oil fuel, as well as Diesel-oil and petrol, lubricating-oil, engine- and refrigerator-cooling circulating systems, and air-conditioning and general ventilation.—*"The Shipbuilder", Vol. XLVIII, No. 389, December, 1941, pp. 369-370.*

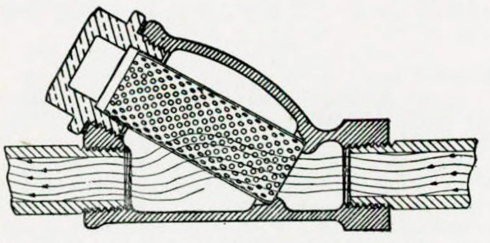


Fig. 6.—*Section of Arkon Type Y Strainer.*

New Finnish Motorships.

Two cargo liners, the motorships "Selma Thorden" and "Kristina Thorden", have recently been constructed at the Crichton-Vulcan yard, Åbo, for Finnish owners. They are sister ships of 3,645 gross tons, 387ft.×51ft. 3in.×33ft. 7in., with a d.w. capacity of 6,000 tons on a draught of 23ft. 8¼in. The ships are of the open shelter-deck type, strengthened for navigating in ice, and have eight watertight compartments, with three cargo holds forward of the machinery space and two aft. No. 1 hold is specially designed for the transport of motor-cars from America to Finland. The total bale capacity is 327,610 cu. ft.., of which 13,850 cu. ft. is refrigerated cargo space on the main deck around the engine room. The cargo-handling equipment includes 10 electric winches, and among the derricks is one capable of lifting 25 tons. The propelling machinery consists of a 7-cylr. single-acting 2-stroke Krupp Diesel engine developing 3,600 b.h.p. at 120 r.p.m., the cylr. diameter being 650 mm. and the piston stroke 1,250 mm. The engines of these two vessels are the first of their type to be constructed in Finland, and are designed to give the ships a service speed of 15 knots. The auxiliary machinery includes three 80-kW. dynamos driven by 120-b.h.p. Krupp 4-stroke engines and a 10-kW. auxiliary generator. An oil-fired Clarkson boiler is installed for heating purposes.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 284.*

Diesel-electric Submarine Tenders for U.S. Navy.

Two 9,500-ton depôt ships for submarines, under construction for the U.S. Navy, are being equipped with Diesel-electric propelling machinery. The vessels are sister ships, but whereas one of them will employ direct current for the main propulsion motors and ship's auxiliaries, the other will operate with alternating current. The output in both cases is 12,000 s.h.p. and the propeller speed of the twin screws is 140 r.p.m. Synchronous motors will be used for driving the propellers in the a.c. ship, this being the first time that such machinery has been adopted in an American warship. The propelling machinery is arranged in two separate W.T. compartments, each containing four Diesel-engined generators, one propulsion motor, an excitation motor-generator set and one control unit. The operation of the two propulsion systems is entirely independent. The generating plant thus comprises eight units, each alternator being driven at 759 r.p.m. by a 1,600-b.h.p. two-stroke engine. The alternators are three-phase 62·5-cycle 1,150-kW. 2,530-volt units at 95 per cent. power factor. They are of the closed, self-ventilating type with surface water-coolers. Of the four generators in each compartment, two are solely for propulsion and are excited from a separate motor-generator set, whilst the remaining two have direct-connected exciters and may be used either for propulsion or for parallel operation with the ship's auxiliary generators, in order to provide the necessary power for charging the storage batteries of submarines alongside. An 850-kW. motor generator driven by a synchronous motor is installed for this purpose. The two synchronous main propulsion motors, each rated at 5,900 b.h.p. at 2,500 volts, are directly coupled to their respective propeller shafts. Dynamic braking is employed for rapid stopping and reversal of the propellers. The synchronous machinery is excited by two separate motor generators, one of which is capable of providing the excitation current for the four propulsion generators, whilst the other supplies that required for exciting the corresponding propulsion motor. For all speeds between one-quarter and full speed the fuel supply to the Diesel engines is regulated and their speed correspondingly controlled. When running in parallel the adjustment is made simultaneously on all engines. The engine speed control provides for frequency of synchronous running between 16 and 62·5 cycles. Simultaneous and automatic rheostatic adjustment of the propulsion generator and motor fields at various speeds and loads is also provided. Two transformers are brought into operation when it is necessary to use the propulsion generators to supply additional power for the ship's services. The load imposed by the latter will in certain cases amount to as much as 2,500 kW., whilst the total connected load may be 6,000 kW. A special demand imposed upon the generating system is that from two single-phase arc furnaces of 125 kW. A comparison between the propelling installations of the two ships shows that the a.c. system requires 20 per cent. more space than the d.c. arrangement, but the total weight of the latter is 47 per cent. greater and the total estimated cost not less than 50 per cent. higher.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, pp. 286-287.*

