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Modern Developments of Asphaltic Floorings for Use On Board Ship.

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THE following paper is intended to explain the basic principles which underlie the modern use of asphaltic mediums for decking purposes on board modern ships, and to indicate directions in which economy may be achieved in the future laying of decks on ships of all types.

The paper covers first a survey of Regulations as regards decking material, and proceeds then to detail the general character of asphaltic materials. This section includes reference to the various qualities inherent in asphaltic material, and also certain of its disadvantages.

Following is a description of new ideas and methods which have been devised for overcoming the disadvantages previously instanced, and for obtaining the maximum value from the virtues of bituminous materials, of which asphalt is one.

The paper concludes with specific comparisons of deckings laid to Board of Trade requirements of wood, magnesium chloride compositions, ordinary asphalt, and modern asphaltic mediums.

One of the principal problems with which the naval architect is faced in designing and equipping a modern vessel, is that of providing efficient, economical, hard-wearing, and preservative deck coverings over the steel of which the horizontal platforms and divisions of his ship must be constructed, for reasons of strength and sometimes of watertightness.

For many years wood was the material invariably used to cover steel decks where such covering was essential, but the increasing cost of wood, the fact that it required to be well-cared for, especially on weather decks, and the fact that any laxity in this respect resulted in unseen but nevertheless serious eating away of the steel plating under, has brought about a demand for less expensive, more permanently reliable, and more easily laid materials.

There is relatively an enormous area of steel deck plating to be covered in any passenger ship, while, even in ships which are mainly cargo-carrying, the extent of the deck surface needing covering often runs into many hundreds of square yards. It is not surprising, therefore, that a great deal of attention was early directed to the provision of effective substitutes for wood, and that there were put on to the market very many such substitutes.

It is the case that coverings to steel decks are not required, in the main, for any reason connected with the ability of a ship to remain afloat. They are called for simply to enable the ship to be made habitable, and it is for that reason that the rules governing the provision of deck coverings are the province of the Board of Trade and not of the Registration Societies. It is important that the attitude of the Board of Trade should be appreciated, and the following extract from Circular

1671, issued by the Mercantile Marine Department of the Board of Trade in June, 1928, establishes this.

"The Board's Instructions require the iron or steel decks forming the floors or crowns of compartments or spaces in which passengers and crew are accommodated to be sheathed with wood, or with an approved composition as a substitute for wood. Generally, such sheathings must be non-absorbent and sanitary, and must provide a good foothold, be bad conductors of heat, and be incombustible".

The attitude of the Registration Societies is concerned entirely with the matter of ensuring maintenance of the steel deck plating, and this is shown by the fact that Lloyd's require that "Where wood sheathing is laid over a steel deck . . . the wood deck is to be efficiently caulked and payed", while, if a composition is substituted, it is laid down that "If the chemical composition of the material is such that there is a possibility of corrosive action taking place between it and the steel, it is recommended that the steel deck be coated with an approved insulating compound". The British Corporation are a little more explicit in regard to the matter of substitute compositions, the Rules reading as follows :—"Deck compositions may be laid on steel decks which are not exposed to weather, excessive moisture or heat, provided the material is not destructive to steel or is effectively insulated from the steel by a non-corrosive protective covering which is proof against attack by chlorides. . . . The steel plating is to be thoroughly cleaned with alkaline solution before the composition is laid".

That insistence upon the necessity for the avoidance of the use of material, in a manner which will invite corrosion is a matter of very great importance, and that it is so recognised by the Board of Trade, appears very clearly from the second paragraph of the Circular 1671, which reads :—"The binding agent used in mixing a large number of deck sheathings is magnesium chloride, and a serious objection to the use of such sheathings is the liability to corrosion of the steel decks upon which they are laid, owing to the difficulty experienced in practice of fixing the whole of the magnesium chloride; any deficiency in the amount results in the sheathing breaking and crumbling, and free chloride may bring about corrosion of the steel decks. Good results can be assured only by carefully proportioning, mixing, and laying the materials, and by preparing the surface of the steel on which they are to be laid. In practice it is found necessary to require steel decks to be coated with anti-corrosive paints or other protective compositions before sheathings are laid; this precaution is especially necessary when sheathings are laid on the crowns of oil fuel compartments, and in such cases the anti-corrosive compositions used must be insoluble in fuel oil".

Those who have had actual experience of the work of repairing and reconditioning ships in which large use was made of magnesium chloride deckings, before the short-comings of this class of material had been fully recognised, will require no emphasis to be laid upon the absolute necessity which exists for giving proper effect to the requirement that the steel deck plating must be thoroughly protected before material of this character is used. In very many cases steel deck plating has been found to be eaten completely through over large areas under magnesium chloride decking compositions.

The first use of magnesium chloride wood substitute was approved in 1904, but at the time of Circular 1671, there were no fewer than 23 different named materials, all using magnesium chloride as the binding agent. Generally, the thicknesses required for these substitutes was from ¾in. to 1in. on iron or steel decks forming the floors of passenger or crew spaces, and 2in. to 2½in. on iron or steel weather decks over passenger or crew spaces. If used on the crowns of oil fuel spaces, the minimum thickness which is approved is 1½in., but in such cases this material must be laid on top of a proper anti-corrosive composition itself insoluble in fuel oil.

Some asphalt was used as decking in place of wood during the war, but it was not until after the war that a really serious attempt was made to utilise asphalt, commercially, as a decking material, and then its first use is believed to have been to act as a reinforcement and protection to a steel weather deck over insulation, which deck was in a relatively poor condition. The complete covering of the steel with a thick layer of asphalt, served to provide a watertight and hard wearing top surface that entirely satisfied the working conditions, and saved a considerable expenditure that might have otherwise have been necessary.

Since that date a large number of similar jobs have been carried out successfully, while a very considerable amount of repair work has been done, utilising asphalt as a top covering over wood decking which had been allowed to get into a very bad state of repair. In the normal way, the making good of a steel deck which has been covered with wood, but which has been permitted to get into a very bad condition, may involve very heavy expense, as lifting of the wood deck is likely to disclose the fact that the steel deck under is too badly corroded to make it possible to lay new wood planking on top of it. The problem has been solved, in many cases, in a very simple way, although at the expense of adding a fair amount of weight to the ship, by laying a substantial thickness of good ordinary asphalt straight on to the faulty wood decking without previously disturbing this. The resulting top covering, being watertight in itself, has practically halted all deterioration which was going on underneath, with the result that this expedient proved itself to be a complete success.

At the present time technical advance has progressed a very great deal beyond this point, and the results achieved with the use of ordinary asphalt along the lines referred to above, can be greatly improved upon, even for repair and maintenance work on old wood decks, while the successful use of asphaltic materials, by themselves, for every class of deck covering, on weather decks, or in accommodation spaces, in cabins or in wash-places, for crew's quarters or for the severe service called for in cattle spaces, in refrigerated chambers or for sports decks, has lifted this class of material into a position of primary interest to naval architects and shipbuilders.

The lines along which progress and development have proceeded are of interest in themselves, and also as indicating that such advances as have been recorded have been the result of pursuing logical lines of thought, directed towards the best use of the special qualities which are inherent in asphaltic materials. To appreciate the progress which has been made it is desirable that some short description should be given of asphalt, in order that there may be opportunity to realise the extent to which this class of material may find its place in shipbuilding specifications in the future, and in order that marine superintendents and marine engineers may be able to assess the extent to which this material is likely to be of use to them in maintaining or reconditioning the ships in their charge.

Asphalt.

Natural deposits of rock asphalt are found in various places on the Continent, particularly in France, Switzerland, Italy and Sicily. Although the first discoveries of this material were made early in the eighteenth century, it was not until 1854 that there was serious effort to make use of material from these deposits for the purpose of providing a hard-wearing surface for taking foot and vehicular traffic.

Natural rock asphalt consists of limestone rock almost uniformly impregnated with bitumen, this material having probably been formed, naturally, in some such manner as have the deposits of shale and other mineral substance which are found in various places permeated by petrol carrying oils. Sometimes asphalt has to be mined, sometimes, as in Italy, it can be cut out from open quarries. It is this natural rock asphalt which is crushed, ground and afterwards graded in order to bring the material to a form suitable to enable it to be pressed into a hard, watertight road surface. The material in its final form and ready for use contains definite proportions of asphalt screened through sieves of fineness from a standard 10 to the inch to standard 200 to the inch.

Spread out evenly on the prepared site of the road, it is compressed with the aid of heavy heated tools until the whole of the layer of carefully graded molecules of asphaltic powder is firmly welded together into a slab of hard watertight hard-wearing material. This form of compressed asphalt contains round about 10 per cent. of bitumen, which in conjunction with the careful grading serves to bind the limestone constituent more and more firmly under the effect of traffic loads, in the manner which is very familiar in the main streets of most large towns.

Discovery of the fact that rock asphalt was simply limestone impregnated with bitumen, led to the development of synthetic asphalt, the initial work being carried out in Belgium by a chemist, De Smedt. His research work was highly successful, and it was found possible to build up excellent "artificial asphalt" by taking suitable limestones or other equivalent mineral matter, and by treating these in such a manner that they took up the required amount of bitumen. De Smedt's discovery opened up a greatly increased field, for supplies of suitable limestones were easily obtainable, while supplies of natural bitumen were much less restricted than were the supplies of natural asphalt. Notable sources of supply of natural bitumen are the natural lakes which exist in the Island of Trinidad, from which close upon five million tons of bitumen have already been taken, without apparently appreciably affecting the content of these lakes.

A further step forward in the production of "artificial asphalt" resulted from the fact that it was found that a material, very similar to natural bitumen, could be extracted from enormous supplies of asphaltic oils, tapped in the United States, after these oils had been made to give up their lighter fractions by distillation. At the present time, therefore, there are three different sources of asphalt—natural rock asphalt; synthetic asphalt composed of limestone or the like and natural bitumen; and synthetic asphalt composed of limestone or the like and residual bitumen obtained from certain crude oils by distillation. It is only within the past thirty years or so that synthetic asphalts have made any great progress on this side of the Atlantic, perhaps for the very understandable reason that British financial enterprise was more concerned with the development of the concessions held by British interests in the sources of natural rock asphalt.

The whole subject is an extremely important one, and for those who are interested there is a good deal more information to be obtained from technical literature dealing with the development of asphalt for use on roads. Sufficient has been given here to establish certain important facts which have a considerable bearing on the manner in which special asphaltic combinations have been produced for ship work.

Deck Sheathings—Bituminous Compositions.

It is under the above heading that the Board of Trade deal with asphaltic decking materials, and it will have been made clear, from the foregoing, that this is a correct definition, although it cannot be too carefully pointed out that the principal constituent is not bitumen but some form of mineral stone. Bitumen might be looked upon as the vitally essential element in an asphaltic decking material, but of very great importance, in up-to-date asphaltic decking materials, are the mineral and other constituents which go to the make-up of the finished composition.

Just as, in road making, there are a number of forms in which asphalt is used, and a very wide variation of the schemes adopted in making a final hard-finished road surface, so with asphaltic deckings there are different mixtures to be used for different services, and certain very distinct methods of finally laying the material and causing it to adhere firmly in place on the ship.

In some cases a finished job is required which will be sufficiently hard to stand heavy service even when the ship is in tropical waters, the decking being exposed to the heat of the sun. This is a most difficult condition to comply with, but it is one which has been satisfied with a substantial measure of success, with proper selection of the bitumen, limestone, and other minerals added to function as hard filling material. More often, the temperature conditions to be satisfied are not unreasonably high, the material is to be laid in some between deck space, and is simply required to present a clean, hygienic surface of pleasant coloured appearance, either for passengers' quarters, alleyways, crew quarters or public rooms. In such cases a modification can be made in the composition of the decking material which will ensure that it shall have all the qualities enumerated, and, in addition, be able to withstand the most severe vibration and working stresses the ship may be called upon to sustain, without any sign of cracking on the part of the deck covering.

Asphaltic decking material is also required in washplaces and lavatories in which a very hard, close, watertight surface is essential to the obtaining of first-class results. Decking of this type has been used most successfully for service in troop washplaces on Admiralty troopships, to the virtual exclusion of any other form of deck covering during recent years. For refrigerated work asphaltic compositions and special methods have been developed, which result in the production of perfectly watertight, hard-wearing, elastic decks in refrigerated chambers, which decks are entirely free from any fear of pulling away from the sides, of cracking or of perforation.

It has been remarked that bitumen plays an essential part in the composition of asphalt, and here, at once, appears one of the principal reasons which have reacted to bring about a decided increase in the use of asphaltic materials for ship work. Bitumen is one of the most important preservative materials known in the field of steel structural work. It is hardly going too far to suggest that probably 90 per cent. of the materials used to preserve structural steel work in positions where immunity from corrosion is the most essential factor, are of a bituminous character. Bituminous paints and enamels cover enormous areas in every steel ship of any size, and the extent to which their use would be increased, if only they could be obtained with a range of really light colours, is difficult to over estimate. The very fact that asphaltic material has bitumen as its fundamental constituent, explains at once why it is that it should be welcomed for use as a decking material, once certain of the disadvantages attached to its use were overcome.

In coming to discussion of the practical methods which have been adopted for the application of asphaltic mediums for the service of marine vessels, attention must first be drawn to certain disadvantages which attached to the use of asphalt for decking purposes when this was used in its normal state and according to methods which had proved satisfactory ashore.

In the first place, it must be remarked that asphalt contains limestone and that therefore there is need that care should be taken in laying asphalt upon steel decks, whether these be new or old. If asphalt is laid direct down on to steel plating, although this may have apparently been very carefully cleaned and dried, there often follows a blowing-up of the asphaltic surface in small humps or bubbles—a phenomenon which can occasionally be observed on shore. The most practicable method of obviating this, and one which is invariably successful, is to ensure that between the asphaltic material itself, and the steel deck, there is a suitable underlayer which will serve to kill any action of this kind. The action does not always arise from there being contact between the steel plating and the asphalt, but can arise simply from the presence of dirt containing some matter which is capable of combining with the limestone and giving off sufficient gas to form a bubble.

In the second place, it is the case that when ordinary asphalt is laid to any thickness on a steel deck, there is inevitably a considerable amount of heat transmitted to the deck plating, with the result that the temperature of the steel of the deck is raised, so much so that there is difficulty below deck, owing to the fact that the paint on the underside of the deck is blown down in large blisters. This circumstance is especially noticeable if attempt is made to lay thick asphalt covering over a between-deck space in which passenger accommodation is fitted, the white paint or enamel on the overheading coming down in a manner which gives rise to a good deal of trouble. The point is one which should be watched carefully, if asphalt is being relied upon to replace wood decking over a steel deck which has worn thin. In this case, also, one remedy which can be adopted, and which has been proved to give satisfaction, is that of interposing between the steel deck and the asphalt a material designed to absorb a large amount of the heat and so insulate the steel plating itself.

In the third place, it is the case that if attempt is made to lay asphalt direct to steel deck plating, it is often possible to obtain a result which has a good appearance from the surface, but is nevertheless unlikely to prove consistently satisfactory on service, for the very good reason that the material is not adhering to the deck plating all over, so that once water is able to creep below the surface at any one point, it makes its way all over the greater part of the space apparently covered by the asphalt. The extent to which such infiltration can take place, of course, is dependent to a great extent upon the quality of the workmanship, but it is a factor of which account must always be taken, and it is one factor which, again, can be removed entirely if a suitable material is properly laid under the asphalt itself.

In the fourth place, it is well recognised that the steel plating of the deck of a ship is exposed to a variety of stresses and strains which result in it bending and buckling and stretching and contracting. Asphalt, if prepared for the service in a manner which is to give it a hard-wearing quality, cannot by its nature partake of all these various movements, so that, unless special measures are taken to make good its deficiency in this respect, there will certainly develop cracks and fissures, sometimes slight and sometimes well marked, but in any case providing a way for water to get down to the steel plating under the asphalt itself. This trouble is bound to be experienced wherever asphalt is laid to take a hard-wearing surface, unless precautions are taken to provide that there shall be an elastic medium, between the steel plating which is flexing and the asphalt, which cannot partake of that flexing movement. This medium should not only fasten itself firmly to the deck plating, so that it effectively prevents any water from getting down to the steel, and adheres firmly to that, under all circumstances, but it should also be capable of becoming more or less an integral part of the asphalt itself, so that there can be no chance of separation between the asphalt and the elastic medium.

In the fifth place, where the service required of the finished deck is a particularly severe one, either for very cold climates or for very heavy shocks and weights, it is necessary that there should be something approaching the same type of construction of the asphalt decking, when completed, as holds in the case of a really first-class asphalt road In the case of a first-class road, there is always a double layer of asphalt, a bottom layer or "binder" course, and a "top or wearing" course. This is the accepted method of making-up the best type of hard service asphalt road, and the same principle can be used with useful effect in the case of ships' decks. The use of the fillers, which are essential to the obtaining of the necessary hardness in the top surface, naturally detracts from its resilience and increases its brittleness, so that the under layer of more resilient material is of the greatest assistance in preventing cracking under the influence either of wear or shocks. In the most modern form of asphaltic decking both the upper and the lower layers are of quite distinct grades of asphalt, the double layer being carefully graded and thicknessed so that there will be an adequate amount of strength and also resilence for each particular service. Obviously, a different combination of the asphaltic materials is required in the case of a cold storage chamber to what is required in the case of a sports deck, exposed to the sun at its height, but by the use of this system of the two layers of asphalt all variations of service can be met satisfactorily. In order to obviate the difficulties referred to under the previous headings, the combined asphaltic decking should be laid upon a material which will afford the essential binding element between the steel deck and the lower layer of the asphalt.

In the sixth place, before asphalt could become a really valuable material for use as decking it was essential that its weight should be reduced very considerably. Asphalt itself is a fairly good conductor of heat, and, as a consequence, it is impossible to accept a thin layer of ordinary asphalt on the decks over accommodation. The above two facts led to the consideration of ways and means of reducing the weight of asphaltic mediums for use as decking, and to the search for means of reducing its conductivity. Both of these aims were interlinked, and in the final solution of the problem, it was found possible to produce a mixture of cork and asphalt which not only reduced the weight of the "binder" underlayer of the decking, but also considerably improved its non-conducting properties, while at the same time improving the resilience of the material to a very marked degree.

The importance of the weight reduction is worthy of note, since the areas to be covered with decking in a modern ship are very great so that a saving of many pounds per square yard on the weight of the deck covering, amounts in the whole ship to hundreds of tons, when one is considering a liner having very large accommodation spaces. In modern practice, the use of magnesium chloride deckings is extensive, and it is in competition with this type of decking that the weight factor is of such great importance. The weight per cubic foot of most decking of magnesium chloride type is in the region of 85lb. The weight of ordinary asphaltic material is about 150lb. per cubic foot, i.e., about one-and-three-quarter times the weight of the magnesium chloride material. Such a difference in weight was a very big handicap, particularly as the Board of Trade insisted upon an inch thickness of asphaltic material, in spaces in which they accepted only a three-quarter-of-an-inch thickness of magnesium chloride decking. As a result of a good deal of research, for a suitable mixture of cork and asphalt, it was found possible to produce an asphaltic material that would not only combine the low weight of the magnesium chloride decking with the advantages of the asphaltic material, but also serve excellently greatly to improve the sound and heat insulating properties of the ordinary asphalt.

In the modern development of asphaltic deckings this material is an essential part of the whole decking, and affords a lightening of the weight, an improved resilience, and much better sound and heat insulating value. This is reflected in the extremely light deckings which can be fitted of asphaltic material when advantage is taken of these new materials. It might be remarked, in passing, that the admixture of the cork and asphaltic material is a matter which requires proper appreciation of the characteristics of the two materials, and a proper grading of the bitumen and fillers other than the cork. The finished material, when made in accordance with carefully conducted experiments, can be produced to satisfy a wide range of requirements both of insulating value, and of hardness. On the other hand if it is not made with the skill required, it will disintegrate on service and give very unsatisfactory results. The matter is worthy of mention, since a trial carried out with material which is badly made may condemn a system of working which has stood up to severe tests when treated properly.

It is also to be noted that the use of a mixture of cork and asphalt is not to be recommended for a top surface, unless the primary requirement is one of ease of tread, and long wearing qualities are not necessary. On the other hand this material, again if properly graded and finished, makes an ideal surface for the taking of rubber carpet or linoleum. If badly made the result will be unsatisfactory, for the granules of cork will not stand up to the work required, or else the material will be heavier than it should be.

The foregoing special considerations apply to any class of asphaltic decking work and may be taken as applicable to the whole range of such work whatever the name under which the decking is laid. There are these fundamental points to be observed in every case, and although different manufacturers and layers of asphaltic deckings may have their own particular ways of getting over the difficulties referred to, the broad principles detailed must be observed in every case, if the best is to be obtained from the use of this valuable class of decking material.

It is as well now to set down some of the advantages of the material, as these result from the use of the most up-to-date methods of applying asphaltic mediums.

In the first place, one great advantage is that there is no need to pierce decks to obtain a firm anchorage of the under material used as the basis of the decking. This material can be laid in such a manner that it is adhesive, of itself, to the steel deck plating and is quite definitely fastened down by the application of the heat which is in the asphaltic material laid on the top of it. The fact that there are no holes at all in the steel plating upon which the decking is laid is a matter of the greatest importance when the deck has been in service for many years, for it is at the end of a long time, when wear has at last made repair necessary, that the complete state of preservation of the steel deck plating, and its freedom from holes is likely to be instrumental in keeping the cost of the repair down simply to that of floating a little additional layer of asphaltic material over what is already in place. There is no comparison between the small cost of making good a deck covering of asphaltic material and one of wood, or even of magnesium chloride material. In either of the other two cases the whole of the original covering must be removed and the steel deck exposed over the area which requires treatment. Incidentally, asphaltic material is an excellent material to use to repair a faulty wood deck without the expense of lifting it, the only points to be observed carefully being the necessity of placing a proper underlayer material over the wood of the deck in order to prevent the forming of any bubbles as previously described, and also the desirability of using a properly graded mixture of cork and asphalt so that the finished weight of the repair may be as little as possible.

The second point of advantage is one concerned rather with the practical laying of the material at the shipyard. If magnesium chloride decking is laid, there is always a considerable interval necessary before it is possible to walk upon the decking which has been put down. This always gives rise to a good deal of waiting about at the shipyard, and leads to a good deal of lost time and inconvenience. Further, as it is rarely possible completely to block off spaces to be covered, it often happens that a considerable yardage will be interfered with, owing to someone taking a short cut across the space before the material is properly set. With the laying of asphaltic mediums as deckings, there is no such locking-up of alleyways, and so on, since this material can be laid and walked on as soon as it is cold.

The third point of advantage is that it is

DRAWING SHOWING APPROVED THICKNESSES OF
COMBINATION ASPHALTIC FLOORINGS FOR DIFFERENT SERVICES, AS FOLLOWS:

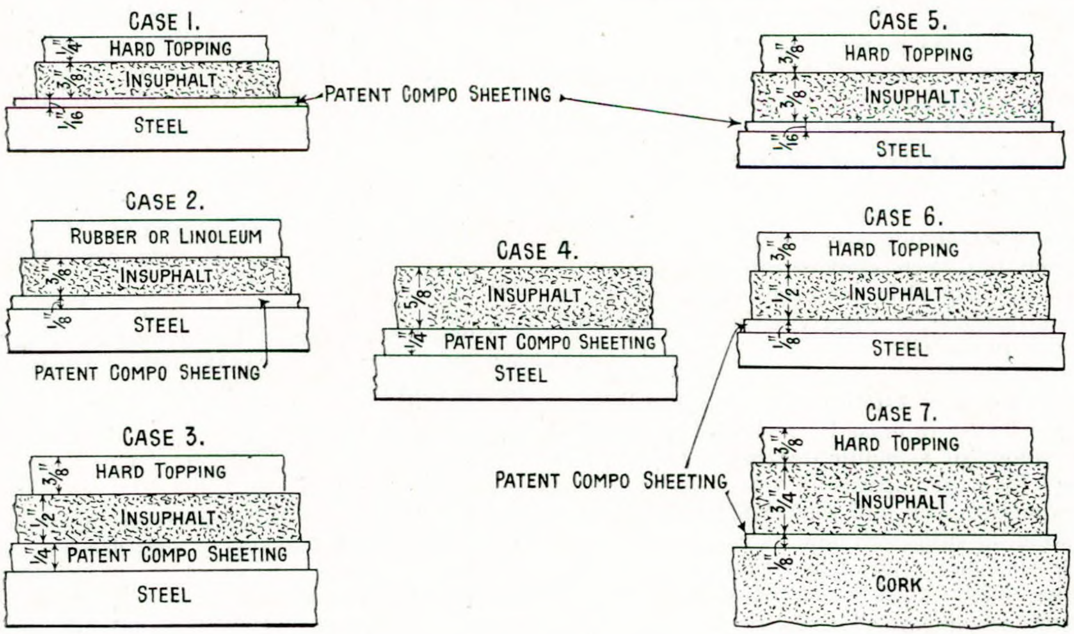
CASE 1. ON DECKS FORMING THE FLOORS OF PASSENGER & CREW'S ACCOMMODATION.
CASE 2. ON DECKS IN ACCOMMODATION SPACES UNDER RUBBER OR LINOLEUM.
CASE 3. ON WEATHER DECKS OVER ACCOMMODATION OR ELSEWHERE.
CASE 4. ON EXPOSED DECK HOUSES UNDER SKID DECKS.
CASE 5. ON SPORTS DECKS.
CASE 6. IN WASHPLACES AND LATRINES, BATHROOMS ETC.
CASE 7. IN INSULATED CHAMBERS AND SPACES.

TABLE Nº 1.
WEIGHTS OF DECKINGS (LB. PER SQ. YD.)

CASE (SEE ABOVE)	1	2	3	4	5	6	7
WOOD DECKING	70	–	85	70	70	–	–
MAGNESIUM CHLORIDE	56	56	–	–	–	–	–
ASPHALT	112	56	220	–	–	–	–
CEMENT BASIS	–	–	–	–	–	180	190
COMBINATION ASPHALTIC	55	28	82	48	69	78	94

TABLE Nº 2.
COMPARATIVE THICKNESSES

CASE (SEE ABOVE)	1	2	3	4	5	6	7
WOOD DECKING	2"	–	2½"	2"	2"	–	–
MAGNESIUM CHLORIDE	¾"	¾"	–	–	–	–	–
ASPHALT	1"	½"	2"	–	–	–	–
CEMENT BASIS	–	–	–	–	–	2"	2"
COMBINATION ASPHALTIC	7/16"	½"	1⅛"	⅞"	7/16"	1"	1⅛"



possible to lay asphaltic deckings on weather deck spaces, and in bathrooms and washplaces, and many other spaces which cannot otherwise be covered except with much more expensive deckings. Magnesium chloride deckings cannot be used in any spaces which are likely to be waterlogged, or even occasionally covered with water for a short time. Cement or tiles or some form of mosaic are the only type of decking which can be used in spaces forming bathrooms and washplaces, latrines and so on, unless, in the more cleanly of these spaces use is made of rubber tiling. None of these deck coverings has the same solid, jointless, and unbroken surface that is given by a combination asphaltic decking which has a really good top surface on it. It is at once pleasing to the eye and quite hygienic, requiring nothing but ordinary soap and water to keep it thoroughly clean.

For weather decks, an efficient asphaltic decking is the only decking that can replace wood, and it is a decking which replaces it at a great saving in cost and improvement as regards the matter of upkeep. Any fault in asphaltic decking can be easily repaired by the ship's staff, provided that there is a supply of suitable material on board, and a suitable pot in which to melt it. The application is made easily and simply after a little practice, and even at the first attempt a sound water-tight job can be made, although it may look a little rough. The facility with which temporary repairs can be made is a big point in favour of asphaltic deckings. With magnesium chloride deckings, unless the material is applied in a perfectly compounded manner, there is the possibility of creating conditions which will result in the rapid eating away of the steel plating. No harm can result with asphalt put down over a suitable under material.

A fourth point of advantage is that combination asphaltic deckings are fireproof. This is a point which has been demonstrated in an actual ship fire, the asphaltic material doing no more than melt round the edges, although the ship herself was practically gutted out in the vicinity. At the present time, when so much attention is being given to the question of the safeguarding of ships against fire, it must be reckoned as a great point in favour of asphaltic deckings, for weather decks and for other spaces in which it is usually the case that wood is laid, that asphaltic combination decking is fireproof, and does not assist in spreading the flame upwards from one deck to another, as does a thick wood deck.

A fifth advantage of asphaltic decking is as applied particularly to the case of sports decks. The fitting of a sports deck of asphaltic material, results in the obtaining of a hard even, jointless surface, which is very much more satisfactory to play upon than a wooden deck exposed to the sun and the weather and generally displaying a rough and uneven surface, unless a good deal of time is spent in keeping it in condition. Not only is this the case, but the first cost is very much less and the cost of maintenance is negligible. The latest forms of asphaltic decking can be applied in colours, and this is an added advantage from the point of view of appearance.

The foregoing general description of the special qualities of asphaltic mediums, for the use of those seeking for economical decking materials, affords opportunity to discuss the applicability of this class of material to the problems which confront the specialist when faced with the problem of making good on some specific job.

There are a number of firms which have made a practice of fitting asphaltic deckings, and they have all their particular methods of tackling the various difficulties to which reference has been made. The Firm with whom the authors of this paper are associated, and to whom thanks are due for permission to publish the information included herein, has spent many years in solving these several problems for themselves, and the attached sketches show more clearly than can be shown in a long series of explanations, precisely what advantages attach to the use of the special methods they have developed, as against the use of wood decking, magnesium chloride decking, or ordinary asphalt.

Case 1 shows combination asphaltic decking suitable for forming the floors of passenger and crew spaces. This drawing and those which follow, are self-explanatory, the sections being as approved where necessary by the Board of Trade. Tables 1 and 2 show comparisons of weights and thicknesses. From Table 1 it is clear that there is a saving of weight of 6½ tons over wood, and of 25 tons over ordinary asphalt per 1,000 square yards in Case 1.

Case 2 shows a drawing of interest to designers using rubber or linoleum coverings. The saving in weight is from 10 to 12½ tons per 1,000 square yards.

Case 3 shows combination asphaltic flooring for weather decking. The saving in weight is no less than 53 tons per 1,000 square yards, as compared with ordinary asphalt.

