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Volume VIII.

SIXTY-FOURTH PAPER

(OF TRANSACTIONS)

THE BEARINGS OF THE MARINE ENGINE,

BY

Mr. JOHN DEWRANCE

(MEMBER).

READ AT

THE ARTS' SOCIETY HALL, SOUTHAMPTON,

ON WEDNESDAY, DECEMBER 9TH, 1896.

THE INSTITUTE PREMISES, 58, ROMFORD ROAD, STRATFORD,

ON MONDAY, DECEMBER 14TH, 1896.

THE UNIVERSITY COLLEGE, CARDIFF,

ON WEDNESDAY, JANUARY 13TH, 1897.

DISCUSSION CONTINUED

ON MONDAY, JANUARY 11TH, 1897,

AT 58, ROMFORD ROAD.

PREFACE.

58, Romford Road,

Stratford, E.,

December 14th, 1896.

A meeting of the Institute of Marine Engineers was held here this evening, presided over by A. J. Durston, Esq., C.B. (Past-President), when a Paper on the Bearings of the Marine Engine, by Mr. John Dewrance (Member), was read and in part discussed.

The Paper was illustrated by Diagrams, and the prominent features of the arguments were demonstrated by an experimental model, which considerably enhanced the value and interest of the paper.

The further discussion of the subject was postponed till Monday, January 11th, 1897.

JAS. ADAMSON,

Hon. Secretary.

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THE BEARINGS OF THE MARINE ENGINE.

BY JOHN DEWRANCE (*Member*).

READ AT 58, ROMFORD ROAD, STRATFORD, E.,

ON MONDAY, DECEMBER 14th, 1896.

CHAIRMAN:

A. J. DURSTON, ESQ., R.N., C.B. *(Past President)*.

The first object of this paper is to lay before the members an explanation of the way that oil enables a bearing to support its load and afterwards to deal with the modifications in the design of the bearings of the marine engine that follow from a right understanding of the principle of lubrication.

To simplify the explanation, the author has constructed a hand machine. The wheel, twenty-four inches diameter, represents a shaft and the bearing may be said to have been flattened out into a plate. If the plate is laid upon the wheel and the micrometer adjusted, the hand will be observed to stand at a given mark. If oil is now put into the trough, so that it touches the wheel, it will be observed that the hand of the micrometer has moved, showing that the plate has risen. This means that between the surface of the wheel and the bearing there is a layer of oil on which the bearing is floating. If now we load the bearing we must either squeeze out this layer of oil or the oil must be subject to a pressure sufficient to support the extra load. By means of a hole through the bearing and a pressure gauge, this point can very readily be proved. As will be seen, as the hole is brought to the point of contact between the bearing and the shaft the pressure on the gauge rises to a point that corresponds to the load put upon the bearing. As explained in a paper by the author, printed in the proceedings of the Institute of Civil Engineers, the oil adheres to the surface of the wheel or shaft, and the force of this adhesion is multiplied by the incline formed by the bearing to the shaft. If the hole is put beyond the centre of the shaft the air in the hole adheres to the shaft and is carried round, leaving a vacuum, as shown by the gauge. Under favourable circumstances this vacuum has amounted to thirty inches, being within a quarter of an inch of the barometer at the time. The conclusion to be drawn from this experiment is that bearing surfaces that are properly lubricated are separated by a film of oil at a pressure per square inch equal to the load that is upon them.

The realization of this fact suggests the following rule, which can be easily committed to memory and is applicable to nearly all classes of bearing. Introduce the oil at the points of least pressure and do not provide a means of escape for it at the points of greatest pressure. It is very easy to find out the points of an ordinary bearing that are least subject to pressure, and the oil can generally be brought there with a little scheming. The means of escape most generally met with are oil holes and channels that frequently occur just at the crown of the bearing where the pressure is greatest.

