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Encouragement of Invention in Workshop Practice.

BY MR. J. HAMILTON GIBSON, O.B.E. (Member).

READ

Tuesday, March 16, 1920, *at* 6.30 *p.m.*

CHAIRMAN: MR. B. P. FIELDEN.

The CHAIRMAN: I have pleasure in introducing to you Mr. Hamilton Gibson, who will now read the paper he has kindly contributed to the Institute.

IN the daily round of operations in an engineers' workshop there is abundant scope for the introduction of improvements. No shop is so perfectly equipped and organised that it is incapable of improvement somewhere or somehow, for there is no such thing as perfection or finality in good engineering practice. The best establishments are those that keep an open mind and a keen perception for any hint that promises something better.

In this consideration care must be taken to distinguish between manufacturing and engineering. Manufacturing implies mass-production and repetition work where methods must necessarily become stereotyped, and changes cannot be countenanced except under very special circumstances. On the other hand a general engineering works—especially one that undertakes repairs—is in a very different category, and marine engine shops, where allied with Shipyards dealing with old and new work, are constantly being brought up against interesting problems that tax the initiative and resources of the staff to the utmost.

Let us in the first place do justice to the designers and draughtsmen, who are always expected to go one better than their last effort; and, to their credit be it said, generally succeed. From their practical experience (and all engineer draughtsmen must go through the mill of actual work) these men know exactly where they can save weight here, or a frame-space there, or eliminate a redundant stay or link somewhere else, without impairing the efficiency of the job. It is a poor draughtsman who cannot earn far more than his pay represents, by economies such as are here indicated: but after all, it is merely his normal work to go on day by day laying out, and piecing together, and then checking suggested improvements. Now just as the best draughtsmen are those who have had the best preliminary practical training, so also the best foremen and shop-managers are the men who have learned something of the importance of design. It is not enough that they should be able to read and interpret a drawing. They ought to know why and wherefore certain forms of construction are shown, and if they do not, or if the reason is obscure, or if it appears that a simpler method could be devised, then they should be encouraged to discuss the matter with the draughtsman, and whatever is decided should be embodied at once on the drawing. By these means, and by full and frank discussion, mistakes are obviated, and real improvements often effected. During the author's experience as engineering manager he always insisted on the ironfoundry being consulted at the outset of a job, and the patterns being made accordingly. It seems a small matter; but when one has to go far afield for castings—to the Clyde, to the North-East Coast, or the Midlands—it is astonishing to find the variations in foundry practice that obtain: and it is just as easy to make the patterns one way as another, so long as one knows beforehand. This is perhaps a digression, but it serves to emphasise the importance of close co-operation between design and construction.

Improvements emanating from the drawing office may therefore be treated as all in a day's work. The economies effected are not always immediately obvious, and it is sometimes difficult to assess their true value, unless of course it happens to be something really new and novel, which may develop into a real invention.

In the workshop, however, it is different. The management continually finds itself up against the necessity of devising some new method to speed up production of some essential part to keep pace with the rest of the work, or some little mechanical contrivance is put into operation that proves to be much superior to existing methods, and the improvement can be expressed at once in terms of time saved, and money gained.

In recent years, several firms have developed systems of bonuses and rewards for such improvements: but the best scheme in the author's opinion, and one that so far appears to work most satisfactorily from the employee's point of view, is to secure the invention by a provisional patent taken out in the joint names of the firm and the employee. The firm pays the patent fees, and if the "improvement" (which is the legal term, by the way, for all such inventions) has already resulted in a real economy, a cash payment to the employee is made on account. In many cases the improved appliance is of such a nature that the firm where it originates cannot very well market the article: and it is then handed over to another firm who specialise in such fittings, any Royalties that accrue being divided with a generous bias in favour of the inventor. The employee is therefore protected from the anxiety and fear of infringement, which is always a possibility where a single individual is concerned. Moreover he has the advantage of the free expert advice and assistance of the firm's regular patent agent, and has the satisfaction of knowing that if there is anything at all in his invention he is sure to make something out of it. On the expiry of the provisional period the patent is completed at the firm's expense; or it may be dropped if found to be valueless. But in the latter case the employee is free to complete the patent himself if he so desires. The patent is thus secured for four years (or longer under the new Act), a sufficient period to establish its value, when annual taxes become due.

Altogether the scheme is extremely fair and generous, and in strong contrast to the old days when an employee who presumed to invent and patent anything, even at his own expense, was looked upon with a certain amount of disfavour.

In this connection the author well remembers the experience of an intimate friend of his, which shows how far we have advanced in such matters. As works manager he was responsible for an Indian Government contract involving certain stringent tests. The first batch of material failed to pass the tests; but after many sleepless nights and several experiments the manager hit on a method of manufacture which saved the situation. The material, some thousands of pounds worth, triumphantly passed all the tests, and the customers were well satisfied. At the next Board Meeting the Works Manager was called before the Directors. He naturally expected to be complimented on his success, as he had in effect invented a new process which meant many future orders. Imagine his surprise when the enormity of his shortcomings was pointed out to him, and he was reprimanded for not thinking of the process before!

That was 25 years ago. Employers have more sense nowadays. They recognise that a man is something more than a mere machine: that he is a thinking being, and that if by a flash of inspiration or exceptional skill he produces something outside and beyond his usual routine he should get some credit for it. The inventive instinct is strong in most workmen, engineers especially. There is something in human nature that revolts at unnecessary labour, even if it does at first sight appear to provide work for a greater number of hands. The story of the (apparently) lazy boy who invented the first valve gear, by connecting the tappets with string to the moving beam, has been duplicated under similar circumstances over and over again in engineering history. We don't suppose that the lad worried much about losing his job as valve tender. He would be sure to make good at more congenial work and meanwhile the steam engine industry has received a decided fillip that meant employment for many more individuals.

The inventor does not usually take account of such trifles as the temporary displacement of labour when a brain-wave overtakes him. He has created something that did not exist before, and one must confess that invention has a fascination all its own that is incomparable. If it happens to be something really useful all the better. And no one is more likely to invent useful devices than the man who is working among the multitudinous apparatus of a modern shipyard, where constant improvisation of jigs and fixtures and appliances is the order of the day.

Let us now take a few examples that have come to the author's notice. We will see how the various devices came to be evolved, the uses to which they have been put, and perhaps the mere recital will suggest similar "gadgets" that members present may have come across in their experience.

1. The cover studs of cylinders, turbine casings, and large valve boxes are apt to get damaged during the time they are knocking about an engine shop waiting for the final assembling of a set of machinery. It was the practice to go over such studs, before completion, with a solid die nut to restore the threads as far as possible. A fitter engaged on this work noticed that frequently the die nut got across the threads and the stud was irretrievably ruined, necessitating its withdrawal and replacement by a new stud. He therefore made a split-die nut (Fig. 1) with threads backed-off *the reverse way*, dropped it over the stud, set it up on to the good threads by a grub screw and then screwed it off the stud with a left hand motion. Result, entirely satisfactory, practically all damaged studs saved, and

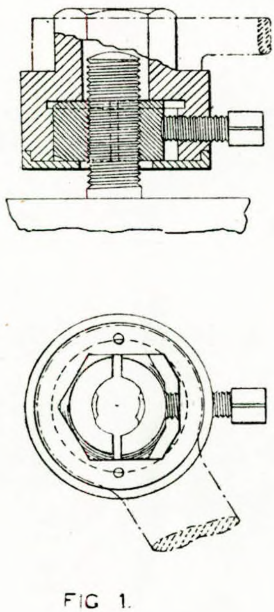


FIG 1.

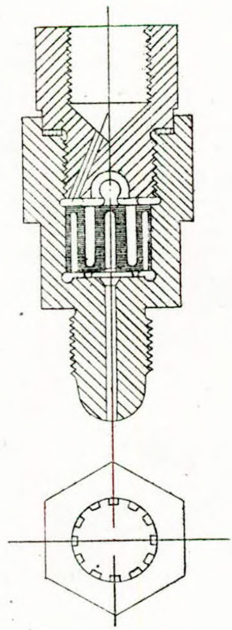


FIG. 2.

much time and trouble obviated. The firm of tool makers who took over the appliance, are supplying sets, not only to engine shops, but to vessels where they have been found extremely useful for such things as boiler stays.

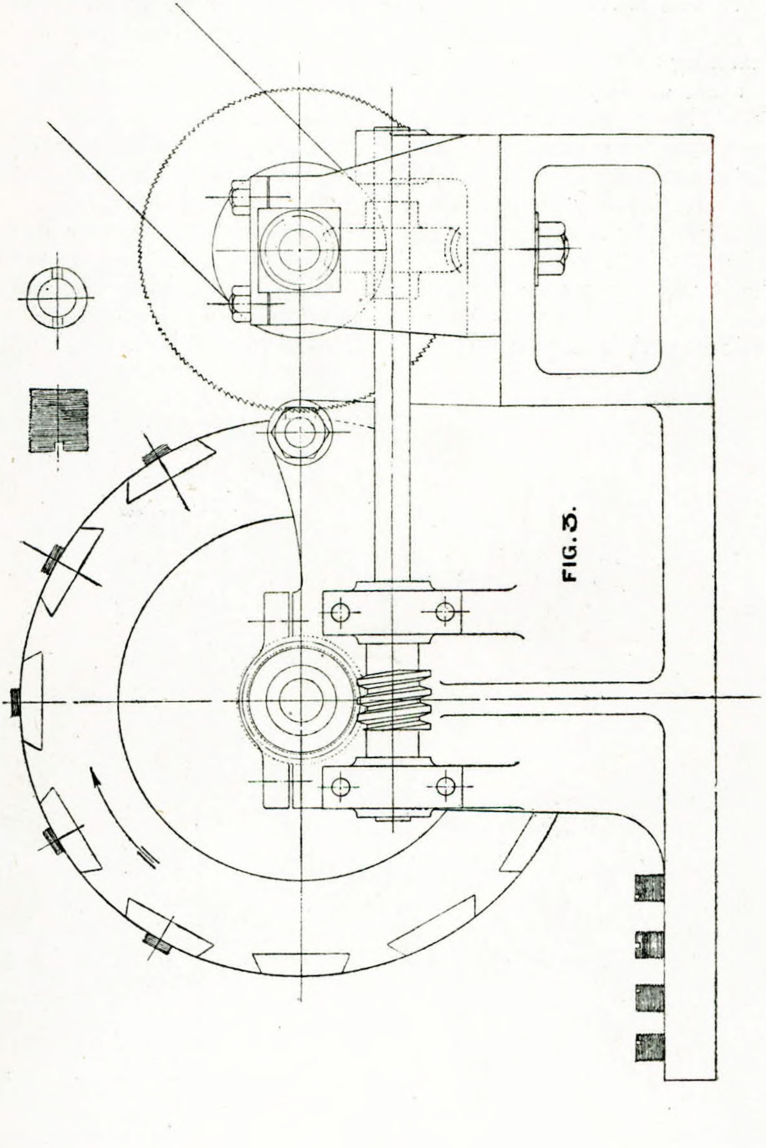
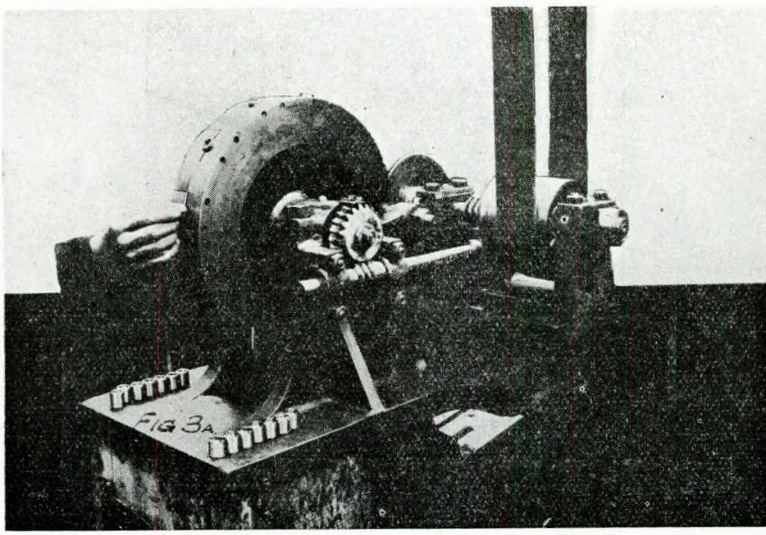


FIG. 5.

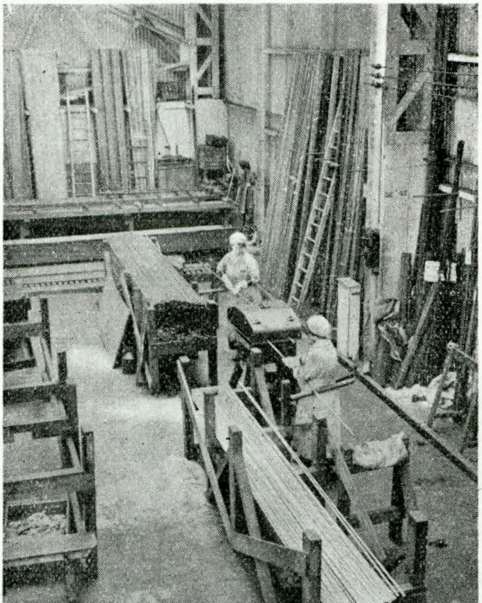
2. The ordinary fuel oil strainer containing a perforated cartridge and fine wire gauge is difficult to overhaul and clean. Imagine the job of pricking out bits of grit from a wire sieve after they have been driven in at 3,000 lbs. pressure by the fuel pump of an oil engine! The serrated and grooved plug device shown in Fig. 2 was submitted to the Admiralty, who immediately gave it a trial and subsequently adopted it in submarine engines. It will be seen that the serrated plug can be withdrawn, cleaned thoroughly and put back very readily. The man who experienced this brain-wave has had no cause to regret his inspiration.

3. During a rush of condenser work it was found that progress was being delayed for lack of tube ferrules. The existing



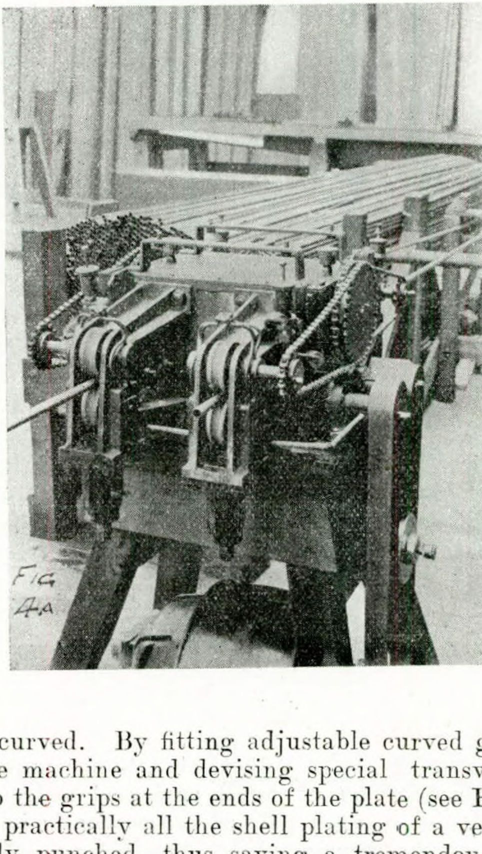
appliances for cutting the screw-driver slots were hopelessly inadequate. The foreman therefore rigged up a machine (Fig. 3) which not only saved the situation, though only working half-time; but has been adopted for other work such as cutting the slots in the turrets of castle-nuts. The machine was made over to a tool-maker who has already supplied several to engine builders and others.

4. Another little worry in connection with condenser production was the time taken in cleaning the outer surface for inspection. Eleven men, working overtime, could not keep pace with requirements. The foreman in charge, who by the way had been through the drawing office and was an excellent draughtsman, sketched out a twin polishing machine (Fig. 4), got permission to put it in hand, and as a result two girls sufficed to replace the eleven men. The foreman received a substantial reward for his resource and ingenuity.



5. The cone-ends of pressure gauge pipes are sweated and brazed on to the pipe ends, and in the process become distorted. It is impossible to fair them up satisfactorily by means of a file. So an old tool-maker made a portable truing apparatus (Fig. 5) something like a small valve re-seater, and by two or three turns of the handle the correct shape of the cone is quickly restored. It does the job first rate, and the man certainly deserved his reward.

6. The multiple punching machine for ship work is normally only suitable for rectangular plates. It occurred to one of the shipyard staff that the usefulness of the machine might be considerably enhanced if it could be adapted to punch plates whose



sides were curved. By fitting adjustable curved guides to the back of the machine and devising special transverse sliding carriages to the grips at the ends of the plate (see Fig. 6) it was found that practically all the shell plating of a vessel could be satisfactorily punched, thus saving a tremendous amount of templet work, and making a much better job. The original makers of the multiple punch acquired the patent, and are incorporating it in their new machines. And the inventor of the improvement has every reason to congratulate himself that his firm had the foresight and enterprise to father his improvement.

7. The nuts of the holding down bolts of submarine engines, after being hardened up, are finally secured by locking plates, each covering about half-a-dozen bolts. A pattern-maker fitted a pattern over the hexagons, castings were made in the brass

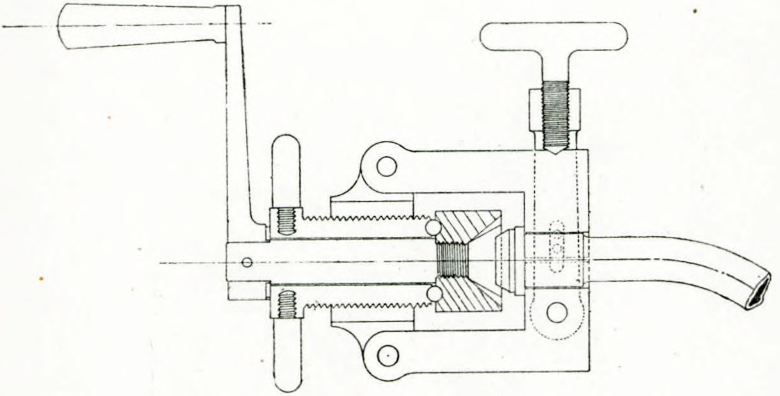


FIG. 5.

foundry, and then fitters had to trim and file and secure them in place. The erector in charge saw a way of eliminating the first two trades. He made an adjustable template (Fig. 7) dropped it loosely over the series of nuts to be locked, tightened it up and used it to mark off the varying position of hexagons on a thick strip of rolled sheet brass. A hexagon punch fitted to a fly-press was used to pierce the holes, and the job progressed smoothly and swiftly without enlisting the aid of pattern shop and foundry, resulting in a considerable saving in time and wages.

8. In gearing up sluice valves, etc., to the upper deck of a warship large numbers of small cast-steel mitre wheels are used. The fitting of each pair of mitre wheels in its bracket so that they would gear smoothly, involved considerable time, and a large expenditure in files. Even then each pair had to be carefully marked to ensure that the same pair of teeth always meshed together, otherwise they might lock and jam. The foreman made a rough rig-up with a dividing head on an emery grinder (see Fig. 8) which reduced the time by 90 per cent., and

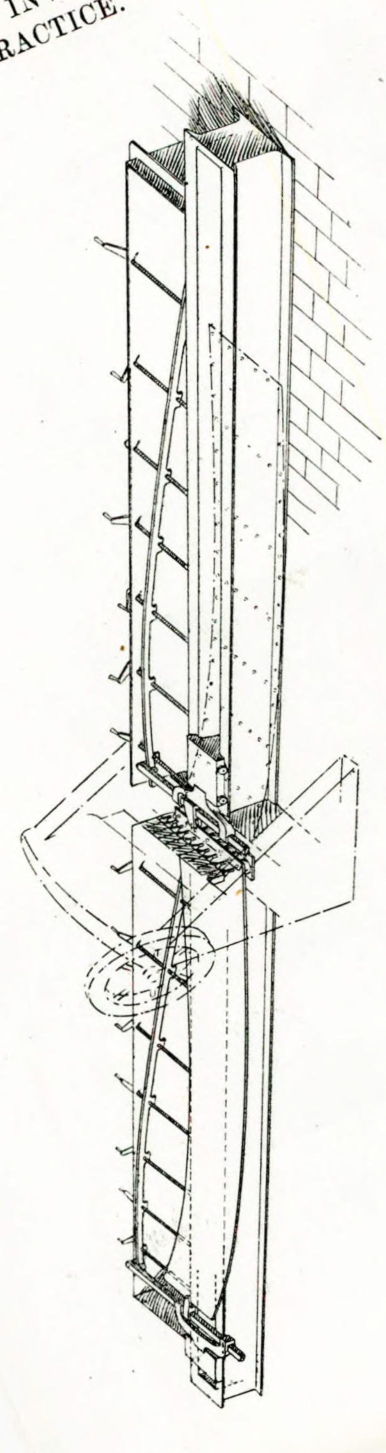


FIG. 6

moreover made a better job. Of course, as an accurate gear-cutting machine the apparatus is very imperfect, but it is quite good enough for its purpose and the resultant mitre wheel teeth

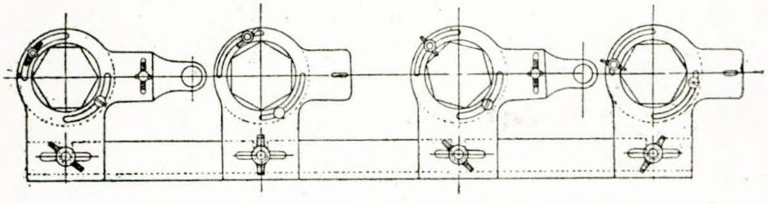


FIG. 7.

are at any rate of equal thickness and equally pitched. This is a good example of doing just what is necessary and no more, for the particular class of work required.

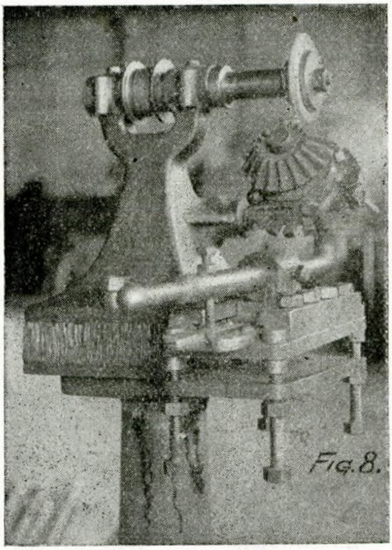


FIG. 8.

9. It is generally admitted that test cocks on a high pressure boiler are of little or no use, as it is difficult to determine whether steam or water is issuing. The Board of Trade rules tacitly acknowledge this and permit an extra water gauge in lieu of a set of test cocks.

ENCOURAGEMENT OF INVENTION IN WORKSHOP PRACTICE.

An engineer draughtsman engaged on boiler mountings, and who had had some awkward experiences at sea with broken gauge glasses and unreliable test cocks, conceived the idea of trying a perforated metal tube instead of a gauge glass in the extra water gauge mounting. Normally, of course, this gauge is shut off, but when required to show the water level it is operated in the usual way. The effect is clearly shown in the photograph (Fig. 9). The steam jets are almost invisible, whilst the water jets show as unmistakeable white cones causing clouds of vapour. The water level is thus located to within an

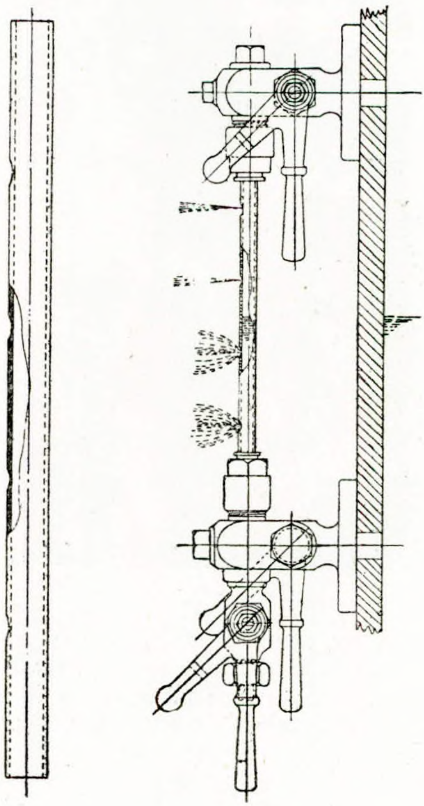
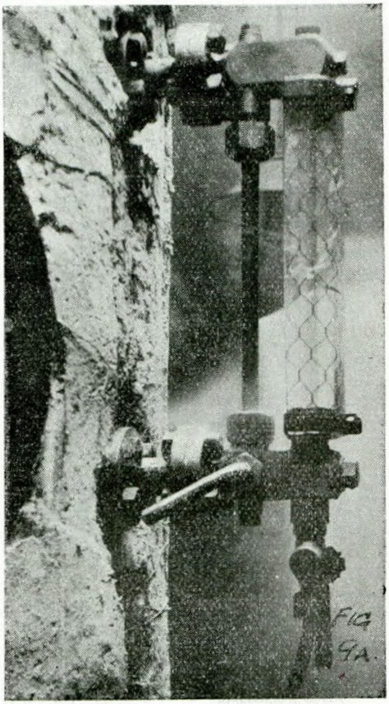


FIG. 9.

inch or two according to the pitch of the holes, and the gauge can then be shut off again. Representatives of the Admiralty, Board of Trade and Lloyd's have seen and approved the fitting, and it is being adopted in mercantile work. The inventor, of course, benefits accordingly.



10. The facing by hand of sea-valve packing rings on the ship's skin is a long and laborious process, involving chipping, filing and scraping to a surface plate, often in a very inaccessible position. The simple grinding apparatus devised by a ship fitter, and shown in Fig. 10, makes a superior job in a fraction of the time previously taken.

11. Under-water shell plating is countersunk on the outside, and the rivets should just fill the countersinks and no more. The shipyard labourer who countersinks the holes operates at

the end of a long spring-mounted lever and cannot conveniently see what depth he is cutting. To ensure the countersinks being of uniform depth his foreman made the simple attachment (shown in Fig. 11). All that the man has to do now is to weigh

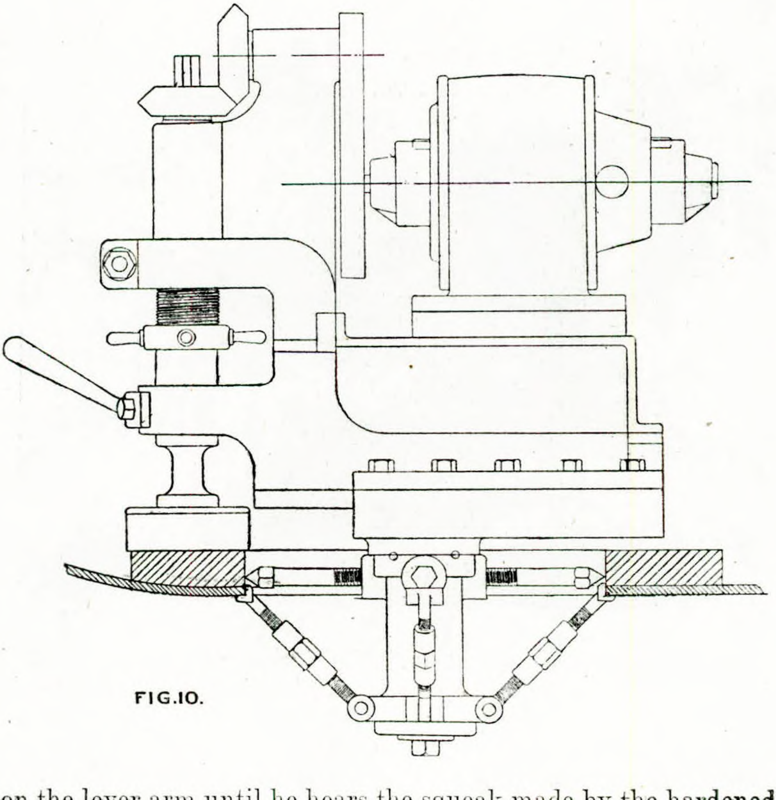
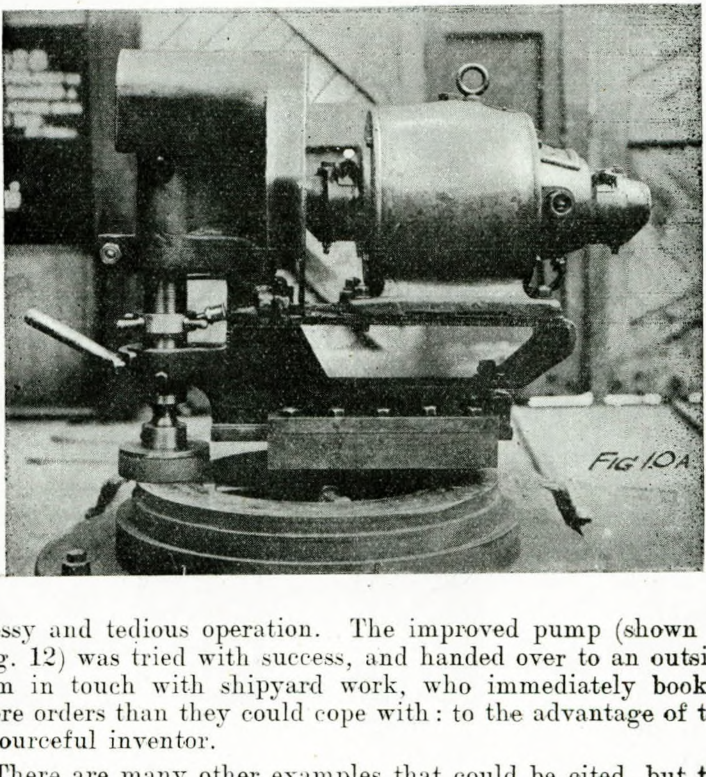


FIG.10.

on the lever arm until he hears the squeak made by the hardened steel ball on the surface of the plate, when he changes over confidently to the next hole. The perfect condition of the first ship's bottom after the introduction of this little innovation was sufficient justification for an award to the inventor, and the device is now being marketed.

12. The injection of liquid red-lead between the laps of plating is an essential process in ship-building, but the old-fashioned injector is a crude piece of apparatus consisting as it

does of a piece of heavy tubing with a screwed nozzle at one end and a screwed gland at the other through which a screwed spindle operates the piston or plunger. To re-charge the pump the screwed gland is slacked back, the plunger withdrawn and the spindle screwed back to its starting point—altogether a



messy and tedious operation. The improved pump (shown in Fig. 12) was tried with success, and handed over to an outside firm in touch with shipyard work, who immediately booked more orders than they could cope with: to the advantage of the resourceful inventor.

There are many other examples that could be cited, but the dozen that have been selected will perhaps serve to show the unbounded scope that exists for such practical improvements in a typical marine engineering establishment. Sometimes, of course, one has suggestions brought forward that are manifestly impracticable or valueless, and in such cases considerable tact and patience has to be exercised so as not to discourage the would-be inventor, and above all to dispel any suspicion of favouritism. But the practical worker is generally amenable to reason, which is more than can be said for certain amateur inventors who sometimes manage to invade one's sanctum, and waste valuable time by describing some visionary scheme that is going to revolutionise the engineering world. The scheme of co-operation, however, that is outlined in this paper has the merit of inducing and inspiring that confidence between employer and employee which is one of the first essentials of real

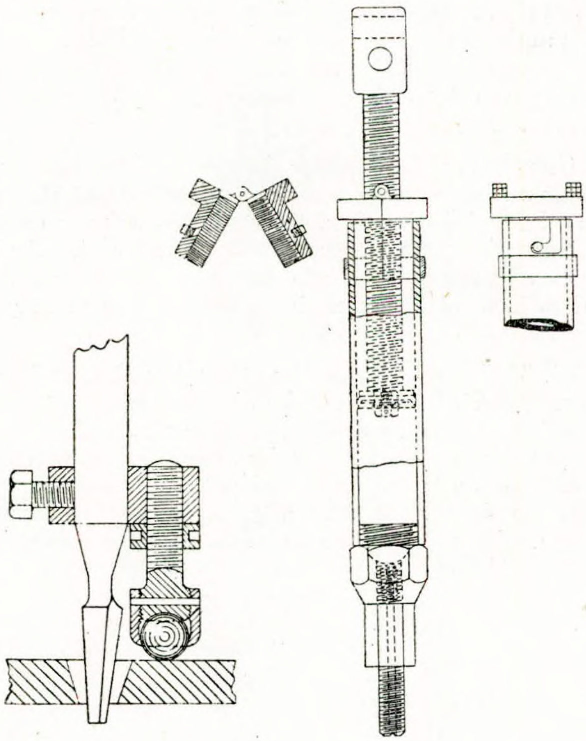


FIG. 11. FIG 12.

progress. It is a hopeful sign of the times; and that the principle is spreading is evidenced by the number of patents that are constantly being published under the names of prominent firms coupled with the name of "John Smith," or some otherwise obscure individual whom you may be sure is an employee of the firm.

ENCOURAGEMENT OF INVENTION IN WORKSHOP PRACTICE.

The author was somewhat at a loss for a suitable subject when he consented to prepare a paper for this meeting, but when, in conversation with your distinguished president, he suggested its title, Lord Weir at once agreed that the subject was full of interesting possibilities.

The possibilities have not been exhausted by any means, but it is hoped that as far as it has gone the paper has been of general interest; and, on the principle of "that reminds me," no doubt members present will be able and willing to supplement the examples given by apt quotations from their own varied experiences.

The CHAIRMAN: The paper just read illustrates what has been done towards advancement in methods of doing certain work, and I think that Mr. Gibson's paper may convey to us something which we were previously unaware of. As he states, the paper will remind you of other improvements and we shall be glad to have other examples, especially from our sea-going members.

Mr. W. McLAREN: I saw the other day at a works a suggestion box. I don't know what the ultimate result of this will be, but there is a certain amount of suspicion attaching to a suggestion box on the part of the individual who might take advantage of it. There is always the question "What do you consider is a reasonable value?" If we suggest some extravagant condition it is a difficult position to be in both for the receiver and the giver. The giver believes he has got Utopia in his mind and can't get rid of it and does not believe his next-door neighbour can see through a brick wall as he does. I had one experience once when I was sent to see an arrangement and consider its merits. It was perpetual motion. I asked the inventor "How are you going to get over the shock?" He could not get over the question when it was pointed out that it involved perpetual motion. Coming back to the workshop, there is no doubt that in the older days the crude tools we had to work with have been the means of development. We may take the cycle for example. Repetition work was the order of the day. That caused improvement in the various types of machinery. There is still improvement to be made, but where is the line to be drawn as to what is fair remuneration for invention? What we would like to see is continuity of employment if you have done anything good.

Mr. F. O. Beckett: With regard to this water gauge I remember having a lot of trouble in the Red Sea, and the suggestion I made then to overcome the difficulty was to have three short gauges. The risk is very much reduced of the glass breaking than where you have a long glass, but I could never get anyone to take that up. I notice the remark that some people get discouraged and I regret to say that as a boy during the Inventions Exhibition I was very much discouraged in this way. We had a strike of coal miners and my thoughts were of applying a machine for coal cutting, and I was downed at once for making the suggestion. That of course was workshop practice; but the idea eventually has gone on. My thought was of a sprocket wheel and chain (endless) to cut coal. My idea was crippled in the bud. Other things I have burned the midnight oil over, but I could never get anyone to take them up, and since then I have not troubled myself.

With regard to this locking apparatus for locknuts we have had that for many years for pistons. With regard to this filter you speak of, is it made of brass?

Mr. Gibson: No, it is all steel.

Mr. McLaren: A man who has been able to produce some useful thing by the exercise of his brains should feel that he will get some recompense. We have a family of members connected with this Institute who tried that plan of reward some years ago. That is the Denny family. Some of their awards for suggestions went up the scale to about £10. That is where the difficulty is, to fix an amount. There was a man belonging to Bristol who fitted up one of the finest machines that is now being copied abroad. That is the packing machine. The man was a conscientious fitter, a good worker and a fast worker, and if that man had been encouraged we should have been heading the world in the manufacture of packing machines. That man died very poor.

Mr. J. B. Hall: I am afraid it is not given to all of us to make these natty little inventions, but harking more towards the side that Mr. McLaren touched in opening the discussion, I don't quite agree that, supposing some person has achieved an invention, that that should mean continuity of employment as payment; that is rather looking at payment from the serfdom side of view. If a man's brain has evolved some invention that makes for success surely that man should receive some definite payment for it, so that he can please himself whether he stayed on or went further afield, not that he should be bound hand and foot. When a man has invented something it is undoubtedly a great source of trouble to find out what actual payment should be made to the inventor, for when there are two persons to a contract it rarely turns out that both sides are satisfied. In most cases it is the inventor who feels that he has not received that which he considers his due. No doubt many of those small "make-shift" inventions which we have all at some time experienced have been useful for the moment, and have not been carried further. We all know that when we are in a difficulty we devise some method to get over the trouble, but we never think of it as a thing to be patented. We do something for the moment and it is probably a success, thus with the Marine Engineer the great majority of these "make-shifts" have been lost and never thought as worthy of a patent.

Mr. W. McLaren: The law, I believe, stands to-day that whatever a workman creates during his working time belongs to his master.

Mr. George Adams: This paper no doubt brings back to members of the Institute many memories happy and otherwise. If we were given a sheet of foolscap and an hour or two we might put in many of those little gadgets which men, put in a difficult position and working under disadvantages, have brought forward to relieve perhaps the monotony of their labour and also to produce far better work. Mr. Gibson has mentioned Lord Weir as having suggested the title of his paper. I know of no firm with a better record for remunerating employees for introducing workshop improvements. I know of many things workmen have devised in the way of improvement for turning out work and put before the firm, many of which have been patented, while all have been remunerated. I know another place on the Tyne where suggested improvements have been amply remunerated, and the introducers of many of these little contrivances should be encouraged and promoted. Of course a man can go elsewhere and carry his plans with him, but as the conditions are considered both from a financial and working point of view he generally decides to remain where he is. In all classes of engineering to-day you see many of these little side-shows and improvements that are made by the introduction of small units. Take the instance of the turret lathe or take the building of the marine engine and see what improvements have been introduced. All these improvements have crept in simply from ideas of workmen and foremen who have put them before their firms, and thus they have come into general use. Then again in boiler making, where, for example, the back shell plate and back end plate are hydraulically riveted, it was done from the device of a man employed by a firm at whose works I first saw it. That was a very valuable introduction to the firm who remunerated him exceedingly well and it gave encouragement. With regard to condensers: the simple contrivance to-day for packing tube ends, compared with what it used to be by cotton washers. There is now the fibre ferrule. There is yet another contrivance, and that is putting in a short sleeve of cotton packing which will fill up the space when pressed. If we consider the turbine, many rapid improvements have come into being. Take the rotor blading of turbines. It used to be the common practice to pare out the grooves and put in one blade and one stop and work round one by one. To-day we see quite a different method employed. There are many other things. The clever contrivance for cutting milling tools may be cited. The introduction of electricity into engineering has brought about many ways by which improvements can be carried out, for example, welding by the electric and acetylene processes. We see how many changes and improvements which are practically workshop practices, that the subject of the paper is well illustrated in our experience.

Mr. J. Thom: It appears to-day there are workshops and masters who deal more kindly with those who bring improvements before them than the old fogeys were accustomed to in years gone by. As business stands to-day with masters and men there is still room for improvement, and if it is possible to bring them closer together it would be better for both their interests. There is no doubt that work could be carried out much more satisfactorily and with greater speed than now if workmen and masters were more of a mind. It is nearly impossible to speak of improvements without returns—that is, the improver getting some return in the shape of money. You, Mr. Gibson, have shown how this can be arranged and how easily it has been done, and it is very much to the credit of the engineering world that such is the case. This not only applies in marine engineering work, but in all classes of work, no matter whether it is engineering or anything else. There are always possibilities of improvements, and when one speaks of improvements it means that what was done before can be done in less time and at less expense than before. If not, it is not an improvement. A patent must be an improvement in the quality of the work produced, and it must be at less cost or it is not a patent. Many marine engineers at sea have had this kind of work to do many times, and the farther back you go the more there was to do because machines were not so perfect nor boilers so satisfactory as at the present day, and there were more possibilities of difficulties happening on voyages, and also the chance for the engineer to show how the difficulty could be surmounted by improvements.

The CHAIRMAN: Mr. Adams made reference to condenser tubes and packing, it would be interesting to know what is his experience as to the efficiency of the style of packing referred to and if the tubes were satisfactory after a fair service.

Mr. GEORGE ADAMS: I have tried thousands of ferrules and in each case it was an easy fit in the tube and easy in the stuffing box, when screwed up fairly tight; the condenser was then filled up inside to test the ferrules. I had a case to-day of opening out a condenser which had been going for seven or eight years, packed in a similar way. We had occasion to renew some tubes—nothing to do with packing—we took out the fibre ferrules from the tubes which had been giving trouble. Of course it is up to the engineer to bear in mind he has got these fibre rings in his condenser and always have water in while under steam. Generally speaking our experience has been a satisfactory one.

The CHAIRMAN: You have not found that these rings collapse the tube at all?

Mr. ADAMS: No; I have never found any collapse of the tubes.

The CHAIRMAN: How much larger do you make the diameter than the inside of the tube?

Mr. ADAMS: It is an easy fit on the tube.

Mr. W. S. PARSONS: When a young man enters the engineering world, who has no large sum of money at his command, he has two ways of being a success. The one by diligence and hard work he may obtain to some good salaried position. The other by invention he may become well off or perhaps even wealthy. The latter, of course, offers by far the greater possibilities, but unfortunately the gift of useful invention is not the heritage of every engineer; unhappily it is the exception rather than the rule to find the engineer and useful inventor combined in the one man.

diminishing the amount of labour employed. Moulton, he said, was paid 11d. an hour, which was the usual rate for carpenters.

Mr. R. Young, M.P., asked if that were the usual way of dealing with a man of inventive ability.

Witness said it was the usual commercial practice.

Mr. Trevor Watson, for the Treasury, contended that the work did not call for any high degree of inventive skill. He submitted that there was no case for an award, but if the Commission thought this was a case were a small award might be given by way of recognition of useful work the Department would accede to it.

Mr. Justice Sargant (chairman) said the Commission would consider its decision.

Mr. Parsons: We cannot always blame private firms. There are occasions when Governments can be censured over that kind of thing.

Several Members.—The case, if quoted correctly, is a very bad example of no reward being given to the deserving.

Mr. Beckett: There is one thing in London that has annoyed me very much, and that is to see workmen belonging to the telephone department or other electrical places putting two ends of wires together. I should have thought it would have been possible to devise an instrument to do the work in a fraction of the time at present occupied over the job.

Mr. A. H. Mather: The difficulty it seems to me is where to draw the line between what is done in the ordinary course of the work of an individual and anything of an extra nature by which his firm in particular and engineering in general benefits. Mr. Adams referred to the various operations in connection with the construction of turbines, and that is a case in point. Adjustments had to be made in connection with turbine work that were very delicate in every direction, and in order to carry that work out successfully and get the adjustments as exact as they were required certain pieces of apparatus had to be designed. They have been designed in the ordinary course of working, and as such evidently come within the regular work of the staff. Could it be held that pieces of apparatus of that kind were the subject of special consideration for the men who actually designed them or would a case of that kind come

The inventions which Mr. Hamilton Gibson has shown us are of course typical of what one would expect. There is nothing epoch making in either or any of them, neither could any wide genic claim be made when protecting by patent. One would regard them to a great extent as the useful fruits of necessity. For example, none of the inventions considered require any real scientific knowledge such as the production of the wireless telegraph and telephone.

I feel that we must express great thanks to Mr. Hamilton Gibson for having brought forward the subject matter of his paper, and he has done the engineering trades a great service. In fact it is not confined to the engineering trades, but rather applies to all businesses where machinery is in general use.

It seems to me a great deal turns on what rewards the inventor will have. It is difficult to devise a scheme by which a man will get a real reward in proportion to the value of his invention. It may be but a small improvement and only worth a small consideration, or it may be a very valuable thing and therefore worth a big consideration. It is one of those things which causes serious friction between employers and employed; but there is no doubt it could be developed and bring about much better relations between master and man than have obtained in the past. There was a report in the newspapers last night bearing on the subject which I will hand up to the Chairman to deal with.