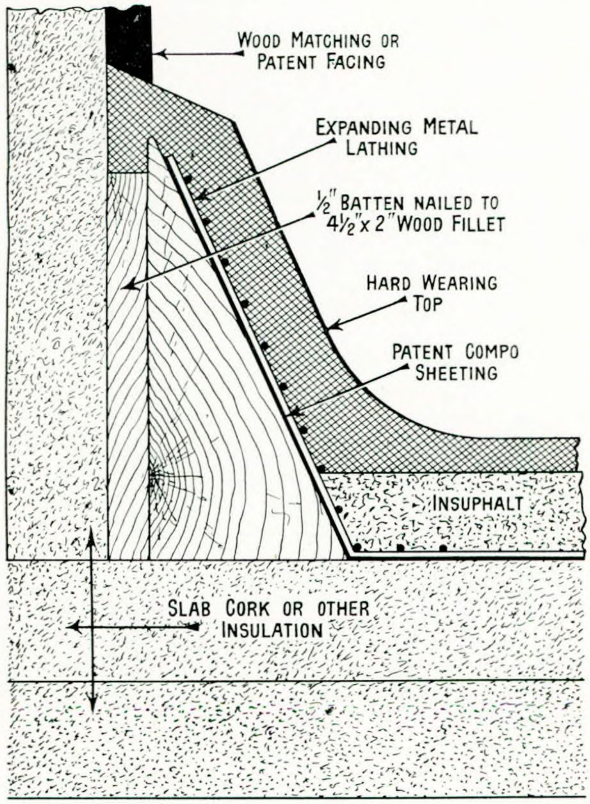
Case 4 shows an application which is of interest where sun decks are fitted.

Case 5 shows a sports deck laid with combination asphaltic flooring.

Case 6 shows an application in lavatories or washplaces and indicates a considerable saving in weight.

Cases 7 and 8 show special application of this flooring in the case of refrigerated spaces.

It is a commonplace that where advantage is taken of the facilities afforded by asphaltic deckings, as against wood decking, they show a marked reduction in first cost. This can be checked at any time by obtaining competitive quotations against the cost of the wood decking. As against the cost of magnesium chloride deckings there is a little difference in favour of magnesium chloride material un-



less the deckings are planned to be laid in a good run. The preparation of asphaltic material requires boilers and so on, so that it is only possible to get the greatest economy by properly arranging the work with this in view. The larger the area to be covered the lower the cost per unit area.

The special mixtures and materials which are shown in the attached sketches have all been subjected to long tests, much of the data on which the present mixtures have been based, having been obtained from tests carried out at the National Physical Laboratory. Particular value attaches to the qualities of the binder material "insuphalt", and also to the character of the patented compo sheeting which is used with this particular type of decking. It is the special qualities of these materials which have made possible the use of this Combination Asphaltic Decking to the thicknesses shown in the drawings.

It is worth noting that the patent compo sheeting is an impregnated felt in which care is taken to incorporate the correct amount and quality of bitumen, to ensure that there will be complete cohesion between the "binder" layer of asphalt and the sheeting, and also between the sheeting and the deck plating. On shore, this material, suitably prepared for the particular service, has shown good results under test, where applied as an underlayer to rubber tiling set down on to a cement surface, while it appears also to have good qualities for use in spaces in which there is a difficulty in making unreinforced bituminous material remain in position owing to vibration or other special circumstance.

In submitting this paper, the intention of the authors has been to emphasise the importance of asphaltic mediums for deck coverings in ships, since there is obvious reason for the giving of attention to this class of material, now that it has been practically proved, by actual service, to be economical and efficient.

It is the experience of the authors that there is an increasing appreciation of the utility of this class of material, but that the nature of the physical characteristics of asphaltic mediums and of the special requirements in actual working are not yet fully realised. It is hoped that this paper will lead shipbuilders to investigate the matter more fully, to the end that eventually they may themselves be able to carry out the work of laying asphaltic deckings wherever these are a sound commercial proposition.

Provided that carefully prepared materials are used, and that the men are trained by specialists in laying of these approved deckings, there should be no difficulty in obtaining satisfactory results.

INSTITUTE NOTES.

ADDITIONS TO THE LIBRARY.

Purchased.

Kings Rules and A.I. Amendments (K.R. 6/32). Published June, 1932, by H.M. Stationery Office at 2d. net.

Presented by the Publishers.

Nickel Bulletin No. 7 on "The Light Aluminium Alloys". Published 1932 by The Mond Nickel Co., Ltd., London.

Proceedings, Vol. XLVIII, No. 1, 1932, of the Institute of Metals containing the following papers:

Hanson and Rodgers on "The Thermal Conductivity of Some Non-Ferrous Alloys".

O'Niell and Greenwood on "Observations on the Pressure of Fluidity of Annealed Metals".

Hudson and McKeown on "The Properties of Copper in Relation to Low Stresses. The Effect of Cold-Work, Heat-Treatment, and Composition. Part I.—Tensile and Compression Tests under Short-Time Loading".

Tapsell and Johnson on "The Properties of Copper in Relation to Low Stresses. The Effect of Cold-

Work, Heat-Treatment, and Composition. Part II.—Creep Tests at 300°C. and 350°C. of Arsenical Copper and Silver-Arsenical Copper.

Elam on "Some Bronze Specimens from the Royal Graves at Ur".

Friend on "The Relative Corrodibilities of Ferrous and Non-Ferrous Metals and Alloys. Part III.—Final Report. The Results of Three Years, Exposure at Southampton Docks".

Vernon on "The 'Fogging' of Nickel".

Bengough and Whitby on "Magnesium Alloy Protection by Selenium and Other Coating Processes".

Sidery, Lewis and Hutton on "Intercrystalline Corrosion of Duralumin".

Seligman and Williams on "Note on the Interaction of Aluminium and Water Vapour".

Gayler and Preston on "The Age-Hardening of Some Aluminium Alloys of High Purity".

Saldau and Zamotorin on "The Solubility of Aluminium in Magnesium in the Solid State at Different Temperatures".

Gough and Cox on "The Behaviour of Single Crystals of Bismuth subjected to Alternating Torsional Stresses".

Bollenrath on "The Influence of Temperature on the Elastic Behaviour of Various Wrought Light Metal Alloys".

Rosenhain on "The Testing of Castings".

Körber on "The Plastic Deformation of Metals".

"The Mechanical Handling and Storing of Material", by G. F. Zimmer, A.M.Inst.C.E. Published 1932 by Crosby Lockwood & Son, 880 pp., in two volumes, 3 guineas.

This is a veritable mountain of a book, containing practically every type of mechanically operated gear for handling material of all kinds—either in descriptive letterpress, or else in the shape of very complete photographs or drawings.

It is many years since the first edition of this book was published; the present edition is the fourth, and has been brought right up-to-date, so far as it is possible to make this claim for any volume in these days of extremely rapid advance.

The work deals with every conceivable type of runway, conveyor, elevator, coaling, discharging and loading apparatus; mechanical, hydraulic and pneumatic handling plant; floating plant of the continuous and intermittent operating types; details of plant, skips, grabs, and so on, in fact there is no subject concerned with mechanical handling upon which I tested this book without finding something of value.

Naturally, in any vast assembly of material such as is given in these volumes, there is opportunity to find matters which one would like to see dealt with at greater length, but, equally naturally, one has to be content with getting the major facts and a good deal of the minor information —then going to the sources from which Mr. Zimmer himself has had to collect his data, in order to be able to get right down to any peculiarly personal problem. It is a great advantage of any book of the character of the one under review, that it does make it a simple matter to supplement such fairly complete information as it gives itself, by putting one in possession of the names of the firms or other sources from which special details can be obtained.

The book forms a very valuable work of reference, and is one it is safe to say many members will be able to refer for information, specifically required, or for an hour or so of quiet delving into some of the directions along which human initiative has set itself to make progress.

"The Stability of Ships", by George Johnson, B.Sc. Published 1932 by "The Journal of Commerce & Shipping Telegraph", Liverpool, 5s. net.

The Royal Society for the encouragement of Arts, Manufactures and Commerce, year by year administer a fund, due to the late Thomas L. Gray, from which they offer prizes for Essays and Inventions concerned with "The advancement of the Science of Navigation and the Scientific and Educational interests of the British Mercantile Marine".

The book which is the subject of this review, is the prize-winning effort for the year 1931, the subject being "The Stability of Ships, with special reference to the particulars which should be supplied by Shipbuilders, and also the value of any mechanical devices for ascertaining the M.G., with which you are acquainted".

The Council, in awarding the prize, stated that "They formed a very high opinion of it (the essay submitted for the competition by Mr. George Johnson, B.Sc.), and expressed the wish that it might be produced in book form, as it would be of great value to mercantile marine officers".

This preamble to a review of this well-produced volume is desirable for the reason that it gives, in an unchallengeable manner, evidence of the intrinsic worth of the book itself. No fewer than 45 essays were submitted for this competition, from men well qualified to write upon the subject, and Mr. Johnson's was the best.

Mr. Johnson has dealt with his subject in a very neat and thorough fashion, not an easy thing to do with a mass of problems which may well run into a large volume, and at the same time he has handled essential points in a manner which gives all the information necessary to the subject, without any elaborate details. If there is one outstanding feature of the book, it is the way in which Mr. Johnson treats really tricky matters—by encouraging such a confidence in his own rightness on matters of doubt, that the reader is quite satisfied to accept what Mr. Johnson tells him is the correct thing to do, without feeling that he should bother about a long explanation.

Mr. Johnson appears to have taken as the basis of his Table of Contents, the syllabuses of the British Board of Trade examinations for Masters and Mates in the Mercantile Marine, but it must not be taken that the course for stability could be tackled from this book alone. The matter is too condensed to make the book a suitable textbook, by itself, and it is too short, of course, to contain any examples for working out. The real function of the book is for ready reference at times when routine is being established, or when some matter of doubt has arisen. It is emphatically a book for the permanent use of men who have passed their examinations, or are desirous of giving a final polish to their preparation for the taking of the extra master's examination.

A very sound piece of work indeed, far more than an essay, more an authoritative treatise and worth far more than 5s. (the price) of any master's money.

"Metallurgy", by Edwin Gregory, B.Sc. (Lond.), A.Met. (Sheff.), Blackie & Son, 1932, pp. 284, 17s. 6d. net.

This volume should prove a valuable addition to metallurgical literature and should be of considerable assistance not only to the engineer, for whom it is stated to have been primarily written, but also to the more advanced student of metallurgy.

The book divides itself into two parts, the first part dealing with iron and steel, the second portion being concerned with non-ferrous alloys.

The various processes employed for the manufacture of iron and steel are described accurately and concisely. Under the heading "'Uses of Basic Bessemer Steel" one would, however, be inclined to disagree with the author on certain points, and, in this connection, it would be interesting to know what authority he has for stating that the process is regularly employed in the manufacture of such materials as boiler and ship plates, or large quantities of steel castings.

The author very properly calls attention to the need for a thorough understanding of the principles dealt with under the heading "The Constitution of Metallic Systems". The subject is, moreover, a fascinating one and it is pleasing to note that it has been dealt with very fully and with commendable clearness.

The allied subjects of Metallography, Heat Treatment, and Properties of Iron and Steel, find a prominent place in the work and are treated concisely, yet with that completeness which their importance undoubtedly warrants.

The section dealing with the hot working of steel, is one which should also be of particular interest to the engineer, and illustrates the wide differences in mechanical properties which may be effected in varying circumstances.

In regard to special steels the author, who is obviously familiar with these products from actual contact, speaks with confidence and full knowledge. This section will be found one of the most satisfying in the book and illustrates the very wide range of materials now available to meet the ever-increasing demands of the steel user.

The non-ferrous engineering alloys are dealt with in an adequate fashion and, while very rapid advances have recently been made in this branch of metallurgy, the information contained in the present volume appears to be fully up-to-date and may be considered authoritative.

Altogether the book is clearly and concisely written and well illustrated, the micrographs calling for a special word of commendation.

"Elements of Steam Power Engineering", by F. B. O. Sneedon. Published 1932 by Longmans, Green & Co., London, 5s. net.

The author of this book has set himself a number of objectives in order to satisfy the general needs of students of elementary steam power engineering. He has ably discharged his task, and the result is a work which is so comprehensive in the field that it covers, that it should occupy an honoured place in engineering technical colleges. Just sufficient information is provided on each subject to give students an intelligent idea of the fundamental principles of each type of apparatus, but at the same time sufficient is given to build future studies upon a suitable foundation. It sets appropriate trends of thought, and as the stimulation of correct thought is the object of education, the book is thus of high educational value.

Between its covers a great deal of good matter is to be found and many suitable references on specialised subjects are included. The worked examples are excellent as are the diagrams and illustrations. It is regretted, however, that a chapter is not devoted to the elementary outline of the turbine steam cycle with bled steam and reheating, and I hope in any subsequent edition this is included.

The author deserves congratulation on the very useful book he has produced.

"Advanced Mechanics of Materials", by F. B. Seeley. Published by Chapman & Hall, 1932, 31s. net.

This book, written by the Professor of Applied Mechanics at the University of Illinois, deals with topics which, according to the author, are more advanced than usually dealt with in the first course of strength of materials in the colleges of the U.S.A.

It is divided into four parts, namely: Preliminary investigations, special topics consisting of analysis of stresses, discussion of stress concentration, etc., and an introduction to the analysis of statically indeterminate stresses. Unfortunately many of the symbols used in this book differ from those usually adopted in this country.

The book is well written and illustrated by diagrams, and a number of problems are set on the various sections of the work covered. At the end of each chapter a list of references is given, both English and American publications being quoted.

The part dealing with "special topics" includes chapters on thick walled cylinders, limitations of flexure formulæ for sections with one axis of bending, unsymmetrical bending, curved flexural members, flat plates and torsional resistance of non-circular sections. These would hardly be considered "special topics" in our colleges.

The chapters dealing with localised stress are well written and illustrated by good diagrams. The author advocates the use of pottery-plaster specimens in determining the stress concentration caused by fillets, the straw-etching method for ductile materials, rubber models with reference lines on the surface for plastic materials, and points out the limitations of each method. Prof. Coker's polarised light method is described and reference is also made to Griffith and Taylor's soap film method.

The section dealing with analysis of stress of statically indeterminate structures includes the well-known Maxwell-Mohr method, Castigliano's theorem and the principle of least work, and many typical cases are worked out.

Whilst the book does not contain any new methods of attack for the various problems, it is written in a readable manner and would form a very useful addition to any engineer's library.

"Pitman's Electrical Educator", edited by Sir Ambrose Fleming, M.A., D.Sc., F.R.S. Published 1932 by Sir Isaac Pitman & Sons, Ltd., London, 3 guineas.

Many of the authors of text books and treatises on Electrical Engineering as it stands at the present day, seem to experience a difficulty in being able to give a comprehensive treatment of the whole field in a small compass.

The subject of wireless telegraphy, for instance, is so remote from the design of direct current motors that the full study of each requires separate books. The aim of the work under review seeks to combine in three volumes the treatment of the general principles underlying the various sections of electrical engineering, the other branches of science leading up to it and its application to industrial purposes.

The publishers and the general editor, Sir Ambrose Fleming, are to be congratulated upon their selection and arrangement of the various subjects dealt with, the publication consisting of a series of contributions by some of the leading scientists of to-day. It is intended to deal with all matters that might concern a student working his way up in the profession, and to act also as a guide or book of reference for those engaged commercially in the industry.

The subjects usually found in text books on electrical engineering are dealt with, and in addition there are some interesting articles on automatic telephones, drawing for electrical engineers, education and training, wireless telegraphy, television, electric traction, electric welding, electro-plating, etc., etc. All branches of heavy current electrical engineering are included in turn.

At the same time criticism might be levelled at the advisability of extending the publication to include subjects which have only a bearing on electrical engineering—"Electrical Salesmanship" is one for instance. The essence of salesmanship lies in qualifications which should apply equally well to all branches of engineering. The same might also be said of advertising. Mechanics and heat engines are subjects which might preferably be left in their own domain.

However, it appears to have been the editor's endeavour to embrace all scientific contributions that might be of assistance to the student of electrical engineering, and much tribute is due to him for the general excellency of the compilation. We can certainly recommend it as an outstanding work of reference and as an invaluable aid to students of matters appertaining to electricity.

Additions to the Library.

"The Creep of Metals", by H. J. Tapsell. Published 1932 by Oxford University Press (H. Milford) London, 30s. net.

The publication of this book should be welcomed by those who have to consider the properties of materials subjected to high temperatures. It is an unfortunate fact that different investigators of the creep of metals have obtained different results as regard creep rates, elastic limits and limits of proportionality for apparently similar materials.

The author gives a review of the work which has already been done and the results are criticised. Factors influencing the results of creep tests such as sensitivity of equipment, the condition of the material tested and the importance of stating with creep rates the duration of the test after which such rates exist, are emphasized. Bearing in mind these factors, useful comparisons have been drawn leading to correlation of the values obtained by the various investigators.

In the preface, the author expresses a hope that the book will help towards the adoption of standardized methods of creep testing, and this should meet with general agreement.

The application of ordinary short-time tests at high temperatures is dealt with before proceeding with considerations of short and long-time creep tests. Attention is drawn to the effect of time or speed of testing in the determination of the limit of proportionality, and on the values obtained for the proof stress to give a certain deformation, and ultimate strength. The practical usefulness of the results obtained from ordinary short-time tests of materials at high temperatures is discussed.

In Chapter III strain and temperature during creep are dealt with, it being indicated that strain hardening takes place and is a function of both temperature and time. Further, it is shown that temperature hardening or temperature softening may occur, and the influence of such factors on the creep of materials under prolonged loads is discussed.

In dealing with the characteristics of normal creep curves, it is shown that these are similar for different materials at certain temperatures. Curves are given for a steel at a temperature where considerable strain hardening takes place; also at a temperature showing little strain hardening. These curves illustrate the influence of strain hardening in reducing the rate of creep, and attention is drawn to the variation of creep rate during the life of the material.

Attempts have been made to estimate from short-time creep tests values of the maximum stress which materials may be expected to withstand for long periods. A description of these tests is given and it is shown how a knowledge of the primitive creep characteristics may in some cases be useful in determining safe stresses which produce little or no deformation.

The next chapter contains a description of the methods adopted by various investigators who have studied the behaviour of materials at high temperatures by means of long-time creep tests, and of the manner in which the results have been presented. The author draws attention to the necessity of close control of the temperature over long periods.

The various schools of thought which exist regarding creep are mentioned, the author appearing to support the view of those who believe that a limiting creep stress does exist, i.e. a stress below which creep will not continue up to the point of fracture. It is, however, pointed out that limiting creep stress is not necessarily a stress which a material would withstand for infinite time, but rather that which may be sustained for a time period of sufficient length for practical purposes. The author believes that at a stress equal to or not far below the limiting creep stress, the creep rate will diminish with time at certain temperatures and ultimately vanish. Following these arguments it is considered that a stress equal to that which produces, at some time within a period of about 30-40 days, a creep rate of 10^{-5}in. per inch per day, may, for practical purposes, be taken as the limiting creep stress. In quoting this value as the maximum stress for long life, the author rightly draws attention to the importance of considering the ductility of some materials at high temperatures.

In the concluding chapters space is devoted to the analysis and comparison of the results obtained by the various investigators and very useful conclusions are set forth. The theories which have been advanced from time to time are carefully reviewed and considered. Results relating to the total creep within a given period are given and should be helpful to those who are particularly concerned with deformation of materials in service.

The author states:

> "Since in the case of steels the creep rates corresponding to 1 per cent. deformation in 10,000 hours or longer are very small and at the lower temperatures have been found to be still decreasing at the end of the test period, the possibility of amounts of deformation exceeding 1 per cent. in the times stated is, at the lower temperatures (300°-500°C.) very unlikely, and the factor of safety on the long time strength (limiting creep stress) is large. At the highest temperatures there is doubt regarding the creep subsequent to the test period and therefore of the amounts of deformation at the creep limits given after many thousands of hours of service".

In dealing with the modifying influences on creep many important points are discussed, including heat treatment, hot and cold work, grain size, structural instability and intercrystalline cracking.

The conclusions drawn indicate the importance of the long time tests and show how in certain circumstances misleading conclusions may be drawn from the results of short time creep tests.

The creep properties of non-ferrous metals are considered under the headings of materials for moderate and for high temperatures.

The effect of time in producing structural changes in material is dealt with, and it is shown how grain growth and spheroidization may lead to a reduction in strength.

The final chapter deals with design and should prove of great value in deciding suitable working stresses. The author suggests that a factor of safety of 3 on the limiting creep stress gives stresses for medium carbon steels between 350°C. and 550°C. which show reasonable margins of safety on both stress and temperature and do not give rise to appreciable distortion. With reference to distortion it may be mentioned that the values given for working stresses by the author correspond closely with values of stress given by K. Baumann* for 0·15 per cent. carbon steel giving rise to a creep rate of 10^{-7}in. per inch per hour and it is understood that these rates exist after a test of about 5,000 hours. It is suggested that distortion in a given period can be roughly gauged by long time tests at the stress and temperature the engineer proposes to adopt and the results of French, Kanter, Spring, and Norton are referred to. It is rightly mentioned that only a qualitative estimation of the distortion can at present be made.

The author has for a long while been associated at the National Physical Laboratory in connection with the subject of creep, and is therefore especially competent to deal with it. He is to be congratulated on the concise and clear manner in which the book is written and for the very valuable review of the experimental work already published.

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* Paper by K. Baumann given before Institution of Mechanical Engineers entitled "Future Development of the Steam Cycle".

Additions to the Library.

"A Primer of Engineering and Building Science", Part I, by S. Owen. Published 1932 by Blackie & Son, London, 2s. net.

This is a little book consisting of 64 pages divided into six chapters, in which a number of terms used in Applied Mechanics are defined and illustrated, each chapter concluding with a number of examples culled from past examination papers of the Union of Educational Institutes.

As the title of the book indicates, these examples are based upon cranes, roof trusses, etc., and are very simple in character. The book will prove very useful to the beginner approaching the subject for the first time.

"Mathematics", a textbook for Technical Students, by B. B. Low, M.A. (Cantab.), A.M.I.Mech.E., A.M.I.A.E. Published 1932 by Longmans, Green & Co., Ltd. London, 448 pp., 12s. 6d. net.

The author has produced a book rightly called "Mathematics", since, although it is for the use of technical students, and hence has a practical bias, the foundations of all mathematical applications are clearly and logically determined.

A tremendous scope of the subject has been covered in one book, from simple equations in algebra to differential equations in the calculus.

The first four chapters are devoted to algebra, including simple and quadratic equations with their graphical solutions, indices and partial fractions.

These are followed by three chapters on logarithms, trigonometry and series, which will be found of great value for reference when studying the more advanced mathematics which appears in later chapters. In the subject matter on trigonometry even the difficulties which arise in developing Sin (A+B) where obtuse angles are used, are mentioned. Three useful chapters on conic sections and plane and solid geometry appear in the middle of the book, which will be of particular mathematical and practical value to students in engineering and naval architecture.

An excellent chapter is devoted to the determination of empirical laws and we commend those who are engaged in research and experimental work or are about to produce a thesis involving the production of empirical laws, to thoroughly digest this particular part of the book. The latter part of the work is devoted to the calculus, from simple differentiation and integration to differential equations.

Throughout the book numerous practical examples are worked out and explained, while there is also a number of exercises to be worked at the end of each chapter. In some of these exercises hints are given as to the "method of attack", and this greatly enhances the value of the book. We feel that more of these hints could be given in this volume, leaving the mathematical solution to be completed by the student. Especially does this apply to the work on integration and differential equations, although the derivations of a number of well-known engineering formulæ (both mechanical and electrical) have been clearly explained.

It would of course be too much to expect in a book of such wide range not to find the earlier chapters on the simpler mathematics somewhat scant in explanation for a junior student. The author also assumes that the student has a fair knowledge of the particular practical side of the mathematical problems involved, as is evident by the mere statement that $\frac{dq}{T} = d\phi$ where ϕ denotes entropy, with no previous explanation of entropy given. It is, however, a work planned on the right lines, and one to which every third year student should have access.

The book is a fitting tribute to the author's famous father, Professor D. A. Low, since it exhibits that inherited quality of "ease of expression and description" always to be found in the father's excellent books, and it should complete a series of works which have already helped many technical students.

"Molesworth's Pocket Book of Engineering Formulæ", 30th edition, edited by A. P. Thurston, D.Sc. Published 1931 by E. & F. N. Spon, Ltd., 6s. net.

This book, so well known to engineers, has reached its 30th edition. The preface of the first edition is dated November, 1862, and is reproduced. The shape and size has been maintained, save that it is much thicker, and that by the use of thin paper the number of pages has been increased many times.

The number of editions testifies to the value of the book to the profession, and there is no doubt but that this new edition will maintain the reputation of an old friend.

We are tempted, however, to warn users of all pocket books that unless they know how a formula has been derived and therefore its limits of applicability, the results obtained should be applied with care.

"Estimating", by T. H. Hargrave. Published 1932 by Sir Isaac Pitman & Sons, Ltd., London, 7s. 6d. net.

Anyone "already dealing with this most interesting and important work—the duty of estimating" (to borrow a phrase from the preface to this book) will agree with the reviewer that a treatise on estimating which runs into an early second edition must be a book to be acquired immediately on introduction. Even the most competent estimator occupying a position commensurate with his importance would desire to possess, at any reasonable price, a new publication on this subject, especially as the scientific consideration it has so far received may be measured by its meagre bibliography. At the price, the purchase of this book should be a good investment to any engineer, and particularly to any engineering estimator—(surely for the sake of clarity the book should have been entitled "*Engineering* Estimating").

The author, in common with many other technical writers, makes frequent use of the term "the young engineer", which provokes the question——what is a "young" engineer? If there is any limiting age beyond which an engineer sheds that description, the reviewer at least is of opinion that an estimator should never incur such a distinction, for paradoxically an estimator surely grows younger, in the sense of mental alertness and capacity, as he grows older in experience. In fact, a young engineer under 25, *ipso facto,* cannot possibly be a competent estimator in the full sense of the term.

The essential factor in estimating, however, is not experience alone, but experience plus information; in other words, the application of all available data must be supplemented by the intelligent use of the widest possible information, i.e., concerning market fluctuations, economic conditions affecting both parties to the prospective contract, and particularly information as to the special circumstances of any firms competing for the same order which may enter into the bases of their tenders. From this comment one could develop a very important and instructive discussion on chapter I of this book, though it would be somewhat "above the heads" of young engineers.

It should be rendering a real service to the three groups for whom the book is intended, to suggest that the young engineer should study it as affording an excellent grasp of the elements of estimating practice, the manager or head of an engineering business should use it as a reliable reference book and an incentive to a constructive criticism of his own estimating organisation, and lastly those actually engaged in estimating should use it as a "frame of reference" by which to co-ordinate the details of their present practice.

The book has been carefully planned, lucidly written and admirably produced.

Benevolent Fund.

The Committee gratefully acknowledge receipt of a donation of £1 1s. from Thomas Dunlop, Member, Sandakan.

BOARD OF TRADE EXAMINATIONS.

List of Candidates who are reported as having passed examinations for certificates of competency as Sea-Going Engineers under the provisions of the Merchant Shipping Acts.