When the pressure on such a bearing is intermittent, the oil goes in when the pressure is taken off and escapes out again when the pressure comes on, the effect being that the bearing is only able to support a proportion of the load that it could support if lubricated according to the rule. It is quite impossible to lubricate such a bearing at all, if subjected to a continuous load. Not a drop of oil will run down the hole at the crown of the bearing, and if oil is put on the shaft elsewhere it runs out at the hole at the crown.

The diagrams (upon the wall) represent the principal bearings of the marine engine to which this rule has been applied. No. 1 is the big end of the connecting rod of a vertical inverted marine engine. In this case the two sides are the points of least pressure, and, as will be seen, the oil is led to chambers at the sides. From these chambers, suitable inclined planes are provided and the oil will arrive at the surfaces which have to bear the load at a pressure per square inch equal to the load. It will be noticed that in each case the means of lubrication are in duplicate. This, in the case of large bearings, is strongly recommended, as otherwise one half of the bearing is only lubricated by the oil that has passed through the other half, and in very large bearings this is not always found to be sufficient, especially when the bearings are new. The double supply of oil is also a great safeguard against failure.

Diagram No. 2 represents the crank shaft bearings. The duty of these bearings is almost identical with that of the big end of the connecting rod. As will be seen, the lubrication is also the same. It seems to be very generally the custom to make these bearings hexagonal or square on the outside. Such a bearing is very difficult to get out to examine or scrape up. The bearing shown is circular and is prevented from turning with the shaft by a square part on the top half. Such a bearing can be taken out very readily.

Diagram No. 3 represents the little end of the connecting rod. Here again the oil requires to be delivered to the sides the same as to the big end. The diagram shows the oil conducted through the pin. At the end there is a swivel joint. One of the pipes shewn brings the oil for the little end and delivers it through the pin; the other pipe brings the oil for the big end and delivers it on the other side into a chamber from which it is conducted by two pipes to both sides of the big end.

Diagram No. 4 shows the general arrangement of these pipes from the lubricators to the bearings.

Diagram No. 5 shows the thrust block. It is strongly recommended that the cooling water should be kept away from the oil, as the mixture of water and oil is an inferior lubricant to pure oil. As will be seen, chambers are formed in the casting through which water can be circulated. There is a difficulty about this form of bearing, in that there is no point of least pressure at which to introduce the oil, so it is necessary to make one. To accomplish this the edges are sloped off as shewn on diagram No. 6. With inclined planes such as are shewn, it is possible to draw the oil in between the surfaces up to any pressure.

If once we accept the principle set out in this paper it follows of necessity that a hot bearing is due to a failure of lubrication. If the oil is supplied, as shewn by the diagrams, this may be due to the fact that the shaft is not round, is not running true, or else, that it is not smooth enough. Shafts should be finished by clamps lined with emery cloth till they are well polished. Another cause may be that the bearings are not properly fitted. It is no light task to surface up a bearing so that the shaft beds thoroughly.

Having dealt with the subject of the means of lubrication, the next point is the oil. In these days of competition and lowest tender, very inferior oils are sometimes used in very superior ships. Adulteration of oils is so general that the names by which they used to be known has no longer any real meaning. Whenever it is possible it is the safest way to have the samples of oil examined and reported upon by a chemist, who also has the means of testing the lubricating properties.

Another very important point is the material of which the bearing is composed. Marine engineers seem to be very generally agreed that the bearing should be lined with one of the alloys known as the white metals. These may be divided into three classes. The first contains anything up to 80 % of tin, the second anything up to 80 % of zinc, and the third anything up to 80 % of lead. If we could make sure of always using perfectly neutral oil there would be very little to choose between these three classes, but in order to obtain a neutral oil, such as is prepared for clockmakers, the oil is agitated with zinc and lead shavings, a portion of each is converted into zinc or lead soap which is afterwards separated from the oil. The principal impurity of lubricating oils is oleic acid which rapidly corrodes lead and zinc. The plates shewn are examples of this. The effect then of using an alloy that contains a large proportion of lead or zinc is that the impurities of the oil combine with the surface of the bearing. Of course this may be avoided by using a very pure oil, but those that are responsible for the lining of the bearing, are not always responsible for the quality of oil used, and even if they are at the time they cannot make sure that they will always have it under their control. Tin is not affected by oleic acid or any of the impurities of oil, so the safest way is to use an alloy composed principally of tin, and only containing enough of the most suitable metals to harden it to the utmost. Many of the alloys at present used are too soft and yield with a load of even as little as a quarter of a ton to the inch. Such a metal is liable to squeeze out in use. An all round lining metal ought to stand at least five tons to the square inch without any yield, the best alloys will stand eight tons.