The CHAIRMAN (reading):—

WORKMAN INVENTOR.

PAID 11D. AN HOUR: DEVISED SHELL FILLING MACHINES.

A workman's designs for cordite-filling machines were discussed by the Inventions' Commission sitting at Westminister to-day.

Mr. A. G. Watkins, who was general manager of the Gloucester National Filling Factory, said that Mr. Moulton, the workman in question, was selected from a number of foremen, and put in charge of the making of labour-saving devices. While doing this work he designed two machines for filling 60lb. cordite charges and 8in. high velocity cordite charges. These machines did the work for which they were designed, and had the effect of within a man's ordinary employment? That occurs to me as one of the difficulties in the way of deciding what recompense an individual should receive.

Mr. G. T. Gillespy: While it is certainly right that remuneration should be given for improvements suggested by workmen and adopted by the management, there are classes of work where this is hardly possible as, for instance, in a shop engaged on press-tool work, die forging, etc., in which ingenuity must be exercised on nearly every new job that comes in, and designs of dies and methods of procedure decided on by the combined work of fitter, foreman, draughtsman, and manager.

I remember a worthy man in the machine shop who had a grievance which he aired at every opportunity. He alleged that he had not been remunerated for designing and producing a tool for forming oil grooves on the guides of a marine engine which was adopted by the management for use in all cases. The particular form of groove was found to be a good one for obtaining a uniform distribution of oil on the crosshead shoe, and if his statement was correct a reasonable reward would have been well earned in this particular case.

Mr. Gillespy also described a clever device designed by a foreman for applying a belt drive to a rose-bit used for finishing the holes for coupling bolts in a triple expansion engine crankshaft.

Mr. H. Neville: One point has occurred to me in regard to the class of men from whom had come those suggestions which were described in the paper. It appeared from the references that foremen, charge hands, and draughtsmen were responsible for the majority of the improvements, and that the men who did the actual work and used the tools provided for them in the ordinary way were quite content to leave matters as they were. I would therefore ask the author to kindly give his experience on this point.

In these days when employers have complained that it is difficult to get their workmen to do anything more than they are actually obliged, there should be considerable value in the scheme of payment described, if it meant that increased output was the result. Of course trades union rules might prevent this extra payment, but so far as the speaker knows there are no such rules in force at present.

I have also found that once a man has made suggestions, had them adopted, and received payment for them, there followed other suggestions from fellow workmen; whereas if no notice were taken of suggestions then little thought was given to improving existing appliances or methods.

Mr. PARSONS: Invention is not very well understood in workshops. If you go to some workshops you will find that the men have never heard of the Patent Acts. If some means could be found to teach the workpeople what is patentable and what is not patentable it would be of advantage.

Mr. G. T. GILLESPY: It is not generally appreciated that under present Patent Law, provisional specifications are not published if the patent is not carried further by the inventor, and he may again take out a patent for the invention at a later period if he so desires. We have been patenting inventions in this country for two or three hundred years, and therefore it is necessary to determine the novelty or otherwise of an invention before spending time and money on a patent. The Patent Office make a search, but it is not always conclusive, and an inventor should make a search himself or employ a patent agent to do so. Many instances of the same thing being patented over and over again will be found in the Patent Office records.

The CHAIRMAN: Mr. Gibson states that justice should be done to the draughtsman and designer. I agree. They have a very responsible position, and success or failure of ships and their machinery depends largely upon their ability. They have to be always inventing or developing improvements, and their work has largely made shipping, both Naval and Mercantile, what it is, and I venture the opinion they should be paid by results.

There are few Marine Engineers who are not inventors at some time in their lives, although they might not be patentees. It is part of their life to overcome troubles, and the present position of shipping has been gained by the work of thousands of engineers towards the general advancement. This Institute is a link between the different interests and through this Institute is exchanged information for the benefit of all.

The author mentions a machine for polishing condenser tubes for inspection. I take it he means Government inspection. I am not aware of any inspection of condenser tubes for Mercantile ships, neither do I think it is necessary, for the only test necessary, apart from composition of material if wanted, is a hydraulic test, and I think I am correct in stating this is the usual commercial practice. I agree that test cocks are unsatisfactory fittings and the metal tube described appears to me to be superior. I presume that the Board of Trade would allow valves to be used in connection with this tube and if so this would also be an improvement. Mr. Adams mentioned having used fibre ferrules as packing for condensers with good results. Recently I saw a condenser which had been packed with fibre ferrules and the expansion of the ferrule had been so great after immersion in water that the tube was squeezed in. Probably the ferrule when fitted was too tight on the tube, but personally I prefer cotton packing.

As you are aware the usual method of replacing a propeller shaft is to remove the tunnel plate and put the new shaft in via the hold. During the war a twin-screw vessel was drydocked with cargo in the hold, and it was found that a new propeller shaft was required. It therefore became necessary to find some other than the usual method for the new shaft to go in (which fact proves that necessity is the mother of invention) so a hole was cut in the side of ship in way of tunnel and the old shaft was pushed out into the drydock and the new shaft was passed in through the hole into the tunnel; after the work was finished the hole was plated up and is there for future use.

Another departure from the usual way of doing things, which if described may help some Chief Engineer in an emergency, was the repair done to replace a stern tube nut which had been rendered useless by a rope having been wound round the propeller. The remaining thread was chipped off and a short stuffing box and gland was fitted so that the box was jointed to the stern frame and two turns of rubber were fitted in the gland. This box took the place of the stern tube nut, and it was never found necessary to remove it, and of course the cost of removing the stern tube to have a new thread cut on it was saved.

Mr. Gibson is well qualified to write a paper on Geared Turbines, and this is a new development that we are all interested in at the present time, and I hope he will find time in the future to contribute a paper on this subject to the Institute.

Mr. Hamilton Gibson: I am very glad that the subject of my paper has aroused such keen discussion. I expected, of course, that the mere association of ideas would lead members present to draw upon their own experiences. We are sorry to observe that some of the speakers have met with disappointment and discouragement in their efforts to introduce improvements, but they are only in the position of Kipling's hero McAndrew, whom you will remember was so disappointed at the reception accorded his differential valve gear that he "burnt the working plans last voyage." What we have to remember, however, is that an improvement is not necessarily patentable but that a patent must always be an improvement. A good many of us are quite capable of making improvements, in fact our whole lives are devoted to that object, but it is not everyone who has the "vision" that enables him to look ahead and see what possibilities there might be in such an improvement. I think, however, that times are better now than in the past and that the tendency is to encourage invention rather than to discourage it. As regards rewards, I think that on the whole the royalty system such as I have described is the fairest. In most cases men would far sooner stand or fall by their inventions than take a lump sum. Many workmen are inclined to be suspicious—you must treat them with the utmost patience and tact if you are to get their confidence. Practical workmen do generally bring forward practicable and workable ideas, and they should be given the same attention and patience as a staff man or a foreman—in fact, rather more so. The difficulty is to assess the value of an invention or improvement—is it worth £5 or £50? No one can tell in the early stages. If you are satisfied that the improvement introduced into your workshop is actually saving time and money you can generally afford to give a man £5 or £10 to be going on with, and if afterwards it is found to be patentable you can arrange to pay him a certain percentage of the royalties.

I have seen suggestion boxes in operation and agree that workmen generally are not favourably disposed towards them. They drop their ideas through a slot and are not quite sure what happens; it is much better, in my opinion, to meet the individual face to face and go into each matter on its merits. The instances given in my paper are mere examples and could be multiplied indefinitely. I wished, however, to emphasise the importance of the human element in engineering and to indicate how relations between employer and employed can be improved if we go the right way about it.

Taking the questions that have been raised seriatim, I note that your Chairman would have preferred a paper on turbines, but really I think that that subject has been rather overdone lately and decided to strike out on a new line.

Mr. Fielden, however, is good enough to suggest that at some future time a paper on Geared Turbines would be acceptable to the Institute, and I will keep this in mind. With regard to the polishing of condenser tubes for inspection, it was, of course, Government inspection that I alluded to. The Admiralty were driven to a very rigid inspection of condenser tubes in view of the universal adoption of water-tube boilers in the Navy, and it can be readily understood that with something like a quarter of a million horse-power going through the engine shop at any one time the inspection and manipulation of condenser tubes became a very serious item. The machine described (No. 4) left a dull polish on the outer surface of the tube which showed up any flaw or lamination at once, and such tubes were of course immediately rejected and not subjected to further tests and inspections such as internal polishing, hydraulic tests, drop tests, etc. The reference to the ends of condenser tubes collapsing due to pressure of the packing reminds me of a very interesting experience. We had some tubes which collapsed slightly as described. The internal diameter of the tube was restored by driving in a drift when it was found that the "cold work" thus done on the tube had locally hardened the metal and enabled it to stand up satisfactorily against the collapsing pressure. This suggested a small roller attachment something like the expander used in boiler tubing, but with the rollers disposed outside the tube, and a plug was made to fit the bore at the ends of the tube. The effect was to locally harden the tube ends, and it enabled the Admiralty to use a quantity of soft condenser tubes which had been imported from abroad during the war. Mr. Fielden's description of the ingenious method adopted to replace a propeller shaft through the side of the ship instead of by the usual method through the hold, reminds me of a somewhat similar experience that occurred some years ago. We had a channel-steamer in dry dock which required some extensive repairs to the bottoms of the large double boilers; there was no room to work between the bottom of the boiler and the skin of the ship, and to have lifted the boilers would have involved an enormous expense in the clearing away of saloons, etc. By removing several of the ship's plates, however, the boilers were satisfactorily repaired and tested.

As the Chairman truly remarked, Marine Engineers are forced at some time or other to be inventors, and it is their life's work to tackle and surmount such problems as are here described.

I must thank Mr. McLaren not only for operating the lantern but for leading off in the discussion. I think I have dealt with one or two of his points in the preceding general remarks. I cannot say that I agree that it would be a wise thing to promise continuity of employment as a reward for bringing forward improvements. As one of the latter speakers, Mr. Hall, hinted, and I think rightly, the idea smacks rather of serfdom and tends to undermine that independence of character which we so much admire in the British working man. If an improvement is worth anything the man bringing it forward should be able to feel that he is deriving benefit directly and immediately.

Mr. Beckett considers that the small facing machine for sea valve rings (Fig. No. 10) might be adapted for the facing of water-tight door frames, and I see no reason why this should not be done. It would require, however, some other means for setting up on the bulkhead unless the door frame were small enough to come within the ambit of the circular sweep of the machine as shown. With regard to his system of having three short water gauges set one above another, I am afraid that the objection would be raised that we were multiplying instead of reducing the number of fittings. One advantage of eliminating test cocks is that we reduce the number of holes in the boiler shell.

Mr. Adams very truly points out that no useful purpose is served by inventing merely for the sake of inventing, and with that we must all agree. It is also important, as he says, that the problem that we are trying to solve must first be stated generally. We will find that the mere statement of a problem, if it can be stated clearly, goes a long way towards providing the solution. It is also of paramount importance that the improvement or invention should "make good." Frequently what appears to be a brilliant invention turns out to be a dud in practice. The reference to extruded turbine blading is a case in point. This certainly promised well but results were so disappointing that this type of blading is not likely to survive.

The newspaper paragraph referred to by Mr. Parsons shows a disgraceful state of affairs, but, of course, one would like to know all the circumstances before passing judgment.

In reply to Mr. Neville I can assure him that in all the cases that have come under my notice the workmen, including labourers and apprentices, receive equal attention if they have anything at all that they wish to bring forward. Of course some men are modest and retiring, and others too much inclined to push themselves forward, but as I said in my above remarks this can be got over quite well if one uses tact and patience and sympathy in dealing with all such matters.

I am very pleased indeed to have had this my first opportunity of visiting the Institute and making the acquaintance of so many fellow members.

A hearty vote of thanks was accorded to Mr. Gibson for his paper and coming so far to read it himself and adding to his interest.

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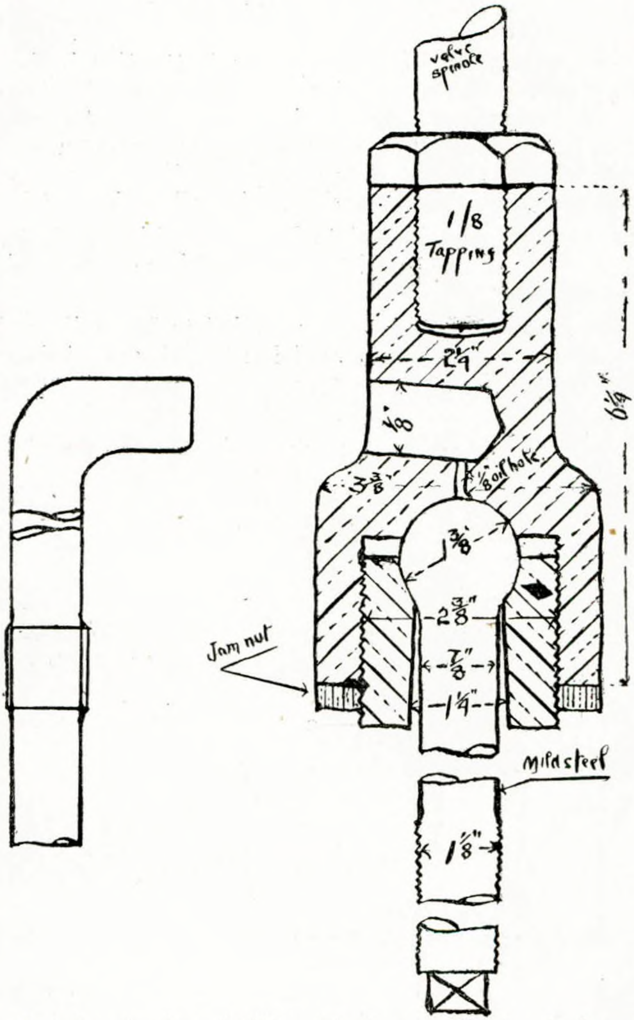
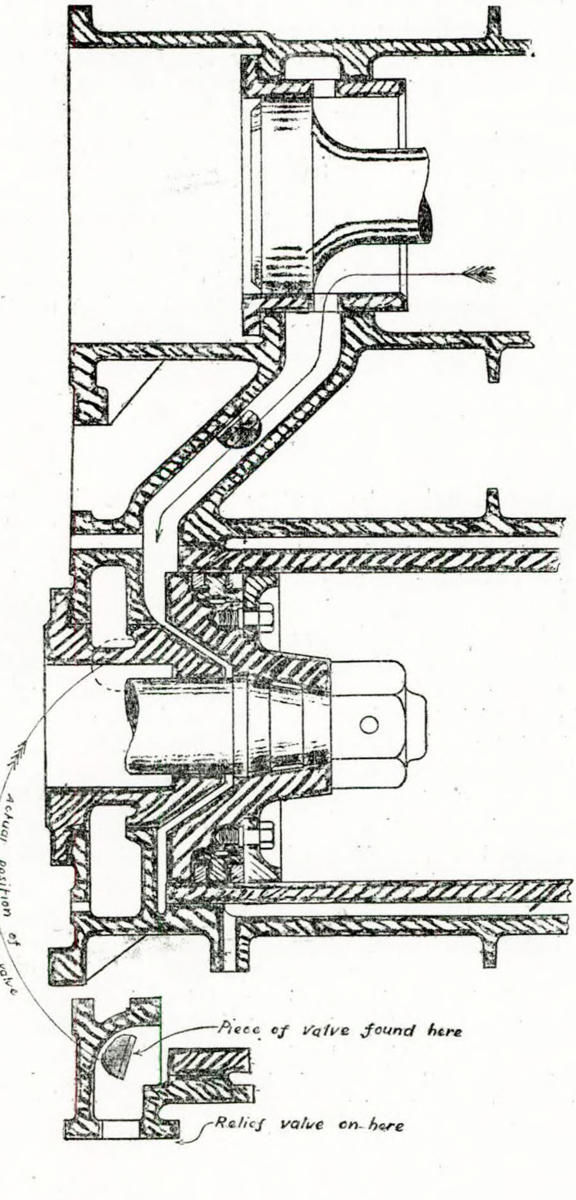


The sketch reproduced (Fig. A) shows a device designed and fitted by one of our members, Mr. Joseph C. Phillips, to the Weir pumps in the steamer of which he was chief engineer. He points out that it consists of a ball joint and cup, and was fitted in place of the well-known knuckle joint found in this class of pump which had become somewhat slack. It is simple in construction, and is thus less costly in construction, being more readily made when circumstances demand the easiest method of renewal. It will last probably the lifetime of the pump, as it is capable of readjustment.

The engine stop valve of the Union S.S Co. of New Zealand's S.S. *Maunganui*, was found, while the engines were being overhauled in port, to be fractured, and the missing parts could



not be located within the limits of the chest. The piston and rod were accordingly drawn from the cylinder for further search, and the missing piece was found in the recess formed in the bottom of the cylinder casting for the relief valve, as shown in the illustration (Fig. B) showing the cylinders and ports in section. The incident is a most unique one, as it appears from the circumstances that the fractured piece passed from the stop valve through the casing and cylinder ports to its final resting place during one revolution of the engines—90 revs. per minute —without fouling the valve or piston. The drawing, accompanied by a letter, was received from another of our members, Mr. W. Smart, Supt. Engr., U.S.S. Co., of New Zealand. This is not a case of an invention to improve on working conditions by means of the human faculty, but of the broken material itself acting to avoid a worse calamity.

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Notes.

ONE of our members has sent us from China the January issue of Millard's Review of the Far East containing special references to Sir John Gordon, the retiring British Ambassador at the Court of China. Many members who know the ports of China and the average Chinaman will be interested to read the testimonies of some in the upper circle of Chinese life regarding the Ambassador, to show their views and sentiments, while to those who knew China to some extent 40 years ago and were acquainted with the views then prevailing, the testimonies are of special interest. The following quotations from a few of the many letters show the helpful hand which may be exercised by a wise representative at a foreign Court to general advantage, and those whose duties have brought them into contact with the hand workers of China will realise all the more readily the importance attaching to the views expressed by the brain workers:—

Marshal Tuan Chi-Jui, former Prime Minister, expressed his views thus: "Sir John Gordon has been in our country for over 40 years. Being a diplomatic official he has numerous friends throughout the length and breath of China. Though a man of firmness and resolution, he is frank and simple, sympathetic and easily accessible. He is honoured and loved by all who come in contact with him. This accounts for the increasing prestige of the British Empire, for which he has won the admiration of the Chinese people. . . . . Now Sir John is about to return to his own country. I sincerely hope that after his return he will further show his friendliness in helping the solution of Tibetan affairs in order to fulfil the hope of our people and to enhance the friendliness and goodwill of the two nations. Being a friend of Sir John I am earnestly looking forward to the time when he will visit China again, and then I will lead the country in tendering to him our most hearty welcome. That will prove even a greater time in the capital than the time when the monument was erected in memory of the triumph of right over might. On the eve of his departure, instead of mere words, I tender my best wishes."

The former Grand Councillor, Na Tung (Manchu Dynasty) states " of all the foreign ministers in China Sir John is the one I know best. I first made his acquaintance in Tsungli Yamen days. Since then we have always been on the most intimate terms. In the year when Sir John was appointed British Minister to China I was Grand Secretary and had many official dealings with him, although they became less when I undertook the duties of Inspector-General of Troops, Junior Guardian of the Heir Apparent, Grand Councillor, and Acting Viceroy of Chihli. Our personal relationship, however, remained as warm in my later career as before. In official matters Sir John advanced the strongest possible arguments in favour of Great Britain. I may add that I did the same in favour of China. We argued and discussed. My experience was that we could always arrive at a settlement. Sir John is a fair-minded man, and a solution of a problem is always possible with a fair-minded man. His sense of justice enhanced my high opinion of him and ever increased my admiration."

Dr. Wang Chung-Lui, former Minister of Justice and now President of the Law Codification Commission, states: " My relation with Sir John has been that of a friend. We have met on the broader platform of common human interests rather than on the narrower basis of official intercourse. This gives me a unique opportunity of knowing the man behind the diplomat, and because I have learned to respect the man I am better able to appreciate the diplomat. . . . . Many have spoken as if it were the first duty of a diplomat to obtain as many concessions as possible from the country to which he is accredited, forgetting that momentary, possibly ill-gotten gains, at the expense of one country cannot but re-act in the long run to the lasting detriment of the other. This I conceive to be a grave error. At least so far as my own country is concerned I am convinced that the interests of China and of any other country are in many respects identical. This may be graphically represented by two intersecting circles, the overlapping segments of which stand for the interests common to both countries. It is here that the true diplomat finds a field for a full display of his abilities. In proportion as he is able to bring the two centres nearer, the more embracing will the common segments become. In this Sir John has signally succeeded. He has brought closer together the people of China, the centre of Chinese interests, and the people of Great Britain, the centre of British interests, to the great advantage of both. He has not been an idle spectator, but an active participator in the colossal changes which have taken place in the Far East since he first set foot on the shores of China, 43 years ago. He has seen the passing of the old time mandarin, whose knowledge of the world did not extend beyond the confines of the Celestial Empire; he has seen the gradual opening of China to foreign intercourse; he has seen the rapid development of Western education in place of the former one-sided concentration of Chinese literature. All these innovations profited by his keen sympathy, and whenever possible he has thrown his weight on the side of progress. The suppression of the importation of Indian opium, the encouragement given to railway construction, as well as the immense growth of British trade in the Far East, stand to his credit. Sir John Gordon will leave China followed by the best wishes of all who know him. His intimate knowledge of Chinese affairs, his ripe experience as a diplomat, and his clear comprehension of international politics will, we venture to hope, continue to exercise a beneficial influence on Great Britain's foreign policy. May he have many years of quiet and enjoyment in his well-earned retirement."

There are many other letters from Chinese gentlemen couched in similar terms of respect and appreciation.

The following paragraph appears in the same journal, which is published in Shanghai:—"According to a British expert, Targeh iron ore in Hupeh yields as high as 60 per cent. of pure iron, while the vein is so thick that even at the surface with an annual output of 1,000,000 tons it would be sufficient to last 100 years. The supply actually may be multiplied several times when deeper layers are surveyed. The Han-Yeh-Ping Iron Works at Hanyang and Tayeh produce over 160,000 tons of raw and 60,000 tons of steel per year, but in the future this output will be far surpassed."

The mining of coal may be also largely developed in China, as there appears room for it.

Boiler Explosions Act.—An inquiry was held into the circumstances which led to a steam trawler being abandoned for a time and eventually towed into port; the case indicated the risk attached to the wear and tear of boiler doors and the necessary care required to avoid disaster from inaccurate joints. The boiler of the trawler was single ended 10ft. 6ins. dia. by 9ft. long with two plain furnaces 2ft. 11ins. dia., thickness 11/16th in., w.p. 160 lbs. Two manhole doors were provided, one on the top and one between the furnaces. From the details which came to light at the inquiry the joint for the lower door was too tight on the spigot and when put in place the outer edge curled up, but it was thought apparently that when the door was tightened by the dog stay stud nuts it would right itself. The boiler was filled, and steam raised, meantime the door being tightened up. When the trawler left port a slight leak from the door joint was noted, which it was thought a further tightening up would cure. A hammer was used on the spanner in the tightening up, which apparently had the effect of lowering the door to the limit of the slackness of the spigot, with the result that the water and steam burst forth on the upper part and made the stokehold untenable. It was considered a grave risk to remain on board, as there were two drums of carbide of calcium in the engine room. The vessel was abandoned pro temp. after dealing with the fires as far as possible, and leaving the doors open. The trawler was afterwards towed into dock, and on examining the boiler, when cooled down, no damage was found to the furnaces or combustion chambers. The evidence pointed to the cause of the explosion as being due to the curled edge of the joint at the lower part of the door doubling over in the tightening up, making it uneven, the use of the hammer with the spanner then brought the door down and the upper part of the joint was split, leaving a passage for the water and steam.

The enquiry was conducted by Mr. Jas. P. Turnbull, Board of Trade Surveyor.

Another instance coming under the Act for inquiry may also be referred to, indicating the risk due to oil sediment deposit within the area of the heating surface. In this instance the vessel was fitted with three single-ended boilers 15ft. 6in. dia. × 11ft. 10in. in length, each having three corrugated furnaces, 3ft. 6in. dia. with separate combustion chambers, pressure 180 lbs. There was no donkey boiler. The port boiler, after being examined in April, 1919, was used during a voyage to Montreal and in port for auxiliary purposes till arrival in London on 5th July, 1919, when the fires were allowed to die out and the centre boiler was used in port. Ten days later the fires were again set away and when steam was ready this boiler was used as the auxiliary on the day before sailing from London on July 17th, when the steamer left at 3 a.m. with the gauge glasses showing nearly full up. At about 8 a.m. something went wrong with the port boiler, and the stokehold became filled with steam and dust. The Chief and Second Engineers then tried to reach the boiler tops, but the steam drove them back at each attempt, the safety valves were eased and the engines opened out to full speed; when the steam was reduced the vessel was anchored. It was then found that the port furnace had collapsed near the tube plate end and evidently the starboard chamber was leaking badly. It was resolved to return to London, where the boiler was carefully examined, when the wrapper plates of the centre and starboard chambers were found bulged, in addition to the port furnace damage. The demands on the steamer were such that time did not admit of the repairs being carried out then, and she sailed for Canada with the port boiler out of action. On her return a thorough investigation of the port boiler was made. The starboard and centre chamber wrapper plates were found to be bulged in from the top row of stays down a distance of about 2ft. 4in., the starboard chamber damage being the more severe. The flanges of the combustion chamber back plates were also set in. The starboard chamber plate had been forced over the stays, hence the serious leakage. The port furnace was pocketed about 9½ins., starting from the back corrugation and embracing four corrugations. The heating surfaces generally were found comparatively free from scale, with no sign of corrosion on plates or stays. Careful examination of the damaged wrapper plates showed distinct signs of overheating, these being most pronounced on the starboard chamber, and there was on the right side a thin deposit of a black powdery substance. The auxiliary check valve is fitted 15½ins. below the combustion chamber crown, on the back of the boiler between the centre and starboard chambers; no internal feed pipes are fitted, but the chest opening projects about 7ins. into the boiler with a closed end, and having four rectangular ports on the upper circumference through which the feed flows. An auxiliary condenser is fitted and the feed pump draws from it in port. It appeared from the position of the damaged plates relatively to the check valve that the feed water would be discharged so near that any greasy sediment would be deposited thereon, and the probability is that this is what happened and caused the damage. An analysis of the black deposit found on the plates confirmed this view. The deposit acting on the water side of the plates led to over-heating and brought about the collapse. The damage to the furnace was due to the sudden outlet for the water at the combustion chamber plates fractured at the stays, leading to shortage of water on the furnace crown. The inquiry was conducted by Mr. A. H. Longstaffe, Board of Trade Surveyor.

International Exhibition of Motor Boats, Marine and Stationary Engines.—This Exhibition, held at Olympia on March 12 to 20th, was a fitting corollary to the Shipping, Engineering and Machinery Exhibition held in the same building last autumn. After arrangements had been completed for visits by our members to the Exhibition, the time available admitted of short notice regarding the invitation extended by the management committee to forward names and addresses of those on our membership roll who desired to take advantage of the opportunity; however, over 150 invitations were issued.

The Exhibition was interesting and valuable in that internal combustion engines by different makers were on view and each style had its own special advantages indicated by those in charge. The catalogue of the exhibits did not include much descriptive matter beyond the list of details shown by each exhibiting firm, thus minimising its value for a reference study; the descriptive pamphlets at the stalls helped to make amends for the shortcomings to some extent.

The boat builders were well represented by samples of ships' boats and small motor craft for pleasure and commercial service. Fittings and accessories suitable for all kinds of sea, coastal or river service, including tools, cooking plant, cabin fittings and insulation materials through which no obnoxious insect life can pierce. The Main Hall only was occupied, and the view from the gallery was pleasing to the eye of the visitor.

An interesting lecture was given on March 17th by Dr. W. R. Ormandy, on The Liquid Fuel Problem. Beginning with the discovery of coal, he traced the progress of development in industrial work and the enterprise necessary by colliery owners to meet the growing needs; then the internal combustion engine entered upon the scene with the question as to where from and how the supply of oils and spirits could come to meet the growing needs of the world. Having foreseen the difficulty in answering the question, he had studied the subject for some years, advocating and recommending the Government to help in the solution by amending the regulations regarding the supply of alcohol, which could be distilled from otherwise waste vegetation, thus encouraging private enterprise to step in and build up for future needs. The recommendations had apparently been passed through a series of departments and nothing had been done; now the world at large is unable to meet the growing demands for oils and spirits required to keep land and sea transport moving onward. The enormous and increasing consumption in America of oils and spirits could not be met by American production from oil fields, and no doubt restrictions would be made when the position threatened to become acute. Meantime, it was urged that those engaged in transport work and the manufacture of motors and engines should move swiftly and strongly to urge that immediate steps be taken to provide the vital spirit necessary to keep the wheels of productive energy in motion.

J.A.

OFFICIAL NOTICE TO MEMBERS.

Remit from Annual Meeting to Council.

As a result of the discussion on the subject at the Annual Meeting on March 26th, the following Resolution was passed and remitted to the Council to deal with:—

"That the Entrance Fees, Annual and Life subscriptions of all grades of the membership of the Institute be increased by 50 per cent., excepting only the Graduate Section, which shall remain unchanged."

The Council at the meeting held on April 13th discussed the subject and endorsed the terms of the Resolution.

An Extraordinary General Meeting of members is herewith called for Friday, September 3rd, to ratify the resolution and for Tuesday, September 21st to confirm it, at 5.30 p.m. on each occasion.

Jas. Adamson,
Hon. Secretary.

It was also suggested at the Annual Meeting that in view of the financial requirements of the Institute, added to by the desirability of placing the balance of the revenue account on the credit side, those who were willing to do so might voluntarily give a donation for the current year as the Resolution will not take effect till next year.

———o———

Election of Members.

Members elected at a meeting of the Council held on March 9th 1920:—

Members.

Thomas Cansfield Alderson, *c/o* Eagle Oil Transport Co., Ltd., 16, Finsbury Circus, E.C.2.
Henry Andrew Stanhouse Anderson, Monte Bello Private Hotel, New Brighton, Cheshire.
Nicholas A. Anfilogoff, Lathol House, Thames Haven, Essex.
Norman Scott Beatty, Busch House, Isleworth, Middlesex.
Henry Baldwin Beer (Engr. Lt., R.N.), 24, Union Street, Birmingham.
Hy. Aldwell Braddock (Engr. Capt., R.A.F.), 174, Upper Brook Street, Manchester.
Charles Christian, "Lauriston," 3, Tanza Road, Hampstead, N.W.3.
Arthur Cornelius Denham, 1, High Street, Misley, Essex.
Herbert, Alexander Fleet, Tientsin, N. China.
Frank Fowling, 101, Lewisham High Road, S.E.14.
Malcolm Elliott Heasley, 35, Auckland Road, Ilford, E.
Kirk Arthur Jenkin, 49, Obelish Road, Woolston, Hants.
Robert Black Leadbetter, Eldon House, Wellington Street, Dunoon.
Richard Lowdon, 30, Milton Road, Lowestoft.
Harold Robinson McClelland, 286, St. James's Street, Montreal, Quebec.
Thomas Hugh McDermott, Ingress Abbey, Greenhithe, Kent.
James MacGregor, *c/o* Messrs. Crichton, Thompson & Co., Ltd., 17/19, Cockspur Street, W.
Donald MacKenzie, 141, Bath Street, Glasgow.
Henry Charles Matheson, 48, Alexandra Street, Canning Town, E.16.
Wm. Lynn Nelson, Cottage, Horseley Hill Road, S. Shields.

Edwin Fredk. Hylton Nicholson, 846, Romford Road, Manor Park, E.12.

Robert Oldershaw, 27, Lumsden Avenue, Southampton.

James V. O'Sullivan, 5, Knockrea Terrace, Blacknock Road, Cork.

Edward A. Prendiville, 68, Mersey Road, Rock Ferry, Cheshire

Donald Grant Fairley Ralston, 22, Hatherley Gardens, East Ham, E.

V. B. Ratsey, 4, Inner Temple, Dale Street, Liverpool.

Richard Incledon Rennell, The British Oxygen Co., Ltd., Elverton Street, Westminster, S.W.1.

James Henry Riley, 26, Bolton Road, Pendleton, Manchester.

Albert Edward Seaton, 32, Victoria Street, S.W.

William John Stone, 25, Hermon Hill, Snaresbrook, Essex.

Edward Alexr. Stanley Swinson, Crecora, Bloomfield, Belfast.

Joseph Pattison Thompson, 15, Adolphus Street West, Seaham Harbour.

W. Bernard Thompson, 52, Burnt Ash Hill, Lee, S.E.12.

Robert George Towns, 11, Lichfield Road, East Ham, E.6.

James Knowles Walker, 6, Howburn Place, Aberdeen.

Frank Welburn, Napier Engineering Co., Byculla, Bombay.

Frank White, 1, Primrose Villas, North Field, Hessle.

Alfred Ernest Whiteside, 133, Fernhead Road, Maida Vale, W.9.

Associate-Members.

Harold Roy Johnson, 5, Syndhurst Gardens, Kelvinside, Glasgow.

James Robert Scott, Messrs. R. & H. Green & Silley Weir, Blackwall.

Associates.

Edwin George Cleveland, 16, Elespeth Road, Wembley, Middlesex.

Herbert Harland Denton, 5, Waverley Road, Bournemouth.

Graduates.

Angus Macniven Campbell, 36, Muswell Avenue, Muswell Hill, N.10.

Hunter Robert Miller, 4, East Restabrigg Terrace, Leith.

Stanley Taylor, 200, Algernon Road, Ladywell, S.E.

Student-Graduate.

Leonard Nightingale, 6, Ingleby Road, Ilford, E.

Transfers:—

From Associate-Member to Member.

T. H. Ellis, 165, Great Dover Street, S.E.

William Webb, Engineers' Bungalow, Jacob Sassoon Mill, P.O. No. 12, Parel, Bombay.

John C. Thompson, Hawthorn Lodge, Dunstan, Gateshead-on-Tyne.

From Associate to Life-Member.

John R. Beveridge, Gordon Villa, Balmoral Avenue, Belfast.

From Associate to Member.

Joseph Vickers Hutton, 18, King's Terrace, Southsea, Hants.

A. H. Hydes, 70, Manor Road, Rugby.

From Graduate to Associate.

William J. L. Howard, Swan House, Clifton Rd., Darlington.

INSTITUTE OF MARINE ENGINEERS
INCORPORATED.

Patron: HIS MAJESTY THE KING.

SESSION 1920-21.

President: LORD WEIR OF EASTWOOD, P.C.

Hon. Treasurer: ALFRED ROBERTSON. *Hon. Secretary:* JAS. ADAMSON.

Members of Council.

Chairman: JAS. M. DEWAR. *Vice-Chairman:* G. J. WELLS.

G. C. BLAIR.
A. E. CRIGHTON
B. P. FIELDEN.
H. J. FLETCHER.
J. B. HARVEY.
JAMES KEITH.
WM. MCLAREN.
W. E. MCCONNELL.
H. RENNIE.
H. A. RUCK-KEENE.
A. E. SOWTER.
F. M. TIMPSON.

Conveners of Committees.

Awards—JAS. ADAMSON.
Finance—CHAIRMAN OF COUNCIL.
Issue of Transactions and Advertisements } F. M. TIMPSON.
Junior Section—G. J. WELLS.
Lectures on Internal Combustion Engines } JAS. ADAMSON.
Library and Reading Room—W. MCLAREN.
Papers { G. C. BLAIR, W. E. MCCONNELL.
Property—J. M. DEWAR.
Social Events—A. ROBERTSON.
"Titanic" Engineering Staff Memorial Fund—JAS. ADAMSON.

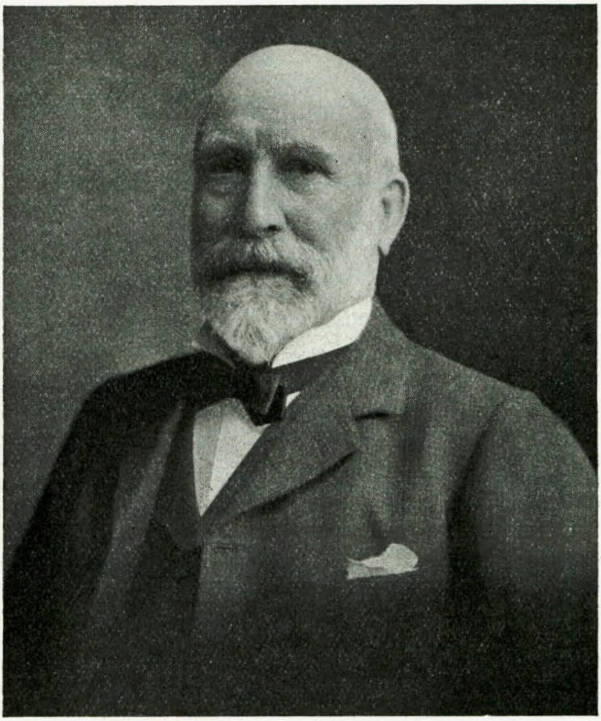
Representatives.

Advisory Committee, Board of Trade, JAS. SHANKS.
British Marine Engine and Boiler Design and Construction Standardization Committee—B. P. FIELDEN, J. MCLAREN, H. RENNIE, A. WALKER.
Institute of Metals, A. BOYLE.
Engineering Training Organisation,—JAS. ADAMSON.
Standardisation of Gearing—A. E. CRIGHTON.

Vice-Presidents:

GEORGE ADAMS (London).
CHEVALIER BELIARD (Belgium).
ALEXR. BOYLE (London).
R. J. BEVERIDGE (Belfast).
F. J. BLAKE (Southampton).
J. BROWN, C.B.E. (Glasgow).
W. V. BROWNE (Italy).
W. J. WILLETT-BRUCE, O.B.E. (Liverpool)
J. S. CAIRNS (Japan)
SIR G. J. CARTER, K.B.E. (Liverpool).
W. EARNSHAW (New Zealand).
MAJOR D. EVANS, D.S.O. (Queensland).
ENGR.-REAR-ADMIRAL G. W. HUDSON, R.N.
J. J. KEHOE (Sea Service).
SIR JAS. KEMNAL (London).
P. LANNES (France).
ROBT. LESLIE, O.B.E. (London).
J. S. MCGAVIN (China).
F. A. MURDOCH (Bombay).
SIR THOS. PUTNAM, J.P. (Darlington).
R. REID (Calcutta).
J. W. RICHARDSON (North East Coast).
J. R. RICHMOND, C.B.E. (Glasgow).
W. P. ROBERTSON (Sea Service).
G. M. SALMON (America).
JAS. SHANKS (London).
J. E. SPURGEON (Egypt).
R. E. THOMPSON (Australia).
R. WILLIAMSON, J.P., C.B.E. (Cardiff).
W. G. WINTERBURN (British Columbia).

Obituary Notices.



*JAMES WEIR.

The death, on July 10th, of the father of our President is recorded with deep sympathy and regret; he was known personally to many of our members and his personal qualities were appreciated by all.

James Weir was born in 1842, served his apprenticeship with the firm of Randolph and Elder, Glasgow—the progenitor of the Fairfield Engineering and Shipbuilding Co—he afterwards went to sea in the Bibby Line, serving for some time in the Company as chief engineer, his last ship being the *Oporto*. While at sea, the disabilities under which the engines and boilers suffered, induced thoughts and plans to bring about im-

*We are indebted to the *Marine Engineer and Naval Architect* for the reproduction of the Portrait.

provements with a view to reduce, or eliminate, the causes of the troubles experienced. To reduce the deterioration in boilers, due to variation in temperature, the Hydrokineter was evolved, and to lessen the corrosion by reducing the corrosive elements, the feed heater and special pump came into being. Mr. James Weir, with his brother George, started business in Glasgow in 1876 as consulting engineers, meantime developing his inventive genius with the result that the Hydrokineter and special pump were followed by the condenser and the air pump. Extension of premises became necessary to meet the growing demands for the Weir specialities, and about 1880, the foundation portion of the present premises at Cathcart was established. On the retirement of Mr. George Weir to Australia, the business was formed as a private company, and the younger generation became partners. On the retirement of his father as the active head, Lord Weir became the predominant partner. Mr. James Weir, after his arduous work in connection with engineering, devoted himself to work on the land near Lockerbie, in Dumfrieshire, and studied the adoption of the best appliances for the reproduction of the products of the earth and the improvement of cattle, realising that the growing importance of farming operations demanded conservation of national energy to meet our requirements, as far as possible within our own limits. Mr. Weir was a Vice-President of the Institute and from its inception manifested a great interest in our operations, being one of our first year's members. When the new premises were under contemplation, he presented £1,000 towards the fund being subscribed for the present building. He contributed a paper to the Institute in 1891, entitled "Steam Engine Efficiency." He also contributed papers to other Institutions, and at the Chicago Exhibition Engineering Congress, in 1893, he gave one on "Steam Engine Boiler Feeding," while amid the surroundings of his country life he wrote a book on "The Energy-System of Matter." His brother Thomas, formerly Supt. Engineer of the China Merchants S.N. Co., is now living in retirement at Helensburgh. To Lord Weir, Mr. J. G. Weir, C.B.E., and their two sisters, we accord our respectful sympathy on the death of their father, whose memory will live in the minds of Marine Engineers for many generations.

Lord Fisher (Hon. Member I.Mar.E.).—Born in 1841, in Ceylon, where his father was A.D.C. to the Governor, young Fisher entered the Navy in 1854, and served during the Russian and China wars, receiving his lieutenant's commission in 1860.

He thus early gave evidence of his powers, and was appointed gunnery lieutenant of the *Warrier*, our first seagoing ironclad. As a commander, he took up the study of the torpedo, and in 1873 was sent to Fiume to arrange with the Whitehead firm for the purchase of this new weapon. While still a junior captain, he was appointed in 1881 to command the *Inflexible*, the biggest ship of her day, and after the bombardment of Alexandria was landed from her and invented the first armoured train for use against Arabi. Invalided from Alexandria through illness contracted on service, he was appointed on his recovery to command the gunnery school at Portsmouth, and afterwards served successively as Director of Naval Ordnance, Admiral-Superintendent of Portsmouth Dockyard, and Controller of the Navy. In time, he filled nearly all the higher posts open to a naval officer, for he was twice Commander-in-Chief afloat, including the command of our principal Fleet, then in the Mediterranean; he was Admiral-Superintendent of the principal dockyard; he was Commander-in-Chief at Portsmouth, the leading naval port; and from 1892 to 1915 he had four terms of service as a member of the AdmiraltyBoard, the last being from October, 1914, to May, 1915, when he resigned office sooner than agree to a further depletion of our North Sea forces to assist the adventure at the Dardanelles.

A mere summary of his reforms would occupy more space than can be afforded here, but it may be mentioned that his strategical insight was indicated by the gradual transfer of our main fleet to the North Sea; his tactical skill was shown by the building of the Dreadnought types of ships, in which big guns and speed were the leading factors; his organising powers were shown in his dockyard reforms, and in the introduction of the nucleus crew system, whereby all ships of fighting value were kept ready for instant mobilisation; and his administrative genius was manifested in the improvements in the technical education and training of the *personnel*. Lord Fisher strove hard to raise the position of the engineers of the Navy—"the real masters of the modern Fleet," he called them. His Osborne scheme of 1902 was not kindly received by all at first, as it appeared that by making all officers enter together he was closing the door to the engineer class, who had previously entered through Keyham, and many of whom could not afford the more expensive Osborne training. In reality, his object was to exalt engineering in the naval curriculum by making every officer take it up to a certain extent as being indispensable to his training and equipment, and though the scheme has been modified by experience, this principle remains, and executives and engineers are now one in entry and education up to the moment of specialising.

Ever on the alert for every invention or discovery which would assist the Navy, he was the champion of Lord Kelvin's compass, of the water-tube boiler, the turbine engine, the submarine, wireless telegraphy, and a host of other modern innovations. It was due to him that the control of submarine mines was taken over from the Royal Engineers, and he devised the first mine-layers and mine-sweepers. His faith in oil was complete, and under his enthusiasm and inspiration the Navy did a great deal for the advance of oil as a fuel and prime mover. The great war vindicated his work, and it was fitting that the most decisive battle of the war, that at the Falklands should have been won by his ships, and as the direct outcome of one of his first orders after returning to office. Yet the result of his labours did not end with the war. He has left his mark upon every part of the multitudinous activities of the Naval Service as it is to-day. He has, moreover, left a record and example which the Navy and the nation will ever recall with pride and affection.