Spark Arrestor for Large Marine Diesel Engines.

An improved form of spark arrestor for large marine Diesel engines, for installation in the exhaust conduit or funnel of a motor-ship, is the object of a new British patent. The construction of the device, which was originally developed in Holland, is shown in sectional elevation and plan (Fig. 1). It consists of a cylindrical casing (*5*) with frusto-conical bottom and top ends (*6, 7*) having inlet and outlet openings (*8, 9*) of the same dimensions. A bi-conical chamber (*10*) acts as a deflector; between this and the bottom end (*6*) is a circular series of fixed spin-inducing vanes (*11*), whilst between the circumference of the chamber (*10*) and the top end (*7*) is a ring of vertical baffle vanes (*12*). Two cyclone separators (*13, 14*) at the top and bottom, respectively, are attached to the outside of the casing (*5*) and communicate with its interior through openings (*15, 16*). A perforated cylinder (*20*) inside the vaned wall (*12*) contains long and short radial baffles (*17, 18*) between which is a sound-absorbing material such as glass or steel wool. These baffles cause the gas to reach the outlet (*9*) in a steady axial flow and act as sound chambers for the higher frequencies, the lower frequencies being partially damped in the chamber (*10*), which may also be lined with a sound-absorbing material. The resonance in the exhaust conduit can be controlled by suitably dimensioning the bottom opening and the angle of the upper cone of the chamber (*10*), the maximum diameter of which should not exceed that of the inlet and outlet openings. The vanes (*11*) in the casing (*5*) impart a rotary movement to the inflowing gases, any sparks or particles being thrown outwards and discharged into the cyclone separators. The gases have to pass between the vanes (*12*) in order to reach the outlet (*9*) and are therefore suddenly deflected through an angle of about 150°, causing the heavier particles rotating with the gases to rebound into the mass of vapour in the casing.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 303.*

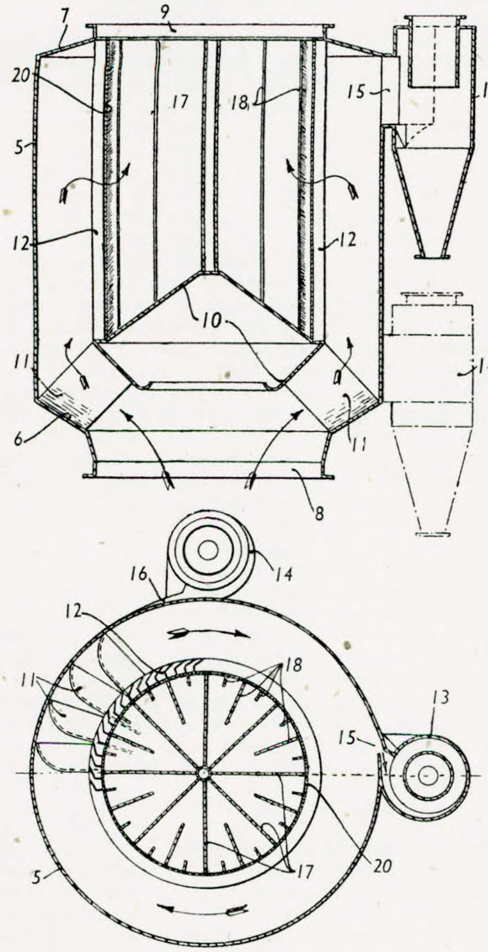


FIG. 1.