It is a very general custom among marine engineers to hammer the alloy after the bearing is lined. If the alloy is as hard as is desirable it cannot be very ductile, and this hammering cracks it in all directions; if, on the other hand, the alloy is ductile enough to stand hammering, it is conclusive proof that it has too low a compression test to be suitable for lining marine bearings. The author feels considerable diffidence in appearing to lay down the law to those who have had so much more experience of marine bearings. It is, however, right to say that the points dealt with are no untried ideas, but are the result of many years of study of the subject, and a very long series of experiments. It would take too long to even outline these experiments, but they entirely confirm the facts laid before you in this paper.

DISCUSSION

AT

58, ROMFORD ROAD, STRATFORD.

MONDAY, JANUARY 11th, 1897.

CHAIRMAN:

A. J. DURSTON, ESQ., C.B. *(Past-President).*

The CHAIRMAN: Mr. Dewrance has very kindly submitted a paper for our consideration to-night, on "The Bearings of the Marine Engine." It is a very important subject, and one that concerns every one of us. There is not one among us who has not looked at the bearings, when the temperature was increasing, with very serious thoughts, and who has not been greatly relieved when that temperature was reduced. Mr. Dewrance now gives his views on the subject, founded on the results of the experiments that he has carried out, and discussion is now invited.

Mr. W. C. Roberts (Vice-President): I have no remarks to make on the experiments which Mr. Dewrance has explained to us. Those experiments are quite new to me. My experience has been with ordinary bearings for engines, and with those we were unable to get at the pressures except by calculations in the ordinary way. As far as white metal is concerned, we have had the experience of Mr. Dewrance's special brand, which, I believe, is one of the most suitable white metals for the purpose, and up to the present it has always given great satisfaction, and proved a great saving in crank shafts. There is a certain amount of give and take in the white metal, which the ordinary hard metal has not.

Mr. Fortesque Flannery, M.P (Vice-President): I am very sorry that, owing to my inability to be present at the opening of the meeting, I did not hear the whole of the paper, because I should then have understood it better, but so far as I have been able to follow it, I understand that this machine has for its object the demonstration of the wedging action of the oil, when carried round by the surface of the shaft—that is to say, there must necessarily be friction between the oil that is placed in the bearing and the skin of the shafting, so that as the shaft revolves it tends to carry round the oil with it, and that forms, as it were, a film of oil wedged between the surface of the shaft and the bearing that is about it. The oil enters after the surface of the shaft has passed the point in the bearing which is nearest to it—when it lacks oil, so to speak, having parted with it, and therefore there is a suction action tending to form a vacuum as compared with a pressure at this other point. That, I think, demonstrates to us very clearly what may be shown by a model scientifically conceived and ingeniously constructed. It shows clearly to us, in common parlance, that the point of greatest pressure in a bearing is that nearly in line with the axis of the cylinder, because as the crank comes upwards the bottom of the crank pin and the top of the bearing is necessarily subject to the greatest pressure, and similarly on the down stroke the top of the crank pin and the bottom of the bearing are subject to the greatest pressure. Mr. Dewrance has shown very clearly that if he is right we have hitherto been all wrong. I am not prepared to say at the moment that there is not something that might be urged against his view. I confess it is entirely novel to me, and extremely interesting, but on the spur of the moment one is not willing to commit oneself to a new demonstration, however accurate and interesting it may appear to be. But Mr. Dewrance has made out a very strong case, and, as far as I can judge at the moment, a case that is quite unimpeachable. He has shown us that we should introduce the oil at the point of least pressure in a bearing. Hitherto we have always been in the habit of introducing our oil at the top of the bearing, and that is clearly demonstrated by this model, and by the arguments of the author, to be near the point of greatest pressure on the up stroke, as below is nearly the point of greatest pressure on the down stroke. Mr. Dewrance has not referred to any instance of a practical trial of his system in competition with the ordinary bearings, but, personally, I should be only too glad to give this system a fair trial in the hands of one who would do justice to it, and report to Mr. Dewrance on the results. I think the matter is of sufficient importance to deserve being dealt with at the earliest possible date. There are one or two points that occurred to me during the reading of the paper, about which I may, perhaps, be allowed to offer a few remarks. Mr. Dewrance referred to the difference between square bottom or hexagonal and round bottom bearings. In modern practice, the system of making the bottom brasses round at the bottom so that they may be lifted out without lifting the shaft, has become very general, and, although that system has some disadvantages, I think that on the whole, the balance of advantages is in favour of the round bottom bearing. There is, for instance, the disadvantage of not being able to line up quite so quickly as in the case of square bottom bearings, but so far as my personal experience goes, I think that round bottom bearings offer the greatest advantages, and, generally speaking, I am giving them the preference when I can. With regard to diagram 4, showing the arrangement proposed by the author for leading the oil pipes from the lubricators to the ends of the connecting rod, it occurred to me that there may be some objection to that long series of pipes and joints. There is always the danger of clogging, and the danger is, that once you have a pipe clogged you may get your bearing heated before you have a suspicion that anything is wrong. Even the model shown here this evening did not work quite as was intended or expected, owing, as the author suggested, to clogging.

