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The Advantages to the Shipowner of Closer Co-operation between the Naval Architect and the Marine Engineer.

READ

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On Tuesday, March 11th, at 6.30 p.m.

CHAIRMAN: MR. H. J. VOSE (Vice-Chairman of Council).

The Papers Committee of the Institute of Marine Engineers selected the title for this paper and asked the author to write it. At first sight the title appeared to be an attractive one, and it was for this reason, although perhaps in a somewhat rash moment, that the author agreed to comply with the request. None the less, the subject is a difficult one about which to write, and there are many pitfalls.

It may at once be said that the advantages of co-operation are obvious, and it is almost impossible to write about the obvious without being verbose and redundant. Certainly the title might well have been "The *necessity* to the Shipowner of closer co-operation. . . . ." However, even to discuss the advantages of such co-operation, it is essential to examine the procedure appertaining to the design, building and running of a ship.

In speaking of the design of a ship, it should be understood that this includes not only the hull of the vessel, but also the main machinery and all items of hull equipment and auxiliary machinery. The shipowner, at any rate in the first instance, gives very little information to the designer. This generally consists of the trade route, an approximate length which must not be exceeded, a maximum draft, the cargo deadweight, cubic capacity for cargo, the numbers of each class of passenger, the service speed and the length of run for which fuel must be provided, and almost certainly the probable cost of the completed vessel.

In these days there are a very large number of diverse types of main machinery, many of which must be fully considered, and this consideration forms an essential part of the design work. The designer must be cognisant of the possibilities of the different types of machinery, and these possibilities include first cost, fuel and lubricating oil consumption, size of machinery spaces, weight and revolutions, personnel required, reliability and at least a good general knowledge of their operation. The design process in the first instance must be one of trial and error, because the type of machinery will affect the length of the engine and/or boiler rooms, and the length of these spaces, taken in conjunction with the load draft, very often settles the depth to be given to the ship, in view of the requirements for the spacing of bulkheads under the rules of the International Convention.

The height of the machinery is also an important consideration in so far as it affects the casings on the passenger decks, and with the internal combustion engine this may be a drawback, in that it cuts out a certain amount of deck space that would otherwise be available for passengers. The height of boilers in steam machinery may also affect the depth in so far as it is desirable to keep the boilers completely under a certain deck, which may not be possible unless the depth of the ship is made greater than was perhaps originally intended. The fore and aft space occupied by the machinery will also have an effect on the length of the vessel in so far as the cubic space for cargo is modified, the available cargo space being generally greater for internal combustion engines than for steam machinery. In this connection also, the size of the machinery space is important, in order to make sure that the maximum tonnage deduction is procured. The weight of machinery, coupled with the weight of fuel necessary for the voyage in question, also has its effect on the deadweight left available for cargo, and this again may modify the dimensions of the ship.

In some cases auxiliary machinery will have quite a predominating influence upon the design, particularly if it is desired to fit electric generators driven by internal combustion engines, as these occupy a good deal of length and considerable height as compared with steam turbine driven electric generators. There is also the effect of the weight and relative distribution in the ship of the main machinery in so far as it affects the stability of the vessel, which generally results in some modification to the beam. A knowledge of propellers is necessary, and the effect upon them and upon the main machinery of revolutions.

Accessibility and general ease of overhaul of main and auxiliary machinery should be fully considered, and this involves also the question of the removal of machinery parts either about the ship or from the ship with the maximum facility. The design of the bossing in twin-screw ships, must be considered from this point of view, as well as from that of maximum efficiency of propulsion.

Electrical equipment is becoming, and even has become, of the first importance in ship design, and knowledge of this branch must be included in the equipment of the designer.

Mechanical ventilation is frequently an important feature of a modern vessel. This includes not only ventilation of the living spaces, but also of the machinery spaces, and the use of cooled air for refrigeration purposes. Under this heading also is the question of heating, which may be done by warmed air or by other methods, such as steam and electrical heating, and these must be considered so as to gauge the relative merits of the different systems in first cost, economy of running and convenience of installation. Pipe work has not by any means always received the attention it deserves in ships, and in many instances the pipe arrangement can be simplified in layout and made more easily accessible by attention to the arrangement in the early stages of the design. It is not necessary for this purpose to comment in detail on all the various branches, but there still remain many others, such as joiner work, carpenter work, decoration of public rooms and special cabins, size and convenient arrangement of all cabins, together with their equipment, whilst the arrangements of the kitchens and their dependencies, as well as the very important question of cargo gear, call for special attention.

It may be said with justice that most of these various branches are dealt with by specialists. This is true and must remain true, but to give a specialist a free hand is fraught with danger, for the simple reason that the specialist has a tendency, not unnaturally, to consider his part of the work the most important of all, with consequent loss to other parts.

In the ultimate, for the best results, the complete design must be in the hands of one individual, or at the most two persons, and they must be able to work together in complete harmony. If the person finally responsible is to get the best result, he should have a more extended knowledge than is generally understood to be covered by the separate terms Naval Architect and Marine Engineer, but certainly whatever may be meant by these terms, the necessity for co-operation between the naval architect and marine engineer must be apparent in view of all that has been said with regard to the ramifications involved in the design of the complete vessel.

It should be assumed that the design stage has resulted in the production of general arrangement plans showing all accommodation, machinery and cargo spaces, general layout of machinery, in fact a complete picture of the spaces in the ship, and their contents, as well as the equipment on the decks. It would also include the steel scantlings of the hull, a general design and layout of the machinery, and, what is very important, a completely detailed hull and machinery specification.

With this material in hand, the owner would be in a position to issue enquiries to the shipbuilders. During this design stage, however, it must have been the business of the designer to discuss with the owner and his various officials the special requirements of the owner's trade and ships, and to ascertain particularly whether these requirements are merely a survival of custom and can be improved upon, or whether, as in some cases, they are essential for the service.

During the construction of the ship a thousand-and-one things will arise, some of major, and naturally many of minor, importance, but every one of them must be considered fully. The more attention that is given to the construction and the more supervision there is, within limits, the greater will be the number of points that will arise, and be settled to the advantage of the ship. Herein the value of close co-operation between the various departments is again emphasised.

During the early stages of the construction, working plans will be considered not only by the designer, but also by the officials of the various departments in the owner's organisation, and later, representatives from these various departments will be sent to the shipyard, and the necessity of co-ordination of their various views and requirements is obvious if the balance of affairs is to be obtained in the final production.

In the running of the ship each of the owner's departments obtains its experience which is, in the main, recorded and made available for the design of the next vessel, and here again collection and co-ordination of the various points that arise is of the utmost necessity, especially when it is remembered that there are very many departments concerned in the running of a ship.

It is of the greatest value to the owner if a system is devised whereby all experience gained in service, and suggestions for improvement, are docketed and centralised for future reference in the designing and building of new tonnage. Even a lowly member of a crew may be responsible for a good suggestion. While, of course, co-operation is in existence to-day, it should be apparent from what has been said that, to obtain the most successful results, those technically responsible should have had the widest possible training and experience in order that they may co-ordinate the multifarious factors which all play their part in the very many diverse branches of trades and departments concerned in the production of the completed ship.

Mention has already been made of the probable meaning of the terms Naval Architect and Marine Engineer, but very little thought will lead one to despair as to how, in fact, they should be defined. It is doubtful if it is possible to produce at the moment a correct definition of a naval architect, but if it be said that he is a man who designs ships, then many men to whom the term "naval architect" is applied, fall short of this definition. This is equally true of the term "marine engineer." Some people speak loosely of a naval architect as a man who prepares the preliminary calculations and plans for a ship design, and in so doing makes certain calculations, with regard to displacement, deadweight, horsepower and speed, stability and trim, and he also prepares a very outline plan of the arrangement of the ship on a small scale.

This work, of first importance as it is, is not by any means the total, there are very many other things to be thought of in connection with the hull alone, to say nothing of the machinery. There is also the further development of the design and the outline arrangement plan is probably altered very considerably. Such an individual hardly ever sees the shipowner's staff and generally takes no part in the very important constructional and equipment details which arise when the working plans are developed and the construction proceeds.

The term "naval architect" is undoubtedly used very loosely, and this is in direct contrast to the use of the terms "doctor," "solicitor," "barrister," "dentist" and "chartered accountant." In short, an individual who is not a naval architect in *any* accepted sense of the word is quite free to start in practice as a consulting naval architect. Whether he obtains business or not is not a matter of concern here, and is only mentioned to illustrate how the term naval architect may be used and abused.

Equally, the term "marine engineer" covers many various degrees of training and experience, and it may well be a question for consideration as to whether any definition can or should be devised.

These remarks are not made in any carping spirit of criticism, but rather to lead up to the point that it would be advantageous if some effort were made to define more clearly what these terms mean and to limit their use to those who comply with the definition. Incidentally, the production of a definition would inevitably result in broadening the basis of training and experience for those who would become entitled to call themselves naval architects or marine engineers or some other name or names which may be adopted.

From what has already been said, the necessity for this broadening of the basis must be apparent. It would result in raising the status of the profession, and in giving better service to the shipowner. It must surely always be that those people who become eminent in the profession do so because of personal qualities which fit them for such eminence, but, however good may be a man's personal qualities, he is bound to be a better man if his training and experience has been guided and arranged on a broad basis.

Many men now occupying responsible and even prominent positions admit that they would be more valuable to their employers, and to the country, if their training had been on a broader basis. A man can accomplish a very great deal by energy and personality, but, if training and knowledge be added, then he can accomplish much more, and that more efficiently.

The matter of training raises a very important question and one that has already given rise to endless discussions, and no doubt will in the future give rise to many more. There does, however, seem to be in this country, as compared with the Continents of Europe and America, much too strong a tendency to train boys and young men in strictly watertight compartments of the divisions embraced under shipbuilding and marine engineering. There are, of course, exceptional cases where men have been trained both on the hull and the machinery sides, but there is no concerted action in this country to provide dual training, so far as the author is aware.

The division between the hull and machinery sides is also carried on after the preliminary training has finished, and it is not at all uncommon to find hull and machinery departments working in absolutely watertight compartments, the one either refusing or failing to appreciate the difficulties of the other, with the result that, when a compromise is the only solution, on many occasions one department gains its point at the expense of the other, which, after all, is bad business.

Almost any employer to-day will say that he can get plenty of men with a limited outlook who are suitable only for specialised jobs, but that he finds great difficulty in obtaining men of initiative and all-round experience, for what after all are the important positions, taken from the point of view of the commercial benefit to the firm and the country in general.

Much has been said for and against university training for those engaged in shipbuilding and marine engineering, and, in spite of its unpleasantness, the fact must be faced that employers do not particularly favour those who have had such a university education, unless it be to place them in some small corner of the drawing office where they can work out calculations that may sometimes be a little intricate. Many years ago the author said facetiously, that in shipbuilding and marine engineering, a man may be valuable in spite of a university training. This, of course, was a deliberate exaggeration. None the less, there is something about a university training which seems to take away the initiative of many men, and the author believes that this is recognised. In any case, indications are that a university training is not sought after so much as it was say twenty to twenty-five years ago.

There are, as is well known, quite a number of scholarships offered by different bodies to apprentices from shipbuilding and marine engineering works, and these scholarships are tenable at various universities where there are courses in marine engineering and naval architecture.

The position has become so acute to-day that it is hardly possible to obtain candidates for these scholarships. This is probably due to more than one reason, but undoubtedly due to the fact that apprentices find that after completing their university course it is difficult for them to obtain positions, particularly against the competition of their fellow apprentices who, during the three or four years university life, have been doing practical work, with the result that they are looked upon by the employers as being more value to them than those who have been cut off from practical work during their university courses. This may be an unpleasant truth, but it has to be examined and faced. There probably is another reason in that young men in these days will not bother to study in order to compete for scholarships.

The universities also have made the matter more difficult in making the courses four years instead of three as formerly, and the author is of the opinion that most young men look upon four years as too great a time for them to be absent from the practical side of their business, because, although the ultimate gain of a university training should go without saying, it certainly does not show any immediate reward after the university course is finished, especially as compared with their colleagues who have remained in the works during that time. There is also the added difficulty that although university courses are now for four years, the scholarships are only for three years.

A university training is undoubtedly valuable, but, none the less, the author thinks that this training could be made more valuable and less open to criticism, by the omission of some of the higher technical parts and attention to more practical points. Many practical matters could be acquired more readily at a university than at a works, where the young man has not the advantage of being able to see and appreciate and have explained to him the various processes that are in common use. This is particularly true in these days of mass production, repetition work and piecework. Necessary as are these procedures for industry, they are bad for apprentices who are in a works to learn as much as possible of their trade. Equally, large works by their very magnitude make it more difficult for the apprentice to learn all branches of his business.

Trade practices can be taught at the university just as the calculations for a displacement sheet and the geometry of a valve diagram. In other words such matters as detailed steel work, machinery work, piping, ventilation, cargo gear details and many others can be taught at a university. Such teaching would also be good mind training. If the universities would include such subjects in their curriculum, it would surely follow that employers would look upon university graduates with more favour, and that apprentices themselves would be more eager to obtain a university degree. This would all be of the greatest value to the shipowner, because all his employees would then have, more or less as the case may be depending on the individual, a broader basis of training which must inevitably produce greater co-operation between them.

A sound technical training to be useful, must have a practical application, or it cannot be of real value to industry. The question is raised here, with all due respect for past customs and present methods, as to whether the education of men for industry is not too much in the hands of educationalists. Is it not time that the industrialists themselves took a more intimate concern in this matter? Not a general concern, which is already existent, but a detailed one, with a view to obtaining the closest collaboration between the universities and industry, for the production of men with the most efficient combination of technical and practical training.

It has been somewhat difficult to write this paper for the reason already mentioned, that it seems to be stressing the obvious, in so far as there *must* be advantages to the shipowner of co-operation between the naval architect and marine engineer. If any good can come out of this dissertation it must be the conclusion that the training of young men, both in the works and at the universities, should be broadened, and that in the universities it should be made more practical.

DISCUSSION.

The CHAIRMAN said that the lecturer was probably well known to everyone present, both by reason of his professional reputation and his prominent association with several of the leading institutions. He was peculiarly qualified to deal with the subject of his lecture, and it was very good of him to have spared the time necessary to prepare his paper and to have hastened his return from Italy in order to deliver it personally and reply to the discussion. Mr. Hamilton Gibson had kindly consented to open the discussion from the point of view of the Marine Engineer, and Mr. E. F. Spanner would then give his views as a Naval Architect. The subject would then be open to general discussion.

Mr. J. HAMILTON GIBSON (Member of Council), in opening the discussion, remarked that the Chairman had indicated that he was going to speak for the engineers. He had no idea that it was to be quite so much in the nature of a debate, and the notes he had prepared were not made with that object in view. He had treated the subject generally, and he would have something to say from various angles. Proceeding, Mr. Gibson said: "I know of no one who could have handled this subject better than Mr. Wall. He has had just the experience that is required; first as naval architect for a firm of shipowners, then for a firm of shipbuilders, and now as a link between shipowner, shipbuilder and engineer. Mr. Wall and I were colleagues for some years, he on the ship side and I on the engine side, and it may be taken for granted that we are in entire agreement as to the advantage to the shipowner of close co-operation between the naval architect and the marine engineer.

It is notorious, however, that this desirable co-operation does not always exist. There are shipbuilding establishments where one side or the other predominates unduly, to the detriment of the product. I was lucky enough to be brought up in a privately-owned shipbuilding and engineering firm, where the proprietors took the utmost pride in turning out a perfectly balanced job, and where complete co-operation prevailed.

I can recall the interesting early stages of several important vessels—now historic—where, the machinery spaces being allotted, the engineers made their first rough shot at the weights and centres of gravity of the boilers, engines, shafting and propellers. If these did not suit the ship, we had to try again, and the best compromise was effected by friendly give-and-take. That, of course, is the ideal method by which the shipowner gets the best of what shipbuilder and engineer can produce in collaboration.

Mr. Wall refers to pipe-work not always receiving the attention it deserves. I take it that he means the pipe-work all over the ship, not in the engine-room only. There was a time when I acted as a sort of liaison officer between the ship and engine side, and one of the jobs I had to do was to arrange the run of pipes outside the engine and boiler rooms. I particularly remember those which had to be led along the ammunition passages of the older battleships—hydraulic mains, ventilation trunks, voice pipes, electric cables, steering controls, telegraph shafting, etc. It was a terrible job to make those leads fit in neatly, particularly where they had to go through the watertight door bulkheads. I certainly think that, as regards such pipe-work, Mr. Wall has instanced a case where the engineer and the naval architect could collaborate with advantage.

Sometimes the shipowner puts forward a requirement that affects both ship and engines. Take, for instance, the disposition, size and height of funnels. For appearance sake he may want oversize, squat affairs, pitched so as to bear no relation to the position of the boilers. The shipbuilder find that his 'tween deck accommodation is upset. The engineer wants funnels much higher to ensure a good draught. Who is to settle the question? Clearly it is a matter where the naval architect and the engineer must get together and advise the shipowner for his own good.

But who is the shipowner in these days? The author finds some difficulty in defining the terms naval architect and marine engineer; and no wonder, in view of the people who claim the names—and get away with it! I suggest that a similar difficulty occurs with the term "shipowner." Time was, in the days of Cunard, Guion and Inman, when no doubt existed. Now, in many cases, the personal contact is lost, and we have to deal with a department that merely carries out the terms of a specification approved by the board of directors, with little or no ship-sense, its main concern being the cheapest possible transport of cargo and, maybe, passengers.

As the author observes, there are many pitfalls in a full consideration of this very intriguing subject, and there are many points of view that can only be composed and settled by a sympathetic appreciation of the problems affecting every interest concerned in the building and running of a ship. In the composing of such differences as may arise, thus permitting the work to be carried on, such men as Mr. Wall in their professional capacity perform a most valuable service.

In my opinion, the so-called "training" of apprentices in nearly all our big establishments is a national disgrace. Departmental, or water-tight compartment, systems are often carried to ridiculous extremes, and the wonder is that a boy can pick up as much as he does in his course through the shop. When I had a free hand as manager I always had engineer apprentices in pairs passing through the pattern-shop, the smithy, the foundry, the boiler-shop, the copper-pipe shop, and the power station, besides the normal fitting shop, and work afloat. It was not difficult to arrange, and I may say that these lads, almost without exception, now occupy important positions.

How can we expect shipbuilding and engineering to prosper under the present narrow conditions of training? Technicians and educationalists have done their best to bring about a better state of affairs. I myself was chairman of a committee formed some years ago to investigate and report, and, beyond registering our conclusions and opinions, nothing happened! A similar enquiry had been held in Liverpool some years previously, with a similar result. Both reports were based on data supplied by leading authorities on the practical and academic sides, but our investigations proved fruitless. It may perhaps be too much to hope that H.M. Dockyard system of simultaneous practical and theoretical training will ever be adopted by private firms, but in my opinion the best hope for the future lies in that direction, and the sooner the industry realises this, and acts upon it, the better.

MR. E. F. SPANNER: Co-operation, of course, is absolutely essential if naval architect and marine engineer are to produce to the shipowner a vessel representing the best possible value for the money he has expended. The two must not only be partners in the enterprise of building a new ship, they must be close friends. I have known cases in which the final result was not the best possible because, while there was sound knowledge on both sides, there was lack of complete sympathy between the naval architect and marine engineer. A very little selfishness will spoil a design. With the extraordinary number of different machinery propositions now on the market, the naval architect is faced with a tremendous task, for he must spend a great deal of time continually in following the progress of marine machinery development. Naval architects would welcome with open arms the advent of some form of marine engine which—definitely and with absolute finality—could be adopted to the exclusion of all the others. To be perfectly candid, the position often occurs at present that the naval architect is called upon to act as the final arbiter—to decide between the claims of a dozen or more different types of machinery installations. I am sure that, among engineers here to-night, I could awaken discussion of the merits of rival machinery arrangements which would wax decidedly warm. We naval architects are, fortunately or otherwise, much more single-minded in our outlook. We rarely argue amongst ourselves—unless it be about matters on the borderline between our own domain and that of the engineer—or matters about which we know nothing at all—airships, for instance.

There are many sound reasons why naval architects and marine engineers should find it easy to work in close harmony, the one with the other. Training in mathematics, natural science, applied mechanics, metallurgy, and other fundamentally important subjects is shared by both branches. The two follow diverging lines only when they come close to the practical application of their early theoretical training. The naval architect has then to concentrate on hydrodynamic problems and the marine engineer on thermo-dynamic problems. The naval architect has to learn how to build a thin-shelled vessel of considerable size which can be pushed through the water safely and economically while carrying heavy loads. The marine engineer has to learn how to develop large horse-powers on a minimum consumption of fuel, and at the lowest terms of weight, space and cost. I think that, shortly, describes the two diverging branches.

Well, the marine engineer's task appears to show no signs of having come to any end. What about the naval architect? I feel, personally, that far from having reached the end of our own particular road, there is good reason to hold that we are very far from having discovered the right solutions to many of the problems peculiar to the science of naval architecture. Naval architect and marine engineer, therefore, can share a common feeling that they are still very busy on development work. Neither has retired from active and aggressive research work.

I am greatly interested in the subject of the education of young fellows for these two great professions. I think most here will agree with me that what are commonly reckoned the prizes of life are not often distributed among technical men. Naval architects and marine engineers do not often die rich men in the financial sense. Juggling with money seems to produce greater financial gain than does juggling with strains and stresses, or pressures and temperatures. Yet I am certain that there is no satisfaction greater than is experienced by the designers of a successful ship, whatever her size. Incidentally, naval architects and marine engineers in this country—the whole body of each profession—will feel a great thrill when news reaches them that some British vessel, as yet on paper, or in the air, has succeeded in lowering the *Bremen's* record.