Ships Specially Designed for Welding.

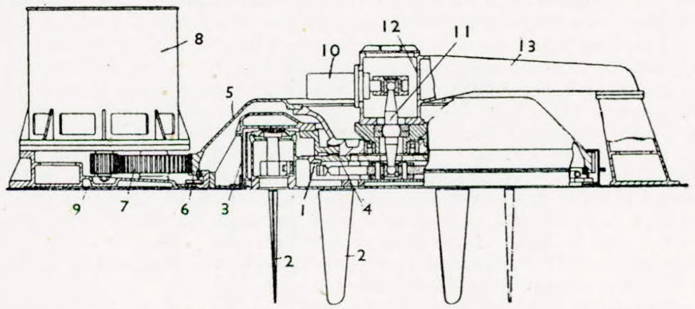
One of the most remarkable developments in present-day shipbuilding in America is the widespread application of welding. Despite the satisfactory progress made in welded construction, however, naval architects do not always seem to appreciate its importance. Ships essentially designed for riveting are being welded, and in order that full advantage can be taken of the possibilities of welding it becomes necessary to re-design hulls and hull details. Very great economies in building costs could be effected with hulls so designed as to allow downhand welding of all seams. An immense amount of data is now being collected in the U.S. shipyards that will be of great assistance in solving this problem, and thus in arranging for the modification of designs of hulls so as to be essentially suitable for building by welding rather than by riveting. It is a notable and curious fact that some of the new Pacific Coast yards, which are now constructing large numbers of ships, have a very wide experience in welding but no previous experience in shipbuilding. Nevertheless, the manner in which they build the hulls is reported to be "an eye-opener to old shipbuilders".—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 273.*

Single Lever Control.

German builders of Diesel engines seem to be in complete agreement as regards the latest development in control mechanism for oil engines. Three of the leading manufacturers, the M.A.N., Krupp and Humboldt-Deutz works, have all introduced and patented new systems of control mechanism for marine Diesel engines in which the basic principle is the employment of a single lever to carry out all the necessary operations, both for starting and reversing the engine. Whether this is really simpler than having one lever for the reversing gear, and another, or a wheel, through which the engine is started and the speed regulated, is problematic. It is, however. interesting to note that German designers appear to be adopting communal ideas.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 274.*

New Drive for Voith-Schneider Propellers.

Voith-Schneider propellers, which were fitted to several British-built ships before the war and which are being widely employed in Germany for minesweepers and similar craft, are usually arranged for electric propulsion. The normal practice is to fit the vertical-shaft electric motors above the propeller housings, and this necessitates a height which is not always available. A patent has recently been taken out in Germany to overcome this difficulty, the



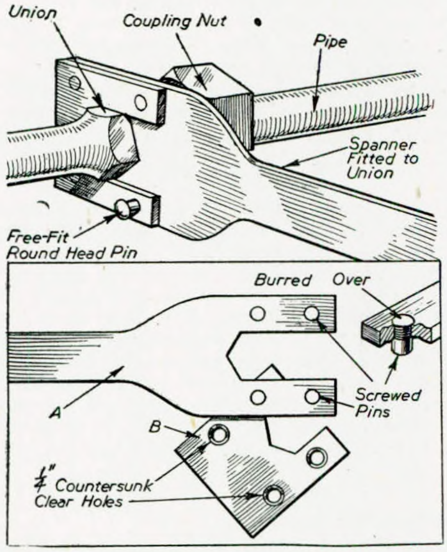
inventor being one of the leading engineers of the Siemens-Schuckert Company, Dr.-Ing. Theodor Buff. The accompanying illustration shows the arrangement, (*1*) being the rotating portion of the propeller and (*2*) being the blades. The part (*1*) has a fixed support (*3*) carried in a bearing (*4*), and is rigidly attached to a bell-shaped toothed wheel (*6*) which meshes with an intermediate wheel (*7*) and is driven by a spur wheel (*9*) keyed on to an electric motor (*8*) through the wheel (*7*). The operating gear (*10, 11*) for carrying out the necessary movements of the propeller blades (*2*) is supported in a casing (*12*) which is carried by framework (*13*) fixed the the bed-plate. It is claimed that this arrangement does not require any greater height for the electric driving motors than is actually taken up by the propellers and gear.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 297.*