Then I heartily endorse what Mr. Dewrance has said about the quality of the oil, and when I tell you that some oil is sold and bought, and bought readily, at 3/- per gallon, while there are plenty of people who will offer you oil at 1/1½ per gallon, I think you will see that there must be something wrong somewhere. I cannot say quite where it is, but I do know with regard to a good deal of it, that if you hold the oil up to the light it has that bluish tint, which is so suspicious of petroleum and adulteration. I know of instances where great damage has been done by the use of this inferior stuff, amounting in some cases to hundreds of pounds, and I therefore very heartily endorse the remark that the oil should be most carefully selected and tested. In regard to oil, the cheapest is too often the dearest, more than any other article of engine-room stores. The author does not mention in his paper the melting point of the alloys referred to. That is a very important matter, and I think it would be adding to our information if the author, before he closes, would tell us something about the melting points and the character of these three alloys of tin, lead, and zinc. The desideratum in white metal is to get such an alloy as will be sufficiently stiff to stand the pressure and the hammering, and not run in the event of the bearing getting hot; and if we had from the author some statement as to the melting points of the various alloys, in conjunction with the information on the other points, I think it would be of assistance. Then there is another point, upon which the author might enlighten us. He might give us his ideas as to the advantages of strips of white metal, as compared with slabs. Some makers make their white metal in the form of strips, two inches wide, which are alternated with brass or cast steel, about an inch and a quarter wide. But other makers give only one strip of the brass or cast steel, and then on each side of that strip there extends for several inches a large slab of white metal. One of those practices is probably better than the other, which, I am not prepared to say, but I think we should be glad of any hints that the author could give us on that point also. The advantages of having alternations of white metal, and either steel or brass—whichever may be the face of the bearing—are very great, arising from the different wearing powers of the two metals. I remember some 25 years ago, when the White Star steamers first came out, and were the observed of all observers on the Mersey, that they had great difficulty with their bearings. This one thing which, simple as it appeared, made all the difference between the success of that line in its first stages and comparative failure, was that the bearings gave so much trouble on the first few voyages.