These two professions are finding it difficult to obtain recruits. It is a great pity, but it is a state of affairs that can only be remedied by continued effort on the part of those of us who are in these professions, to encourage the younger generation to take pride in and to develop fully their inventive instincts. Further, if the youngsters see that there is optimism and enthusiasm and hearty good fellowship amongst naval architects and marine engineers, there is likelihood that they will decide that may be they might do worse than set out to follow the same road. Certainly, as I have already indicated, there is little enough financial incentive to bring them along.

Finally, I should like to say that, in my opinion, discussions on matters of general character such as are covered by Mr. Wall's paper are very stimulating and helpful to those who are satisfied to follow these two important branches of applied science. They help to establish the feeling that marine engineers and naval architects are contributing something of very great worth to the cause of civilisation, and not themselves becoming mere machines in the process.

Mr. J. CALDERWOOD, M.Sc.: I was very pleased when I saw the announcement of Mr. Wall's paper, because the subject is one in which I have always been deeply interested, but I wondered very much how Mr. Wall would approach it, because it must have been a most difficult subject on which to write a paper. If he had tried to deal with various points on which closer co-operation was desirable I am afraid he would never have finished, as there are so many; he has, however, avoided this difficulty and has treated the subject in a most interesting matter. I think the paragraph on page 211 strikes at the root of the matter, where he says: "it is not at all uncommon to find hull and machinery departments working in absolutely watertight compartments. . . ." He might have gone further and said that it is extremely common. Even where both ship and engines are built by the same firm we find that the two departments do not work closely together, and however far the management goes in trying to arrange co-operation they very rarely succeed, because the heads of the departments have generally such a narrow outlook. Possibly the naval architect has been trained at a college or in a drawing office and night schools, but the whole of that training has been in the theory and practice of naval architecture. The amount he has been taught about the engineer's problem is negligible. The same applies to the engineer, and the result is that when there is a discussion, neither will give way. That is bad business, not only for the shipbuilder but for the shipowner also, because it inevitably increases the cost of the ship. This lack of co-operation is found not only in the drawing office but in the shipyard, amongst the workmen and foremen. A shipyard foreman will very often hold up a job if he thinks it is going to save his department a little money, although it may cost the engineering department ten to twenty times what he is saving. Such difficulties would be greatly reduced if the responsible officials in each department had to acquire before their appointment a knowledge of the other department and its work.

Whilst I agree generally with Mr. Wall, there is one point where my ideas differ from his. That is the method by which he suggests that the universities could be made more useful. It seems to me that the trouble at present is that the universities, generally, in their course of training try to be too practical instead of keeping to their job, i.e., that of giving a sound grounding in the elements of physics, mathematics and other subjects which it is necessary for engineers and naval architects to know. They try to tackle practical problems which can never be tackled in a university. The result is that many students go through a university and then go into a works thinking that because they have learned something about these practical problems at the university, they already know all there is to know about practical shipbuilding or engineering; this is probably why many employers do not like university-trained men. In my opinion, the university should be kept to the purely theoretical side and the university course should run in conjunction with works training. The sandwich system is already fairly common and is spreading. If practical training is to be carried out in school it should be the works school, not a university school. The elementary practical work might be carried out in a works school, as is done in a very few cases both here and on the Continent.

Turning to what I imagine was more in the minds of the Papers Committee when they chose this subject, i.e., various problems where co-operation would be an advantage to the shipowner, I would like to mention two particular problems where we are very far from getting the best results at present. One is in relation to propellers. I do not think it is an exaggeration to say that propeller design has been at a standstill possibly for forty years. The staffs of various tanks have carried out series of systematic tests on the same type of propeller. None of them has made any extended efforts to design a propeller which would give its best efficiency at a higher revolution speed. In the case of reciprocating engines it would be a distinct advantage to the engineer to be able to use higher revolution speeds. It is a point to which naval architects might give more consideration. At present in some cases the engineer puts forward a higher-speed engine, and it is put in with an inefficient propeller. In other cases the naval architect has his way, and an engine running at a low speed is put in; the ship costs more and is inefficient.

The other point is in relation to engine seatings. There the engine builder submits his engine drawings to the naval architect, who in many cases designs the seatings without sufficient consultation with the engineer. In one case the engine framing may be such that a comparatively light seating would be suitable; in another a very heavy seating is required, but these points are given no consideration. I have seen cases where an absurdly heavy seating has been put forward, and others where an absurdly light seating was provided.

The Papers Committee are to be congratulated on having asked Mr. Wall to give us this paper, as I feel sure that no one could have tackled the subject in a more interesting manner than that which he has adopted.

Mr. E. G. WARNE: I think that the paper Mr. Wall has read to us, taken in conjunction with its elaboration by the foregoing speakers, has scarcely followed the lines one thought it would take. It has dealt with training and university systems. I should like to add a tribute to Mr. Hamilton

Gibson's remarks on the question of training of apprentices. He mentioned the system of putting apprentices through the various shops in pairs, which is not a common practice. I think it is one which should be more generally adopted. The naval architect, during his early training, should have more opportunity of acquiring engineering knowledge. On the other hand, the young engineer finds that a veil of secrecy seems to be drawn over the ship side of the question which prevents him readily acquiring any satisfactory knowledge of ship construction.

Mr. Wall says that: "The height of the machinery is also an important consideration in so far as it affects the casings on the passenger decks, and with the internal-combustion engine this may be a drawback, in that it cuts out a certain amount of deck space that would otherwise be available for passengers." Engine designers have been to a good deal of trouble to show that Diesel engines offer an advantage as regards space occupied when compared with steam engines plus boilers; Diesel engines do not necessarily cut into the passenger space so much as steam engines. Perhaps Mr. Wall would state what he had in mind when he suggested that internal-combustion engines might be a disadvantage. Possibly he had actual cases in view. Later on, again on the same subject, he says: "In some cases auxiliary machinery will have quite a predominating influence upon the design, particularly if it is desired to fit electric generators driven by internal-combustion engines, as these occupy a good deal of length and considerable height as compared with steam-turbine-driven electric generators." That may be so, but why does the shipowner adopt Diesel-driven auxiliaries on the largest steam liners as well as on motor vessels? I suggest it is because of their superior fuel economy and the consequent effect on the ship's performance. Mr. Spanner suggested that naval architects would like to discover a type of machinery which would exclude all other types. This seems to point more clearly to the supremacy of internal-combustion engines. Possibly Mr. Spanner will find his work rendered easier in future than in the past!

Mr. H. E. J. CAMPS (Visitor): It occurred to me on reading the title of this paper that it was a subject which completely spoke for itself and upon which, to those who know the subject, very little could be said. Then it occurred to me that possibly there were two aspects of the matter. One of these is that upon which Mr. Wall has concentrated, and which Mr.

Hamilton Gibson and other speakers have emphasised, namely, the co-operation between the naval architect in the shipyard and the engineer in the engine works. There are, of course, several firms in the country who not only build ships but also build and fit the machinery. In these cases I cannot conceive that there would be any lack of co-operation between the naval architect and the engineer. If the efficiency of a ship for which the shipbuilder is building his own engines is to be any criterion of the commercial success of the ship later on, it must necessary follow that there must be complete co-operation between the naval architect and the engineeer in their departments. I cannot conceive that the *Bremen*, *Berengaria*, or the White Star liners would have been efficiently turned out or would have achieved the fame they have if there had not been complete co-operation between the naval architect and the engineer. But that is not entirely the case where the ship and the machinery are not built by the same firm. In these circumstances there is frequently a lack of co-operation between the naval architect in the shipyard and engineer in the engine works, and sometimes it has been costly to both engineers and shipbuilders, and has led to somewhat difficult circumstances for the shipowner. There is one other department where co-operation could be very greatly extended, and it is between the engineer who is responsible to the shipbuilder, and the engineer who is responsible for the maintenance and running of the ship, and the naval architect who is responsible for the building of the ship and of future ships. Perhaps one illustration will show what I mean. Most steamers have at some time during their life-time fires in their bunkers. There is no subject which is more open to discussion than bunker fires, but a great deal of improvement could be made in the design and equipment of steamers if the superintendent engineers, who know all the circumstances, would discuss these circumstances with the naval architect and give him an opportunity to try to eradicate the danger of such conditions in ships in future. Other examples have been mentioned by previous speakers, for instance the advantages which would accrue from co-operation between the naval architect and the engineer in the design of propellers. Whether there has been sufficient investigation of the effect of propellers on the run of ships' lines is open to question. It is to the experimental tanks that we look for improvement in that direction.

There is one particular feature of the paper about which I should like to say a few words, because Mr. Wall knows I have a great deal of personal interest in it. It has been emphasised by Mr. Hamilton Gibson; I refer to the question of training. I may be old-fashioned, but I am one of those who believe that technical training is the most important in the first instance. You can train a boy's hands and fingers to do a great deal more in his younger days than you can in later life, when his brain is more capable of absorbing theoretical work than at 14-15 years of age, so that I suggest that the most suitable training you can give to a boy is to let him serve two or three years after he has left school at the practical work, and leave his concentrated theoretical training until two or three years after he has started to serve his apprenticeship. A university training may be considered a very desirable thing, and so it is, but there is one thing which a university training cannot do, i.e., to implant into a boy's mind and habits those things which can only be imbibed by daily association with the men in the works. The human element cannot be instilled into a university student's mind; it must be acquired by actual experience. That brings me to my final proposition on the question of training, that the system which has been adopted on the North-East Coast, the Clyde, and Liverpool is the best to ensure that future engineers and naval architects will know their work from a scientific, practical, and commercial point of view; that is, to spend their holidays from the universities in the works, but that that should not be started until they have had two years' continuous work in the shops. A boy will maintain a continuity of school training by attending night classes after his day's work. In my apprenticeship days university degrees were not known so far as naval architecture and marine engineering were concerned. As an apprentice I worked from 6 a.m. to 5 p.m., but five nights a week I spent at the College of Science in Belfast. You cannot altogether dictate to a boy what his training and education are to be unless you have some idea as to what he is going to do eventually. If he is going to cultivate a commercial career it is desirable that he should have some knowledge of both departments; if as a naval architect to a shipowner, he requires not only a sound knowledge of naval architecture but engineering as well. If shipbuilders and marine engineers are going to supply themselves in the future with the class of men who will be serviceable to them and give them the best results, they must be prepared, I think, to train these boys for their own service and let them serve an apprenticeship in both departments—shipbuilding and engineering, and not limit them to studying for themselves the theoretical side of both these branches of the industry.

I am much obliged to the Institute for giving me on opportunity to support Mr. Wall. I consider that his paper will do a great deal of good, and that the discussion will be of advantage both to him and to this Institute.

MR. C. F. GRANT: There is one point which Mr. Wall has not mentioned. Superintendent Engineers all know that in years gone by they had to learn their business and carry it through, which did not leave much time for studying naval architecture. It has been my pleasure to be associated with Mr. Wall in connection with stability of certain ships. The Company for whom I was engaged as Superintendent Engineer were very much concerned about stability, and they took advantage of Mr. Wall's knowledge of naval architecture and approached him with regard to drawing up tables of stability of the different ships, with which most of you are possibly familiar. They proved very successful and were a great help to the company, the masters of the ships, and myself. I think Mr. Wall might have mentioned this in his paper, as it is a very good example of the advantages of the close co-operation between the naval architect and the marine engineer. If any question arose in the office whether a certain ship abroad could take certain cargoes with safety, these tables proved invaluable.

MR. F. O. BECKETT: It is my opinion that a man may be by nature a successful naval architect or a successful engineer, but not both. Referring to the training of apprentices in pairs, I think it would be much better if the last year of apprenticeship, six months was served in the drawing office under an efficient designer. It would give them a broader outlook later on. With regard to shipowners, I should think that the shipowners of the present day who maintain close personal contact with the naval architect and the engineer could be counted on the fingers of one hand. The administrative methods of the modern liability company prohibit the exercise of individuality on the part of the principals in relation to the members of the staff. The leading naval architects of former days were much more in the public eye than are those of to-day, who, though their work in connection with large cargo and passenger vessels is of much wider range and intricacy, are mere units in large commercial organisations. As regards repair work I have known several instances of weakness of construction causing trouble with steering engines, etc., which had to be rectified by some local stiffening carried out by the engineer on board. These weaknesses of construction were due to pressure being applied by the shipowner on the naval architect to keep down the cost.

Mr. T. R. THOMAS, B.Sc.: Before proceeding to the discussion of one or two points of Mr. Wall's paper, I should like to explain on behalf of the Papers Committee that they considered that the subject was one which would be of interest to the Institute, and that if Mr. Wall consented to contribute a paper on the subject, as he has done, it would be an interesting one. In adding my thanks to those of the previous speakers, I would suggest that the attitude of the Papers Committee has been fully justified, and their request to Mr. Wall has resulted in a most interesting paper.

Mr. Wall admits that the term "naval architect" is a difficult one to define. I think that the fault is that the term has been loosely applied and that, although there are naval architects unworthy of the name, Mr. Wall and those in a similar position are more than naval architects, they are in reality technical advisers to the shipowner. If we assume that this is the proper function of the naval architect; then we must agree that his present education is too restricted and does not entirely fit him to act as a liaison officer between the shipbuilder and the marine engineer. Mr. Wall said there is no concerted action in this country to provide dual training, but in this connection I would point out that there is a degree in marine engineering at Durham University, the training for which combines marine engineering with a course of naval architecture. As regards the value of a university training, it is sometimes forgotten that the knowledge obtained at a university means very little, and the fact that an individual has attended a university course cannot add to his ability. One of the disadvantages of such a training is, in fact, the tendency for a young man who has just completed it to think that he knows rather more about his business than he actually does. This, however, should not blind the young man's prospective employer to the fact that the training as such has been of considerable value, in that if the man has the ability to take advantage of it, he will in the course of time be a very much better man than one who has not had a university training. He is likely to have a broader outlook and be better able to tackle new problems. Mr. Wall rightly deplores the fact that a university training is not sought after so much as it was. It is a very unfortunate fact that the number of students of naval architecture at our universities and the number of students applying for membership of the Institution of Naval Architects are falling year by year. This, I think, has been due to the fact that the shipowner leaves his interests more and more in the hands of the shipbuilder and does not now, as he did in the past, employ a naval architect to look after them. I think, however, in course of time the shipowner will realise that his present attitude is unsound.

It has been suggested that, so far as repairs to ships are concerned, there is at present a lack of co-operation between the designer of the ship and the repairer. This has been truer in the past than it is now. In recent years the design of the structure has been practically left to the classification societies, and I can assure Mr. Spanner, who I think raised this point, that the British Corporation gives it full consideration. Nevertheless, I am sure that the classification societies would welcome the assistance of a competent naval architect employed by the shipowner to solve some of the many problems which arise when the ship is being designed.

THE CHAIRMAN: I suppose we can all think of some points with which Mr. Wall has not dealt. Speaking as an engineer I might say that when the naval architect designs the ship he rules off a piece and says to the engineer, "Here you must put your engines." If I might quote one of our recent papers I could state that although an engineer can design as perfect an engine as possible, yet in spite of that we find trouble when the ship gets to sea, due to vibration. Professor Dalby gives an easy solution to this difficulty. He says it is quite easy to produce a ship without vibration; all you have to do is to find one of the nodal points of the ship, put your engines right on top of that point, and there will be no vibration. The naval architect indicates that point, but he almost invariably fails to put it at the right spot! That is one of the difficulties in which the naval architect might help the engineer. We all know that co-operation is a good thing; we find instances of it every day. I often have designs come before me in which perhaps I see a note "The shipyard to join up here," or in a ship plan "Engineers to join up here," (particularly as regards pipe line). A little later one goes on board the ship and finds the complete engine room installation of pipe lines. Later still, the ship comes along and the engineer has to take away a number of his pipes because of the lack of co-operation between the ship and engine men.

Having thrown out a challenge to the ship side, now I would like to say a good word for the naval architect. Some few years ago I was looking at a ship which went across the Atlantic, and in her upper structure one of her main strakes of plating was cracked right through amidships. That was because the calculations had been so fine. I was interested to find out how matters progressed from that point, and how the naval architect got over that difficulty. In a ship I saw later on he built the ship with a crack already in it, and joined it up with some leather or rubber substance.

With reference to university education, I do not know any man who has made a success of engineering who would not have been a better man with a university training.

MR. W. HAMILTON MARTIN (by Correspondence): The Author spoke about the qualities which a naval architect should possess. The ideal naval architect would no doubt need to be a man who has wide experience and vision, can be decisive, and yet accommodating when required. He must be able to pre-conceive a design and then carry it into effect with the least waste of materials in obtaining the required strength, and supervise its building, giving his valuable guidance to the shipbuilders and working in complete harmony with the latter, this co-operation resulting in a serviceable job turned out at the estimated cost or less. The finished job must be one which not only does all that is required of it with a reasonable margin, but is an improvement on his previous job, and one which satisfies the owners, makes a good name for itself among passengers and crew, pleases the eye of the mariner, and meets with the deserved, kindly constructive criticism of his fellow naval architects. We are fortunate indeed in having had many outstanding men in Britain who have closely approximated to this ideal.

In the shipbuilding works where the general manager has been sufficiently well informed to decide personally on both the engineer's and naval architect's problems with regard to vessels, the best results have generally been obtained. Instances of this kind, however, have been all too few and far between. Men in high positions in industry, whether engineer managers or naval architects, should all have had a very thorough practical training to which has been added the required theoretical schooling. They must be able to appreciate the other man's point of view and his difficulties, whether he be an equal, an engineer, a shipowner, a fireman or a trimmer, all of whom can contribute advantageously towards improvement in design and operation, if the naval architect knows how to co-ordinate and disseminate their views Only men with inborn personality and power, who can command respect and attention, will prove able to induce the many trades and departments involved in ship construction to co-operate harmoniously and thereby obtain the best results in a vessel. He must needs be a worker with great foresight, and one who is prepared to give up part of his spare time to technical literature, so as to keep abreast of improvements in these fast moving times.

The practical training should be started very early, so as to acquire that intuition, self-reliance, knowledge of materials, tools and constructional methods so vital to him in his later work. Theoretical training will not give him the same opportunity to do this, and the few months he may be able to spend in practical work between his college sessions are all too short, while he has then already attained an age when it will often prove difficult for him to step down to the level of, and be on equal and sufficiently intimate terms with, the artisans in the shipyards, from whom he is supposed to pick up his elementary and so highly necessary first practical knowledge of the methods of construction and other practices met with in shipbuilding. The University atmosphere is often considered to be quite unsuited to young men who are to lead in higher positions in industry later on, a truth which probably also holds in this case.

The naval architect of a necessity acquires a large part of his knowledge by theoretical training, which is one more reason why he should be first moulded to accommodate himself to the rough and tumble practical training which gives him the highly necessary experience which will bring out the man in him and prove whether he is fit for the high position he later intends to acquire.

The knowledge acquired in the works or in the shipbuilding berths can never be forgotten, and the younger a boy is set to it the more lasting will be the impressions and the more receptive and accommodating will become his mind. Any later theoretical training will certainly prove a valuable addition to this practical experience, and the two will then more readily unite and give him that combined knowledge so necessary in his profession.

It would seem that instead of taking this training in spasms, alternatively with his college career—or worse still, after it—

this practical training ought to take precedence, but should be closely followed by the theoretical training, which, as the Author rightly pointed out, should consist more of trade practices and less of educationalisms. A student who has had such a practical training of three to four years, which could possibly be run partly in conjunction with his high school period, will be able to digest the theoretical training, and naturally the trade practices, very much sooner and more thoroughly, which would lead to the so much desired shortening of the theoretical training period referred to, or leave some time to be given to the commercial side of engineering and shipbuilding and the question of economics.

These are matters which lie outside our control, but the education authorities might be well advised to consider the question in conjunction with the engineering institutions concerned, and possibly some representatives from works who have had their own training schools for apprentices.

I would like to add my appreciation to the Author for his most interesting paper, a valuable addition to our Transactions.

Major J. M. ELLISON (by Correspondence) : It is to be hoped that the title of Mr. Wall's paper will be a contributory asset in bridging over this gap which has remained open so long, as it has proved detrimental in many ways to all concerned.

Having served for five years in marine engine works, also a further five years in shipbuilding, and afterwards on various classes of land engineering, I feel that this paper is particularly welcome. In my case this dual training and accumulated knowledge have been of the greatest value personally, especially when I have been left to work out problems on my own resources, but there must always be a decided leaning to either the architectural or mechanical side. The purely defined members of either group are of little use in themselves, and can only be classed as the "slaves of specialisation."

It is regrettable still to find the naval architect and marine engineer displaying their specialised arts in such deep and narrow channels, which undoubtedly leads to non-co-operation, selfishness, and confusion to the shipowner. The marine engineer appears to be possessed of the greater specialisation of the two, the following case being an example. The shipowner asks his specialists to ascertain the reason for his latest built ship attaining inferior speed, and the procedure of the two gentlemen concerned is interesting. I think it will be found that the marine engineer will at once examine the horse-power development and propeller design, and not having had any hull experience he will go no further; on the other hand, the naval architect will try to find out by some means what is the actual horse-power developed, examine propeller design, and will then branch off into his own sphere, by checking the co-efficient of fineness, displacement, resistance, etc. In a case like this, unless there is co-operation, the resultant information required to be placed before the shipowner is liable to be unsatisfactory. With the dual training, one man should be able to diagnose cases of this kind, and report satisfactorily.

I regret that I cannot quite agree with the Author that the employer prefers men with a good all-round training and experience, as in many cases where I have applied for appointments, I have been informed that it is the specialist they require, and who really matters. Shipowners are, I find, particularly biased in this way.