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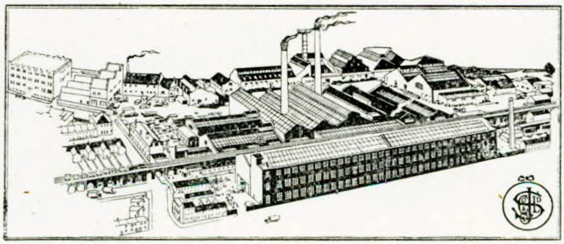
VOLUME XXXII.

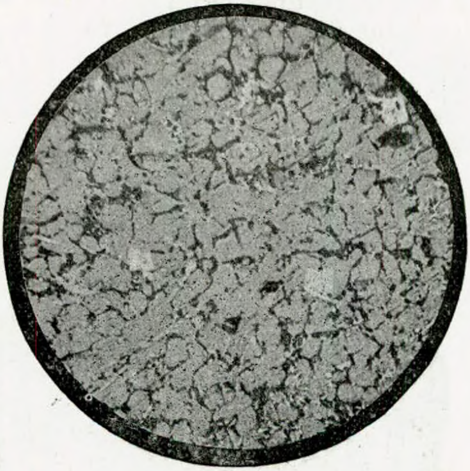
Visits to Works.

VISIT TO MESSRS. J. STONE & CO., DEPTFORD, MAY 8TH.—The Works at Arklow Road were first visited and with the paper read by Mr. J. Hamilton Gibson fresh in our minds, the illustrations of inventions in the workshops were all the more impressive and valuable. The materials and work dealt with by the Firm for sea service are well known to many of our members, but a brief description may fittingly be given for general information.

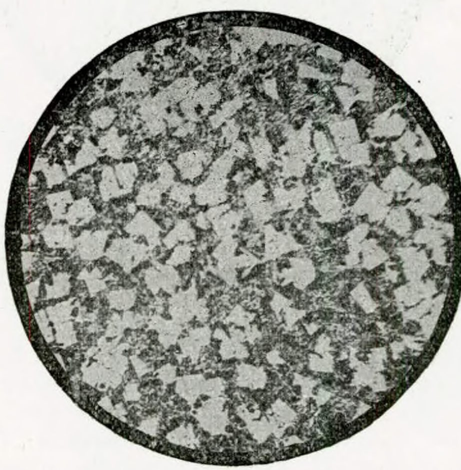


The Laboratory, with samples of good, bad, and indifferent material, indicating causes of failure, illustrated by microscopic views of the crystal structures, was full of interest and instruction showing that scientific research plays an important part in the work of the engineer and that labour without technical knowledge is insufficient to insure progress. Microphotographic and other apparatus and their uses in testing metals for varying conditions of service were explained. The testing machines showed the faulty material; the subsequent analyses indicated the cause, or causes, and suggested the steps to be

Photomicrographs of white bronzes, specimens cut from ingots magnified 25 times.



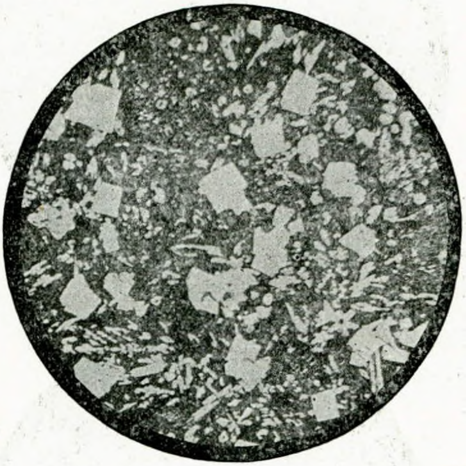
Specimen of Navy White Bronze.



Specimen Auto A.

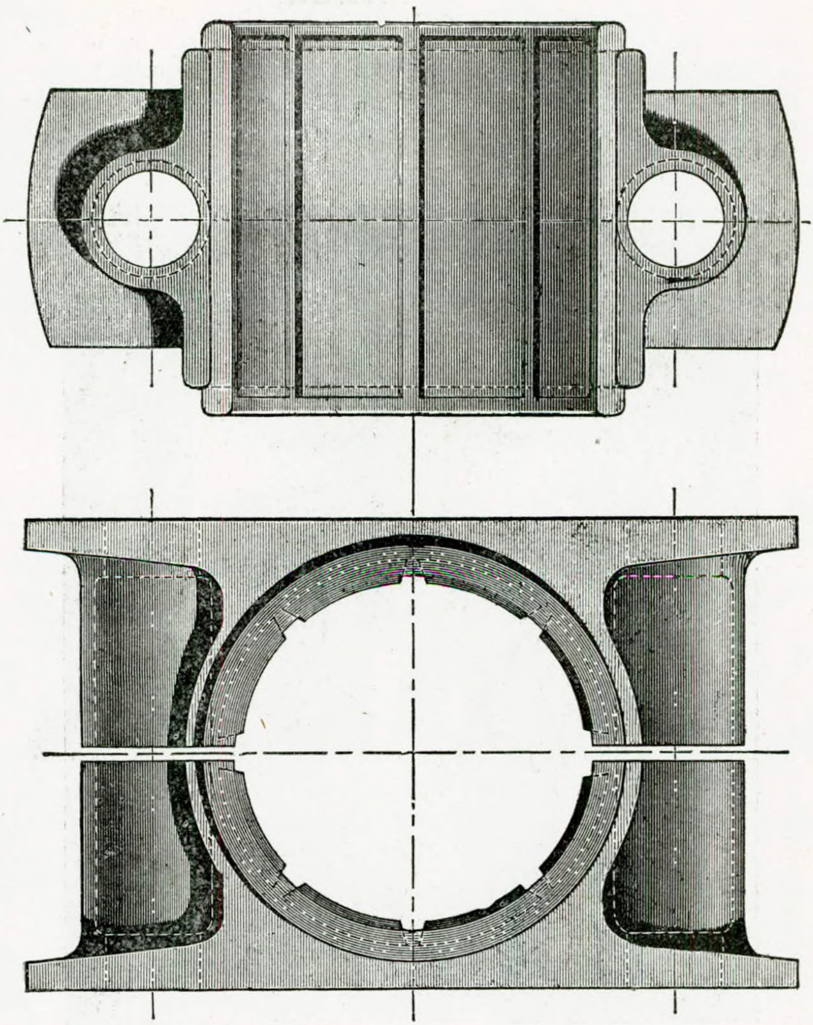
taken for improvement. Many unique specimens of failures and accidental conditions were shown and examples of what the results should have been. We were aroused from these contemplations by an exhortation that we were simply on the threshold and much remained to be seen.

Passing on we saw stocks of ingot metals and other products awaiting despatch; non-ferrous forgings and stampings; brass castings of all kinds; we then turned into the department where copper nails and rivets were in process of being made by automatic machines, drawing in the copper wires and rods and discharging the finished products, illustrative of the inventive faculty *in re* devices for automatic work. The double advantage was here afforded of studying the devices and witnessing the results in the handling of the finished articles—when cool enough.



Specimen Auto C.

In transit from one department to another, the changes due to development and extension of premises with consequent removal of operations to fresh ground were very striking to members who had visited the works in previous years. The Ash expeller design and details were shown by drawings, and after the apparatus was described, we were conducted to see an ejector pump at work, the platform representing the stokehold floor with a grating through which ashes were passed; doors were fitted for removal to show the passing of the water with the ashes for discharging them into the sea. Several incidents were cited to show that in cases of emergency arising from collision or torpedo damage, the ejector pump had been used with success for clearing water from the stokehold and keeping leakage under subjection long enough to enable the vessel to reach port.



The bearing is cast with panels as shown, and also a lip running round the edges for preventing the metal moving laterally.

The white bronze is easily run down, and should be melted in ladles over a coke fire. It should not be run down in crucibles, but if no ladles are to be had and crucibles have to be employed, great care must be taken that the metal is not overheated.

All bearings which have no cross ribs in the middle must have their faces tinned all over before the white bronze is poured in, and in addition, several holes should be drilled in the face of the bearing about 1¼in. diam. by about ¾in. deep.

Stone's white metal for bearings is well known and appreciated for its lasting properties. The examination of the samples and the care bestowed upon the ingredients in the mixing, for different purposes, deepened the impression as to the attention with which the metal is treated to evolve the best and most uniform results.

Ash Expeller.

Bulkhead doors operated under a central system is another feature of manufacture which we noted in passing from one department to another. The doors are operated hydraulically by pressure from double actin g pumps in the engine room; these automatically maintain uniform pressure. Safeguards are provided so that in case of fire a fusible plug may act in closing a door, or in the event of immediate passage being wanted for members of the staff or crew, provision is made beside the door so that it can be opened and closed again on the spot sharply. The design of the doors and the systematic manipulation of them from a central station with the local safeguarding provisions have been the work of time and testing under working conditions with a view to meet every circumstance for the safety of all concerned. Three different types of doors were shown:—(1) A trunk door, to open and shut locally and from bridge. (2) A horizontal door, to open and shut locally and from bridge. (3) A vertical door, to shut only from bridge and to open and shut locally.

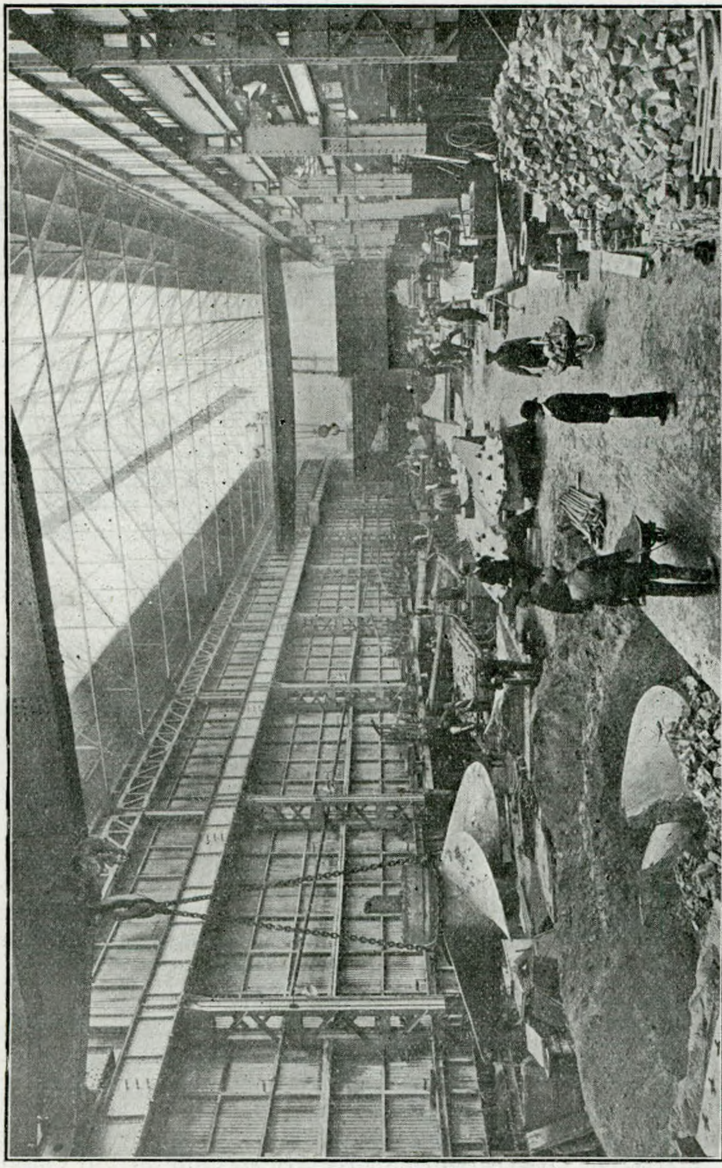
The Machine Moulding Shop includes a large foundry devoted exclusively to machine moulding, and castings of axle-boxes, slide valves, motor parts, etc., were seen in course of manufacture; adjoining to this is a Bronze Foundry devoted to small Manganese and Phosphor Bronze castings, varying from loco axle-boxes to small timing levers for motor cars. In the Brass Foundry one noted specially the large number of castings that were moulded in one box.

Electrical Shop.—Dynamos and Switch Gear for the firm's celebrated Train Lighting System were observed in very considerable numbers, either in course of erection or on test, prior to despatch to their destination.

Tool Room.—A new central tool room has just been completed and is one of the best lighted and equipped examples of this very necessary department. A measuring machine first made by the firm 12 years ago, capable of measuring from $\frac{1}{10000}$ in. to 30 in., aroused considerable interest.

Recovery Plant.—When dealing in metals of intrinsic value, the recovery and grading of all scrap metal and sweepings is of great importance; this is under the superintendence of the laboratory staff to ensure that no scrap is used for any charge that might have a deleterious effect in the casting.

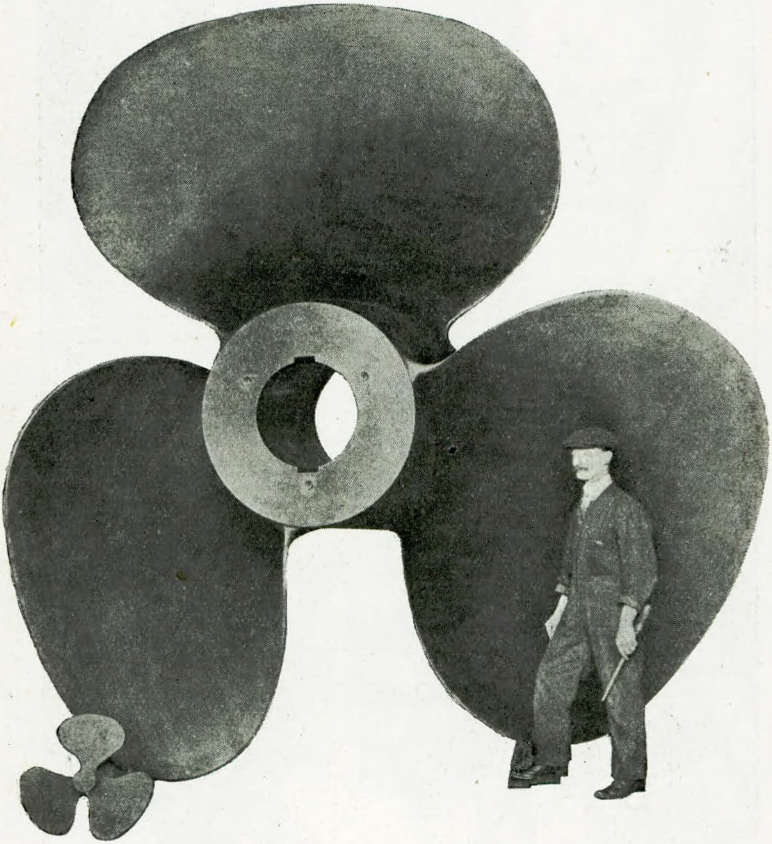
After a tour round the old Works with all their associations, cars were provided and we drove to Charlton to the new Works which are specially equipped for dealing with propellers from start to finish, including the process of moulding the pattern blade and the set-to-pitch planing machine which was at work. These two stages were examined with considerable attention and interest, as an excellent opportunity was afforded of seeing the *modus operandi* which many have only been able to read



Foundry.

Propeller Shop.

about without the practical demonstration to rivet the theoretical explanation to the mind; we could follow the manufacture of manganese bronze propellers from the foundry, where the raw material is made up into ingots and their composition checked by the laboratory staff before their issue to the



Turbine Propeller.

foundry. The furnaces and drying stoves were found to be of great interest; these have been specially designed by the firm for their own purpose. Through the Fettling Shop, where the propellers are clipped to area, backs trimmed up and balanced on rails, to the Machine Shop, where a large amount of very heavy machinery is installed, and the firm's patent machine for planing the faces of the propellers mathematically true to pitch.

At the close of the visit we assembled to partake of a hospitable tea provided to cheer our parting.

A vote of thanks to Messrs. Stone and to the members of the staff for their kindly courtesy was proposed by Mr. G. J. Wells and seconded by Mr. J. B. Hall. Mr. J. H. Peters replied on behalf of the Company and the staff who had devoted the afternoon to our delectation, and in doing so, had surrendered their Saturday afternoon golf.

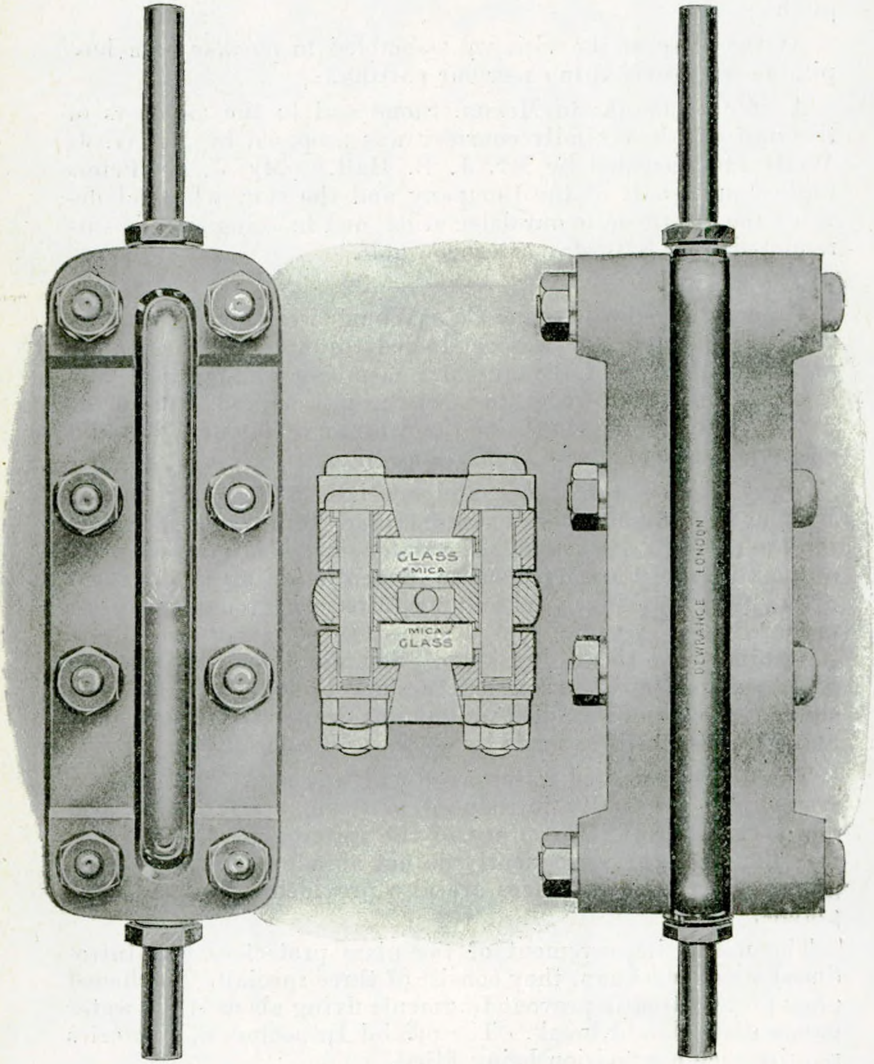
MESSRS. J. DEWRANCE & CO'S WORKS were visited on May 29th, when our party was conducted through the various departments by Mr. Lawrence and members of the staff, who kindly gave the afternoon to meet the visitors and explain the details of the fittings made by the firm, an action of self-denial on their part which was highly appreciated.

Many of the appliances and specialities familiar in the Engine Department were examined and improvements in up-to-date methods discussed. The water gauge columns with the automatic safety arrangement to prevent scalding in the event of the glass breaking, were on view, fitted with toughened glass prepared in the works and designed as an extra precaution to minimise the risk of breakage. Samples of specially treated glass were selected and tested to show their ability to resist sudden shock and strain, a weight was dropped upon the glass and a further test was made by dropping it upon the floor.

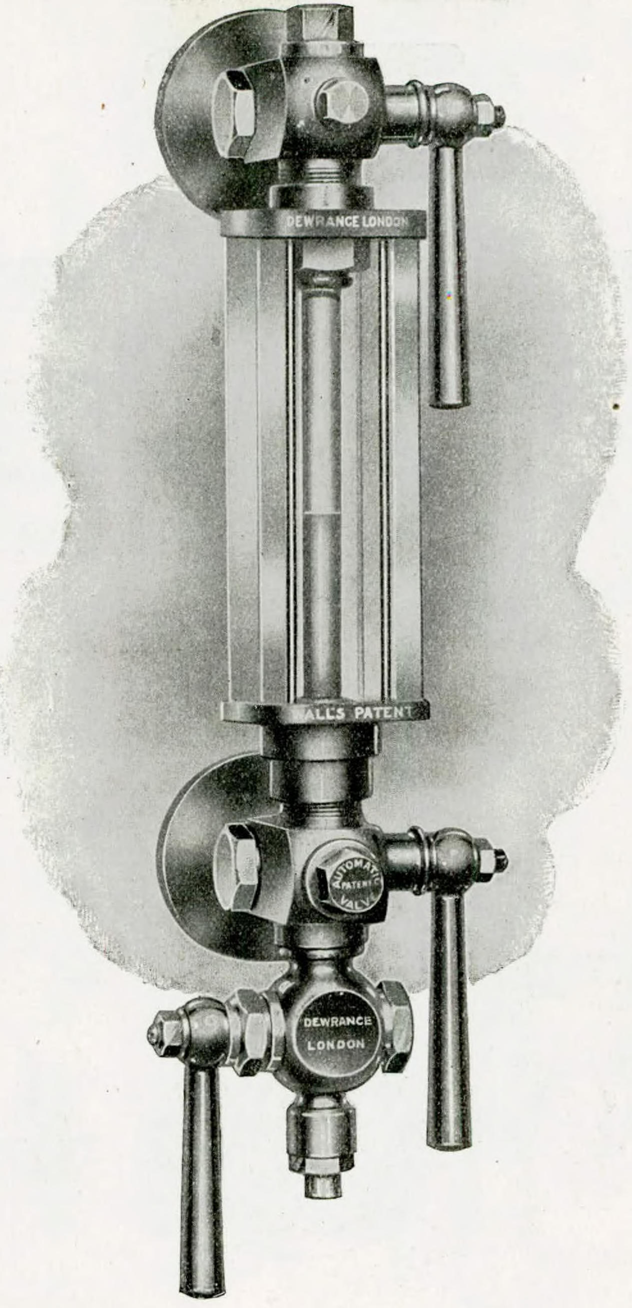
The asbestos packed watergauge which is made tight by this system was originally introduced to steam users by the firm many years ago. The plugs of the watergauge have a non-metallic bearing, consequently do not abrade so readily as the ground plug. The gauges are also provided with hexagonal glands.

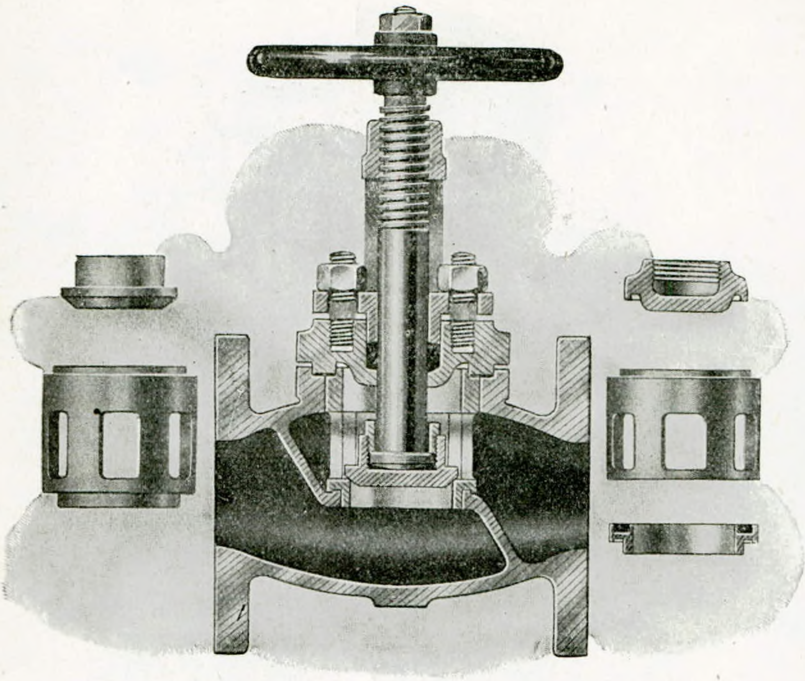
The useful improvement of the glass protectors was introduced some years ago, they consist of three specially toughened glass plates fitted to prevent fragments flying about if the water gauge glass should break. The official Inspectors of Factories require such a provision being fitted.

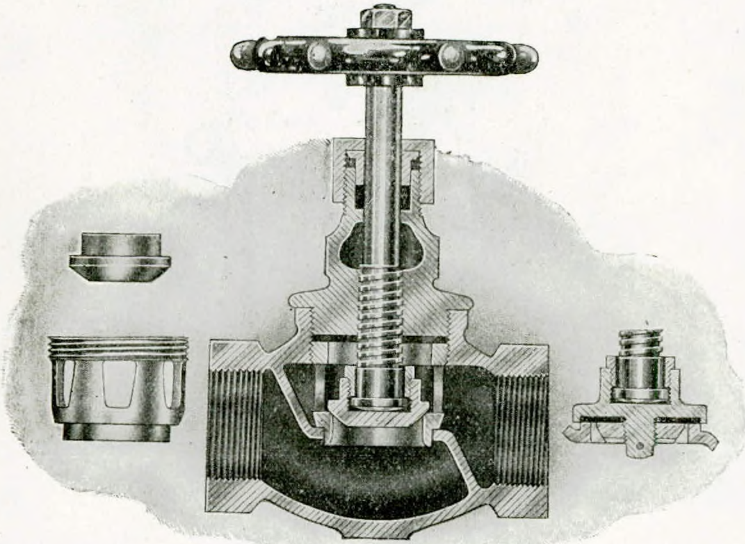
The gradual advance of steam pressure, of superheat, and the introduction of the internal combustion engine, have exercised the minds of all makers of material exposed to the increasingly



Transparent Water Level Indicator.


DEWRANCE LONDON
WALL'S PATENT
AUTOMATIC PATENT VALVE
DEWRANCE LONDON





severe strains and stresses due to the changes, and the question of how the altered conditions were being met naturally arose when valve chests in different stages of manufacture were viewed, as a defect in a cast-ion chest or casing is more serious since the days of 60 or 80 lb. pressure when repairs might be more readily effected to remedy defects. Specimens of cast steel were shown and the special features explained to indicate the process of manufacture in order to obtain the desired results in sound castings, reliable for present day service.

For these high pressures and temperatures which now reaches 300 to 500 lbs.□ with a superheat of 750°F. Siemen-Martin steel or other suitable material must be employed.

The glass of the transparent water level indicator is specially toughened. It is a fitting which can be made of cast steel. There are two specially toughened glass plates fitted into a frame and bolted up to the centre part which keeps them sufficiently far apart to allow of a space for the steam and water, the joints being made with a special high pressure packing. The effect is that the water level is more clearly defined as indicated in the illustration. The transparent water level indicator shown, has a thin sheet of mica interposed between the glass and the water and steam, the glass is thus kept good, and with a light behind the water level shows clear.

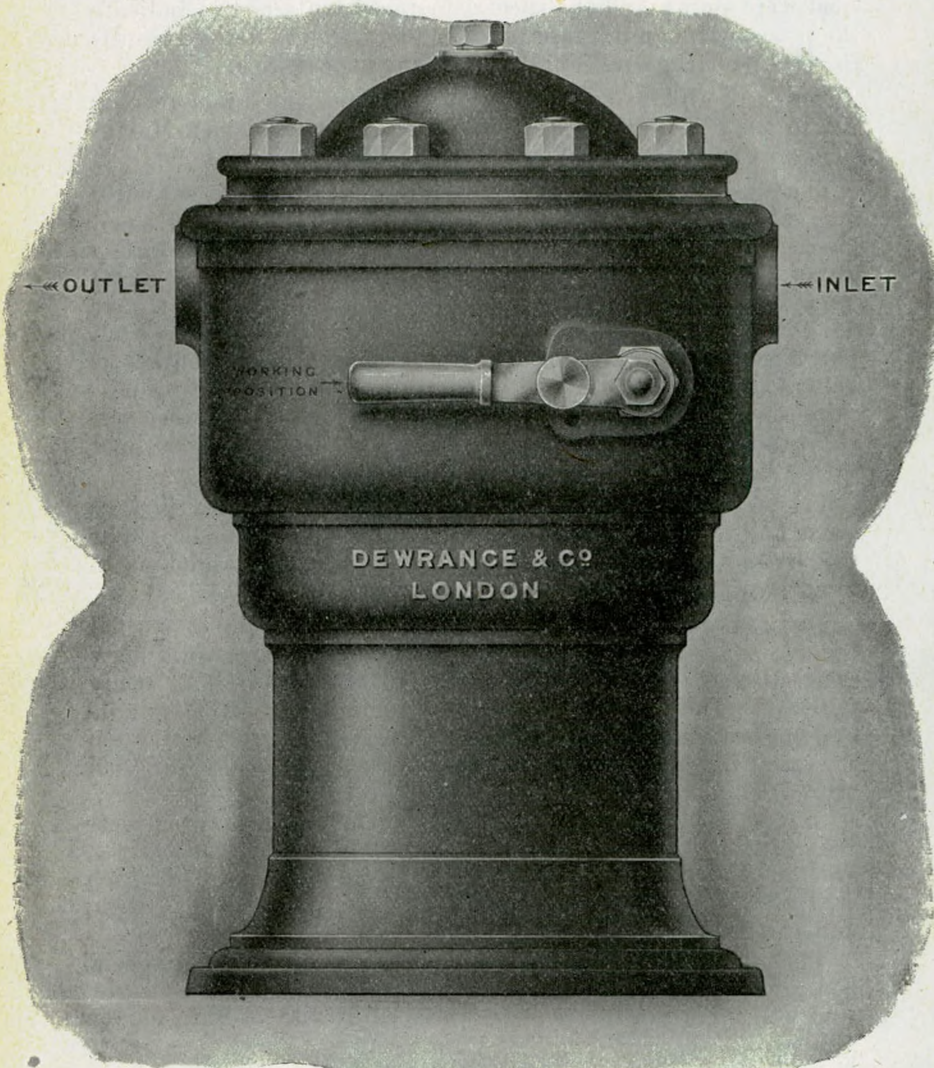
The variety of valves and cocks made by the firm is very great and the different designs in respect to details show that the views of customers are met in respect to joints and packings, also facilities for renewal of parts.

The renewable stop valves illustrated are made of special bronze, the seats being compressed to give greater durability and are constructed as are also the valves, to admit of ready renewal. The valve is readily detachable from the spindle and the seat can be unscrewed from the body of the chest when the cover is removed. The valves and seats are made of nickel alloy for high pressures.

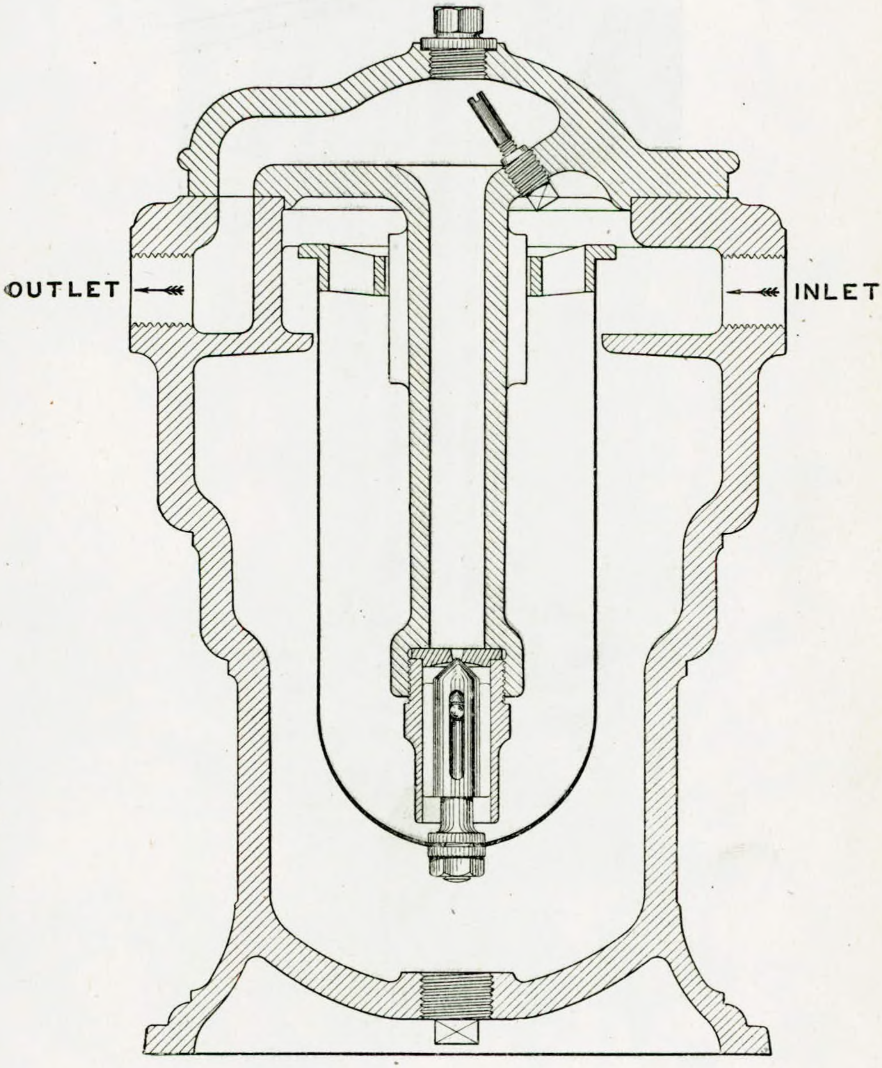
Safety valves of the lever and spring loaded types were inspected with attention, also reducing valves, relief valves, fusible plugs, expansion glands, steam traps, a sample of which is illustrated, the float steam trap, pressure gauges and fittings; lubricators and connections.

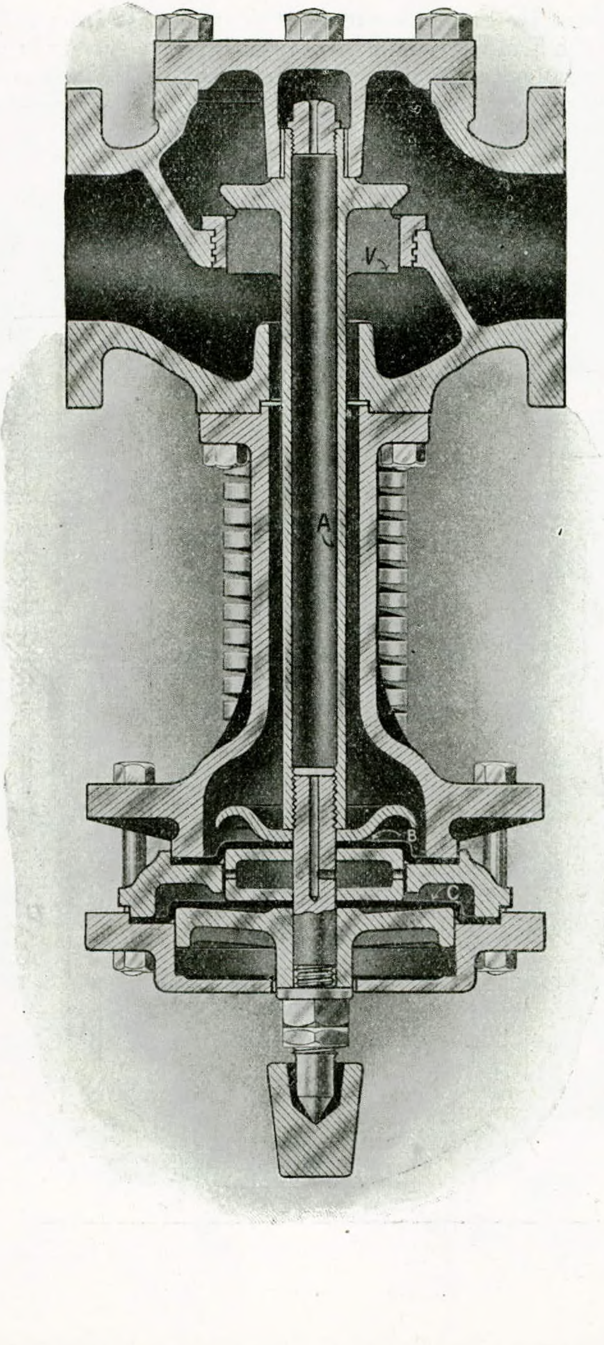
The double control reducing valve illustrated, has special features and advantages over the old form of lever and weight, and will maintain the required reduced pressure within narrow limits.

The float steam trap is provided with a pilot valve, when the float is filled with water the pilot valve opens, the momentum of the falling float opens the main valve and rapidly discharges the water, the trap then shuts off suddenly until enough water has accumulated to fill the float and cause another discharge, the valve seats are made renewable of nickel alloy.

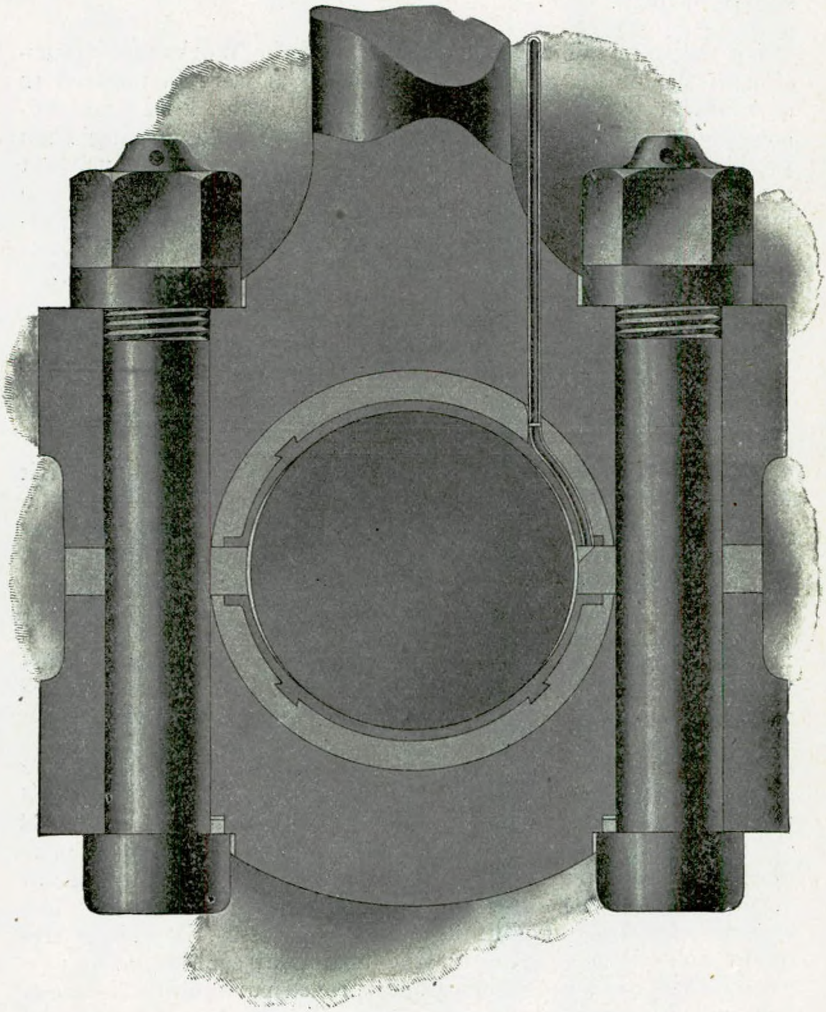


The pressure gauge department proved most interesting; we learned the firm were the first to introduce the system of making pressure gauges with an oval spring tube. The department is most complete with apparatus for obtaining exact pressures up to 10 tons on the square inch.




V
A
B
C

The different kinds of bearing metal for light or heavy loads, quick or slow speed, were stored in the department devoted to the purpose and illustrations were on view showing bearings ready to receive the metal, and others with it poured on or bored out ready for work. The illustration shows connecting rod brasses lined with white metal of the wheel brand type.



The laboratory is an important feature in all establishments where high-class metals are dealt with and chemical action has to be considered and its influence overcome, and Messrs. Dewrance have a thorough knowledge of all that is necessary for the purpose of the testing, analysing and mixing of the different metals to produce the best results to suit the special sphere of duty.

On the conclusion of the inspection of the Works and discussion of the points of interest, the visitors were introduced to a comfortable tea, spread before them by the kind and considerate hospitality of Sir John Dewrance who, having been unable to be present on account of the illness of a relative, sent a message of welcome. A vote of thanks to the Firm and the members of the staff for their kindness and courtesy was proposed by Mr. William McLaren and seconded by Mr. S. Martlew.

Mr. Lawrence, in responding, expressed the hope that the visit had proved of interest and practical value to all.

Skefko Ball-bearing Works, Luton, June 26th.—Our visit to the Skefko Works on June 26th was a most interesting one, and we are indebted to the members of the staff for their explanations of the various processes in operation for turning out the bearings and securing accuracy in the finished product.

The rods and tubes used are essentially of the most reliable material, and as we proceeded through the works this was illustrated step by step, as the machinery and testing at each stage were examined.

We saw the rods and tubes of Swedish chrome steel as they arrive from the SKF steel works in Sweden, where only ore is used, obtained from mines owned by the Company. These rods are first trued in special lathes, and then passed to the automatic machine department, where the machines, fed with four rods at a time, cut off the outer and bore out the inner races. The embryo races then go through many processes, including frequent controls as to gauging and testing at each stage of progress. The hardening department proved particularly interesting, with its special furnaces whose temperature is checked by a double pyrometer control. The treatment employed hardens the steel throughout, a fact that contributes to the long life of the SKF bearings.

The ball factory was probably the most interesting department, with its grinding machines, which turn out balls to an accuracy of ·002 mm. The first process in the manufacture of small balls is carried out in machines fed with coils of steel wire. These machines draw in a requisite length of wire, cut off a billet, and stamp the billet into a ball. The larger balls are hot forged. The rough ball then passes through the rough grinding machines, after which it is hardened with rigid control checks after each operation, oil grinding and precision grinding follows in ingenious machines, which are specially made by the company for their own use. Various polishing processes are then carried out in revolving bins, until the finished ball, with a mirror like surface, is ready for its final tests. These tests, both ocular and otherwise, make it impossible for a ball with the smallest defect to get into use, and we were interested to see one of the women operators detect a soft spot in a 3/16 ball, and pick out the offending ball with a magnet.

We were also invited to inspect the well equipped works laboratory, where the metallurgist was kind enough to demonstrate a test in the crushing machine. A 1in. ball was placed between two others in the machine, and pressure gradually increased, until the middle ball was crushed at about 40 tons. In this laboratory, samples are taken from each consignment of steel that arrives, and searching tests made to check the quality of the steel.

When the tour of the works was completed, Mr. P. J. H. Proctor delivered a lecture on the application of the ball-bearings to marine work, after which an excellent tea was served and partaken of with high appreciation of the courtesy of the Company and of the staff for the kindness manifested by them in escorting us through the various departments, and for which a vote of thanks was accorded.

LECTURE BY MR. P. J. H. PROCTER.

Ball-bearings now play an important part in the technique of modern engineering. Modern conditions make it imperative that engineers take advantage of every means by which economy may be effected in the use of power, and since one of the principal means of attaining this end is to reduce frictional resistance to the lowest possible point, ball-bearings, already widely used, are coming more and more into favour as time goes on. It would seem, however, that Marine Engineers have not yet fully realised the possibilities and advantages of ball-bearings, especially as regards their application to ships' machinery.

Construction.—The main feature connected with the manufacture of the bearings will have been brought to your notice during the tour of the works, but before passing to a consideration of the application of these bearings to marine engineering, a few comments on their design and performance might prove of interest.