About this time, Mr. Horsburgh, who for many years has occupied the position of superintending engineer to the White Star Co., had come over from Belfast. He lifted all the shafts, took out all the bearings, and drilled holes about a quarter of an inch deep, and about an inch and a quarter in diameter. He then filled those holes up with white metal. Those holes were placed, not in a line, but zig-zag round the bearing. The white metal studs were then made perfectly true to a bearing with the shaft, and after a little while, the white metal, being softer than the brass, wore almost imperceptibly, and these small holes, arising from the greater softness of the white metal, formed little recesses for the oil, and as the shaft revolved over the comparative ridges of the brass it carried some of the oil round with it. These bearings gave little or no trouble afterwards, and that difficulty which, small as it was, made, as I have said, all the difference between success and comparative failure in the initial stages, was absolutely and satisfactorily overcome.

Mr. J. H. THOMSON (Chairman of Council): I am very glad that this subject has again been brought before the Institute. In a paper that was recently read before the Institute, Mr. Ross advocated the same principle in lubrication that is now brought forward by Mr. Dewrance. I do not quite know that we all followed Mr. Ross exactly at that time, as the discussion covered much other ground, but now that the matter has been further explained, members will more clearly understand now the advantages that were claimed for this system. I am sure all present feel extremely indebted to Mr. Dewrance for the manner in which he has brought the subject before us. With reference to the pressure shown on the gauge attached to the machine on the platform, it may be within the recollection of some members that at one or two of our earlier meetings this circumstance of the rise of pressure was referred to by Mr. McFarlane Gray, who at the same time stated that a pressure of even 200 lbs. could be, or had been, shown through the lubricating pipes.

Mr. J. T. SMITH (Member of Council): I have not very much to say on this subject; but with regard to diagram 4, I should not advocate boring a hole through the pin like that, and I am afraid it would have a tendency to develop a fracture. I think, too, that the oil pipes, jointed and fixed as shown, might be improved upon. I have sailed with a telescopic oil arrangement, and I certainly think that it can be improved upon. In one part of the paper the author says that pure oil is better than oil and water. Now, for thrust bearings, I have not found that to be so. I have found that with oil and water the bearings will run cooler than with pure oil.

Mr. J. G. HAWTHORN (Member): To a certain extent the subject of this paper revolutionises the usual marine practice in connection with lubrication. Those who have had experience at sea are more or less conservative, and when putting the oil down the centre pipe on the top of the bearing, it is generally considered that the bearing is getting the oil; but after looking at the diagrams on the wall, and seeing the machine at work, one begins to look at the matter from a practical point of view, and question if the oil going in at the side would be carried round the bearing and lubricate it more efficiently. Seeing the machine at work, one feels convinced that it is so, when we see the vacuum formed. We could not have had anything to better demonstrate that the best place to put in the oil is at the side of the bearing. I would like to ask Mr. Dewrance, however, if he can inform us the limits of pressure between the two surfaces when the oil should retain its viscosity. We have read a good deal as to the pressure which oil can stand, but I think the whole of the experiments hitherto have been carried out in connection with sliding friction. What is the limit of thickness of oil at which the bearing will run? That is a point on which Mr. Dewrance might kindly give us information. With respect to the crank pin bearing, would not the line of thrust down the connecting rod have something to do with the probable success of this system? For a main bearing, undoubtedly, there seems no reason why this method of lubrication should not prove the best, or, indeed, wherever there is vibratory or oscillating motion; but I am somewhat sceptical as to whether it would answer for a crank pin. The point, however, upon which I would specially ask information, is—has Mr. Dewrance made any experiments to bring out the limit of pressure when the friction between the shaft and the bearing would overcome the viscosity of the oil? We have been told that some oil will stand pressures up to 500 lbs. per square inch, and that might be so between flat surfaces, but the same result might not occur in a round bearing. If, by adopting this method, we could run the bearings tighter with safety, and so get rid of the thumping which is frequently so troublesome, then the system of lubrication set forth by Mr. Dewrance would be a great benefit to the engineering profession.