Name.	Grade.	Port of Examination
For week ended 14th July, 1932 :—		
Dunlop, Samuel H.	Ex.1.C.	Belfast
Sykes, Herbert	Ex.1.C.	Leith
Gelling, Douglas W.	Ex.1.C.	London
Kossick, David	Ex.1.C.	Newcastle
Jamieson, John	1.C.	Glasgow
Breheny, James C.	2.C.	"
Piggot, Robert	2.C.	"
Robertson, James B.	2C.	"
Bonner, Thomas H.	1.C.	Hull
Meadley, John B.	2.C.	"
Jones, Edward	1.C.	Liverpool
Kilty, Kevin N.	1.C.	"
Scott, Leonard	1.C.	"
Thompson, Wallace	1.C.	"
Tocque, Philip	1.C.	"
Smart, John A.	2.C.	"
Whitton, Thomas B.	2.C.	"
Wright, William	1.C.M.	"
Embleton, William	1.C.	London
Grainger, Allinson	1.C.	"
Bowie, Robert M.	2.C.	"
Taylor, Stanley	2.C.	"
Whittaker, John H.	2.C.	"
Croll, John F.	1.C.M.	"
Armstrong, Harry E.	1.C.	Newcastle
Kennedy, Paul	2.C.	"
Kennedy, William H. H.	2.C.M.	"
Matthews, John P.	1.C.M.E.	"
Bannatyne, Andrew B.	1.C.M.E.	Liverpool
Clewett, Norman S.	1.C.M.E.	Cardiff
Sharp, Robert N.	1.C.M.E.	"
Allan, Richard S.	1.C.	Sunderland
Shaw, Herbert E.	1.C.	"
Ambrose, John	2.C.	"
Dickson, John	2.C.	"
Hill, Basil K.	2.C.	"
Jackson, Albert H.	2.C.	"
Malone, William G.	2 C.	"
Bracken, John E.	2.C.M.	"
Jenkins, Thomas	1.C.M.E.	"
For week ended 21st July, 1932 :—		
Cromarty, Robert W.	Ex.1.C.	Liverpool
Haydock, William L.	Ex.1.C.	"
Jackson, Richard	Ex.1.C.	"
Younge, Edward C.	Ex.1.C.	"
Langlands, Thomas B.	2.C.	Cardiff
Morris, Arthur N.	2.C.	"
Roscoe, William N.	2.C.	"
McLuckie, Russell	2.C.	Glasgow
Dempsey, Neil	2.C.	"
Darroch, Robert A.	2.C.	"
Hogg, Richard W.	1.C.	"
Cramond, Gordon	1.C.	Leith
Marshall, Mitchell	1.C.	"
Robertson, Alexander	1.C.	"
Spence, James S.	1.C.	"
Brown, John D.	2.C.	"
Catto, Robert J.	2.C.	"
Leitch, John	2.C.	Leith
Thom, James	2.C.	"
Murphy, Norman G.	2.C.	Liverpool
Taylor, George	1.C.M.	"
Stephenson, Frederick E.	2.C.M.	"
Allen, Robert F.	2.C.	London
Fox, Stanhope	2.C.	"
Harding, Edmund	2.C.	"
MacDermott, Maurice	1.C.M.	"
Brunton, Arthur J.	2.C.M.	"
Humphrey, Herbert N. G.	2.C.M.	"
Irving, Richard H.	1.C.	Newcastle
Sutherland, John	2.C.	"
Crocker, William J.	1.C.	Southampton
Millar, Robert	2.C.	"
MacMillan, Murray A.	2.C.M.	"
Jones, Robert J.	2.C.M.E.	Glasgow
Stephen, William O.	1.C.M.E.	Southampton
Wise, Leslie R. L.	1.C.M.E.	London
Scott, James McD.	2.C.M.E.	Liverpool
Palin, Frederick G.	2.C.M.E.	"
Douglas, Leslie B.	1.C.M.E	"
Taylor, Frank	1.C.M.E.	Leith
For week ended 28th July, 1932 :—		
Craney, Edward	1.C.	Newcastle
Avery, George R.	2.C.	"
Harrison, Alfred	2.C.	"
Tait, Thomas	1.C.M.	"
Knox, George H.	1.C.	Liverpool
McFall, Albert	1.C.	"
Armer, John	2.C.	"
Caskie, Sinclair J.	2.C.	"
Davies, Nathaniel T.	2.C.	"
Jaboolee, Framroze K.	2.C.	"
Jones, Robert H. O.	2.C.	"
Keogh, James A.	2.C.	"
Rawley, Matthew J.	2.C.	"
McEachran, Donald L.	2.C.	Glasgow
Petrie, Donald S.	2.C.	"
Taylor, John	2.C.	"
Macdonald, John A.	2.C.M.	"
Crosby, Charles C. A.	1.C.	London
Sutton, Alexander G.	1.C.	"
Yates, Alfred F.	1.C.	"
Horsford, James R.	2.C.	"
Leach, Ben E.	2.C.	"
Polack, Ivor J. E.	2.C.	"
Beattie, Robert P.	1.C.M.	"
Rowell, George L.	1.C.	Sunderland
Harrison, Robert C.	2.C.	"
Kettlewell, Frank E.	2.C.	"
Pearson, John R.	2.C.	"
Ridley, Harold	2.C.	"
Walker, Richard	2.C.	"
Wallett, Frederick E.	2.C.	"
Downey, William A.	2.C.M.	"
Stephenson, Edward	1.C.M.E	"
Hodgetts, John	2.C.M.E	Newcastle
Candlish, Leslie S.	1.C.M.E.	"
Allison, Norman J.	1.C.M.E.	Glasgow
Hodgson, Alexander D.	1.C.E.	"
Maylor, John	1.C.M.E.	Liverpool
McArthur, Donald	1.C.M.E.	Glasgow
Parkin, Fred	1.C.M.E.	Sunderland
Pallan, William S.	1.C.M.E.	Newcastle
For week ended 4th August, 1932 :—		
Stark, David	1.C.	Leith
Wood, Joseph, G.	1.C.	"
Fairlie, Norman	1.C.M.	"
Kinnaird, Ian	2 C.M.	"
Youldon, Joseph S. H.	1.C.	London
Culling, Henry J.	2.C.	"

Name.	Grade.	Port of Examination.	Name.	Grade.	Port of Examination.
Davies, John T.	2.C.	London	Matthews, William N. ...	1.C.M.	Newcastle
Hollingworth, Alfred G. ...	2.C.	"	Mills, Robert	2.C.M.	"
Stone, Hugh M.	2.C.	"	Prior, Peter R.	1.C.	Southampton
Wolfe, Reginald G.	2.C.	"	Batey, Joseph W.	2.C.M.E.	Newcastle
MacLeod, Norman, A. ...	1.C.M.	"	Vogan, Robert J.	1.C.	Belfast
Foster, John	1.C.	Liverpool	Hillock, David, A.	2.C.	"
Bailey, Sidney J.	2.C.	"	Strain, John W.	2.C.	"
Ghandy, Kaikobad	2.C.	"	Kirk, George R.	2.C.M.	"
Thomas, David C.	2.C.	"	Richardson, John A. ...	1.C.	Cardiff
Fieldhouse, Norman ...	1.C.M.	"	Hutchinson, George R. ...	2.C.	"
Valentine, David W. ...	1.C.M.	"	Phillips, Ivor M.	2.C.	"
Town, Robert H.	2.C.M.	"	Stirling, Henry	2.C.M.	"
Longstaff, John	1.C.	Newcastle	McAuslan, Peter S.	1.C.	Glasgow
Phillips, William S. ...	1.C.	"	McCaig, David O.	1.C.	"
Alder, Ralph N.	2.C.	"	McFarlane, Thomas A. ...	1.C.	"
Ashworth, James	2.C.	"	Mackenzie, Malcolm ...	1.C.	"
Dimond, James W.	2.C.	"	Wingate, Gabriel	1.C.	"
Hunter, John W.	2.C.	"	Reid, Charles	2.C.	"
Johnson, William B. ...	2.C.	"	Bean, Alexander D.	1.C.M.	"
MacDonald, John A. ...	2.C.	"	Aitkenhead, John P. ...	2.C.M.	"
Phillips, Alfred H.	2.C.	"	Forrest, Hamilton	2.C.M.	"
Wright, William H.	2.C.	"	Wheadon, John H.	1.C.M.E.	Southampton
Ainslie, Thomas	1.C.M.	"	Macniven, Hugh	1.C.M.E.	Glasgow
Armstrong, Hugh	1.C.M.	"	Virtue, Robert	1.C.M.E.	Leith
Benjamin, Afred M. ...	1.C.M.	"	Scott, Leonard	1.C.M.E.	Liverpool

ABSTRACTS.

The Council are indebted to the respective journals for permission to reprint the following abstracts and for the loan of the various blocks.

Boiler Explosion Report.—S.S. "Mari".

The boiler was of the cylindrical multitubular single-ended marine type, having three corrugated furnaces approximately 4ft. in diameter and each furnace was connected to a separate combustion chamber. The combustion chamber tube plates were $\frac{13}{16}$in. in thickness and the tubes were $3\frac{1}{2}$in. in outside diameter. In the centre combustion chamber one horizontal row of tubes was omitted on account of the lap joint of the front end plate, which was in three parts.

The boiler was provided with the usual mountings, including spring-loaded safety valves adjusted to lift at a pressure of 180lb. per square inch.

The boiler was coal fired and worked under natural draught, and was about 24 years old at the time of the explosion.

Particulars and Dates of Repairs.

At Cardiff, in March, 1930, the centre furnaces of both boilers were renewed and the boilers tested by hydraulic pressure to 185lb. per square inch. Several stay tubes were also renewed at this time and the working pressure was reduced to 170lb. per square inch on account of the distorted condition of the wing furnaces of the starboard boiler. At Bilbao in February, 1931, the above-mentioned furnaces were renewed and the starboard boiler was tested by hydraulic pressure to 180lb. per square inch. In the port boiler at this time 4 or 5 stay tubes and about 15 plain tubes were renewed in the starboard nest of tubes, but no stay tubes appear to have been renewed in the centre nest. Several combustion chamber stays in the port and centre combustion chambers were also renewed and the working pressure was restored to 180lb. per square inch.

Nature of the Explosion.

The explosion was of a violent nature. The back tube plate in the centre combustion chamber of the port boiler was forced off the ends of several tubes, thus permitting part of the contents of the boiler to escape.

The tube plate bulged over an area of approximately 2ft. 9in. vertically by 2ft. 4in. horizontally and the maximum deflection, which was at the centre of the bulge, is stated to have been about $1\frac{1}{4}$in.

Cause of the Explosion.

The explosion was due to the threads on several of the stay tubes and in the stay tube holes having become wasted by corrosion so that the stay tubes ceased to act as effective stays against the pressure on the tube plate. The tube plate around the ends of the stay tubes had been caulked to a considerable extent and as this tends to close in the tube ends it would further reduce the efficiency of the stay tubes as a means of support. The corrosion of the threads was probably due to leakage, which may have been caused by a heavy scale having been allowed to form around the necks of the tubes.

Observations of the Engineer Surveyor-in-Chief.

This report deals with a disastrous explosion from a boiler of a foreign-owned steamship which resulted in one man losing his life and two being injured. The explosion was of a violent character, the back tube plate in the centre combustion chamber of the boiler being forced off the ends of several tubes. The corresponding plate in the port combustion chamber was found to be considerably bulged, and it was probably only a matter of time before this plate would have been forced over the tube ends.

It is evident that little care had been exercised by those responsible for working the boiler to keep the heating surfaces clean, as there was a heavy coating of scale on the tubes, and particularly at the tube ends. This would tend to cause overheating, with leakage and consequent corrosion of the screw threads at the stay tube ends. Heavy caulking of the tube plate in way of the stay tube ends had evidently been resorted to in order to stop the leakage, and this was one of the main contributory causes of the explosion.

The caulking of tube plates around leaky stay tubes is frequently thought to make an effective repair, but the actual effect is to close in the finely screwed ends of the tubes and thereby force the threads of the tubes away from those in the tube plate, further reducing their holding power already adversely affected by corrosion. The danger arising from this practice is clearly illustrated in this case and cannot be too strongly emphasised. Leaky stay tubes should be dealt with by expanding them into the screwed holes in the tube plate and not by caulking the tube plate to the tubes; if this does not prove to be effective they should be replaced by stay tubes screwed to fit tightly into the tube plates.

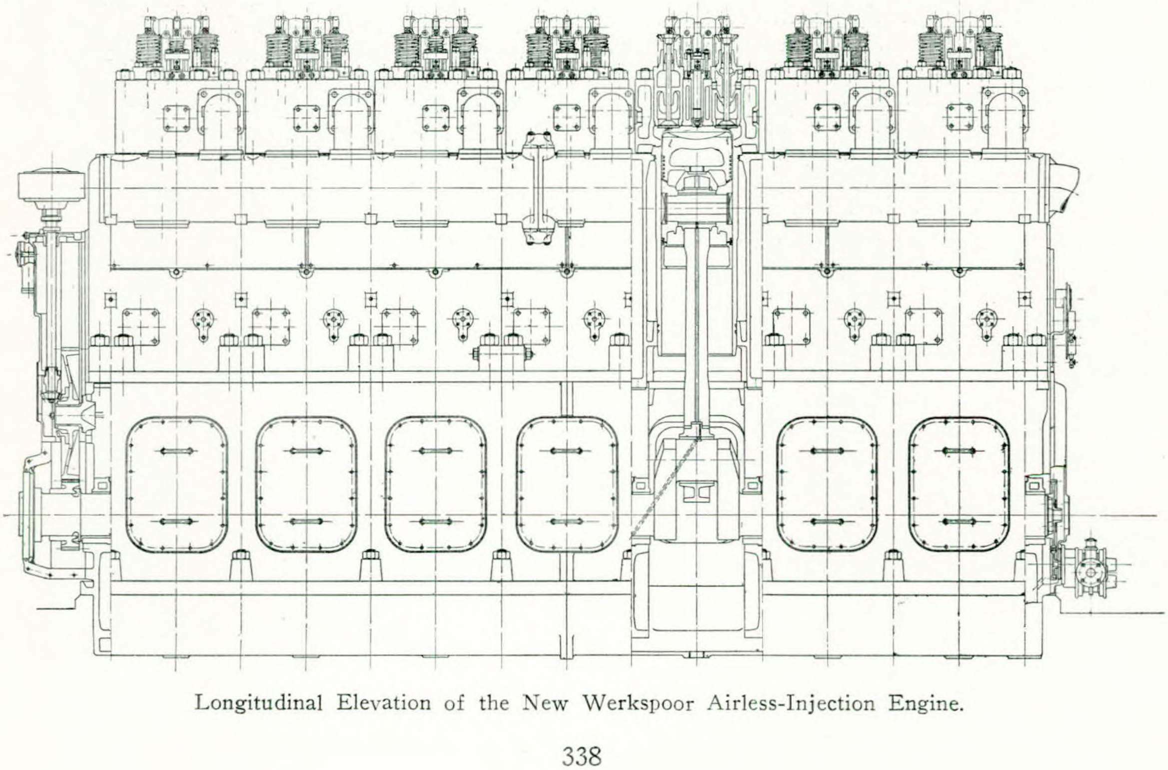
A Werkspoor Airless-Injection Diesel Engine.

Pioneer Dutch Builders Introduce Range of Medium-Speed Compressorless Engines for Stationary and Marine Work.

"Gas and Oil Power", June 2, 1932.

Werkspoor, of Amsterdam, took up the building of Diesel engines as early as 1903, their first engines being of the open "A"-frame type. These were followed by totally-enclosed engines with, of course, air injection of the fuel, of which a large number were built both for land and marine use. A few years ago, it may be recalled, a double-acting, four-stroke cycle engine was evolved, and more recently they produced a single-acting, air-injection engine with the firm's own system of supercharging, in which the lower sides of the working pistons are cleverly used as supercharging pumps.

The Dutch firm's latest development for powers below 1,000 b.h.p. is an airless-injection trunk-piston engine, which has been designed with a view to producing an engine of great simplicity, robustness, reliability, and economy. It is worthy of note that the following constitutes the first complete description of the new engine to be published. The new engine is being built in powers ranging from 50 to 900 b.h.p., and is suitable for land installations as well as for marine auxiliary work and also, in directly-reversible form, for the propulsion of vessels of moderate size. The type, which is known as the T.M. and T.M.S. types for stationary and



Longitudinal Elevation of the New Werkspoor Airless-Injection Engine.

marine propulsion purposes, respectively, is available in three cylinder sizes, namely, 300mm. bore by 480mm. stroke; 350mm. by 570mm.; and 390mm. by 620mm. The first is rated at 66 b.h.p. per cylinder at 350 r.p.m.; the second at 91 b.h.p. at 300 r.p.m.; and the third at 112·5 b.h.p. at 275 r.p.m. The first two sizes are available in stationary or marine auxiliary forms, with any number of cylinders from one to eight, but the largest size is not available as a single-cylinder engine. The rating of all three sizes is the same in directly-reversible form, and is standardised in three-, four-, five-, six-, seven-, and eight-cylinder sizes.

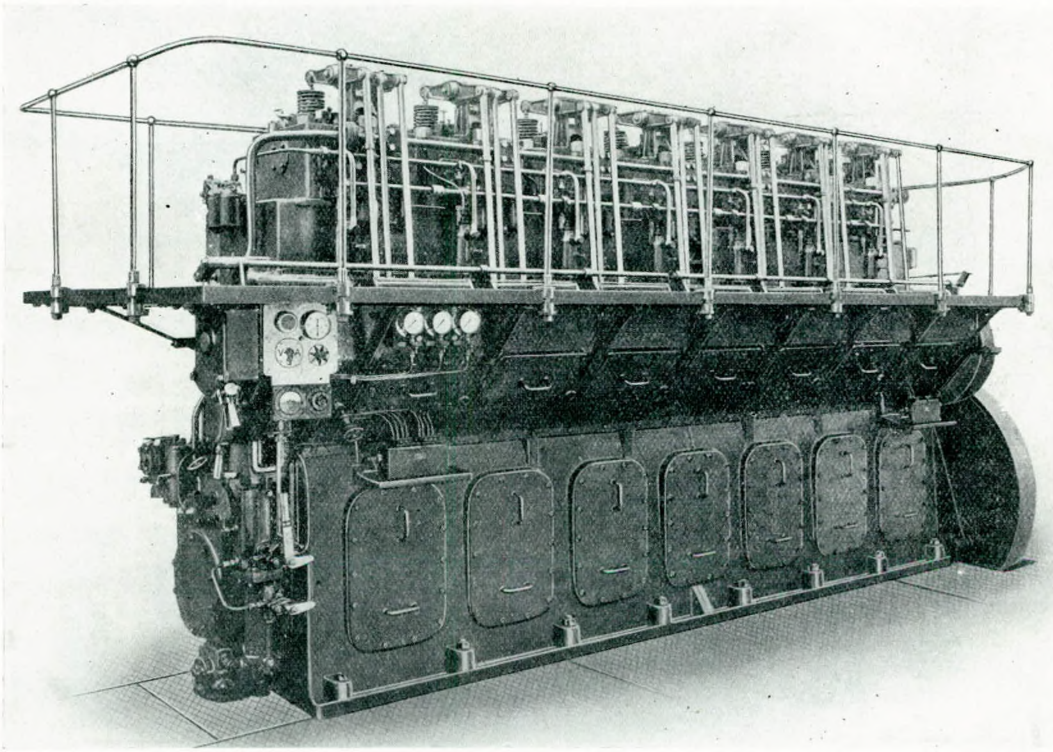
Weight Saving.

The fuel pumps are of the separate unit type, and have been placed high up against the cylinder beam, each pump being as near as possible to the corresponding cylinder, thus ensuring that the pump, pipe and valve unit is exactly alike for every cylinder. In this way all the pumps work under precisely the same conditions. The pumps are driven from the camshaft, which runs along the engine near the bottom of the cylinders. This shaft is driven from the crankshaft by means of a train of straight gearwheels.

The inlet and exhaust valve levers are actuated by means of long push rods. The fulcrum shafts carrying the valve levers rest in supports placed on top to the cylinder covers. The latter construction, combined with the low position of the camshaft, considerably simplifies the removal of the cylinder covers, as it is only necessary to disconnect the pushrods and water and fuel pipes before the cover can be lifted. Valve levers and their supports need not be removed from the cylinder cover.

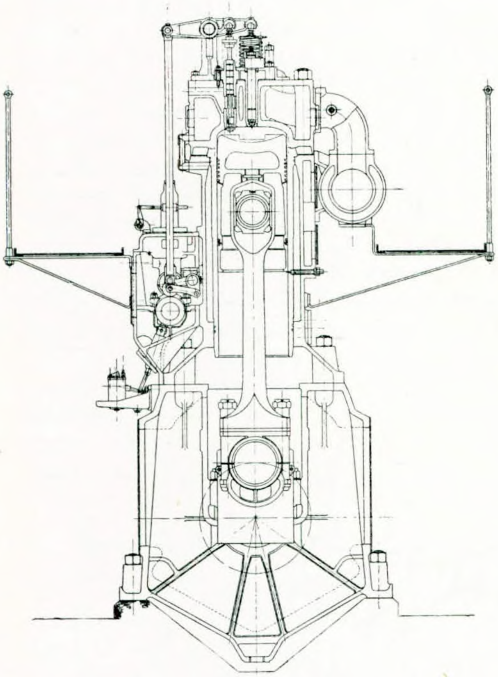
The bedplate and main frame together form the crankcase, which is a single casting, provided, as the illustrations show, with large inspection doors which ensure good accessibility. The cylinder beam is bolted directly to the top of the crankcase, and the entire construction is rigid, strong, and light.

The engine, we understand, is cheap and light for a given horsepower; complete with all accessories, it weighs between 100 and 120lb. per b.h.p. Attendance has been reduced to a minimum, and the unit needs hardly any attention when running. Starting is very simple, the engine being started up on air and changed over to fuel by means of one lever.

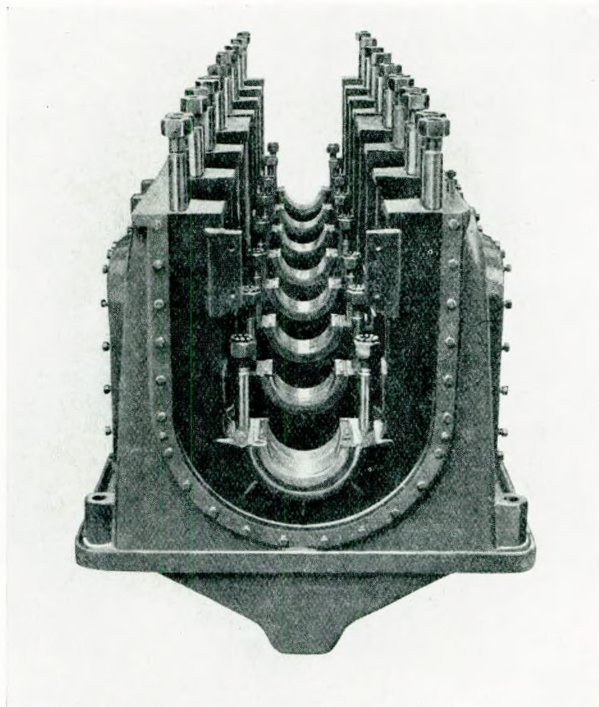


One of the New Type Werkspoor Airless-Injection Engines, showing its Clean Appearance, Large Crankcase Doors, etc

The cast-iron crankcase is in one piece for engines with five cylinders or less, and in two pieces for six-, seven-, and eight-cylinder engines. The walls are of ample thickness to carry the combustion stresses, and special reinforcing ribs are cast underneath the main bearings, which, as one of the illustrations shows, consists of a semi-circular lower bearing shell, which can be removed by turning it round the crankshaft, with a cast-steel cap. The cylinder beam is a box-shaped iron casting, cast, like



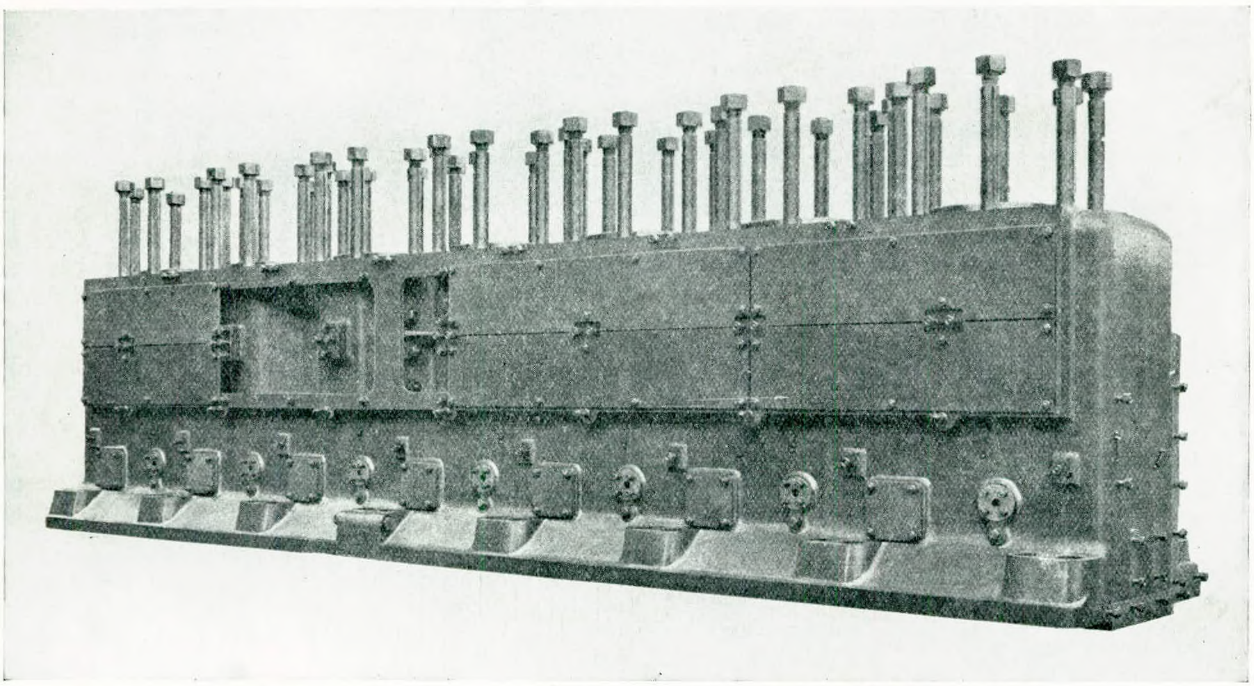
Transverse Section, showing Shape of Combustion Chamber, Valve Gear, etc.



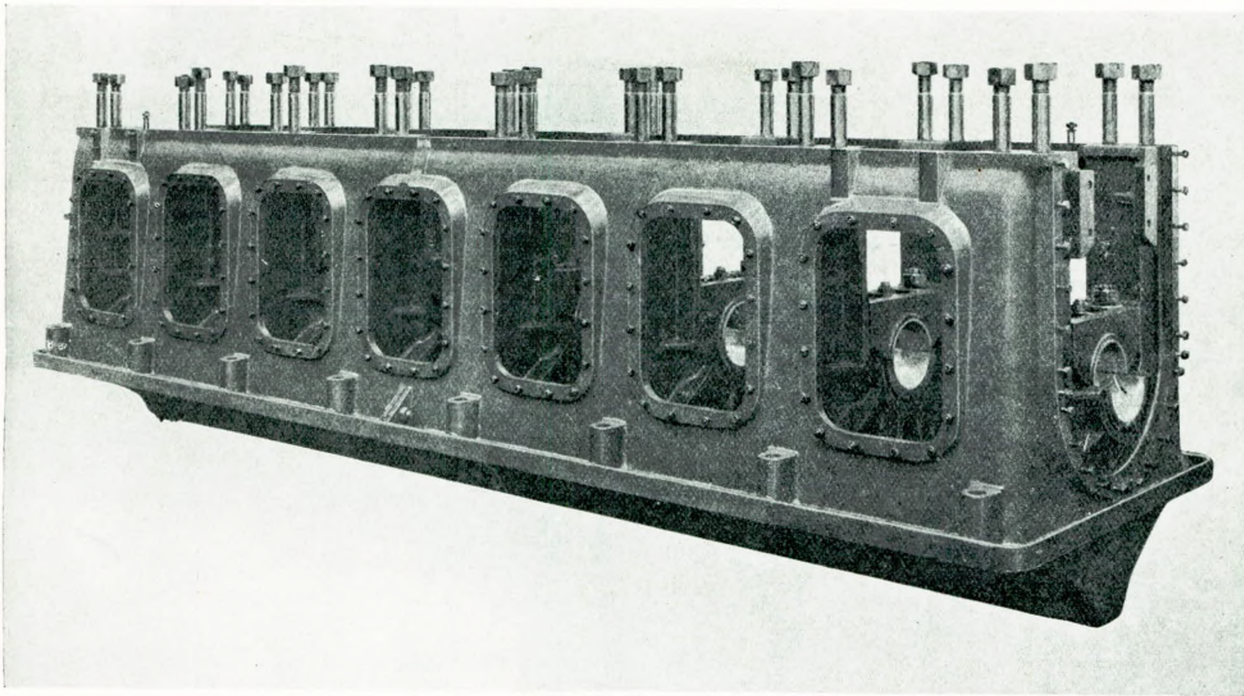
End View of Crankcase-Bedplate Casting for New Werkspoor Engine.

the crankcase, in one or two pieces; it is bolted to the crankcase top. Special walls are cast in the beam, to form a cooling water space around each cylinder, this arrangement, it will be recalled, having been a feature of all Werkspoor Diesel engines for many years.

The cylinder liner, cast of special quality Perlitic iron and machined all over, is drawn into



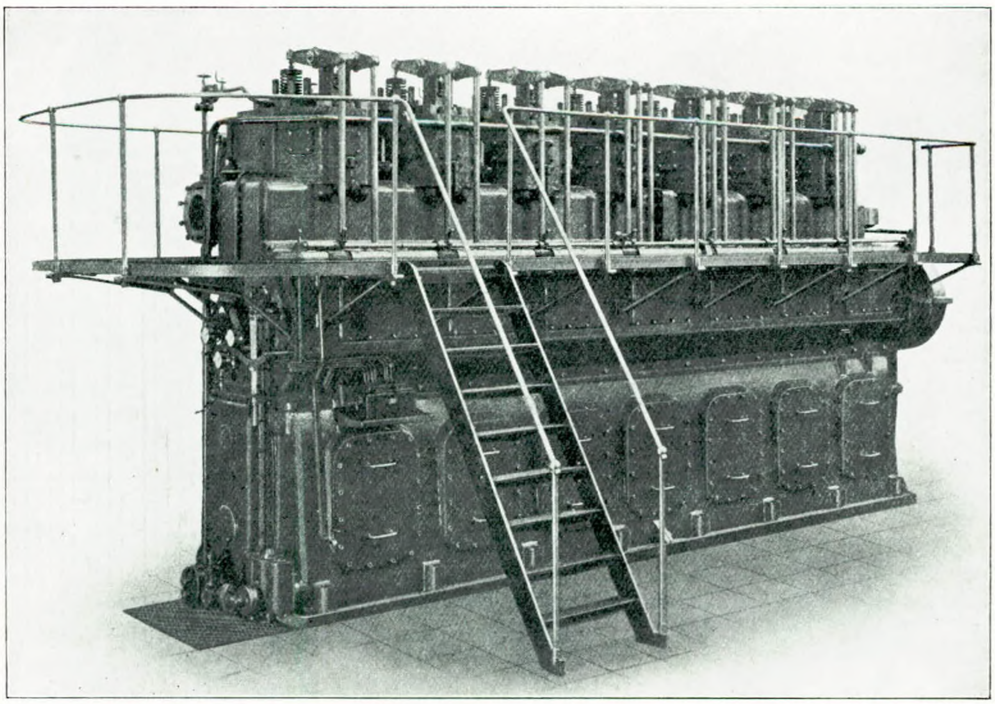
Monobloc Cylinder Beam of a Seven-Cylinder Werkspoor Trunk-Piston Airless-Injection Engine.