University training, or preferably the "sandwich system," should be encouraged more, and my experience of the latter is that it has been abused by the employer, because when apprentices left the grime and cold winter mornings behind to work in a more comfortable environment, great dissatisfaction was caused among the others who were unable to afford the fees, also the employer's interest in these "part timers" ceased, and when they returned to the works for the summer they were given superficial jobs. As our lives become more democratic, I feel that the chances of the academical training leading to a desired success, and being well recognised, will not mature quickly.

It is thought that the sooner naval architects "cement over" their "sharp edges" of specialisation, and the marine engineer "files down" his, the better will be their co-operation, to the benefit of all engaged in the building and running of ships.

MR. W. MCLAREN (by Correspondence): One can appreciate the Author's difficulties in preparing a paper on this subject, knowing what a naval architect has to contend with in the passenger and cargo carrying production of a first-class ship, which may be of 18,000 tons displacement or more.

To my mind, even if the co-operation desired between the naval architect and the marine engineer is taken for granted, there are still other persons connected with the running of a ship whose co-operation is necessary to protect the interests of shipowners and to give the best results.

The shipowner may be, and generally is, a very keen business man, and has on his staff a marine superintendent and a marine engineer superintendent, and these two officers relieve the owner of all technical work pertaining to the running of his ships.

Supposing the owner desires to increase the scope of his trading, and to take advantage of the advances that have been made in providing comfort for the passengers, he consults his technical staff and they decide to call in the assistance of a naval architect, that is a man fully qualified in his profession and presumably a member of the Institution of Naval Architects. We may similarly presume that the superintendent engineer is a Member of the Institute of Marine Engineers and that the marine superintendent possesses a Board of Trade Master's certificate.

The naval architect should be able to obtain from these two officers particulars of all the requirements that the owner has in mind, such as the cargo space (and if for general cargo from a locomotive to a tea kettle, that would determine the hatchway opening), the ports of discharge whether open roadsteads, harbour wharves or docks, number and classes of passengers, number of executive and petty officers, including wireless operators, crew for decks, and the ship's doctor and his surgery staff, engineer's staff (varying according to class of propelling machinery, whether steam or internal combustion), solid or liquid fuel space, speed and radius to which the ship is expected to travel, electrician and refrigeration staff, butcher and his assistants, chief steward and his staff with the cuisine department and the utensils, such as baking and roasting ovens, stockpots, ham cooking cases or containers, boiling pans, grills, hot cupboards or closets, scullery with ample supply of hot and cold water for washing up and teak washing and rinsing tanks, wine and cigar store, and last, but not least, the barber and his corner, I mention as some of the persons whose co-operation is necessary during the fitting out stage.

The decorations may present one of the most difficult of the naval architect's problems, necessitating the assistance of an artist.

Now the naval architect cannot gain this experience necessary for the specification for such a ship at a University, but only by practical experience, and to enable him to be responsible for the acceptance of the ship from the builders requires all the co-operation available. The technical education of those intending to follow the profession of naval architecture or marine engineering should start not later than 16 years of age, and if shipbuilders and engineers could bring the Universities to the works and not the works to the Universities, some headway could and would result.

Why not a grant to the employer from the State, per capita for apprentices attaining a certain standard of proficiency at his works, thereby inducing employers to encourage boys to interest themselves more in their craft?

Mr. G. J. WELLS (Vice-President) (by Correspondence): The Author's plea for the closest co-operation between the engineer and the naval architect must be cordially supported by everyone concerned in shipbuilding. What is the undertaking that can succeed under divided management? I do not know of any. Unity of purpose between all concerned in any undertaking is absolutely essential to obtain the best results.

The Author's views, however, upon university education are not at all likely to pass without comment and, I should expect, will be seriously challenged by many who have paid serious attention to the problems involved. To deal with the Author's remarks adequately is impossible in the space available in a discussion, particularly as the matter involved hardly arises out of the Author's main subject.

The Author says " that employers do not particularly favour those who have had such a university education, etc." If that is so, why is it that all the leading institutions impose an educational test upon all candidates seeking membership? It is to be noted that in lieu of the Institute's examination, the degree of certain univerisities will be accepted!

When it is remembered that of these institutions, the Civil Engineers, Mechanical Engineers, and NavalArchitects include in their membership list almost everyone that counts in the professions concerned in the Author's criticisms and statements, one wonders if the Author is " ploughing a lonely furrow."

The statements made by the Author inevitably lead one to the conclusion that his angle of view is very narrow and inconsistent. How does he reconcile the statements (a) that " a university training is undoubtedly valuable, etc., . . . " with (b) " the fact that apprentices find that after completing their university course it is difficult for them to find positions, particularly against the competition of their fellow apprentices who during the three or four years university life have been doing practical work, with the result that they are looked upon by the employers as being of more value to them, etc.? "

Now the university training is either worth having or it is useless, but the Author immediately adds what is apparently a contradiction! and in the back-ground both the institutions of which he is a member insist upon their members having qualifications equal to the university standard for a first degree! How is all this to be reconciled?

Another difficulty that the Author must face is wrapped up in the latter part of the quotation above and also made in other places either directly or by implication. The employer who, to fill a vacancy from a group of young men, including graduates and non-graduates, selects one that possesses the greater practical experience, obviously does not require a graduate, and one infers that the position to be filled demands the ability of a craftsman, one capable of using tools, or supervising their use, and this employer is wise in preferring a man with the wider shop experience. But this is only another illustration of the truth of the old saw concerning the mutual fit of pegs and holes. The Author says that his hypothetical employer, when asked to accept a graduate as a pupil apprentice, often makes the objection that he has had no practical training! My reply to that position is that it is not the reply made to a non-graduate, why then to a graduate? Both of them require shop-training, the graduate having the advantage at the start of the better mental equipment. The schoolmaster does not refuse admission to the young child because he cannot read, but places him amongst the beginners. Both the graduate and the non-graduate have to learn shop and/or field work alike; why do many employers make so much noise about an ex-apprentice being worth more in the shops than one who has not had any such training, and realising the value of such knowledge, offers himself just as the apprentice did once?

Just one other question. The Author writes " In any case indications are that a university training is not sought after so much as it was twenty to twenty-five years ago." Now I venture to say that this statement is untrue, and should be glad to know how the Author can support it. May I venture to remind him that Glasgow, Edinburgh, Newcastle-on-Tyne, Leeds, Manchester, Liverpool, Birmingham, Nottingham, Cambridge, London, Sheffield, etc., all have schools of engineering attached, whereas 25 years ago, how many of these places granted an engineering degree? I think that the Author will have to modify this statement when he has looked into the statistics a little more closely. There are many more points to which grave exception may be taken in this part of the paper, for instance, the statement that "Trade practices can be taught at the university, etc.," is one of several that illustrate the Author's complete failure to realise what is meant by a university education; it seems clear that for "university" in the paper one should read "technical," and then some of the statements made might pass. With a long and varied experience in engineering work, first, followed by some years experience as examiner in the Faculty of Engineering, as well as a member of the teaching staff of possibly the largest university granting degrees in engineering, I feel confident that the Author would do well to re-cast many of the statements made in the latter part of his paper.

The AUTHOR'S reply: I felt a great deal of trepidation on coming here to-night, and I had some worries also when writing the paper. I am sure that whatever the paper lacks, the discussion has added a great deal on the subject. Mr. Hamilton Gibson struck the right note when he said it was not a debate.

I do not agree with Mr. Spanner that we want only one type of engine to put into a ship. After all, we must make the best use of the various available types of machinery.

As regards the question of education, one cannot generalise easily. You have to meet all sorts of people in business, and they do not carry a placard on them to say how they were educated, and with regard to university education I think that, probably due to my own fault, a little too much stress has been laid upon it here to-night. If I had used the term theoretical training instead of university education, perhaps it would have avoided some misunderstanding. I used the term to signify theoretical training. To me it is matter of pure indifference whether the training is acquired at night or day schools or by dint of hard work and perhaps personal tuition. I was trying to emphasise that we ought seriously to consider our views as to how that training should be accomplished and of what it should consist.

Mr. Hamilton Gibson instanced a shipyard with which he was connected turning out a perfectly balanced job as a result of a systematic "give and take" principle operating between the two sides; Mr. Camps seemed to think that the necessity for closer co-operation in such a yard could not exist. I have, however, found it actually in existence, and I think the reason is that the departmental manager is naturally full of his particular troubles, and he has got to get over those with the least difficulty possible. When the other department comes up against him he sees only, and very humanly, just the extra amount of trouble he will get on that particular part of the work, and if he can squash it he is going to do so. The general manager of such a yard should be the type of man we are talking about, in that he should be able to listen to the departmental managers, and of his own knowledge decide on the merits of the case, because after all one has to compromise frequently. Mr. Camps spoke of this matter, and I might give an illustration of it. In a very high-powered job a question arose in connection with providing the necessary accommodation for the passengers, and there was a trivial matter to the ship side of getting sufficient air down to the boiler rooms for the forced draught fans. The ship people said it was "a damned nuisance, as it was going to upset the cabins of three decks, port and starboard." I looked upon the matter from the important point of view of getting the air down to the boiler rooms. We eventually got those ventilators down without loss of space for the passengers simply by co-operation between the two sides. The other alternative would have been fatal.

Mr. Gibson and Mr. Beckett questioned who is the shipowner of to-day. I think we all agree that individual shipowners are few and far between, and that we are controlled more by financiers than by industrialists, which I think is also regrettable. I do not think we could do much to alter that, but I do say that it is a reason why we should take more unto ourselves. We have to advise the people concerned, and the more we can get right up to their job and tell them not only the technical point itself but how it affects the first cost and the running cost we are thereby going to do a lot of good to our own profession, as well as assisting progress.

As regards the question of simultaneous training as mentioned by Mr. Hamilton Gibson and Mr. Camps, I am entirely in agreement with them. I do not believe it is possible to keep any young man at school till he is 17 or 18 years of age, put him through a university course for four years, and then put him in to run the practical side of the business; it is not humanly possible. Mr. Spanner said that sympathy was necessary, but I think that a knowledge of the other man's side is most likely to create that sympathy. I might illustrate this by referring to a society with which Mr. Camps is associated—the Society of Consulting Marine Engineers and Ship Surveyors. I think it is safe to say that before that society was formed engineers and ship surveyors looked upon each other as natural enemies, but as soon as the society was formed these men got to know each other, talked together about their jobs, and met their mutual difficulties in such a fine spirit that the whole of the work was forwarded.

There is another point in connection with the difficulty of the marine engineer getting to know something about ship design. When one talks about ship design one probably means the more abstract parts such as strength, propulsion, stability, and trim. There, of course, a little training in these particular branches is absolutely essential, because they are bound to be of an intricate nature involving calculations, and it only strengthens the argument for closer co-operation.

Mr. Calderwood said that the separation of the two sides into water-tight compartments was extremely common. I agree with him, also that that is a reason for advocating the broader training. The point that Mr. Calderwood touched upon principally was the fact that the naval architect, as he described him, had a drawing office and school training and knew nothing of engineering. It emphasises the point that if we get rid of that ignorance, the one of the other, we shall get closer co-operation. He does not agree with me that the universities are too theoretical. I think perhaps the real difference between us is as to the definition of practice and the definition of theory. The point of view depends on how one defines the two. I agree with him that the works school would be most valuable. There again the training should include all sorts of subjects. Mr. Calderwood also referred to the propeller question. It is interesting and very satisfactory to see that we are to have a new experimental tank at Teddington. It is unfortunate that there has not been time in the past for the necessary research work; we may advance on these lines in future. It must be a special branch which must look into these matters. One cannot expect the ordinary shipbuilder, naval architect, or marine engineer to deal with them. As regards engine seatings, I am absolutely in agreement with Mr. Calderwood. I think that in recent years collaboration between those concerned in this matter has been greatly improved, but even to-day there is much room for improvement in that direction.

The Chairman said that the engineer could produce a perfectly designed engine, but that the naval architect could not find the nodal point. My only comment on that is that the ship does not vibrate when the engine is not running!

Mr. Warne agreed that each should have training in the other's science. He seemed to ask me to explain why the height of internal combustion machinery cuts out deck space more than that of steam machinery. It is not a question of actual length of casings. It is simply due to the fact that internal combustion machinery is so high that the casings have to be well up in the ship, whereas in the steam job you can get them down to a reasonable width. These disadvantages are small in themselves, but they do mount up. I remember one case—a 24,000 ton liner. We examined the complete designs, and found that with Diesel machinery we not only lost passenger cabins but the arrangement was very awkward compared with the steam job. One difficulty was that we could not get a passage through the ship that was absolutely straight and wide, which was a most important feature. Nevertheless these ships were finally built with Diesel machinery. That arose out of other major considerations outweighing this minor one. Mr. Warne also mentioned the question of auxiliary machinery. He asked "Why does the shipowner adopt auxiliary machinery of the Diesel type?" That hardly bears on the point I was making. I meant that if you are going to adopt it you must bear in mind this feature of Diesel machinery and arrange accordingly. There are some ships in which it is practically impossible to adopt Diesel generators or auxiliaries because they are so high; you have not always the length and height to spare.

With regard to Mr. Camps' observations concerning bunker fires, it all comes to this; that you must co-ordinate right through the piece. It is of no use having one man in a shipyard designing ships which he never sees afterwards and never hears what happens to his work. If you ask a builder to do a certain thing in a certain way, he may have good reasons for doing it in some other way. He says, "We did it in this way for certain other companies." Then you ask, "Well, how did it work out?" and he does not know and cannot tell you. You can probably tell him that it has not been a success. There is room for improvement in co-operation in matters of that kind.

Mr. Camps talked about the sandwich systems of training on the North-East Coast and at Liverpool, and mentioned the commercial point of view. That is a criticism that can be and is levelled against technical people, that they do not always study the commercial side as fully as they might, and it is up to us in these days to do so; I feel that we can be of great assistance to the shipowner in so far as our technical work must have a bearing on it.

Mr. Camps also said that the shipowner should train his boys in both sides. As far as I can see, the shipowner is not training anyone these days. That is up to ourselves. One hears of a dearth of marine engineers to-day. There again training is necessary to produce men who can do the job. Things are so complicated that we have got to take this question of training and grapple with it.

Mr. Grant was very kind in his reference to stability tables. Even to-day stability is such a vexed subject that I thought I would steer clear of it!

Mr. Beckett said that an engineer was born, not made. I recently read an account of an interview with Lindrum, the billiards champion, in the Strand Magazine. He said that champion billiard players are made, not born, whilst good ones are born, not made. A man may be born with the potentialities of a good engineer, but if he does not work it up by training he will not be a champion engineer, anyway.

Mr. Thomas contributed something to what should be the definition of a naval architect. I think that is too big a subject to go into here, but he said that it is not possible to train in both sides fully. I hardly think that is the point we have in front of us. It is a question of getting a working knowledge of each, so that we can appreciate the important points in both. I was very pleased to hear about the dual training at Durham. It is not only a dual training at the university which is necessary, but dual training more generally. I do not quite agree with Mr. Thomas about the older men not liking to see the younger men with degrees. I think it is much deeper than that. If the employer thought he could get the advantage in employing the university men it would not count at all. If any one of us here was asked to choose between a man who had had no technical training and only practical experience, and a man who had had little practical experience and technical training, I do not think there is much doubt that we should choose the latter, provided he was a man who had established himself at all in the engineering world.

I think this question of the lack of students at universities is a very serious one, and whether we are to be able to do any thing about it or not depends on ourselves, but I think that some concerted action ought to be taken for a better training of the young men coming along to-day. Whether that is within the scope of your Institute or some other I must leave with you.

Mr. Thomas suggested that more shipowners ought to employ naval architects than do so at present. Naturally, I agree. He says that the structural design is left to the classification societies. I quite agree. I think that the owner leaves too much to the classification society, and seems to think that if he has got the hall-mark of that society everything must be quite right about that ship. I think the classification societies would be the first to tell you that that cannot possibly be the case!

The Chairman mentioned pipe lines and co-operation. Really pipe work in a ship is such a big matter that you cannot pay too much attention to that subject.

I will conclude by thanking you very much for coming to hear this paper, and also for the vigorous discussion which has taken place on it. I am going away feeling very satisfied in that I had something to do with initiating this meeting and getting such a good discussion out of the paper. (Applause.)

A hearty vote of thanks was unanimously accorded to Mr. Wall, on the motion of the Chairman. A vote of thanks to the Chairman, proposed by Mr. W. McLaren, was also carried with enthusiasm, and the meeting then terminated.

THE AUTHOR'S REPLY TO DISCUSSION BY CORRESPONDENCE.

Mr. Hamilton Martin's contribution does not call for any comment. I find myself in agreement with him and think he has expressed his views exceedingly well.

Major Ellison instances cases of the specialist branching off in his own line to the neglect of other possibilities, thereby emphasising the need for co-operation. It does seem to be true that the employer loses a certain amount of interest in apprentices who break up the continuous service in the works by taking up technical training.

Mr. McLaren emphasises some of the points in the paper as to the necessity for the co-relation of all the various officials connected with running and maintenance of a ship.

I certainly think that some co-ordinated effort should be made to train boys and youths, along lines similar to that suggested by Mr. McLaren.

Mr. Wells has, to use a popular phrase, " missed the bus." It was only a short time ago, since the reading of this paper, that Sir Josiah Stamp, President of the L.M.S. Railways, expressed the same views on University training as I expressed in the paper.

In one respect only do I concede to Mr. Wells' expression of opinion, in so far as I said at the meeting in my reply to the discussion, that " if I had used the term theoretical training instead of university education perhaps it would have avoided some misunderstanding."

The full discussion on the paper and various expressions of opinion I have received since the appearance of the paper, confirm me in the belief that it is not I who am " ploughing a lonely furrow."

I am not aware of having said that I do not favour education, and agree that institutions are right in imposing an educational test on candidates. None the less the Institution of Naval Architects does not impose such a test. I have yet to hear of any technical institution that admits candidates to *full* membership on an educational test. They ask for very solid proof of primary responsibility and practical knowledge. Where, therefore, is Mr. Wells' point about educational tests alone?

The whole point, which Mr. Wells seems to have missed, is that the purely educational side is only a part of the main question. Statements (*a*) and (*b*) which Mr. Wells takes from my paper are not contradictory. The answer is in (*b*), in that the employer is looking for a man with practical experience; if the university trained man had that in addition, he would get the job.

I have been forced to the conclusion that Mr. Wells is deliberately misunderstanding my paper and is not sufficiently in touch with facts as they exist to-day. He seems to think that if an employer is looking for someone superior to a craftsman, he will of necessity look only amongst graduates. How very far from the truth. Does Mr. Wells think that graduates are filling all or even a large proportion of the superior and subordinate positions in works to-day?

On the question of acceptance of pupil apprentices, Mr. Wells has again gone astray. The matter under discussion is not apprentices, but persons for responsible positions.

Mr. Wells mentions the various universities that give engineering degrees. He does not mention that the students are now fewer than formerly. He does not say what happens to the graduates after leaving. He must be obsessed by his connection with "possibly the largest university granting degrees in engineering." He has also failed to realise that I am anxious to improve the value of university degrees, but I will not, ostrich like, put my head in the sand. I am myself a graduate of London University and the Royal Naval College, Greenwich, and withal, I say, do not let us rest on our oars in the belief that university education to-day is all that it could or should be.

A hearty vote of thanks was unanimously accorded to Mr. Wall, on the motion of the Chairman. A vote of thanks to the Chairman, proposed by Mr. W. McLaren, was also carried with enthusiasm, and the meeting then terminated.

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ABSTRACTS.

THE GROWING SCARCITY OF STUDENTS OF NAVAL ARCHITECTURE. "Engineering," 11th April, 1930.

In view of the long and continuous endeavours which have been jointly made in educational and professional circles to meet training requirements for the various branches of the engineering profession, and in view of the generous financial support and encouragement given by industry towards educational opportunities, the present marked diminution in numbers of young men studying shipbuilding and marine engineering at our technical schools, and Universities, is to be regretted not only from the industrial, but from the national, point of view.

Attention was directed to this matter by Mr. A. T. Wall in his recent paper read before the Institute of Marine Engineers on "The Advantages to the Shipowners of Closer Co-operation between the Naval Architect and the Marine Engineer." From the statistics of attendance, it is evident that there has been in recent years a serious depletion in enrolments in the particular courses of study mentioned. This is in contrast to the general increase which has taken place in the courses of study in other engineering branches, civil, mechanical and electrical, and more especially in contrast with the very marked increase in other faculties. It is clear that the activity of any industry must be reflected in some measure in the recruitment of apprentices, and in consequence there is to be expected a fluctuation in the numbers of student enrolments in some correspondence with the periods of variation in industrial activity. So far as the shipbuilding industry is concerned, however, the correspondence of this fluctuation with trade is not clearly evidenced in any short period of survey and from the pre-war time records of one of our prominent shipbuilding centres, the numbers of students attending the higher technical courses were actually above normal in the dull times of trade. This relation was by no means paradoxical, as the reason may be advanced that in the dull periods of trade a greater number of students are free to avail themselves of educational opportunities. The abnormally high influx of technical students immediately after the war tended to level up the almost total absence of students in the sessions during the war. The drop which we are now considering has been very rapid; it began in 1923 and has been so severe that there has been created a considerable outstanding balance or leeway in numbers of trained men.

Before going further into the matter we would refer to the paper delivered at the opening of the 1926 session to the North-East Coast Institution of Engineers and Shipbuilders by Sir Theodore Morison, on the subject, "How Should an Engineer be Trained?" In this paper the suggestion was made, and acted on, to form a special education committee to examine and report generally on the training of engineers, taking account of industrial practice and requirements for training, and to advise on the best means of embodying and correlating these requirements in the prescribed courses of study. The pamphlet, entitled "Engineering Training for Officers' Rank," has been published by the Committee. We draw attention to it on the present occasion as being of the greatest use in formulating any views on the present crisis, and we earnestly recommend its perusal to all young men intending to enter the profession of engineering.