Mr. R. Leslie (Hon. Treasurer): This is a subject that is well worth the attention of every one here to-night, not only the older members, but also the younger members, whose time is coming on. This machine that Mr. Dewrance has kindly brought before the Institute to demonstrate the action of the oil, goes a long way to support his case theoretically, but, practically, I am a little doubtful about it. One of our members already brought forward here the idea of putting in the oil at the side of the main bearing, but I do not think it has been done in actual practice. As far as the connection at the cross-head is concerned, I think the only place you can put the oil in there is on the top of the pin. The great point, in my idea, is to introduce the oil nearest its work, because, unless you do, it may pass out at the side of the bearing before it gets to its work. I should like, if it were possible, to bring a machine before the Institute, made to marine dimensions on a small scale, giving the actual pressure, working at 160 lbs., on the crank pin, and let us see the effect then. This machine is very good for demonstrating the theoretical part, but I should very much like to have an actual main bearing, and a cross-head as well, so that we could see the action of it. We now have engines which go to Australia and back without it becoming even necessary to slow down, and the oil is introduced there near the top of the bearing. They run very cool and very economically, and one, I think, needs to be cautious before making a move from that good practice. I do not think that there is anything more important about a marine engine than the main bearing, and next, the first importance of having it made of the very best material, which is always the cheapest in the end; and if you have the best material and the best lubricant, you can start with a certain amount of confidence that you will make a good voyage, assuming that you have a good allowance in length of bearing. We know of cases where shafts have been coupled together out of truth, and no lubricant would make such shafts work well; but that, I think, is a very rare occurrence. As a rule, they are adjusted so well that there is not much chance of their going wrong in that way. We do not even hear anything of that kind taking place now. I venture to say that the main bearings of engines now give 70 per cent. less trouble than they did in my younger days, and I have had experience in 21 steamers, and in 12 as chief engineer, in the service of a Company. I know that in my young days we used to have a lot of trouble with main bearings, and I think that generally it was the metal in the bearing that gave the trouble. We used the best castor oil we could get. It would be well for every shipowner to impress on his superintendent engineer the necessity of getting the best possible bearings, as it is a principal point in an engine, to a great extent, at any rate. Some of our shipowners like to cut down prices right and left, and they wonder afterwards why they do not get their engines to run satisfactorily. If they had an engineering head they would understand more about it, and I am very pleased that Mr. Dewrance has been so kind as to bring this machine before us. I should be more pleased still if we could have a working model of a crank and main bearing to work with the load upon it, and let us see the effect of introducing oil at the top and at the side. We might, perhaps, by that time be able to get a gas engine here to drive it with.

Mr. F. W. SHOREY (Member of Council): I think that most, if not all of us, will agree that we have had a very interesting and valuable paper. It puts the matter in a very short and concise form. The paper is really a *multum in parvo*, and much more interesting than when one has to wade through a lot of figures and calculations. From the title of the paper I was led to believe that Mr. Dewrance would have told us some way in which bearings should be constructed, and also the alloys that would work best in the main bearings. We know that there are various metals—almost every metal founder has his own special make, and all are claimed to be good—and I was in hope that Mr. Dewrance would have brought forward some special metal or alloy which would be an improvement on those now in use. I think the method of lubrication he has shown us fairly good, but not so good as if the oil syphon was put a little to one side of the contre. Many good metal bearings have been condemned unjustly, because they have had too little surface, and I am very pleased to see that builders are now giving us much greater bearing surfaces. Both in the Royal Navy and in the mercantile marine, we have been increasing the power of our engines very much of late—larger engines, heavier weights, and consequently more friction, and I think we are greatly indebted to Mr. Dewrance for the manner in which he has tried to bring before us to-night the best method of lubrication.

I do not wish to sound a note of alarm, but some few weeks back I was asked to see the model of an engine that was going to run without bearings at all, it was so evenly balanced. But sufficient for the day is the evil thereof, and we have to deal with things as they are. I have been delighted with the paper and the discussion, and I only hope that every engineer will keep his bearings as well lubricated and as free from dryness as this lecture has been.