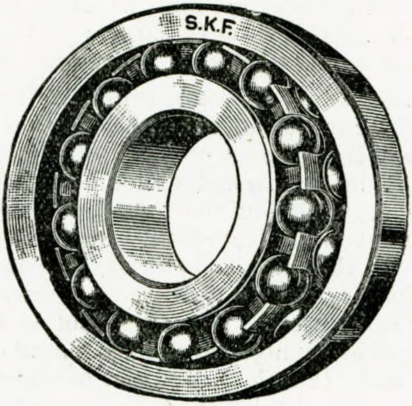
Historical.—The ordinary cup and conecycle hub-bearing is one of the earliest examples of ball-bearing construction, and is still found to have a wide field of utility within certain definite limits. The necessity for adjustment, and the low carrying capacity of this type, prevented its further development, and led to the introduction of the ordinary single-row annular type of bearing.

Annular Type.—The structural simplicity of this bearing makes a strong appeal on the ground of efficiency, and setting aside the questions of the quality of material, heat treatment, etc., the principal item calling for attention is the proportioning of the race grooves. Early experience has proved that the maximum efficiency is obtained by balls rolling between two flat plates. The capacity, however, of a bearing designed on these lines would be small, since the minute area of the contact surfaces would result in pressure of a very high intensity. The reduction of this pressure intensity is obtained by providing race-ways whose curvature tends to encircle the ball, and the annular grooved ball bearing represents the most efficient compromise where load carrying capacity and frictional loss may vary inversely with one another. It is interesting to note that the stresses set up in a bearing of such construction are beyond anything encountered in ordinary engineering; a fact that will be readily understood when consideration is given to the small area supporting an intensified load. The ball, of course, actually deforms, and in consequence a certain slight sliding effect is experienced. In this annular type bearing, the balls are introduced between the races through a filling slot, and while this method makes it possible to use the maximum number of balls, there is no doubt that severe stresses, which will affect the life of the bearing, must be set up whilst the balls pass the filling slot. This disadvantage is particularly noticeable when the bearing is called upon to sustain any thrust load.

SKF Bearing.—Passing from this consideration to the design of the SKF double-row self-aligning bearing on view, it will be understood that its peculiar property of alignment permits of two rows of balls being inserted without the use of any filling slot. The large curvature of the outer race gives a smaller frictional loss and less sliding effect, and while the capacity per ball is reduced, the total capacity of the bearing is greater than that of a similar annular type bearing, on account of the large number of balls fitted. You will doubtless have obtained some idea of the accuracy necessary in the manufacture of these bearings, but to make this clear, it might be stated that a bearing cannot even be assembled if the balls are ·002 mm. too large in diameter. You will understand, therefore, why the ball-bearing manufacturer objects to supplying spare balls to be fitted in a bearing which has been running some time, since the result will obviously be neither a credit to him nor of advantage to the user. The balls manufactured in our works here are graded in lots which are correct within ·001 mm. Consequently, it is impossible to say which grade should be used for a bearing, without having it here for examination. It is impossible, in the time at my disposal, to enlarge on the many interesting features connected with the manufacture and design of the SKF self-aligning bearing, but it will be understood that every possible care is taken to ensure that the product that leaves our works is in accord with the highest traditions of this class of manufacture, and that its unequalled efficiency as a means of reducing frictional losses makes it eminently suited for use in Marine Engineering.

As the present design of marine motors is passing through a most interesting stage, I propose to bring to your notice a few of the applications which have been tried out by us, and successfully adopted by our clients, hoping that I may thus help you to realise the advantages that such applications confer.

Fig. 2 illustrates the crankshaft of a four cylinder two-stroke unit developing 180-h.p. at 260 r.p.m. You will notice that the crankshaft is solid and is not built up. The bearings are our standard 1,400 type, capable of taking a steady, constant load of 42,000 lbs. at 300 r.p.m. The balls are $2\frac{1}{2}$in. diameter. The fitting of the end bearing presents no difficulty, as it is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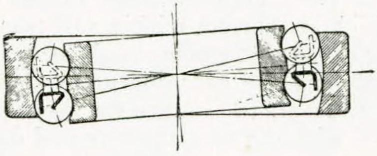
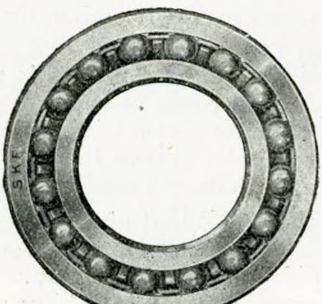



SKF

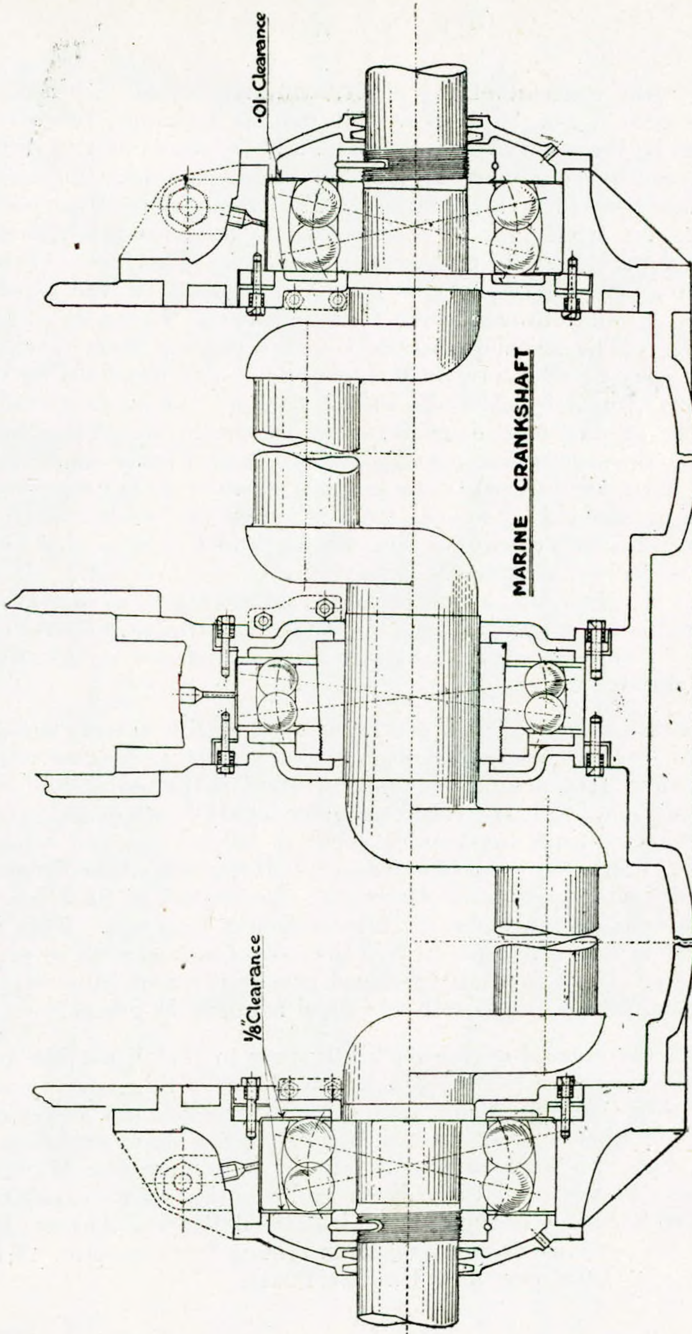


Fig. 2.

passed over the end of the shaft, and registered against a shoulder by a nut, as shewn. The middle bearings, however, have to be threaded over the cranks, and to overcome this difficulty, the bearing used is of sufficient internal bore to allow of it being fitted in this manner. It is then mounted in position on two split tapered sleeves, which are clamped tightly together on the shaft by means of a nut. This nut, whilst clamping the sleeves, firmly fixes the bearing on the taper. The right hand bearing acts as a guide bearing, fixing the shaft laterally. The method of protecting the bearing from foreign matter may be of interest. On the outside our usual fitting of a cover with felt washers is employed, and the same method could be applied on the inside, using a split cover. The illustration, however, shows a method which has recently come into use. A washer is fixed to the housing by three or more screws, which by the aid of helical springs, press the washer in the direction of the bearing so that the machined edge nearest the shaft is pressed against the inner ring of the bearing. This ensures a tight joint, which protects the bearing from anything that may be thrown up from the crank pit. It also renders the crank pit more air-tight, a vitally important point in the two-cycle engine.

The advantages to be gained by using the SKF bearing are as follows:—(1) Increased engine efficiency, due to almost total abolition of frictional losses, and resultant reduction of fuel oil consumption. (2) Increased security against stoppage. (3) Reduction of time and trouble spent in lubrication and attention. (4) Simplification of fitting. (5) Reduction of the dimensions of the motor in axial direction is facilitated, as SKF bearings are considerably shorter than ordinary bearings. This is of great importance, especially in the case of motors with several cylinders. (6) Essentially reduced consumption of lubrication oil, since the bearing is self-contained running in grease.

From the crankshaft we naturally pass to the thrust blocks, and here we undoubtedly have the most interesting bearing on board ship. We all know well enough the efficiency losses of the Horse Shoe type of Thrust Block. It has many disadvantages, but it is still retained. Perhaps because the Marine Engineer knows it. With all its faults he knows its capabilities, and were one to suggest to him a Ball Bearing Thrust, he would say perhaps, as one gentleman said on first seeing an SKF Bearing, "Take away that Chinese Puzzle."

It has, however, proved to be no puzzle, and in the form of a Propeller Thrust Bearing is a peculiarly suitable fitting, with all the reliable features of the Horse Shoe type, and none of the weaknesses. This has been proved on many occasions. The requirements placed upon it are, however, very great, and may be briefly summarised as follows:—(1) It must be capable of taking up propeller pressure even under the most trying conditions, and this without constant inspection. (2) It must be self-lubricating, and of a simple and reliable construction. (3) Friction in the bearing must be the least possible. (4) It must not take up too much space. (5) The movement of the ship must not influence the running of the bearing unfavourably.

Fig. 3 illustrates the type of thrust block used in submarines. This particular type was supplied by us and fitted by Messrs. Armstrong Whitworth in 1914 to H.M. submarines. It consists of our standard "R.M." type double-row self-aligning bearing with two single thrust spherically seated bearings. The radius of the spherical seating is struck from the centre of the radial bearing, and the whole unit can thus align itself, distributing the load equally over all the balls at all times. During bad weather or forced steaming the ordinary type of thrust bearing is a source of constant anxiety, proper adjustment being lost on such occasions, and the propeller thrust often taken on one shoe. This state of affairs, inevitable with the ordinary thrust block, can never occur in SKF bearing.

The SKF bearing is self-lubricating, and if we consider the co-efficient of friction of a Horse Shoe bearing as ·06, for normal running, and that of a ball-bearing as ·001, the saving of frictional losses, and resultant increased efficiency of the engine become apparent. It may be interesting here to note the saving in lubrication. While the engine is at rest, the Thrust Block should be nearly filled with a good non-corrosive grease, but while running the bearing requires no attention whatsoever, the grease acting merely as a preservative. When time permits the bearing may be cleansed out with benzine, and the grease renewed as occasion demands. Fig. 4 illustrates a type of Thrust Block fitted to turbines. In this case the bearings are mounted on the forward end of the reduction gear shaft.

From main machinery we might now turn to the auxiliaries, where a wide field has already been covered by our applications. As an example, Fig. 5 illustrates SKF Bearings applied to the vertical shaft of a Turbo Pump for Messrs. G. & J. Weir. The weight of the complete unit is 200 lbs., and it revolves at a

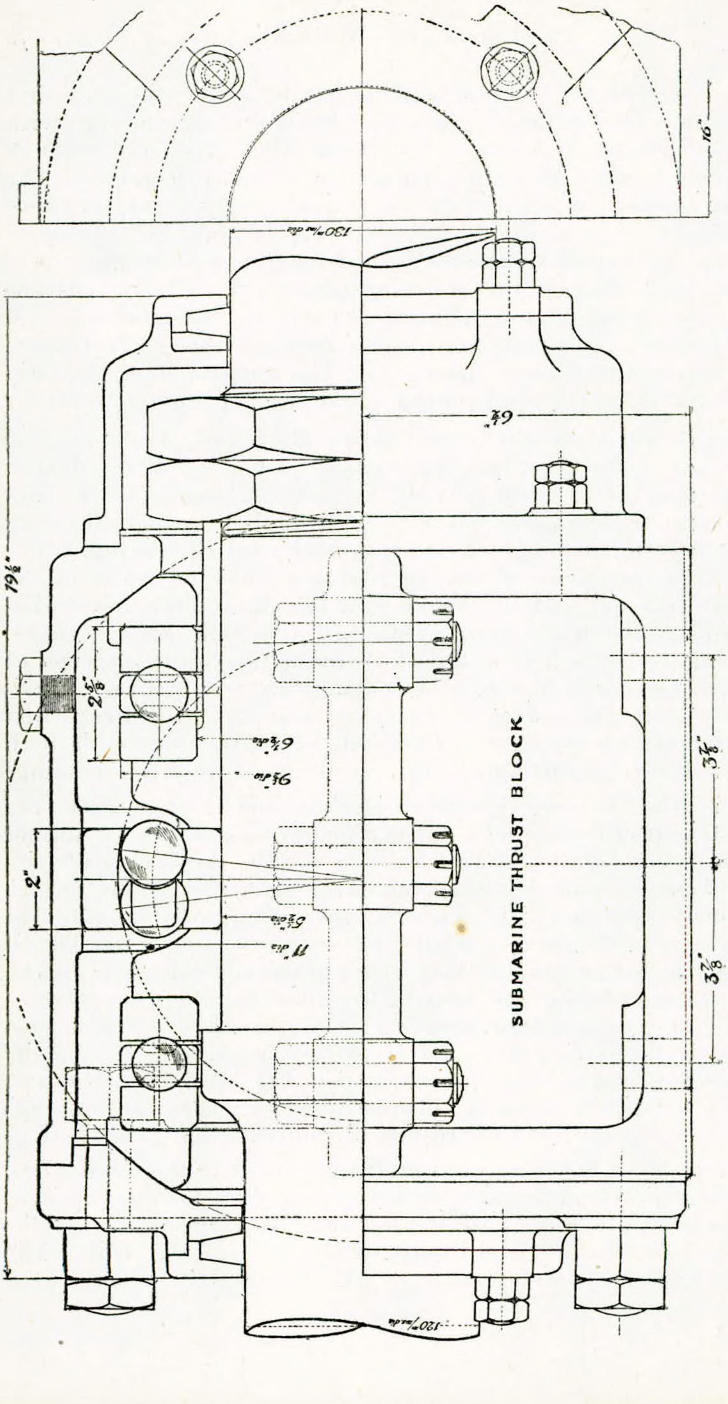

SUBMARINE THRUST BLOCK
16"
19½"
6¼"
3⅞"
3⅞"
2"
2⅝"
130m/m dia
120m/m dia
6½" dia
9¼" dia
5½" dia
11" dia

Fig. 3.

speed of 3,000 r.p.m. The radial load is taken on two 1314 bearings, while the weight of the shaft, with any resulting

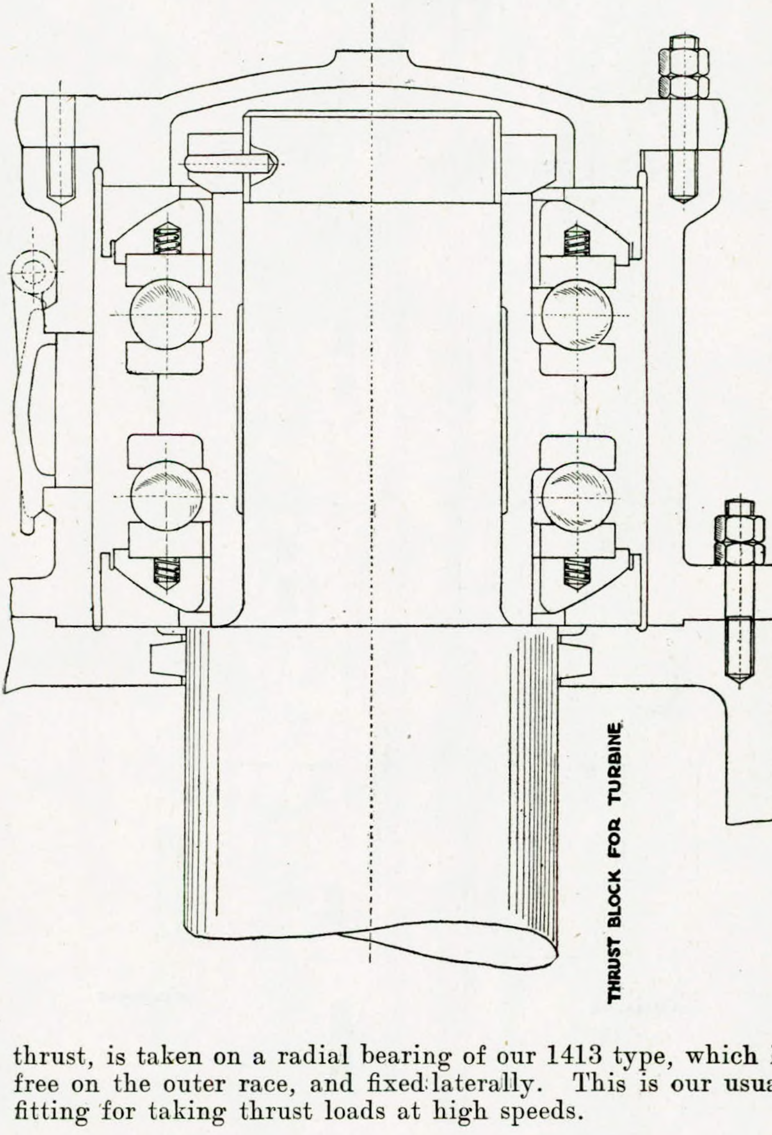
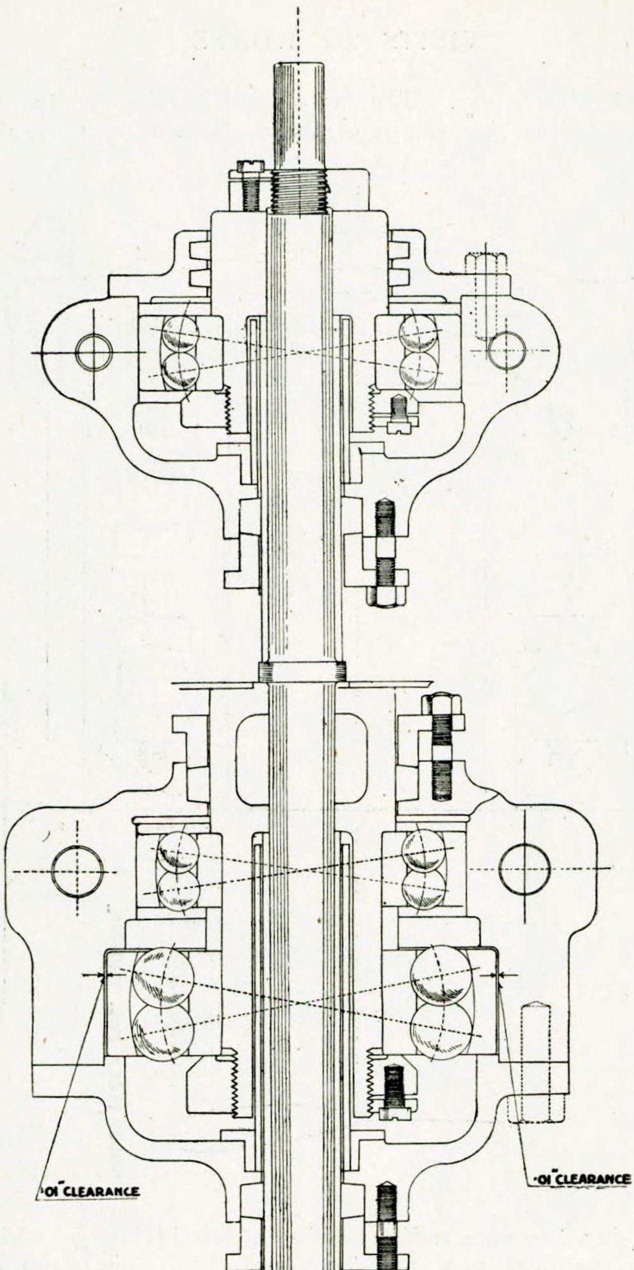


Fig. 4.

thrust, is taken on a radial bearing of our 1413 type, which is free on the outer race, and fixed laterally. This is our usual fitting for taking thrust loads at high speeds.



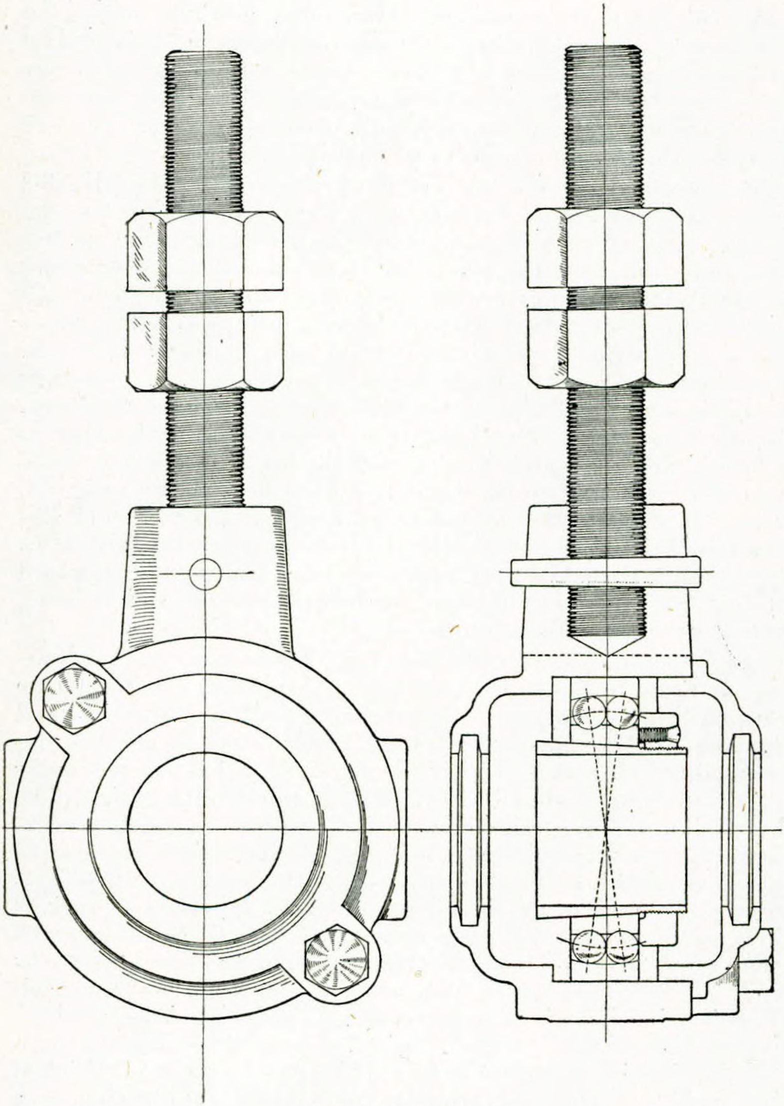
VERTICAL SHAFT FOR TURBINE PUMP.

Fig. 5,

Steering Gears.—These form a particularly suitable application for SKF Ball-bearings. How often has the finding of the Courts of Enquiry on collisions at sea been "Failure of the Steering Gear to act." The causes of these failures may be many, but the fitting of ball-bearings throughout the control shafting and engine, certainly minimises them. Let us consider the advantages to be gained by their use.

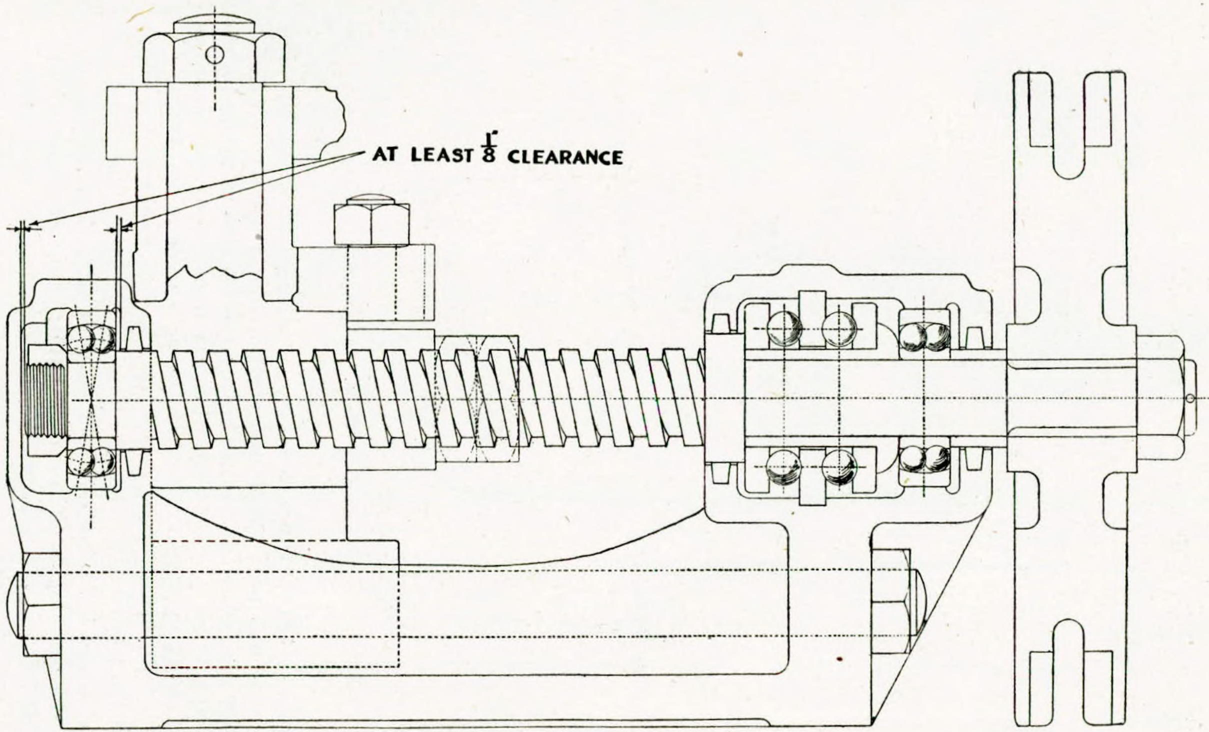
Fig. 6 shows our special type hanger, which can be adjusted to any required drop. Our standard 1500 Adapter type bearing is enclosed in this hanger, and will run without attention for three or four months, when the latter has been filled with grease. The bearings are self-aligning, and so counteract all deflections of the shaft without binding the bearing. Since there is no wear down with resultant play, instant movement from rest is assured. These bearings possess all the necessary features of an ideal bearing for Steering Gear Control Shafting. In the Gear Wheel Brackets we fit a single thrust bearing to take up the thrust and thus to keep the gear wheels constantly in mesh. Coming to the rudder, I have here shown (Fig. 7), an application to the actuating gear of Kitchen's Patent Reversible Rudder. The thrust is taken by our standard D.L. type double thrust bearing, and the radial load by our standard R.L. type. This application has been approved, and is being fitted throughout these units.

As an interesting application, Fig. 8 shows our thrust bearing as fitted to the rudder stock of a ship by one of the Clyde Shipbuilding Companies. The bearing is 22 in. diameter, and supports the 50 tons weight of the rudder stock. The bearing is mounted on a cast steel block which is in halves, the lower part forming a stuffing box, fitted with an oil tight gland. The bearing thus runs continuously in grease. To facilitate examination or renewal of the bearing, a collar which revolves in a recess in the bracket is formed on the stock. When it is necessary to examine the thrust bearing, the rudder stock is lowered by slackening the adjusting nut until the collar rests on the recess in the bracket, thus supporting the weight of the rudder. The complete ball-bearing can then be removed. This bearing has given every satisfaction in the ships to which it has been fitted. In conclusion, I may add that the ball-bearing has by no means attained the development of which it is capable. The war brought commercial engineering to a standstill. It is, therefore, surprising, that in view of this the ball-bearing has developed in marine engineering, to the extent it has.



SPECIAL HANGER FOR CONTROL SHAFT STEERING GEAR.

Fig 6.



KITCHEN'S REVERSING RUDDER GEAR
Fig. 7.

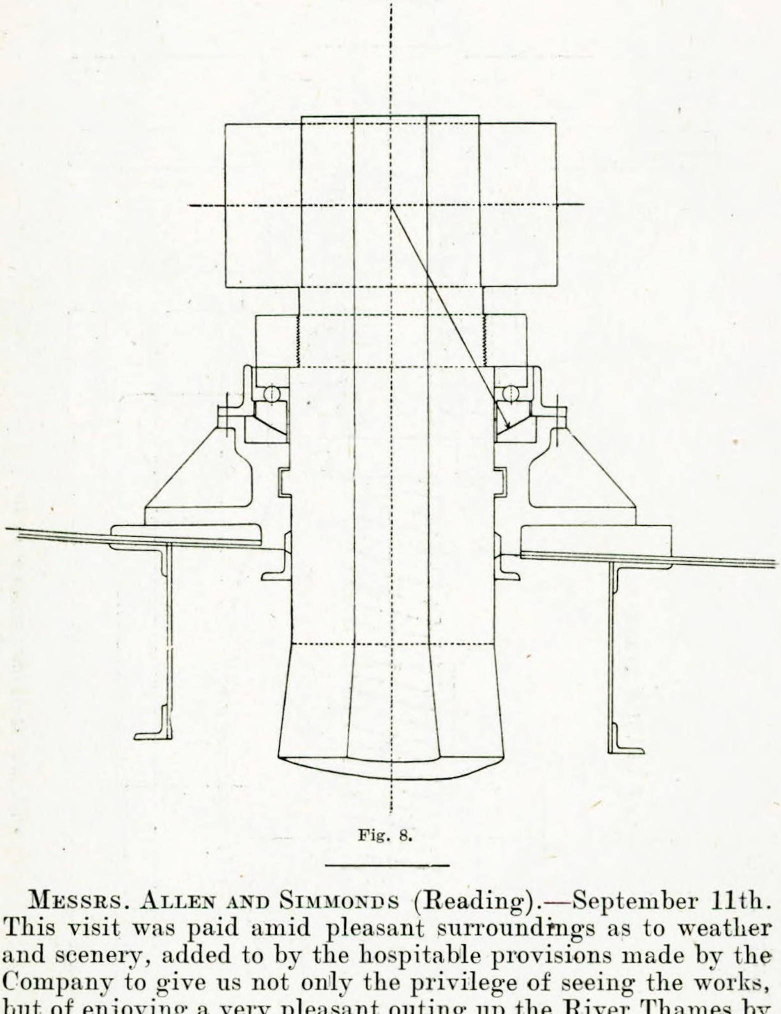


Fig. 8.

MESSRS. ALLEN AND SIMMONDS (Reading).—September 11th. This visit was paid amid pleasant surroundings as to weather and scenery, added to by the hospitable provisions made by the Company to give us not only the privilege of seeing the works, but of enjoying a very pleasant outing up the River Thames by steamer from Reading to Maple Durham, above the lock through which we passed.

The works have been in course of considerable extension to meet the growing requirements—adding to industrial employment and to the resources of the country to meet our necessities. The motor carriages, which conveyed us to the works from the station, were made by the Company in its extended field of work, and the trips to and fro gave a good opportunity of examining and testing them.

The Allen piston rings are now well known to Engineers, and the various stages in their manufacture were examined with interest. The composition of the metal for these rings has arrived at its best by means of many test trials; the degree of compression in the finishing stage to give desired results being also arrived at, while close attention to accuracy in machining and fitting have combined to give a good resultant.

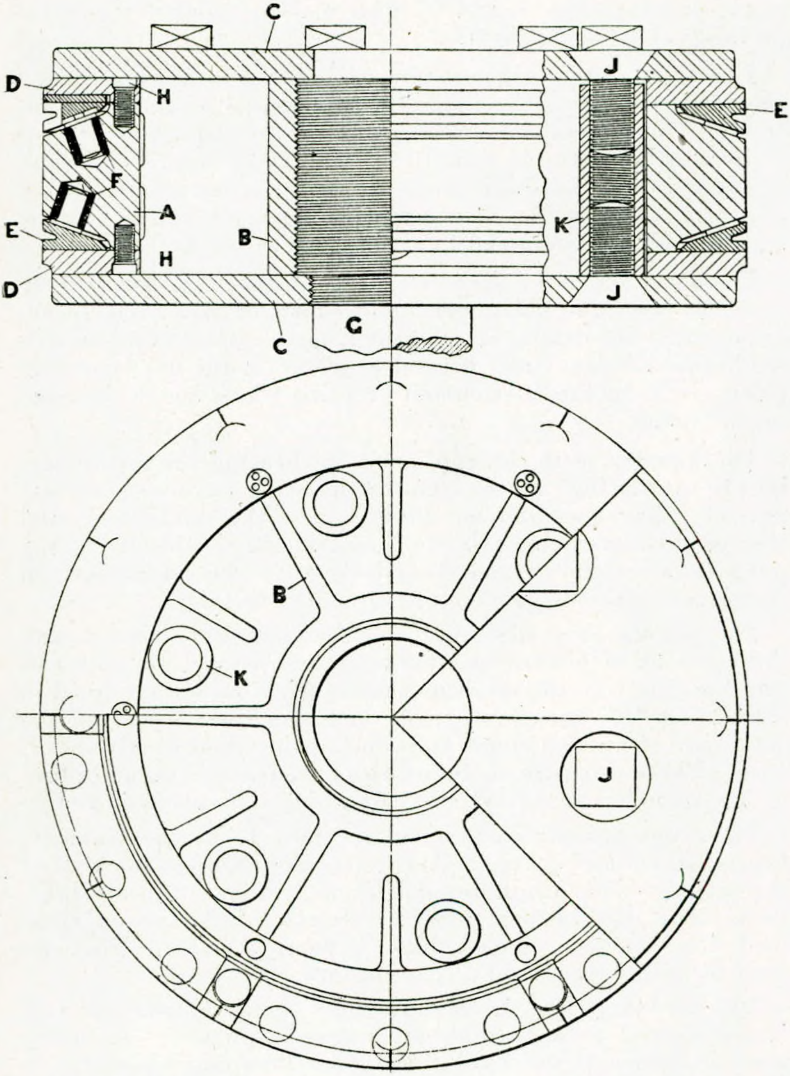
The development of the piston rings in the form now largely used has been due to the persistent efforts of Mr. Allen in endeavouring to produce an efficient ring to satisfy the demands for higher efficiency and greater economy in the use of motive power, by reducing friction and avoiding waste due to the passing of steam.

The foundry, with the appliances for heating the metal were highly interesting, all the connections being examined and explained. The core and moulding boxes, the sands used, and the special ingredients mixed or used on the moulds for facing purposes were shown and described, with the advantages in connection with the pouring of the molten metal.

The pattern shop adjoining and the store were visited, and the patterns of pistons and piston valves viewed in course of construction. In the machine shop much time was occupied in examining the variety of tools and machines used for the making of the piston rings, and compressing them to give hardness. These rings are made in three or more sections according to the diameter of the cylinder for which they are required.

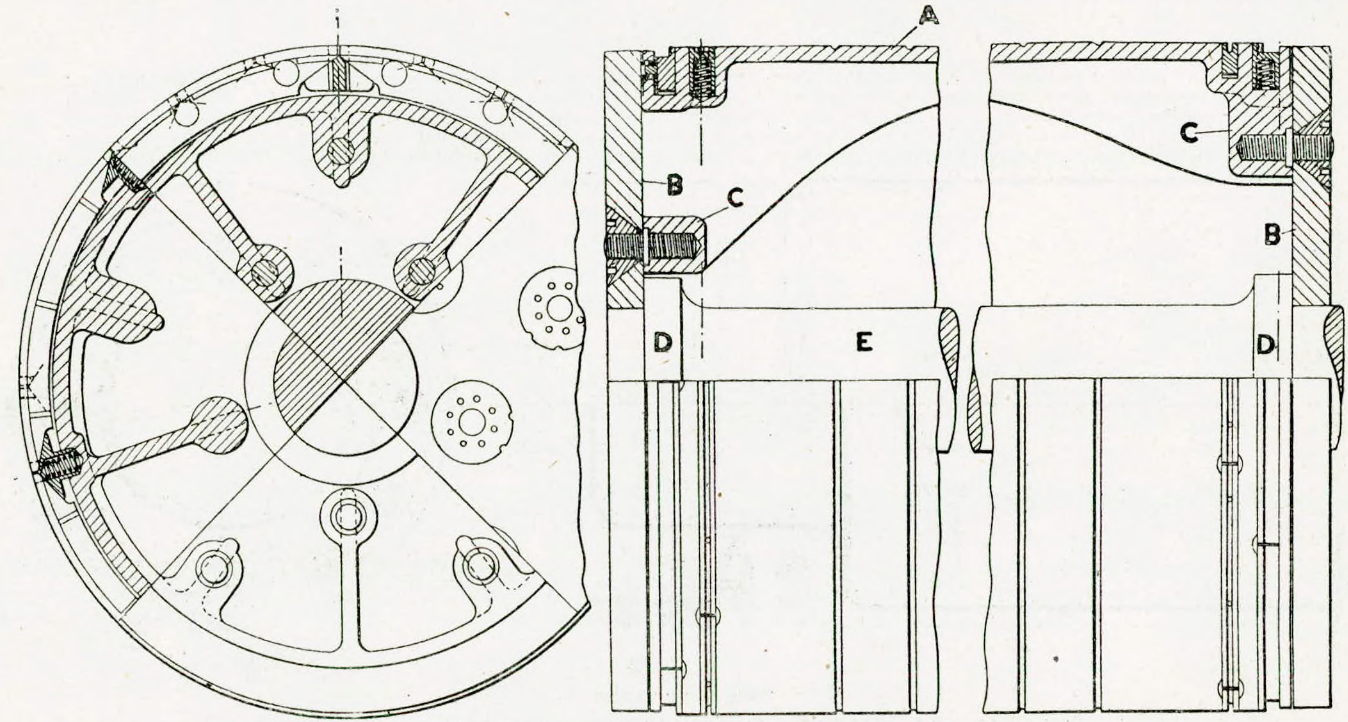
The rings are cut with strict accuracy to fit the segments behind which are springs to keep each section up to the wall of the cylinder with minimum of friction, yet maintaining tightness. The illustrations show the details of the piston rings used either for the cylinder, valve, or pump chamber. They are used for either steam, oil or gas engines.

The workshops for the manufacture of motor cars and carriages showed these in different stages of progress, including some in course of overhaul. We were then carried off to the large showroom and garage, adjoining which is a large erection being built and equipped for repairing and storing motor vehicles of different kinds. A few steps from this department is the Great Western Hotel, into which our steps were directed, Allen Patent Built-up Type Marine Piston fitted with oblique type rings.



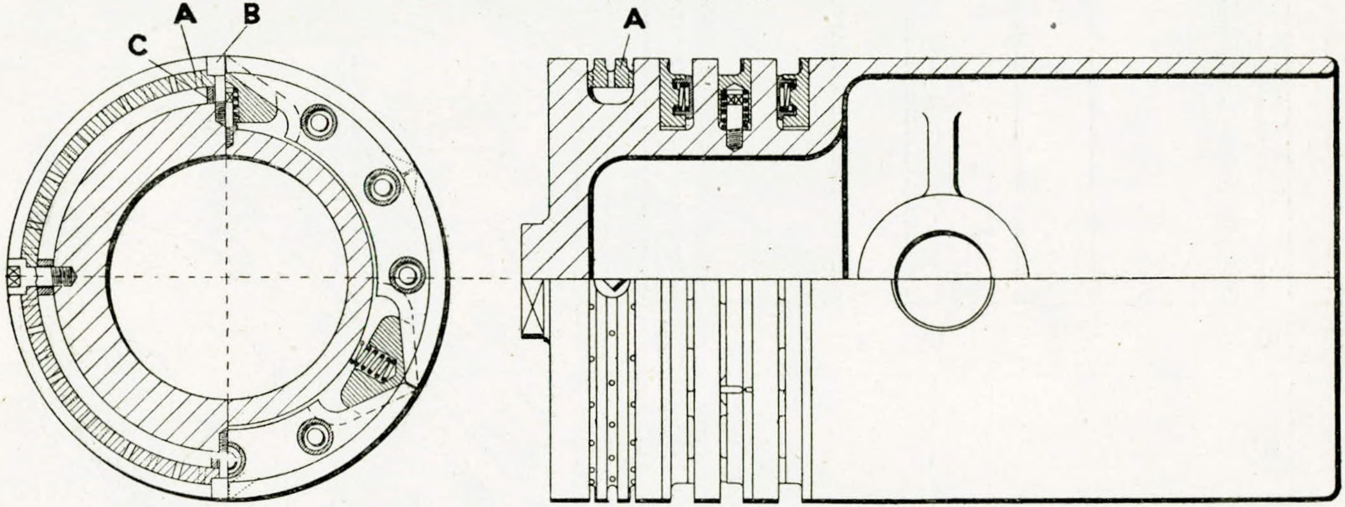
The Piston consists of a tread or packing ring carrier A, a central screwed boss with webs B, two end plates C, and cast iron distance plates D, against which the piston rings E are pressed by the force of the springs F. The central boss and one end plate are locked together by screwing on to the piston rod G. The distance plates D are secured to the sides of the carrier ring A by screws H. The whole is then clamped together by screwing on to the piston rod G. The distance plates D are screwed to the sides of the carrier ring A by screws H. The whole is then clamped together by means of screws J and tubular distance piece K.

The Allen Patent Uniflow Type Piston Illustrated shows the fitting of two pressure balanced and two A type rings.



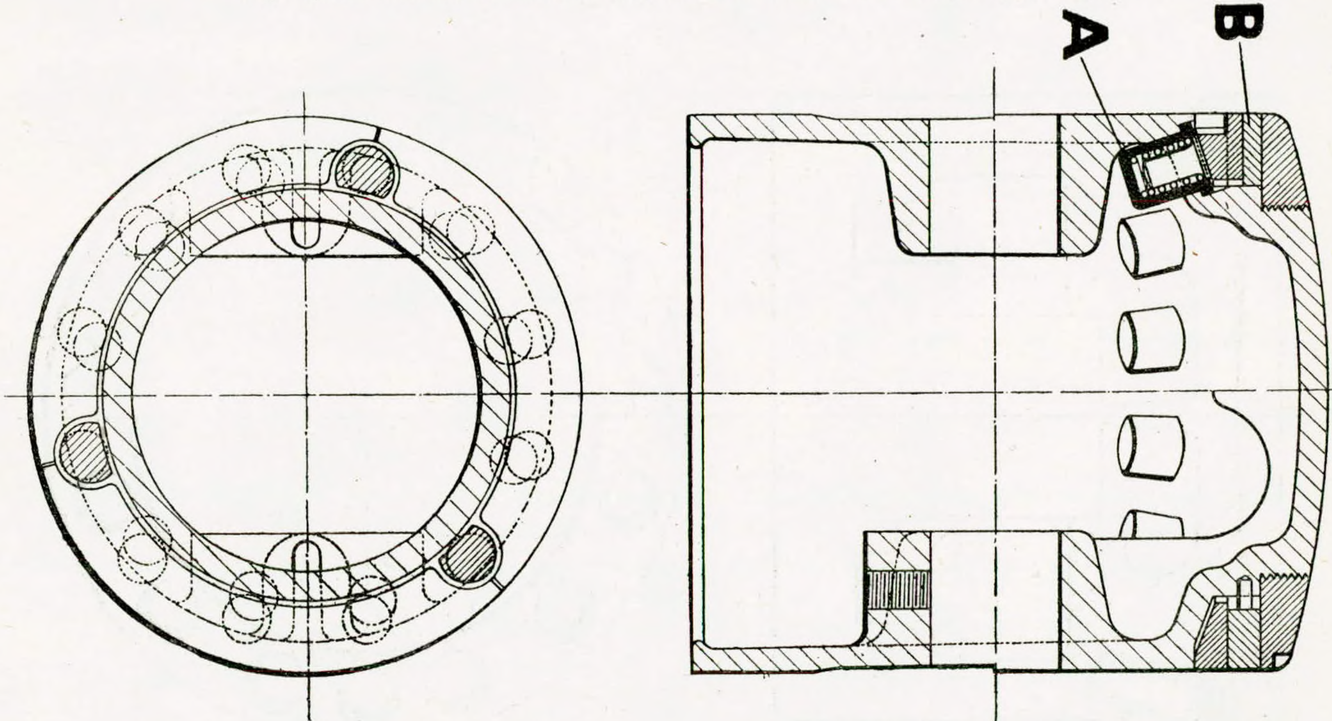
The three main parts of the piston comprise the central tread A and the two end plates B. The tread A is provided with webs and bosses C into which studs are screwed. By means of these studs the plates B are screwed to the ends of the tread A, at the same time gripping the flanges D, thereby securing the whole to the piston rod E. The flat polished end plates and the large air gap enclosed prevent loss of heat and condensation.