On our present subject of the lack of entrants for naval architecture and marine engineering, the following remarks from Mr. Wall's paper well state the present position:—"In any case, indications are that a University training is not sought after so much as it was, say, twenty to twenty-five years ago. There are, as is well known, quite a number of scholarships offered by different bodies to apprentices from shipbuilding and marine engineering works, and these scholarships are tenable at various Universities where there are courses in marine engineering and naval architecture. The position has become so acute to-day that it is hardly possible to obtain candidates for these scholarships. This is probably due to more than one reason, but undoubtedly due to the fact that apprentices find that after completing their University course it is difficult for them to obtain positions, particularly against the competition of their fellow apprentices who, during the three or four years' University life, have been doing practical work, with the result that they are looked upon by the employers as being of more value to them than those who have been cut off from practical work during their University courses. This may be an unpleasant truth, but it has to be examined and faced. There probably is another reason in that young men in these days will not bother to study in order to compete for scholarships. The Universities also have made the matter more difficult in making the courses four years instead of three, as formerly, and the author is of the opinion that most young men look upon four years as too great a time for them to be absent from the practical side of their business, because, although the ultimate gain of a University training should go without saying, it certainly does not show any immediate reward after the university course is finished, especially as compared with their colleagues who have remained in the works during that time. There is also the added difficulty that although University courses are now for four years, the scholarships are only for three years."

While these remarks give some particular reasons in explanation of the state of affairs, there are probably other factors also at work. As already suggested the matter is clearly partly attributable to the present severe conditions prevailing in the shipbuilding and allied trades. This simple explanation, however, illustrates an erroneous assumption which students are likely to make, and is apt to lead to a policy of *laissez faire*. The severe competition in shipbuilding has brought to public notice the processes of reconstruction which are being made within several commercial groups of the industry, and it is probable that to some possible students rationalisation methods may seem to be connected with a limitation in the number of entrants to the profession and industries concerned. Such an idea is, however, a short-sighted one. Certainly, the conditions of the industry to-day may not offer immediate and lucrative prospects, but this should not have such a serious effect on the attitude of youth as to turn many away from entering the profession. To the eager and enthusiastic, the view should be taken that better prospects will necessarily follow and will reveal themselves in due time.

The severity of the competition in the important industry of shipbuilding will result in efficiency of method and intense application from all those engaged in it. The industry must, however, have the necessary recruitment of young men, and the prospects of the highly-trained man should improve with more intensive methods. From the employer's side, no discouragement is or will ever be made to young men to come forward. We, therefore, advance the plea to all likely entrants to regard the present difficulties as temporary.

The growing and multiplying fields of research in shipbuilding, engineering, and the allied trades, and the numerous and various positions for experts, inspectors, and supervisors, not to mention the possibilities of careers in many new branches not so directly connected with the trades, but of scientific importance, will always cause a demand for men of high technical attainments and expert knowledge. If the true cause of the scarcity of students lies, as we fear it does, in the attitude of the young men themselves, then we are sure that the best remedy will be the stirring of youthful ambition, and with this intent we would further point to the higher positions in administrative control and responsibility which may be reached. These positions are best filled by men who have demonstrated their value, not necessarily in any specialised channel, but by their general aptitude, personal qualifications, and, as the most necessary adjunct to meet modern conditions, their high standard of knowledge based on a thorough technical training.

THE NEWCOMEN SOCIETY. "Engineering," 28th Feb., 1930.

At a meeting of the Newcomen Society, held at the Institute of Marine Engineers, on February 19th, Engr. Capt. E. C. Smith read a paper on "Pioneer Ships of the Atlantic Ferry." Transatlantic steam navigation was established in the years 1838-1840 by four separate companies. The Atlantic, however, had been crossed by steam vessels long before then. In 1819, the *Savannah*, an American sailing ship, fitted with a 90 h.p. engine, crossed from America to England, but she took 27 days, out of which she used her engine very little. In 1827 the Dutch-owned S.S. *Curacao* went from Rotterdam to Surinam in Dutch Guiana, but her tonnage was small, and it was quite out of the question for her to steam the whole distance. Six years later, H.M.S. *Rhadamanthus* crossed from Plymouth to Barbadoes, via Madeira, and, later in the same year, the Canadian steamship *Royal William*, crossed from Nova Scotia to Cowes, but her voyage also was a long one. Neither of these passages was connected with any considered plan for establishing regular steamship communication. The real pioneer of the Atlantic Ferry was an American lawyer and business man, Junius Smith, who lived in London. In 1832 Smith went to New York and back by sailing packets, which took 54 days, and 32 days, respectively, for the outward and homeward voyages. The following year Smith put forward a project for placing steam vessels on the route, and, in 1836, he formed the British and North American Steam Navigation Company, with offices in London, and placed a contract with Curling and Young, of Limehouse, for the *British Queen*.

About this time, the Great Western Steam Ship Company was building the *Great Western* at Bristol, and the Transatlantic Steam Ship Company, of Liverpool, had been formed for purchasing the *Liverpool*, a fine vessel then in hand for Sir J. Tobin. The *Great Western* was the first vessel completed, but, in 1838, the London Company chartered the *Sirius* and the Liverpool Company chartered the *Royal William*—not to be confused with the *Royal William* which crossed from Canada in 1833, and in 1838 the *Sirius*, the *Great Western*, the *Royal William* and the *Liverpool* all made passages to and from New York. The *Sirius* and the *Royal William* were, however, found too small for the work and were quickly withdrawn, and, during 1839, the service was maintained by the *Great Western*, the *Liverpool* and the *British Queen*.

To these were added in 1840, the ill-fated *President* of the London Company and the *Britannia*, *Acadia* and *Caledonia* of the Cunard Company, the last three running from Liverpool to Halifax and Boston, instead of to New York. Of the three pioneer companies, that in Liverpool soon sold their vessel to the Peninsular and Oriental Steam Navigation Company. In March, 1841, the London Company lost the *President*, and then sold the *British Queen* to Belgian owners, but the *Great Western* continued to run most successfully until 1846, making, in all, some 74 double passages. The *British Queen* and *President*, built in London, were engined, respectively, by Napier, of Glasgow, and Fawcett, Preston and Company, of Liverpool. The engines of the *Liverpool* were made by Forrester, of Liverpool, and those of the *Great Western*, by Maudslay, Sons and Field. From some manuscripts which at one time belonged to Joshua Field, Engr.-Capt. Smith was able to give dimensions of the ships and their engines and particulars of their voyages. All the ships had low-pressure flue boilers, working at about 5 lb. per sq. in., and side-lever engines driving paddle wheels, but the *Sirius* and *British Queen* were both fitted with Hall's surface condensers and evaporators. From a table included in the paper it was seen that the average time for the outward voyage by sail was 34 days and for the homeward voyage 22 days, whereas the averages for the three steam ships were 17 days and 15 days. respectively.

A New Experimental Tank at Teddington. "The Engineer," 28th February, 1930.

In the recent report of the Advisory Council for Scientific and Industrial Research, reference was made to the offer of the Department to subscribe a sum not exceeding £10,000 towards the cost of an additional experimental tank at the National Physical Laboratory at Teddington. The new tank is required to give increased facilities for the experimental and research work on ship resistance and propulsion, and the testing of ship forms and propellers, which is now being carried out at the "William Froude" National Tank. At the annual dinner of the Chamber of Shipping, which took place on Thursday, February 20th, Mr. J. H. Thomas, the Lord Privy Seal, stated that as a result of representations made to him by the shipping and shipbuilding industries, the Government had decided to build a second tank for the testing of ship designs at Teddington, the cost of which would be £40,000. Mr. Thomas expressed the hope that the provision of additional testing facilities would result in the design of more efficient ships, and further stated his belief that the Blue Ribbon of the Atlantic was held by Germany only temporarily. We understand that the detailed designs of the new tank are now being considered by Mr. G. S. Baker, the superintendent of the Froude Tank, and his staff. The new tank will be specially designed for mercantile marine work, and will not, therefore, necessarily be so large as the 'William Froude" National Tank, presented by Sir Alfred Yarrow, or the Rome tank, recently completed which, in addition to testing ship designs and propellers, will also be employed for naval and high-speed hydroplane work. Mr. Baker and his staff have for long laboured under great difficulties, and it is satisfactory to learn that additional facilities are now to be provided which should enable a larger amount of experimental work to be undertaken and to be dealt with expeditiously.

NEW SHIPBUILDING ORDERS. "The Engineer," 14th March, 1930.

During the last few days the Anglo-Saxon Petroleum Co., Ltd., the shipping company of the Royal Dutch Shell Group, has placed orders with shipyards in Great Britain and on the Continent for no less than twenty new motor tankers. The total value of the orders is estimated at about £3,600,000. Each of the vessels will have a dead-weight capacity of about 11,500 tons, and will be propelled by twin-screw Werkspoor supercharged engines, the designed speed being about $12\frac{1}{2}$ knots. In this country two ships will be built by Harland and Wolff, Ltd., at the firm's Govan yard, and two by Swan, Hunter and Wigham Richardson, Ltd., at Wallsend-on-Tyne. Two further ships are to be built at Belfast by Workman Clark (1928), Ltd., and two by Hawthorn, Leslie and Co., at Hebburn-on-Tyne. It may be recalled that the last-named firm has already under construction three vessels for the Anglo-Saxon Petroleum Co., Ltd. The continental orders are divided between shipyards in Holland, Germany and Italy. Both the hulls and propelling machinery will be built to the owners' own specification, and by adopting supercharging the maximum output in relation both to space occupied and weight will be obtained. An order has also been received by Vickers-Armstrongs, Ltd., for a large electrically propelled passenger liner for Furness, Withy and Co., Ltd., of London. The liner will be built at the firm's Naval Yard at Walker-on-Tyne, which has now been closed for some eighteen months. The electrical propelling equipment will be constructed at the engineering works of the General Electric Company at Witton, Birmingham, in collaboration with the Barrow-in-Furness engineering department of Vickers-Armstrongs, Ltd., at which latter works the boilers and the auxiliary machinery will be constructed. These orders will give considerable satisfaction in shipbuilding yards and the allied industries. The announcement is also made that the Cunard Steamship Co., Ltd., has sent out preliminary inquiries and specifications for a new fast Atlantic liner to replace the *Mauretania*.

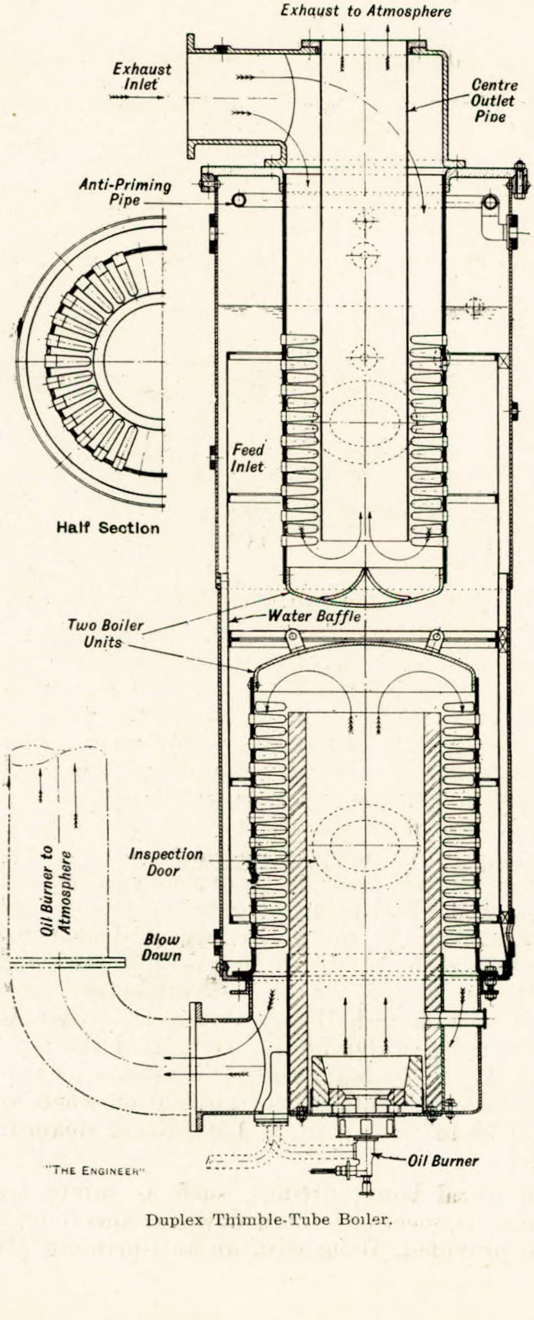
A NEW DUPLEX THIMBLE-TUBE BOILER FOR MOTOR SHIPS. "The Engineer," 21st March, 1930.

In the accompanying drawing we illustrate a new type of duplex thimble-tube boiler which has been specially designed by the Clarkson Thimble-Tube Boiler Co., Ltd., to fulfil the duties of a combined exhaust gas silencer boiler and an oil-fired unit. The boiler is the first of its type, and it was recently installed and tested on the motor trawler *Saint Martin Legasse,* the first of four trawlers now under construction for La Morue Française at the shipyard of Cox and Co. (Engineers), Ltd., Falmouth. The particular trawler referred to is propelled by a seven cylinder "Polar" two-stroke airless injection engine supplied by the Atlas Diesel Co., Ltd., of London. It has a continuous output of 700 S.H.P. at 214 r.p.m., and the cylinder bore is 340 mm. with a stroke of 570 mm. As our illustration indicates, there are two separate thimble-tube boiler units which are enclosed in a common boiler shell. The overall height of the boiler over the exhaust boxes is 12ft. 2½in. with a diameter of 4ft. 3in.

The top unit is arranged to receive the exhaust gases from the engine. They pass down through the nest of water-filled thimble tubes and return through a central outlet pipe. The designed heating surface is 108 square feet, and with an assumed exhaust gas temperature of 480° Fah., an output of 300 lb. of steam per hour at a working pressure of 75 lb. per. sq. in. is estimated to be obtained.

The bottom unit is arranged for simultaneous, or independent, oil firing on the Wallsend Howden low-pressure air system, the burner being supplied by the Wallsend Slipway and Engineering Co., Ltd. It is arranged to fire vertically upwards within a combustion chamber formed of refractory material and so arranged that the hot gases pass down through the nest of water-filled thimble tubes. The heating surface is 180 square feet with a designed output on oil firing alone of 800 lb. of steam per hour. The capacity of the thimble tubes for removing the heat from the gases may be gauged from the outlet temperature of the gases measured near to the boiler shell just before the bend, which was only 446° Fah. A good feature of the design is the well-submerged crown of the lower unit, which is half-way down the boiler as measured from the working water level. If desired the top boiler unit can be run dry as a silencer should no steam be required. The estimated output of both units in operation when working at a pressure of 75 lb. per sq. in. is 1,100 lb. of steam from and at 212° Fah.

All the usual boiler fittings, such as safety valve, water gauge, feed connections, blow-down connection and a stop valve, are provided, along with an anti-priming pipe fitted at



Duplex Thimble-Tube Boiler.

the top of the boiler. On Wednesday, February 19th, preliminary trials were run off Falmouth, and it was found that the steam generated from the exhaust gases alone was quite sufficient for the operation of all the auxiliary machinery required at sea, without making use of the oil burner, and the silencing effect was, we understand, particularly good. During the trials, which extended over five hours, the temperature of the exhaust gases measured at the inlet of the boiler rose steadily from 318° Fah. to 568° at the end of the trial. The exhaust gas outlet temperatures corresponding to the above figures were 258° Fah. and 400° Fah. respectively. As the lagging of the boiler had only just been completed and a certain amount of drying out had to take place the trial performance was regarded as most satisfactory.

Two boilers of the same type are being supplied for a new motor yacht which is being built by William Beardmore and Co., Ltd., at Dalmuir, for Major Courtauld. Each boiler will work in conjunction with a 700 S.H.P., two-stroke Sulzer oil engine, and with an exhaust gas temperature of not less than 550° Fah., it is designed to produce 400 lb. to 500 lb. of steam per hour. With oil firing, each boiler will have a designed output of 600 lb. of steam per hour, the working pressure being 50 lb. per sq. in. Boilers of the type we have described are supplied not only as complete boilers, but also as standardised thimble-tube boiler units, which are hydraulically tested to Lloyd's and the Board of Trade survey regulations, and are ready for fitting into boiler shells constructed by the shipbuilders in their own boiler shops.

H.M.S. "ACHERON." "The Engineer," 21st March, 1930.

On Tuesday, March 18th, there was launched from the Woolston yard of John I. Thornycroft and Co., Ltd., a British destroyer, H.M.S. *Acheron*, which in some respects marks an important development in the construction of naval vessels. The feature of interest in her design is the fact that she is the first war vessel to be fitted for the use of high-pressure superheated steam, combined with air preheaters. Her machinery consists of Parsons turbines driving twin screws through reduction gearing, and supplied with steam from three Thornycroft boilers. According to Sir Charles Parsons, her consumption of fuel oil should be about ½ lb. per horse-power hour, or almost the same as that of a heavy oil engine of equivalent output. Sir Charles has also stated that with this consumption she should be from 10 to 15% more economical than her sister ships fitted with turbines using half her boiler pressure. The *Acheron* is the 101st British destroyer built by Messrs. Thornycroft. She belongs to the 1927-28 programme. Her length is 312ft. between perpendiculars, and designed displacement about 1330 tons. It is anticipated that her speed will be about 35 knots. Her armament consists of four 4·7in. guns, two 2-pounder pom-poms, five machine guns, and eight 21in. torpedo tubes. The fuel oil capacity is 380 tons.

PROPELLING MACHINERY COMPARISONS. "Shipbuilding and Shipping Record," 20th March, 1930.

A few years ago, when the economic possibilities of the motorship first began seriously to attract shipowners in this country and abroad, it was not uncommon to find, in the technical press and in papers before learned societies, carefully drawn up comparisons of steamships and motorships for different trades, speeds, and other conditions. To-day, when the economic value of the different systems of propulsion are fairly established for a variety of conditions, such comparisons are not so common; they can truly be said to have served their purpose. All compilers and students of these interesting tabular data must have often wished, we think, that some broad-minded shipowner would build a series of similar ships with different types of machinery and give to the technical world an accurate summary of their operation, preferably on the same route at the same time of year, over an extended period. This hope has now been realised, for Mr. W. Hinchcliffe, superintendent engineer of the Ellerman Lines, Ltd., has recently given a summary of two similar vessels, one a steamer and the other a motorship, in a paper he presented before the Liverpool Engineering Society.

The two single-screw vessels considered by Mr. Hinchcliffe are the *City of Roubaix* and the *City of Lille*, and both have been described in our pages. The former is propelled by single-reduction geared turbine machinery supplied with superheated steam, at a pressure of 300 lb. per sq. in. from four single-ended Scotch boilers, which are readily convertible from coal to oil-burning or *vice versa* as market conditions dictate. The *City of Lille* is propelled by a four-cylinder Doxford type airless-injection heavy-oil engine of 4,500 B.H.P. at 87 r.p.m. The main characteristics of the two ships are as follows:—

	City of Roubaix.	*City of Lille.*
Length overall	475 ft. 9 in.	465 ft. 8 in.
Length, between perpendiculars	455 ft.	445 ft.
Breadth moulded	58 ft. 2 in.	57 ft. 9 in.
Depth moulded	34 ft. 7 in.	33 ft. 11 in.
Block and midship area coefficients ...	0·745 0·987	0·732 0·9854
Draught moulded	27 ft. 11¾ in.	28 ft. 1¾ in.
Erections, per cent. of total length... ...	79	85·77
Displacement, tons	15,940	15,290
Total D.W., tons	10,860	10,290
L/B.	7·82	7·7
L/D.	13·15	13·12
B/D.	1·651	1·703
Capacity, gross cub. ft.	684,720	632,990
Capacity, bale cub. ft.	618,640	568,260
Net tonnage	4,555	4,054
Main propelling machinery	Three-stage single-reduction geared turbine	Four-cylinder heavy-oil engine
Propeller shaft r.p.m.	85	87
Total designed shaft horse-power	4,500	4,500
Propeller—		
Diameter	19 ft. 3in.	18 ft. 9 in.
Pitch	17 ft.	17 ft. 6 in.
Surface, sq. ft.	120	110
Speed in knots at 95 per cent. draught ...	13·25	13·3

From the table it will be seen that the vessels are sufficiently alike in general characteristics as to make a careful comparison of their service results really useful. So far as the lines of the two vessels are concerned, the *City of Roubaix*, which has a cruiser stern, is fuller aft than the motorship. A model of the turbine-driven vessel was tested in the National tank, while no experiments were carried out with the *City of Lille*. It is rather unfortunate that the lines of the two vessels were not more nearly similar, for this important factor renders comparison more difficult than would otherwise be the case. At the time the orders were placed, however, the owners had no intention of making this interesting machinery comparison. A third vessel was built and fitted with quadruple-expansion engines, it should be mentioned, but as her lines were very much fuller than those of the two ships mentioned, her service results were not included by Mr. Hinchcliffe in his paper.