Mr. JOHN ADAMSON (Member of Council): In the course of the paper the author spoke of "a very general custom among marine engineers to hammer the alloy after the bearing was lined," and he then referred to the evils and disadvantages of this hammering. I have had a good deal to do with this lining up of bearings, and can testify that the metal must be hammered to a certain extent, although sometimes it is overdone. The hammering is necessitated by the shrinkage of the metal. I should be glad, however, if Mr. Dewrance could give us a few hints on this particular point.

The CHAIRMAN: Before I call upon Mr. Dewrance to reply I should like to make one or two remarks. First of all, I should like to say how much we all appreciate and value the remarks of Mr. Flannery, who put the matter before us in a way that greatly helped the subsequent discussion. With regard to the interesting incident mentioned by Mr. Flannery as to the use of those circular white metal plugs, I recollect that a good many years ago some of the engineers in the Navy thought the same thing, and in one ship the plan was tried with success. But in another ship where we put these plugs in the bearings they turned round on their centres, and it seems to me that with round plugs there must be this liability. Had the holes been oval this would not have occurred. I mention that as a matter of experience, which, I think, you should know. Mr. Dewrance's suggestion is a very interesting one, and should it prove to be successful in actual working, it would enable us, as Mr. Hawthorn has suggested, to carry our bearings much more nearly adjusted, and so reduce the hammering action. This No. 4 diagram has been alluded to, and reference was made to telescopic joints. I know that in the Navy we rather had the fear that these pipes would seize, and that they would then be found walking about the engine-room platform in a manner extremely unpleasant to anybody who might happen to be there. Then it would be very interesting to the members of the Institution if Mr. Dewrance could give us some particulars as to the pressure—the clearance that would be allowed with his system between the bearing and the crank shaft. Looking at the bearing that has been passed round this evening; at the first blush, the device for preventing the oil from flowing out at the two ends would appear to give us rather too close a fitting bearing at the ends, but experience would show whether there is anything in that or not. Mr. Dewrance has also told us about the different white metals, and it looks from the experiments that the one in which tin is most used is the most desirable—at any rate, it is the least liable to be affected by the acid in the lubricant. On that point the Admiralty practice, as a rule, is to use for main bearings the white metal in which tin is the largest constituent, but in some cases—for torpedo boats and torpedo boat destroyers—we have had an alloy containing about 69 per cent. of tin, 29·6 per cent. of zinc, and 1·4 per cent. of copper. That was adopted for lining the A bracket bearings of the screw shafts outside, because lignum vitæ was not suitable for the purpose in those small boats. I will now call upon Mr. Dewrance to reply.