Internal Combustion Engine Piston fitted with three pressure balanced rings and patent intercepting or scavenging ring.

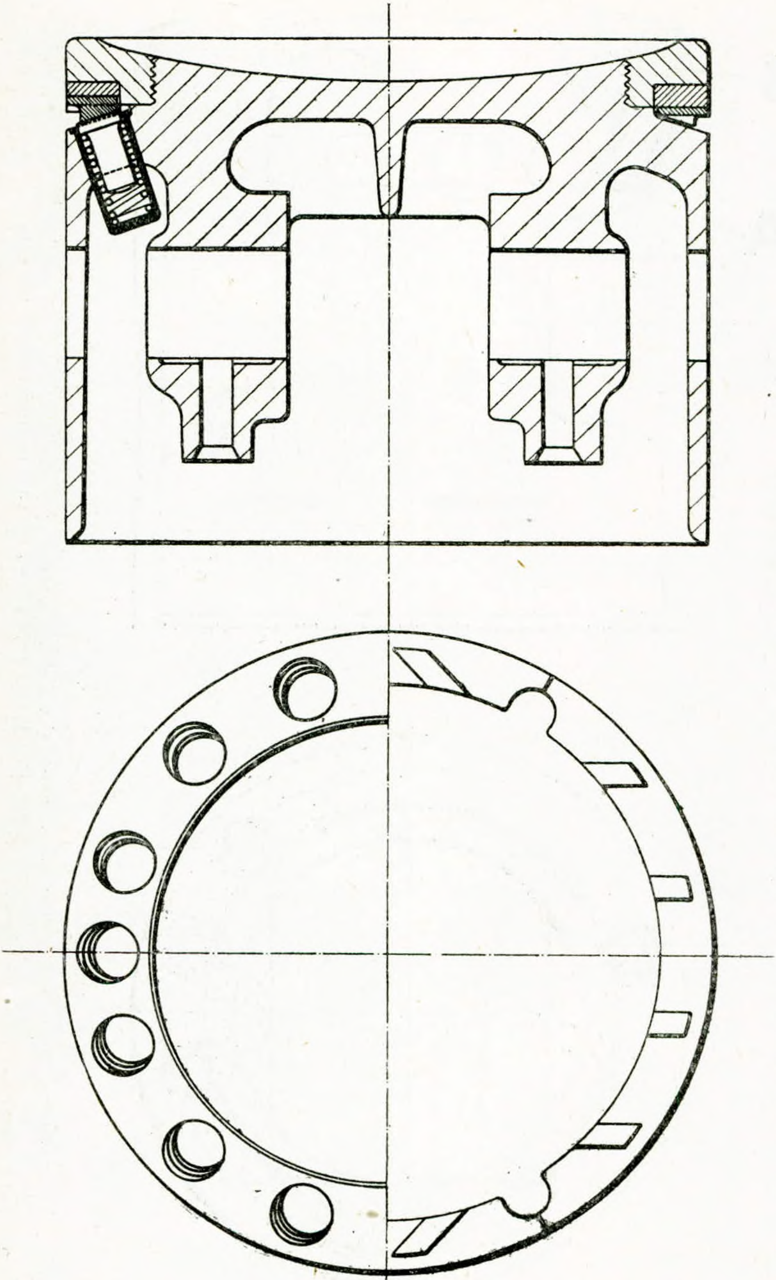


The packing rings are of the standard pressure balanced type, fitted with flush-side or rabbeted seals. The intercepting or scavenging ring A, which is placed near the piston head, is constructed in two halves, which are fixed in the groove by screws B. The ring is held off the bottom of the groove by distance collars C, ample space being allowed between the ring and the bottom of the groove. The use of this ring prevents carbonised particles or other solid matter from getting to the packing ring. The packing rings are thus kept free and unrestricted, and wear is reduced.

High Speed Internal Combustion Engine Piston fitted with oblique type ring.

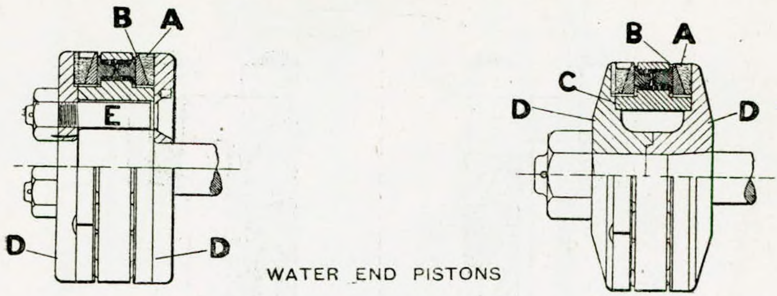


The springs are housed in pockets or thimbles A, which are pressed into holes drilled in the piston body. The springs are thus protected from the hot gasses and maintained at a moderate temperature by the action of the oil inside the piston splashing on to the thimbles.

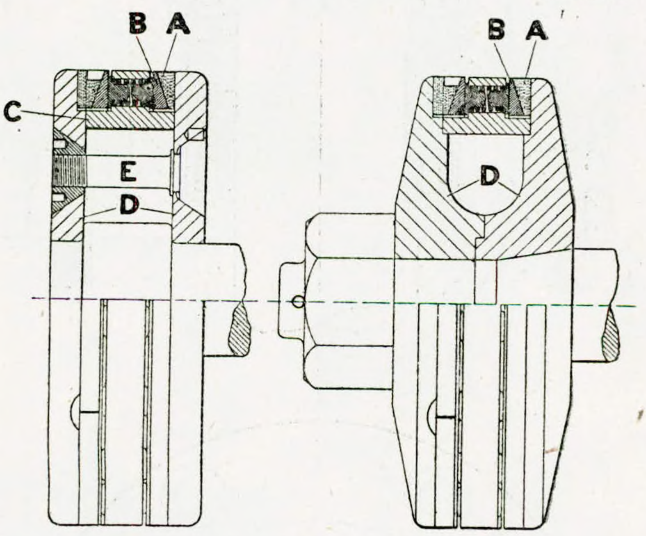


Another type of High Speed Internal Combustion Engine fitted with oblique type ring.

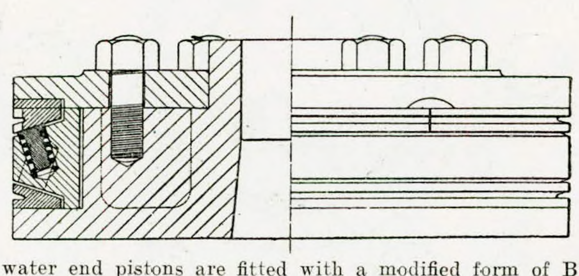
Weir Pump Pistons fitted with Allen Patents.



WATER END PISTONS

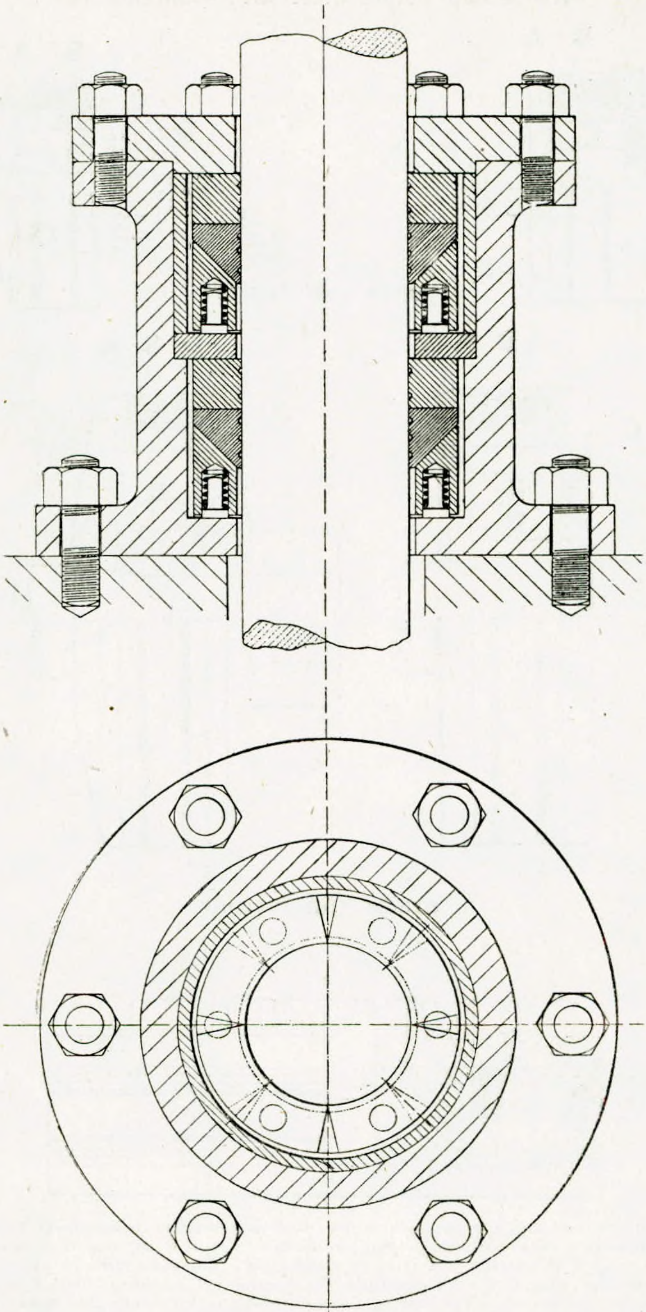


STEAM END PISTONS.



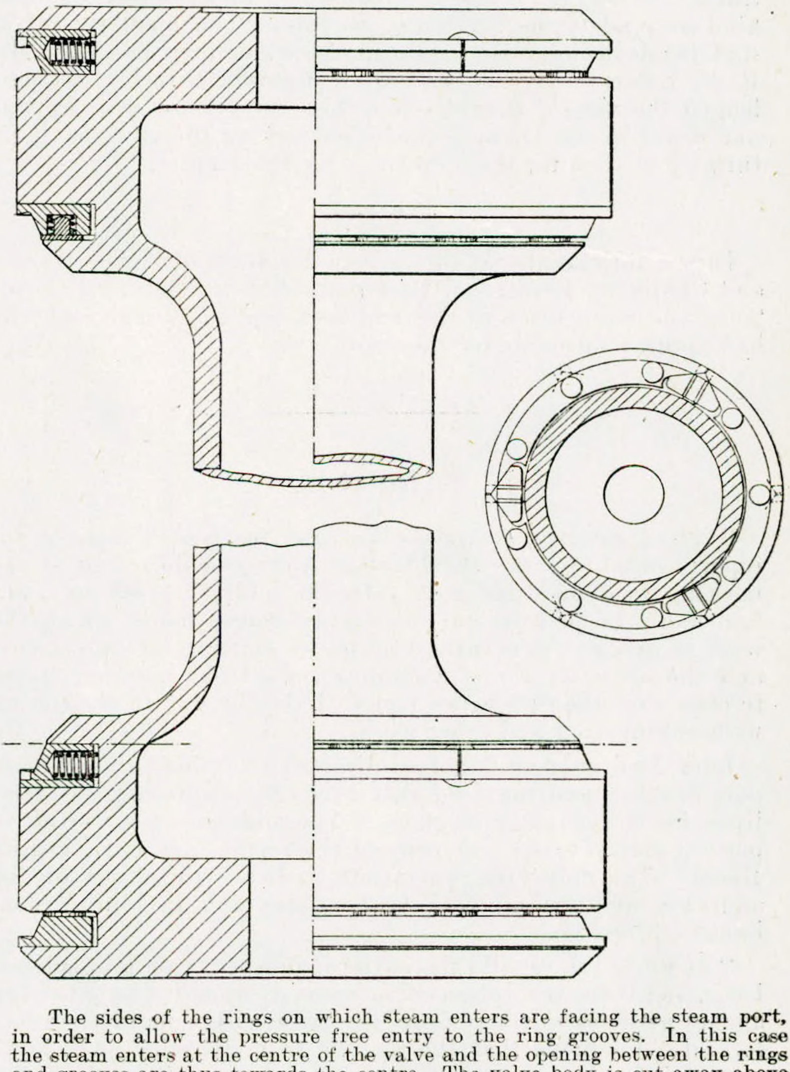
The water end pistons are fitted with a modified form of B type ring. The packing ring proper is composed of vulcanite or woodite, while the wedge ring B is a solid cast iron or steel ring. The side springs exert a pressure on the ring B which expands the segmental packing ring A outwards by the wedge action. The springs are housed in the removable tread or hull ring C, which is clamped between the end plate D by the bolts E. The steam end pistons are fitted with oblique type rings.

Allen Patent Double Type Frictionless Metallic Rod Packing.



In this case two single packings are placed in line, being separated by a central distance washer.

H. P Piston Valve of Marine Engine fitted with pressure balanced rings.



The sides of the rings on which steam enters are facing the steam port, in order to allow the pressure free entry to the ring grooves. In this case the steam enters at the centre of the valve and the opening between the rings and grooves are thus towards the centre. The valve body is cut away above and below the rings to prevent block packing.

and we partook of a high tea to prepare us for the two hours river trip to follow. After tea a vote of thanks was proposed by Mr. J. Shanks, and seconded by Mr. A. Dunbar, from Australia, conveying to the Company our appreciation of their kindness and to the Secretary, Directors, and members of the staff for devoting their time and attention to receive us. Mr. R. E. Evans, Secretary, and G. F. Craven, Director, acknowledged the vote of thanks. We then entered the waiting cars and drove to the Thames side to embark on the river boat, returning in time for the 8.30 train for Paddington.

In was intimated that the visit to the works of Messrs. Fraser and Chalmers, Erith, had been postponed till Saturday, Sept. 25th, and notification of this had been sent to all members who had applied for cards for the visit.

Notes.

British Science Guild.—We have received a copy of the report containing the Presidential Addresses delivered at the meeting held on June 20th. In the address given by Lord Sydenham he pointed out the disadvantages under which the work of production is carried on under existing circumstances; and the necessity for a reorganisation of our national forces to cope with the difficulties met with day by day in connection with engineering and other work.

Lord Montague of Beaulieu directed attention to the Transport Services and the need that exists for improving the facilities for the carriage of goods. The addresses are worthy of perusal and of study. A copy of the report is in our Reading Room. The following quotations indicate the scope of the addresses and include the closing paragraph in Lord Sydenham's address:—

"If we fail to rebuild the national prosperity on a broadened basis, and if the revolutionary movement supported by a foreign agency assumes an active form, the cause will be mainly psychological. I believe that the menace to civilisation, which we can plainly see, arises from a perverted mentality which has affected all classes." . . . "While the national wealth grew rapidly and riches fell to a new social class, including many manual workers, great towns sprang up, and from want of forethought the accommodation of their constantly swelling populations failed to fulfill the requirements of sanitation or even of decency." . . . "It is true that capital in private hands may be tyrannically used, and that this has happened in America especially. Capital in the hands of Trade Unions may also be used for tyrannical purposes. This is a danger to Society which must and can be prevented." . . . "The problem before us is to reconcile capital and labour, each necessary to the other, and to recognise that a preverted psychology has affected both. Only by goodwill, involving mutual concessions, can the spirit of unreasoning hostility be exorcised, the manual worker be given a new interest in his labour with new opportunities of economic advancement, and this old country of splendid traditions be saved from disaster." . . . "The horizon of the Empire is dark with heavy clouds. We are threatened with greater dangers than that of German militarism, which has been broken mainly by the spirit of the British race. The survival of civilisation, already submerged in some parts of the world turns upon the application of scientific knowledge to the national life. We can fulfil the vital requirements of our people only by complex organisations, the disintegration of which would mean suffering, starvation and disease, because nature cruelly punishes the violation of her laws. If knowledge is power, as Bacon held, it follows, as Goethe said, that 'There is no more dreadful sight than ignorance in action,' and Plato, who anticipated Goethe by more than 2,000 years, pointed out that the spectacle is more dreadful in proportion to the capability and the energy of the ignorant agent. I firmly believe that upon the psychology of the British people the future of civilisation must largely depend. We can, if we will, not only reconstruct our prosperity on broader and more stable foundations, but help to save the stricken and distracted peoples of Europe. Whether we rise, as an Empire, to the accomplishment of the mission which Providence holds out to us, or whether we go under like the great Empires of the past, will be determined by the moral qualities which our race retains from the training of its long history, from the teaching of its greatest men, and from the shining example of its heroes on sea and land and in the air."

Crystal Palace Exhibition.—The oil section is of much interest to Engineers, and contains many exhibits from firms dealing with oils, motor spirits and different types of engines using these; also fuel oil appliances. The production of oil from the wells, process of refining, with samples of the various kinds of oils and spirits are illustrated and explained at various stands of well-known firms. The Anglo-American Oil Co. show at intervals a cinema film of the petroleum industry from the well to the consumer.

Lectures are delivered in connection with the Institution of Petroleum Technologists on appointed evenings, the final one is at 6 p.m., September 22nd, by Prof. J. S. S. Brame, on "The Utilisation of Heavy Oils."

STUDENT GRADUATES.—In order to enable prospective candidates to gauge the standard of qualification for the examination the questions set this year are printed for guidance.

Theoretical Mechanics.

A

Define a unit of "work" and a unit of "power." A steam engine raises 800 galls. of water per minute from a mine 300 yds. deep; what is the effective horse-power? (A gallon of water weighs 10 pounds).

Define "force," and explain how it may be measured. What units are employed by the engineer in estimating the magnitude of a force?

State the conditions that must be satisfied by a system of coplanar forces acting upon a body, that the body shall remain at rest.

Define "Acceleration" and "Velocity," and explain the relationship between them. If the increase of velocity of a body is 15ft. per second per second, and the body moves 60 yds. between the 4th and 6th seconds, find the initial velocity of the body.

State the formula giving the energy stored up in a body in motion. Explain the meaning of each symbol and the units in which each would be expressed if the energy is expressed in foot-pounds.

A body whose mass is 10 lbs. is acted upon by a force of 10 lbs., find its velocity after it has described 12 yards from its position of rest. State the velocity in feet per second and miles per hour. (Take $g = 32$ feet per sec. per sec.).

Draw an equilateral triangle ABC. A particle moves from B to A with a velocity of 15 ft. per sec., find the magnitude and direction of the velocity that must be impressed upon it at A to make it move in the direction AC with the velocity of 20 ft. per second.

B

Define the specific gravity of a solid or liquid. Explain how you would determine the specific gravity of petrol whose specific gravity = 0·760.

Determine the depth below the surface of the sea, at which the pressure is = one ton per sq. foot, taking the weight of sea water at 64 lbs. per cubic foot.

A cubical vessel 3 ft. high is filled with water, find the resultant pressure on the bottom when it is filled with water. It is tilted so that the base is inclined 45° to the horizontal; find the resultant pressure on the bottom when: (1) the top is closed, and (2) when the top is open.

State the conditions of equilibrium of a floating body. A cylinder of uniform density whose axial length is three diameters, is placed in water, show that there are two positions of equilibrium; if placed in still water, would it take either position indifferently? If one position is more likely to be assumed explain the reasons for the preference.

Describe the barometer, and state how its indications are related to the depth from which water may be raised by means of a lift pump.

A cylindrical vessel is filled half full with water. It is then set in rotation about its axis, which is vertical. Find the shape of the surface assumed eventually by the liquid.

Heat and Heat Engines.

A

Explain how you would measure a quantity of heat in British thermal units. Give the definition of the "British Thermal Unit."

Give a brief description of a thermometer and its use. Explain how you would proceed to graduate a thermometer in Fahrenheit degrees and Centigrade degrees.

State the relationship between the pressure temperature and volume of a perfect gas; how may this relationship be experimentally determined?

Explain clearly the meaning of the term "Mechanical equivalent of Heat." State its value, and describe an experiment by which this value may be determined.

What do you understand by the term "Latent Heat"? Describe an experiment by means of which the value of the Latent Heat of Steam may be found, stating particularly any precautions you would take to obtain an accurate result.

What is the calorific value of an average sample of coal? How would you determine the value experimentally?

B

Explain the reasons why expansive working tends to economy in the use of steam. State why the amount of expansion in a single cylinder must not exceed 3 or 4 times the initial volume.

Sketch a normal indicator card from the high pressure cylinder of a compound engine; and show (by additional sketches) how its outline would be changed if (*a*) the eccentric sheave was advanced too much in consequence of the key-way being incorrectly set out, and (*b*) if the slide valve was replaced on the valve spindle before a washer $\frac{3}{8}$ths inch thick had been put in place, thus making the valve spindle too short.

In modern marine engines, piston valves are frequently used in place of slide valves; sketch any piston valve which you may have examined. Explain their advantages over slide valves.

Explain the "four-stroke" and "two-stroke" cycles, as employed in Internal Combustion Engines. State the advantages and disadvantages of each cycle.

Describe the cycles adopted in Diesel Engines, and enumerate the points in their design which differ from standard practice in oil engines.

Describe with sketches a gear for reversing Marine Internal Combustion Engines, and explain how starting is effective.

Machine Construction and Drawing.

Draw (1) the outside elevation of the relief valve; (2) a plan; and (3) a section on AB. Scale, half size.

Sketch a cotter joint, and explain its use.

Sketch a lubricator suitable for a crank pin of an engine running at 350 revs. per minute continuously for long periods of time.

Note :—The Sketches should be approximately to scale.

Give three methods of locking nuts and state the advantages of each.

Sketch and describe some form of adjustable spanner suitable for various kinds of nuts. State the material used in making the several parts.

What uses are served by Dowell pins? Sketch a pin suitable for use in fixing the position of a cylinder on the engine frame; show also the pin in position.

Applied Mechanics.

State Hook's law of elasticity. Define Young's "Modulus of Elasticity." A bar of mild steel of one inch diameter is prepared for testing in the usual manner, and subjected to a tensile load gradually increased until the specimen fails. Assume suitable values for the Ultimate stress, the Elastic limit, and the Modulus of Elasticity; draw a probable curve with strain and stress as axes of reference.

What is the difference between "hardening" and "tempering" of steel? Describe the operation of hardening and tempering of a chisel, state how the degree of tempering suitable is determined.

State the "Principle of Work," and show how it is applied in solving mechanical problems.

Define "Mechanical Advantage," and "Velocity Ratio" as applied to simple machines, and give the relation between the quantities. A screw-jack is employed to lift weights, the pitch of the screw is $\frac{3}{4}$ inch, and the lever gives an effective radius of 30 inches. Find its "Mechanical Advantage" and "Velocity Ratio."

Sketch a mechanism suitable for use in a planing machine in which the cutting stroke is slower than the return stroke. If the return stroke is to be made 60 per cent. faster than the cutting stroke give the requisite proportions in your sketch, and show that your figures are correct. State the advantages of such a gear.

The axes of two shafts intersect at right angles and one is to be driven by the other by means of a belt and a pair of pulleys. Sketch the arrangement of the pulleys and belt, and indicate clearly the driving shaft and the direction in which the driving belt is moving. State the conditions that must be observed for successful running and show that they are complied with in your sketch.

The right-handed leading screw of a lathe has four threads per inch, and it is required to cut a left-hand thread of 11 threads per inch. Sketch the arrangement of gear wheels you would use, given that the number of teeth of the wheels provided are as usual multiplies of five, between 30 and 120 teeth.

Describe and sketch an ordinary lift pump. The diameter of the bucket is $4\frac{1}{2}$ inches, and the leverage of the handle is 6 to 1. The height of the spout above the water in the well is 25 ft., neglecting friction find the force necessary at the end of the pump handle to work the pump. The weight of water = 62·4 lbs. per cub. ft. If the total frictional resistances of the pump is 20 % of the useful work done, by how much must the force be increased.

A reservoir 12 ft. deep, and 40 ft. wide by 60 ft. long contains 18 ins. of water. Find the nett work done in filling up the tank. If the combined efficiency of pump and engine employed is 45 %, and the reservoir is filled in two hours, calculate the I.H.P. of the engine. The level of the river from which the water is pumped is 20 ft. below the bottom of the reservoir.

A girder simply supported at its ends carries a brick wall $13\frac{1}{2}$ ins. thick and 6 ft. high, find the maximum bending moment, and maximum shear force both in magnitude and position. The span of girder is 10 ft. and a cubic foot of brickwork may be taken at 105 pounds.

Mathematics.

A

Find the numerical value of $\frac{a+x}{a-x} + \sqrt{\left(\frac{a+x}{a+2x}\right)}$

when $a=7$, and $x=-16$; also find the factors of $-x^3 - ax^2 - bx^2 - cx^2 + abx + acx - abc$.

Solve the following equations:

(a) $$\left.\begin{aligned} \frac{x}{25} + \frac{y}{2} &= -\frac{3}{10} \\ \frac{x}{2} - y &= \frac{7}{2} \end{aligned}\right\}$$

(b) $$\frac{\sqrt{a} + \sqrt{a-x}}{\sqrt{a} - \sqrt{a-x}} = \frac{1}{a}$$

Show that:

(a) $\frac{a-x}{b-x} = \frac{x-a}{x-b}$ also that (b) $a\sqrt{x} = \sqrt{a^2x}$.

Show that if $a:b::c:d$, that $(a+b):a-b)::(c+d):(c-d)$.

QUESTIONS.

A journey of 330 miles would be made by a train in 36 minutes less time, if its speed were increased by 5 miles per hour. Find the speed of the train in miles per hour.

A man cycled from one town to another, the first half of the distance he travelled at $2\frac{1}{2}$ miles per hour slower than his usual rate, but for the remainder of the distance at $1\frac{1}{2}$ miles per hour faster than his usual rate. Find his usual rate of cycling.

B

Show that if a diameter of a circle cuts a chord at right angles it will bisect it.

Show that the locus of the middle points of a system of parallel chords is a straight line, and that this straight line is an axis of symmetry of the circle.

Define a parallologram. A quadrilateral ABCD, whose opposite sides AB and CD are equal and the adjacent angles B and C equal, show that the two sides AD and BC are parallel.

Show how to draw a circle through any three points, A, B and C. Prove the truth of your construction.

Divide a line AB internally at any point C into two parts AC and CB; then show that the square on the whole line AB together with the square on either segment is equal in area to double the rectangle under the whole line and that segment together with the square on the other segment.

In a triangle ABC draw a line from the vertex A perpendicular to the base BC meeting it (produced if necessary) at the point D; then the sum of the squares on one side and the alternate segment, is equal to the sum of the squares on the other side and the alternate segment.

Show that if one side of a quadrilateral contained within a circle be produced, the external angle is equal to the angle opposite to the internal adjacent angle.

C.

Find the difference between the angles 130°, and 0·7854 radians, stating the difference in degrees, and radians. What is meant by an angle of 0·5 radians?

Explain the meaning of the expression Sin A, and show that its numerical value is constant so long as A remains unchanged.

Prove the truth of the following identities:—

$$\text{Sin A} = \sqrt{1 - \cos^2 A};$$
$$a^2 = b^2 + c^2 - 2bc \cos A;$$
$$\cos 2A = 2 \cos^2 A - 1;$$

In a triangle ABC, the sides AB, BC are 8 and 7 inches long respectively and the angle BAC $= 56°$, find the length of the side AC, and the angles ABC and BCA. Having given that cos $56° = 0.5592$.

What is meant by the statement "log $2 = 0\cdot3010$"? Rewrite the statement in the form $a = b^*$. Calculate the natural number whose log to the base 10 is $= 0\cdot5$.

The speed of a steamer 15 knots and its course is due E. At 10 a.m. a light-house bears N.E., and at noon its bearing is N.W., find the time when the light-house was due N., and its distance then from the steamer.

English.

Parse the words in italics in the following passage:—

Cowards die many *times before their deaths;*
The valiant never taste of death *but* once.
Of all the wonders *that* I *yet have heard*
It seems to me most strange that men *should fear*;
Seeing that death, a necessary end,
Will come, *when* it will come.

What is the significance and use of the Subjunctive Mood? Compare it with the Indicative Mood. Write out the Present Indicative and Present Subjunctive of the Verb, "to be."

Give the three degrees Positive, Comparative, and Superlative of five Adjectives with more than one Superlative form.

Explain the following expressions:—"The other day," "Which is which," "Methinks I saw it," "Perish the thought," "Ipso facto," "Laissez faire," "Al fresco," and "N.B."

In what different ways can differences of gender be expressed? Give examples.

Explain the terms Participle, Perfect Tense, Proper Noun, Infinite Mood, and Possessive Case. Give instances of each.

Mention any words that are spelt more ways than one. State with reasons the spelling which you prefer.

Give six words peculiar to technical engineering. Explain them and give their derivation.

Write a short essay on *one* of the following:—

(*a*) Field Sports. (*c*) Electricity.

(*b*) Bridges. (*d*) Marine Engines.

Write to dictation and punctuate the passage read.

Electrical Engineering.

What is meant by the *Resistance of a* Conductor? How does the resistance vary as the length and diameter of a wire changes? State the effect of a change of temperature upon the resistance.

Find the resistance of a copper wire 600 ft. long 0·065 inch diam. at 30° C, having given that a copper wire 1 ft. long and 1/1000th of an inch diam. has a resistance =9·96 ohms, also that $R = r\ (1 + 0{\cdot}003824\ t + 0{\cdot}00000126\ t^2)$; where r = resistance at 0° C, and R = resistance at t° C.

Explain some instrument suitable for determining the potential difference between two conductors. Make sketches of the details, as well as of the general arrangement of the parts.

Describe and sketch (*a*) a permanent magnet, and (*b*) an electro-magnet. By means of curves show the directions of and the relative intensities of the magnetic field in the space surrounding the magnets. Give the materials suitable for making the magnets sketched.

Describe and sketch an Accumulator or Secondary battery, and explain the principles underlying this method of storing energy.

What is meant by "Insulation"? State the laws of leakage, and illustrate your answer by a sketch and description of an insulator for an overhead line suitable for high voltage.

Describe and illustrate the arrangement of the circuits and connections of switch resistances and fuses for starting a shunt wound motor showing the circuits complete from the supply mains to the motor armature and field coils. Give the reasons for the particular scheme adopted.

Show how the generators are coupled up to a three-wire system of mains for a lighting supply. Explain the advantages of this arrangement of mains.

Explain and illustrate a system of mains suitable for the distribution of current for the lighting plant of a passenger steamer, giving the conditions that must be satisfied to ensure safety.

Sketch and describe the construction of any instrument suitable for indicating continuously the magnitude of the current carried by a conductor. Explain the principles involved in its construction, and state if the instrument described requires calibration.

LLOYD'S REGISTER SCHOLARSHIP.

The following questions, which were set for the examination held in July, indicate the requirements for candidates, and are published with a view to give information on the subject, so that preparatory studies may be entered upon for next year's examination by probable candidates:—

Arithmetic and Algebra.

Given that the solid contents of a square box is 792 cub. ins., and its depth is $5\frac{1}{2}$ inches. Find its length in centimetres.

Two cogged wheels work together, there being 32 cogs on one and 36 cogs on the other. The larger wheel makes 64 revolutions per second. How often will the same cogs come into contact during six working days of 10 hours each?

A founder is required to supply a ton of fusible metal, consisting of eight parts by weight of bismuth, five of lead, and three of tin. The only bismuth he has in stock is in an alloy consisting of nine parts bismuth, four of lead, and three of tin. How much of the alloy must he take and how much lead and tin must he add to make up the order?

A steam engine of $4\frac{1}{4}$ horse-power working 51 days of six hours consumes 25 tons of coal. How much coal will be consumed by a 17 horse-power engine working at the same work for 3 days of $8\frac{1}{2}$ hours?

Two trains start simultaneously from stations A and B, 300 miles distant from one another. After they meet, the train from A completes the journey to B in four hours, and the train from B completes the journey to A in nine hours. Find the rate of speed of each train.

Find the value of X in the following equation:

$$\frac{5X-7}{2} - \frac{2X+7}{3} = 3X-14.$$

A crew which can pull at the rate of nine miles an hour finds that it takes twice as long to come up a river as to go down; at what number of miles per hour does the river flow?

Find the values of X and Y in the equations:

$$\frac{X+Y}{2} - \frac{X-Y}{3} = 8 \ (1) \quad \frac{X+Y}{3} + \frac{X-Y}{4} = 11 \ (2),$$

Simplify $\frac{1}{(a-b)\,(a-c)} + \frac{1}{(b-c)\,(b-a)} + \frac{1}{(c-a)\,(c-b)}$

Expand $(1 + 2X \times X^2)^3$

Find the product of $A\frac{1}{2}$, $A\frac{1}{3}$, $A\frac{1}{4}$ and $A\frac{1}{5}$.

Extract the square root of $7 + 2\sqrt{10}$.

Find the sum of the first "n" natural numbers and also the sum of their squares.

General Knowledge; English History, Literature and Grammar.

> "Now stir the fire and *close* the shutters *fast*,
> Let *fall* the curtains, *wheel* the sofa *round*,
> And while the bubbling and *loud* hissing urn
> Throws up a steamy *column*, and the cups
> *That* cheer *but, not inebriate*, wait on each;
> So let us *welcome* peaceful evening in."

Analyse the above passage and parse the words in italics.

From what source is the word "sofa" derived?

Mention other words derived from the same source.

To what dates and events would you assign the adoption and discontinuance of French as the language of the court and nobility of England?

Name the authors of the following works and give a short sketch of one of them: "Paradise Lost," "The Faëry Queen," "Vanity Fair," "Robinson Crusoe," "The Task," "Kenilworth," "The Excursion," and "The Idylls of the King."

Give a noun, an adjective and a verb formed from each of the following Latin words: *disco*, *sedeo*, *scribo*, *verto*, *duco*, and *dico*.

Explain the terms "metaphor" and "simile," and give appropriate examples.

Discuss the advantages and disadvantages of electricity as a motive power.

What metals are must useful in engineering? Describe their origin, preparation, and applicability.

Geometry.

Through two given points on opposite sides of a given line, draw two straight lines which shall meet in that line and include an angle bisected by it. What is peculiar in the cases where the points are equidistant from the given line or where they are both in the perpendicular to it from one of them?

Prove that the diagonal of a rhombus bisects each of the angles through which it passes. Construct a rhombus containing six square inches and having an angle of 45°; measure the longer diagonal.

The sides AB, AC, of the triangle ABC are bisected in E and F respectively; a perpendicular is drawn from A to the opposite side, meeting it at D. Show that the angle FDE = angleBAC. Show also that AFDE = $\frac{1}{2}$ ABC in area.

If a quadrilateral be described about a circle, the angles subtended at the centre of the circle by any two opposite sides are together equal to two right angles. Construct a quadrilateral having sides 1in., $1\frac{1}{2}$ins., 2ins. and $2\frac{1}{2}$ins. and measure its three diagonals.

Describe an isosceles triangle having each of the angles at the base double of the third angle. If the base of such a triangle measure 1·5in., what is the area of the triangle?

Describe a circle which shall pass through two given points and which shall touch a given straight line.

Mechanics: Principles and Problems.

A railway train, the mass of which is 126 tons, rests on an incline and is kept from moving downward by a force equal to a weight of 15 cwts. What is the slope of the incline?

What resistance does a nut offer when placed in a pair of nut crackers, at a distance of $\frac{3}{4}$in. from the joint, if a pressure of 5 lbs. at a distance of 4ins. from the joint is just sufficient to crack it?

A body falls in air from a height of 4,000 metres. Find the time of its fall and its velocity when it strikes the ground.

If A, B and C are any three points in a straight line and O any point not in that straight line; if a force represented in magnitude and direction by OA act from O to A, another force BO, from B to O and a third CO from C to O. Show that the resultant of these forces cuts the straight line ABC in a point D such that AB = CD.

P lbs. is greater than Q lbs. Each is attached to a separate string of an Atwood's machine. Above the mass of Q lbs. is placed a mass $\frac{P^2 - Q^2}{Q}$ lbs. which can be detached in the ordinary way during the motion. The system starts from rest and moves for "t" seconds at the end of which $\frac{P^2 - Q^2}{Q}$ is detached Show that in "t" seconds more the system will be at rest for an instant and that then the motion will be reversed in direction.

Explain the terms "centre of pressure" and metacentre as applied to bodies in contact with liquids.

Practical Engineering.

State what you know of the formation of scale in a marine boiler. What are its chief constitutents and in what way other than by the use of fresh water may its formation be largely prevented? In a ship making a long voyage during which fresh water is not available for feeding the boilers, what is the maximum density that you would permit in them? Give your reasons for fixing this limit; how would it be maintained, and what would be the results of allowing a greater or a less density?

Sketch and describe two methods of connecting the furnaces of a marine boiler to the combustion chambers, showing how the joints of the plates are worked, and state the advantages of each.

A higher vacuum is usually carried in turbine than in reciprocating engines. Explain fully the reasons for this practice and the causes of the greater economy resulting from it.

The pressure of steam in a boiler fitted with a spring-loaded safety valve of ordinary construction is found to rise when steam is blowing off, although the valve is of ample size and the various parts in free working order; explain the probable cause of this and state what alteration you would suggest to prevent it.

State how you would ascertain the actual amount of pressure existing in a condenser and explain the effect of the temperature of the condensed steam in connection with this pressure.

What advantages are derived from ball roller bearings? Give sketch and description of a type which has come under your notice.

Describe, with sketch, the propeller shaft giving the necessary diam. for 600 h.p. to meet the Board of Trade rule. State systems of lubrication you know to be used for the stern tube bearings.

Describe the propeller and how it is built up and fitted on the shaft. State what different types of blades are used with a view to economy in running, including consideration of the renewal and repair problems.

Sketch and describe a form of link motion used in a modern marine engine. What are the chief advantages of the one you describe?

Why did Watts' invention of the condenser effect great economy? Why does condensation take place in the cylinder of a modern steam engine cylinder, and how do we attempt to get rid of it?

Sketch and describe the construction of the air-pump bucket with its valves and packing. Of what materials are the body of the bucket and of the valves respectively made? State also what you know of the different types of air-pump and the advantages claimed for each.

The diameter of the cover of a steam engine cylinder has 14 one inch stud bolts; the diameter of the bore of the cylinder is 20 inches; the maximum steam pressure is 200 lbs. per square inch. Find the stress of the bolts due to the steam pressure, assuming that the joint covers the whole width of the flange. The diameter at the bottom of the thread of a 1in. bolt = ·84in.

State the relative advantages and disadvantages of Diesel engines compared with steam engines and boilers for large ships.

Describe the most important job you have been engaged at in the workshop, whether in the machine or fitting department.

State the mechanical advantages and disadvantages of steam turbines in marine engines; explain the action of any steam turbine you are acquainted with.

STATICS, DYNAMICS, THERMODYNAMICS, AND HYDROSTATICS.

Define velocity constant and variable. Express a velocity of 1,800 miles per day in feet per second.

Define acceleration constant and variable. Compare the following accelerations: (*a*) one in which 20 ft. per second is added every minute and (*b*) one in which 20 ft. per minute is added every second.

A mass of 8 lbs. hangs by a chain 20 ft. long, the weight of which is negligible; and is pulled out by a horizontal force to a distance of 12 ft. from the vertical through the point of support. Find the tension of the chain.

Two men A and B carry a mass weighing 200 lbs. hanging from a pole between them. If the men be 5 ft. apart and the mass be 2 ft. from A, what part of the weight will be borne by each?

A cubical box, the volume of which is one cubic foot, is three quarters filled with water, and a leaden ball, the volume of which is 72 c. ins., is lowered into the water by a string; it is required to find the increase of pressure on the base and on a side of the box.

Suppose you have a cubic foot of ice at the melting temperature and that you gradually apply heat to it, what changes of temperature and volume does it undergo?

If a Fahrenheit thermometer marks 40°, what are the corresponding marks on a Reaumer and Centigrade.

TRIGONMETRY (Math. tables may be used).

Define a radian. Give its value in rectangular measure. What advantage does it posssess as a unit? Express $\frac{3\pi^c}{4}$ in rectangular measure ($^\circ\ '\ ''$) and 180° in circular measure.

In a circle, whose radius measures 4 ft. what is the length of an arc of 80° and what angle subtends an arc measuring 3 ft.?

$A = 90^\circ$ $B = 60^\circ$, $C = 30^\circ$ and $D = 45^\circ$. Prove that $\cos^2 C - \sin^2 C = \cos B$ and that $2 \sin D \cos D = \sin A$.

Prove by geometrical method the formula:—

$\text{Sin}\ (A + B) = \sin A \cos B + \cos A \sin B$, and shèw that $\cos 75^\circ = \frac{\sqrt{3} - 7}{2\sqrt{3}}$.

Prove that $\sin 5 A \sin A = \frac{1}{2} (\cos 4 A - \cos 6 A) = (\sin^2 3 A - \sin^2 2 A)$ and that $\frac{\sin A + \sin 3 A}{\cos A + \cos 3 A} = \tan 2 A$.

At a distance of two miles a church tower is seen along a horizontal plane to subtend an angle of 1° 5′ 6″. Find its approximate height.

If $s = \frac{a + b + c}{2}$ where a, b and c are the lengths of the sides of a triangle, shew that the area is expressed by $\sqrt{s (s-a) (s-b) (s-c)}$. If a = 16 ft. b = 8 ft. and c = 12 ft. find the area of the triangle.

Two observers 1,000 yards apart and in the same vertical plane with a balloon, but on opposite sides of it, take its angles of elevation at the same moment 36° and 54°. Determine the height of the balloon.

Two mountain peaks are 4,970 yards apart and the angle of elevation of the higher one as seen from the other is 9° 14′. How much higher is the one than the other?

The following named candidates for the Lloyd's Register Scholarship having passed the examination creditably were each accorded a scholarship of £100 per annum for three years by the Committee of Lloyd's Register.

Chas. H. Turner, Tynewydd Road, Barry, Glam. Graduate.
John Knox Brown, Hill Road, Barrow-in-Furness. Graduate.

Review of Books presented to the Library.

Report of the Committee of the Institution of Civil Engineers appointed to investigate the deterioration of structures of timber, metal, and concrete, exposed to the action of sea-water, edited by P. M. Crosthwaite, M.I.C.E., and G. R. Redgrave, Assoc. I.C.E. Civil engineers and others interested in the maintenance of wharves, jetties, etc., should find this report very useful. It contains numerous illustrated accounts of decay in structures, from different parts of the world.

Ships' Boats.—E. W. Blocksidge. *Longmans, Green & Co.* 25/-.—A very thorough and comprehensive volume on this important subject, which will be of great value to shipmasters and superintendents.

Electricity (5 volumes) *Bennett College*.—A useful descriptive work for beginners, which, with little reference to mathematics, covers a wide field, commencing with the first principles of magnetism and electricity and embracing telephones, dynamos, motors, power-house practice, etc. Special chapters deal with wireless telegraphy and cinematograph work.

Modern History of Warships, by Wm. Hovgaard, late Commander Royal Danish Navy. *E. & F. N. Spon*, Haymarket, S.W.1. 42/-.—Contains much valuable information relating to the development of warships from the early part of the last century when iron, steam power, and armour commenced to be introduced, up to 1919; and also deals with guns, projectiles, mines, and torpedoes. A very useful book for those interested in naval matters.

Proposed Increase of Fees Meeting.