Wasteful Auxiliary Machinery.

In cargo motorships it is usual to have two or three similar generator sets, according to the size of the ship, the power of the main engines and the nature of the general equipment. On some occasions, as for instance, when the ship is in port, the load is too small even for a single dynamo to run at a reasonable efficiency. A dynamo engine thus operating temporarily under unfavourable load conditions increases maintenance costs and causes repair bills to be higher than would otherwise be the case. In some instances it might be more economical and satisfactory from the standpoint of general running if a high-speed Diesel generating set were installed, capable of taking the full load in the circumstances mentioned when running at three-quarter output. The cost of such a plant would be relatively low, the space occupied would be small and the life of the main dynamo engines would be beneficially influenced.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 274.*

Ring Spanner for Union Couplings.

The accompanying sketch shows a simple method of holding a union coupling with a ring spanner in order to prevent the ordinary spanner from damaging the hexagonal portion of the union. The ring spanner also serves to hold the union when it is necessary to slack off the coupling nut. The device is easily made, and only consists of two pieces of flat steel fitted to the union as shown. In order to use the spanner it is merely necessary to remove three of the countersunk screwed pins from the plate *B*, to swing the latter over the pipe. The screwed pins are then replaced and tightened, after which the spanner is slipped onto the hexagonal union of the coupling.—*A. F. Crossman, "Practical Engineering", Vol. 4, No. 99, 11th December, 1941, p. 563.*



Method of making a spanner for a union coupling.

Smoke Control for Boilers.

To check the smoke nuisance, an American company has developed two photo electric units that can be installed on any type and size of boiler burning oil or any grade of coal fed by hand or stoker. One is an indicator-signal apparatus that gives the operator warning by bell or light, or both, the instant the smoke exceeds the maximum allowable density. The other is an automatic smoke-control device that feeds steam and air, or air only, to over-fire jets as soon as the fire starts smoking excessively because of a deficiency in oxygen. It is claimed that the latter unit makes it possible to use coal of lower grade without loss in boiler efficiency and that it has shown fuel savings of as much as 20 per cent. in the case of large and small boilers. Both models are operated with a.c. or d.c. of 115 volts.—*"The Iron and Coal Trades Review", Vol. CXLIII, No. 3,851, 9th December, 1941, p. 575.*

Performance of Modern Turbine Ships.

In the course of a paper recently read before the American Society of Naval Architects and Marine Engineers by two engineers of the Bethlehem Steel Company, who built several of the U.S. Maritime Commission's turbine steamers of the C-2 and C-3 classes, it was stated that the average fuel consumption during the trials of seven of these ships was 0·59lb./s.h.p.-hr. for all purposes, with oil fuel having a calorific value of 18,500 B.Th.U. per lb. Under service conditions, when boilers are often dirty, the condensing-water temperature is high and other circumstances may be unfavourable, the mean fuel consumption over a period of years will certainly not be less than 0·65lb./s.h.p.-hr. for all purposes. As against this, a modern motorship has a fuel consumption of 0·37 to 0·38lb./b.h.p.-hr. for all purposes, and it remains unaltered throughout the life of the ship. A comparison between the two types, both based upon the most modern design, shows, therefore, that the fuel consumption of the steamer is 70 per cent. higher than that of the motorship. In the case of the C-3 class steamship "Examiner", in which an experimental 1,200-lb./in.^{2} reheat installation is being utilised, it is estimated that a fuel consumption of 0·513lb./s.h.p.-hr. will be realised. This is 12·8 per cent. lower than the consumption in the vessels of the standard 425-lb./in.^{2} design, but on the other hand, the total weight of the machinery is 9 per cent. greater and the cost very considerably higher, although it has been stated that ultimately the increased capital cost will be about the same as the difference in weight. Even this figure, however, would involve an additional expenditure of about £20,000 (based on American prices), so that the advantage to be gained by adopting very much higher steam pressures appears to be somewhat questionable, at any rate for moderate-powered installations.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 274.*