Carefully conducted trials were made with the machinery of both ships, under approximately similar conditions, and the results of these are given in the paper. The results of the second voyage of the *City of Roubaix* and the first voyage of the *City of Lille* are also given, as these were made over almost identically the same track to Australia, the vessels leaving this country within 36 days of each other. Both vessels left Australia for the United Kingdom almost simultaneously. The steamer used coal on the outward trip and oil fuel on the return passage. The voyage abstracts are most interesting, the average Admiralty coefficients for the two voyages revealing that there is little to choose between the two vessels on this score, the voyage mean coefficients for both being about 283, obtained on a S.H.P. basis. The value of Diesel generators and electrical winches is clearly brought out in the paper, for the port consumption of the motorship, which is so equipped, was appreciably less than that of the steamer, being 109 tons of oil as against 535 tons of coal plus 25 tons of oil in the case of the ship with steam auxiliaries. The relative costs of deck fuel per ton of cargo handled is approximately 3·5d. and 11·1d., resulting in a saving of about £1,100 per annum in favour of the electrically-equipped ship on a basis of 35,000 tons of cargo handled per year. While these are most impressive figures, it should be remembered that in a great number of ports the cargo is handled by dockside cranes, thus tending to discount the superior efficiency of electric winches and Diesel generators in such cases.

The voyage figures are summarised in the paper as follows:—

	Steamship.			Motorship.		
	£	s.	d.	£	s.	d.
Fuel and lubricating oils...	6,060	9	10	5,493	5	9
Wages, expenses, provisions and fuel for cooking ...	4,174	12	11	4,911	1	0
Total	£10,235	2	9	£10,404	6	9

The wages of the whole crew, in each case, is included. Although the motorship has an engine-room staff of 24, as against 47 in the engine and boiler rooms of the *City of Roubaix*, the higher rate of pay of the engineers on the motorship helps to turn the scale in favour of the steamship, for, although the engineering personnel is smaller, more watchkeeping engineers are carried on the Diesel ship. The results may perhaps disappoint motorship enthusiasts, inasmuch as they were collected on a long passage, where the motorship is at its best. The *City of Lille* unfortunately lost time in Australia, due to a strike of dock workers, and it is conceivable that on another voyage of the same character the results would be reversed. We should like to see Mr. Hinchcliffe give us a second paper after the vessels have been in service for, say, three years. Results collected over such a period would serve to give a fairer comparison than the figures for a single voyage. Over such an extended period the effect of weather is to a great extent eliminated from the comparison.

PERSONAL. "Shipbuilding and Shipping Record," 20th March, 1930.

Mr. B. C. Curling, until recently assistant secretary, has been appointed secretary of the Institute of Marine Engineers. Mr. James Adamson, the venerable honorary secretary, and number one on the membership roll, will continue to act in this

Mr. B. C. CURLING,
Recently appointed Secretary of the Institute of Marine Engineers.

capacity. Mr. Curling was educated at the Mathematical School, Rochester, and served an Admiralty apprenticeship in the engineering department of H.M. Dockyard, Chatham. After several years at Chatham as an estimator and draughtsman, he joined, in June, 1911, George Kent Limited, the hydraulic engineers of Luton, as estimator, becoming successively chief draughtsman and technical business manager. In July, 1919, he was appointed commercial manager and secretary of The Kitchen Reversing Rudder Co. Ltd., Liverpool, and was subsequently, in July, 1921, appointed by the council to the assistant secretaryship of the Institute of Marine Engineers.

THERMAL EFFICIENCY IN STEAMSHIP PRACTICE. The Importance of the "Back-pressure" and "Pass-out" Principles. "The Shipbuilder," April, 1930.

It is now beginning to be more and more realised that substantial economies, both afloat and ashore, are waiting to be effected in connection with power production by means of steam engines or turbines. The essential fact is that, in the case of ordinary condensing units, even of the largest size and the latest design, with high steam pressures and temperatures of superheated steam, about 60 per cent. of the total heat of the coal is lost during the process of condensation.

In order to obtain the necessary degree of vacuum, a vast volume of cold water has to be pumped through the condenser, amounting under normal conditions to 450 or 500 tons of water per ton of coal burnt in the boilers. Consequently, for this reason alone, the theoretical maximum thermal efficiency from the raw coal to the place of use is only 40 per cent., and in actual practice the figure is very much less. Thus the average large marine installation with triple-expansion engine or turbine under the best conditions can only show a thermal efficiency of about 12 to 14 per cent., while most electric-power stations have an efficiency of from 15 to 18 per cent. Certainly in a few cases, by using abnormally high steam pressures and temperatures, such as 500 to 1,800 lb. per sq. in. and 700 deg. to 850 deg. F., figures of 20 to 25 per cent. are being obtained for plants of say 100,000 to 350,000 H.P., but about 12 per cent. thermal efficiency can be taken as the average for all condensing units, irrespective of size.

In steamship practice, therefore, the better method from the thermal point of view is to develop to the utmost the use of back-pressure high-speed engines, or small turbines, for electric lighting and similar auxiliary-power uses, these units being allowed to exhaust at any desired low pressure, say, 5 to 25 lb. per sq. in., to provide heating steam for radiators, baths, lavatories, cooking, laundry work, and other uses. On these lines, the overall thermal efficiency is 50 to 65 per cent., which is far ahead of any condensing engine or turbine, because the 60 per cent. heat loss in the condenser is avoided. The right installation for the conditions must be used, however; and in

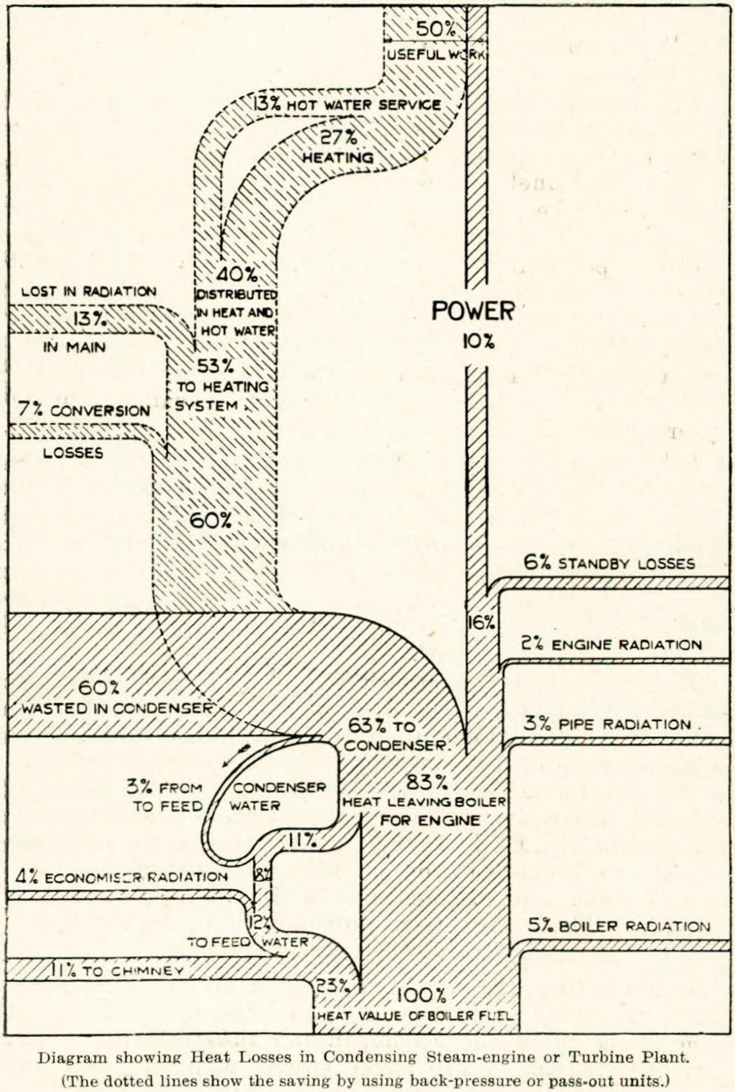


Diagram showing Heat Losses in Condensing Steam-engine or Turbine Plant.
(The dotted lines show the saving by using back-pressure or pass-out units.)

this connection it may be mentioned that Messrs. Belliss and Morcom, Ltd., of Birmingham, have supplied over 1,450 installations of back-pressure or pass-out engines and turbines, which include many for well-known steamship companies, the British Admiralty, and also the navies of Foreign Powers.

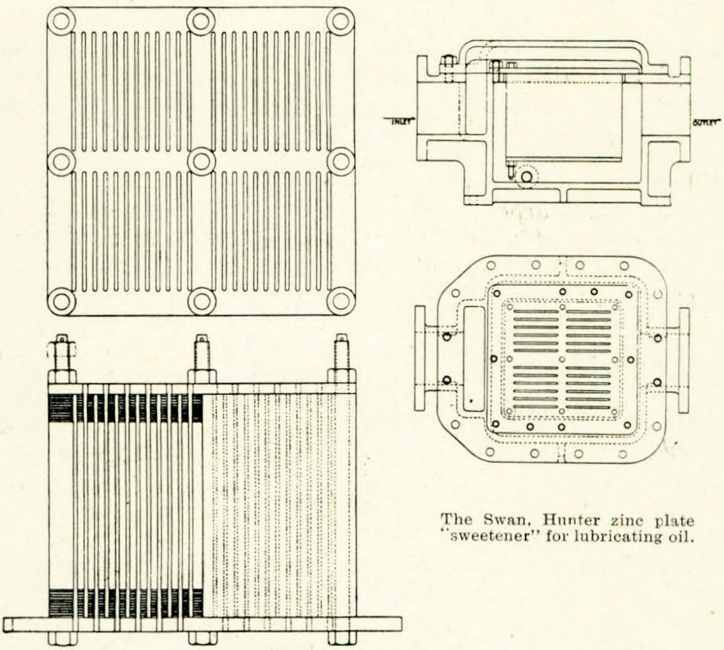
The value of the principle, and the reason for obtaining only 12 per cent. thermal efficiency with condensing units, will be obvious on considering the diagram accompanying this note. Thus, under the very best conditions, the thermal efficiency of steam generation—that is, up to the point where the steam leaves for the engine or turbine—is 83 per cent., including 11 per cent. funnel-gas loss, as well as radiation, sensible heat in ash and clinker, and other items. On the average, however, the ordinary industrial and marine steam boiler plant does not exceed 60 per cent. efficiency, and much improvement in this connection can be effected. Added to this are the losses due to radiation from steam pipes and engine, as well as stand-by losses. The net result is that, as shown on the diagram, 63 per cent. of the total heat passes to the condenser, because of the latent heat of steam, and only 10 per cent. is available for actual power production, 3 per cent. being returned in the boiler feed. If the steam pressure is increased, the overall thermal efficiency rises; but this is relatively a minor matter compared with the prevention of the 60 per cent. condenser loss, which occurs irrespective of pressure and superheat, so that the value of a combined power and heating system will be obvious.

THE SWAN, HUNTER LUBRICATING OIL " SWEETENER."
" Motorship," March, 1930.

Due to the fact that corrosion had been observed in the crankshafts of two oil-engined ships, Messrs. Swan, Hunter and Wigham Richardson undertook the design of a lubricating oil sweetener, as it was discovered that the corrosion was caused by the particular oil used in the forced lubricating system. The necessary experiments were conducted under the direction of Mr. H. J. Young, F.I.C., who ascertained that if the oil were brought in contact with zinc cuttings no corrosion occurred, the acidic compounds in the oil forming salts with the zinc. These salts were proved to have no corrosive properties with respect to steel and white metal.

A lubricating oil sweetener evolved on the principle indicated was fitted in four vessels, and the device in its latest form is shown in the accompanying illustrations. The zinc plate unit consists of 110 plates spaced with 981 steel washers

0·01 in. thick. There is a total active surface of 13,000 square ins., the designed velocity between the plates being 1·5 ins. per second and that at the inlet slots 27 ins. per



The Swan, Hunter zinc plate "sweetener" for lubricating oil.

second. The maximum working pressure is 50 lb. per square inch, while the plate unit weighs 220 lb. As the capacity is 75 gallons per minute, the apparatus is extremely compact. It is only 26 ins. long, measured from face to face of the pipe flanges, less than 20 ins. wide, and the height is below 16 ins. The bore of the inlet and outlet orifices is 5 ins.

There are two mild-steel end plates secured by nine ½-in. bolts, the unit being enclosed in a cast-iron chest and cover. Lifting holes are provided for withdrawing the plate unit and a drain plug is fitted.

STEAM AND MOTOR SHIP FUEL BILLS. "Motorship," March, 1930.

Some figures were published last month giving details of the first performance of the steamer *City of Hongkong* after she had been fitted with the new auxiliary turbo-electric plant to increase efficiency and raise the speed. The improvement was undoubted, and it is interesting to compare the fuel consumption of this vessel, now representing one of the most economical of coal-fired steamers, with that of a corresponding motor ship.

An excellent opportunity occurs as the motor ship *Amerika* is of practically the same size. The *City of Hongkong* is 470 ft. long b.p., with a beam of 61·5 ft. and a gross tonnage of 9,178.

The *Amerika* is 465 ft. long b.p., with a moulded beam of 62 ft. and a gross tonnage of 10,100.

The coal consumption of the *City of Hongkong* is 59 tons daily for all purposes, with an average speed of 12·26 knots. It is not so stated, but we will assume that the vessel is fully laden when these figures are attained.

The oil consumption of the *Amerika* (when fully laden) for all purposes is 24 tons per day at a speed of 14 knots. This is equivalent to, approximately, 16 tons per day at a speed of 12·26 knots, and is little more than one quarter of the amount of coal used under corresponding conditions in the *City of Hongkong*.

THE DESIGN OF AIRLESS-INJECTION ENGINES. "Motorship," March, 1930.

The rapid reversion from the air-injection Diesel engine, which has been paramount for so many years, to the compressorless type, is one of the most far-reaching changes that have occurred in Diesel-engine design generally for the past five or six years. Commercially, it has the effect of reducing the average fuel consumption from 0·4 lb. per b.h.p. hour to anything between 0·36 and 0·38 lb. per b.h.p. hour and of allowing the manufacture of a lighter and smaller engine of given power than before, whilst leading to considerable simplification both in construction and operation. It is natural, therefore, that shipowners should demand and engine builders should wish to supply such engines, and the figure of 60 per cent. representing the compressorless engines compared with the total number of marine Diesel motors on order which we gave a short time ago, will probably be increased.

Such a change does not come without introducing difficulties. The shipowner will not accept the new design with reservations. He will not, for instance, agree that if he purchases airless-injection motors they will either have to run on more expensive fuel, or that the grades of oil on which they will operate satisfactorily are more limited in their range than those which may be utilized, with success, in air-injection motors.

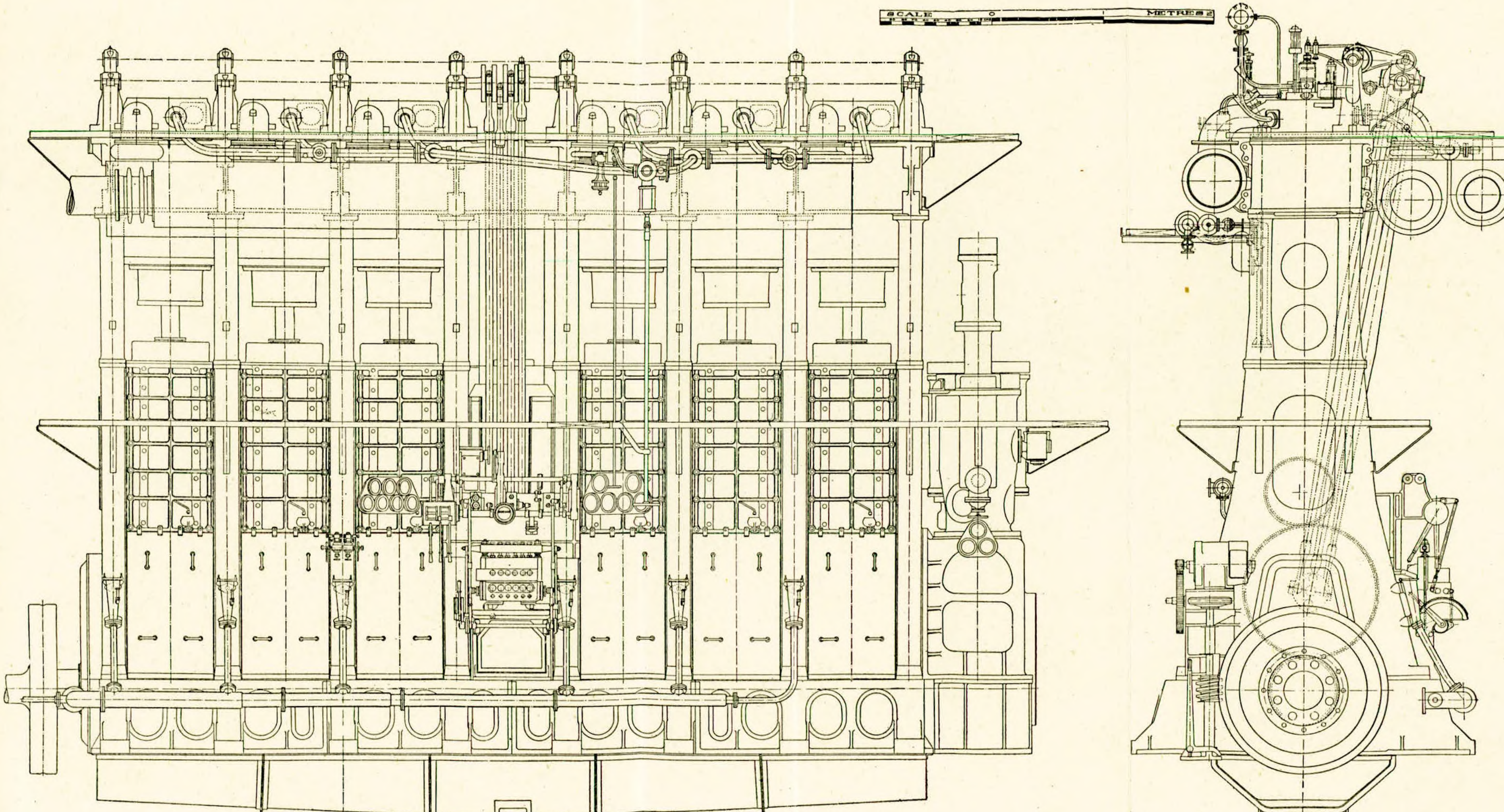
It is, therefore, for the builders to ensure that by their design the compressorless engine has the same flexibility in fuel utilization as the air-injection model. No standard system can be fitted which will prove the most efficient for every type of engine. The opposed-piston motor, for instance, with its through scavenge and the moderate degree of turbulence imparted to the scavenging air, also its relatively high pump pressure, offers different problems to the designer of the fuel system than does a double-acting engine with the scavenging and exhaust ports in the centre. The four-stroke single-acting motor with the fuel valve and exhaust valve in the top of the cylinder rings yet another change.

Neither can it be said that very effective atomization at high pressure solves the problem, irrespective of turbulence, any more than it is true to state that everything depends on turbulence and that the efficiency of atomization is unimportant. The problem is thus all the more difficult since it is not capable of a common solution.

It is essential that shipowners should not be disappointed with the results of airless-injection machinery because they find that in their necessity of purchasing fuels all over the world the combustion and running generally of the engines have not proved up to expectation. All engine builders who are rapidly developing airless-injection machinery should therefore experiment continuously with every possible grade of fuel that is likely to be supplied to ships, and should improve their fuel-injection system until it is proof against any disability dependent on the variations in the grades of fuel available at the numerous bunkering stations throughout the world.

A NORTH-EASTERN PRESSURE-CHARGED ENGINE. Prof. Hawkes's Report of Trials on the First of Two 2,750 B.H.P. Units for the Holt Cargo Liner *Maron*. "The Motor Ship," March, 1930.

The following is a report of trials carried out by Prof. Hawkes at the request of the builders—the North-Eastern Marine Engineering Co., Ltd.—on a new engine designed and built by them in accordance with the specification of Messrs. Alfred Holt and Co., the owners of the M.S. *Maron*, in which the engine, together with a similar motor, will be installed. A description of the engine was given in "The Motor Ship" of January, 1930.



Figs 2 and 3.

The principal object of these trials was to ascertain the heat-flow to liners, heads and pistons, as determined by the measurement of the heat carried away by the cooling media, when the engine was running at various powers at constant speed.

The nominal speed of the engine is 138 r.p.m., giving a piston speed of 1,177ft. per min., but for the trials which I supervised it was decided that the revolutions should be 115 r.p.m., so that data obtained at a lower piston speed would be available for comparison with other engines.

The engine, which is of the four-stroke single-acting type fitted with the Büchi system of exhaust turbo-charging, has six cylinders of 620 mm. (24·4ins.) bore and 1,300 mm. (51·2ins.) stroke. Figs. 2 and 3 give, respectively, an end view and a longitudinal elevation of the engine.

The nominal power of the engine is 2,750 B.H.P. at 138 r.p.m., and the engine has been specially designed to work on the Büchi system at this power. The flywheel, which is secured to the after-end of the crankshaft, is 3·9ft. in diameter and weighs 2·58 tons.

Blast air is supplied by a three-stage compressor, of the steeple type, driven by an additional crank at the forward end of the crankshaft. The compressor is fitted with a piston-rod and cross head, and the H.P. cylinder is entirely separate from the L.P. cylinder, the H.P. piston being attached to the L.P. by a rod passing through a gland in the L.P. cylinder cover.

One fuel pump is fitted for each cylinder. The fuel-pump block, which is clearly shown in the photograph, is situated at the front of the engine, between Nos. 3 and 4 cylinders. The fuel pumps are actuated from the crankshaft through gearing.

The blower unit, which was manufactured by Messrs. Brown Boveri, of Baden, consists of a single-wheel exhaust-gas turbine directly coupled to a two-stage blower. Fig. 4 shows a photograph and Fig. 5 a sectional elevation of the turbo-blower.