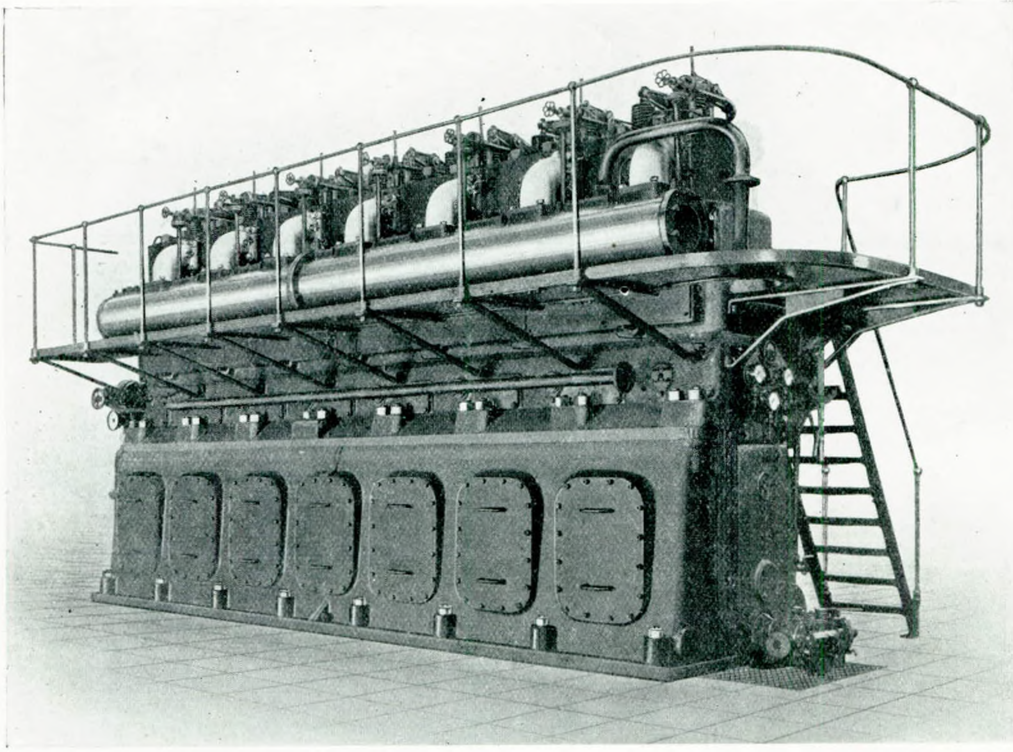
The Well-Ribbed Crankcase of the T.M. Werkspoor Engine with Main Bearings in Place.

the beam. As the arrangement drawing shows, a narrow edge rests on top of the beam, and the liner is firmly supported at top and bottom. At the same time the liner, which is cooled over its entire length, is free to expand downwards. The cylinder cover is a square casting of special iron, the bottom being slightly concave, as the drawing shows. The cover is held down to the cylinder liner by a number of heavy nuts on studs fixed in the cylinder beam.

The cast-iron piston is exceptionally long, so as to keep down the side pressure on the cylinder wall. The piston crown is made thick enough to carry the combustion pressure without any need of supporting ribs, and, therefore, it can adjust itself to the varying temperature without the risk of excessive heat stresses. Six pressure rings are provided, while three scraper rings are fitted in the piston skirt below the gudgeon pin. This



Camshaft Side of Seven-Cylinder Werkspoor Airless-Injection Heavy-Oil Engine.



Exhaust Manifold Side of the Engine illustrated above, which is suitable for Stationary or Marine Service.

from the camshaft and delivering the small quantity of oil which is required for this purpose directly to the cylinder walls.

Marine Engines.

In the smaller powers, the Werkspoor T.M. engine is suitable for marine propulsion by the addition of a clutch and reverse gear, while for larger powers the engines are directly-reversible. In the case of the reversible engines the normal governor is replaced by a fuel regulating lever, which is used for regulating the

is of large diameter in special quality steel hardened and ground to size, and is held in the piston.

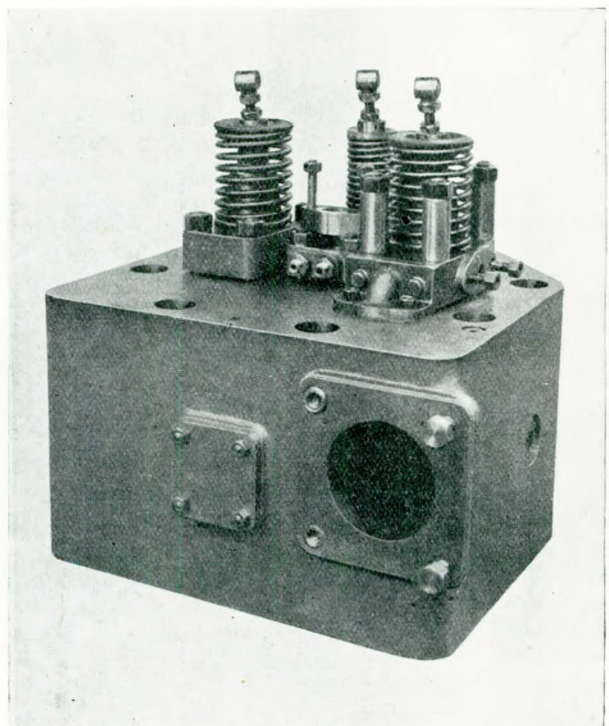
The marine type connecting rod is a steel forging machined all over. The big end bearing consists of two rigid steel castings, both white-metal-lined and fixed to the bottom end of the connecting rod by means of two bolts. The split small end bearing is a steel casing, white-metal-lined, and fitted in the eye of the connecting rod with an adjusting plate.

The crankshaft is a single solid forging, provided with a flange for coupling to a generator, pump, or belt-pulley shaft.

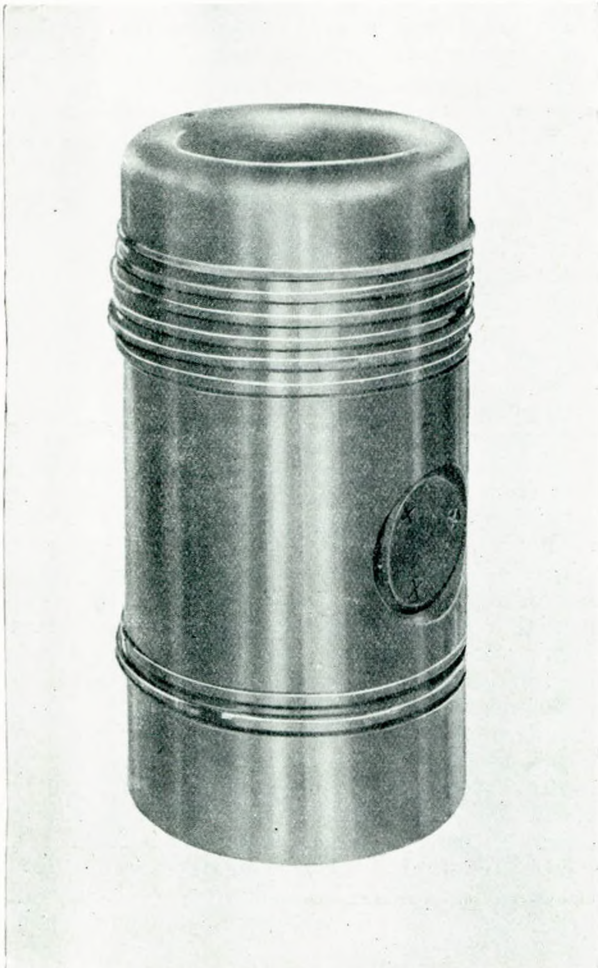
The valves are all housed in separate cages, which are fitted vertically in the cylinder cover. The inlet and exhaust valves and cages are similar, except for the largest size of cylinder, wherein the exhaust valve cage is water-cooled.

Lubrication.

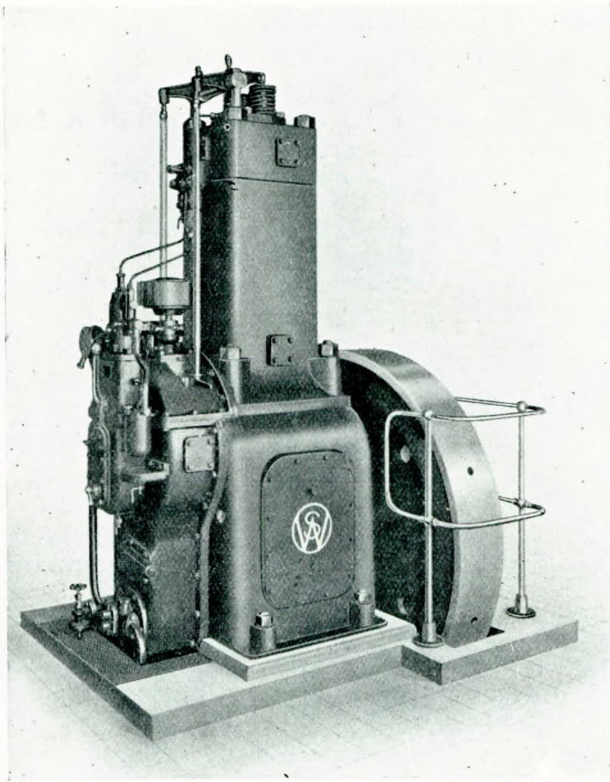
All moving parts, including the camshaft, are lubricated by means of a pressure feed system; the oil is pumped to the main bearing and passes through the crankshaft to the big end bearings, and through the connecting rod to the small end bearings, from which it flows back to the crank pit. The oil pump draws the oil through a filter and returns it again to the main bearings. The cylinders are lubricated by a special pump, mounted underneath the camshaft casing, this pump being driven



Cylinder Head, with Valves in place, for Werkspoor Airless-Injection Engine.



Piston for the T.M. Type Werkspoor Engine, showing Crown Contour.



Single Cylinder Engine of the New Werkspoor Airless-Injection Range.

engine speed. An overspeed governor is fitted to prevent the engine from racing when the propeller leaves the water, or in case the propeller shaft should break.

The Michell type thrust block is built into the crankcase at the after end of the engine. Engines with three and more cylinders are built directly reversible by means of a very ingenious system of two-cycle starting, every cylinder being supplied with a starting valve, so that starting is possible in every position of the camshaft. Two sets of cams are fitted on the camshaft, one for ahead and one for astern running.

The camshaft can be made to slide in a lengthwise direction, so as to bring the correct cams under the valve lever pushrods. This sliding motion is imparted by hand for the smaller engines and by means of a servo motor, operated with starting air, for the larger ones. The starting lever is fitted at the control station, and a revolution counter and an indicator for the direction of running are fitted on the instrument board.

The performance of these engines is very good indeed, full load specific consumptions of under 0·30lb. per i.h.p. per hour being obtained; the mechanical efficiency at full load is 80 per cent., and this performance is realised on ordinary Diesel fuel.

Gas v. Electricity.

"The Engineer", 1st July, 1932.

Speaking at a West of England Conference of the British Commercial Gas Association at Dartmouth on June 24th, Sir Francis Goodenough, chairman of the Association, said: "In a country where coal is the one native source of heat and energy, gas can never be seriously affected by the competition of electricity, however sedulously that method of distributing coal-power be fostered by Ministers of the Crown and others who are trembling already at the pending disclosure of the cost of the grid and its effect upon the price of electricity when all the capital charges have to be met annually by the users of electricity. Unfortunately, these political excursions into industry have never to be paid for by those responsible for them—or they would never be undertaken. When the true history of the grid comes to be written, it is likely to form an outstanding warning against State-aided and State-boosted enterprise".

Soap in Lubricating Oils.

"The Engineer", 1st July, 1932.

According to the "Journal" of the American Society of Automotive Engineers, experiments have shown that greatly increased bearing load capacities are obtainable with lubricants containing sulphur and lead soaps. Under test, a straight petroleum lubricant failed at 10,000lb. per square inch, while the addition of 10 per cent. sulphurised fatty oil permitted of increasing the load to 20,000lb. per square inch.

To Straighten a Shaft.

"The Engineer", 17th June, 1932.

Writing to the Editor of the "American Machinist", Mr. P. N. Nielson, of Wallasey, describes a method he adopted to straighten a short stiff shaft. An armature shaft was badly bent, the bent part being short in proportion to its diameter. He says that "as it was not possible to use heat and the screw jack was not effective, we resorted to what I think was an unusual procedure. It occurred to me that when a shaft is welded it is distorted with the high side opposite the weld. We therefore got the electric welder to strike an arc on the high side of the bend, depositing a small bead of metal about ⅛in. diameter. The result was surprising, the shaft being perfectly true. The fact that the shaft was true first time was probably due to luck, but there is some possibility of useful results with practice. The bead can be removed from the shaft without disturbing the trueness of the shaft".

Coal from Dover.

"The Engineer", 17th June, 1932.

It was stated in Parliament recently by Mr. A. C. Walsh, managing director of Pearson and Dorman, Long, Ltd., and chairman of the Kent Coal Owners' Association, that Dover was the only possible port from which to develop an export trade of any importance. There was a shorter land haul than to other ports and larger ships could use the port. They had shipped coal to Belgium and France and sent one cargo to Greece, but the principal export at present was to Holland where the coal was used in steel works at Sluiskil. That, he believed, was taking the place of German coal. Their coal was good coking coal, and he thought that in that respect it was so superior to Continental coal that there would be a large market for it; but they must be able to ship it at a reasonable cost. Coal could be put into ship at Dover 4d. a ton cheaper than at Queenborough, and there was a further saving of from 3d. to 6d. a ton arising from the possibility of using larger ships at Dover.

Steamship Promise and Performance.

"The Shipbuilder and Marine Engine-Builder", June, 1932.

Probably at no previous time in the history of steam-engine development has there been such an intensive search after every possible source of increased efficiency and economy as is being pursued at the present time. For this wholly desirable condition, two main factors may be held to be largely responsible. The first, and possibly the greater, of these is not exactly new, since its urge has been apparent for some years past. We refer to the internal-combustion engine and to the undoubted challenge which that highly efficient prime mover has introduced, and still vigorously maintains, for the propulsion of almost every type of ship in which the steam engine was formerly supreme. The second factor is of comparatively recent origin, and arises from the present abnormal condition in the shipbuilding and marine engineering industries. There are unfortunately few, if any, marine engineering organisations which at the present time are working at other than a fraction of their potential output, with the natural result that designing and estimating staffs have now greater opportunities for more intensive and detailed research into mechanical and thermo-dynamical problems than have hitherto been available in times of normal productive activity. The joint effect of these two factors is to be seen both in this country and abroad in the shape of an ever-increasing number of steam-machinery types and alternatives, for each and all of which varying degrees of attainable economy in fuel consumption are claimed. Never before has the shipowner been confronted with such an imposing array of apparently attractive and convincing methods of improving the efficiency of existing steam reciprocating machinery, or been able to adopt new machinery arrangements promising to establish new standards of performance which, it has been suggested, may be tantamount to rendering obsolescent similar steamships already in service.

For the purpose of the present discussion, the case of the steam reciprocating engine alone will be considered, and some of the modern aids to economy will be briefly indicated. At the low-pressure end of the cycle a variety of types of exhaust steam turbine have been applied, transmitting their recovered energy to the propeller shaft through hydraulic, mechanical and electrical means respectively. Other and more recent applications of the exhaust-steam turbine are the utilisation of the recovered energy for the mechanical compression of the steam between the high-pressure and intermediate-pressure cylinders or for the electrical superheating of such steam, without pressure increase. At the high-pressure end of the cycle there are the possibilities of increasing the initial pressure and temperature of the steam, the fitting of one form or another of poppet-valve gear, and the bleeding of receiver steam for raising the feed-water temperature. The fitting of air-heaters, smoke-tube economisers for feed-heating, boiler-water circulators, and even, in a limited number of cases, pulverised-fuel firing or mechanical stokers—these are but a few of the numerous measures of economy which are now being actively canvassed. Given the necessary financial backing, it is, of course, open to any shipowner to apply almost all these measures or principles in a single ship, with the certainty of high first cost and a promise of economy not always capable of being accurately assessed in advance.

It is in respect to the latter aspect of the question that there would appear to be some room for improvement. While it cannot be gainsaid that real and substantial progress towards the betterment of steam-engine performance has been made, it is equally true that the best interests of steam are not likely to be served by advancing claims for any specific system which subsequent service performance results may prove to be extravagant. Certain of the alternative systems to which brief reference has already been made are of a proprietary character, and there has undoubtedly been a recently observed tendency—possibly fostered by the prevailing and keen competitive conditions—to assess too highly the economies attainable. All too frequently it happens that the most careful theoretical calculations as to anticipated results, or even the results attained under specially favourable trial-trip conditions, are incapable of being maintained in service, and in such circumstances the cause of real progress is injured. Representative of such examples as we have in mind is the case quoted in Mr. Allan Stevenson's paper recently read before the Institution of Engineers and Shipbuilders in Scotland. The ship in question was of 2,800 tons deadweight-carrying capacity, and was fitted with a Lentz engine in which the steam intermediate between the h.-p. and i.-p. cylinders was electrically superheated by means of energy generated by an exhaust-steam turbine. The trial-trip performance as published gave a coal consumption of 6·53 tons at 9·56 knots; whereas in service the average performance of two voyages in March of this year, embracing 24 days of fair-weather steaming and burning good Welsh coal, worked out at 8·85 tons per day at 8·45 knots speed. If this consumption is corrected on the basis of the cube law to that corresponding to the trial-trip speed of 9·56 knots, the comparable service consumption becomes 12·81 tons per day as against the claimed figure of 6·53 tons. Since this figure represents but little gain over what can be attained in a normal well-designed triple-expansion steam engine fitted with ordinary slide valves, the shipowner may be forgiven for asking in such cases whether the added complication and increased first cost are justified.

Such an example as that quoted is perhaps an extreme case, but it serves to show the wide gap which sometimes exists between calculated and service performance. Although apparently an elementary consideration, it is sometimes overlooked that the law of conservation of energy is immutable. Higher vacuum shows a gain which is largely nullified by the additional steam required to provide the greater quantity of circulating water and to heat the colder condensate, increased air-heating adds to the fan load, and higher feed-water temperatures call for live or bled steam; so that the net, and not the gross, gain is the final criterion. The need of the moment appears to be for a freer publication of actual performance results in all installations which claim to represent departures from stereotyped practice and which likewise claim to represent new fields of economy, since the actual results in service are the only and the final test of efficiency. When performance falls short of promise, the obvious and legitimate weapon of the shipowner is the formulation and enforcement of onerous and exacting guarantees, although clearly such a relationship is neither conducive to the encouragement of future enterprise on the owner's part nor is it in the interests of technical progress.

Without in any sense appearing to discourage the exploration of every reasonably promising avenue of improvement in the efficiency of the steam reciprocating engine, we are sometimes tempted to ask whether the present tendency towards the multiplication of so-called economy expedients is not leading us away from the virtues of sturdy simplicity and dependability upon which the popularity of the steam reciprocator has hitherto been so soundly established. Some of the alternative fittings to which we have referred—notably the exhaust-steam turbine—are soundly conceived and productive of material economy. Others which are described as new methods of increasing efficiency add to the complexity and cost of the installation, make merely fractional contributions to overall economy in consumption of fuel, and are, in fact, thinly disguised modifications of principles which are by no means new. The tendency, in other words, is towards increased first cost and away from simplicity, with frequently the concomitant of an absence of solid service economy to justify the change.

Although the present subject title does not include within its scope a comparison between the steam reciprocator and the Diesel engine, it is perhaps pertinent here to observe the trend of progress in respect to the latter prime mover. The numerous gadgets which were characteristic of early marine Diesel engines have one by one been discarded as experience and confidence have accumulated. There is a slow but gradual drift from the multi-valve four-stroke cycle to the simpler two-stroke cycle engine, particularly of the double-acting type. Airless injection is superseding blast injection, with the virtual elimination of the not always trouble-free and heavy air compressor which the latter principle involves. Engine design is becoming cleaner in outline, the work of the foundry is being simplified, and weight per unit horse-power as well as specific fuel consumption is being reduced. That this tendency is sound is demonstrated by the fact that, with the modern Diesel engine, promise and performance are practically synonymous—the gap is virtually non-existent.

The steam reciprocating engine has been, and is, a tried and trusted instrument of propulsion, for which there is certainly still a wide field of application. It is to be doubted, however, whether the present tendency towards the multiplication of minor economy expedients, for which unsound claims are sometimes advanced, is in the best interests of its future scope; and this, we consider, is an aspect of the subject over which steam engineers would be well advised to ponder carefully.

Development of the Water-Tube Boiler for High Capacities.

"Steam Engineer", July, 1932.

The trend of development in water tube boiler design for high pressures has, in recent years, been towards dividing the heating unit into sections in order to secure the highest efficiency from the radiant heat. This trend would appear to have been initiated less than ten years ago, and in 1924 Dr. D. S. Jacobus presented a paper at the First World Power Conference, London, entitled "Present Practices in Steam Generation in the United States", in which the series of two-stage boiler was described; a design which was later adopted in the now famous Calumet station of the Commonwealth Edison Company, the unit being put into service in November, 1926. The success of this unit was followed by similar installations in other stations, and appears to be now accepted as a standard arrangement for high pressure work for the orthodox type of boiler.

We do not propose to deal with the different types of boilers in the present article, but to briefly record the development of the horizontally inclined tube design which has so long been associated with the firm of Messrs. Babcock & Wilcox. The more recent designs of this type of boiler reveal the gradual evolution which has taken place during recent years, necessitated by the modern demand for higher pressures. There is no mechanical difficulty in building a water tube boiler for super-pressures, but to merely strengthen the low-pressure design means increasing the capital costs disproportionately to the economy effected by the higher pressure. It is this problem of overall efficiency which concerns the boiler designer to-day, and the problem has been met with the design under consideration in a simple manner. The water-cooled furnace and boiler tubes are arranged in such a manner so as to make the fullest use of the radiant heat, which results in a design consisting merely of a large water-cooled furnace, below a row of tubes only sufficient in number to absorb the maximum amount of radiant heat, the hot gases leaving to pass on through a steaming economiser.

It is of interest here to note some comments of

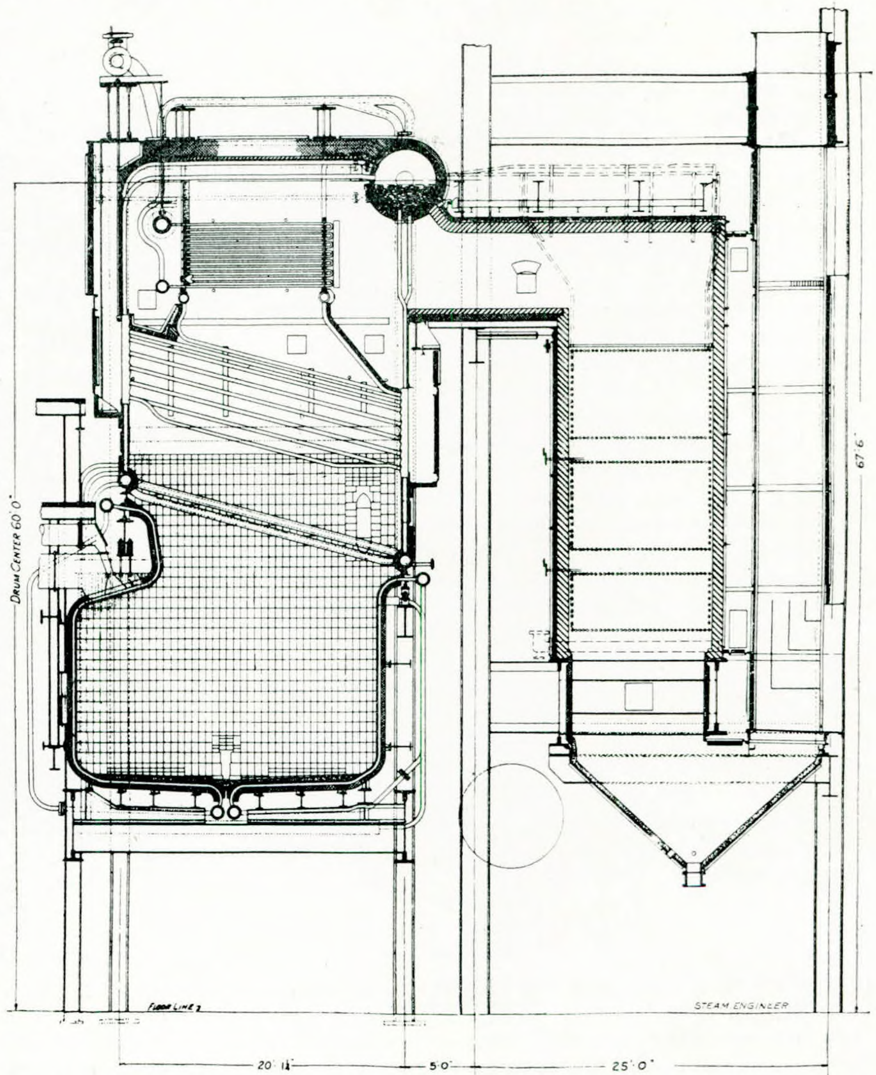


Fig. 1.—New Unit installed for the State Line Station, U.S.A. showing the latest Slag-Tap Furnace.

Prof. L. K. Ramzin of the State Thermo-Technical Institute, Moscow, in a paper presented at the recent Japanese Sectional Meeting of the World Power Conference. Referring to his recent researches he stated that "Calculations indicated that if all the upper tubes of the boiler were completely eliminated and only the widely spaced tower sections left, on which the superheater was imposed, then, with an average evaporation of 27lb. per sq. ft. per hour the temperature of the gases, on leaving the boiler would only be about 800° F. It should be noted, however, that this is a calculated figure. At the same meeting Prof. Tore Lindmark, of the Technical University, Stockholm, presented a paper on "The Most Favourable Relation Between the Heating Surface in the Furnace of a Steam Boiler and the Total Heating Surface of the Boiler", in which he made the following remark referring to the use of water-walls: "Consequent increase of the heating surface in the combustion chamber not only gave increased protection against damage from overheating, but also gave a large increase in the evaporation per sq. ft. of heating surface. This led to a gradual increase in the surface exposed to radiation, and to a new phase in the development of boiler design".

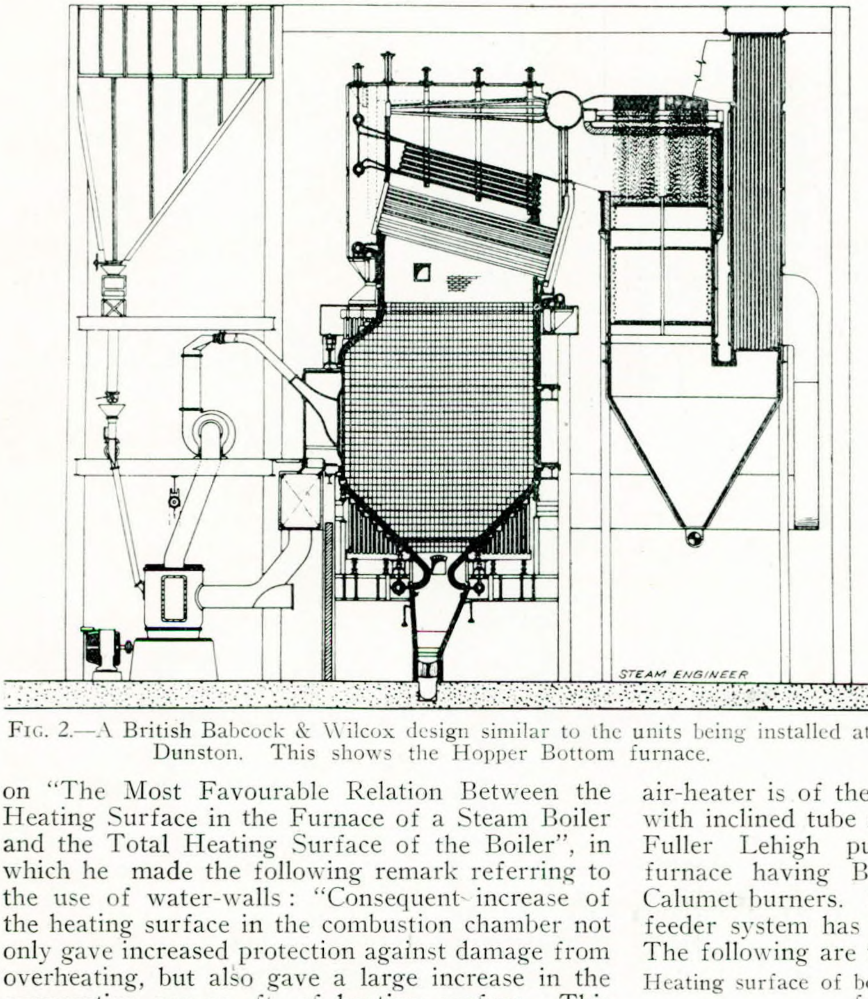


FIG. 2.—A British Babcock & Wilcox design similar to the units being installed at Dunston. This shows the Hopper Bottom furnace.

The co-ordination of boiler and furnace design thus became a matter of fundamental importance for any particular set of conditions, and at the same time consideration must be given to the method of firing, furnace volume, and ash fusing temperature. In the paper by Dr. Jacobus referred to above the author mentions the researches of Babcock & Wilcox in 1916 with an oil-fired unit consisting of a tube surface of 187 sq. ft. placed over a refractory lined furnace. The superheater surface was 51 sq. ft. and the steaming economiser surface 685 sq. ft. This boiler operated at a pressure of 600lb. per sq. in. and was run at times to evaporate over 15lb. of water per hour per sq. ft. of total boiler and economiser surface. The rate of evaporation of the boiler proper with 2in. tubes was about 45lb. of water per hour per sq. ft of heating surface.

This and subsequent research proved conclusively that the steaming economiser was a practical unit and that high rates of evaporation could be expected from a limited area of boiler heating surface when equipped with such a steaming economiser, and still retain the general features of the orthodox boiler plant.

The results of this research work were embodied in the design of the Calumet boiler, which followed generally the arrangement of the experimental boiler referred to by Dr. Jacobus. The Calumet details are of particular interest. The boiler was built for a working pressure of 375lb. per sq. in., the gases making a single pass over the boiler tubes and superheater. The boiler proper is seven tubes high and built of 3¼in. tubes 17ft. long. The economiser is of the loop type counterflow design, connected to the steam and water drum in a special manner to permit of steaming in the economiser. The tubular air-heater is of the single pass counterflow design, with inclined tube sheets. The boiler is fired with Fuller Lehigh pulverised fuel equipment, the furnace having Bailey water cooled walls, and Calumet burners. Incidentally the original bin and feeder system has been converted to direct firing. The following are the heating surfaces:—

Heating surface of boiler	5,938 sq. ft.
„ „ „ furnace	2,460 „ „
„ „ „ economiser	8,365 „ „
Total wetted surface	16,763 „ „
Superheater heating surface	4,908 sq. ft.
Airheater „ „	41,700 „ „

The guaranteed output for this unit was 200,000lb. of steam per hour, but its operation was so satisfactory that the load was gradually increased to 250,000lb. per hour, when the feed pump reached its limit. By means of a booster pump the load was further increased to 300,000lb. per hour when the limit of the induced draught was reached.