In accordance with the official notice to members issued in April, and the subsequent reminders, a meeting was held in the Lecture Hall on Friday, Sept. 3rd, presided over by Mr. A. Boyle, Vice-President, when the notice convening the meeting was read as follows:—As a result of the discussion on the subject at the Annual Meeting on March 26th, the following resolution was passed and remitted to the Council to deal with: "That the Entrance Fees, Annual, and Life Subscriptions of all grades of the membership of the Institute be increased by 50 per cent., excepting only the Graduate Section, which shall remain unchanged." The Council at the meeting on April 13th discussed the subject and endorsed the terms of the resolution. An extraordinary General Meeting of members is herewith called for Friday, September 3rd, at 5.30 p.m., to ratify the resolution.

The Chairman, in opening the proceedings, stated that while averse to increasing the fees, he had carefully considered the subject, and examined the conditions, especially the increased costs in connection with the valuable monthly issue of the Transactions, and it seemed to him that it was desirable to view the resolution favourably. The views of members should now be expressed freely and openly.

Mr. J. B. Hall supported the resolution on the ground that the advances in costs of material with the higher wages justified the increases proposed.

Mr. B. P. Fielden expressed the view that the operations of the Institute had been carried on from the start on very economic lines, and in studying the expenses to see where these could be cut down he had found none which would warrant exception being taken to. The Transactions were sent to all on the roll, including the Graduates, who paid a small fee which only covered about one-third of the cost of the transactions alone, the desire being to help and encourage the apprentices educationally. Messrs. Wm. McLaren, J. B. Harvey, and F. O. Beckett would have preferred to exempt the entrance fees from the 50 per cent. increase if such could be done, without detriment to the finances of the Institute.

Mr. Whiteside said that the Resolution was fully discussed at the Annual Meeting, and agreed to with unanimity, since then there has been time for all to consider it, and many who were not at that meeting have expressed the opinion that it was necessary as costs have so much increased, and several members have already sent contributions in advance to assist the finance department of the Institute.

After further comments it was unanimously agreed that the resolution be passed, when the Chairman put it to the meeting.

The Hon. Secretary gave notice that another meeting would be held on Friday, September 24th, at 5.30 for confirming the resolution.

At the subsequent meeting held on September 24th the Resolution was unanimously confirmed. The chair was occupied by Mr. A. Boyle.

JAS. ADAMSON,
Hon. Secretary.

SLACK MANHOLE DOORS. — A joint blew out in one of the boilers of a dredger last November, and the result of the Board of Trade enquiry which was conducted by Mr. J. M. Binmore, showed that largely due to corrosion, the spigot was 25/32nd inches smaller than the manhole; the joint blew out and scalded the engineer, who was examining it at the time, on account of leakage showing at the door of the other boiler. The steam pressure was not high, and fortunately the scalding was not serious. These cases emphasise the importance of careful watching and examination.

Engineer-Lieut. G. Hollins, R.N., has forwarded the following interesting note:—I have recently seen at Messrs. J. W. Kirkham's, Ltd., Lark Street, Brass Works, Bolton, an old scrap phosphor bronze propeller blade being cut up and which indicates porosity in the centre of casting which it is considered might be of interest. The metal shows normal over whole surface on first being cut, but the portions which have been sawn off and laid aside are exuding matter which becomes green and increases in thickness the longer it is exposed to the atmosphere. This is only seen in the centre of the casting, the outer metal showing good and bright for about an inch deep from the surface all around the blade. Thickness of blade where cut is about 5 ins. and width of blade about 3 ft. The green growth on parts which have been longest exposed to atmosphere have the appearance of fungus, and is in some places $\frac{1}{4}$ in. thick. This is possibly due to the outer surface of casting cooling before the centre, and in contracting, exerting forces which tend to separate the molecules of centre portion and though the blade may have had a test bar cast with it and this test bar may have stood the tensile test, yet the blade is apparently unsound in the centre.

MEMBERSHIP NOTES.

Intimation has been received that Mr. Thos. Blacklock, Member, was awarded the O.B.E. and was also presented with a silver medal by Lloyd's for special service.

By an error the number accorded to Mr. Jas. Shanks (Vice-President) on the membership roll was printed 1368 instead of 386, as it appears in the previous year.

Alterations to Membership Roll.

The following alterations in addresses are noted :—

Jas. Allen, O.B.E., 21, Villiers Road, Southall, Middlesex.
N. A. Anfilogoff, Lathol House, Thames Haven, Essex.
R. A. B. Ayliffe, Calle Azopardo 1345 Buenos Ayres.
G. K. Baguley, Associate Member, 15, Clarkson Street, Ipswich.
E. F. Banner, 36, Tweedy Road, Bromley, Kent.
E. C. S. Bedgood, "Haworth," Sandy Road, Renfrew.
E. Beeching, Newcastle Road, Gt. Yarmouth.
E. A. Beldam, St. Chads, St. Mary's Road, Ditton Hill, Surrey.
P. R. Bray, Bank of British W. Africa, Tarquah, W.A.
Alex. C. Butcher, Nav. Dep., Sydney, N.S.W.
C. W. Coppinger, 48, Tressilian Road, Brockley, S.E.4.
R. C. Coulthard, U.S. Ship Board, Mersey House, 2, Quai Rouen, Antwerp.
Jas. Crichton, B.Sc., M.E., Messrs. Crichton, Thomson & Co., Cockspur Street, S.W.1.
F. M. Curror, 23, Ordnance Road, Southampton.
R. C. Dodgson, 86, Queen Street, Sheffield.
A. Dunbar, Princes Wharf, South Melbourne, Australia.
A. R. Evans, 5, Clive Place, Penarth, Cardiff.
Thos. H. Fenner, 4, Spadina Road, Toronto, Canada.
Herbert A. Fleet, 9, Rue de l'Amiraute, Tientsin, China.
H. E. Fletcher, 21, Northwood Road, Forest Hill, S.E.
S. G. Gordon, 4, Lloyd's Avenue, London, E.C.3.
J. Hannah, 303, Coldharbour Road, Redlands, Bristol.

Geo. J. Harman, Chin. Mar. Cust., York Buildings, Chater Road, Hong Kong.
G. O. Hollins, D.S.C., Admiralty Engineer Overseer, 37, Arcade Chambers, St. Mary's Gate, Manchester.
W. W. Houfe, Palace Hotel, Shanghai.
W. J. Lapper, "Merton," Hertingfordbury Road, Hertford.
J. G. Latta, Fairford, Maughline, Ayrshire.
Lindsay, J., Government Dock Yard, Dawbona, Rangoon.
R. L. Logan, 18, Norwich Road, Forest Gate, E.7.
Donald Macdonald, Flat A, 19, Pembridge Square, London, W.2.
Duncan McDonald, Staghurst, Stornoway.
A. E. Millward, Royal Naval Barracks, Shotley, Harwich.
Jas. Macgregor, C.M.G., Messrs. Crichton, Thomson and Co.
W. Pollock, Wybourne Grange, Tunbridge Wells.
V. B. Ratsey, 14, Water Street, Liverpool.
R. Reeves-Moore, 30, Victoria Street, Germiston, Transvaal.
Richard B. Rennell, British Oxygen Co., Sydney Street West, Belfast.
J. W. Richardson, B.O.T. Office, 73, Robertson Street, Glasgow.
J. Rossolymos, 86, Leadenhall Street, E.C.3.
Chas. de Grave Sells, O.B.E., 5, Via Ponte Calvi, Genoa.
D. Smail, 105, West George Street, Glasgow.
W. Smart, Ings Avenue, St. Clair, Dunedin, New Zealand.
H. J. Sonne, Lloyd's Register of Shipping, Frederiksgrade, 12, Copenhagen.
C. W. Starnes, 7, Foxbourne Road, Balham, S.W.17.
J. Stericker, 18, Beulah Hill, Norwood, London, S.E.19.
Jas. Stewart, Dunedin, Banchory, Kincardineshire.
M. Swanston, 222/5, Strand, W.C.2.
H. J. Turner, Companion, Spring Field, Hawk Green, Marple, Stockport.
A. Ward, Associate Member, Hugh Dene, North Road, Clayton, Manchester.
W. A. White, Pearl Assurance Building, Northumberland Street, Newcastle-on-Tyne.
Chas. Williams, 3, St. John's Square, Cardiff.
Jas. Wood, Rhodesian Trading Co., Buluwayo.
P. B. Wells, Graduate, 24, Laburnum Avenue, Wallsend.

The Machine Tools and Engineering Exhibition held at Olympia is an exceedingly good one, and the promotors are to be congratulated on the visible results. The improvements made in the manufacture of Machine Tools and the advances in construction to meet new and growing requirements in the Engineering Industry were very marked. To the older visitors, keenly interested in the changes made since the days of their apprenticeship, the tools and appliances, with means for accurate adjustment to save time and labour, were noted and studied, while visitors of the younger generation were also keenly alive to the possibilities before them. The gallery, as well as the main body of Olympia, was fully occupied, the stands of Exhibitors throughout showed the fruits of their industry and efforts to supply up-to-date machinery with accurate appliances for increasing output and diminishing time and labour in the process. The visit was both interesting and educational and our thanks are accorded to the promoters for their courtesy towards us.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

Patron: HIS MAJESTY THE KING.

SESSION 1920-21.

President: LORD WEIR OF EASTWOOD.

VOLUME XXXII.

The Screw Propeller.

The Evolution of a New Type.

BY MAJOR J. H. W. GILL, O.B.E. (Member).

READ

Tuesday, October 12, 1920, *at* 6.30 *p.m.*

CHAIRMAN: MR. J. B. HALL (Member).

DURING the past three-quarters of a century the screw propeller has received the attention of many eminent mathematicians and experimentalists. Its action has been explained by several different theories, some of which are duly supported by mathematical proofs, and the results of much laborious and carefully conducted experimental work are recorded in various publications.

In spite, however, of the amount of attention devoted to this subject the need for fuller investigation is admitted by the best authorities, even when the screw propeller is considered apart from the effects of, and on, the hull of the vessel to which it is attached.

When dealing with a complex subject it is advisable to confine the investigation, in the first place, to considerations affecting the prime essential, which in this case is the screw propeller itself, apart from hull effects, and to arrive at a clear conception of the first principles involved, in so far as these can be ascertained.

Probably the clearest fundamental definition of a screw propeller is that given by Mr. G. S. Baker, who states that:—

> " A screw propeller is a means of pushing a ship forward by thrusting water aft ";

while Mr. S. W. Barnaby has condensed the elementary theory of propeller action in the following words:—

> " If the weight of the mass of water acted upon by the propeller in pounds per second = W, and if the sternward velocity in feet per second imparted to it in relation to still water = S, then the reaction which constitutes the propelling force is $\frac{W.S.}{g}$, where "g" = 32·2 feet per second."

This fundamental conception of the general principle of the operation of a screw propeller constitutes a starting point from which the study of propeller action may be undertaken; and the further this study is pursued, the more apparent becomes its complexity.

If a screw propeller merely acted upon a column of water of approximately its own diameter and pushed this column directly aft, then its action would be fully explained on simple theoretical grounds.

In practice, however, a propeller acts upon a column of water which has a diameter greater than its own, on the intake side, and contracts to considerably less than its own diameter, on the discharge side; this contraction of the whole column of water directly acted upon depending on the acceleration imparted to the water by the screw, and only a small portion of the total acceleration and consequent contraction taking place while the water is actually passing through the screw. Furthermore, the column of water acted upon is given a spiral motion by reason of the rotation of the propeller, is disturbed by centrifugal action while in contact with the blades of the propeller, and is incomplete as a column on the discharge side, owing to blade interference and other causes tending to unequal acceleration and pressure values over different portions of the section of the column.

These variants of the simple fundamental conception of propeller action all come into operation even when the propeller is working under conditions as nearly ideal as can be practically attained, while further complications are introduced by the effects of blade thickness, form, and pitch. If air is taken down from the surface, or released from the water, still further disturbance of theoretical conditions occurs, apart from the true cavitational effect which obtains when the total head of the water acted on by an immersed propeller is insufficient to balance the velocity of flow necessary to follow up the blades of the screw.

In view of the numerous departures from ideal conditions of operation, which are inseparable from the working of propellers in actual practice, it is evident that the assumptions which are necessary as a basis for any serviceable theoretical treatment of the subject must be modified in accordance with the results obtained from consistent and carefully conducted trials, carried out with models of a reasonable scale under conditions resembling those of actual practice.

A long series of such trials was carried out by the Messrs. Froude in this country and by Admiral Taylor in the United States, and the results of these trials, supplemented by the less exhaustive work of other investigators, and by observations of full scale trials, have at least served to establish the principle of similitude as applicable to screw propellers and to lay down certain broad rules for propeller design which have been summarised by Mr. Peter Doig, as follows:—

"The best diameter to use (for a screw propeller) is closely proportional to the fifth root of the horse power, inversely proportional to about the six-tenths power of the revolutions per minute; and practically independent of the speed of the boat"; also "The pitch ratio, or $\frac{\text{Pitch}}{\text{Diameter}}$ varies inversely with the value $\frac{\text{Diameter} \times \text{Revolutions.}}{\text{Speed.}}$"

It is also generally accepted as the result of experiment that "gaining pitch," though theoretically desirable, has proved to be of little if any value with the open type of screw propeller; that small bosses, thin blades, and high finish make for efficiency; that in many cases it is of practical advantage to work at a relatively high slip, and that notwithstanding the labours of many eminent men, much remains to be established on the subject of screw propeller design, especially in the case of high revolution speeds.

Now there is a quantity of published information extant which, if carefully analysed, appears to point towards one solution of the problem of high-speed screw propellers and to indicate that the most satisfactory method of approaching the investigation is by consideration of, and experiment on, the actual conditions of flow through and around typical screw propellers revolving in a water channel of relatively large sectional area.

The Theorem of Bernonilli relating to fluid flow defines the conditions as to pressures and velocities in an accelerated stream, under ideal circumstances.

The writings of Mr. R. E. Froude deal minutely with the theoretical aspect of the acceleration and contraction of the stream of fluid acted upon by the propeller, and postulate a theoretical " Actuator ", which takes the place of the propeller and satisfies the conditions of rational analytical treatment of ideal cases.

The pressures (and consequently the velocities) obtaining around typical model screws are recorded in the diagrams plotted for a variety of experimental conditions in Admiral Taylor's work.

Considerable information is contained in a paper dealing with " Tests on Model Propellers," by Mr. J .L. Hodgson.

Sir Charles A. Parsons and Mr. S. S. Cook have proved that in the case of a water siren, which possesses certain resemblance to that of a propeller, the erosive effect of cavitation was eliminated by confining the tail race in a short nozzle; and, finally, several mathematicians have shown that propeller action can be accounted for by attributing its effect to certain forms of vortex flow.

Careful consideration of a mass of published theoretical and experimental work, dealing directly and indirectly with conditions of fluid flow analogous to those obtaining in the region of a working screw propeller has led to the conclusion that this flow, in the immediate vicinity of the propeller, closely resembles that of a spiral vortex.

The screw propeller in operation imparts both axial acceleration and whirl to the column of water acted upon and the column contracts under its impressed velocity, while this action takes effect from some distance ahead of the propeller and extends to some distance astern thereof. A close imitation of a natural spiral vortex must therefore be formed in a portion of the column of water acted upon, disturbed only by the interference of the propeller itself.

Further consideration of records of actual conditions obtaining in propeller race and in vortex flow indicates that, in order to prevent disturbance of what appears to be almost natural vortex action and also to obtain the benefit of a controlled tail race, which is found to result from the water siren experiments, it is desirable to surround the propeller by a nozzle shaped shroud of vortex contour, occupying the position of the "tube" referred to in Mr. R. E. Froude's conception of a theoretical "Actuator."

Experience gained with propellers operating near to, or closely surrounded by any fixed surface has shown that it is preferable to fix the shroud to the blade tips and make it part of the revolving propeller, at the expense of augmented external friction, rather than to incur the eddy losses obtaining between the blade tips of a revolving propeller operating at small clearance within a fixed shroud of any form. During the course of the investigation, photographs were taken of the actual flow of water through typical propellers under various conditions of operation, also of the flow conditions obtaining in spiral vortices, originated by mechanical stirring but allowed to assume natural conditions. The result of comparing the contours of the flow obtaining in these two sets of records was an extraordinary agreement between the curves of contracting flow under acceleration, in the two cases; and an analysis of the curves of contraction proved that semi-hyperbolic curves of the nature $y\,x^2 = \text{constant}$, fitted the conditions of flow through a working propeller equally with those obtaining in a natural vortex.

Before developing these analytical results, early experiments had been carried out with model propellers of 5 inches diameter by 4 inches pitch, both in an open or normal state and when fixed in nozzle shrouds of curvatures calculated for $a \times v = \text{constant}$, where "a" is the cross sectional area and "v" the velocity of flow, the shrouds being made of various lengths, and revolution speeds of values up to 3,200 per minute being employed.

The results of these experiments showed that at the same immersion and speed of current the shrouded screws absorbed slightly more power for the same revolution speed, did not take air from the surface so readily as did the open screws, could be run at much higher speeds of revolution without incurring fluctuations in the thrust, and produced a markedly less disturbed wake.

Further experiment proved that there was no measurable loss of power in the nozzling of the water stream, that the difference in power input for the same revolution speeds was accounted for by the surface friction outside the shroud, that this loss was considerably less than had been anticipated, that the shroud could be curtailed at the intake side without loss of efficiency, but was very sensitive to alteration of length on the discharge side, and that the curvature of shroud most nearly resembling the contour of a vortex produced the best results.

The theoretical conditions which appear to govern the design of a shrouded screw propeller were subsequently examined in detail, and the relations obtaining between shrouded propellers and correctly designed open screws for the same power input and revolutions, were investigated at considerable length.

The results of this examination can best be illustrated by taking the simple case of replacing a propeller of the normal open type, for which the horse power input, revolutions, and conditions of working are known, by one of the shrouded pattern; though this illustration is only cited as a mean example and cannot be taken as applying to all cases.

An average taken of the recorded results of a large number of published and original experiments with typical model screws of pitch ratios varying from ·8 to about 1·5, and working over a fairly wide range of slip, shows that, taking the diameter of the propeller as a unit, D, the total axial length of the disturbance due to the action of this propeller, on the intake side, amounts to about 1·5D, that the minimum diameter of the tail race is about ·7D and that this minimum section occurs at slightly over ·4D astern of the mean plane of the propeller disc. The distance to which the disturbance extends astern of the smallest section of the race is not well defined but it cannot be taken as less than about 2D.

Recorded results give values of from ·6D to ·85D to the diameter of the smallest section of the race, and place this smallest section at from ·22D to ·62D astern of the propeller disc; but the numerical mean of a number of reliable observations can be taken at ·7D and ·416D.

Now the result of recorded observation has indicated that the stream of water acted upon by the propeller contracts between the propeller disc and the smallest section of the race according to the mean values given above, and in accordance with a vortex shaped form of which the boundaries conform to semi-hyperbolic curves of the nature yx^2 = constant; the "y" axis being parallel to or coincident with that of the propeller shaft, and the "x" axis being at right angles thereto and somewhere ahead of the propeller.

Applying this information to the case of replacing an open propeller of 10 units diameter (the units being inches feet, or any other linear measure) by a shrouded screw to work at the same horse power and revolutions:—

Propeller diameter $D = 10$;

Diameter of smallest section of race $\cdot 7D = 7$;

Distance of smallest section of race from mean plane of propeller face $\cdot 416D = 4\cdot 16$;

Boundary curve of contraction of race from propeller diameter, 10, to smallest diameter of race, 7, (or hyperbolic curve passing through "x" ordinates $\frac{10}{2}$ and $\frac{7}{2}$ which are 4·16 apart on "y" axis) is found to have a constant value of $yx^2 = 100$, with the axes intersecting at a zero point 4 units ahead of D.

These data, on being plotted, evidently give the boundaries of the mean natural contraction of the stream of water acted upon, from the propeller disc to the smallest section of the race.

Now the area of any transverse section of this contracting column is proportional to the square of its diameter; therefore the area at D of 10 units diameter is to the area of the smallest section of the race, of 7 units diameter, as 100 is to 49; consequently, the axial velocity of the contracting column, which varies inversely as the area, has a little more than doubled in value between the mean plane of the propeller disc and the smallest section of the race, in the average case quoted. It therefore becomes apparent that the propeller of diameter D may be replaced by a smaller propeller, placed further along the race and bounded by the contracting column; but this smaller propeller must have axially increasing pitch, the pitch at any transverse section in the contracting column being related to the pitch of the original propeller of diameter D, inversely as the square of the diameter at that section is to the square of diameter D, without taking into account any angular variation in the whirl.

Experiment has shown, however, that this smaller propeller would derive little, if any, benefit from its theoretically correct increasing axial pitch, and would lose in efficiency by reason of churning effect, unless it be encased in a shroud. The contour required for such a shroud is obviously defined by the hyperbolic curve bounding the contraction of the column of water acted upon, and we thus arrive at the main features affecting the design of what may be termed the "Vortex" type of screw propeller.

It will here be instructive to consider a diagram which has been plotted, in accordance with observed results, to illustrate the nature of the curves bounding the contracting flow between the propeller disc and the smallest section of the race, in the mean case which shows a contraction from D 10 to D 7 in 4·16 of length, and in the two extreme quoted cases of D 10 to D 6 in 2·2 of length and D 10 to D 8·5 in 6·2 of length. The hyperbolic curves of the nature yx^2 = constant, which have been observed to form the contour of the contracting column in the immediate vicinity of the screw, have the radii of the respective sections of this column as their "x" ordinates and the axial distances intercepted between these sections as the differences between the lengths of the corresponding "y" ordinates. The value of the constant for the equation to the curve of contraction in each of the cases named is readily determined from the radii at the propeller disc and at the smallest section of the race, taken in conjunction with the intercepted axial distance between these radii, after first determining the unknown "y" values, as follows:—

Denoting the two "x" ordinates in each case by x and x_1, and the corresponding "y" ordinates by y and y_1.

For the Mean Case. (2.)

D 10 gives ordinate $x = 5$ (and $x^2 = 25$).
D 7 ,, ,, $x_1 = 3{\cdot}5$ (and $x_1^2 = 12{\cdot}25$).
"y" ordinate corresponding to $x = y$
,, ,, ,, ,, $x_1 = y_1 = (y + 4{\cdot}16)$.

Then $y \times x^2 = y_1 \times x_1^2$.

$$y \times 25 = (y + 4{\cdot}16) \times 12{\cdot}25.$$
$$y \times 2{\cdot}04 = y + 4{\cdot}16.$$
$$y + 1{\cdot}04\,y = y + 4.16.$$
$$y = \frac{4{\cdot}16}{1{\cdot}04} = \underline{4.}$$
$$\text{and } y_1 = 4 + 4{\cdot}16 = \underline{8{\cdot}16}.$$

Substituting in yx^2 = constant.

$$\left.\begin{array}{r} 4 \times 25 = 100 \\ 8{\cdot}16 \times 12{\cdot}25 = 100 \end{array}\right\} \text{constant for curve.}$$

FOR HIGHER EXTREME CASE. (1.)

D 10 gives ordinate $x = 5$ (and $x^2 = 25$).
D 6 ,, ,, $x_1 = 3$ (and $x_1^2 = 9$).
"y" ordinate corresponding to $x = y$.
,, ,, ,, ,, $x_1 = y_1 = (y + 2{\cdot}2)$.

Then

$$y \times x^2 = y_1 \times x_1^2.$$
$$y \times 25 = (y + 2{\cdot}2) \times 9.$$
$$y \times 2{\cdot}78 = y + 2{\cdot}2.$$
$$y + 1{\cdot}78\,y = y + 2{\cdot}2.$$
$$y = \frac{2{\cdot}2}{1.78} = 1{\cdot}24.$$
$$\text{and } y_1 = 1{\cdot}24 + 2.2 = 3{\cdot}44.$$

Substituting in yx^2 = constant.

$$\left.\begin{array}{l} 1{\cdot}24 \times 25 = 31 \\ 3{\cdot}44 \times 9 = 31 \end{array}\right\} \text{constant for curve.}$$

FOR LOWER EXTREME CASE. (3.)

D 10 gives ordinate $x = 5$ (and $x^2 = 25$).
D 8·5 ,, ,, $x_1 = 4{\cdot}25$ (and $x_1^2 = 18{\cdot}06$).
"y" ordinate corresponding to $x = y$.
,, ,, ,, ,, $x_1 = y_1 = (y + 6{\cdot}2)$.

Then

$$y \times x^2 = y_1 \times x_1^2.$$
$$y \times 25 = (y + 6{\cdot}2) \times 18{\cdot}06.$$
$$y \times 1{\cdot}384 = y + 6{\cdot}2.$$
$$y + {\cdot}384\,y = y + 6{\cdot}2.$$
$$y = \frac{6{\cdot}2}{{\cdot}384} = 16{\cdot}14.$$
$$\text{and } y_1 = 16{\cdot}14 + 6{\cdot}2 = 22{\cdot}34.$$

Substituting in yx^2 = constant.

$$\left.\begin{array}{l} 16{\cdot}14 \times 25 = 403{\cdot}5 \\ 22{\cdot}34 \times 18.06 = 403{\cdot}5 \end{array}\right\} \text{constant for curve.}$$

The hyperbolic contour of the contraction of the column of water directly acted upon is, however, shown by photographic records of the flow through propellers in operation, and also deduced from the curves of pressures existing around a working screw, to obtain only for a short distance ahead and astern of the propeller. The explanation of this fact appears to be that it is only when fairly close to the intake side of the screw that a whirling motion is imparted to the column of water acted upon and that immediately after the smallest section of the race is reached the column begins to expand under frictional retardation. The curves plotted from the foregoing data serve to exemplify the conditions obtaining in the cases of medium, high, and low true slip and though it may be objected that definite boundaries assigned to the contracting column imply a fairly sharp demarcation between the velocity and pressure conditions obtaining for a short distance ahead and astern of the propeller, the fact that such a partition does exist in practice, appears to be definitely indicated by a number of experiments and by photographic records.

The length to which the shroud shall project beyond the leading edges of the blades in an axial direction, in order to counteract local eddies, and the length to which it shall project in an axial direction beyond the following edges of the blades, in order to secure a complete race column, are largely matters of experiment and experience, small departures from the provedly correct values, especially on the discharge side, having a very marked effect on efficiency. In the case, however, of a shrouded propeller of average dimensions replacing an open screw of pitch diameter ratio equal to unity, the normal overall length of shroud can be taken as approximately one-third of D.

The axially projected length of the blades is governed by the blade area required on the thwartship projection, by the necessary pitch, and by convenience of design.

As the shrouding of the propeller overcomes the practical objections to wide tipped blades, the thwartship projection of the propeller face can have blades with radial edges, and consequently with parallel edges in the fore and aft projection.

The blades may be raked, or even curved, to act squarely on the stream of water flowing through the shroud, though little practical advantage has hitherto been found to result from such a refinement; and in the case of the boss there is little if anything to be gained by making it other than cylindrical, though its after-end must be terminated by a streamline fairwater of not less than two diameters in length.

The shrouded type of propeller may be built up or produced as one casting, both methods having been employed in practice, and, as the blade sections can be made thinner than those for an open screw and the diameter be also reduced, the extra weight of the shroud is largely compensated for.

Before considering the advantages to be obtained by the use of the shrouded type of propeller outlined in this paper, it will be well to consider the objections which have and may be advanced against it, for the reason that any such apparent innovation must necessarily be examined in a critical spirit by those versed in the art to which it applies, and must inevitably be deprecated by many whose vested interests or personal convictions are affected by a departure from accepted practice.

The particular design of propeller referred to herein is not the subject of any startlingly original invention, but merely results from collecting and applying known facts, and permissible deductions therefrom, to the solution of a definite problem. Its justification lies in results and conclusions recorded in the writings of masters of the art and in the actual experimental data obtained by observing, photographing, and analysing the flow of water through propellers of different types.

Some of the chief objections raised, and the ways in which they may be met are briefly summarised as follows:—

Objection. The shrouded type of propeller has been tried previously and has failed.

Reply. Careful search through Patent Office records, published papers, and books on propellers and kindred subjects, has failed to disclose any previous attempt to apply a correctly designed nozzle shroud fixed to and rotating with the propeller. There have been failures with encased propellers of certain types but none recorded with the type now put forward.

Objection.—Skin friction on the shroud renders the design incapable of competing with the open propeller.

Reply. There is undoubtedly skin friction on the shroud, but it is not found to increase according to the square of the velocity of rotation, as was predicted; nor is it similar to *disc* friction with the eddy making effects inseparable therefrom. Furthermore, the surface of the shroud is easily machined to a high degree of smoothness, and the frictional loss can thus be reduced to a minimum; witness the case of the shrouded impeller commonly employed in centrifugal pumps.

Objection. Attaching a contracting nozzle to an advancing propeller is similar to towing a " drogue " through the water.

Reply. This would be true if the nozzle were not doing useful work in consolidating the race column and preventing radial flow. Also the reduced pressure due to velocity of flow within the shroud implies an excess pressure on the outside of the shroud where the water is not axially accelerated, this pressure having a resolved component of forward thrust on the outside of the shroud.

Objection. A greater proportion of the total acceleration of the fluid stream acted upon takes place ahead of the screw and a less proportion astern of the screw than in the case of the open propeller acting upon an equal volume of water per revolution.

Reply. This is true when replacing an open screw by one of the shrouded type of smaller diameter, as would usually be the case, but it must be recollected that the Kinetic energy remaining in the race after the water has left the propeller, is wasted as far as propulsion is concerned. It is therefore probably advantageous for the propeller to work near to the smallest section of the race, instead of allowing a large proportion of the total acceleration and consequent contraction of the water column to take place astern of the propeller, as in the case of most open screws.

Objection. The relatively large and axially increasing pitch employed in the shrouded screw will produce excessive rotation of the race, the energy from which could only be recovered by fixed guide blades astern of the propeller.

Reply. This is partly covered by the reply to the previous objection, which deals with the desirability of acting upon the water column near to its smallest section, while the fitting of guide blades astern of the propeller, though of apparent advantage with some types of screw, introduces additional frictional surface at a position where the water stream has a high velocity.

Objection. The shrouded propeller, replacing an open screw of larger diameter, will be working at a higher slip.

Reply. The shrouded propeller will normally be working on the same water column but nearer to its greatest contraction, and it appears that the true slip, or velocity with which the water column is projected astern, does not attain its full value till the minimum race section is reached. This may account for the fact that in certain cases an improvement in performance is secured by reducing the diameter and increasing the pitch of open propellers, and at any rate indicates that in certain cases a high true slip need not necessarily imply an unfavourable overall efficiency. Additional proof of this is furnished by the good results obtained with shrouded propellers in towing, which is generally accepted as the most unfavourable condition for small diameter screws of large pitch ratio.

Objection. The curvature of any one shroud, following an assumed contraction of race column is only correct for one particular condition of true slip.

Reply. This is correct, but the same argument applies to any other type of screw propeller, in that the best efficiency is attained at one particular slip value under working conditions. In the case of a properly designed vortex type shrouded propeller it must also be recollected that the acceleration of the fluid stream consequent upon the axially increasing pitch, and the contraction of area in the shroud, are correctly proportioned one to the other.

Objection. Stern-going power must be poor or even totally absent.

Reply. There is no apparent reason why the nozzle shrouded propeller should not operate in going astern practically as an open propeller of diameter equivalent to the outlet from the shroud. Here again actual trials have proved that the stern-going power of the nozzle shrouded propeller is quite satisfactory.

Objection. Floating objects may become jammed in the contracting shroud.

Reply. This is considerably less likely to occur than that the blades of an open propeller should be damaged by such objects, and the shrouded screw is less likely to pick up ropes, nets, etc., than are the blades of an open propeller.

Objection. The weight is greater than that of an open propeller.

Reply. The diameter is normally made smaller than that of the open screw, which partly disposes of this objection; the blades may be made thinner and correct balance is easy to attain.

Objection. The manufacturing difficulties and cost are greater than in the case of an open propeller.

Reply. This is quite correct, but the process of accurate manufacture is not a difficult engineering problem with appliances of comparatively simple design, and the cost is offset by maintenance of pitch under conditions of service, and certain advantages gained.

Some of the theoretical and practical advantages which it is possible to obtain by the use of a screw propeller of correct design, carrying a nozzle-shaped shroud of suitable form, may now be considered:—

In the first place, the accepted facts are that the purpose of the device is to develop a propulsive reaction by continually pushing a mass of water astern; that the instrument employed for this service consists of from two to four short inclined planes mounted on the end of a revolving shaft whose axis lies in the direction of the required resultant reaction; and that the instrument must necessarily impart a whirling motion to the water in addition to giving it an axial acceleration.

Now, when Nature whirls and accelerates a fluid stream, the balance of pressures and velocities is arrived at in that particular form of flow which is known as vortex action, and this may be accepted as being produced with a minimum input of energy. There is obviously a parallel between propeller action and the condition obtaining in natural vortex flow; and, though it must be admitted that Nature does not institute and maintain a vortex by rotating a fluid at one point through the medium of a crude device like a propeller; also that the propeller will necessarily cause disturbances which militate against true vortex flow; and furthermore that Nature does not produce a vortex with the object of developing propulsive reaction; yet the general conditions of flow are similar, and the observed agreement between the flow through a working propeller and that in a natural spiral vortex is remarkable and convincing.

Having arrived at this stage of the argument the logical deduction is that, when designing a propeller, means should be adopted to imitate the natural condition of vortex flow, the necessary precautions evidently being to employ axially increasing blade pitch, in conformity with the natural acceleration of the stream operated upon, and to counteract radial flow and other disturbing factors, so far as possible, by encasing the propeller in a shroud of suitable contour. This is the object aimed at in the design of a "Vortex" type shrouded screw propeller, and practical results appear to justify the theoretical basis of the design.

The water is constrained to flow through the propeller under conditions which appear to be those indicated by natural laws.

The eddy effects which obtain when the tips of propeller blades operate close to a bounding surface are avoided by rotating the shroud with the propeller.

Axially increasing pitch can be employed with certainty and advantage.

Wide tipped blades can be employed without the penalty of vibration.

The race column is a complete stream instead of being a disturbed discharge.

The localisation of pressures is minimised, with resulting reduction in what may be termed "incipient cavitation."

There is a region of constant but reduced pressure around the intake to the propeller shroud instead of there being localised areas of reduced pressure behind the blade tips, approaching and receding from the surface of the water as each blade comes uppermost; and air is consequently not so readily taken down at light draft.

The "helm" or "clawing" effect of the propeller, tending to swing the stern of the vessel, is materially reduced. The effect of acceleration on one side, and retardation on the other side, of the propeller, when "pitching" or "scending," is practically eliminated.

When towing, or otherwise working at a high true slip, the water is dealt with as by an axial flow pump, and "churning" is materially reduced.

The blades of the propeller, being supported at both ends, may be made thin, the increasing pitch tending to stiffen them; and they are well protected from damage due to ice, floating obstructions, or grounding.

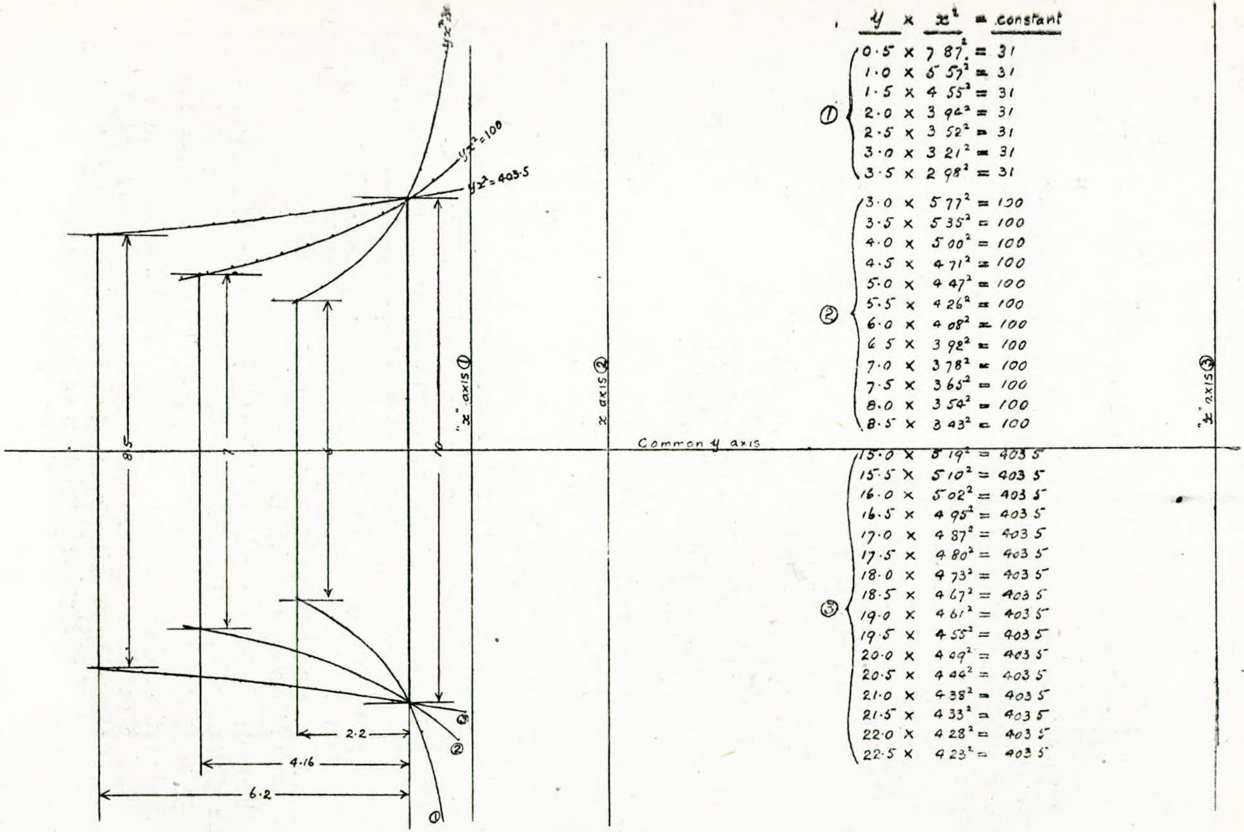
The "out of pitch" effect, which obtains when an inclined shaft is installed, is practically disposed of.

Propellers of smaller diameter may be employed, and experiments indicate that higher revolution speeds can be adopted, which may result in modification, or in certain cases elimination, of reduction gearing.

No extravagant claims for increased speed, reduced fuel consumption, etc., are made, nor is it contended that one shroud contour fits every condition.

There are also cases in which the open type of screw will undoubtedly be preferred.

It is admitted, however, by those best qualified to express an opinion that there has been little practical advance in the evolution of the screw propeller during many years past, in spite of changing conditions, and this paper is submitted to the consideration of Marine Engineers as indicating the broad outline of a design, which both theory and experiment appear to justify as a rational solution of the high speed and small diameter propeller problem.



	y	×	x²	=	constant
①	0·5	×	7 87²	=	31
	1·0	×	5 57²	=	31
	1·5	×	4 55²	=	31
	2·0	×	3 94²	=	31
	2·5	×	3 52²	=	31
	3·0	×	3 21²	=	31
	3·5	×	2 98²	=	31
②	3·0	×	5 77²	=	100
	3·5	×	5 35²	=	100
	4·0	×	5 00²	=	100
	4·5	×	4 71²	=	100
	5·0	×	4 47²	=	100
	5·5	×	4 26²	=	100
	6·0	×	4 08²	=	100
	6 5	×	3 92²	=	100
	7·0	×	3 78²	=	100
	7·5	×	3 65²	=	100
	8·0	×	3 54²	=	100
	8·5	×	3 43²	=	100
③	15·0	×	5 19²	=	403 5
	15·5	×	5 10²	=	403 5
	16·0	×	5 02²	=	403 5
	16·5	×	4 95²	=	403 5
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	21·0	×	4 38²	=	403 5
	21·5	×	4 33²	=	403 5
	22·0	×	4 28²	=	403 5
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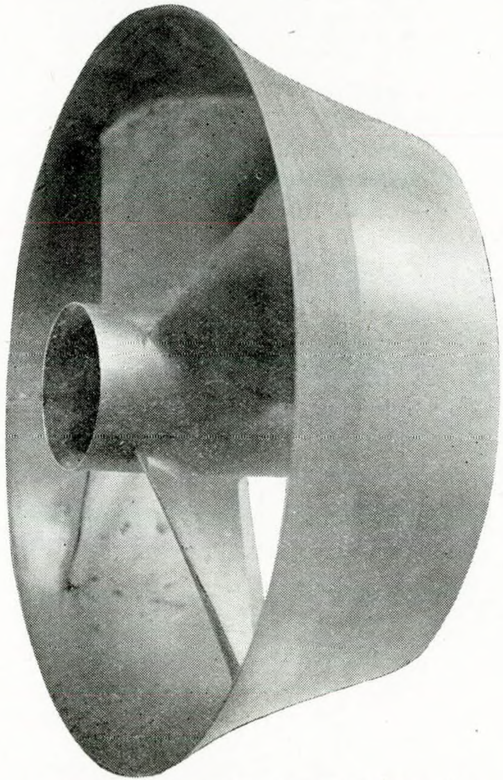
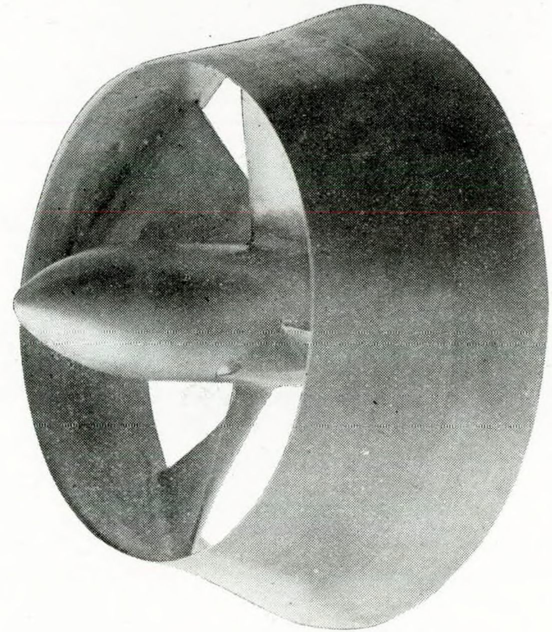
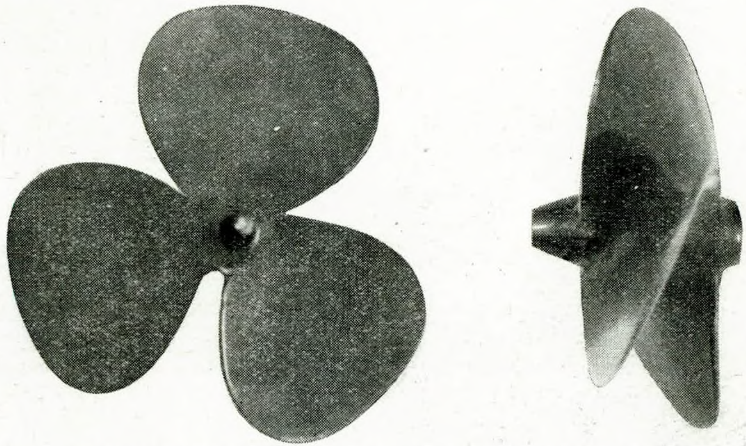
Diagram showing contours of contraction of water column between propeller of 10 units diameter and smallest section of race, in the mean and extreme cases quoted.



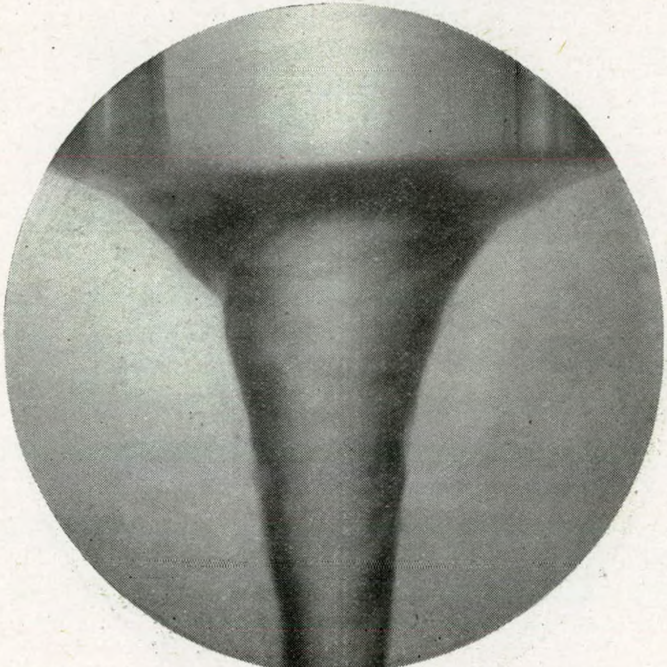
Four-Bladed Vortex Type Propeller of 8ins. mean diam. and 13ins. mean pitch.—after end.