The main engine has two exhaust manifolds. Nos. 1, 2 and 3 cylinders are connected to one manifold and Nos. 4, 5 and 6 cylinders to the second manifold. These manifolds are led to two separate inlet branches on the exhaust-gas turbine casing. There is a common outlet branch from the turbine leading to the atmosphere. The blower discharges the air under pressure into a common main from which branches are taken into the inlet valve in each cylinder head. Following the usual Büchi practice, the timings of the inlet and exhaust valves are such that there is an appreciable overlap, which results in the scavenging of the cylinder clearance spaces of exhaust gases.

During the shop trials the turbo-blower was supported on a temporary structure, arranged so that the distance of the

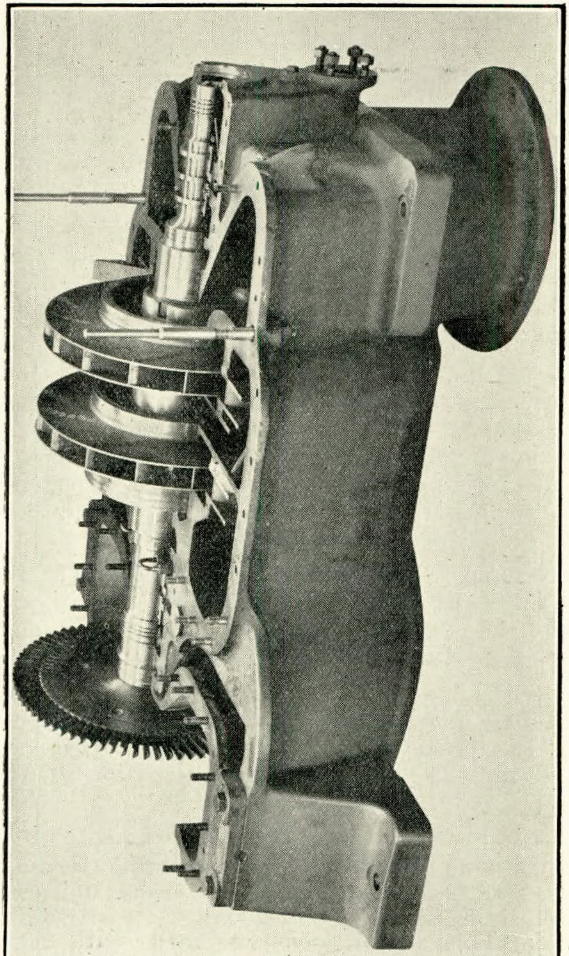


Fig. 4.

blower below the air and exhaust mains was about the same as it will be above these mains when it is fitted in the ship; and, so far as practicable, the ship's air and exhaust pipes

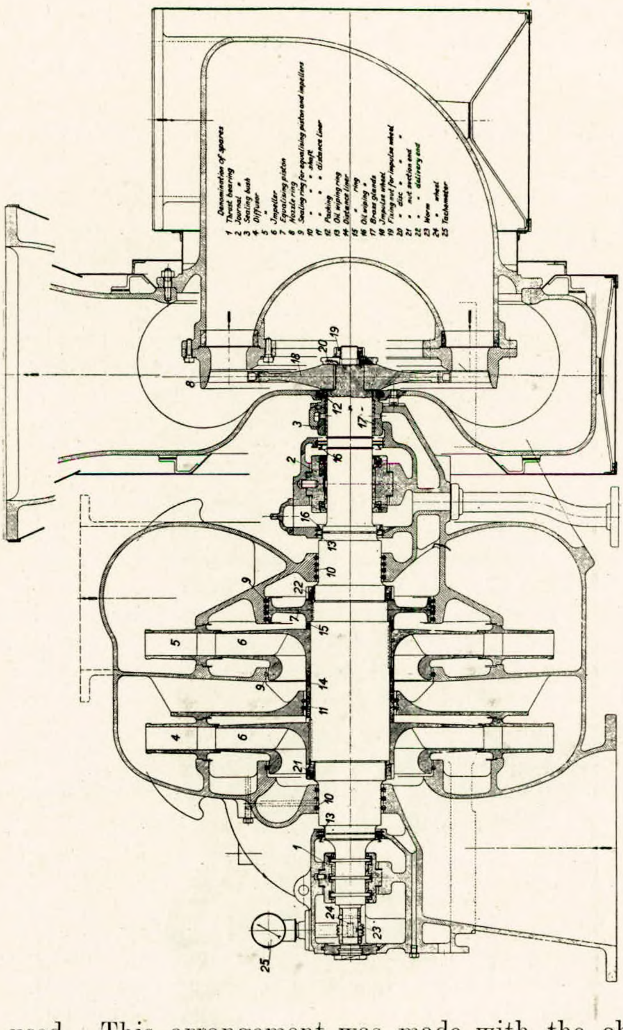


Fig. 5.

were used. This arrangement was made with the object of imitating, as closely as possible, the air and exhaust-main conditions, which will obtain in the ship.

Forced lubrication is employed for the main engine and for the turbo-blower. During the shop trials an electrically-driven forced-lubrication pump took its suction from a storage tank and discharged into the oil system through a strainer. After passing through the bearings the lubricating oil drained from the crankcase to the storage tank. A lubricating-oil cooler was not in use during the shop trials. A cooler will be fitted in the ship.

Sight-feed lubricators were employed for cylinder lubrication.

The general design of the liners and heads follows the usual N.E.M. practice. In this instance, however, the liner and head of each cylinder are separate castings, the liner being secured to the head by stainless-steel studs and nuts, and the whole viz., the head, joint and liner—surrounded by the cooling water, which is supplied by an electrically-driven pump. Lubricating oil was used for cooling the pistons. The methods employed for measuring the quantities of cooling media passing through the engine are given later.

Power Measurements.

During the trials the B.H.P. developed by the engine was absorbed by a Heenan and Froude dynamometer of the compound-lever type supplied with water from an overhead tank, in which the level was maintained constant. At the conclusion of the trials the dynamometer was disconnected from the engine and balanced, and the necessary dimensions were taken for checking the constant—which is 300. All weights were checked and found correct.

Indicator diagrams were taken from the power cylinders and from the air compressor every 30 minutes. The indicator springs were calibrated before the trials, but there was no opportunity for checking the indicator drives.

Fuel Measurement.

The quantity of fuel passing to the engine was measured by direct weighing. Two tanks were employed, each fitted with a shut-off cock and flexibly connected to a three-way cock in the common suction pipe leading to the fuel pumps. Each tank, of about 17 cubic feet capacity, was placed on the platform of an Avery self-recording weighing machine. At the commencement of a trial one of the tanks was put into communication with the fuel pumps, and the other tank was shut off and filled with oil from the storage tank. The change over from one tank to the other tank was made as necessary during the trial. No heaters were fitted in the fuel system.

The total leakage of fuel oil from the pump glands during the four trials was 6 lb.

Samples of fuel oil, which were taken during each trial, were forwarded for analysis and for the determination of the calorific value, viscosity, etc. The analysis is as follows:—

ANALYSIS OF FUEL.

Carbon	86·77
Hydrogen	12·57
Oxygen	0·14
Nitrogen	0·03
Sulphur	0·49
Ash	None
Water	Trace
	100·00

Specific gravity at 15·5°C.	0·8725	
Flash point, close test	90°C = 194°F.	
Soft asphalt	0·03 per cent.	
Hard asphalt	0·11 ,, ,,	
Setting point	Quite liquid at —24°C. = —11°F.	
Viscosity.	Time of flow of 50 c.c. from Redwood's viscometer in seconds.	
At 70°F	47	
At 100°F.	38	
	Gross.	Net.
Calories	10,740	10,060
B.Th.U.	19,330	18,110
Lb. of water, evaporated from 100°C. by 1 lb. of the oil	20·0	18·73

The revolutions of the main engine were recorded by a Harding counter. Readings were taken by me every 15 minutes, at the instant the fuel consumption was recorded.

Measurement of Cooling Water.

The jacket-cooling water on its passage to the engine passed through a water meter. The water was then led, in series, first to the air compressor cylinder jackets and coolers, then to the piston-oil cooler and finally to the main engine cylinder jackets. The discharges from the jackets and exhaust-valve housings were led to a common collecting pipe and passed to waste.

The water meter was checked at the works of the Water Co. before it was installed and found to be, for all practical purposes, correct.

The thermometer used for registering the temperature of the cooling water after it had passed through the air compressor and piston-oil cooler, and before it entered the engine jackets, was placed in the common supply pipe as near as possible to the engine. The outlet temperature was registered by a thermometer placed in the common collecting pipe.

Readings of the meter and of the thermometers were taken every 15 minutes.

Measurement of Piston Cooling Oil.

The piston-cooling oil was supplied by a separate electrically driven pump arranged so that it could take its suction, through a strainer, either from two calibrated measuring tanks or from the oil storage tank. The oil discharged from the pump, after passing through a filter and cooler, was led by telescopic pipes to the hollow piston rods, which were fitted with internal pipes. The oil passed up the rods, on the outside of the internal pipes, to the pistons, returning through the internal pipes to collectors attached to the engine columns. The oil from the collector of each cylinder was led to an inspection trough, which communicated with the common drain-pipe leading back to the lubricating oil tanks.

Measurement of Air.

The blower section pipe terminated in an enlarged vertical pipe, about 4ft. diameter and 10ft. in length, in the top end of which was fitted a shaped nozzle, of wood, having a mean diameter of 19·75 ins. The nozzle coefficient was taken at 0·965. The pressure drop through the nozzle was measured by an inclined-tube manometer, filled with paraffin, which was calibrated before the trials. The temperature of the air entering the nozzle was recorded by a thermometer placed near the top of the enlarged vertical pipe. The pressure in the blower-discharge pipe was measured by means of a U-tube filled with mercury.

A large tank, in which was fitted a throttle-plate containing an orifice 4·503ins. diameter, was employed for measuring the air passing to the blast compressor. The coefficient assumed for the orifice was 0·59. The pressure drop across the orifice was measured by means of a manometer filled with paraffin. A thermometer was placed near the orifice for measuring the temperature of the in-going air. Records were taken every ten minutes.

Exhaust-Gas Turbine.

The pressure of the exhaust gases entering the turbine was recorded by a U-tube filled with mercury. With the object of recording directly the means of the pressures in the two exhaust pipes leading to the turbine a connection was taken from each pipe to a Y-piece, and the common leg of the Y was connected to one limb of the U-tube.

The temperatures of the gases entering the turbine were recorded by two iron-constantan thermocouples and one nitrogen-filled thermometer in each inlet pipe. The couples, the leads from which were connected to a multipoint indicator, were calibrated before the trials. The glass thermometers were calibrated after the trials and any necessary corrections have been made in the tabulated results. The means of the readings of the four thermocouples and the two glass thermometers have been taken as the exhaust temperatures for the purpose of estimating the adiabatic-heat drops in the turbine.

The pressure in the exhaust-outlet pipe from the turbine was recorded by a U-tube filled with water. The pressure was found to be approximately atmospheric for all trials. The temperatures of the gases leaving the turbine were also registered by two thermocouples and one nitrogen-filled glass thermometer.

The revolutions were recorded by a tachometer driven from the turbine shaft.

Exhaust-Gas Analysis.

Samples of exhaust gas were taken continuously from the exhaust pipe leading from the turbine. Two samples were taken simultaneously, the total volume withdrawn during each trial being about 10 litres. Each sample was analysed in the works laboratory immediately after each trial, and the mean results are given in Table V for Trials 2, 3 and 4.

Trial Results.

Four one-hour trials were carried out at brake mean pressures of 69·9 lb., 88·2 lb., 110·3 lb. and 125 lb. per sq. in. The engine was run at the trial load for a sufficiently long period before each trial was commenced to ensure that stable conditions had been reached.

The principal records and deductions are given in Tables I to VI, and in the following curves:—

Fig. 6: I.H.P. fuel per h.p. and mechanical efficiency on a b.h.p. base.

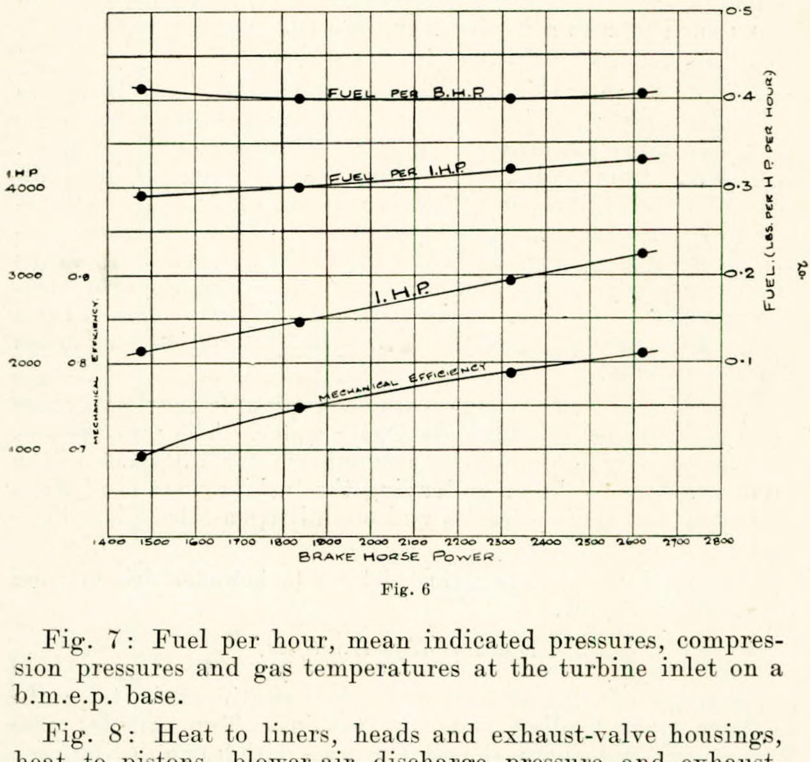


Fig. 6

Fig. 7: Fuel per hour, mean indicated pressures, compression pressures and gas temperatures at the turbine inlet on a b.m.e.p. base.

Fig. 8: Heat to liners, heads and exhaust-valve housings, heat to pistons, blower-air discharge pressure and exhaust-turbine inlet pressures on a b.m.e.p. base.

In Table III the "B.Th.U.s per sq. ft. of surface per hour" to the liners and heads have been obtained by dividing the *total* heat to the cooling water by the total surface of the liners and heads, assuming that the heads are plane surfaces and that the exposed liner surfaces are cylindrical, of length equal to the stroke *plus* the clearance volume divided by the piston area. As already mentioned, the head and liner of each cylinder are surrounded by a continuous water jacket, and it was not possible, therefore, to separate the heat to the heads

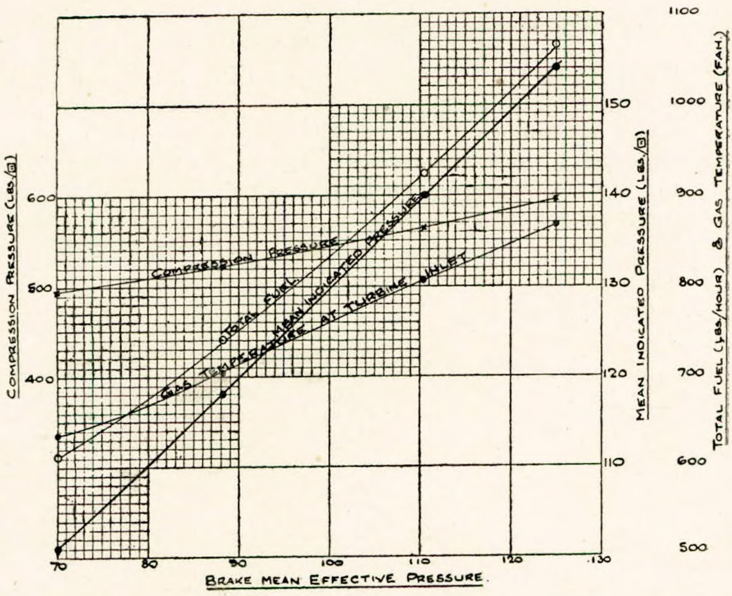

Compression Pressure (lbs/□)
600
500
400
Mean Indicated Pressure (lbs/□)
150
140
130
120
110
Total Fuel (lbs/hour) & Gas Temperature (Fah.)
1100
1000
900
800
700
600
500
Compression Pressure
Total Fuel
Mean Indicated Pressure
Gas Temperature at Turbine Inlet
70
80
90
100
110
120
130
Brake Mean Effective Pressure.

Fig. 7.

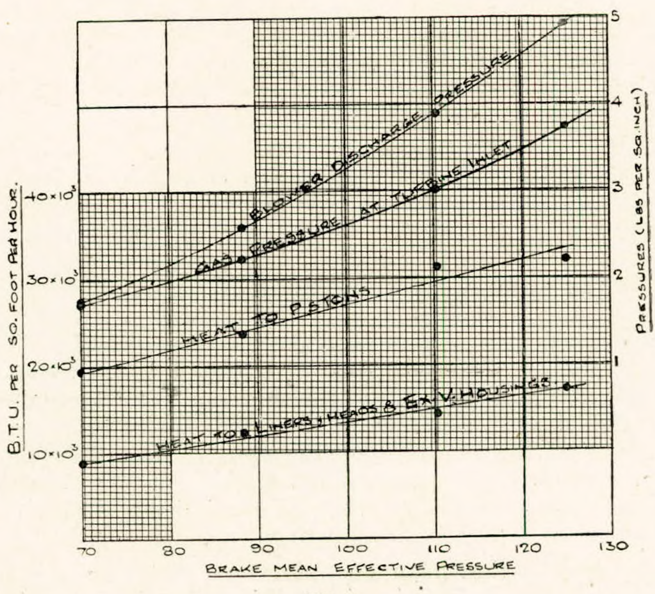

B.T.U. per sq. foot per hour.
40×10³
30×10³
20×10³
10×10³
Pressures (lbs per sq. inch)
5
4
3
2
1
Blower Discharge Pressure
Gas Pressure at Turbine Inlet
Heat to Pistons
Heat to Liners, Heads & Ex. V. Housings
70
80
90
100
110
120
130
Brake Mean Effective Pressure

Fig. 8.

from the heat to the liners. Moreover, the total heat to the cooling water includes the heat transmitted through the exhaust-valve housings—which could not be separately measured—consequently, the average heat transmissions per sq. ft. of liner and head surface, given in the table, are slightly higher than the actual figures.

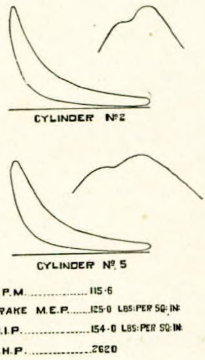


Fig. 9.

In calculating the average "B.Th.U.s per sq. ft. per hour" to the pistons it has been assumed that the pistons are plane surfaces. The average specific heats of the lubricating oil used for piston cooling, over the ranges of temperature given in Table III, vary from 0·4 for trial 1 to 0·412 for trial 4.

Mercury-in-steel thermometers were placed in the exhaust branch from each cylinder, and the mean readings are given in Table V for record purposes—as these thermometers will be in use when the engine is in the ship. The readings of these thermometers are not the true mean temperatures of the gases in the exhaust pipes and must be regarded of value for comparative purposes only. At the turbine inlets the gases would approach a uniform mixture, although the mixture would probably not be complete. It was for this reason that two thermocouples and one glass thermometer were placed in each exhaust pipe, adjacent to the turbine-inlet branches, and the means of the readings of the couples and thermometers were taken, as already mentioned, as the mean exhaust temperatures for calculating the adiabatic-heat drops in the turbine.

Any error in the mean gas-inlet temperature would affect the adiabatic-heat drop in the turbine, but if the maximum reading obtained in trial 4 be taken as the gas temperature instead of the mean of the readings of all the thermometers which is given in Table V, the isothermal work and the adiabatic work of the blower expressed as percentages of the adiabatic-heat drop in the turbine would only be reduced from 47·5 and 49·3 to 46·6 and 48·4 respectively. It should be mentioned that the variations in the readings of the thermocouples and the thermometers were less in Trials 1 to 3 than in Trial 4.

A heat balance, based on the higher calorific value of the fuel, is given in Table VI. Owing to the large quantity of water which was passed through the jackets and coolers of the blast-air compressor, and the consequent small rise in temperature and the possible large errors in estimating the heat rejected to the water, the "heat to compressor" has not been included as a separate item.

TABLE I.

POWERS AND FUEL CONSUMPTION.

Trial Number.	1	2	3	4
Duration (minutes)	60	60	60	60
Brake load (lb.)	3800	4800	6000	6800
B.M.E.P. (lb. per sq. in.)	69·9	88·2	110·3	125
Average r.p.m.	117·2	115·3	115·7	115·6
B.H.P.	1485	1845	2314	2620
I.H.P.	2145	2465	2935	3230
Mechanical efficiency (per cent.)	69·2	74·8	78·8	81·1
Total fuel per hour (lb.)	612	740·5	926·5	1066
Fuel per i.h.p. per hour (lb.)	0·29	0·3	0·32	0·33
Fuel per b.h.p. per hour (lb.)	0·412	0·401	0·4	0·407
Thermal efficiency on b.h.p. basis taking H.C. value of fuel (per cent.) ...	32·0	32·8	32·9	32·3

Conclusions.

As will be seen from Table I and Fig. 6, the full consumption per b.h.p. did not vary to any appreciable extent throughout the trials. In this connection it should be mentioned that the engine had been running at 138 r.p.m. during the

TABLE II.

AVERAGE CYLINDER PRESSURES.