The evaporation for this unit is given as follows, in lb. per hour per sq. ft. of heating surface :—

Total output (lb. per hr.) ...	200,000	250,000	300,000
Boiler, furnace and economiser	11·94	14·92	17·90
Boiler and furnace	23·80	29·77	35·71

The success of this unit led to the installation of similar units in different stations including the State Line station designed for a pressure of 800lb. per sq. in. There are six boiler units in this station each with a boiler heating surface of 10,294 sq. ft., the inclined tubes being 20ft. long by 3¼in. outside diameter, the lower tubes being spaced wide apart in order to form a slag screen and also to make more efficient use of the radiant heat. The combustion chamber has a volume of about 21,000 cub. ft. and is equipped with Bailey water walls with a total surface of 3,870 sq. ft. Each steaming economiser has a heating surface of 19.820 sq. ft. and each air-heater a heating surface of 56,401 sq. ft. When evaporating 450,000lb. of steam per hour per boiler unit the flue gas temperature entering the steaming economiser is given as 1,300° F., and entering the air-heater at 650° F., the air leaving the air-heater at about 375° F.

The development described in these notes are clearly illustrated in the sectional views of recent installations shown in Figs. 1 and 2. The State Line station has since placed a repeat order for six boilers, four of which are to the design shown in Fig. 1 and two are re-heat boilers.

Economic Speed in Ballast.

A Simple Examination of Fuel Costs.

"The Burntisland Shipyard Journal", No. 5, July, 1932.

The economics of speed in cargo vessels is a subject of more than academic interest and, provided investigations into the subject are made under strictly comparative conditions, the results are valuable pointers as to the direction in which greatest economy lies.

In the case of the loaded condition the effect of variation in speed in the normal tramp cargo steamer is, broadly speaking, determined by the value of the time saved in the case of runs made at higher speeds, set off against the extra cost of the fuel necessary to obtain the higher speeds, together with the loss of freight-paying deadweight that results from the larger weight of fuel that must be carried. The combined effect of the two items, i.e., the higher fuel cost and the loss of freight-paying deadweight is such that, in the case of freight rates in which no recognition for speed is given, it does not pay in normal circumstances to run at speeds more than about nine knots.

But in the case of the ballast condition, for all practical purposes, only one of these items applies; it is only the extra cost of fuel that has to be compared with the value of the time that is saved by running at higher speeds. In the following, the effect of varying the speed in the ballast condition is examined in the case of a 7,800 d.w. vessel, the conditions being constant as to weather, quality of fuel, etc., throughout the whole range. A voyage of 6,000 miles is used, and in addition to her ballast, the vessel is bunkered for the round voyage—in fact, a normal condition for a ballast run to the River Plate. The vessel has engines of ordinary triple expansion design using saturated steam.

A summary of the important figures which determine the economic ballast speed is given in the following table :—

Speed (Knots) ...	8	9	10	11	12	13
Voyage time (days)	31·25	27·78	25·0	22·73	20·83	19·23
Consumpt. per day (tons)	9·70	12·77	16·80	21·6	27·9	36·3
Consumpt. per Voyage (tons) ...	303	354	420	491	581	698
Cost at 16/- per ton	£242	£283	£336	£393	£465	£558

If the running costs, together with standing Capital Charges, are taken at £40 per day, these amount to :—

8	9	10	11	12	13
£1,290	£1,111	£1,000	£909	£833	£769

which, when added to the fuel cost, give totals as follows :—

8	9	10	11	12	13
£1,532	£1,394	£1,336	£1,302	£1,298	£1,327

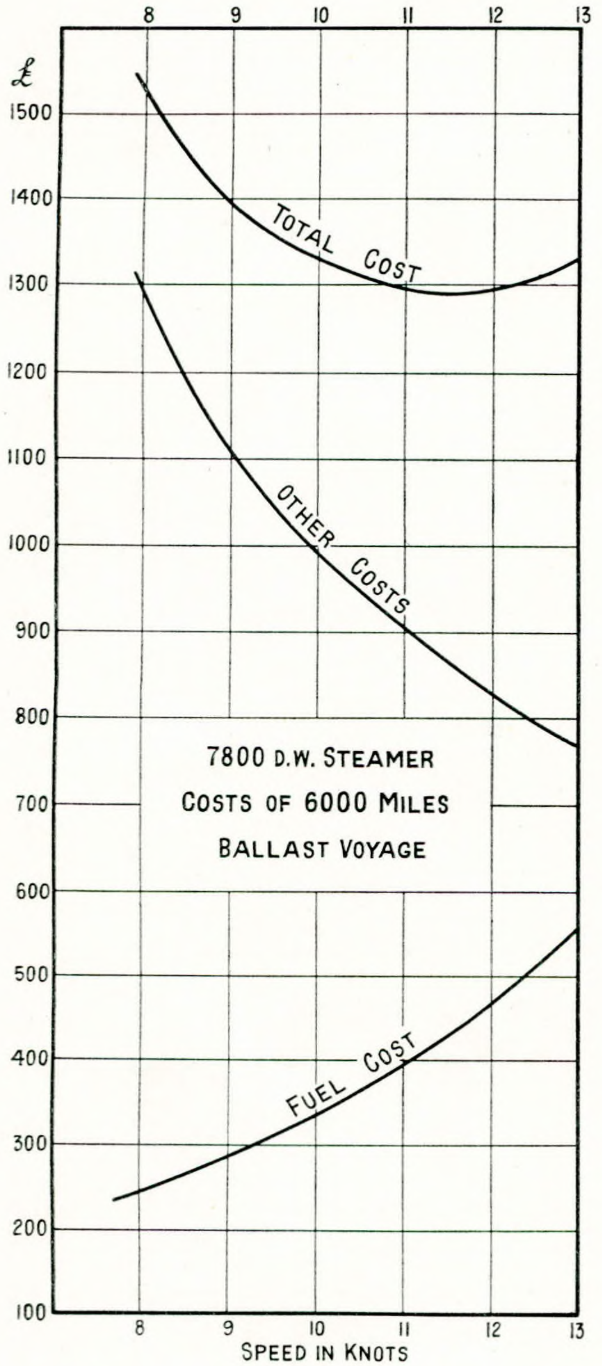
The various figures are illustrated in the accompanying diagram from which is seen, at a glance, the upward trend of the "fuel cost" and the downward trend of the "other costs", as the speed is increased. When the two items are combined in the curve of "total costs", it is seen that the trend of the curve is such as to produce the most economic condition at about 11½ knots.

The economic speed of 11½ knots in the ballast condition should, however, be considered as one related to a state of weather in which excessive racing of the propeller would not be experienced.

To attain this ballast speed, "Economy" vessels do not, however, require to run at very high rates of revolutions. In the present instance these are no more than 64 per minute; in fact, the revolutions in the ballast condition are practically the same as those required for the same speed in the loaded condition.

This simple examination of the subject is useful as showing the difference in the economics of the loaded and ballast voyages. In the case of the former, a complete voyage, out and home to the Plate, loaded each way, requires an additional amount of fuel to be carried to the extent of shutting out about 350 tons of freight-paying cargo outwards and about 190 tons homeward, if the voyage speed is increased from 9 to 10 knots.

This is a heavy additional charge to make against speed, and, together with the extra cost of fuel and other attendant increases that arise, when set



Running Costs for Ballast Voyage.

off against the saving in time, is not justified unless a freight rate above the normal market level is paid in recognition of the shorter time occupied on the voyage.

It may be of interest to add that the amount of horse power required for $11\frac{1}{2}$ knots in the ballast condition is about 50 per cent. greater than that required for 9 knots in the fully loaded condition, for corresponding conditions of weather. From the point of view of the respective displacements, and comparing at a given speed, the propulsive efficiency taken by itself, is much less in the ballast condition than when loaded, this arising from the partial immersion of the propeller when in ballast. In the case of the vessel just examined the useful work performed by the propeller represents 74 per cent. of the power delivered to it in the loaded condition, and only 64 per cent. in the ballast condition. As in all investigations of this nature, it is not, however, merely a question of propulsive efficiency alone that has to be considered; the ultimate test must always be that based on the commercial economics in which propulsion is only one item, and in determining the economic ballast speed in the foregoing, the whole of the contributory factors have been taken into account with that end in view.

Coal—The Fuel for British Cargo Ships.

"The Burntisland Shipyard Journal". No. 5, July, 1932.

In the trade recovery of Great Britain there is nothing of greater importance than that coal—our national product—should return to its eminent position amongst our industries.

The estimated world's reserve of coal and oil show great disparity. The resources of oil are computed to be only about one-tenth that of coal. But, in spite of this, the potential supply of oil is hardly likely, in the early future, to be so reduced as to cause a new demand for larger quantities of coal. *An increased demand for coal can only be brought about by making it more economical to use coal.* No nation has suffered more than Great Britain from the displacement of coal by oil, and it therefore behoves all who can to play their part in bringing coal back to the important position it used to occupy in the economics of the nation.

One of the greatest blows to our mining industry has been the tremendous development, during the past 20 years, of oil as a marine fuel. Oil used for steam raising under boilers or in internal combustion engines has enormously reduced the demand for coal shipped direct as bunkers or for export to bunkering stations throughout the world.

In many directions, during the period referred to, oil has rapidly attained an advantage over coal, but the present position reveals intensely interesting possibilities for a return to our national product. So long as the average size cargo tramp ship required from 1,500 to 1,800 tons of coal for a round River Plate voyage, in which was incurred loss of time and higher cost of refuelling at Cape Verde

Islands, it was comparatively easy to put forward designs based on oil fuel which required an appreciably reduced weight of fuel to be carried, releasing space and dead-weight to freight-paying cargo. Had that comparative state of affairs continued, there is little doubt that oil would have made still further progress. The advent of the ship specially designed for economy, however, has created a new outlook for coal. This type of vessel, using less than 1,000 tons of coal fuel for steaming purposes during the round voyage of some 12,000 miles (the call at the islands is avoided, and bunkers for the homeward voyage are stowed in spaces not required for cargo), has removed the principal handicaps from which the cargo ship suffered in the original comparison.

The future of coal for cargo ships is bound up with (*a*) ship design, (*b*) machinery design, and (*c*) supply of economical fuel, each of which requires the close attention of the respective experts.

In regard to ship design a new position has already been reached, as referred to above, but almost without any sensible change in the methods of using coal fuel or in power production. Entirely by external features of design concerning the hull, propeller, etc., the amount of power required has been considerably reduced. For instance, in a 7,800 d.w. ship specially designed for economy, only 990 i.h.p. is required for 9 knots loaded speed, under voyage conditions taken as 15 per cent. worse than that of "fine weather on trial". For normal machinery equipment the coal consumption is about 16 tons per day.

The time is undoubtedly ripe for bold changes in the means of power production. So far as the above figures are concerned appreciable reduction is already available by the addition of superheating and other not excessively costly appliances, as a result of which the daily consumption can be reduced to 13½ tons. Any further reduction can only be attained by the addition of relatively costly mechanical features, such as an extra cylinder to the engine, making that unit quadruple instead of triple, or an exhaust turbine, the latter probably further reducing the consumption to about 11 tons per day. On the low basis of 13½ tons the increased capital cost may hardly be justified. The most economical line of approach would seem to be a complete revision of the power production plant using coal in a pulverised form, attaining a rate of consumption which would bring the consumption of these vessels down to no more than about 11 tons per day.

The development of pulverised fuel is being watched with considerable interest. The convenience of mechanically preparing and delivering the coal to the furnaces has obvious advantages. It is a more rational method than hand-firing; it admits of a comparatively cheaper grade of coal being used; combustion can be better regulated and boiler efficiency increased.

Ship and engine designers are playing an important part in the reclamation of the position of coal as a marine fuel, but support will require to come from the coal industry. Experience, so far, clearly points to great possibilities of pulverised coal as a marine fuel, and, given the best means of stowing, handling, and consuming it on board the vessel, it only requires that there be available at the bunkering ports supplies of coal suitable for the purpose. If the cheaper grades of coal are all that are required for combustion in pulverised form, it may be in this way that an outlet for a larger proportion of the "smalls" output of our mines can be found. The enormous extension of demand for motor spirits and lubricating oils has made possible the large supplies of oil that have been put on the market for marine purposes. In fact it is no exaggeration to say that these qualities are merely the residuals of the oil industry. The aim should be, therefore, to assist our great national industry of coal mining by further developing the design of our cargo ships, enabling them to utilise an inferior or residual coal. The reduction in the amount of coal fuel attained in modern economical designs and the reduction in cost that should result from being able to use this lower grade are no disadvantages to coal; on the other hand, these are vital means of encouraging its use, thereby assisting to retrieve a position largely lost to oil—a foreign product.

From the point of view of the shipowner, it is also of importance to remember that the adoption of steam machinery admits of the possibility of using coal in its various forms, or even of oil, if, under circumstances, the latter was at some time justified, whereas the installation of an internal combustion engine definitely commits operation to oil alone.

Colloidal fuel has recently again come into prominence, and while, in the case of cargo ships, it is not likely to be found more economical than the conditions anticipated in the foregoing, this composite type of fuel should be of assistance to the coal industry, if it takes the place of oil in those classes of passenger vessels, in which liquid fuel, despite its cost, has a definite advantage over coal alone from other points of view.

Progress in the design of coal burning steam boilers and propelling machinery must move steadily towards greater efficiency of power generation. *The day may not be far distant when power for propulsive purposes on board ships will be produced by an expenditure of only one half the quantity of coal that is used in the vast majority of normal steam installations.* Confidence is increasing that such a performance will be accomplished. When that expectation is fulfilled, the competition between the respective merits of coal and oil may well take on a new aspect and react with considerable advantage on the coal mining industry of Great Britain.

Steam or Motor Tugs for Long Voyages.

A Detailed Comparison of Vessels having both Types of Machinery.

By Ir. A. Roorda, of Sliedrecht, Holland.

"The Shipbuilder and Marine Engine-Builder", Aug., 1932.

In the competition between steam engines and internal-combustion engines the latter have generally proved superior where large bunker capacity is required. Sea-going tugs for long voyages, however, are an exception to this generalisation, although large bunker capacity is of the utmost importance in these vessels.

In deciding between steam and internal-combustion engines for tugs, considerations of reliability, first cost and fuel consumption relative to the work done play an important part. Other factors are the price of fuel, number of crew and wages, readiness, and general suitability for the work a sea-going tug has to perform. The reliability of the modern marine internal-combustion engine may be safely considered to equal that of the steam engine.

The question of first cost does not lend itself to general treatment; while the price of fuel—a varying factor as to place and time of purchase—is best disregarded in a technical comparison. The number of the crew is somewhat larger in a steam tug, but in all probability this is compensated by the higher wages paid to the engine-room staff of a motor tug.

The fuel consumption depends (1) on the design and type of the engine, and (2) on the horse-power required. The first need not be considered here, as engine-builders are in a position to furnish complete information as to the consumption per horse-power under different loads.

With respect to readiness, the motor has a decided advantage over the steam plant, as it can be started immediately at any moment from cold. This implies a second advantage—no fuel consumption is involved when the tug is lying idle.

Eliminating the considerations mentioned as lying outside the scope of a technical comparison, the naval architect responsible for the design of the most suitable tug to meet any stated requirements can concentrate on the remaining two of the deciding factors, viz., the horse-power required to perform a given amount of work, and the general suitability of the engines compared for service in sea-going tugs.

When engaged in working out the design for a tug of moderate size, the author decided to extend his calculations so far that they might give a fair comparison between a steam and a motor tug.

The design on which the comparison is based is for a sea-going single-screw steam tug of 850 i.h.p., with a bunker capacity of 300 tons of coal and with fresh water and stores in proportion, sufficient for a voyage of about 500 hours. Particulars and the general arrangement of the vessel are given in the first column of Table I. and in Fig. 1.

Table I.—Particulars of Sea-going Tugs.

Type of Tug.	Single-screw Steam.	Single-screw Motor.	Twin-screw Motor.
Length B.P.	148ft. 0in.	138ft. 0in.	160ft. 0in.
Breadth moulded ...	26ft. 7in.	23ft. 0in.	26ft. 7in.
Depth at side	15ft. 0in.	13ft. 3½in.	16ft. 3in.
Mean draught loaded without keel ...	13ft. 1in.	11ft. 3in.	13ft. 10in.
Maximum draught aft loaded	16ft. 5in.	14ft. 4in.	16ft. 0in.
Type of engine installation	Triple-expansion	Diesel motor	2 Diesel motors
Engine power	850 i.h.p.	750 b.h.p.	2×835 b.h.p.
Normal r.p.m.	110	145	240
Estimated hull weight, tons	337	240	397
Estimated engine weight, tons	180	135	230
Fuel weight with bunkers full	300	96	216
Fresh water and stores	86	40	60
Displacement loaded, tons	903	511	903
Mean displacement (fuel and stores half consumed)	710	443	770

The Steam Tug.

The speed of the engine is taken at 110 r.p.m., the normal steam inlet 55 per cent., and the maximum steam inlet 69 per cent. With the normal speed and steam inlet, the i.h.p. is 850, and the shaft horse-power delivered to the propeller 710, the engine efficiency (including the shafting) being taken as 83½ per cent. at full load. The mean towing speed is taken as 8 knots. For these conditions a suitable propeller was sought from a series of model-propeller results. Propellers Nos. 1 and 2 mentioned in Table II. give the same propeller efficiency at 8 knots. No. 3, although giving a slightly lower efficiency at this speed, has been included in the calculations, which cover a range of towing speeds from 3 to 12 knots for steam inlets of 55 and 69 per cent. The turning moment of the engine was calculated for 110 r.p.m. and kept constant at all speeds, which means that the power developed is directly proportional to the r.p.m.

Table II.—Propellers for Steam Tug of 850 i.h.p. at 110 r.p.m.

Number of propeller ...	1	2	3
$\frac{\text{Projected area of blades}}{\text{Disc area}}$	·50	·50	·50
Diameter	11ft. 9in.	10ft. 6in.	9ft. 9in.
Pitch	9ft. 5in.	10ft. 6in.	11ft. 9in.
$\frac{\text{Pitch}}{\text{Diameter}}$ ratio	·80	1·00	1·20

Fig. 2 gives for the three propellers the r.p.m., shaft horse-power, thrust horse-power and propeller efficiency. As was to be expected, propeller

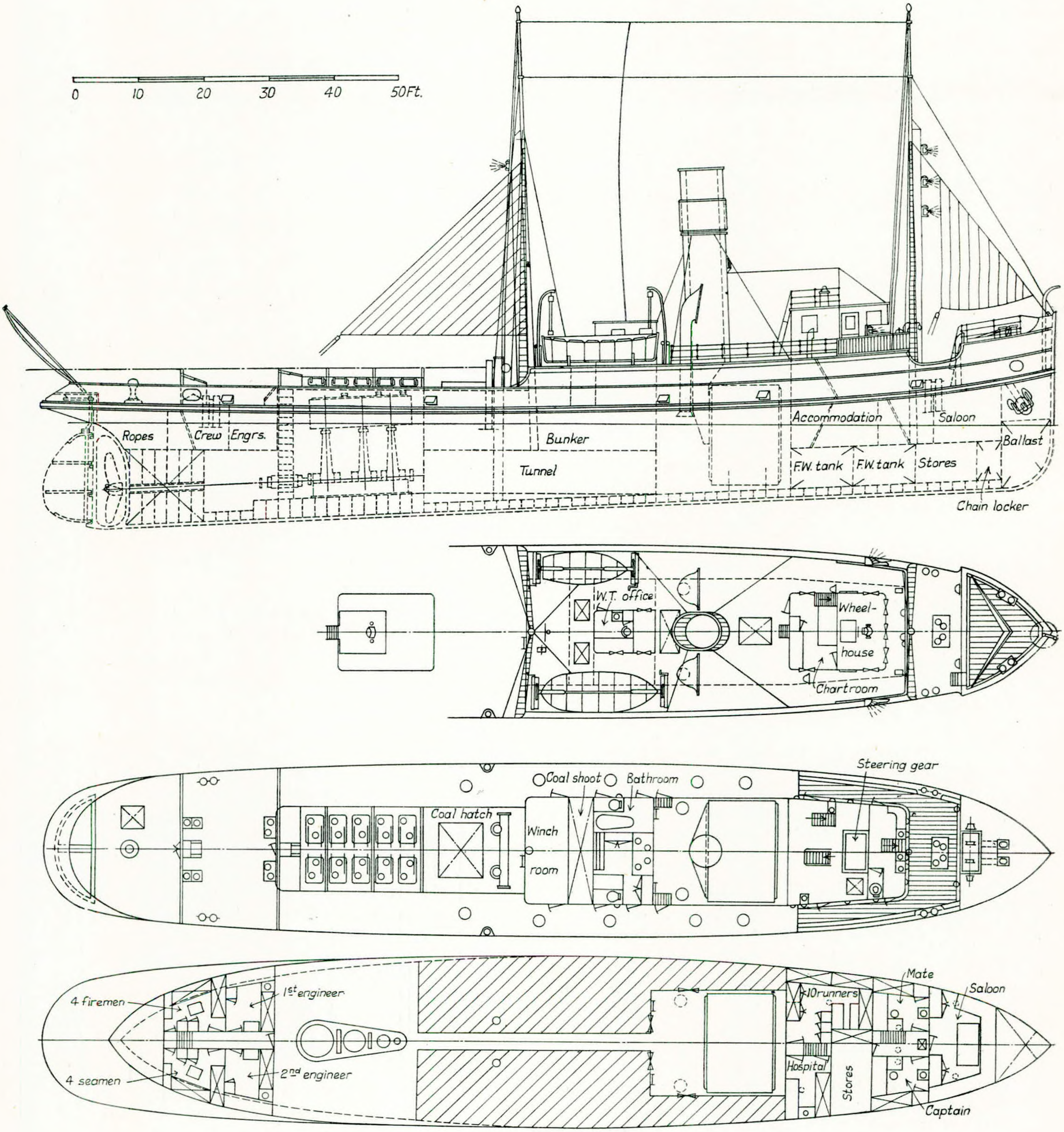


FIG. 1.—Sea-going Single-screw Steam Tug of 850 i.h.p.

No. 1, having a small pitch ratio, gives the best result at low speed, and No. 3, having a large pitch ratio, at high speed, with normal and maximum inlets. Propeller No. 2 was selected as a good average at all speeds. It will be clear from Fig. 2 that an alteration of the steam inlet does not directly affect the choice of propeller—the form and relative position of the efficiency curves are the same. At all speeds the propeller efficiency with an increased steam inlet is lower than with the normal. In tugs, the possibility of altering the inlet largely influences the choice of propeller in an indirect way. To explain this, it is worth while to consider the effect of raising the steam inlet above the normal in a towing vessel.

The steam engine can be adapted to different loads by altering the time during which steam is admitted into the cylinders. As is well known, this is done by means of the Stephenson valve gear. This is of special importance in towing, as the power must be varied over wide ranges to suit the towing speed. In most engines for tugs, the turning moment can be increased still more by means of an arrangement permitting the temporary admission of high-pressure steam into the intermediate and low-pressure cylinders. In this way, the shaft horse-power at a given r.p.m. may be raised by 50 per cent. and even more. How long this supercharging may last depends on the capacity of the boiler.

The effect of supercharging is clearly indicated in Fig. 3. Raising the steam inlet from 55 to 69 per cent., or 25 per cent. above normal, gives about 25 per cent. additional power on the same r.p.m. At a towing speed of 3 knots, the revolutions rise from 92 to 101, making the total increase in shaft horse-power about 35 per cent., and the propeller efficiency drops from 0·29 to 0·27, or about $8\frac{1}{2}$ per cent. The result is an increase in tow-rope pull of about 27 per cent. at a speed of 3 knots. The importance of this increase in speeding up a heavy tow is obvious.

Many steam tugs have a propeller pitch relative to the diameter much larger than that of propeller No. 2, chosen from the curves of Fig. 2, for which the pitch and diameter are equal. The reason will be clear from Figs. 2 and 3. At medium towing speeds, the efficiency is about the same for large and small-pitch propellers. At high speeds and when running free, a large pitch gives higher efficiency. At low speeds, generally occurring while the tug is getting her tow under way, a large tow-rope pull is more important than propeller efficiency, and a large pull is obtainable by raising the steam inlet.

The tug of 850 i.h.p. normal could only use 740 i.h.p., or 87 per cent. of her full power, at 3 knots. By supercharging, however, she can use 990 i.h.p., or 17 per cent. above her normal power.

The Motor Tug.

Three types of motors are considered—with 145, 200 and 240 r.p.m. The first corresponds to a heavy Diesel engine, as recently installed in large trawlers and tugs, and that at 240 r.p.m. to high-speed Diesel engines fitted in some salvage tugs.

The first step is to decide what power is required at the different r.p.m. to accomplish the same work as the steam tug of 850 i.h.p. at 110 r.p.m. In order to enable the effect of the dimensions of the vessel to be disregarded at first, the same work is here defined as "giving approximately the same thrust horse-power over the range of towing speeds considered".

The propellers chosen for the motors are those giving the best efficiency at a towing speed of 8 knots. Particulars of these propellers are given in Table III., the ratio of pitch to diameter being 0·60 in all cases. For the slow-running motor a somewhat larger ratio, and for the fast-running

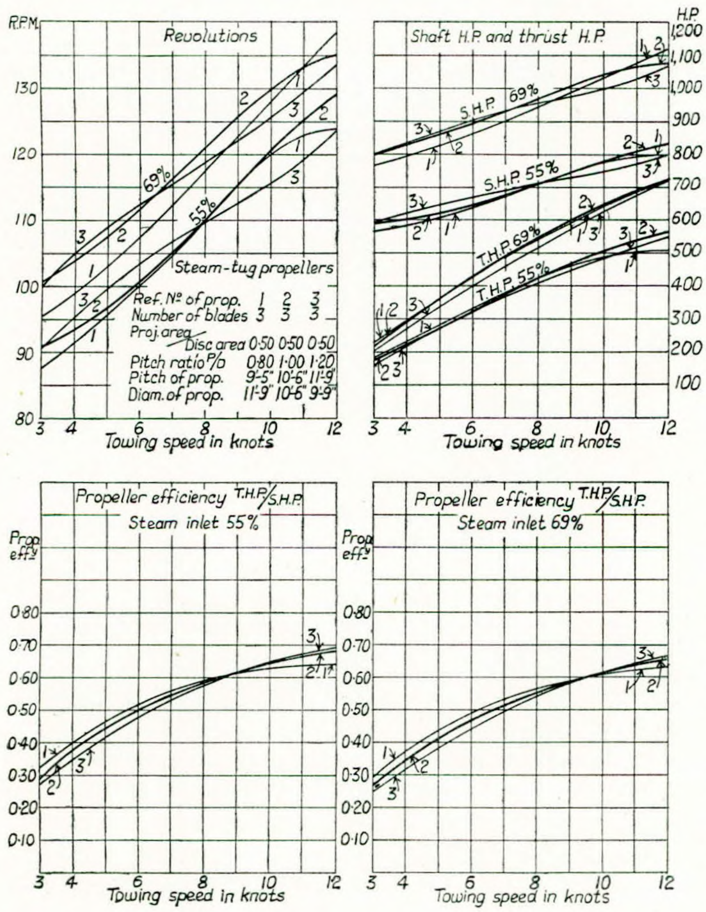


FIG. 2.—Choice of Propeller for Steam Tug.

motor a smaller one, might be taken without affecting the conclusions. With these propellers, the motors give their normal power on normal revolutions at 8 knots towing speed. The normal

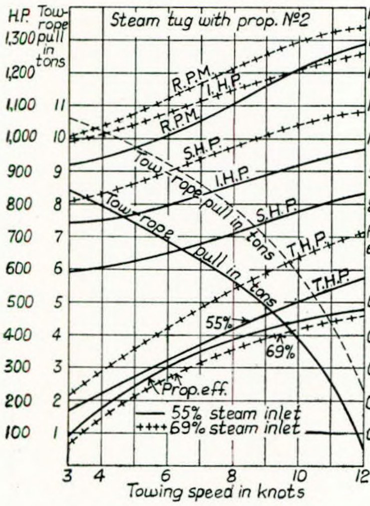


FIG. 3.—Effect of altering Steam Inlet.

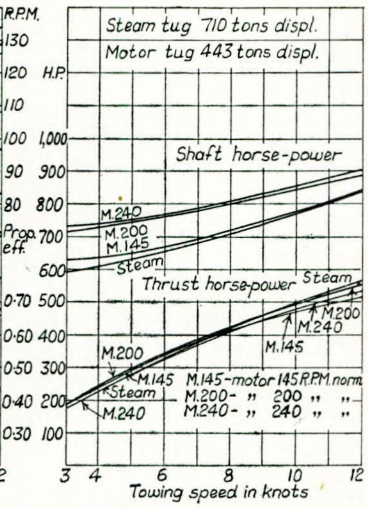


FIG. 4.—H.p. of Steam and Motor Tugs (Towing).

power is 725 s.h.p. (750 b.h.p.) at 145 r.p.m., 800 s.h.p. (825 b.h.p.) at 200 r.p.m., and 810 s.h.p. (835 b.h.p.) at 240 r.p.m. These motors do not give exactly the same thrust horse-power at 8 knots, but the average for all speeds is practically the same, the greatest difference being about 3 per cent.

TABLE III.—PROPELLERS FOR MOTOR TUG.

Normal r.p.m.	145	200	240
Projected area of blades / Disc area	·25	·25	·25
Diameter	10ft. 10in.	9ft. 0in.	8ft. 0½in.
Pitch	6ft. 6in.	5ft. 5in.	4ft. 10in.
Pitch / Diameter ratio	·60	·60	·60

Comparison of Single-screw Steam and Motor Tugs.

The curves of thrust horse-power for the steam engine and the three motors shown in Fig. 4 lie close together. Taking the thrust horse-power as a measure of the work done, we may safely say that we are able now to compare the steam engine and motors on a basis of equal work. The shaft horse-power required to do this work is highest for the fast-running motor and lowest for the steam engine, the values at 8 knots corresponding to the normal power stated in the foregoing.