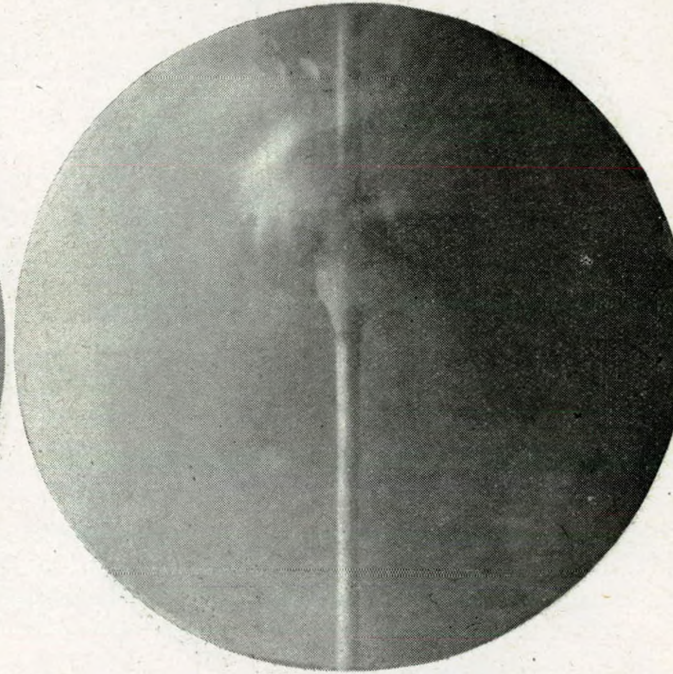
Four-Bladed Vortex Type Propeller of 8ins. mean diam. and 13ins. mean pitch.—forward end.



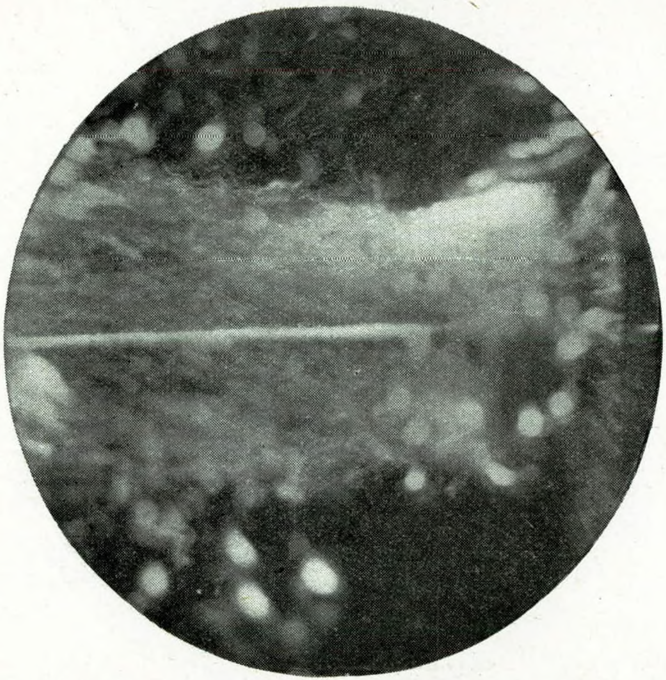
Typical Model Propeller used in obtaining photos of flow—actual size.



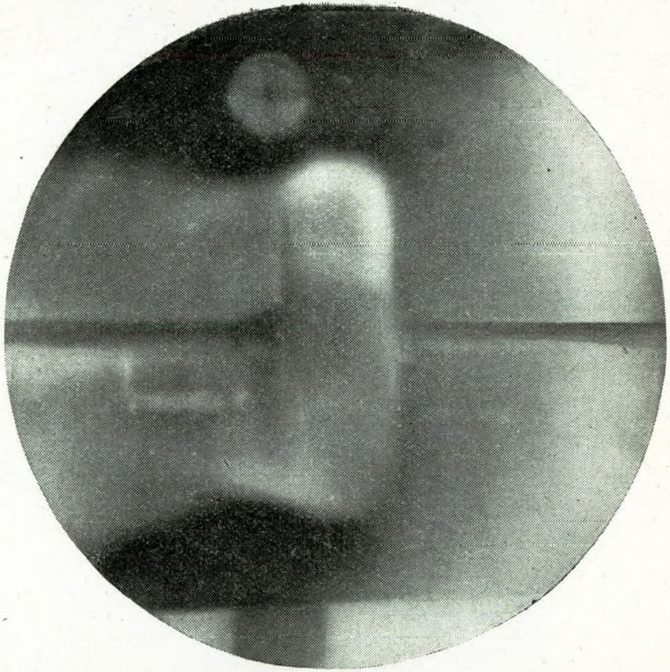
Natural Spiral Vortex in refraction free water cell—
about full size.



Typical Model Screw of open pattern rotating in water stream; note coincidence of swirl at incoming side of screw-top—with that in natural Vortex.



Typical Model Screw of open pattern, rotating in water stream, air injected to show contracting flow from intake (right) to tail race (left].



Typical Model Screw of open pattern rotating in water stream. Powder injected to show contracting flow from intake (right) to tail race (left).

Visits to Works.

Fraser and Chalmers' Engineering Works, Erith.—Members who availed themselves of the opportunity of visiting the works of Fraser and Chalmers, on September 25th, agreed that they saw something of more than passing interest. The company manufacture the Impulse Type for both land and marine steam turbine, turbo-blowers and turbo-compressors, conveying and transporting machinery, mining machinery covering the entire equipment of metalliferous and metallurgical mines including steam and electric winding engines, rolling mills equipment and seamless tube plant, and also blast furnace gas cleaning plant.

Increased, and efficiency in, production was seen exemplified; and being affiliated with the General Electric Co., Ltd., London and Birmingham, the various works of the organisation render them in a position to undertake complete contracts of any magnitude without calling upon numerous sub-contractors. Large extensions have been completed recently, and everything we saw pointed to a great endeavour in engineering progress by the British manufacturer. The party was met by representatives of the different departments, who conducted the tour through the various machine shops, explaining principles and details of different plant under construction.

It was not possible in the time to thoroughly go into all the minute details of the exceedingly interesting plant examined; perhaps the most interesting to us generally was the marine turbine of the impulse type, which Messrs. Fraser and Chalmers were the first British firm to take up the manufacture of. The set seen was in an advanced stage of completion, being the type incorporating the ahead and astern turbine in one casing and having high and low pressure turbines, the ahead power being 2,900 s.h.p. at a turbine speed of 3,500 r.p.m., this speed being reduced through double reduction gearing to 78 r.p.m. for the propeller shaft. The astern turbines developing 70% of the ahead power. High pressure and low pressure turbines are designed so that each gives half the total power developed and steam interconnecting pipes provide for either high pressure or low pressure unit ahead or astern being run independently by a simple re-arrangement of steam pipes. This includes the admission of live steam to the low pressure turbine in case of an emergency. The H.P. casing contains the high pressure ahead turbine, consisting of one velocity wheel with two rows of blades utilising a greater heat drop than a single row and consequently exposing the casing to a lesser pressure and temperature, with a number of single-bladed wheels, and also the high pressure portion of the astern turbine. Similarly, the low pressure casing embodies both the ahead and astern turbine low pressure stages. The low pressure exhaust branch leads from the centre of the casing at the bottom, to which the condenser is bolted direct, the turbine being designed to take its weight without further support or danger of distortion due to stresses from pitching and rolling.

The expansion of steam in the first stage of the high pressure ahead or astern turbines takes place in the nozzle blocks, consisting of nickel-steel nozzles, cast in special cast-iron, suitable to employ the highest possible steam pressure and temperature. For the remaining stages the nozzle openings are similarly cast with guide vanes in diaphragms which are divided horizontally, each half fitted into its half of the casing; the top halves being bolted to the casing so that they lift with the top half casing, exposing the whole of the rotor for inspection. On the inner periphery of the diaphragms are fitted glands of the labyrinth type, effectively sealing the leakage of steam between the stages. The shaft packings are also of the labyrinth type to prevent the leakage of steam out, or air into, the turbine, and consist of cast-iron boxes carrying on their inner periphery a number of brass rings which are caulked into grooves in the boxes. These rings have knife edges which practically touch a steel sleeve which is pressed and keyed on to the rotor shaft. Between each brass sleeve is a ring turned on the steel sleeve which prevents any leakage of steam having a straight path through the small clearance spaces. Steam sealing is provided, but neither lubrication nor water is required for these glands. The rotor blades are machined from square blocks of nickel steel containing 5% nickel, each blade having a shank of such a shape as to form a distance piece maintaining it in correct pitch, and are secured to the wheels by countersunk rivets.

The governor-end of the shaft is arranged for an adjustable Michell thrust bearing to take the axial thrust in the turbine, which is very small, with the impulse type, so that the duty of the thrust is mainly to locate the shaft.

Numbers of turbines were seen on the test beds, comprising high, low and mixed pressure machines for coupling direct or through gearing to turbo-alternators, turbo-blowers and compressors. Here the combined resources for manufacturing complete plant are substantiated, the alternators being built by the allied works, the Erith works, producing the blower and compressor units.

Fraser and Chalmers have the reputation of having constructed the majority of turbo-blower units running in this country, and also of completing the largest turbo-compressor yet produced by British manufacturers. A minute inspection was made of the turbine blade manufacturing, and detail parts of the governing gear, etc., and, in the foundry, of the casting in of the steel guide vanes in the diaphragms. The foundry created particular interest, being one of the largest in the south, and capable of producing castings up to 35 tons in weight. Some large winding engine drums were to be seen in the finished state.

In the mining department machine shops a variety of plant was open to inspection, including crushing, grinding and concentration machinery for mineral ores, stamp mills, including high duty stamps with a falling weight of 2,000 lbs., all being specialised items of the firm's products. The spacious boiler and plate shop also included sections of this plant, the necessary plate work required for mills and the different water-jacketed blast furnaces for copper, tin and lead smelting; also types of copper converters.

The Bettington boiler for atomised fuel particularly interested us. Fraser and Chalmers' Engineering Works took this matter up at its inception, and as sole manufacturers of this boiler, were also pioneers in the development of the use of pulverised fuel. Considerable work had been carried out in the pre-war period, and a number of boilers installed which generally had given satisfactory results, but some inherent defects had manifested themselves under actual conditions, and the rectification of these defects had received considerable thought. The war period made it practically impossible to continue the research and development necessary. It has again been possible to give serious consideration to the subject, with the result that these initial troubles have now been overcome, and the boiler is being re-modelled on lines which will make it a satisfactory unit.

The subject of atomised fuel has always been one of considerable interest to Marine Engineers, and naturally our members were considerably interested in what they saw in connection with the boiler and these later developments. The use of pulverised fuel is undoubtedly one which has come to stay, and there is no doubt that in the near future much more will be heard of this subject, as present conditions make it imperative that every advantage which can be taken of the utilisation of fuel to its utmost value must be carefully considered by all users of steam power. This boiler, together with its pulveriser, is unique in so far that "run of mine coal" after being put through a roll crusher and crushed to about 1in. or $\frac{3}{4}$in. cube, can be fed direct to the pulveriser, which also acts as a fan and is then crushed to the fineness required and fed direct to the boiler, the fan giving the requisite amount of air which is required for complete combustion. A special air heater is part of the equipment, thus the coal which is fed to the pulveriser, is deprived of the usual amount of moisture in run of mine coal, that is 7 to 8%. It was stated that in some of the experiments carried out the coal has as much as 15% of moisture, and even then did not require to be dried before being used. The objections to the storage of pulverised coal is overcome as the coal itself is stored in the bunker and pulverised as required only. The chief advantages claimed by this type of boiler is increased efficiency, and, moreover, any low grades of coal can be utilised which would not give good service in the ordinary boiler fitted with the standard fire grate, while steam can be raised in a very short time, and small floor space is required for the equipment.

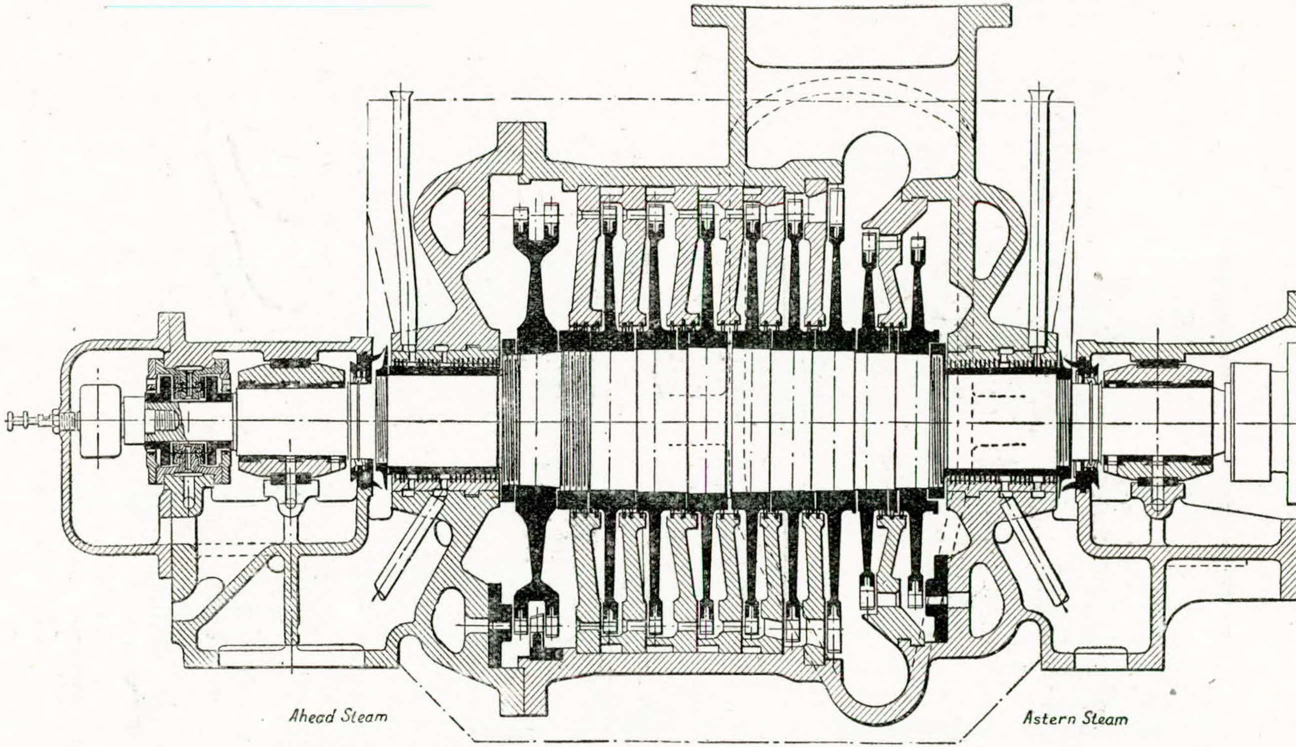
Large steam and electric winding engines were being erected in a huge bay specially equipped for the purpose, and here again evidence was observed of the ability to complete entire plant manufacturing both the mechanical and electrical portions.

It was only possible to inspect detail parts of conveyors, grabs, and transporters, comprising as they do a great amount of steel structural work erected on site. A type of grab seen completed was capable of a load of $2\frac{1}{2}$ tons per lift, and under normal working conditions would handle up to 150 tons per hour, and the design of conveyor belt employed had been installed dealing with plant up to 1,500 tons per hour.

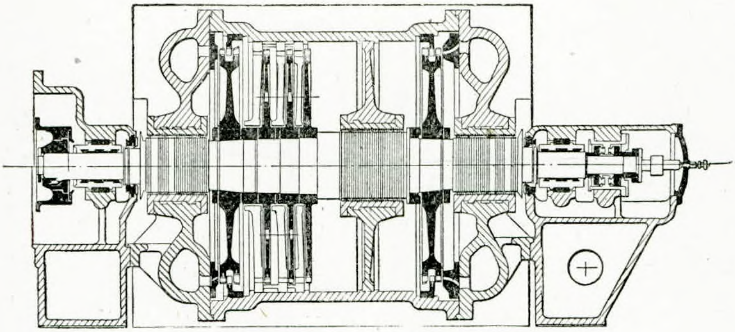
Information was given as to the mechanical handling of heavy bulk materials such as coal and ores, down to conveying grain, boxes and packages, and some typical plants were briefly described.

The tour terminated at 5.30 p.m., when all adjourned for tea provided by the firm and a general round table discussion. A vote of thanks was proposed by Mr. J. B. Hall and seconded by Mr. M. Yuill, home from Japan, which the staff in acknowledging, expressed their extreme interest in such a meeting and hoped that future occasions would again bring them in contact with the members of the Institute.

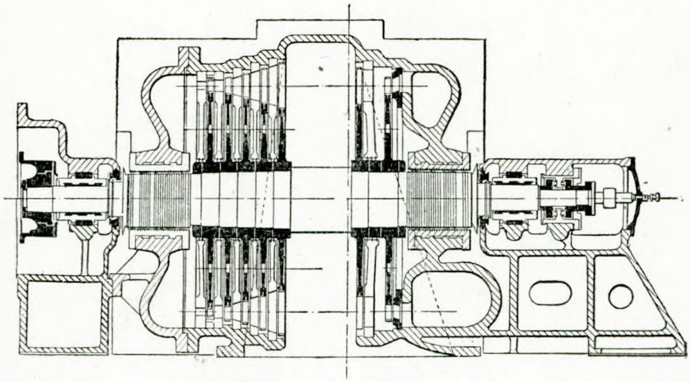
Illustrations of the works and machinery including details of the turbine are on the following pages.



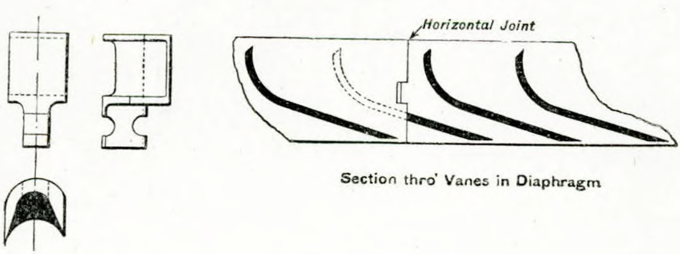
Fraser & Chalmers Impulse Type Marine Turbine, 1,000 s.h.p., in single casing. Speed, 4,000 r.p.m.



High Pressure Ahead and Astern Unit.



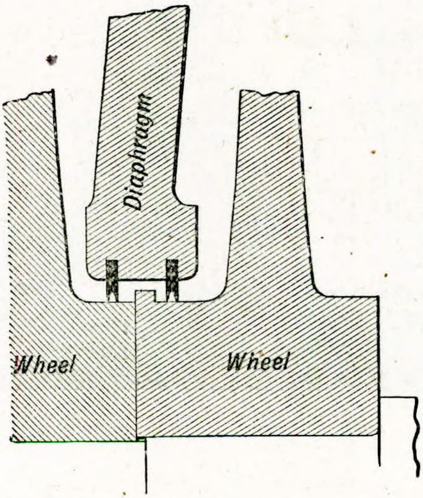
Low Pressure Ahead and Astern Unit.



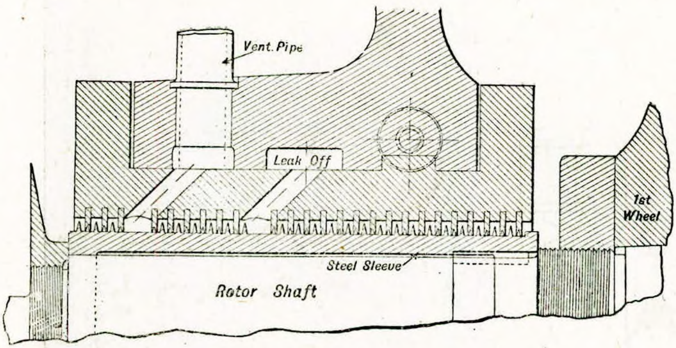
Section thro' Vanes in Diaphragm

Typical H.P.
Turbine Blade

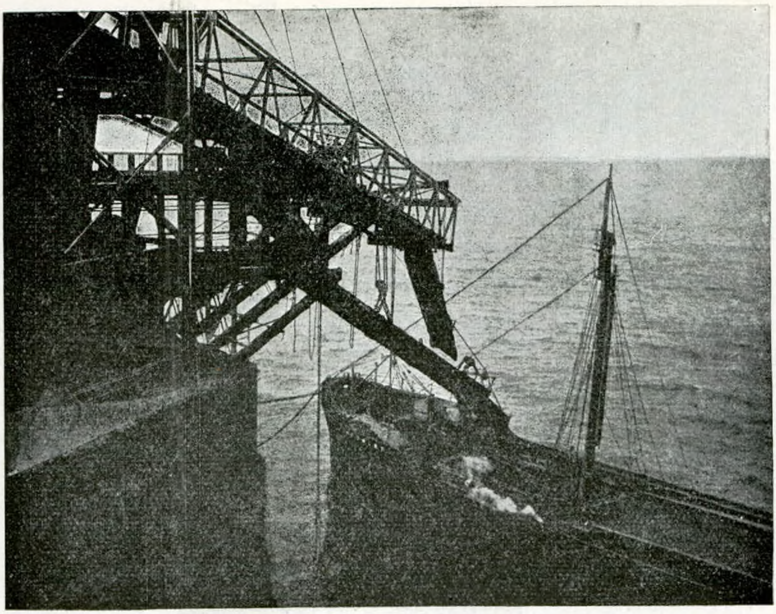
Datails of Blades and Nozzles.

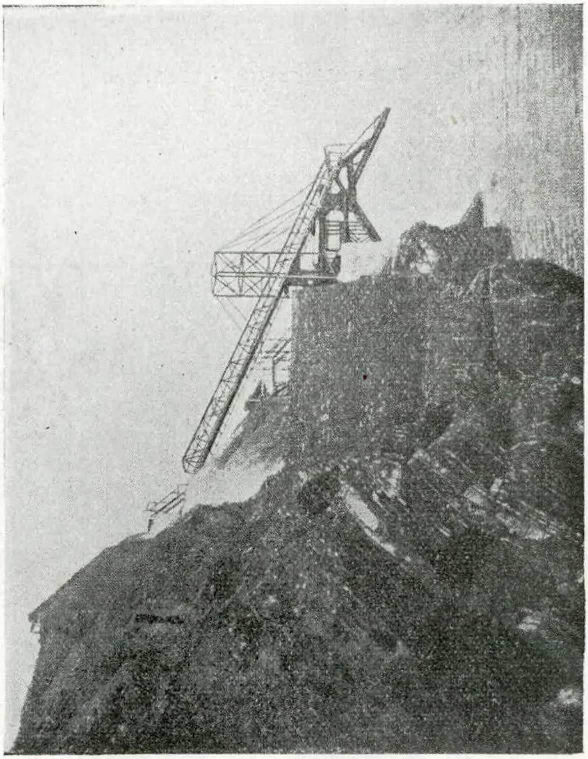


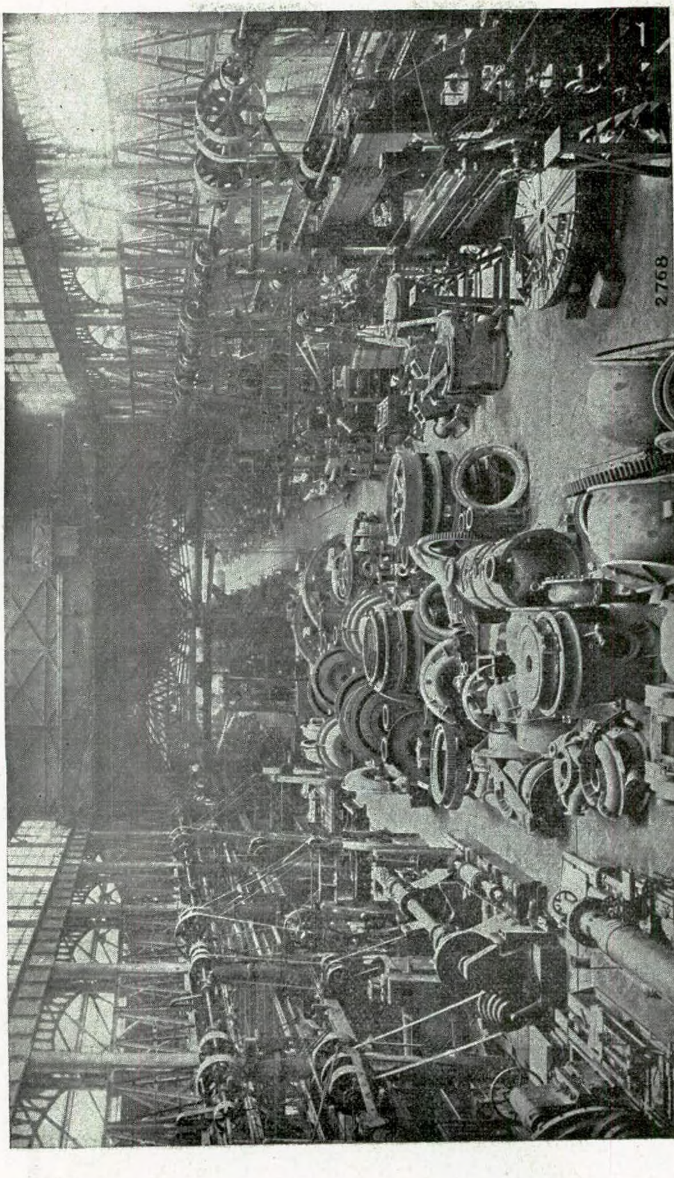
Labyrinth Packing on Nozzle Diaphragm.



Labyrinth Packing at end of Casing.



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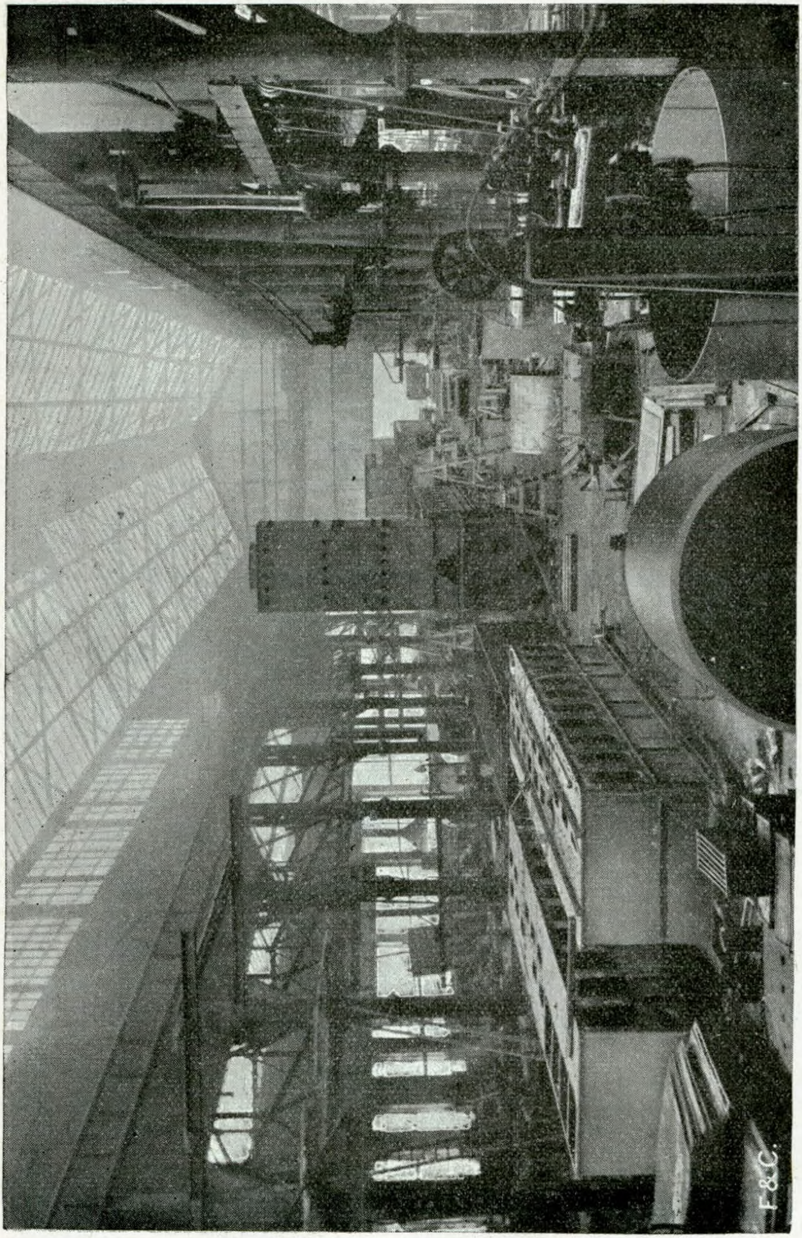

F & C.

THE NATIONAL PHYSICAL LABORATORY was visited under ideal conditions as to weather on October 9th. Considerable additions have been made since our former visits, and each year the usefulness of the Laboratory has become more manifest to all branches of engineering, and indeed to all sections of industrial works.

We were met at the entrance by members of the staff and conducted to different departments, where the specialities of each were described by those in charge, and to one and all we acknowledge the kindly courtesy with which we were received, and accord our thanks for their kindness.

In the engineering section are many machines for testing purposes. The testing of the sample of a rod was in action to show the elongation and breaking strain with the percentage above the normal tensile strength. The machines in the department are designed for testing all strains and stresses to which metals are subjected, according to their intended service; one of the largest machines being used for testing coupling links for railway wagons. Samples were on view and the process explained. A recently constructed machine for testing notched bars was explained, showing the hammer and anvil swinging, with indicating pendulums to record the results of the test. Tests are conducted with the object of determining the best class of oil to suit different kinds of gear and metals used; also for speed load working temperature.

The Aerodynamics Department, which is still being added to, contains specimens of the sectional parts of air vessels, showing their shapes with experimental data and trial results under different conditions with speed and power relative to form and weight. The extension of space and building allotted to the department illustrate the growing importance attaching to it. There are several air tunnels for testing the effect of air pressure on the models, the pressure and velocity being obtained from motors from 20 to 200 h.p., according to the dimensions of the tunnel, the smallest being 4ft. and the largest 7ft. × 14ft., the velocity of the air reaching about 100ft. per sec. in the latter.

In the Electricity Department we were shown methods for testing lamps, current, and the various instruments and appliances for power and lighting plant. Devices produced under the stress of war conditions for detecting and locating sounds, signalling arrangements under water, and special appliances in connection with munitions, occupied the close attention of the staff during the past years, and their records and search work are now being applied for general service under better auspices. The testing of radium compounds was shown in action in a darkened room. These luminous compounds were largely used on discs for aeroplanes during the war.

The Metrology Department occupied much time and attention in viewing the various gauges and their application to different classes of work, with the limiting allowances necessary for passing the final test. Here also the war work imposed great demands on the staff, in testing, passing and rejecting munition requirements. The close tests for screw threads and gearing were specially noted and dwelt upon, and it was particularly interesting to see the contour of the threads shown on a screen by lantern and highly magnified, 50 times, to compare the actual with the standard. The results of experimental work disclosed from time to time with new combinations of metals and the tests applied to discover their applicability for various purposes were on view in the Metallurgy Department, and indicated where scientific research is playing an important part in developing and strengthening industrial progress and advancement. The necessity of obtaining a metal for the cylinders and connections of the internal combustion engine, the severe shocks and strains with high temperature is an illustration of this and of the fact that we are aye learning if our aim is so directed. Several interesting appliances for demonstrating and testing alloys for high temperature service with aluminium as the base, copper, nickel and magnesium being added in certain percentages. The heating furnace and rolling mill for dealing with and testing non-ferrous metals were not in operation but in their quiescent state were open for investigation, with explanation of the process. Specimens were arranged on the bench with particulars inscribed to show composition and test results. Samples of rolled block, and rods which had failed in the process were also on view. The Froude tank and apparatus used for testing the skin friction of ship models, the speed and power developed under varying conditions, and with propellers of different types were closely examined, discussed, and the recording instruments explained. Several wax models complete and under construction were on view; also a wooden model of a submarine. The valuable work done in connection with the ship design is well known, showing where body plans can be altered with advantage in economical running. Experimental tests have also been made with hydroplane models.

The submarine menace received considerable attention in the past years, with a view to locate and deal with the enemy, including the netting process. There are several other departments of interest, optical, chemical, heat, refrigeration, wireless, oil, etc., with their various testing instruments and samples.

Members who were unable to take advantage of the opportunity to visit the Laboratory on this occasion and desire to see it preferably with the work in full operation may have the privilege accorded to them on special application.

Our visits to works on Saturday afternoons have the disadvantage that we do not see all the machinery in motion, with, however, the compensating privilege of examining quietly the machines and appliances, receiving at the same time explanations from members of the staff, to whom we are indebted for their kindly courtesy and attention. In closing this record of our visits for 1920, we tender our appreciative thanks to all, with pleasant memories of our meeting.

Synopsis of Syllabus for Lectures.

THE following is a synopsis of the syllabus for a course of lectures now being arranged for the forthcoming months. A conference of Representatives was held on October 20th at 4 p.m. in the Lecture Hall of the Institute with a view to adopt the best method of procedure in order to place before those desirous of becoming acquainted with the Internal Combustion Engine, the vital points necessary to know in connection with the running and maintenance of this type of engine. The attention of apprentices is directed to the advisability of attending the lectures and taking advantage of their opportunities to study the subject.

I. Fuel oil, natural supplies and difference in values; density, viscosity and flash point; storage; tanks, valves and pipe systems; troubles due to defective arrangements; leakage of oil or gas; presence of water, dirt, sluggish flow; remedies.

II. Conversion of fuel into gas. Types of engines; heat of evaporation. (*a*) Types using petrol; carburetters, ignition gear; compression. (*b*) Types using paraffins; heat necessary, vaporisers, ignition gear; compression. (*c*) Types using heavy oils, compression; injection by pump; combustion; sub-divisions (*c*1) Compression to give combustion, Diesel engines; (*c*2) hot-plate or bulb for ignition. Conversion of heat into mechanical energy; effects of heat on matter; expansion; change of volume; combustion tests for perfect combustion; effects of richness of mixtures and of compression; ignition; products of combustion; composition and analysis results.

III. Correct mixtures, carburetters, function and action for best results; types; choked tubes; regulator; jets; wicks; throttle valves, vaporisers, different types; hot bulbs.

IV. Schemes of operation, alternate expansion and contraction; cycle; 2 or 4 stroke; valves required for each; advantages and disadvantages; valveless types; modification of valves for different fuels; operating valves; cams and cam shafts; timing of valves; scavenging; indicator cards; throttling; fuel injection valves; troubles and remedies, starting gear.

V. Fuel supply per carburetter, vaporiser; solid injection, hot bulb, air blast, Diesel; throttle valve; pump; governor; size of valves; timing, opening; atomisation; possible defects.

VI. Mechanism specially required for marine work. Cams and connecting gear; several types; reversal operation; clutch gear; starting arrangements; compressed air gear.

VII. Marine engine working, fly-wheel; thrust bearing; propellers; location of fuel tanks; gear for working, cam-shaft, reversing; starting gear; compressed air gear.

VIII. Lubricating arrangements, open and close crank pin; gravity and forced systems; gauges and indicators for regulating oil; defective lubrication troubles.

IX. Log book data. Rate of fuel consumption; of lubrication; authentic entries, changes with causes; minor defects and remedies, stoppages and reasons, temporary repairs; vital parts for periodical overhaul and re-adjustment; spare parts necessary and advisable.

X. Auxiliary machinery, oil engine winches; methods of driving steering gear, windlass and capstan; oil engine driven dynamos; air compressors and other auxiliaries.

The syllabus was accompanied by the following letter and sent to each of the firms engaged, directly or indirectly, in the building of the oil engines:—

DEAR SIRS,

As a result of consideration by a Committee, elected by the Council of the Institute of Marine Engineers, on the subject of the Internal Combustion Engine, with special regard to its care and maintenance, from the engineer's point of view, and to give opportunity to engineers to study and acquaint themselves with the various details; it has been decided to arrange for a course of lectures during the forthcoming months, based upon the enclosed syllabus, which is subject to modification at a Conference to be held in our Lecture Hall on Wednesday. October 20th, at 4 p.m., and to which your Representative is very cordially invited, in order that we may resolve upon the best procedure.

We are very desirous of embracing in the lectures, all types of oil engines, for the information and guidance of those entrusted, or about to be entrusted, with their running efficiency.

We shall be glad if you will kindly appoint a Representative to attend the Conference on October 20th, and your views and comments on the enclosed copy of the proposed syllabus will be much appreciated.

Yours faithfully,

JAS. ADAMSON,

Hon. Secretary.

—o—

Books Presented to the Library.

BOILER MAKING. *Bennett College Ref. Lib.* An elementary work which appears to be intended as an introduction to the workshop side of boiler making. It deals with land boilers principally, and the references to angle irons and the use of oxy-acetylene welding are not applicable to marine practice. The absence of the elements of boiler design and the formulæ and calculations necessary thereto, limit the usefulness of the volume to the class of apprentices and those who have had no experience in works where boilers are made.

Election of Members.

Members elected at a meeting of the Council held on the 14th September, 1920:—

Members.

William Anderson, 35, Manor Place, Dunedin, N.Z.
Henry Toms Andrews, 6, Harbour View Road, Penarth, Glam.
Robert Baillie, c/o Messrs. John Reid (London), Ltd., 4, Lloyd's Avenue, E.C.3.
Robert Bell, 28, Northbrook Road, Ilford, Essex.
Herbert Bibby, "Inglenook," Blundell Avenue, Hightown, Liverpool.
Henry Bishop, 4, Rue Pereyra, Alexandria, Egypt.
Francis Geo. Brookes, 35, Ilton Road, Penylan, Cardiff.
Joseph Robt. Greenwood Brown, 29, Manor Road, Gt. Crosby, Liverpool.
Wm. Millett Burns, 68, Henniker Gardens, East Ham, E.6.
John L. Chaloner, 4, High Street, Highgate, N.W.
David Cochrane, The Rising Sun Petroleum Co., Yokohama, Japan.
John C. Collingwood, 567-81st Street, Brooklyn, New York.
Alfred Ernest Cozens, 472-84th Street, Brooklyn, New York.
Bernard Chas. Curling, 47, Devonshire Road, Claughton, Birkenhead.
Leslie McLeod Donald, 7, Trossachs Road, East Dulwich.
Wm. Cawson Donald, 89, Capel Road, Forest Gate, Essex.
George Diticy-Evans, Murray Road, Bicton, Freemantle, W.A
James Fairgrieve, c/o Asiatic Petroleum Co. (North China), Ltd., Yangtetzekiang, Chinkiang, China.
Douglas Ferguson, Ardath, Barnhill, Dundee.
Joseph Tyerman Forsyth, Empingham, Stamford, Lincoln.
Robt. Wilson Gunston, Merton Hall Farm, Romford, Essex.
Leighton B. Hansen, 72, Pascoe Street, Williamstown, Victoria, Australia.
Leonard Jas. Jeffrey, 53, Headcorn Road, Thornton Heath, Surrey.
John Lamb, 33, Potterdale Terrace, Gateshead.
Arthur Walter Loveridge, 68, Van Road, Caerpshilly, Glam.
Murdoch McAffer, 48, Gibbshill Terrace, Greenock.
Linton McCallum, 48, Elmgrove Road, Gorleston-on-Sea, Suffolk.
W. A. MacLeod, 7, Fairlop Road, Leytonstone, E.11.
Thos. Scott Morrison, P.O. Box 463, Hong Kong.

Ernest Orchard, 27, Stallcourt Avenue, Cardiff.
George Ormiston, 5, Lloyd's Avenue, London, E.C.3.
Henry Grayson Parsell, 103, Worcester Road, Bootle, Liverpool.
John Pratt, Ellice Street, Cellardyke, Fifeshire.
Agenor George Emanuel Raffin, Office of Chief Inspector of Factories and Boilers, United Provinces, Sarsaya, Ghat, Cawnpore, India.
William Robertson, 14, Erskine Road, South Shields.
Frederick Reginald Rogers, Holt Technical School, Leighton Road, Birkenhead.
Roy Wilson Stubbs, "The Limes," St. George, Bristol.
William Henry Timbrell, Chinese Government Salt Gabelle, Foochow, China.
Junichi Uenohata, c/o N.Y.K., 1 Chome, Yurakucho, Tokio, Japan.
Richard Wildridge, 75, Pitt Street, Sydney, Australia.

Companion.

Chas. Joseph Heath, F.R.C.S., 34, Devonshire Place, London, W.1.

Associate-Members.

Alexr. Dunston Burgess, 65, West Regent Street, Glasgow.
Leonard Clive Cox, 32, Claremont Road, Gravesend.
Russell Gordon, 71, Holmewood Gardens, Brixton Hill, S.W.2.
Norman Geo. Hinch, "Sunnyside," Morcott, Uppingham, Rutland.
Alfred Bruce Singleton, Meadow Bank, Cults, Aberdeenshire.

Associates.

William Boyle, 98, Denham Terrace, Wallsend-on-Tyne.
Ernest E. Franklin, 4, St. George's Place, Brighton.
George Moody Riddle, 30, Upper Elsdon Street, North Shields.
John Muir Young, 3, Queen's Road, Leytonstone, N.E.

Graduates.

John Knox Brown, 9, Hill Road, Barrow-in-Furness.
Mathias Wilfrid Kurth, 258, High Street, Poplar, E.14.
John McCreesh, 24, The Crescent, King's Road, Wallsend.
James Frederick Pilton, 85, Galbraith Street, Cubitt Town, E.14.
Frank Warburton Richardson, 1, Grosvenor Terrace, Hillhead, Glasgow, W.
Chas. Wm. Oakey Turner, "Eversleigh," Lynewydd Road, Barry, S. Wales.

Student-Graduates.

William Reid Anderson, 68, Mile End Avenue, Aberdeen.
William Arthur Cameron, 59, Craigie Lounings, Aberdeen.
John Shand Cruickshank, 239, Great Northern Road, Woodside, Aberdeen.
Leslie Edward Feather, 68, Clayton Park Square, Newcastle-upon-Tyne.
George Robinson Hutchinson, 26, Ripon Gardens, Jesmond Park, Newcastle-on-Tyne.
William McGregor Manley, 83, Stanley Street, Aberdeen.
James Mackie Mitchell, 2, Grosvenor Terrace, Aberdeen.
William George Robb, 174, Crown Street, Aberdeen.

INSTITUTE OF MARINE ENGINEERS
INCORPORATED.

Patron: HIS MAJESTY THE KING.

SESSION 1920-21.

President: LORD WEIR OF EASTWOOD.

VOLUME XXXII.

DISCUSSION.

The Screw Propeller—a New Type.

BY

MAJOR J. H. W. GILL, C.B.E. (Member).

Tuesday, October 12, 1920.

CHAIRMAN: MR. J. B. HALL (Member).

[N.B.—On Page 131, October issue, the descriptive notes under the illustrations of the model propeller should be transposed, *i.e.*, forward end on the left-hand side of illustrations.]

MR. GORDON: Just by way of discussion I would like to ask whether the propeller proposed is confined to the small type or whether Major Gill thinks it would suit large vessels. He suggests that "no extravagant claims for increased speed, reduced fuel consumption, etc., are made," but are there any claims at all to increase speed and lessen fuel consumption?

MR. W. BROOKS SAYERS: Accompanying these remarks are the following, which I regret I cannot be present to explain fully:—

1. Model portion of multi-shrouded propeller, either Rotor or Stator.

2. Model of built propeller with radial fins, since improved on with regard to the concentric fins on face.

3. Photo of 'Stator' propeller added to its own propeller on S.Y. *Thistle* (own propeller is also shown).

While it is possible that some advantage may be obtained in special cases by the use of a vortex shaped shrouding, rotating with blades and attached thereto, the opinion is confidently expressed, based on considerable experience in actual test of model propellers, model vessels 'screw' propelled, motor boats and yachts, that in the main, and as a general rule, the shroud will be found to be a sheer disadvantage.