Trial Number.	1	2	3	4
B.M.E.P (lb. per sq. in.)	69·9	88·2	110·3	125
M.I.P. (lb. per sq. in.)	101	118	140	154
Compression pressure (lb. per sq. in.) ...	496	521	562	595
Maximum pressure (lb. per. sq. in.) ...	588	623	665	694

TABLE III. (COOLING CIRCUITS.)

Trial Number.	1	2	3	4
LINERS, HEADS AND EXHAUST-VALVE HOUSINGS :—				
Cooling water (lb. per hour) ...	75200	86000	86100	98000
Inlet temperature (°F.) ...	52	51·8	52·8	52·1
Outlet temperature (°F.) ...	78	80·2	85·7	86·5
B.Th.U.s per hour, total ...	$1{\cdot}955 \times 10^6$	$2{\cdot}44 \times 10^6$	$2{\cdot}83 \times 10^6$	$3{\cdot}37 \times 10^6$
B.Th.U.s per b.h.p. hour ...	$13{\cdot}16 \times 10^2$	$13{\cdot}2 \times 10^2$	$12{\cdot}2 \times 10^2$	$12{\cdot}86 \times 10^2$
B.Th.U.s per sq. ft.-hour ...	$9{\cdot}89 \times 10^3$	$12{\cdot}3 \times 10^3$	$14{\cdot}3 \times 10^3$	$17{\cdot}05 \times 10^3$
PISTONS :				
Cooling oil (lb. per hour) ...	17580	20650	24050	23280
Inlet temperature (°F.) ...	62	64	63	67
Outlet temperature (°F.) ...	116	120	126	132
B.Th.U.s per hour, total ...	380×10^3	463×10^3	607×10^3	623×10^3
B.Th.U.s per b.h.p.-hour ...	$2{\cdot}56 \times 10^2$	$2{\cdot}51 \times 10^2$	$2{\cdot}62 \times 10^2$	$2{\cdot}38 \times 10^2$
B.Th.U.s per sq. ft.-hour ...	$19{\cdot}5 \times 10^3$	$23{\cdot}8 \times 10^3$	$31{\cdot}2 \times 10^3$	$32{\cdot}0 \times 10^3$

official acceptance trials on January 2nd, 1930. The trials referred to in this report, which took place on the following day, were run at 115 r.p.m. with the fuel-cam settings arranged for a speed of 138 r.p.m., as there was no opportunity to adjust the fuel cams to suit the lower speed.

The exhaust gases during Trials 1, 2 and 3 were colourless. Owing to darkness it was not possible to see the end of the exhaust pipe during Trial 4, but from test-cock observations the gases appeared to be clear.

The difference between the air pressure in the blower discharge pipe and the mean pressures in the exhaust pipes increased from 0·45 lb. per sq. in. in Trial 1 to 1·2 lb. per sq. in. in Trial 4. One would expect, therefore, that the "negative work," or "pumping loss," would be slightly greater in

TABLE IV.

TURBO-BLOWER AND BLAST-AIR COMPRESSOR.

Trial Number.	1	2	3	4
BLOWER :—				
Air inlet temperature (°F.)	59	58	56	57
Air discharge temperature (°F.)	85	93	107	121
Barometer (lb. per sq. in.)	14·45	14·48	14·48	14·48
Discharge pressure (lb. per sq. in. absolute)	16·21	17·07	18·37	19·4
Capacity of blower (lb. per sec.)	7·32	8·16	9·10	9·85
Blower air per lb. of fuel (lb.)	43·0	39·6	35·325	33·225
Isothermal work per lb. of air (B.Th.U.)	4·11	5·85	8·45	10·4
Adiabatic work per lb. of air (B.Th.U.) ...	4·18	6·0	8·68	10·8
BLAST-AIR COMPRESSOR :—				
Air inlet temperature (°F.)	54·5	53·5	54·3	53·7
Air per second (lb.)...	0·457	0·5	0·51	0·51
Air per lb. of fuel (lb.)	2·7	2·4	1·975	1·725
Blast pressure (lb. per sq. in.)	900	950	1000	1000
Total blower and blast air passing through engine per lb. of fuel (lb.)... ...	45·7	42·0	37·3	34·95

Trial 1 than in Trial 4. Light-spring diagrams, which were taken during the trials, showed that the negative work did decrease with an increase in the brake mean pressure, but the change was not very marked. The negative work during each trial, however, was less than that usual with non-supercharged four-stroke engines.

The rated power of the engine of the *Maron* is based on a b.m.e.p. of 110 lb. per sq. in. corresponding to Trial 3. For the purpose of comparing the heat transmitted through the liners, heads and pistons of this engine with other four-stroke engines, not supercharged, for which authoritative data are available, Table VII has been prepared from the published results of the trials of the six-cylinder engines of the *Sycamore* and *Cape York*, which were tested by the Marine Oil Engine Trials Committee of the Institution of Mechanical Engineers and the Institution of Naval Architects.

It will be seen that the heat to the liners, heads and exhaust-valve housings and the heat to the pistons per sq. ft. of surface per hour, are about the same in the engine of the *Maron* as in the engine of the *Cape York*. In the engine of the *Sycamore* the heat to the liners, heads and exhaust-valve housings (per sq. ft. of surface per hour) is slightly greater, and the heat to the pistons (per sq. ft. of surface per hour) is appreciably less than in the engine of the *Maron*. The heat to the jacket-cooling water, however, includes a certain amount of heat which has been transmitted from the pistons to the liners, and this may be greater in one design than in another. In the circumstances, therefore, I am of opinion that a better comparison is obtained by dividing the total heat to the liners, heads and pistons by the total area of the surfaces exposed to the working fluid. These figures are shown on the last line in Table VII. It will be noted, also, that the heat to liners and heads and to pistons, per b.h.p. per hour and per lb. of fuel per hour, are lower in the turbo-charged engine than in the engines of the *Sycamore* and the *Cape York*. These results indicate that the heat transmitted to the cooling surfaces—and, other things being equal, the heat stresses in the material—are no greater in the turbo-charged engine than in the engines which are not turbo-charged, when the former is developing a brake mean effective pressure about 50 per cent. greater than the latter.

The engine of the *Maron*, which was under my constant supervision, ran smoothly and steadily throughout the trials, without an incident of any kind.

TABLE V.

EXHAUST GASES AND EXHAUST TURBINE.

Trial Number.	1	2	3	4
THERMOMETER READINGS :—				
Turbine inlet (°F)	635	705	803	867
Turbine outlet (°F)	590	662	738	803
Cylinder exhaust branches (°F.)	608	621	694	757
PRESSURES :—				
Turbine inlet (lb. per sq. in.)	16·16	16·7	17·49	18·21
Turbine outlet (lb. per sq. in.)	Atmospheric.			
R.P.M. of turbine and blower	2530	3000	3565	4000
Percentage composition of dry exhaust gases, by volume				
(CO_2)	—	4·45	5·15	5·95
(CO)	—	0·75	0·6	0·6
(O_2)	—	13·45	12·6	11·7
(N_2)	—	81·35	81·65	81·75
Mean specific heat of gases (B.Th.U.) ...	0·252	0·252	0·254	0·256
Mean value of adiabatic exponent ...	1·377	1·375	1·371	1·367
Adiabatic temperature drop (°F.) ...	33	44·4	63	79
Adiabatic heat drop in turbine per lb. of gas (B.Th.U.s)	8·3	11·2	16·0	20·23
Exhaust gases per lb. of fuel (lb.) ...	46·7	43·0	38·3	35·95
ISOTHERMAL WORK IN BLOWER :—				
Adiabatic drop in turbine (per cent.) ...	45·6	48·1	48·7	47·5
ADIABATIC WORK IN BLOWER :—				
Adiabatic drop in turbine (per cent.) ...	46·4	49·4	50·0	49·3

TABLE VI.

HEAT BALANCE—IN UNITS OF 100 B.TH.U.S PER MINUTE.

Trial Number.	1	2	3	4
Heat in fuel, higher calorific value ...	1970 (100)	2385 (100)	2985 (100)	3435 (100)
Thermal equivalent of b.h.p.	630 (32·0)	783 (32·8)	981 (32·9)	1111 (32·3)
Heat to liners, heads and exhaust-valve housing	326 (16·6)	407 (17·1)	472 (15·8)	562 (16·4)
Heat to pistons	63 (3·2)	77 (3·2)	101 (3·4)	104 (3·0)
Heat to compressor, exhaust gases, etc. (by diffce.)	951 (48·2)	1118 (46·9)	1431 (47·9)	1658 (48·3)

Note.—Numbers in brackets are percentages, to the nearest first place of decimals.

TABLE VII.

Engine.	Maron.	Sycamore	Cape York.
Trial Number	3	5	10
Bore (ins.)	24·4	24·41	22·05
Stroke (ins.)	51·2	38·39	39·37
Compression ratio	12·28	13·01	14·39
Mean indicated pressure (lb. sq. in.)	140	94	108
Brake mean pressure (lb. sq. in.)	110·3	73·5	71·7
R.P.M.	115·7	118·8	125·1
Brake horse power	2314	1188	1018
Fuel per hour (lb.)	926·5	537·3	427
HEAT TO LINERS, HEADS AND EXHAUST-VALVE HOUSINGS.			
B.Th.U.s per sq. ft. per hour	14300	15600	14100
B.Th.U.s per b.h p. per hour	1220	1994	1910
B.Th.U.s per lb. of fuel per hour	3060	4410	4550
HEAT TO PISTONS.			
B.Th.U.s per sq. ft. per hr.	31200	19500	33000
B.Th.U.s per b.h.p per hr.	262	318	519
B.Th.U.s per lb. of fuel per hr.	655	703	1236
HEAT TO LINERS, HEADS AND EXHAUST-VALVE HOUSINGS AND PISTONS.			
B.Th.U.s per sq. ft. of area of liners, head and piston per hr.	15800	16000	16800

BOILER EXPLOSION INQUIRIES. "Engineering," 11th April, 1930.

Failures of Steam Pipes and Stop Valves in Ships.—Three recent inquiries, Nos. 3026, 3024, 3029 deal with failures in steam pipe fittings in the S.S. *Carnarvonshire*, *Rimutaka*, and *Pensilva* respectively. One of the operations on board ship which has to be done with the greatest possible care is that of connecting up boilers under steam. That the necessary precautions are usually taken is shown by the infrequency with which accidents occur. The danger through the presence of water in the steam pipes is well known and designers pay particular attention to the draining arrangements. The likelihood of water collecting is sometimes increased by the alteration in the trim and list of a ship while lying at anchor, but this should only lead to still greater care being taken. An instance of the disastrous effects of water in the pipes is given in the report on the accident in S.S. *Carnarvonshire*, which occurred while the ship was lying off Shanghai on May 9th, 1929. The ship was being prepared for sea, and the four boilers were being connected by the fourth engineer. He had already connected the two after boilers, and apparently was about to open the main stop valve of the port forward boiler when with a dull report the valve chest burst, allowing steam to escape violently from the three boilers. The fourth engineer unfortunately lost his life. Examination led to the discovery that the drain cock under the stop valve was still closed while no evidence was forthcoming that the drains on the pipes had been opened either while the ship was lying at anchor or while the boilers were being connected. The only conclusion therefore, was that the explosion was entirely due to water hammer. In the third case, that of the S.S. *Pensilva*, it was also a stop valve which fractured. When discovered, the fracture had already extended about two-thirds of the circumference of the branch to which the main steam pipe was connected, but it was possible to effect repairs, and thus enable the vessel to leave Dakar for England. At Cardiff the whole steam pipe arrangement was dismantled for inspection, when it was found that the sleeve of one of the expansion joints on the steam pipe was seized in position and was then useless so far as acting as an expansion joint. The sleeve, of steel, was indeed found to be pitted to a depth of $\frac{5}{32}$ in., while the gland was seized on the sleeve by an accumulation of rust. In both *Carnarvonshire*, and *Pensilva*, the stop valves were of cast iron and were of good design and material. Report No. 3024 refers to the fracture of the copper steam pipe next to the stop valve of the port engine in S.S. *Rimutaka* while the vessel was on voyage from Monte Video to Las Palmas. "Trouble had been experienced on several occasions with this steam pipe," says the report, "apparently from concentration of stress due to vibration and expansion, and where such is the case a modification of the arrangement is the only sure method of preventing failure."

TRIALS OF H.M. TORPEDO-BOAT DESTROYER "ARROW." "Engineering," 11th April, 1930.

The sea trials of H.M. Torpedo-boat Destroyer *Arrow* were completed recently. The vessel, which is one of eight of the Acasta class, has been built by Messrs. Vickers-Armstrongs Limited, Barrow-in-Furness. We understand that a number of these destroyers have undergone their trials and that the results obtained are so uniform that those recorded on H.M.S. *Arrow* may be taken as representative of the class. The speed obtained, at the designed displacement, was 36·7 knots, with a shaft horse-power of 34,119. No attempt was made to exceed the designed shaft horse-power of 34,000 as the Admiralty trials are required to represent service conditions, and forcing is not permitted. The design of the machinery in all the vessels which have completed their trials is identical, and the weight of that in H.M.S. *Arrow* is 465 tons. In considering the figures quoted above, it should be borne in mind that the speed and powers given are those which were maintained during a 6-hour trial; furthermore, we are informed that these could be maintained for a period which is limited only by the bunker capacity. The fact that the fuel-oil consumption during the trial stood at the low figure of 0·81 lb. per shaft-horsepower per hour is of additional interest, and when the endurance factor is taken into account it will be seen that the figures quoted are highly satisfactory.

AN EXHIBITION OF WEIGHTS AND MEASURES. "The Engineer," 25th April, 1930.

At the Science Museum, South Kensington, a permanent exhibition has been opened illustrating the history of weights and measures. The exhibits cover a wide range in time. The earliest is an equal armed balance of 1350 B.C. from Egypt. Its beam is of wood and it is suspended by a cord. One of the original stone weights used in conjunction with it is shown. Mr. W. A. Benton, of Messrs. Avery, Birmingham, has supplied a number of models illustrating the improvements made within modern times in the means of measuring large weights with accuracy and speed. Among Mr. Benton's models one of the most interesting is a reconstruction of a design for a self-indicating balance contained in a manuscript by Leonardo da Vinci. This balance consists of a metal semi-circle mounted to turn in a vertical plane about a pivot passing through its circular centre and carrying a fixed weight at one end and a pan at the other. The weight placed in the pan is measured by a scale on the circular edge of the disc against a pointer hanging from its circular centre. An alternative design involving the use of an equilateral triangle instead of a semi-circle was also suggested by Leonardo and is illustrated by another of Mr. Benton's models. Among the balances and steelyards is a small Chinese instrument of ivory, which folds up into a case only half an inch thick, and a huge bullion balance made in 1819 by Vandome for the Royal Mint and capable of reading accurately to a fifth of an ounce. Instruments for the measurement of length are included in the exhibition. Among them are Watt's micrometer, Whitworth's millionth machine of 1855, and recently developed National Physical Laboratory comparators making use of an optical principle. Three standards of length have been lent by the Royal Society, namely, Graham's standard yard of 1742, Bird's standard 90 in. of 1750, and Shuckburgh's standard 60 in. of 1796. It was with the aid of these standards that the Standards Commission of 1843-55 was enabled to correlate the Elizabethan yard with the standard yard now in use after the destruction of the Imperial standard in the fire at the Houses of Parliament in 1834.

ELECTRIC AND GEARED DRIVES COMPARED. Extract from discussion on Paper read at the Institution of Naval Architects. "The Engineer," 18th April, 1930.

PERFORMANCES OF VESSELS.

Mr. J. Johnson, after commenting that Mr. Belsey's paper was opportune in view of the fact that interest in the electric drive had quickened appreciably in recent years, said that as the commercial advantages of high-pressure steam were more widely recognised, expert discrimination was becoming necessary to determine its most suitable application. The high efficiency maintained by the water-tube boilers in the *Viceroy of India* and other vessels, however, should allay any doubts hitherto entertained on that score. The use of high-pressure high-temperature steam again raised questions as to the reliability of astern turbines and the adequacy of their power for manœuvring purposes. The conditions, undoubtedly, appeared somewhat more onerous than those which obtained in earlier steam practice, but, given suitable design, there seemed to be no grounds for apprehension. Nevertheless, the conditions attending the manœuvring and reversal of large steamers were, on occasion, very exacting, and there was no room for special tenderness when handling engines under urgent telegraph orders. The graph showed that, with the vessel travelling ahead at full speed, reversal of the propellers was effected in 30 seconds, that they were moving astern at 20 revolutions per minute 35 seconds after ahead steam was shut off, and that, in order to secure that, seven operations were involved. It was also shown that the ship was stopped in 2 minutes 10 seconds. As compared with this performance, a similar steamship fitted with astern turbines was brought to rest in 5 minutes, the operations required being the shutting of the ahead steam valve and the opening of the astern valve. That, however, could be improved upon in emergency by quicker operation of the valves, which would involve no risk to the machinery. The shipowner, naturally, was interested in the possibilities of turbo-electric drive, and must, perforce, closely examine its claims. Absence of noise and vibration, as Mr. Belsey had observed, was an important consideration in passenger ships. Passengers would travel on any vessel in which there was no observable discomfort arising from the mode of propulsion, and that was certainly true of a modern geared drive. Several ships had been commissioned during the last two or three years closely resembling in general proportion the *Viceroy of India*, and for purposes of comparison he gave the following figures illustrating the performance of several ships on the " measured mile " :—

	" Viceroy of India."	" Empress of Australia."	" Empress of Canada."	" Duchess of York.
Length (B.P.)	585	580	625	580
Breadth	78	75	77·5	75·25
Draught	23ft. $9\frac{1}{4}$in.	26ft. $5\frac{1}{2}$in.	24ft. 9in	23ft. $8\frac{3}{4}$in.
Displacement	19,050	22,350	22,220	20,590
Block coefficient (at trial draught)...	·63	·681	·649	·70
Speed on mile	19·35	19·50	21·85	18·50
S.H.P. on mile	17,000	20,000	26,000	15,450
$\frac{D^{\frac{2}{3}}\ V^3}{S.H.P.}$	305	293	316	307

These figures disposed of the suggestion that there was any substantial inaccuracy in the recording of power, for it would be seen that the Admiralty coefficient of the three vessels quoted compared very favourably with the *Viceroy of India*, although she has a block coefficient of ·63—a much finer form than the other vessels.

The *Viceroy of India's* log abstract showed wide variations of performance, which made a close analysis of individual runs rather difficult. In these circumstances, the only basis practicable for making a comparison with other vessels was the complete voyage. The following table is of interest :—

AVERAGES FOR COMPLETE VOYAGE—OUTWARD AND HOMEWARD.

Ship.	Speed.	Displacement.	$\frac{D^{\frac{2}{3}}\ V^3}{S.H.P.}$	$\frac{D^{\frac{2}{3}}\ V^3}{\text{Tons per day}}$ (propn.)	Fuel per S.H.P./hr. (propn.)
" Viceroy of India " ...	16·33	20,170	296	39,325	·702
" Empress of Australia "	19·25	22,500	285	40,850	·65
" Duchess of York " ...	18·20	21,030	284	44,300	·60

The Admiralty coefficient recorded for the *Viceroy of India* against a speed of 16·33 knots was 296. The corresponding coefficient on trial was 350, so that there appeared to be an increase in resistance of the order of 15 per cent. as compared with the "measured mile" conditions. That, of course, was a very high figure for a voyage from London to Bombay and back again, but if it was quite dependable, then the corresponding fuel rate per horse-power was ·702 lb. of oil for propelling purposes. He scarcely had the temerity to suggest that the horse-power might be inaccurate, but it was really not of vital importance, as comparisons could be restricted to the fuel coefficients. Although the *Empress of Australia*, which had a low-pressure steam installation, had registered a coefficient slightly in excess of 4 per cent. better on a 3½ per cent. lower Admiralty coefficient, the *Duchess of York* showed a fuel coefficient 11 per cent. higher, notwithstanding her Admiralty coefficient being 4 per cent. less. The marked differences in speed and their effect upon coefficients would, of course, be realised. Whether the matter was looked at from the angle of fuel coefficients or the cost of producing power, the conclusion reached was the same. On a conservative estimate, there would appear to be at least 12 per cent. in favour of the geared drive at full power; that figure was confirmed by trials and service results alike. He added, however, that over a period of nine voyages, including the tempestuous weather during the winter just ended, the *Duchess of York* had registered a fuel coefficient of 42,000 at a speed of 17·82 knots, the Admiralty coefficient being 269, *i.e.*, 17 per cent. reduction on the "measured mile" performance; also, she had made individual Atlantic passages in fair weather on a fuel coefficient of 48,000, although she was driven at a speed of ½ knot in excess of the designed figure. It would be evident that, when considering the behaviour of the geared drive and turbo-electric drive at reduced powers, the margin of 12 per cent. had to be eliminated before parity was reached.

In view of the claims made for electric transmission at reduced powers, the performance of the *Viceroy of India* seemed disappointing, as, if the condition was examined in which one turbine was operating two motors with one set of auxiliaries shut down, the fuel rate was 0·775 (propelling). The result obtained with geared turbines, on the other hand, at 50 per cent. of the designed power was 0·665 (propelling). The turbo-electric system, as exemplified in the *Viceroy of India*, using high-pressure steam and high-efficiency water-tube boilers, actually fell short of the performance of a low-pressure installation, such as the *Empress of Australia*. One must, therefore, conclude that the thermal advantages of higher pressure and temperature, feed heating, etc., had been swallowed up by the electrical transmission losses. With regard to consumption, he observed that in a ship of this class 10 per cent. of the steaming fuel might amount to 2000 tons on 200 days' steaming, or, say, in round figures, £5,000 per annum. Fuel consumption might be regarded by some as subordinate to other considerations. It should be noted, however, that the higher fuel rate necessitated larger boilers, the heating surface of the *Viceroy of India* boilers being 32,500 square feet for 17,000 S.H.P., as against 30,690 square feet for the *Duchess of Bedford* at 18,000 S.H.P.; that was 12 per cent. greater surface for equal power. Similarly, greater weight of bunkers was required for a given steaming radius. An increase in the weight of machinery and bunkers necessitated an increase in displacement and gross horse-power, or a reduction in deadweight. In large high-speed vessels those were important considerations and had substantial repercussions on first cost and running expenses. In the face of competition such factors comprised the data upon which the choice of propelling machinery had to be made.