Fig. 5 gives the r.p.m. at different towing speeds and the r.p.m. as a percentage of the normal number. As we have kept the turning moment constant at all speeds, the same curves give the s.h.p. as a percentage of the normal s.h.p. The percentage is highest for the fast-running motor at low speeds, and highest for the steam engine at high speeds. It appears that the motors with the propellers chosen give a good thrust at low speeds, which is essential—the more so as many motors for tugs are not fitted with a supercharging arrangement. From the propeller-efficiency curves of Fig. 5 it follows that this high thrust is not a result of high propeller efficiency, as the average propeller efficiency for the steam-driven vessel is considerably higher than for all three motors. It is true that the motor running at 145 r.p.m. has a higher propeller efficiency at low speeds, but only with a sacrifice in efficiency at other speeds, owing to its small-pitch propeller. This fact indicates that it is quite possible to get a good propeller efficiency at low speed even for a fast-running motor, but the higher the r.p.m. the lower will be the average efficiency.

Fig. 5 also shows another set of curves, viz., useful thrust per s.h.p., in kilogrammes. The useful thrust is the thrust of the propeller available to overcome tow-rope pull and ship resistance. They are, in fact, efficiency curves in a modified form, and represent the towing efficiency when ship resistance is neglected, which is often done in comparing towing capacity of tugs at low speed.

The lowest speed on the curves is 3 knots. For a towing speed this is a very low value, chiefly occurring while the tug is getting under way. In starting, the speed is zero. The thrust of the propeller in this case and at very low speed is important, to save time in starting. In many instances the towing trial of a tug is a pulling test, with the vessel held by a steel wire shackled to a

TABLE IV.—STEAM AND MOTOR TUGS PULLING OR PUSHING, WITHOUT SPEED.

Engine.	Steam Inlet.	Normal R.P.M.	Pitch/ Diam.	R.P.M.	S.H.P.	B.H.P.	I.H.P.	Pull, Tons.	Pulling Efficiency— Pull / S.H.P.	Pull / B.H.P.	Pull / I.H.P.
Steam engine	55%	110	·80	77	496		652	10·65	21·5		16·3
„ „	55%	110	1·00	82	531		682	9·90	18·6		14·5
„ „	55%	110	1·20	82	531		682	9·15	17·2		13·4
Steam engine	69%	110	·80	86	695		880	13·20	19		15
„ „	69%	110	1·00	92	742		925	12·35	16·6		13·4
„ „	69%	110	1·20	92	742		925	11·40	15·4		12·4
Slow-running motor ...	—	145	·60	119	587	620	855	11·20	19·1	18	13·1
Medium type	—	200	·60	169	672	702	950	10·85	16·1	15·4	11·4
Fast-running	—	240	·60	206	690	724	1,000	10·25	14·8	14·2	10·3

dynamometer. The pull per i.h.p. or b.h.p. is used as a measure of the pulling efficiency in such trials.

Table IV. contains the calculated figures of pulling without speed for the four engines under comparison. The motors give a very satisfactory pull owing to the small pitch ratio of their propellers. The effect of supercharging is indicated in the table. While the pull exerted by the steam tug is below that of the motors, the pull per s.h.p. is higher. This means a better efficiency for steam. Only the slowest-running motor shows a better figure than that of the steam engine with the chosen propeller. Here it is apparent that the choice of a high pitch ratio for the steam tug, as is usual in practice, is not advisable for tugs specially designed for very slow work. The pull on the tow rope or pushing force for the steam tug with high-pitch propeller and with steam inlet raised to 69 per cent. is only slightly better than that of the slowest-running motor without supercharging, while the pulling efficiency is decidedly lower.

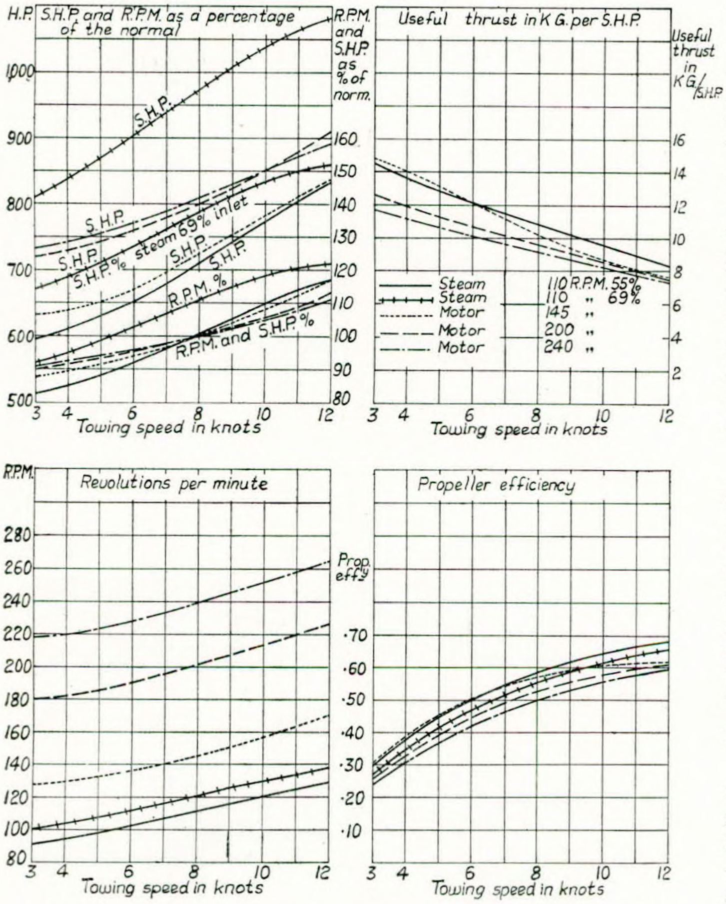


FIG. 5.—Revolutions, s.h.p., Propeller Efficiency and Useful Thrust of Steam and Motor Tugs (Towing).

So far, the size of the vessel has not entered into the question, as we have only compared on a basis of thrust horse-power and useful thrust. Now, although the thrust certainly is a measure of the power of a tug, the pull on the tow rope at different speeds really defines the towing capacity. To obtain this tow-rope pull from the useful thrust, the resistance of the vessel herself must be deducted.

The dimensions of the steam tug are known, and the resistance can be calculated. A motor tug has now to be designed of a size and displacement sufficient to carry the motor installation, oil fuel and stores.

For an absolutely fair comparison, the length of voyage for the steam tug and the motor tug ought to be the same. As, however, no owner will order a motor tug without securing the full advantage of small bunker space and weight, the motor tug has been designed for twice the length of voyage. A steam tug for a length of voyage far above 500 to 600 hours would become too large and heavy for her power, too slow in manœuvring in narrow waters, and not speedy enough for salvage purposes or for rescue work. In the case of motor tugs, no such reasons exist for limiting the length of voyage, the displacement being far below that of a steam tug even for twice the radius of action.

Particulars of the motor-tug design are given in the second column of Table I., and the general arrangement is illustrated in Fig. 6. The type of vessel is the same as when employing steam; but in order to keep the towing bitts well forward, the arrangement has had to be altered. The slow-running motor operating at 145 r.p.m. has been selected, as from the foregoing calculations the best results may be expected from this type.

For comparison, the tugs are taken at the mean displacement with the fuel and stores half consumed and without ballast. In this condition the displacement is 710 tons for the steam and 443 tons for the motor tug.

Fig. 7 gives the curves of resistance for both tugs at speeds from 3 to 12 knots, and includes the useful thrust of the propeller. Deducting resistance from useful thrust for each speed gives the curves of tow-rope pull. The curves for motors running at 200 and 240 r.p.m. are also shown, based on the same hull dimensions. For these, the displacement should be taken somewhat lower in accordance with the smaller engine weight.

The tow-rope pull of the 443-ton motor tug is at all speeds higher than that of the 710-ton steam tug. There is not much difference between the three types of motors. The tow-rope pull per s.h.p., or real towing efficiency, shows the superiority of the slow-running motor. At low speeds the steam tug is at its best, as then the resistance is of minor importance. That the good results of the motor tug are entirely due to smaller displacement becomes clear in comparing the curves for different displacements with those for the same displacement (see Fig. 7). The advantage of the motor tug disappears when the influence of the vessel's dimensions is disregarded.

Ocean-going tugs have frequently to make long return trips without tows, and the comparison between motor and steam tugs would be incomplete if this condition were not considered.

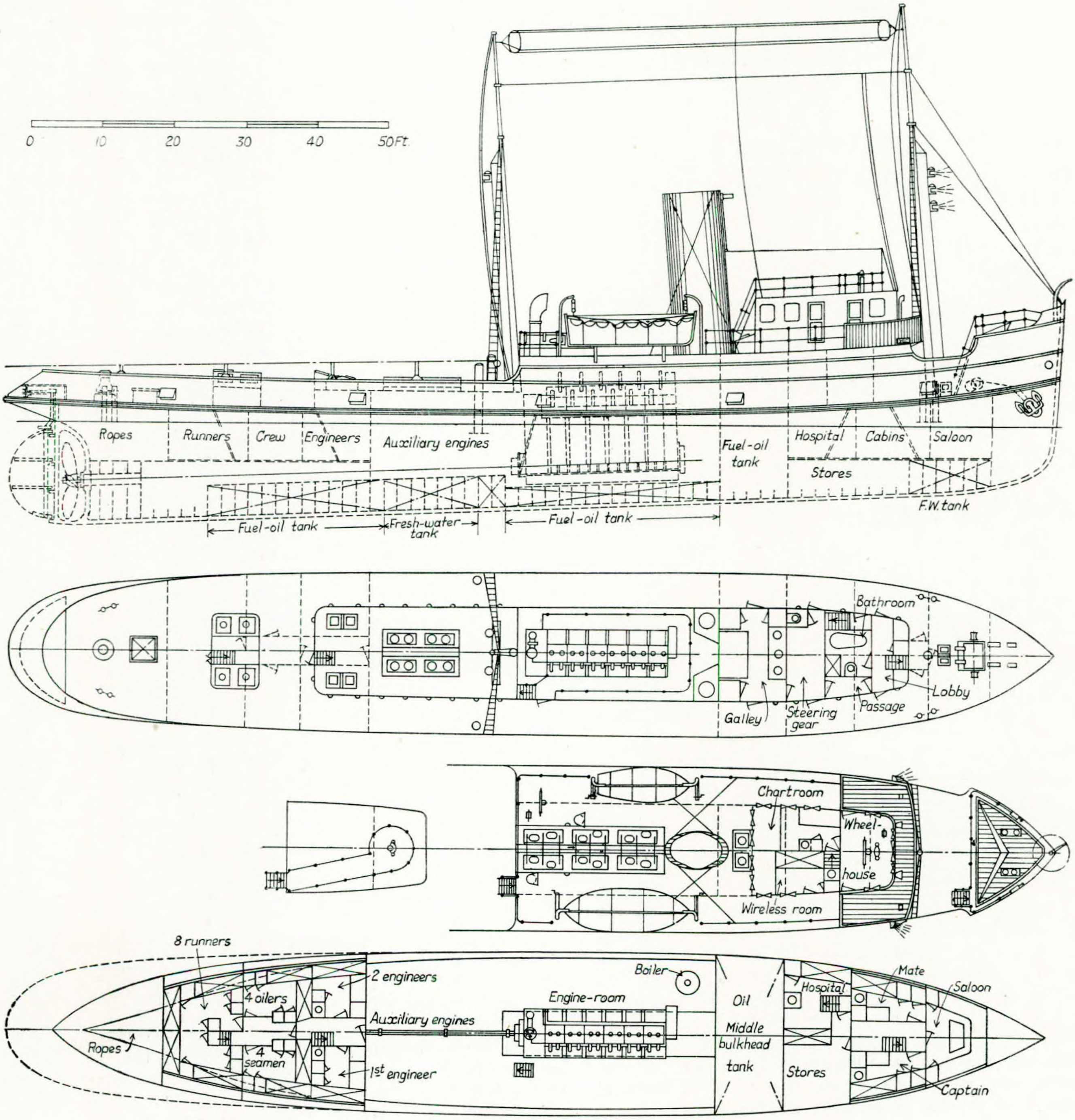


FIG. 6.—Sea-going Single-screw Motor Tug of 750 b.h.p.

The displacement is again taken with the stores half consumed. The turning moment of the engine is not now constant. The propulsion at a given speed requires a definite thrust of the propeller, which is delivered at a certain r.p.m. The propeller can only absorb a corresponding shaft horse-power, from which the turning moment is calculated.

The r.p.m. and turning moments, both as a percentage of their normal value, are shown in Fig. 8. The steam tug at 12 knots requires 93 per cent. of the normal turning moment with a speed of revolution about 13 per cent. above the normal, the s.h.p. and i.h.p. being slightly more than the normal power of the engine, so that the tug will be able to make 12 knots. The motor tug for 12 knots only requires 76 to 80 per cent. of the normal turning moment and 103 to 110 per cent. of the normal revolutions, or about 78 to 88 per cent. of the normal power. The speed of the motor tug will be well above 12 knots, running free, if it should be possible to increase the speed of the motors to this extent. The propeller efficiency for the steam tug is higher at all speeds, but the speed of the motor tug is higher for the same s.h.p. than that of the steam tug. The smaller displacement required more than makes good the defect in propeller efficiency.

When the engine efficiency has to be taken into account, the tugs must be compared on a basis of i.h.p. This is done in Fig. 8 for a motor of 145 r.p.m. and for the steam engine. The s.h.p. for the motor tug is lowest at all speeds, while the i.h.p. is the same for steam and motor.

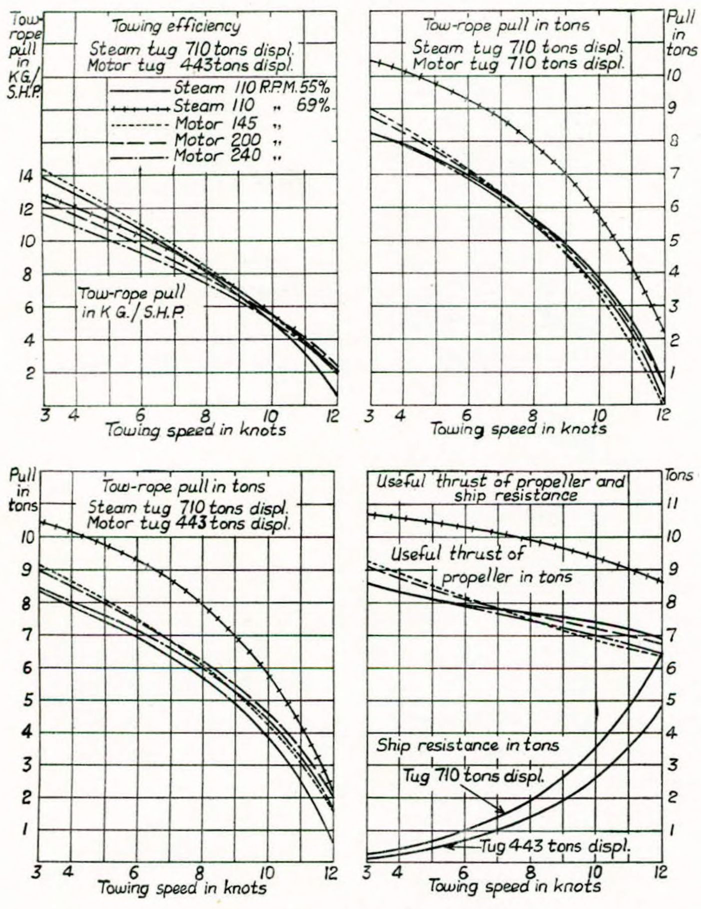


FIG. 7.—Two-rope Pull and Towing Efficiency of Steam and Motor Tugs—Influence of Size of Vessel.

When the displacement is the same, the advantage of the motor tug again disappears, and the power curves give considerably higher values for all speeds compared with those for steam (see Fig. 8). The engine efficiency is given in Fig. 9.

One of the first considerations in designing a sea-going tug is to decide on the position of the towing bitts. The usual place based on experience is at about 43 per cent. of the length between perpendiculars, measured from the rudder-post. This position allows easy steering and manœuvring with a vessel in tow. In a steam tug the engine-room is abaft the towing bitts, and the tow rope passes over the engine-room skylight. In a motor tug, the greater height of the engine makes it necessary to place the main motor in front of the towing bitts. This limits the power of a single-screw motor tug to about 900 to 1,000 b.h.p., and leads to the adoption of the twin-screw arrangement for higher powers, while steam tugs can develop about 1,500 i.h.p. with a single screw.

The centre of gravity of the motor is higher, but that of the fuel can be placed lower than in a steam tug; considerations of stability need not, therefore, play a part in deciding between steam and motor. The difference in draught with bunkers full and empty is smaller in a motor tug than in a steam tug, which must be considered advantageous to the former.

The question of auxiliaries and heating in a motor tug is the same as in other motorships. With the present development of electrical auxiliaries, it is entirely a matter of first cost.

The manœuvring quality of the engine is of great importance. In this respect the steam engine is nearly perfect. The revolutions can be regulated between zero and the maximum. The engine may be started, reversed and stopped innumerable times with absolute reliability. This is certainly not the case with the motor, although much has been accomplished in this direction. The number of manœuvres of a motor tug is limited by the capacity of the air vessels, which must be very large to suit a tug under all possible conditions.

The number of revolutions, too, cannot be reduced below a certain limit, 30 r.p.m. being about the lowest figure given for motors with a normal speed of 150 r.p.m. The speed of the motor tug alone at 30 r.p.m. will be about $2\frac{1}{2}$ knots, and it must be decided in each case if this is sufficiently low.

Another important consideration is the backing power. The advantage in this respect will be with the largest propeller, so far as the author's experience goes.

The displacement of the tug, which, according to the calculations, greatly affects the tow-rope pull and the towing efficiency, has a further influence which cannot be stated in figures. When towing in a seaway, at one moment the tug meets a wave and at the next the tow meets the wave, which tends to retard progress. The momentum of the tug lessens the retarding effect of the passing waves. Under such conditions a tug of large displacement will keep her speed better than a smaller one. In the steam and motor tugs compared, the displacement of the former was 60 per cent. larger than that of the latter. This effect to a certain extent will counteract the advantages of small displacement, which are considerable in fine-weather conditions.

The storage of oil in large quantities presents no difficulty. By fitting a double bottom and tanks under the crew's accommodation (fore and aft if required), the oil bunkers will have a capacity for a length of voyage many times that of the steam tug, while there will still be sufficient space under deck for the accommodation.

The engine foundation and general construction in the engine-room must be heavier in a motor tug, and the construction of the oil bunkers is costly. This is partly compensated, however, by the smaller dimensions of the fuel bunker. The hull of a motor tug of the same dimensions will cost a little more than that of a steam tug.

The number of spare parts for a motor tug will be larger, and this extra cost has to be borne in mind when the price of the engine installation is being considered.

Conclusions.

From the calculations and diagrams, it follows that the deciding factors for the economical use of the power installed in a tug are revolutions, displacement, and the possibility of supercharging. The influence of these, taken separately, appears to be as follows :—

The higher the number of revolutions, the lower the average propeller efficiency.

The smaller the displacement, the higher the towing efficiency and the higher the speed running free.

The better the possibility of supercharging, the better the tug can adapt herself to varying conditions. In addition, supercharging at low speeds permits the choice of a propeller giving a good efficiency at high speeds.

In comparing an *ocean-going steam tug and a motor tug,* we have a case of approximately equal powers on different displacements. According to the diagrams, the motor tug, even with a comparatively high engine speed, is decidedly better in tow-rope pull, towing efficiency, and speed when running free than the steam tug. The motor tug shows this better result with a length of voyage

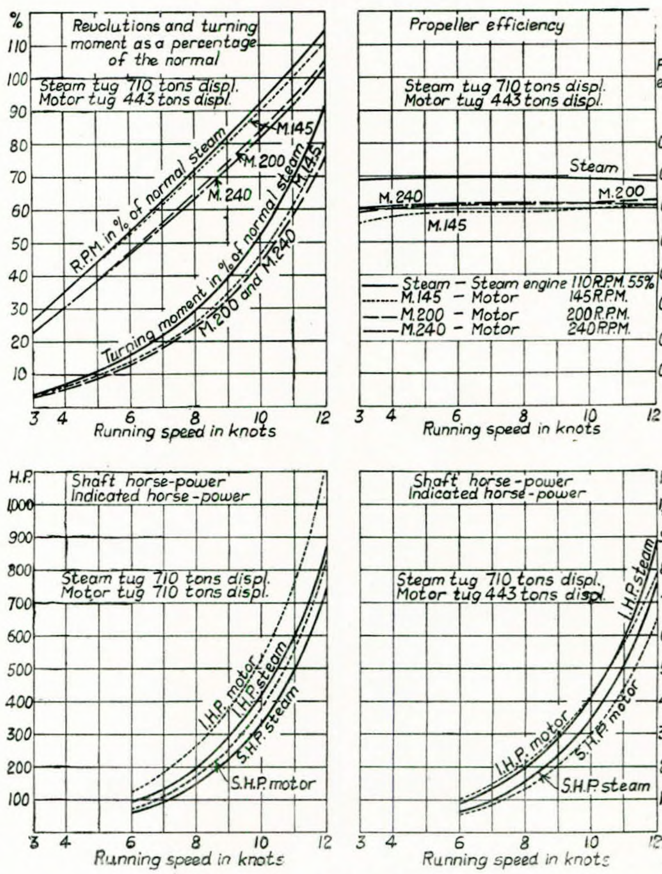


FIG. 8.—Steam and Motor Tugs running Free.

twice that of the steam tug, which enhances the superiority of the former. How far this conclusion is affected by bad weather can best be decided by men experienced in deep-sea towing. If the motor is not provided with a supercharging arrangement, at low speeds the steam tug will probably be superior, especially in bad weather when progress is retarded by head wind and waves. Under such conditions the resistance of the tug is of secondary importance, and the larger displacement of the steam tug may become an advantage when towing in a rough sea.

In comparing a *harbour motor tug and a steam tug,* with small bunker capacities, the case is one of approximately equal power and displacement, but of different r.p.m. Now, the tow-rope pull, towing efficiency, and speed when running free are higher for the steam tug with the lower number of revolutions; while the capacity of supercharging and the manœuvring qualities are at least as good as those of the motor tug, if not better. There seems to be no reason, therefore, to substitute motor tugs for steam tugs for harbour duty, unless instant readiness and saving of fuel consumption when lying idle are very important.

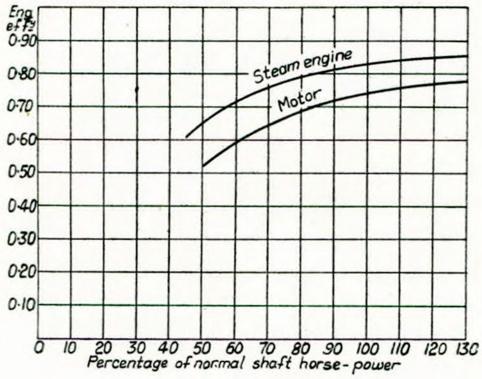


FIG. 9.—Engine Efficiency.

Nevertheless, there are some special cases where motor tugs for harbour work might be preferable. For small powers the motor is often lighter and cheaper than a steam plant, resulting in a smaller vessel, while the fitting of a reverse gear allows the use of a simple non-reversing engine and facilitates manœuvring. For such powers a motor tug has much to recommend it. In the case of tugs used in harbours to push vessels in place alongside quays, large power on small hull dimensions is essential, and efficiency is of secondary importance. With a twin-screw arrangement, large power can be fitted in a very small motor tug; and with propellers specially designed for this work, a high tow-rope pull or pushing force is obtained (see Table IV.).

In cases where the size of the propeller is limited by the draught, it may happen that the small propeller diameter suits the high-speed motor better than the slow-running steam engine, and the efficiency of the motor tug exceeds that of the steam tug.

The *coasting tug with moderate bunker capacity,* say, for about 200 hours running at full speed, comes midway between the ocean-going and the harbour tug. Consequently, the conclusions cannot be so definite as in the extreme cases. There is, however, one point worth mentioning in this connection. It is possible to design a coasting motor tug of, say, 500 to 600 b.h.p. with a bunker capacity for a length of voyage equal to that of an ocean-going steam tug. Such a tug, although too small for heavy deep-sea towing, will be admirably suited for long voyages with a light tow, for which otherwise an ocean-going steam tug would be required—not because of her large power, but because of her bunker capacity. For these voyages a small motor tug would be more economical than a large steam tug.

For purposes of *salvage and rescue,* the instant readiness and high speed in proceeding to the assistance of a ship in distress, combined with the large sphere of action, are in favour of the motor tug. When fitted with a supercharging device, a motor tug can hardly be beaten by a steam tug for heavy pulling work.

When the technical phases of the subject have been reported on by a naval architect along the lines indicated, it rests with the prospective owner to ask for tenders for the designs compared, and to calculate the comparative earning capacity of each. In this calculation all the points eliminated at the beginning will receive due consideration, viz., first cost, fuel consumption per horse-power, price of fuel, wages, repair accounts, etc. The results will differ for different places and different times. The time is past when considerations of reliability alone and a general feeling in favour of steam were the deciding factors.

High-powered Twin-Screw Motor Tugs.

Of late, some high-powered motor salvage tugs have been placed in service; and although experience with these vessels only covers a short period, the results seem to be satisfactory, and the competition is being keenly felt by steam-tug owners. For these reasons, a rough design was made for a high-powered twin-screw motor tug (see the third column of Table I. and Fig. 10). To provide a basis for comparison, the displacement was taken as the same as for the single-screw steam tug of 850 i.h.p., but with a hull of greater length and finer form to suit the higher speed.

This hull can take two motors of 810 s.h.p. (or 835 b.h.p.) at 240 r.p.m., this being one of the types used in the comparison with steam for the single-screw tugs. The bunker capacity is sufficient for 1,000 hours running at full power. The maximum speed running free without supercharging will be about 14·5 knots.

To limit the number of calculations, the same propeller was taken as before, with a speed ratio of 0·60. In accordance with the twin-screw installation, the wake was estimated at half the value of the single-screw, and the resistance augmented with that of the propeller struts.

Fig. 11 shows curves for this tug over a range of towing speeds of from 3 to 12 knots.

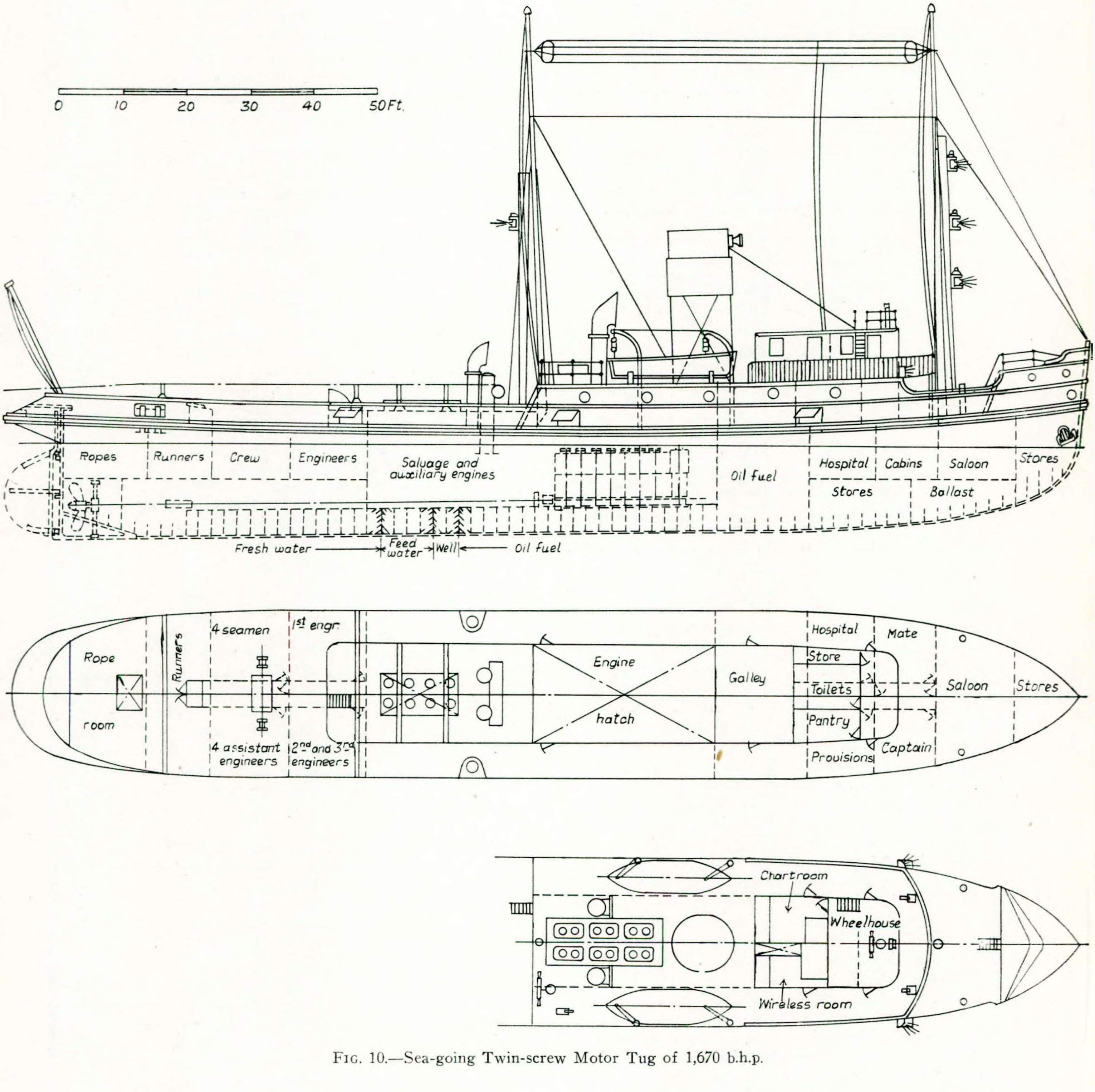


FIG. 10.—Sea-going Twin-screw Motor Tug of 1,670 b.h.p.

and Fig. 12 indicates the tow-rope pull and towing efficiency for comparison with the steam tug with normal and maximum steam inlet. The average towing efficiency of the motor tug is approximately the same as for the steam tug. In fact, the curves would coincide if the pitch of the motor propellers were taken somewhat higher. The tow-rope pull amounts to nearly 18 tons at the lowest speed, and at the high towing speed of 12 knots equals that of the steam tug at 7 knots. The large displacement, tow-rope pull and bunker capacity, combined with the high speed running free and good towing efficiency at all speeds, make the vessel suitable for deep-sea towing as well as for salvage work.