Future Types of Auxiliary Machinery.

In many ships the cost of the auxiliary machinery is almost one-half that of the propelling plant, and in view of this fact it might appear doubtful whether the attention which has been given to improvements in auxiliary machinery is proportionate to that devoted in recent years to the development of propelling machinery. Electricity is now generally employed for operating most of the auxiliaries on board all classes of ship, steam and motor, except the slower-speed lower-powered cargo ships. In the case of motorships of this class, it is usual to drive all the auxiliaries required at sea by steam from an exhaust-gas boiler, whilst in a steamer the additional cost of motor-driven auxiliaries in what is otherwise a cheap ship might scarcely be warranted. The question of applying alternating current for the operation of auxiliaries has frequently been discussed in recent years, as the initial cost would be substantially reduced and the robust construction of a.c. motors, as well as their lightness relative to d.c. machines, constitute important advantages. Synchronous motors are, however, constant-speed machines and variations of speed are required with some of the auxiliary machinery in ships. For this reason it has been found desirable to instal d.c. motors for driving the winches, capstans and other deck or E.R. auxiliaries (including certain pumps) for which the provision of variable speed is essential, in such vessels as are equipped with a.c. electrical installations for power and lighting purposes. The success which has attended the development and manufacture of high-speed Diesel engines for numerous services is also bound to influence the choice of marine auxiliary engines in the future. Saving in weight and space is so important on board ship, that the employment of reliable and economical Diesel generating sets running at twice the speed of those common before the war is likely to become widespread. It may also be anticipated that every four-stroke Diesel engine of 200 h.p. or more will be pressure-charged, and here, again, is an opportunity for the further development of marine auxiliary machinery. Where two-stroke machinery is adopted for driving auxiliaries on board ship, advantage will no doubt have to be taken of the Kadenacy or similar principle for increasing output almost to the same relative extent as pressure-charging with four-stroke engines. Fast-running auxiliary compressors of the multi-cylinder type, which are already proving so successful in many motorships, are also likely to become standard practice.—*"The Motor Ship", Vol. XXII, No. 263, December, 1941, p. 271-272.*

U.S. Maritime Commission's Small Ship Programme.

The secondary or small ship programme of the Maritime Commission, part of which is already under contract, provides for 127 vessels of special types in six main classes. These include 16 coastal type motor tankers, 25 sea-going tugs with geared Diesel engines, 26 motor tugs for harbour service, 45 small cargo carriers of British coaster type, and 15 concrete bulk cargo barges. The small motor tankers are based on an existing design. The question of installing steam machinery and coal-burning boilers in these vessels was considered, but the space available for the purpose made such a course impracticable. The geared Diesel tugs will be 185ft. long and among the largest ever built. They will be suitable for ocean towage work if required, but are primarily intended for service in the Gulf of Mexico and U.S. coastal waters,. Large crews will be carried. The harbour tugs are to have 1,000-h.p. Diesel engines with direct drive. They are to be 100ft. in length and will be equipped for towing. The 45 small coasters are urgently needed to replace vessels of similar type lost through war action. Some of these ships are to be built on the Great Lakes, as their dimensions will enable them to pass through the locks to the ocean. The concrete bulk cargo barges are to be of about 7,000-ton capacity and are, in general, intended for service with high-power tugs. They are not to be self-propelled.—*"The Journal of Commerce" (Shipbuilding and Engineering Edition), No. 35,516, 4th December, 1941, p. 7.*

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