The 'fundamental definition' of a screw propeller attributed to Mr. G. S. Baker, and the condensed elementary theory of propeller action by Mr. S. W. Barnaby, fall short of the correct statement as to the actual; so also the following paragraphs: "The kinetic energy remaining in the race after the water has left the propeller is wasted as far as propulsion is concerned." "After some of the theoretical and practical advantages," etc. In the first place . . . . "propulsive reaction by continually pushing mass of water astern."

The propulsive action of a screw propeller is due to the reaction upon the propeller blade (back and front) consequent on acceleration of a mass of fluid. The sternward stream is incidental only, although in general it is a large and obvious part of the phenomenon.

If the blades of a propeller are relatively long and narrow as in a two-bladed propeller, or as in the four-bladed propeller, illustrated in Messrs. Stone's photos*, then a cylindrical column of water (say) is rotated about an axis radial relatively to the shaft and having the trailing edge of the propeller blade as its centre; the fluid therefore tends to rotate from the 'front' round to the back of the propeller. As new water or fluid is cut into continually, these 'cylinders' cannot exist continuously, but are continually broken in some regular or irregular and intermittently rhythmic fashion dependent on exact conditions, and the water or fluid comes away in broken whirls and shattered whirling forms.

So we get all the troubles of vibrations and apparent or actual collisions (liquid) with losses attendant, which may be hard to diagnose and which are different for every case.

When the propeller is of the 'turbine type'—see again Messrs. Stones photo—the cylinders cannot be produced around the blade radially and a totally different set of conditions is set up. The action is much more nearly that of accelerating a mass simply sternwards, but the tendency is for a return stream

* See September issue, page 58.—J.A.

over the periphery of the blade, which of course gets blotted out more and more as the speed of the vessel increases. This is, if any, the kind of case where shroud, if correctly formed may help by *increasing the mass*, which is at any instant opposing by its inertia the propeller blade and thus increasing efficiency.

Time fails the writer to expound this matter as he would do at this time, but from experiments and comparisons of actions in air and in water propellers he very confidently puts this solution of the vagaries, so called, of the screw propeller forward. Much thought has been given and calculations have been made which establish the theory. More may be said it is hoped as occasion is given. The writer of the paper is thanked for his labours and efforts to solve the problem.

Mr. H. R. PARFITT: I notice that the outside of the shroud instead of being of an ordinary cone-shape, opens out in a sort of bell-mouth. Is that meant to be so?

Major GILL: You refer to the drawing. The contracting shroud is trumpet shaped to correspond to the contraction of the accelerated stream and the increasing pitch. The thickness of the shroud is radiused off at the ends to prevent eddying at the separation and junction of the accelerated stream and the water surrounding the shroud.

The CHAIRMAN: I should like to ask a question. You know at times with cargo vessels that when they are light a large proportion of the propeller is out of the water, and you still get very good results of speed. How does that compare with your shrouded propeller?

Major GILL: The Americans have a particular type of boat with a hollow "V" forward to take air down under the hull, and at the after-end both propeller shafts are brought above the water line. They find that reasonable efficiency can be obtained if you have very wide blades even if only half-immersed, but there is a very uneven stress on the shaft. I should imagine the same would occur with any propeller partly immersed.

Mr. R. GORDON: I would like to ask if you have any particular type of stern this propeller should be worked with.

Major GILL: I think it is merely advisable to get as good a flow as possible to the propeller, and this obtains with this propeller possibly to a greater extent than with an open screw, because of working on a smaller effective diameter, and it is normally made four-bladed. A question was put to me earlier as to whether the propeller is confined to small types or to large sizes. It is not at present in contemplation to make it for large sizes for the time being, but big enough for drifters, where a demand appears to exist. With regard to the second point raised by the first speaker as to whether increased speed or reduced fuel consumption was the result. You put in a small propeller and try to get it to do as much as a big one. It does as well and can be run at a higher revolution speed but not necessarily with more economy, though there are cases where it has done so. With regard to the remarks made by Mr. Sayers and read by the Secretary, the shrouds shown in models submitted appear to be parallel. These have been tried before and have been before the public for a great many years; had they been particularly good they would probably have been adopted. I cannot see any reason for a parallel shroud, and I do not think it is likely to be a practical proposition. As to the propeller with †radial fins on the blades, it is not quite apparent what is in the idea; I cannot understand the object. A 'Stator' propeller similar to that shown in one of the photos was used by the Germans in certain destroyers, and a rather high efficiency has been claimed for it—an increase of 10 per cent. in thrust—but the thing is not particularly new and had it been really good would probably have been adopted long ago. There are certain open propellers with which this Stator propeller might be an advantage, but it does not seem to have justified itself in practice. Mr. Sayers states that in the main the shroud would be found to be disadvantageous. In many normal cases the open propeller is to be preferred, but to state that in all cases the shroud would be a disadvantage is provedly not correct. We have been able to work the propeller at a much lower immersion and have obtained greater revolutions than economically feasible with an open screw. Another statement queried by Mr. Sayers is that energy in race is wasted so far as propulsive effect is concerned. It is possibly a moot point, and I do not think anybody has accepted the responsibility of laying it down as a hard and fast theory. If you look at the matter from the point of view of hydraulic propulsion you are getting a forward thrust, and a forward thrust can, presumably, be reckoned by the backward thrust of the volume of water projected astern. If one says that the pushing forward is due to the resistance of the water in contact with the blades it seems to be rather beside the mark, for where there comes the thrust in pump propulsion, a rather more inclusive conception is to reckon the mass of water pro-

† Mr. Sayers explains in regard to this that the radial fins on the model propeller are structural only in the case of a hollow built propeller and are intended to be covered in.

jected astern as giving you the forward motion. With regard to the narrow-bladed propeller, which, as it were, rolls the water round the following edges of the blades, there is something to be said for and against. It corresponds with the theory put forward about the end of 1918 by a German, and has been illustrated since by the experimental fact that under certain conditions you can replace a propeller by a number of radial rotating spindles and can deduce a theory of propulsion. It must, however, fall short of the actual facts somewhere.

Mr. G. J. Wells: A clear statement has been presented of the deductions from the experiments, but very little said about the experiments—where made and by whom. Sometimes it is said figures will prove anything, and experiments will do the same thing. I would suggest to the author that a propeller of this sort be submitted to the N.P.L., with a request that careful tests be made in a tank, comparing it with another to form a standard and so obtain some data, entirely beyond criticism. We have a claim that a special form of shroud will give definite results. I am under the impression that the Thornycroft propeller is one that will give all that is claimed. Partial immersion is spoken of. A tunnel propeller was used in flat-bottomed boats. The length was 140 feet and the vessel drew 14 in. or 15 in. of water. The propeller was well above the bottom and practically out of water when the ship was moored. When the ship was run the whole propeller was immersed. That propeller subsequently found adoption by Messrs. Yarrow, and it is used with a flap or shutter. The loss of efficiency from the mere fact of shrouding must be comparatively small. The Thornycroft turbine propeller has been used in boats of under 50 feet. The shrouding seems to be a point. I am not sure whether the rotations may make a serious inroad on the friction load. What must be the friction and loss of energy due to actuating those shrouds? The speed of the tip of a propeller in quite moderate revolutions is from 50 to 60 miles an hour. It was in the case of the Thornycroft propellers.

Major Gill: As to how the experiments were carried out the criticism is a just one. Care was taken to carry them out in a manner which could be verified by independent observers. As to how much friction occurred experiments were carried out on the particular point, and the loss of efficiency as between the open and the shroud amounted to something like 18 per cent. in the worst possible case. Since then other experiments have been carried out and have shown approximately the same results with unsuitable shrouds but better results with correct shrouds. As to the experiments being sent to the N.P.L., that has been decided upon. With regard to the Thornycroft turbine propeller I was aware of the experiments. During the latter part of the war I had an opportunity to see one of these propellers in operation. It is undoubtedly a good propeller. There are, however, one or two points which I am not quite sure compare well with the one now under discussion.

Mr. N. Hart: Some time ago I was concerned in some experiments on propellers in air, and we found the efficiency increased very much by using a Stator propeller behind the rotating one, but it was abandoned owing to vibration which was very excessive. The efficiency was undoubtedly increased. Do you think the same thing would occur with water?

Major Gill: It is most interesting to hear that vibration was the cause of abandoning the Stator propeller experiments in air, and the same effect has been observed in water.

Mr. W. McLaren: I would like to express my thanks to Major Gill for his paper. We are given an opening for a wider consideration of the propeller. It is like the surgeon and the physician: the surgeon has gone ahead and the physician has been very slow. With regard to the model, is the boss in proportion to that of an open-bladed propeller?

Major Gill: With regard to the diameter of the boss, it is ·15 of the outside diameter. As to the wake we have made experiments, and had the photographs been sufficiently good I would have produced them. The wake from the propellers is much less than the wake from an open screw.

Mr. R. H. Ferguson: When the further tests are made we would be able to compare the results with those from the propellers in general use at the present day. I move a hearty vote of thanks to Major Gill for his excellent paper.

Mr. R. Gordon: I am sure we would like to hear of further experiments with this new propeller. We are all agreed there is still room for improvement in propellers and we have not advanced as we should.

The Chairman: I trust that at some future date we may hear you again. I have pleasure in passing to you the vote of thanks.

Major Gill: I expected to be thoroughly slated for advancing apparently new theories, and thank you for your forbearance. I am continuing my work in this matter. We have put in a great deal of solid work on this type of propeller, and results have been obtained which have fully justified our going on with it.

The Hon. Secretary announced that the next meeting would be on October 20th, when a Conference would be held at 4 o'clock with representatives of the makers of Oil Engines, all of whom had been invited with a view to arrange for a series of Papers.

The Solid Injection Engine.

BY MR. C. McTAMINEY (Member).

READ

Tuesday, October 26, at 6.30 p.m.

CHAIRMAN: MR. F. M. TIMPSON (Member of Council).

The CHAIRMAN: We are here to-night to hear a paper on the Solid Injection Engine, which looks as if it will arouse a good deal of interest. But I regret that the author of the paper is not present on account of illness, and our Hon. Secretary has arranged to read it for him. Mr. McTaminey has been in charge of the actual running of the engine, and we all want to know what he has to say from that standpoint as many of us have not had experience of the actual running.

I was very interested to read the paper by Mr. David Peel on solid injection Diesel engines published in the proceedings of February last, and as the subject seemed to be of great interest to the members generally, I thought that perhaps some information bearing on the use of solid injection in larger engines might be appreciated, as Mr. Peel's paper dealt more particularly with the submarine type of engine. Having been from May, 1917, till quite lately, in charge of the machinery of the *Trefoil*, an oil tanker running as a Royal Fleet Auxiliary under the Admiralty, I gained considerable first-hand experience of the running of these larger engines.

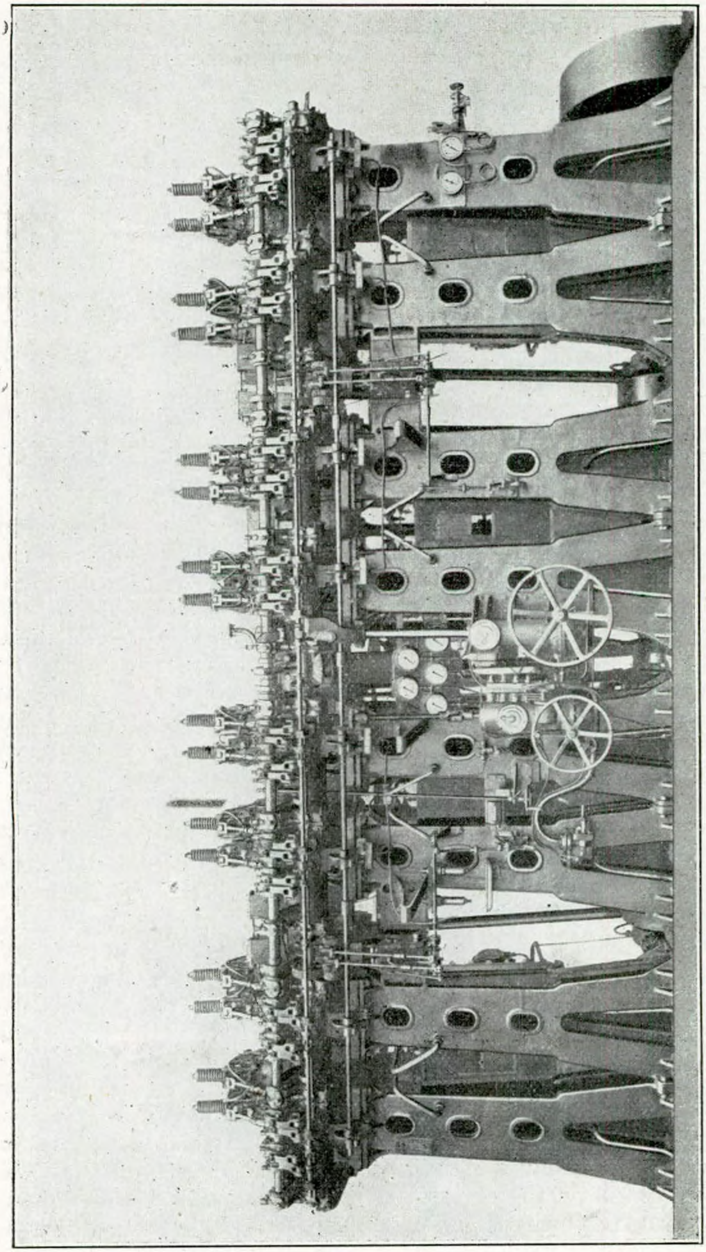
The main engines of the *Trefoil* are of the four-stroke cross-head type, the vessel being fitted with two Vickers' engines, each of eight cylinders and together developing 1,500 brake horse power at 150 revolutions per minute. The vessel herself carries

2,000 tons of fuel as cargo on a displacement of about 4,510 tons, her speed being 11·5 knots at full power and capacity of bunkers 213 tons.

These engines, it may be interesting to note, are the second pair made for the *Trefoil*, the first pair built for the ship having been diverted to the Monitor *Marshal Soult*, one of the ships hastily constructed for work on the Belgian coast. The *Trefoil* was fitted with a replace pair of engines, by the same makers, generally similar to those in the *Marshal Soult*, but with minor improvements.

The original engines formed one of several Diesel marine installations which the Admiralty ordered before the War so as to obtain a comparison of the sea-going merits of the different makes which were on the market. They are not pure commercial engines, as with an eye to development for Warships, it was arranged by the Admiralty that they should be of the low headroom type, and the construction was based on the use of a stepped bedplate—as is common in warship work—together—in the *Monitor* at any rate—with forged columns braced somewhat as in torpedo boat construction, but on a larger scale. As a matter of fact, the second pair of engines had cast columns on the inboard side in order to cheapen cost and facilitate construction, it not being necessary to repeat the experiment in the second pair of engines.

The general construction of the engine is plainly shown on the drawing herewith. It will be noticed that the cylinders are very elementary in form. They consist of a steel fore and aft entablature into which the cast iron liners are dropped, the extension of the liner through the bottom of the entablature being covered by a welded plate jacket secured to the underside of the entablature, and made watertight at the bottom by a pair of rubber rings. The covers are shallow and of cast steel, the valve boxes being separate very much on the submarine lines. The gas joint between cover and valve box is a coned one, metal to metal, the water joint above it being a sliding one made with a pair of rubber rings. The reversing gear is rather out of the ordinary for Diesel engines, consisting of a pair of bell cranks for each valve, these bell cranks being mounted on oppositely disposed eccentrics on a fulcrum shaft. According to the position into which this fulcrum shaft is turned, one or other of the bell cranks engages with the cam below it, and thus gives the correct functions for ahead or astern running as the case may be. From the bell crank which happens to be in action the



motion is carried to the valve by means of a lever moved by the bell crank and connected by a pull rod to the lever on the valve box.

The fuel cams are mounted in sliding blocks on the cam shaft and while the fulcrum shaft is being turned through 180° these blocks are slid along the cam shaft, putting, say, the ahead cam out of action and bringing the astern fuel cam under the fuel valve tappet. A somewhat similar arrangement is used for reversing the air starting valves, which are arranged in one box from which pipes are led to the separate cylinders through a non-return valve at each cover. The gear is operated by an air ram, the movement being steadied by an oil ram acting as a dashpot.

The cylinders are 17 in. diameter with a 27 in. stroke and the pistons are not water-cooled. They ran quite comfortably even under a considerable overload. In passing, I may say that in the engines of the *Marshal Soult* with whose working I am well acquainted—being friendly with her ex-Chief Engineer, Engineer Lt.-Commdr. Baker, D.S.O., who has recently relieved me in the *Trefoil*—there was considerable piston heating at times, in fact the lubricating oil on occasions caught fire though it was never necessary to stop the engines on account of defect throughout the war. This fact I see was mentioned in the discussion arising out of Mr. Peel's paper. The heating had nothing to do with the system of injection, however, being simply caused by the fact that as the vessel often had to sit on the mud, the suctions became choked and the engine did not get any circulating water till the ship had left her moorings and had run for a little time properly afloat. A steam ship, as we all know, would have corresponding trouble—with condensers for instance—in similar conditions. The remedy was to fit a special sea suction as was afterwards done and as is also done for steam ships in the same circumstances.

The *Trefoil* was delivered in May, 1917, and after a very satisfactory sea trial we proceeded to Liverpool, where from August, 1917, to October, 1918, we were engaged in and around Liverpool and Manchester docks and running up and down the Canal with occasional runs to Lough Swilly, Bantry Bay and the Clyde. Being a twin screw ship we relied upon our own manœuvring powers in the Docks and Canal to a greater extent than if we had been a single screw steam vessel, and, as may be imagined our reversing gear had a very thorough test, telegraph orders in the early days coming down sometimes in such quick succession that it was almost impossible to register them in the log. The ability of the oil-engined ship to go astern at full speed, almost immediately, and its possession of what might be regarded as a full head of steam, a full vacuum, and heavy fires at instant call, was fully brought home to me on many occasions and there is no doubt that in the canal and docks we carried out, unaided, many evolutions which would have resulted in piling up a steamship which had attempted them. We had no hitch at any time with the reversing gear and though we suffered from constant changes of junior engineers the new men soon picked up the running of the engines and after a very short time were quite competent to handle the engines. Judging from my previous experience with air injection oil engines I can say that in the *Trefoil* the solid injection engines started, if anything, more rapidly and more smoothly than did the other type. When a number of engine reversals were required we started one or sometimes both of our air compressors to keep our starting reservoirs charged. As the compressors were not in use on other occasions they gave us no trouble, there being ample opportunity of examining and refitting the valves before they became troublesome. There is no doubt that the reversing of oil engines is a matter which has been satisfactorily settled in this, as in many other Diesel designs, and that the fears often felt in this connection are not now justified. It stands to reason that the gear must be kept in order, as in the case of any other apparatus, but in the *Trefoil's* engines the mechanism was easily understood and was readily accessible, so that a little intelligent interest was all that was required to keep the gear up to concert pitch.

The compressors were two in number, each three-stage, and were driven by Vickers' solid injection engines, the air being stored in six riveted air reservoirs. We found it was necessary to keep these reservoirs well drained, otherwise pitting began. The reservoirs were about 2 ft. 6 in. diameter by 11 ft. long with a manhole door at the end, so it was quite easy to examine the interior and to keep them in good condition. This type appeals to me more than did the long narrow bottles used in some other ships I have seen, as I imagine that the insides of the latter are likely to suffer owing to the greater difficulty of inspection. The maximum pressure of air was 600 pounds per square inch, but everything was quite in order as long as we had a pressure of 250 pounds. We usually kept a reservoir charged, and shut off the main air line for use in starting our compressors in case of an emergency such as a leaky joint, but, as a matter of fact, we were always able to obtain plenty of air and had no need to fall back upon our reserve. The engines, as I said, started very quickly, especially when warm, and I can quite believe that the absence of the injection air, which must have a cooling effect upon the charge, accounts for the easy starting from cold. The only precaution to be taken is to prime the fuel system thoroughly with the hand pump, if the engine has not run for several days, or if the fuel piping has been disconnected for any purpose. If this is not done it is plain that considerable starting air may be used in driving the engine simply to pump the air out of the fuel system. I know of a case where owing to neglect of this elementary precaution, a ship twice ran out of air before the main engines were got going. This took place in an air injection installation where there is the liability of air locks occurring in the fuel piping, owing to the injection air being coupled to the fuel system.

On each of the *Trefoil* main engines there are two fuel pumps, each consisting of a two-throw pump driven by spur gearing from the cam shaft. The diameter of the plungers is ·75 in. and the stroke 1·5 in., the pump running at engine speed. The design of the pump is, broadly speaking, similar to that of the ordinary Diesel engines, though owing to fuel pressures of 4,000 pounds being used the parts are more massive. The eccentric straps in particular are very wide and are white metal lined.

Both suction and discharge valves of the fuel pumps are in duplicate, the two suction valves being almost in contact so that the suction valve control affected both almost together. A vent valve is fitted below the upper discharge valve. The output of the pump is varied by a hand lever which raises or lowers the fulcrum of a sway beam to each pump, one end of which beam is operated by the plunger motion, while the other, which is fitted with an adjustable tappet holds the suction valves off their seats for a longer or shorter portion of the stroke of the pump according to the position of the control lever.

The pumps discharge to a fuel main which is a pipe running the length of the engine and fitted with leads to each spray valve, the latter being a cam operated spring loaded valve, similar in general principle to the ordinary Diesel valve, though there are no pulveriser and flame plates or injection air connections. The fuel passes from the main to the spray valve and when the spray valve is opened by the fuel cam the fuel passes through the spraying nozzle to the cylinder. The nozzle is a simple affair consisting of a ball end in which are drilled 5 holes, each about 19-thousandth of an inch in diameter and countersunk on the outside. The nozzle is made of tool steel and stands up very well to its work, though eventually the holes become eroded by the passage of the fuel. The nozzles are small items, easily replaced, and as they last about 12 months, fitting a spare is a trifle. I know there was considerable experimenting carried out by the makers before the right proportions of the spraying gear were discovered, but from the sea-going point of view the whole system is almost ridiculously simple. All one had to do was to adjust the pump control lever to give the required pressure in the main and then it would remain constant for hours. Now and then a touch on the lever might be necessary to bring the pressure gauge pointer back to its exact position on this dial. When altering speed the opening of the spray valves was altered by a second lever and the pump control afterwards adjusted if necessary.

The spray valve is, of course, the soul of the job as it determines the fuel admitted and it must, therefore, be kept perfectly tight. This, however, is easily done and all that is required is care and an interest in the job. We made it a practice to touch up the valves about every month and to give the valve a rub into the seat using a little crocus powder or rotton stone. Afterwards the valve was fitted to a hand pump and tested to full pressure to see it was tight and that when the lever was tapped by a mallet the spray from each hole was clean and that the valve shut off sharply and without dribble.

Our valves had no external gland on the spindle as there was a bell crank inside the valve box for lifting the spindle and the gland was on the bell crank shaft which turned in the gland—the fuel load on the bell crank being taken up by a ball race inside the gland. The glands of the spray valves and of the pumps are packed with soft packing. We generally used Palmetto packing with a turn of Parrametto packing which is a bit harder, or a leather ring at the top and bottom of the stuffing box but most soft packings will do. The Tuck's type of packing may be used as long as there is no india rubber core which would be affected by the fuel. It is not so much a matter of the material of the packing as the care with which it is fitted in the stuffing box. If the stuff is pressed evenly into the box throughout the operation the gland may be slacked back to hand tight after squeezing the lot home and the rods or plungers will run sweetly and soon get a beautiful polish on them. If there is any leakage it is best to repack the gland at the first opportunity, and I always forbade any undue heaving up as it simply tended to score the rod and in the case of a spray valve to prevent rapid closing which would result in smoke and waste of fuel. In my opinion much trouble would be saved with rods of all descriptions, especially in the water ends of bilge pumps, if a similar routine was followed

The fuel pressure of 4,000 pounds to the square inch might cause misgivings to engineers unused to such pressures, but such are quite unfounded and there is no difficulty at all with the joints which are designed for the pressure, or with the glands. I found no more trouble with the solid injection pump or the fuel service than I had with the corresponding fittings in air injection engines I have served with afloat. Perhaps I have been unfortunate in my experience with the latter type of engine, but I must confess I came to regard high pressure air in connection with the fuel in a Diesel engine as a dangerous shipmate. Diesel experts would doubtless have something to say in the matter, but a plain sea-going engineer like myself will probably be excused by most members of this Institute for feeling a bit uneasy in the neighbourhood of an engine that had on occasions in my presence burst cylinder covers through some vagary of the injection apparatus. With the pump injection, on the other hand, everything seems such plain sailing and one has confidence that smoke is probably the most serious result of any failure to treat the system in the proper manner.

I believe that the modern air compressors are much better than those in use some years ago, but even so I reckon that they form the weak spot in the ordinary Diesel engine. Apart from valve trouble the pipes are apt to be scoured and oxidised by the hot compressed air, and I see that Duplicate Compressors are fitted in a number of engines. Explosions in the intercoolers due to the wrong sort of lubricating oil, or as far as that goes, whatever oil is used, seem to take place every now and then in land stations, so I am inclined to think that in ships where conditions are not so favourable, air injection should be regarded as a half-way house to something better.

Speaking of intercooler explosions, I remember that while engines were being built I was talking over Compressor troubles with the makers, and was at first surprised at the statement that as the result of one of these explosions a steel plate separator, though proved to be of perfect quality, had shattered as if made of some very brittle material and that a needle of steel had been shot into the breast of one of their engineers with fatal results.

The cause of this must evidently have been something in the nature of an explosion wave or else a detonation as opposed to the less sudden pressure rise described as an explosion, and owing to oil being very finely broken up, mechanically or perhaps even chemically, and in close association with the oxygen in the highly compressed air. I have thought that the heavy knocking sometimes experienced in air injection engines, when the blast air was excessive, might be due to something similar and that the bursting of covers and the fracture of crankshafts, sometimes happening in engines with the air system, might be due to the same sort of thing in a less violent form. However that may be, nothing of the kind as far as my experience goes can happen with a solid injection engine. High pressures can be obtained if the spray valve leaks or if injection is set too early, but these are matters which require no particular knowledge or care to avoid. Even so the pressures seem to be more gently imposed and in the submarine engines which, by the way, have no cylinder relief valves, I have seen a spray valve held continuously open for demonstration purposes with no ill effects, the result simply being smoke and heavy knocking or "tonking" in the cylinder. The indicator diagram is, of course, very peaky in such circumstances, and I would prefer not to carry out "stunts" of this sort on the larger engines in my own ship, but I feel sure that the results of abnormal conditions with solid injection are more gentle than with air injection, however the indicator may fail to distinguish between the two. It was certainly remarkable how easily the *Trefoil's* engines picked up even at low speed with a practical absence of shock, the whole performance reminding one of our old friend the steam engine, though the oil engine could pick up full power or a bit over in a fraction of the time taken by the steam engine.

During the discussion on Mr. Peel's paper I saw that the solid injection set was stated not likely to be a commercial success, except in the smaller sizes, owing to an absence of turbulence. I don't profess to know what happens inside the *Trefoil's* cylinder, and as a sea-going engineer I am more concerned with fuel consumption per mile run or per shaft horse power. The Vickers' engineers claim that the solid injection system will give at least as good consumption as air injection in similar circumstances, and judging from the *Trefoil's* running which took place on any service fuel that we happened to be carrying for the fleet, I see no reason to doubt their claim. As regards consumption, the unwary shipowner and engineer are sometimes misled by figures being given per indicated horse-power, or sometimes simply per horse power. With steam engines of more or less standard efficiencies this is a good enough basis of comparison, but it would be better to bring all consumptions to a brake or shaft horse power basis, as is done for turbines. This eliminates the frequent error in indicator diagrams, which, as ordinarily taken, are none too reliable on oil engines where temperatures are high, and the figures would then have a practical meaning. The indicated power consumption gives the air injection engine an unfair advantage, as with equal effective consumptions the more inefficient the engine is mechanically, the better the consumption appears for comparison.

In commercial work the mean pressures are moderate, so even if air injection permits of higher duties these will not be required for mercantile marine work. There is in the cylinder at ordinary ratings about twice the amount of air theoretically required for combustion, so, as we have often found in the *Trefoil*, there is room for a fair overload without needing any extra air from a blast compressor. If the engine is in good condition the exhaust remains practically clear even under overload.

Smoke in a Diesel engine seems always to be one of the first things to be criticised in my experience, but I notice that a good cloud is regarded as rather impressive on a steam trial of a coal fired ship, while when burning oil under boilers it is preferred for reasons of economy to maintain a slight colour at the funnel. Semi-Diesels give considerable smoke on service in many circumstances without doing any harm, and it has occurred to me that it would be wise to regard smoke in a Diesel rather as a matter for investigation than for immediate censure. I say this because I have found that while with solid injection any fault is soon evidenced by smoke, yet the exhaust pipes remained practically clean. On the other hand, with air injection engines the exhaust might be very good yet considerable deposit be found in the pipes and on the valves. I can imagine various possible explanations for this, but as I have no means of testing the truth of my idea I simply put it forward as a fact which may be of interest, and one which I think has not been previously mentioned.

The lubrication of the *Trefoil's* engines was forced throughout. These low headroom engines had no division plate between the crankcase and the cylinders such as a purely commercial engine would have, so that the lubricating oil was contaminated by any dirty or burnt oil falling from the pistons, as in a trunk engine. In addition, the bed-plate and drain arrangements led to bilge water occasionally getting into the oil. Even so there was never any thought of bearing trouble, and I am convinced that if only steam marine engines were fitted with forced lubrication to the principal parts the wear and tear and final expense would be immensely reduced. It is a common enough practice nowadays with auxiliary engines, and I am told that in some of the last reciprocating-engined battleships in the British Navy it was fitted to the main engines with most satisfactory results. It is, of course, necessary to prevent salt water mixing with the bearing oil, but this presents no difficulty in a job designed for forced lubrication. When likely to remain in harbour for any length of time I made it a practice in the *Trefoil* to use the hand lubricating pump to pump some fresh oil through the bearings after stopping. This washed out any water which if allowed to remain would pit the journals.

A point that is sometimes overlooked with oil engines is the necessity of periodically cleaning out the water space. What is a matter of routine in the case of a boiler or of a condenser is apt to be regarded as an irksome task in an oil engine. It stands to reason that just as furnace crowns will come down if boilers are allowed to get dirty, so covers may crack or pistons seize if the water spaces of an oil engine are allowed to fill with mud. Nothing should be allowed to stand in the way of a periodical swilling out of these spaces. The oil engine has come to stay and the routine must be made to suit its requirements.

In drawing my remarks to a close it may be interesting to those unacquainted with oil engines to give some comments upon the oil engine from the personnel point of view. Among the number of untrained men who have passed through the Engine Room of the *Trefoil* I found the majority on arrival not in favour of the oil engine. They did not seem confident in the machinery nor in themselves, feeling that they lacked intuition to go to the source of any trouble if it arose. After a while they learnt that a good oil engine does not require a professor to run it, and that it may be run with less trouble than a steam job. They then became enthusiasts for the oil engine as a self-running apparatus, and it was necessary to keep them alive to the fact that there remained work for them in the way of inspection even if repair was not needed. Their general expression of opinion after settling down was that the oil-engined ship was far preferable to the steamer and I am convinced that from the *Trefoil* there has gone out a number of men intent on spreading far and wide the advantages of the solid injection oil engine. You will have gathered my own opinion from the notes I have given, and I can honestly say that my log shows much more work was occupied in keeping steam auxiliaries in order than was devoted to the main engines, experimental and special in design though they were. In my judgment, given a little instruction in the construction and working of the machinery there is nothing to prevent any average steam engineer with some power of adaptability from becoming in a short time fully competent to run an oil engine of large power, and no fear that any highly scientific knowledge is required need be entertained.

If engineers can be made to hold these opinions, the fuel consumption, which is well below half that of oil fired steam ships, should convince owners that it is worth while to consider oil engines for ships for which engines of the power required are being offered, and I am of the opinion that before long we shall see few ocean going cargo ships built with steam engines, and that when freights costs fall, the economy of the oil engine will give to the owner of the oil-engined ship an unassailable advantage over his less enterprising competitor.

As experience is increased it will doubtless be found that there is room for a variety of makes of engine. Judging from the result of development of the steam engine which in its early days took many peculiar shapes, advantageous on paper, but eliminated as the result of sea experience, I am inclined to think that even allowing for the difference in the driving power, evolution will for ordinary commercial purposes result in oil engines being arranged as regards their principal parts, very much on the lines of the latest reciprocating steam engine. When I find myself being persuaded of the virtues of some very novel arrangement of an oil engine, I often realise that the same arguments would apply to a steam engine on the same lines and I become doubtful if the unorthodox type will receive more than a passing favour for ordinary cargo ship use.

As regards the choice between the four and two-stroke cycles for medium powers and speeds there seems little to choose on the grounds of weight and space or cost if the same rating is followed in each case. This being so I favour the four-stroke engine as being practically just as simple as the two-stroke engine, the absence of the scavenging pumps being a great advantage, and subjected to a less continuous high temperature.

The final method of working auxiliaries will, in my opinion, be electric, unless tank heating or other special circumstances cause steam boilers to be in use, but doubtless many owners will be wise in retaining steam auxiliaries till the oil engine has become more familiar to their engineers, thus introducing one novelty at a time. Electric auxiliaries for the engine, such as circulating and oil pumps, are in my opinion much preferable to the pumps driven by sway beams off the engine, and will ultimately become universal.

Solid injection, whatever may be advanced against it from the theoretical side, is undoubtedly a working proposition, and I expect to see it taken up more by various makers now that it is coming into use in commercial vessels and its wide and successful use, hitherto more or less secret, is becoming known. The Americans among other foreign countries seem very much alive to its possibilities and it would be well, now that Great Britain is seriously taking up marine oil engine manufacture, that her engineers should give it full and unbiassed consideration.

ADDENDA.

The following is a description of the engines and some notes regarding the overhaul which may be of interest:—

The engines of the Trefoil are of the "Vickers" heavy oil type, operating on the Diesel principle and adapted for the combustion of heavy mineral oils of high specific gravity and flash point. They are of the vertical four-stroke cycle, single acting type, with trunk pistons and enclosed crank chambers.

The impulse cylinders are three in number $10\frac{3}{4}$ inches diameter and 13 inches stroke designed for a speed of about 320 revolutions per minute. They are made with separate liners and jackets, both parts being of plain design facilitating rapid removal, if necessary.

The Cylinder Liners are made of special cast iron machined all over and so mounted in the entablature as to be free to expand.

The Cylinder Jackets are made of sheet steel and are so constructed and attached as to be readily removable.

The Cylinder Covers are made of cast steel of strong construction and design. They are attached to the entablature and plate steel columns, the arrangement being such that the impulse loads in the cylinders are transmitted from the covers through the columns to the bedplate without passing through the cylinder bodies. Special care has been taken in arranging for the most efficient cooling of the covers. In each cover are fitted one induction, one exhaust, one air starting and one relief valve, and also one spraying nozzle.

The Connecting Rods are of forged steel and are coupled direct to gudgeon pins carried in the pistons.

The Bedplate consists of strong cast steel girders tied together longitudinally by wrought steel channels, the whole being mounted on a strong cast iron seat, to which they are secured, and which acts as an oil well for the forced lubrication system.

The Crank Shaft is made of forged steel, the cranks being arranged in the sequence, and with the necessary balance weights to produce the best possible combination of balance and twisting moment of the set.

The Injection of the Fuel Oil is accomplished by means of the "Vickers" special patented process in which the oil is sprayed directly into the cylinder without the use of blast air. A fuel oil pump of ample capacity, driven by gearing from the engine, is provided, discharging, at a pressure of from 3,000 lbs. to 4,000 lbs. per square inch, into a common pipe or rail. A mechanically operated valve is fitted on each impulse cylinder to measure the fuel oil supply; a pipe is led from the rail to each of these valves and thence to the spraying nozzle in the cylinder cover. A number of very minute holes are bored in the nozzles which, by means of the high pressure of the oil discharge, split the fuel oil up into the fine spray necessary for complete combustion. Screw down valves are fitted in connection with the spray nozzles by means of which any individual cylinder can be cut out.

Forced Lubrication System. A complete system of forced lubrication is provided, both for the cylinders and for all the more important bearings. A pump driven by the engine is fitted for each of these services. For the bearing oil the pump draws from a drain and settling tank, the oil being collected in the cast iron seat and returned to this tank to be used over again after settling and passing through the strainers. For the cylinder lubrication a multiple plunger pump is provided having an independent plunger for each cylinder. Adjustable sight feeds are fitted on the suction side of each plunger for regulating the supply of oil, and in addition a hand pump is fitted in the ship by means of which any cylinder can be flushed with oil at any time. A hand pump is also provided for priming up the lubricating system before starting the engine.

A Circulating Water Pump is provided, driven by the engine, for supplying the cooling water to jackets and other parts where it is required.

A Hartnell Governor is provided to keep the engine speed constant under the varying loads experienced in charging the air storage reservoirs from atmospheric pressure up to 600 lbs. gauge pressure.

As the engine control is most conveniently effected by regulating the lift of the fuel measuring valve, and as a considerable amount of power is required to perform this operation, the governor is arranged to carry out the movements through the medium of a servo-motor. This servo-motor consists of a cylinder containing a piston which is coupled through link work and levers to the fulcrum shaft carrying the measuring valve operating levers. Oil under pressure from a pump is admitted to either side of the servo-motor piston, the only function of the governor being to control the admission of oil to the servo-motor. This is done by means of a balanced piston valve which is easily moved by the governor.

An Inertia Governor is provided, the function of which is to stop the engine should the speed increase 20 per cent. above the revolutions required for full output, due to a sudden removal of the load, or failure of the "Hartnell" governor to come into operation quickly enough. This governor acts by releasing the fuel oil pressure from the rail.

A Flywheel is fitted to the engine to assist in obtaining smooth running of the set; it is of cast iron and also acts as a turning wheel.

Air Compressor.—The air compression is performed in three stages, there are two first stage cylinders each 11·15 inches in diameter, one second stage cylinder 7·2 inches in diameter and one third stage cylinder 3·9 inches in diameter, the stroke in all cases being 12 inches. The compressor is coupled direct to the engine and has two cranks, the cylinders being arranged in tandem; one first stage cylinder and the second stage cylinder are operated by one crank, and one first stage cylinder and the third stage cylinder are operated by the other crank, the first stage being the lower cylinder in each case.

The Cylinders and Jackets are of special cast iron in all cases, the jackets being cast with the cylinders. In the first stage, inlet ports are fitted; in addition to the inlet valve at top of stroke, these ports are fitted with a slide by means of which the amount of air admitted can be regulated.

The pistons, two in number, are made of special cast iron. The first and second stage pistons from one casting, and the first and third stage from the other casting. The gudgeon pins are fitted in the first stage pistons.

Cooling water is supplied to the jackets, covers and other parts by the engine pump. The air between the stages is cooled by means of water jacketted pipes for first and second stage discharges, separators being fitted in these pipes for the purpose of draining any accumulation of water. The air from the third stage discharge, in addition to a water jacketted pipe, passes also through a separator and coil cooler before being finally admitted to the reservoirs.

While overhauling the main engines the following notes were recorded for future guidance:—

Cylinder Covers.—Considerable difficulty was experienced in the lifting of the main engine cylinder covers, it being found necessary to remove several heavy exhaust pipes before covers could be lifted. To avoid this in future, two methods were submitted:—

(*a*) To substitute new branch pipes and a distance piece which could be readily disconnected.

(*b*) Alter the exhaust pipe at the expansion joint to give sufficient space to allow the cover to lift clear and have a distance piece fitted between the valve and original branch pipe.

However, neither of these two methods are being adopted, the first would cost too much and the second would give too little room behind the main engines, but the glands in the exhaust pipe branch piece are being fitted in halves, so that the packing may be withdrawn, and with the exhaust valve out, the branch piece can be turned round and the cover lifted clear.

Valves.—On removing the valves from the covers, all the valve faces were found in good condition, but the internal tubes in several of the exhaust valves were perforated. All exhaust valve tubes required renewal.

Pistons, Rings and Liners.—When the cylinder covers were removed the absence of carbon was very noticeable. The first two piston rings and in some cases the first three, were stuck; the remaining rings, however, were working satisfactorily.

All the cylinder liners were in excellent condition.

Water Jackets.—On removing the liner water jackets they were found with mud accumulated below the inlet and banked up opposite.

Mud doors have now been fitted to admit of periodic cleaning.

Crankshaft and Main Bearings.—On the crank pin there was found to be a wear of 5/1000in., but the surfaces of all bearings were very good. Both crankshafts being re-bedded and all top and bottom ends adjusted.

Turning Gear.—The frame of the starboard turning gear required to be refitted to engine sole plate. On the port engine it was found that $\frac{1}{2}$in. required to be taken off the worm on the vertical shaft, to allow it to clear the crank shaft wheel in all positions, while out of gear.

Cooling Water Pumps.—When these were opened up the valves, spindles and springs were found badly worn, but with a lighter type of valve being fitted no further trouble is looked for in this direction.

Air Compressors.—The power cylinders, pistons, rings and valves were all in good condition. The connecting rods were also in good condition with the exception of two on starboard engine, which were bent at the neck and being replaced from spare. (Water in the cylinder when starting up may have been the cause of the bent rods.)

On the crank pin there is a wear of 5/1000in., most of which has taken place on the underside of the pin, probably due to the engines high speed and the inertia of the piston on the exhaust stroke. The surfaces of all bearings were very good.

A number of the rings in the port air cylinders were stuck, caused by a salt water leak in the 1st stage cooler; this leak will be made good and the rings renewed. The rings in the starboard air cylinders were all in good condition, but as considerable wear has taken place on the 1st stage rings these require renewal.

Control Gear.—The fuel pressure pump suction valves having a constant lift, considerable difficulty was experienced in maintaining a suitable pressure for all loads. The only control over the pump was a throttle on the pump suction pipe, but as this was operated off the spray valve lift control, increasing or decreasing the fuel pressure meant altering the lift of the spray valve, which is not desired at all loads. In this type of pump it is not possible to vary the lift of the suction valves and to avoid the expense of new pumps, a hand controlled throttle on the suction pipe is being fitted in addition, and with this fitted better results are expected.

Cooling Water Pumps.—On opening up these pumps it was found necessary to have them re-bored; this, however, brought bad metal to the surface, so new chambers were cast.

AUXILIARY MACHINERY OVERHAUL.

Dynamo Engines (two).—On opening up these engines the L.P. cylinders were found badly worn, requiring to be rebored and new pistons and rings fitted, the bearings also being re-adjusted.

Fire and Bilge Pumps (two).—Both pumps were in good condition, but new steam rings, also new bucket rings in port pump were required.

Oil fuel Pumps (two).—Both pump rods skimmed up and new rings fitted.

Boiler Room Fans (two).—Piston rods skimmed up, starboard cylinder rebored, new rings fitted for both, and bearings adjusted.

Pump Room Fans (two).—Opened up for examination and found in good condition.

Engine Room Fan.—New rings fitted and bearings adjusted.

Feed Pumps (two).—New steam and bucket rings fitted, also valves lined up.

Air Pump.—New steam rings fitted. Bucket valves cleaned and turned.

Circulating Pump.—New bushes fitted on impeller shaft. New steam rings fitted, and bearings adjusted.

Condenser.—Cleaned, new protection plates fitted, tested and found satisfactory.

Evaporating Plant.—Pump sent to shop and overhauled. Coils annealed and valves ground in.

Cargo Pumps (two).—Valve seats being reseated and valves ground in. Pistons and shuttle valves and buckets found in good condition.

Ballast Pump.—Water end being rebored and new bucket rings fitted.

Capstan and Windlass.—Bearings adjusted.

Steering Engine.—Stronger bedplate fitted; piston valves and steam rings renewed, bearings adjusted.

Boilers, Water Tube (two).—Fire row to be renewed, all other tubes and drums in good condition.

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