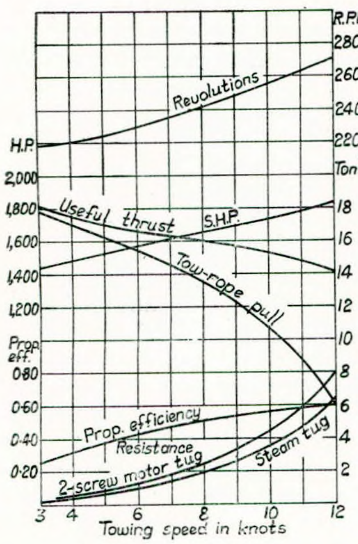


FIG. 11.—Twin-screw Motor Tug.

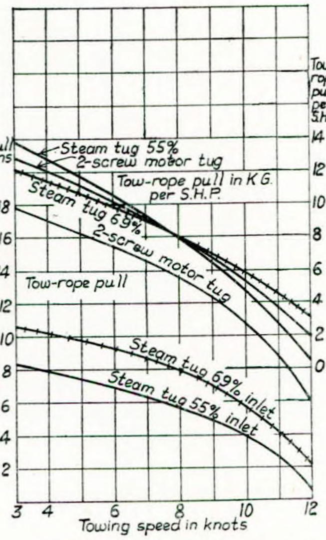


FIG. 12.—Comparison between Twin-screw Motor Tug of 770 tons Displacement and Single-screw Steam Tug of 710 tons Displacement.

Twin-screw motor tugs of this type have been built up to 1,800 b.h.p., with supercharging up to 2,400 b.h.p., and with a speed of over 16 knots.

Note.—The propeller results used for the calculations are those of Dr. Schaffran for three-bladed propellers. For four-bladed propellers, which are more common in tugs, the conclusions will be the same, but the propeller efficiency may be expected to be somewhat higher.

New Materials and Methods in Naval Construction.

(Introductory note to the June number which deals extensively with various recent developments).

"Bulletin Technique du Bureau Veritas", June, 1932.

The new French cruiser "Algeria", built for a speed of 32 knots, is yet able to carry much heavier armour than previous vessels of her class (10,000 ton cruisers). This result has been made possible by recent improvements in methods of construction and materials, which allow a great reduction in the weight of hull and machinery.

The limits imposed by the Washington Conference on the tonnage of various classes of war vessels have acted as a wonderful stimulant to progress in weight reduction.

According to published figures, 550 tons was saved on the hull of the "Deutschland" by the use of welding. Similar methods on the American "Salt Lake City" class resulted in 850 tons saving. The hull weight in each case is about 4,000 tons, so that the saving represents 14 per cent. on the former vessel and 20 per cent. on the latter. Naturally, such results can only be obtained when price is only a secondary consideration.

In the mercantile marine, where price is of first importance, naval development can only be followed at a distance, but progress in metallurgy, arising from the needs of naval vessels, has already made possible some reduction in the weight of hull structure on other types of ships. Everything tends to point to the assumption that the extension of the use of welding will lead to considerable saving on cargo and passenger ships, and already on two Hamburg-America liners saving in weight of about 4 per cent. has been realised.

At the moment, the great problem is to combine welding with metallurgical developments to the best advantage; many special steels owe their properties to heat treatment, and it is difficult to raise them to a welding temperature without destroying at least a part of their quality. It is a difficult problem, but with the help of disarmament conferences it will no doubt soon be solved.

Oil-Coal Fuel for Steamships.

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Assoc. R.S.M., F.I.C., M.Inst. C.E., &c., Past-President of the Institution of Mining Engineers, &c.

"The Engineer", 15th July, 1932.

Now that the Cunarder "Scythia" has got back to Liverpool from her voyage across the Atlantic, a few more details about the result of her experiment on the use of a mixture of coal and oil instead of oil alone for firing one of her boilers are available. The idea that a mixture of oil with finely ground coal, in such proportion as not to increase beyond reasonable limits the viscosity of the oil, should be a practical possibility as a boiler fuel has for some time past been present in men's minds and has, from time to time, been made the subject of experiment, not, as a rule, attended with any great measure of success. The idea was clearly and definitely voiced by a well-known North-country mining engineer, Colonel W. C. Blackett, some nine months ago, at a meeting of the North of England Institute of Mining and Mechanical Engineers. Colonel Blackett's words were as follows:—"Even if it were desired to avoid all the dust nuisance in ships, could this not be done, on the fifty-fifty principle mentioned, by oil and coal-dust mixed and pumped into tanks as now are used? It would seem a comparatively simple task for such brains to prevent the dust settling out of the oil and keep the mixture pumpable. After all, this would use half coal. and who knows whether much more than half could be used in the form of the 'paste' mentioned and pushed as such, instead of pumped as oil"?* This suggestion was evidently very close to the accomplished facts, because the mixture actually used on the "Scythia" is stated to have been 40 parts of coal to 60 parts of oil. No doubt such a mixture would be slightly lower in calorific power than oil by itself, seeing that the calorific power of oil averages about 19,000 B.Th.U., whilst the calorific power of coal averages only about 14,000 B.Th.U. On the other hand, fuel oil, taken even at a cost as low as 1½d. per gallon, would cost about 31s. per ton, whilst bunker coal averages about 13s., so that the B.Th.U. in the form of coal is cheaper than in the form of oil, and, therefore, such a mixture would be more economical than oil alone with respect to the heat units which it is capable of generating. Of course, the cost of grinding the coal to the requisite degree of fineness must be added, but if this operation is performed on a reasonably large scale the cost should surely not exceed 5s. per ton, and might even come down to half that price, depending largely upon the character of the coal that is used. It need hardly be said that the whole problem consists in grinding the coal fine enough, and it is only within the last few years that mills for such purposes, generally spoken of as "colloidal mills", have been available as ordinary commercial appliances.

It may be emphasised here that the term "colloidal" is used in its strictly modern sense rather than in the sense in which the word was originally intended. Perhaps it would be more strictly correct to speak of the coal as a "suspensoid" rather than as a "colloid"; the latter term was invented by the late Thomas Graham in 1861, and first used in a remarkable paper in which he divided all substances into the two classes of crystalloids and colloids, but more recent research has shown that Graham's distinction is not strictly tenable, and to-day the term colloid is generally applied to any body in an extremely fine state of division. The degree of fineness varies to some extent with the substance, but is generally below 10 microns (1 micron=0·00004in.). It follows from the established laws of physics that very minute particles when suspended in a fluid have a very small tendency to fall to the bottom of the containing vessel; such particles obey the law that was formulated a good many years ago by Stokes, the latest form of which, as quoted by Lunnon, is $v=54{\cdot}5\, d^2\frac{s-r}{\eta}$,† where v is the velocity of fall, d is the diameter of the particle, s and r are the specific gravities of the particle and the fluid respectively, η the viscosity of the fluid in dynes per square centimetre. All the above are expressed in C.G.S. units. It would follow from this law that the velocity of fall decreases the greater the viscosity of the fluid, and the smaller the diameter of the particle; but, nevertheless, there would always be a certain definite falling velocity in all cases. The above equation applies, however, strictly speaking, only to free-falling spheres, and the velocity of fall in the case of hindered falling, which must be the case of the mixture now under consideration, must necessarily be very much slower, though how much is really not yet properly known. Again, the crushing of coal does not produce spheres, but irregularly shaped particles, and in any particle, not a sphere, the proportion of surface to mass is necessarily greater than in the case of a sphere. This fact implies increased resistance to fall, and therefore again will slow up the particle, though to what extent is not definitely known as yet. All that we can definitely predicate to-day is that a collection of very numerous particles of crushed coal will fall at a very much slower rate than Stoke's formula would assign to a single spherical particle. The viscosity of oil varies within very wide limits and is largely effected by its temperature, s and r may without serious error be taken as averaging 1·25 and 0·9 respectively, so that obviously even if Stoke's law alone were effective, the rate of settlement must be extremely slow. There are, however, other forces operative. First of all, the oil may be taken as always containing truly colloidal bodies which will keep the particles of coal in suspension, whilst, furthermore, a number of minute particles will be animated by the Brownian movement, which keeps them in motion and prevents their cohering, this latter action being further intensified by the viscosity of the medium in which they are suspended, whilst the convection currents that must necessarily exist in a fluid mass may also help to keep the particles from settling. The facts reported by the authorities concerning the mixture on board the "Scythia" appear to bear out these theoretical considerations, seeing that it is stated that there was no sign of deposit in the tanks containing the fuel mixture.

We are further informed that there was no

* "Trans.", Inst. Min. Eng., Vol. LXXXII, 1931, page 230.

† "The Laws of Motion in a Fluid", by R. G. Lunnon. "Trans.", Inst. Min. Eng., Vol. LXXVII., 1928, page 68.

difficulty at all in pumping the fuel. Another advantage which was demonstrated was that the combustion was quite complete, and that there was no deposit on the decks of the vessel. The only drawback shown on the trip of the "Scythia" was that the jets of the burners had to be cleaned about twice as often as they would have been had oil alone been burnt. As some 150 tons of the oil-coal mixture were burnt on this trip of the "Scythia", the experiment was obviously conducted on a sufficiently large scale to be reasonably conclusive. It is, however, too early to say whether there would be any settlement of the coal out from the mixture on a much longer trip or whether the motion of the vessel had any effect, injurious or otherwise, on the behaviour of the mixture. Such points as these can only be decided by an experiment extending over a much longer period of time and under a wide variety of conditions, but it can fairly be claimed that the first experiment at any rate has proved to be a complete success and definitely encourages further investigation. Nevertheless, it is well to bear in mind that the experiment is still in quite the early stages, and it is impossible to-day to pronounce definitely upon its technical success or otherwise, whilst the economic value of the oil-coal mixture still remains to be demonstrated.

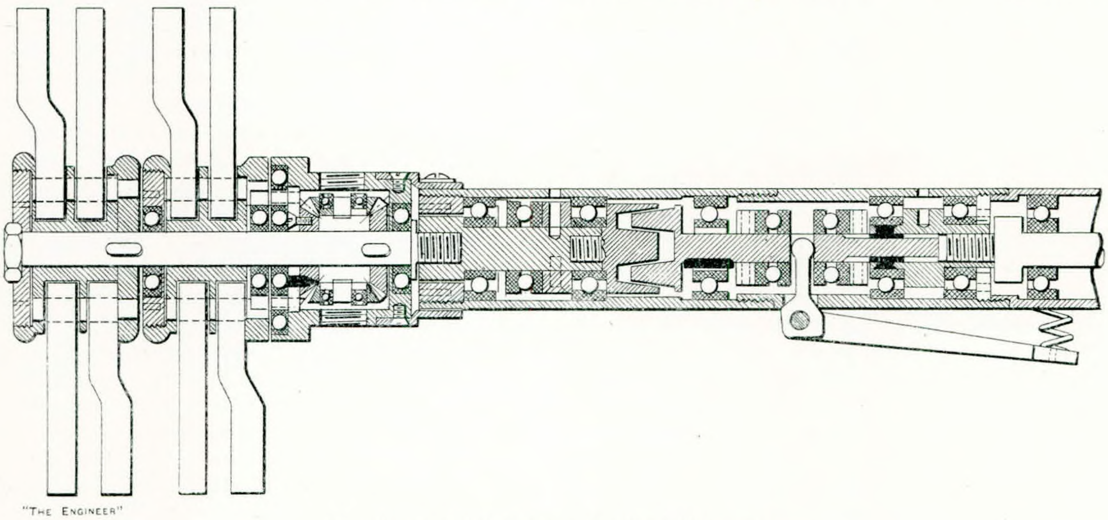
Obviously, the main interest to this country in the successful use of an oil-coal mixture instead of oil alone for firing boilers must lie in the possibilities thereby opened out of increasing our consumption of British coal, and correspondingly diminishing the consumption of oil, practically the whole of which has to be imported. The world's consumption of coal within the last few years has decreased, but not very greatly, whereas the British share in the supply of this coal has fallen off very severely indeed. There are, of course, a large number of causes that have contributed to this result, but among these causes must certainly be included the very obvious fact that oil is more and more taking the place of coal as a fuel. Take one instance (though a very pregnant one) only. In 1922 the proportion of coal-fired boilers to oil-fired boilers in sea-going vessels was more than 3 to 1, whilst to-day it is less than 2 to 1; and the tonnage of motor-driven vessels to-day is more than six times as much as it was ten years ago. This fact has affected this country particularly, because a few years ago we practically supplied all the world's bunkering coal, and it is obviously this trade which has suffered so severely by this competition of oil. If the oil-coal fuel proves to be a technical and economic success, part of this lost trade may well be recovered; it may, however, be surmised that an entirely different class of coal will reap the benefit. In the past the coal preferred for steamship use was a very hard coal like the smokeless steam coal of South Wales, but, if an oil-coal mixture is to be used in the future, it appears probable that the softer coals, and those more easily and more cheaply ground to a fine powder will naturally be preferred. Other things being equal, it is quite obvious that a hard coal will occasion more wear and tear to the grinding appliance than will a soft coal, and will therefore on this account alone be dearer to grind, whilst it is highly probable that the power consumption of the grinding machine will be less and its output be greater, the softer the coal that it is called upon to grind. It is also evident that a coal low in ash will be selected, and here a cleaned small coal—preferably perhaps dry cleaned—will receive the preference. Another advantage of this mixed fuel would be that it will enable collieries to get rid satisfactorily of that portion of their output which is the most difficultly saleable to-day, namely, the very small coal, say, under ½in. Whilst such small coal, if of coking quality, commands a reasonable market, the smalls of non-coking coal are very nearly unsaleable under present conditions, and this new method appears to promise a satisfactory means of disposing of this product. It is therefore from every point of view incumbent upon colliery owners to aid in bringing these experiments to a successful conclusion.

Apparently any class of coal may be used to make the mixture if sufficiently finely ground. As the mixture which the "Scythia" employed was made by the Wallsend Slipway and Engineering Company, Ltd., it was naturally North Country coal that was used, but this is no proof that coal from other coalfields would not give equally satisfactory results. The Institution of Mining Engineers has recently established a Committee for the express purpose of investigating all possible uses of coal and coal products, and it is practically certain that this new method of using coal will come within its purview. As has already been stated, the outlook is a distinctly promising one, and if this oil-coal fuel really proves successful, it assuredly gives good grounds for hoping that it may help this country to regain a portion, at any rate, of the coal export trade which it has lost of late years. The present grave condition of the coal industry should certainly encourage colliery engineers to put forth their utmost energies to make oil-coal fuel a complete success, both technical and economic.

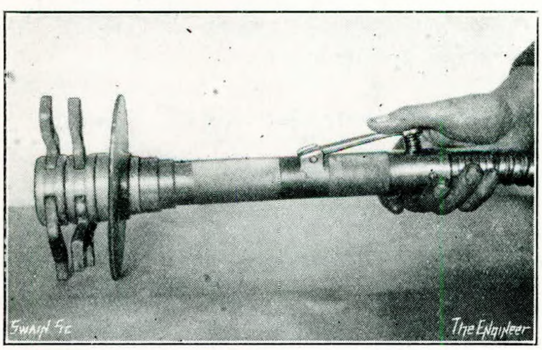
A New Hand-Controlled Rotary Scaling Hammer.

"The Engineer", 15th July, 1932.

Up to the present the extended use of rotary scaling hammers has been somewhat retarded by the difficulty experienced in their operation. In most designs the hammer elements are arranged to revolve in the one direction, with the result that the tool when in operation tends to run on the surface of the work and must be held up to the plate. Nevertheless, with a good design of hammer it is possible to remove rust from a metallic surface at the rate of about 400 sq. ft. in eight hours, compared with, say, 32 sq. ft. possible with hand scaling. We have recently received particulars of the patented rotary scaling hammer illustrated herewith. With this hammer it is claimed that a practised operator can in eight hours remove heavy rust from 1,600 to 2,100 sq. ft. of surface. The hammer differs from other designs, in that the rows of elements revolve in opposite directions. In the small hammer illustrated below there are six elements, while in the larger size twelve are employed, which deliver 36,000 blows per minute, removing the rust very equally. The opposed motion of the adjoining series of hammer elements does away with the running above referred to, as the pressure is thereby equalised, which enables the tool to be worked with one hand. The possibility of damage to edges and gaps in plates is avoided and it becomes possible to work with the tool on the thinnest of sheets without damage being done to the material. The heads of rivets and the spaces between the rivets, also the inequalities and pores caused by corrosion, are cleaned as easily as in the case of flat plates. The same applies to boiler plates, corrugated furnaces, and pipes. The opposed motions of the hammer elements assist in cleaning thoroughly the surface to which the tool is applied.



Hand-controlled Rotary Scaling Hammer.



Scaling Hammer.

The control of the tool is effected by a small lever pressed by the thumb, which places the hammer in and out of operation and saves the necessity of switching off the driving motor. The patented coupling, as will be seen from the drawing, consists of two concentrically arranged double-cone or taper rings which fit accurately within each other and are kept together by the pressure exerted on the lever. During the moment of establishing contact the slight resistance sets up a layer of compressed air between the surfaces, which has the effect of freeing the surfaces in contact as soon as the pressure on the lever is released. The male part of the coupling is fixed to the end of the flexible shaft, which is carried in ball bearings in the normal manner. This part of the coupling is pressed into the female part by means of the spherical end of the bell crank thumb-operated lever, the thrust being taken by ball thrust bearings. When the lever is pressed down the drive is transmitted through the cone coupling to the hammers, the reverse motion for the inside set of hammers being obtained from the differential arrangement of gear wheels shown. The outside sets of hammers run in the direction of the driving shaft and the inside sets in the opposite direction.

The coupling above described is suitable, it is claimed, for a wide range of machines and instruments, including motor cars and braking devices. It may be remarked that in the case of the coupling for the scaling hammer it has been found possible to control the power from a 14 b.h.p. motor quite easily. The advantage of the coupling would appear to consist in its very soft starting and stopping characteristics without endwise movement, thereby enabling a large friction surface to be accommodated in a very small space. This can be accomplished by introducing more than two concentric rings or by lengthening the tapered parts. The coupling has been shown, we are informed, to operate in a reliable manner under all working conditions.

Trial Flight of Large Flying Boat.

"The Engineer", 15th July, 1932.

On Monday, July 11th, the great six-engined flying boat built by Short Brothers, and launched rather more than a fortnight before, demonstrated its qualities in a trial flight over the Medway. The machine, fully loaded, weighs 33 tons. It is a biplane fitted with six Rolls-Royce Buzzard engines, each giving 825 h.p. The engines are placed in tandem pairs between the wings, so that there are in all three tractor and three pusher air screws. The wing span is 120ft., and the total height 30ft. 4in. The tail is of monoplane construction, the rudder being single. The machine is constructed principally in duralumin; but parts below the water line are made of stainless steel. The hull is 89ft. 6in. long and the forward part is fitted with portholes and provides spacious quarters for the crew of ten. There are four machine gun cockpits. One is in the bows forward of the pilot's cabin and another aft of the tail. The other two are placed amidships, one on each side. The petrol tanks are carried in the upper wing and are of sufficient capacity to give the machine a long range. On Monday the flying boat was not fully loaded, but even so it was a creditable performance to get the machine into the air 13 sec. after the beginning of the take-off. The machine demonstrated on the water its ease of control, circling to port and starboard and answering the rudder readily, even when running across the 20 m.p.h. wind that was blowing. Major H. G. Brackley, air superintendent of Imperial Airways, who accompanied the pilot, Mr. J. Lankester Parker, on the flight, declared that the boat was as easy to control as the Kent type, which is well known to be easy to fly.

From Steam to Sail.

"The Engineer", 15th July, 1932.

SIR,—To the interesting list of steamships converted to sail, mentioned by Mr. G. Aylmer in his article in your issue of July 1st, page 9, should be added the historic "Archimedes", built in London by Wimshurst in 1838 for the Smith's Patent Propelling Company, to demonstrate the advantages of the screw propeller of Sir Francis Pettit Smith. This was the vessel which was tried under Brunel's supervision and the performances of which led him to discard the paddle wheels being constructed in 1843 for the "Great Britain", to which Mr. Aylmer refers, and to fit that ship with the screw. The particulars of the "Archimedes" are given in many books, including the catalogue of the Merchant Steamers, of which there are models or illustrations, in the Science Museum. None of these books, however, give the history of the ship. But from the records of Lloyd's Register, it is seen that in November, 1847, the vessel was surveyed at Sunderland for damage repairs, and at the same time her machinery was removed and she was converted to a sailing ship. In August, 1852, she was surveyed on account of change of ownership, and she was reported to have been supplied with one new set of sails and a great deal of new running rigging. In 1854 or 1855, her classification lapsed and her name shortly afterwards disappeared from the Register Book. The "Archimedes" has a place in history beside F. Symington's "Charlotte Dundas", Fulton's "Clermont", Bell's "Comet", and Parsons' "Turbinia", and it would be of considerable interest to know what was the end of her.

July 11th. HISTORICUS.

End of the Manchester Steam Users' Association.

"The Engineer", 22nd July, 1932.

On Friday of last week it was made known that the Manchester Steam Users' Association, which has done pioneer and useful work for over seventy-seven years, has terminated its separate existence and has merged its interests with those of the British Engine, Boiler, and Electrical Insurance Company, Ltd., which company will take over the Association's liabilities, its staff, and its pension arrangements. The Association was founded in 1854 by Sir William Fairburn, Bart., M.Inst.C.E., F.R.S., Sir Thomas Bazley, Bart., Sir Joseph Whitworth, Bart., M.Inst.C.E., F.R.S., Mr. Henry Houldsworth, and other gentlemen for the purpose of preventing steam boiler explosions by competent scientific inspection of boilers. The first inspector was the late Mr. R. B. Longridge, who in 1859 proposed the issue of an insurance policy as a guarantee of efficient boiler inspection. The Committee of the Association did not, however, agree with this proposal, and Mr. Longridge forthwith started the first boiler insurance company, now the Vulcan Boiler and General Insurance Company, Ltd., of Manchester. The annual memorandums of the Chief Engineer of the Manchester Steam Users' Association, notably those of Mr. C. E. Stromeyer, M.Inst.C.E., were, over many years, eagerly read as important contributions to the theory and practice of boiler operation. These memorandums were ably continued by the late Dr. Telford Petrie, who followed Mr. Stromeyer, and by Mr. V. B. Harley-Mason, his successor.

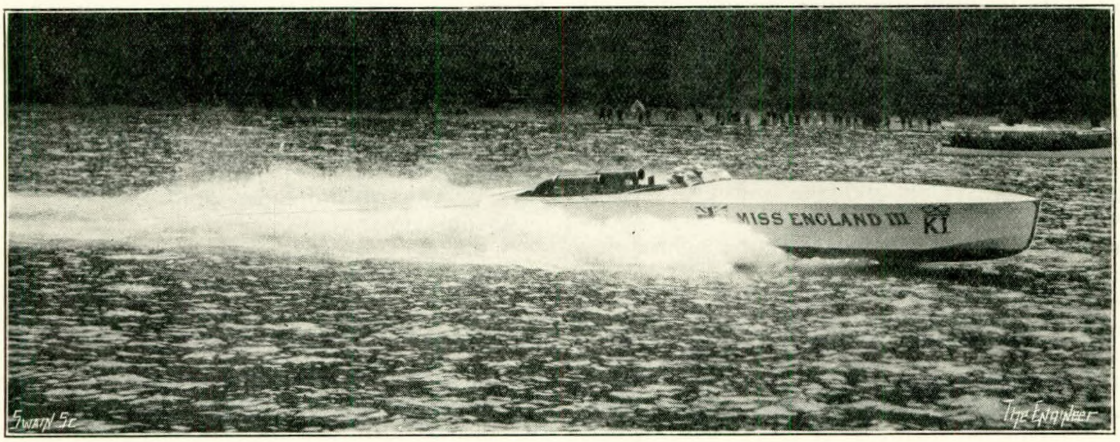
The Speed Boat Record.

"The Engineer", 22nd July, 1932.

Early on Monday morning, Mr. Kaye Don, piloting Lord Wakefield's speed boat "Miss England III.", set up a new world's water speed record on Loch Lomond, with a speed over a measured mile of 119·81 miles an hour. A view of the boat on the course on Loch Lomond is reproduced in the accompanying engraving. The previous record was held by the American, Commodore Gar Wood, with a speed of 111·65 miles an hour. In relation to her weight and size, "Miss England" is the most powerful craft ever built. After her trials at Lake Garda, she was equipped with two new Rolls-Royce engines, exactly similar to those fitted to the Schneider Trophy seaplane which set up the world's air speed record last year. These engines are a modified and improved version of the R type aero-engine first evolved for the 1929 Schneider Trophy contests, this latter engine being in its turn developed from the 825 h.p. "Buzzard" engine. The two engines, which have a bore and stroke of 6in. by 6·6in., have twelve cylinders, and are supercharged, each supercharger rotor having a speed of 25,600 r.p.m. At a crank shaft speed of 3,200 r.p.m., the power output of each of the two engines is 2,200 b.h.p., giving a total of 4,400 b.h.p. The weight of each engine is only 1,630lb., so that the power weight ratio is roughly 12oz. per brake horse-power, compared with 9lb. to 10lb. in an ordinary car. At full throttle, fuel consumption is at the rate of over 300 gallons an hour, or about 5 gallons a minute.

"Miss England III." carries 250 gallons, or sufficient for a run of something over 40 min. The drive from each engine is taken forward to separate gear-boxes in the bow, and thence downwards and sternwards to twin propellers rotating at 7,500 r.p.m. The engines are started up by compressed air. Cooling of the gear-boxes and the transmission, as well as the engines, is by water, the temperature being recorded on dials on the dashboard. The designers and constructors of "Miss England III." were John I. Thornycroft and Co., Ltd. In this connection it may be of interest to our readers to refer to our issue of July 15th, 1910, in which we described under the heading of "Skimming Boats", the late Sir John Thornycroft's "Miranda IV.", which was the first boat worthy to be called a "speed" boat. She was 26ft. long with a 6ft. beam, and displaced about 1 ton. Her engines were of the eight-cylinder type, developing between 100 and 120 h.p. The "Zigerella", a sister ship of the "Miranda IV.", was running as a tender to "Miss England III." on Loch Lomond.

As recorded in last week's Journal note, alterations were made last week to the water scoops for the engine and gear-box cooling water inlets, which were changed from the stern of the boat to a position on the first plane.



"Miss England III." on Loch Lomond.

Refrigerant for Perishable Traffic.

"The Engineer", 29th July, 1932.

It is announced by the L.M.S. Railway that important experiments are being carried out with a new type of refrigerant for preserving perishable goods whilst in transit by rail. Although it was well known that carbonic acid, when used for refrigerating purposes, had an efficiency only slightly less than that of anhydrous ammonia, it is only recently that the possibilities of solid carbon dioxide have been investigated. The special feature of this substance—"Drikold", as it is called—is that it evaporates from the solid at a temperature of approximately 112 deg. below zero Fahrenheit into an absolutely dry gas, which not only possesses a high refrigerating power but also acts as a destroyer of certain bacteria which survive below the melting point of ice. The L.M.S. Railway is chiefly concerned with the transport in door-to-door containers of perishable goods, such as frozen and fresh fish, which require protection from the atmosphere. Each container used for the experiments has fitted into the roof four insulated chambers specially designed for the reception of the solid carbon dioxide, and for the maintenance of the contents at the required low temperature. Experiments have already been made, ranging from mere chilling to hard freezing, i.e., maintaining a temperature of 15 deg. to 20 deg. below the freezing point of water, such goods as salmon, smoked fish, and dried fish being used. In some cases the use of "Drikold" resulted in an increased price being obtained compared with the normal price fetched by the same commodity when transported in the ordinary way. One great advantage of carbon dioxide as a refrigerant is that copper and its alloys can be used in the construction of the refrigerator, whereas ammonia, owing to its corrosive properties, would be out of the question.

The "White" Combined Marine Reciprocating Engine and Exhaust Turbine.

"The Engineer", 29th July, 1932.

The demonstration trials of the "White" patented combined reciprocating steam engine and exhaust turbine for marine propulsion, which have been carried out at the St. Peter's Works of R. and W. Hawthorn, Leslie and Co., Ltd., during the last two weeks, have been followed with keen interest by shipbuilders and marine engineers. Last week we were invited to inspect the engine, which was running under shop trial conditions, coupled to a water brake. The actual technical trials which have been carried out over an extended period were made under the personal supervision of Engineer-Commander C. G. Hawkes, R.N. (Ret.), Professor of Engineering at Armstrong College, Newcastle-upon-Tyne, and include, we understand, a wide range of tests both for steam consumption and for thermal efficiency under differing steam conditions. These tests, we hope, will form the basis of a later article. Meanwhile we give herewith an illustration of the new engine, together with a general arrangement drawing and a lay-out arrangement of the engine in a ship.