With regard to reliability, speaking with a full realisation of the actual faults which experience had shown might occur in astern turbines and mechanical gearing, Mr. Johnson said that he could not find anything inherently objectionable or unsound in them, or any degree of unfitness for the very severe conditions liable to be imposed upon them. His own view was that most mishaps or depreciation incidental to the comparatively slow-speed turbine as used with the geared drive could be overtaken on board ship. It was doubtful whether that could be said of the high-speed turbines used in association with electric drive, a mishap to which would put out of action half the total power. A mishap to one of the three turbines in a geared drive could, of course, be adjusted temporarily without serious loss of power by the removal of a pinion. Turbo-electric propulsion would have to exhibit an overwhelming superiority in terms of reliability and maintenance expenses to warrant the premium which must be faced on account of its inherent disability, as expressed in first cost and fuel consumption, before its adoption could be justified, but there appeared to be no evidence of that superiority.

MOTOR LIFE-BOAT PROGRESS. "The Engineer," 11th April, 1930.

At the annual meeting of the Royal National Life-Boat Institution, which took place on Monday, April 7th, Sir Godfrey Baring, the Chairman of the Institution, referred to the advance made in recent years in the construction of motor lifeboats. In 1910 the Institution had, he said, only ten motor lifeboats, whereas to-day there were no less than eighty-seven with a hundred slipways and up-to-date equipment for launching and maintenance. The Institution was grateful to the large shipping companies which had so munificently presented new motor boats, and he put forward the suggestion that owners of trawlers might support the funds of the Institution. Mr. William Graham, the President of the Board of Trade, moved a resolution acknowledging on behalf of the Government and the public the admirable work in which the Institution was engaged and the thanks which were deserved by all its officials. An interesting service was that performed on March 30th, when the Stromness motor lifeboat made a trip of about 134 miles to the Skerries off the coast of Shetland, where the trawler *Ben Doran* was wrecked with, unfortunately, loss of life, owing to the breaking up of the ship before the lifeboat could arrive. The return voyage was made in the teeth of a south-westerly gale and throughout the whole run of over 270 miles the boat and her engines behaved perfectly. The engines are of the Institution's new 60 B.H.P. submersible type. The Institution is now developing a small high-speed type of engine, which has been primarily designed to provide power for the 35 ft. boats which are furnished with carriages for launching from beaches. The new engine is also fully submersible and is designed to give an output of 35 to 40 B.H.P. at 3300 r.p.m., the geared propeller running at about 900 r.p.m. The few engines of this type which have already been put to work have proved so successful that the Institution has decided to put into production a considerable number of engines for further boats.

MARINE OIL ENGINE INSTALLATIONS. "The Engineer," 4th April, 1930.

A paper on marine oil engines was read before the Manchester Association of Engineers on Friday, 28th March, by Mr. J. Calderwood, M.Sc. The author said that at the present time, for the slower classes of cargo vessels, the shipowner frequently considered the first cost before anything else, and as a result resorted to steam engines on routes on which the internal combustion engine could be adopted with considerable advantage in service economy. The high first cost of the oil engine ship of that type was largely due to the auxiliary machinery, and unless the cost of that plant could be considerably reduced the steam engine was likely to retain its predominance. A fault of many auxiliary installations was the over-elaboration of the arrangement of the pumps, separate units being provided for services that could be run in conjunction and every pump being duplicated, one unit being capable of the full normal duty, while the second was available as a standby. In addition, cross-connections were provided so that the pumps for one service might be used as additional standby for some other duty. Such elaboration greatly increased the cost of the machinery and gave little, if any, extra reliability to the installation as a whole. With care in design the auxiliary pumping installation might be greatly simplified, one pump being used for more than one service, while, by suitable cross-connection, a single standby unit might serve two or more auxiliary systems. With steam auxiliaries, for instance, the engine-cooling system might be arranged so that a part of the water going to the engine could be used in the oil coolers, while the overboard discharge from either piston or jacket cooling might serve the auxiliary condenser. A single pump could, in such an installation, serve as standby for the combined cooling system, for the ballast system and for the bilge service. Another direction in which there were possibilities of saving in the cost of marine installations was by the standardisation of parts of the engine-room equipment, such, for instance, as fuel tanks, filters, air bottles and silencers. Plumbers' and fitters' work could be economised by standardising oil and water connections and piping, while the cost of pumps could be reduced by adopting standard positions for the branches on the pumps.

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INSTITUTE NOTES.

JUNIOR SECTION.—Film Display, Thursday, April 10th, 1930.

On the occasion of the April meeting the evening was devoted to a film display, the principal item being a four-reel pictorial description of "The Manufacture and Operation of the Babcock and Wilcox Water-Tube Boiler." Messrs. Babcock and Wilcox Ltd. very kindly lent not only the above film, but the projector for showing it, and provided the services of an operator. The Chair was occupied by Engineer Rear-Admiral

W. M. Whayman, C.B., C.B.E., Vice-President, whose previous experience with " Babcock " boilers in the Royal Navy and present association with the makers gave special authority and point to his interesting commentary as the various sections of the film were shown, depicting the manufacture of the boilers from the earliest stages, their subsequent testing, despatch, installation and operation.

The second half of the programme included " The R.A.C. International Tourists Trophy Race, Belfast, August, 1929," which was most entertainingly described by Mr. S. C. H. Davis, the world-renowned racing motorist, and " A Holiday Cruise to Norway by R.M.S.P. *Araguaya*."

During the interval Admiral Whayman presented prizes awarded by Mr. J. R. Douglas to the following five juniors, who had entered the competitions recently promoted by Mr. Douglas for the best sketch of an auxiliary engine and the best report of a repair carried out to such an engine: Messrs. W. L. Evans, S. Grant, J. H. Taylor, A. J. Driscoll, and W. D. Rhoades.

The audience on this occasion numbered 105. On the proposal of Mr. G. R. Hutchinson, seconded by Mr. E. R. Hall, hearty votes of thanks were accorded to Admiral Whayman and Mr. Davis for the parts they had played in affording a most instructive and entertaining evening.

Visit to the Works of Messrs. J. & E. Hall, Ltd., Dartford, Saturday, May 10th, 1930.

By the kindness of Messrs. J. & E. Hall, Ltd., the well-known Refrigerating Engineers, a party of 50 Juniors visited the firm's works at Dartford on the afternoon of May 10th. Under the direction of Captain G. Melville Bell, the firm's Superintendent of Education, assisted by four members of the staff, the party divided into three sections and were conducted methodically through the works, to the accompaniment of a most interesting description by the guides, of the various departments and their special features and functions. Questions and answers were freely exchanged and the very thorough inspection of the various types of refrigerating plant in course of manufacture will certainly prove immensely beneficial to many members of the party in their subsequent sea-going careers. The tour of the works occupied nearly three hours, after which the party was entertained to an excellent tea.

Before dispersing, a hearty vote of thanks was accorded to Messrs. J. & E. Hall, and particularly to Captain Bell and his assistants for having so generously devoted their time and attention for the benefit of the visitors. In responding on behalf of the firm, Captain Bell offered to receive similar parties of our Juniors on future occasions on the request of the Committee, and further, to consider annually applications from two or three University engineering students who may be desirous of obtaining four or five weeks works' experience during their summer vacation. Any students to whom this offer appeals should communicate with the Secretary at the Institute in the first instance.

ELECTION OF MEMBERS.

List of those elected at Council Meeting held on April 14th, 1930:—

Members.

Peter Blair Allan, Larut Tin Fields, Taiping, Perak, F.M.S.
David Seton Birrell, 21, Thornwood Avenue, Glasgow, W.1.
John Henry Arnold Cairns, 54, Cotswold Gardens, East Ham, E.6.
Thomas Richard Cullen, *c/o* Marine Office, Butisba, Uganda.
George Richard Reginald Cushing, Southfield House, Joyce Green, Dartford, Kent.
R. Linwood Ingledew, Roseway, West End, Nailsea, Somerset.
Herbert William Jackson, 16, Kensington Gardens, North Shields.
Ernest Jones, St. Albans, Priestlands Park Road, Sidcup, Kent.
James Crawford McGuire, *c/o* The Prince Line, Furness House, Leadenhall Street, E.C.3.
St. Clair Millar, 385, East India Dock Road, E.14.
Joseph Prentice, 88, Wandsworth Road, Belfast.
Rowland Henry Procter, Insurance Engineers, Ltd., 20/22, Lincoln's Inn Fields, W.C.2.
John Alfred Reader, Armdale, Halifax, N.S.
Llewellyn Thomas Gordon Soulsby, Hilltop, Fieldspart Road, Newport, Mon.
George Thompson, 23, Meredale Road, Mossley Hill, Liverpool.
Charles Alfred Norton Williams, D.S.O., The R.M.S.P. Co., Southampton.

Associate Members.

Brian Murray Aitken-Quack, 113, Clive Court, Maida Vale, W.9.

Joseph Charles Beauchamp, 13, Victoria Street, Westminster, S.W.1.

Archibald Taylor Cameron, St. James Power Station, Singapore, S.S.

Gabriel Majcen, 41, Sevington Road, Hendon, N.W.4.

Thomas Frederick Palmer, 9, Archers Mansions, Archers Road, Southampton.

Associate

William Frederick H. Shields, 8, Forbes Road, Faversham, Kent.

Graduate.

Harry Wilcox, 58, Sidney Road, Hackney, E.9.

Transferred from Associate Member to Member.

Edwin George Cleveland, 26, Lyon Park Avenue, Wembley.

William S. Holness, 29, Deptford Green, S.E.8.

Transferred from Graduate to Associate Member.

Edward Shaw, 88, Inverness Place, Cardiff.

List of those elected at Council meeting held on May 5th, 1930:—

Members.

Aubrey Ernest Auton, Canton, Holloway Lane, Chesham Bois, Bucks.

Rowland Marshall Boreham, Carltonville, South Street, Cottingham, Yorks.

James Rennie Connelly, Avondale, 7, Glenburn Park, Belfast.

Thomas Hilton Finn, *c/o* Post Master, Fao, Iraq.

John Malcolm Henderson, 2, Queens Crescent, Lincoln.

Laurence Rhodes, 25, Rue Arthur Rowlatt, Bulkeley, Alexandria, Egypt.

Edward Kemish Wilkins, Redcliffe, 25, Strathallen Avenue, Northbridge, Sydney, N.S.W.

Associate Members.

Arthur Allanson, 4, Wheatlands Grove, Poppleton, York.
Archibald Keith Macnab, 86, St. George's Crescent, Drummoyne, Sydney, N.S.W.

Associate.

Edwin Cottingham, 36, Wilson Street, Lincoln.

Graduates.

John Magnus Platt, 20, Grove Road, Wanstead, E.11.
William Geoffrey Whayman, Midshipman (E.), R.N., Royal Naval Engineering College, Devonport.

"TITANIC" ENGINEERING STAFF MEMORIAL BENEVOLENT FUND.—The following donations are acknowledged with thanks:—R. Carruthers, Shanghai, 8s. 6d.; H. T. Lawson, Bombay, 8s. 9d.

BOOKS ADDED TO LIBRARY.

"On the Bottom," reviewed on p. 101 February issue, was presented by Mr. Frank Cooper (Member).

Presented by the Publishers:—

"Definitions and Formulæ for Students—Marine Engineering." By E. Wood, B.Sc. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. $5\frac{3}{8}$in. x $4\frac{1}{4}$in. 28 pages. Price 6d. net.

This booklet is the latest addition to the excellent series of useful little works on definitions and formulæ of various kinds which Sir Isaac Pitman and Sons, Ltd., have recently placed on the market. Each is of about 30 pages, and the cost is 6d. The present little book is clearly the work of a practical man, for it contains a great deal of data for the marine engineering student, which are not found in any of the companion booklets. It is a really useful, accurate desk companion for the student.

Presented by the Author:—

"Questions and Answers on the Construction and Operation of Diesel, Semi-Diesel and Other Internal Combustion Engines, Air Compressors, etc." By John Lamb. Third Edition. Published by Charles Griffin and Co., Ltd.

Presented by Mr. L. B. Lewis (Member).

"The Public Schools Year Book, 1929." Published by H. F. W. Deane and Sons. Price 10/6 net.

Presented by the Publishers:—

"Practical Geometry and Engineering Graphics." By W. Abbott, B.Sc., A.M.I.Mech.E. Published by Blackie and Son, Ltd. Price 10/-.

This book has been written to provide a course of Practical Geometry for engineering students, and as such it more than fulfils its purpose. It is doubtful whether the average student would find time to digest the whole of this book, for the tendency in the majority of technical institutions is to push on with machine drawing as soon as possible, and as the author states, the time allocated to practical geometry is too limited. Hence the book will be more likely to be used for reference purposes than as a text book. The arrangement of the text with the diagrams on the opposite page is excellent, for there is nothing more annoying when reading any book than to continually turn back and search for the appropriate diagram. The part on graphical differentiation and integration has been well treated and the examples well chosen. The author makes the common mistake with regard to cams in Problem 86. How can a follower reciprocate with uniform velocity when there must be a period of acceleration and retardation at the ends of the stroke?

The statement on page 76 that the second moment of area is called "the Moment of Inertia" calls for comment. The latter term in connection with beam sections is only used by teachers of the old school. Another relic is the use of *stress* diagram instead of *force* diagram.

The graphical treatment of Harmonic Analysis will make this difficult part of the subject more understandable, but arithmetical methods will always be preferred owing to their greater accuracy. For the determination of piston acceleration, the author only gives Klein's construction, although there are several easier constructions.

Despite these minor criticisms this book should be included in the library of every engineering student, and the author and publishers are to be congratulated on placing such an excellent book on the market at a reasonable price.

J.W.

Purchased :—

"The Design of Merchant Ships and Cost Estimating." By Alexander Kari. Second edition enlarged. Published by Crosby, Lockwood and Son. Price 36/- net.

The Yearbook of the Universities of the Empire, 1930. Edited by Sir H. Frank Heath, G.B.E., K.C.B. Published for the Universities Bureau of the British Empire by Messrs. G. Bell and Sons, Ltd. Price 15/- net.

The Analysis of Commercial Lubricating Oils by Physical Methods. Published by H.M. Stationery Office for the Department of Scientific and Industrial Research. Price 1/9 net.

Annual Reports of the Society of Chemical Industry on the Progress of Applied Chemistry. 1929. Vol. XIV. Published by the Society of Chemical Industry. Price 7/6.

The Deterioration of Structures in Sea-Water—10th (interim) Report of the Committee of the Institution of Civil Engineers. Published by the Department of Scientific and Industrial Research. Price 2/-.

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BOARD OF TRADE EXAMINATIONS.

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

For week ended 15th March, 1930:—

NAME.	GRADE.	PORT OF EXAMINATION.
Bryan, Ernest V. A.	1.C.M.E	Cardiff
Morris, Thomas H.	1.C.M.E.	"
Griggs, Edwin	1.C.	"
Mirams, Thomas F. P.	1.C.	"
Williams, John P. R.	1.C.	"
Llewellyn, Henry D. P.	2.C.	"
Shaw, Edward	2.C.	"
Taylor, Humphrey H.	2.C.	"
McIntyre, William P. E. ...	1.C.M.	Glasgow
Sharp, Frank	2.C.M.E	"
Urquhart, John	1.C.M.E.	London
Clarke, Percy	2.C.	"
Pearce, Stanley C.	2.C.	"
Rossiter, Frederick H.	1.C.	North Shields
Westlake, Henry A.	1.C.	"
Bates, Frederick A.	2.C.	"
Jackson, William A. P. ...	1.C.M.E.	"

For week ended 15th March, 1930—*continued.*

NAME.	GRADE.	PORT OF EXAMINATION.
Rea, Gordon	1.C.M.E.	Liverpool
Walker, James R.	1.C.M.E.	,,
Hamill, Robert	1.C.	,,
Jackson, Clarence	1.C.	,,
Yarwood, Alfred W.	1.C.	,,
Parry, Joseph P.	2.C.	,,
Rigby, Victor	2.C.	,,
Rothery, Edward R.	1.C.M.	,,
Dott, John McL.	1.C.	Leith
Stephen, Alexander	2.C.	,,
Fleetwood, Gordon E.	1.C.	Southampton
Harris, Allan D.	1.C.	,,
Lister, Cyril G. W.	1.C.	,,
Shearman, Arthur F.	2.C.	,,

For week ended 22nd March, 1930:—

Fox, William A.	1.C.	Newcastle
Gair, George	1.C.	,,
Porter, Sydney	1.C.	,,
Smith, Herbert D.	1.C.	,,
Mainprize, Kenneth G. ...	2.C.	,,
Fielder, Eric S.	1.C.	London
Smith, Joseph	1.C.	,,
Flood, Frederick C.	2.C.	,,
McLean, Peter	1.C.M.E.	,,
Young, William	1.C.M.E.	Glasgow
Campbell, William M.	1.C.	,,
Sinclair, Donald	1.C.	,,
Carr, George C.	2.C.	,,
Lyon, Alexander	2.C.	,,
Jamieson, Robert	2.C.M.	,,
Arthur, John R.	1.C.	Liverpool
Champion, Frank E.	1.C.	,,
Davison, Albert H.	1.C.	,,
Douglas, Hugh	1.C.	,,
Gall, John	1.C.	,,
McAuslan, Henry B.	1.C.	,,
O'Brien, George R.	1.C.	,,
Rossiter, Percy A.	1.C.	,,
Selkirk, Isaac	1.C.	,,
Smith, Robert H.	1.C.	,,
Williams, James A.	1.C.	,,
Worrall, Robert S.	1.C.	,,
Geary, James A. G.	2.C.	,,
Johnson, Leslie	2.C.	,,
Sims, George	2.C.	,,
Straley, Charles W. G.	2.C.	,,
Whittaker, Harry	2.C.	,,
Wynne, Leslie R.	2.C.	,,
Godfrey, Valentine T. B. ...	2.C.M.E.	,,
Kinghorn, Samuel	1.C.	Sunderland
Allinson, George F.	2.C.	,,
Elphinstone, James A.	2.C.	,,
Freeman, John R.	2.C.	,,
Major, Samuel A.	2.C.	,,
Palmer, Guy M.	2.C.	,,
Sanderson, George	2.C.	,,
Whitington, Stirling C. ...	2.C.	,,

For week ended 29th March, 1930 :—

NAME.	GRADE.	PORT OF EXAMINATION.
Donaldson, James C.	1.C.	Leith
Kemp, Alexander	1.C.	,,
Mitchell, James M.	1.C.	,,
Playle, Thomas St. J.	1.C.	,,
Smith, Fred C.	1.C.	,,
Stevenson, John C.	1.C.	,,
Stewart, Archibald W.	1.C.	,,
Summers, William	1.C.	,,
Dean, Percy	1.C.E.	Liverpool
Corkill, Harry	1.C.	,,
Dobbin, John	1.C.	,,
Halpin, Leo F.	1.C.	,,
Kidd, Harold	1.C.	,,
McIlwaine, Henry	1.C.	,,
Murray, John A.	1.C.	,,
Raitt, William A.	1.C.	,,
Renton, Eric	1.C.	,,
Hall, Joseph	2.C.	,,
Mitchell, William R.	2.C.	,,
Rothwell, Leonard B.	2.C.	,,
Guy, Thomas G.	1.C.M.	,,
Lester, Albert F.	2.C.M.	Southampton
Cole, Reginald L.	1.C.M.E.	,,
MacKenzie, James R.	1.C.M.E.	,,
McQuade, James	1.C.M.E.	,,
Swanson, Douglas	1.C.M.E.	,,
Younger, David H.	1.C.M.E.	,,
Bramley, Percy	1.C.M.E.	Newcastle
Auty, George W.	1.C.	,,
McDougall, Donald	1.C.M.	,,
Crossan, Archibald G.	1.C.	London
Davis, Leonard H.	1.C.	,,
Marshall, Harry	1.C.	,,
Spence, Edgar A.	1.C.	,,
Petit, Frederick C.	2.C.	,,
Riley, Edward H.	2.C.	,,
Wilson, James	1.C.	Belfast
Gregg, Alexander	2.C.	,,
Russell, Ivor E.	1.C.	Cardiff
Cleverdon, Harold J.	2.C.	,,
Halikiopulo, Nicholas	2.C.	,,
Merrick, Stanley F.	2.C.	,,
Mitchell, Henry	2.C.	,,
Tippett, Keith F.	2.C.	,,
Vile, Walter B.	2.C.	,,
Hayes, Tom E.	1.C.M.E.	,,
Musgrove, Clifford	1.C.M.E	,,
Wilson, John F.	1.C.M.E.	Glasgow
King, Thomas J.	1.C.	,,
Torrie, John P.	1.C.	,,
McIntyre, John	2.C.	,,
McLachlan, William	2.C.	,,
Paterson, David J.	2.C.	,,

For week ended 5th April, 1930:—

Place, George	1.C.M.E.	Newcastle
Mitchell, John	2.C.M.E.	,,
Longstaff, John	2.C.	,,
McFarlane, William	2.C.	,,