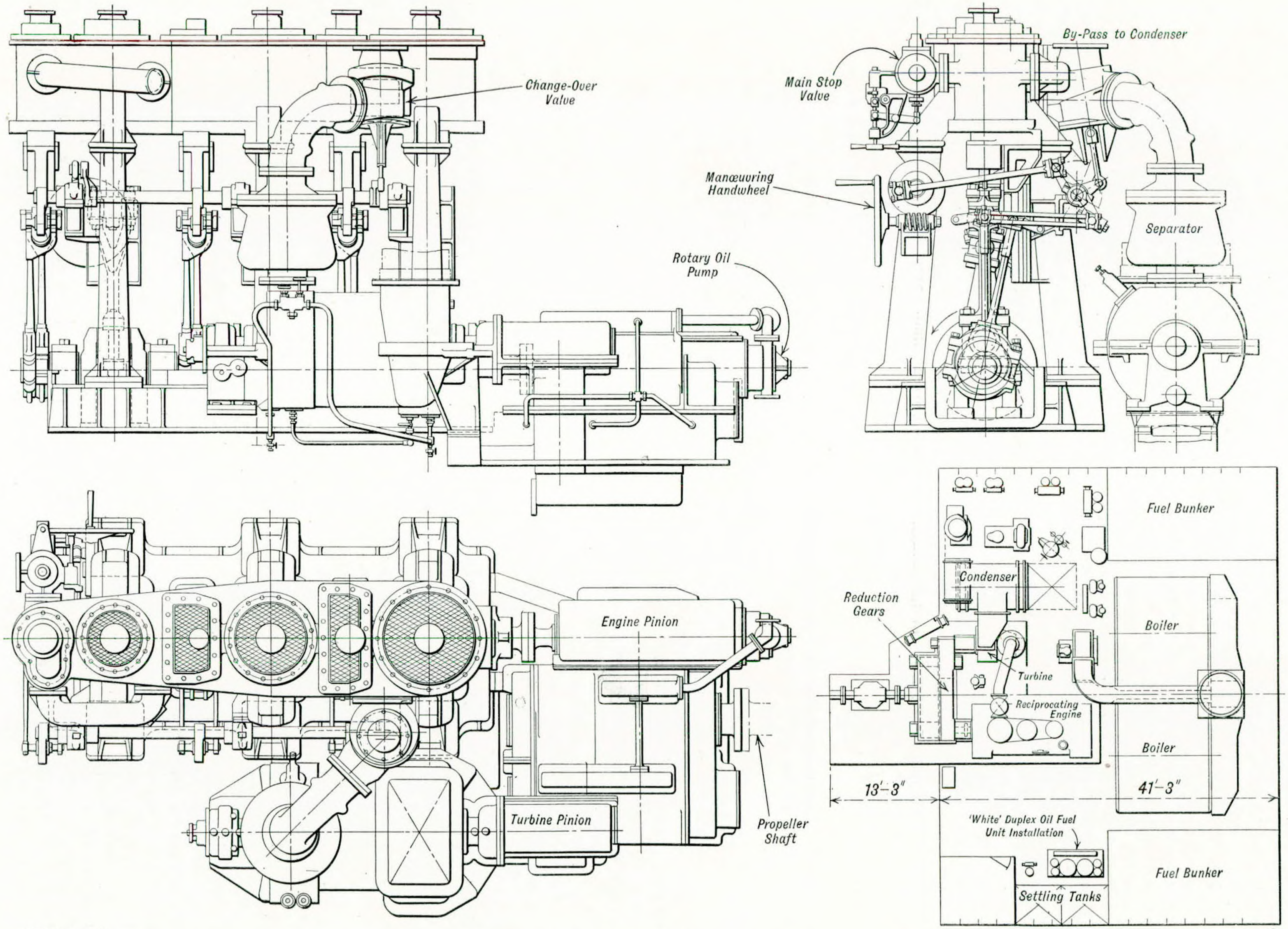
The "White" combined engine is essentially a high-speed reciprocating non-condensing engine which is coupled to the propeller shaft through single-reduction gearing with an exhaust turbine arranged to drive the same main wheel through double-reduction gearing. It was built to the designs of the inventor, Mr. W. A. White, of White's Marine Engineering Company, Ltd., of Hebburn-on-Tyne, by Smith's Dock Company, Ltd., of South Bank, while the Parsons reaction turbine with eight blade rows and an outside casing diameter of about 3ft. 6in., was built by Hawthorn, Leslie and Co., Ltd. The gearing was cut by the Power Plant Company, Ltd., of West Drayton, Middlesex, and includes that firm's patented "carrier ring" flexible coupling with a "White" patented resilient drive comprising a built-up plate type main gear wheel with an arrangement of springs for absorbing shock and giving a smooth drive. The two pinion shafts for the main engine drive and the second pinion of the turbine are both of the standard quill drive pattern.

The engine was arranged for testing by Mr. White in conjunction with the engine department staff of Hawthorn, Leslie, and was supplied with steam at 250lb. per square inch from a water-tube boiler, a gas-fired superheater being employed to deliver the steam at a total temperature of about 500 deg. Fah. at the high-pressure cylinder stop valve with a pressure of about 225lb. per square inch. As will be gathered from the accompanying engraving and drawing, the engine follows generally accepted marine reciprocating practice in its main scantlings and in the Stephenson valve gear arrangement. The high-pressure cylinder is fitted with a piston valve, while on the intermediate and low-pressure cylinders patented slide valves of the Andrews and Cameron balanced pattern are employed, all the glands being packed with United States packing. The cylinder diameters are: high-pressure, 10in.; intermediate-pressure, 14in.; and low-pressure, 18in., with a common stroke of 13in. The designed running speed is 260 r.p.m., corresponding to a propeller speed of 112 r.p.m., and at this speed the output of the reciprocating engine is, Mr. White informed us, about 310 i.h.p., with a turbine output of about 210 i.h.p., making a total of approximately 520 i.h.p. A maximum power of about 650 i.h.p. can be attained. On the occasion of our visit the engine was running quietly at 270 r.p.m. and the pressure readings at various points were: high-pressure stop valve, 220lb.; intermediate-pressure receiver, 86lb. per square inch; low-pressure receiver, 33lb. per square inch; and exhaust to the turbine at atmospheric pressure. The weight of the engine and turbine complete is about 10 tons.

The measured steam consumption was given to us as 8·4lb. per i.h.p. hour, which represents a saving of 36 to 38 per cent. compared with the normal practice for a triple-expansion engine of the same power. It is expected that with a larger engine of the cargo steamer type, having a designed output of, say, from 1,500 to 1,800 i.h.p., specially designed for that power, a steam consumption of about 7·6lb. per i.h.p. hour will in practice be realised.

The general arrangement drawing reproduced herewith shows clearly the change-over valve, the steam separator, and the gearing lay-out. The change-over valve allows the engine to exhaust directly into the condenser instead of to the turbine, and the patent further provides for the automatic operation of the change-over valve in

The "White" Combined Marine Reciprocating Engine and Exhaust Turbine.



520 i.h.p. "White" Combined Marine Engine.

the process of reversing the engine. The turbine is designed to run at 4,600 r.p.m. and the gear ratio for the turbine pinion is 8·5 to 1, that for the second pinion 4·84 to 1, and that for the engine pinion 2·31 to 1. An oil separator of the Vortex type is fitted between the engine and the turbine, and the condenser is of the standard Weir two-flow regenerative type. The governor gear for the turbine and engine controls is operated by an oil relay, the usual Aspinall overspeed attachment forming part of the gear. The relay operating oil is circulated by a Stothert and Pitt rotary oil pump attached to the gear case.

From the lay-out drawing it will be seen that the "White" engine gives a relatively simple arrangement when installed in a ship. Although the drawing shows a condenser separate from the turbine, in practice further space could be gained by making the turbine and its condenser in one compact unit. For the larger sizes of engines we understand that Mr. White intends to employ poppet valves. A small engine with White's patented poppet valves has actually already been built and was demonstrated to us under steam. The indicator cards exhibited showed a wide range of cut-offs down to 0·4 and suggested the possibility of a high economy for the gear. The shop tests of the "White" engine, which, we hope, will be followed in due course with sea trials, will be awaited with interest.

The design of this power unit is in accordance with the particulars set forth in Patent Specification No. 362,255 (amended). Reference to that specification shows that the object of the invention is to simplify and cheapen three-shaft marine type power installations for the purpose of adapting them for comparatively low powers as used, for example, in trawlers. The claims accompanying the specification make it clear that the invention lies in the combination of a reciprocating engine exhausting into a turbine and in connecting the crank shaft and the turbine shaft to the propeller shaft through a gear wheel and single and double-reduction pinion drives respectively. The speeds of the turbine, reciprocating engine, and propeller are in descending order of magnitude and are so chosen that the propeller and the two power units each run at the speed best adapted to efficient working. The specification also covers the extension of the invention to internal combustion engines.

The Saint-Nazaire Dry Dock.

"The Engineer" 5th August, 1932.

When the order for the new big liner was given to the Penhoët shipyard on the understanding that arrangements should be made at once for the construction of an entrance to the port of Saint-Nazaire of sufficient dimensions to allow of the liner leaving the yard, and of its serving also as a dry dock, work was started on the lock in April, 1930, and on Sunday last it was officially inaugurated. The lock has a length of 600m. and its width is 53m. at the bottom and 150m. at the top. It provides a depth of water of 14m. The weight of each of the two gates is 1,500 tons. The lock can be emptied in a few hours to serve as a dry dock for the new liner. It is stated that the ship will be launched during the autumn.

Mares' Nests and Thermo-Dynamics.

"The Engineer", 5th August, 1932.

Was there ever a field so prolific of mares' nests as the science of thermo-dynamics? It has but two laws, each expressible in words of infantile simplicity, yet capable of being more thoroughly misunderstood than almost anything on earth. Nearly every day one comes across examples. From the eminent F.R.S. who publishes books in refutation of Carnot's Theorem to the humbler enthusiasts who devise ingenious but impossible heat engines, there is a chain of incomprehension which seems to defy all reason. Some of its members deplore the high latent heat of steam—its most valuable thermo-dynamic property. Others, following a kindred line of thought, look on the condenser as an evil thing. An engine, for them, should be made to turn all the heat given to it into useful work, whatever Carnot or the Second Law of Thermo-dynamics may have to say about it. A publisher has been found for a recent and expensive book on steam, in which the author devotes considerable space to the advocacy of compressing the exhaust steam from a turbine so as to do away with condensers altogether. But the ambition of most inventors is to obtain power by drawing on the inexhaustible stores of heat in Nature. We do not refer to those who would drive engines, for example, by the heat of the sun in the desert, because, given enough sun and enough desert, nothing but the capital cost of the plant need prevent them from supplying the wants of the desert industries. Nor is there anything, theoretically, to prevent power being developed from the warm surface water of the tropical seas, though the arithmetic of it is sufficient to give an idea of its commercial impracticability. Geysers, or, at any rate, natural steam jets, have, we believe, been harnessed; but their potentialities are too small and too local to be of general interest. Volcanoes afford a more spectacular source of energy, but here, again, their exploitation may be left to the communities who are fortunate, or unfortunate, enough to live round them.

To those inventors who would derive power from any of the sources we have mentioned, we can only wish success, without, however, much hope that they will realise it. As for the other army who seek for something where there is nothing to be got, though they were braised in a mortar their foolishness would not depart from them. Their happiest hunting ground is the atmosphere, whose heat they hope to abstract. They are not concerned, as a rule, with the daily or seasonal changes of temperature, which might conceivably be turned to some useful account, but with the vast uniform stock of heat which exists in the air everywhere and always. The heat is there right enough, or the atmosphere would not exist. All that is required to use it, is to find some permanently lower temperature for our engines to exhaust into. Since Nature has not given us one, say our inventors, let us make one for ourselves. The thing can be done in lots of ways. A refrigerating machine will give us practically any temperature we like, but it hardly appeals to the expert mares' nest finder. More attractive is the idea of using some substance like liquid carbonic acid, which will draw heat from the very coldest natural atmosphere and by its evaporation will furnish gas under ample pressure to drive an engine. The principle is sound enough if Nature would only provide liquid carbonic acid. There is another and much more subtle scheme for utilising low temperatures. Air under pressure and at ordinary temperature will drive an engine, and it may readily be cooled a hundred degrees or more by its own expansion in the engine. The latter will, therefore, exhaust at a temperature far lower than that provided by Nature, so that, if we can only misunderstand Carnot's Theorem sufficiently, it will be evident that the efficiency of the engine will be increased. Does not every book on thermodynamics tell us that the heat which can be turned into work by an engine depends upon the range of temperature through which the latter operates?

A proposal of another kind, though similar in its hopelessness, was put forward in all seriousness at the Fifth International Congress of Refrigeration held at Rome in the autumn of 1927. The "Proceedings" of this Congress have only recently been published, and since the scheme in question has been considered worthy of being included therein, we offer no apology for making it more widely known. The author is Monsieur Emile Guarini, formerly Professor of Physics and Electrotechnics at the Ecole des Arts et Métiers of Lima. His visions as to the end of the coal age and the production of all power from the atmosphere itself are common to all such projects and need not be discussed. They will, moreover, certainly be realised, when the machines employed function according to plan. Monsieur Guarini's machine can, apparently, work either as a self-acting refrigerator, giving, perhaps, a little surplus power to operate the brine-pump, or it may be used as a heat engine for the driving of locomotives or aeroplanes. The principle is simple and ingenious. Liquid carbonic acid is evaporated by the heat of the surrounding air. The saturated vapour at 10 deg. Cent. below zero, with a pressure of about 380lb. per square inch, is admitted to the working cylinder. There it is allowed to expand adiabatically with the production of work. Expansion is carried on until the temperature has fallen to 78 deg. Cent. below zero. At this point 24 per cent. of the gas will have been condensed to liquid form. This liquid is extracted from the cylinder and the remainder of the gas is recompressed by the return of the piston. Since there is 24 per cent. less of it to undergo compression, it is as clear to the inventor as anything can be that the recompression will require less power than was developed during the expansion stroke. He recognises that the dried gas will become superheated by compression, but he proposes to restore its saturated condition by injecting a little of the liquid withdrawn from the cylinder. The remainder of the liquid is pumped back to the evaporator. The inventor states, and we do not disbelieve it for a moment, that the cycle can be carried out as well with steam as with carbonic acid. One can easily calculate that dry saturated steam at 500lb. pressure, expanding adiabatically down to a 29in. vacuum, will turn about 30 per cent. of its weight into water, so what could be more reasonable than to pump this water back into the boiler and just recompress the pure steam remaining? We suggest only two difficulties. To compress the residue of the dry steam to its original volume would require not less, but far more power than the total quantity given out during expansion, while its temperature would rise to something like the melting point of steel. Phenomena of the same nature would, of course, occur in the recompression of carbonic acid, or any other liquifiable gas after the extraction of the liquid of condensation. Nature cannot be cheated in the way anticipated. The latent heat that she gives up on the power stroke must be returned to the latent condition again during the compression stroke, or it will have to be paid for in some unpleasant way.

Lubrication.

"Engineering", 5th August, 1932.

A distinctly curious theory finds expression in a paper on "The Mechanism of Lubrication", which was read at an informal meeting at New York in June last of the Lubrication Engineering Committee. This committee is one appointed by the American Society of Mechanical Engineers, and the authors of the paper in question were Mr. W. F. Parish and Mr. Leon Cammen. We quote as follows from the authors' summary:—

"Briefly, according to this theory a layer of oil is formed on the surface of the metal, the thickness and strength characteristics of this layer being determined by the character of the lubricant and the character of the metal. This layer, in turn, pumps up, under an enormous pressure, oil into the crevices of the metal. (This is in accord with the most modern conceptions of the phenomena of adsorption.) In the course of contact with the bearing surfaces on the journal and the brasses (the same especially applies to ball and roller bearings as well as Kingsbury bearings) the free film plays no part as a means of separating the surfaces of the metal. This is done by the newly discovered powerful adhering layers of lubricant, and when, in the course of operation of the bearing, these are wiped off, they are immediately restored by the oil ejected under enormous pressure from the crevices in and under the metal surfaces".

It is difficult to understand how papers containing such misconceptions of mechanical and physical laws reach the stage of submission to the leading technical societies. Such things do happen, however, and a number of instances could be quoted. As a matter of fact, oil is not pumped into the pores or crevices of a journal by molecular forces. Indeed, it may be questioned as a side issue, whether, in a polished surface pores can exist, since according to Beilby such a surface consists of an amorphous layer analogous to a liquid, all signs of the crystal boundaries being obliterated. The main point, however, is that whilst there is no doubt but that the attraction of the molecules of the metal to the molecules of the oil may produce a pressure, this pressure being due to, and completely balanced by, the attractions in question, is as incapable of lifting a journal as the pressure between a ton-weight and its support is of lifting the weight. Elsewhere the authors seem to be under the impression that the forces due to an electrified surface are inversely proportional to the square of the distance from the surface.

It will be noted that the authors refer to newly discovered powerfully adhering layers of lubricant. In point of fact, the importance and intensity of this adherence was strongly insisted on by Mr. Deeley many years ago, whilst, curiously enough, the apparatus used in the authors' experiments was not capable of developing high stresses in the oil film. They used a 10in. journal which could be rotated at speeds which reached 18,000 r.p.m. At the latter speed the centrifugal force developed on a mass at the surface would be about 46,000 times the weight. This seems a large figure, but a film of oil $\frac{1}{1000}$ in. thick weighs only about $3{\cdot}5\times 10^{-5}$lb. per square inch, and the radial stress exerted on such a film by the centrifugal force would amount to only about 1·6lb. per square inch, which is quite insignificant compared with the intensity of the molecular forces. The surface tension, for instance, is equivalent to a stress of some thousands of pounds per square inch, and the adhesion of the oil to the metal probably represents a stress of the same order of magnitude. It is not surprising, therefore, that it is impossible to wipe an oiled surface clean. Mr. Deeley, it will be remembered, found it necessary to clean the plate of his oil tester by grinding it under water.

As matters stand, the only intelligible theory of lubrication yet advanced is that of Osborne Reynolds. This was formulated in 1886, and nothing of fundamental importance has been contributed to it since. Certain minor slips in his analysis have been detected and corrected, whilst Sommerfeld effected great improvements in the mathematical methods employed. Michell, again, showed how end leakage might be taken into account, and proved the accuracy of his discussion by the invention of his thrust bearing. During recent years much has been written on the subject in every civilised country, but the new work has consisted generally of fairly obvious developments, often involving much heavy and tedious arithmetic, but nothing essentially new. Dr. von Freudenreich was, we believe, the first to include in his calculations the effect of the rise of temperature as the oil passes from the leading to the trailing edge of a brass, and other workers have since extended his results. The general character of the temperature effect was, however, already known, and provided an explanation of the fairly successful use of centrally pivoted blocks. As the viscosity diminishes with rise of temperature, there is a reduction of pressure near the trailing edge of the brass, and the centre of pressure is shifted accordingly nearer the centre of figure than would otherwise be the case. Confirming this view, Mr. Stone, of Melbourne, showed that a centrally pivoted Michell block would not work when air was the lubricant, since the viscosity of gases increases as the temperature rises, and the effect is then to shift the centre of pressure farther away from the centre of figure. Osborne Reynolds's theory has been strikingly confirmed by experiment, though this confirmation has in general been qualitative rather than quantitative in character. It is, in short, practically impossible to ensure that the actual conditions in a test coincide with those assumed in any arithmetical treatment of the problem. Exceedingly minute differences in two apparently identical bearings may be responsible for widely different results This was somewhat disconcertingly demonstrated when the application for an extension of the Michell patent came before the courts. The applicants had arranged for an experiment in which a centrally pivoted block was compared with another which was supported eccentrically in accordance with the Michell patent. In repeated tests made before the trial the centrally pivoted block soon seized, but when the test was made before the judge it refused to seize, though it did get very hot. The difference in behaviour was undoubtedly due to some minute change made at the leading edge of the block, when it was overhauled just prior to the demonstration.

Osborne Reynolds believed that his theory was also applicable to the case of greasy lubrication, and gave a more or less rational explanation of the fact that then the friction experienced was nearly independent of both load and speed. This theory is, we believe, the only one yet advanced which provides a mental picture of the mechanism at work in such cases. There has, of course, been of late years frequent mention of boundary lubrication, but it is difficult to find an authoritative statement of what is implied by the term. At times it would seem that special lubricating powers are attributed to a mono-molecular film of lubricant, whilst in other cases the term seems to be used merely as a synonym for what used to be known as greasy lubrication. That a mono-molecular layer can act as a true lubricant is exceedingly difficult to believe. If two surfaces are in contact and relative motion occurs, something must give. With efficient lubrication it is the lubricant that gives, and in doing so protects the surface from scoring. If scoring occurs there has been no effective lubrication, though there may have been a reduction of static friction. Static tests are not tests of lubrication, though they may demonstrate valuable properties in a lubricant. Lubrication is a kinetic phenomenon. If a deposit of, say, copper were made on a steel surface the angle of repose of a slider would probably be altered. If this alteration were a decrease, it would not be legitimate to regard the copper film as a lubricant. It is equally improper to regard a mono-molecular film of oil as a lubricant, even if it does reduce the angle of repose of a slider. The function of a lubricant is to prevent scoring, and this, a mono-molecular film is unable to do.

There are, however, some very curious anomalies which still await explanation. Johansson gauges can be wrung together and handled as a single unit. This is due to the presence of a very thin film of oil between the opposing surfaces. In this case the layer has certainly not reduced the friction, yet the fact that the gauges can be separated without being scored shows that the thin film does act as a lubricant. With perfectly clean surfaces there would be no adhesion, but scoring would be apt to occur on separating the gauges. In an experiment by the late Lord Rayleigh a glass tripod slid easily over a very slight contaminated surface, but if the layer of lubricant was thick the resistance to sliding was greatly increased. No satisfactory explanation of this anomaly has yet been advanced.

Steam Pipe Lines.

"Shipbuilding and Shipping Record", 21st July, 1932.

In the laying out of steam pipe lines on board ship, not only is it essential that adequate provision must be made for the effects of expansion and contraction, but the pipes must be so supported that the vibration may not cause fatigue stresses which will ultimately lead to failure of the pipe. This is particularly the case in steamships propelled by reciprocating engines, and is exemplified in the report of an explosion which occurred on a steamship of 4,738 tons trading between this country and Eastern ports. The main steam pipe was of annealed solid-drawn copper, but on a number of occasions a fracture developed near the flanges, sometimes at one end and sometimes at the other. After frequent repairs, a new pipe was fitted, but this failed in precisely the same way as the previous one. It was ultimately decided to fit a steel pipe having bends of greater flexibility and provided with adequate supports. The engineer surveyor-in-chief, in his conclusion to the official report, suggests that previous failures of this pipe should have warned those responsible that it was insufficiently flexible to accommodate the expansion and vibration to which it was subjected in service. Two of the repairs made were of such a nature that the original flexibility was actually decreased, and the pipe thereby subjected to increased stresses.

Ship-lighting Dynamos.

"Shipbuilding and Shipping Record", 21st July, 1932.

On the majority of sea-going vessels an independently-driven dynamo is installed for providing the electricity required for lighting and other purposes throughout the vessel. On small craft, however, such as coasters, trawlers and tugs, the demand for electricity may be hardly sufficient to warrant the installation of a separate lighting set. Under such circumstances a small dynamo driven from the propeller shaft or from a convenient position on the main engine can be recommended. In a system of directly-driven lighting which has been brought to our notice, the dynamo, which is belt-driven, is so designed that it generates at the desired voltage when the propeller shaft is running at anything between half and full speed. The dynamo works in conjunction with a battery in much the same way as does a car-lighting set, the dynamo charging the battery at the same time as it feeds the lighting circuits. When the propeller speed drops to below half its normal figure or when running astern, the dynamo is automatically disconnected from the system and the lighting circuits are supplied from the battery, the automatic regulator also serving to maintain a constant voltage in the lighting circuits. The set is made for an output of 5kw., which is sufficient to operate about 100 50-candle-power lamps, and thus appears to be of ample capacity to meet the requirements of the majority of coasters, trawlers and vessels of similar size. For larger outputs, however, particularly if there are a number of electric motors in circuit, the separately driven dynamo has much to recommend it, and in view of the development of the small internal-combustion engine, such generators are now available.

The Ultra-modern Tramp.

"Shipbuilding and Shipping Record", 4th August, 1932.

It appears that the measured mile and service performances of the first of the eleven new tramp steamers for J. & C. Harrison, Ltd., have proved phenomenally successful. This is not surprising in view of the fact that the hull and machinery specifications were the joint product of the owners' three superintendents, three leading shipbuilders, three marine engineering companies, a firm of streamline rudder patentees, and an experiment tank. At least four different parent model forms were separately tested and the best features of each were as far as possible combined in the final model. While a cruiser stern is no novelty even on single-screw ships, we believe that it is the first time it has been adopted on vessels which are of the tramp type in the strict sense of the term. The machinery specifications appear to go right up to the limit of modern but orthodox practice, although nothing is included of a speculative nature. We have heard it stated that the mean Admiralty coefficient, fully loaded on service, is over 400 and the corresponding coal coefficient over 30,000. This performance represents an advance in efficiency of an importance which is probably without parallel since the change-over from sail to steam.

Cast Iron Research.

"Shipbuilding and Shipping Record", 4th August, 1932.

Some interesting data regarding the performance of certain heat-resisting cast irons were given by Sir Harold Hartley during the course of his address as president of the British Cast Iron Research Association at the recent opening of the association's laboratory extensions. In particular, he referred to the heat-resisting cast irons to which the names of "silal" and "nicrosilal" have been given and which have made a marked advance in commercial application during the past year. The possibility of using mechanical stokers on board ship gives added interest to the results of comparative tests made with stoker links of silal, a standard cast-iron link and a white-iron link containing 1·5 per cent. of chromium. The three links were heated together in a steel-annealing furnace for seven three-hour periods to a temperature of 900°C. (1,652°F.) after which it was found that the standard link had shown a growth of 6½ per cent., the chromium-iron link an increase of 3½ per cent., while the silal link showed an increase of only 1½ per cent. Further, the first link was covered with a thick layer of oxide and had oxidised to a considerable extent right through, the second link had scaled badly and graphitised inside, whereas the third was covered with an almost imperceptible layer of firmly-adhering scale and showed no change of structure. The properties of nicrosilal were stated to be even more remarkable and justified its description as the best heat-resisting cast iron yet produced.

Recent Improvements in the Diesel Installations in Vessels of the Hamburg South America Line.

"The Marine Engineer & Motorship Builder", August, 1932.

The Hamburg South America Line have now had some eight years' experience with Diesel-propelled vessels; and in the present article attention is confined to improvements introduced in the light of service performance and experience with starting and injection air, fuel and lubricating oil and fresh cooling water.

Dealing first with the air bottling problems, it is found that the first air drawn through the compressors contains a fair amount of oil in suspension, which is thrown down when the air is compressed. This oil leads to a rapid carbonising and inefficient working of the valves. The air cooler fitted between the various stages of the compressors is also exposed to this oil depositing on the tubes thus greatly reducing their cooling efficiency. Further, a series of slight explosions were continually occurring in the compressor cylinders. This was also due to the oil contained in the air. After this fact had been definitely established, the air lead to the compressors was connected to the main fresh air supply duct to the engine room. This duct was led from the top deck and thus supplied pure air. This change-over has completely cured the troubles previously encountered.

No corrosion has been noticed in fuel oil bunkers. In fact, the oil used appears to have a preservative action. No fuel heating arrangements have been found necessary. Most troubles with fuel oil have been traced to dirty oil, and now there is no doubt that the oil must be cleaned as thoroughly as possible prior to being pumped to the engine. The oil is first coarsely filtered on being shipped into the bunkers. It is then separated in the daily settling tanks by tapping off from the bottom the mud and water. Finally before passing to the engines the oil passes through a fine filter. This additional filter has proved to be very necessary.

The necessity for improved ventilation in the engine room has been made evident by one particular accident. In this particular vessel piston leakage allowed the gases to escape into the engine room and three engineers were poisoned by the fumes. This leakage was possibly due to the space between the cylinder bottoms and the crank case being open. This space was subsequently enclosed and separately ventilated. The improvement in the general condition of the air was made very evident by the fact that whereas the white paint of the engine room turned yellow very soon after the vessel was placed in service, since the alteration was made the paint has remained white for two years.—*Herr Müller. Werft Reederei Hafen,* July 1, 1932; p. 201; 3pp. 5ff.

The Science Museum.

"Engineering", 8th July, 1932.

To mark the passing of seventy-five years since the opening of the old South Kensington Museum, an institution which may be said to have had its origin in the Great Exhibition in Hyde Park in 1851, and which itself was the parent of both the Victoria and Albert Museum and the Science Museum, a special exhibition has been arranged at the latter to illustrate the progress made in certain departments of science and technology, since the old Museum was opened by Queen Victoria and the Prince Consort. The exhibition is not a large one, but by the arrangement of a few objects drawn from the main collections, and others lent for the occasion, it has been possible to show the advance in such things as transport, power, communication, and industrial plant. Thus close beside the model of the first Cunard paddle steamer "Scotia", of 1862, is that of the S.S. "Empress of Britain", reminding the visitor of the improvements in transatlantic steam navigation, while locomotive practice is illustrated by the models of the "Lady of the Lake" built by Ramsbottom in 1862, and the "Royal Scot", designed by Sir Henry Fowler in 1927. The speeds of trains have not increased so much as the power of the locomotives and the weights hauled. The "Lady of the Lake" had a tractive effort of 6,850lb., and was able to draw a train of about 70 tons some 40 to 50 m.p.h., on a coal consumption of about 0·25lb. per ton mile. The "Royal Scot" on the other hand, has a tractive effort of 33,150lb. and can haul a train of 400 to 500 tons at about 54 m.p.h. on a coal consumption of about 0·1lb. per ton mile. The change in road transport in seventy-five years is illustrated by the exhibition of a horse-drawn omnibus of 1837 and a modern motor omnibus, while progress in the air is shown by a comparison between Henry Giffard's dirigible balloon of 1852-7, which had an engine of 3 h.p., and the Imperial Airways Liner "Hannibal", with engines of 2,200 h.p. New and old boiler plant, a horizontal slow-running steam engine and a modern steam turbine, a Lenoir gas engine of 1860 and a Crossley gas engine of 1932, an undershot water wheel and a Pelton wheel, are used to illustrate the changes and progress in the generation of power, and a display of instruments is exhibited to show some of the advances made in communication. The year 1856 will always remain notable in technological history as having witnessed the invention of the Bessemer steel process, the discovery by Perkins of the first artificial dye, mauve, and the manufacture of the first transatlantic submarine cable. Each of these is recalled by models and illustrations, and a special effort has been made to show how the discovery of Perkins has led to great industrial developments, the exhibits in connection with this being shown separately in the chemistry gallery on the third floor of the museum. The exhibition further includes examples of typewriters, sewing machines, planimeters, gas-lighting appliances, measuring apparatus and meteorological reports, while not the least interesting exhibits are the plans and views which show how the estate at South Kensington, purchased by the Commissioners of the 1851 Exhibition, has been utilised for great national institutions. Included among these are views of the old Patent Office Museum, housed in what were once known as the "Brompton Boilers". This museum was started by Bennet Woodcroft who was the virtual founder of the engineering collection now housed at South Kensington.