Mr. Dewrance: Mr. Chairman, I may begin by thanking you all for the kind way in which you have received this paper, and for the trouble you have taken in following my explanations. I must also thank Mr Flannery for his kind offer to have this system of lubrication tried on a practical scale on board ship. Up to the present time the system has been used in connection with several land engines, but it has not been tried on board ship. Mr. Flannery also referred to the possibility of the oil clogging in the delivery to the crank pin bearing, and when in this connection he referred to the clogging of the oil in this machine, he certainly hit me very hard. Such a clogging, if it occurs, must, of course, be put up with, but I understand that in some cases it has been the practice to solidify the oil, and force it through on to the bearings with very good results. Mr. Flannery further asked about the melting points of the various alloys. The melting points of the white metals varies according to their composition, but it may be taken that those composed principally of tin become plastic and useless, so as to be unable to support any load, at a few degrees below 500° Fah. The alloys composed principally of lead will stand a few degrees above 500° Fah., and when you come to metals containing 80 per cent. of zinc, you can raise the melting point to 626° Fah., and that is the highest point to which I have been able to get with that class of metal. To get a metal that will run at 700° you will have to go into a different class of metal altogether. It must be remembered that when the temperature rises above 200° Fah., the viscosity of the oil is so greatly reduced that it does not lubricate the bearings properly, and there is very little chance of the bearing running well until it has been cooled down. It is very bad for the white metal to run out from a bearing, but it is worse to have the shaft damaged by a bronze bearing. Then a question has been asked as to the relative value of strips and slabs of white metal. My experience of strips has been anything but favourable. I have had to do with a large number of bearings which have run very badly with strips of white metal, and when, on my recommendation, the surfaces were entirely covered the results were most satisfactory. Certainly my experience is that bearings lined in strips are not so serviceable as those that have the surface entirely covered. With properly lubricated bearings, the question as to which metal wears the best does not arise in the ordinary sense. The surfaces are separated by a film of oil, and are only affected by the chemical corrosion caused by the impurities in the oil. Therefore, the point is, which metal will best stand the chemical corrosion? Such a thing as wear ought not to occur. Then I have been told that oil and water form a better lubricant than oil by itself. All I can say is that I have conducted a large number of experiments, and that I have always come to exactly the opposite result. I have tried with various substances, and can find nothing better than oil. Mr. Hawthorn dealt with the limit of pressure that the film of oil will sustain. That limit was very high in some of the experiments, indeed, the surfaces have been separated by such a film at pressures up to 4,000 lbs. per square inch. Then the question was asked whether, with this system of lubrication, we could run our bearings tighter. I think that that would be a great advantage which would be gained. The tighter the bearing runs the less the viscosity of oil required, and all you require is to give sufficient clearance to allow for the expansion of the shaft. I have found that it is only necessary to bore out the bearing larger than the shaft, so as to allow for the expansion of the shaft, and for the film of oil—that the bearing which fits so tight that it will only allow for the expansion of the shaft and the film of oil, is the best form of adjustment, and that anything you give beyond that simply means that you are thrashing your oil out at the ends to an unnecessary extent. Mr. Leslie says that the present bearings are so perfect that you do not need to better them. That has not been my experience. I have seen great ocean liners, whose shafts have had to be lifted at tremendous expense, after running only a few months. But, besides that, we want lighter machinery, we want lighter things everywhere. We want more power out of our engines. Several members have spoken of the advantages of plenty of surface in the bearings, but if bearings can be lubricated in a way that will enable them to bear increased loads with safety, it will economise weight and enable the designers of marine engines to get more power into a given space. There are circumstances under which it would be a very great advantage to a designer of marine engines to have a bearing at a particular point capable of bearing a heavy pressure, and, as I have already stated, I have had bearings running up to 4,000 lbs. per square inch. I think you will all agree that that leaves an enormous margin to play with, over and above what is in use at present. Mr. John Adamson said that the shrinkage of the white metal necessitated the hammering. The shrinkage varies according to the composition of the metal, and one of the arts in alloying metals is to get a result that will shrink as little as possible. I have had cases where there was no need for any hammering, and I do not think that the shrinkage in a well composed white metal is sufficient to necessitate hammering.

In conclusion, I should like to pay a tribute of acknowledgement to Mr. Ross, whose paper was only placed in my hands last Saturday. I had no idea that such a paper had been read before the Institute. Unfortunately Mr. Ross was not able to be present when his paper was read. His paper was read for him, and in the discussion he appears to have been rather cut up. I will conclude however, with the expression of a belief that, in the paper I have brought before you, I have ventilated not only my own views, but also those of Mr. Ross, in advocating that the oil should be put in at the side of the bearing instead of on the top.

Mr. RUTHVEN proposed a hearty vote of thanks to the author of the paper, which was unanimously passed;

and, on the suggestion of Mr. HAWTHORN, supported by Mr. J. H. THOMSON and others, it was agreed that the discussion on the subject should be adjourned until Monday, January 11th, 1897.

Mr. FLANNERY proposed a vote of thanks to Mr. Durston for presiding on the occasion, and said that Mr. Durston by his presence that evening had shown that his gratitude was not limited to a sense of favours to come. Having filled the office of President of the Institute, his interest in its work had not diminished, but had rather increased.

Mr. LESLIE seconded the motion, which was carried by acclamation.

Mr. DURSTON, in acknowledging the vote, expressed his high sense of the importance of the work in which the Institute was engaged, and said he should be only too pleased if any small services that he could render would tend to bring the Royal Navy and the mercantile marine closer together, and promote good feeling between them. He was first of all, and before everything, a marine engineer, and was very much interested in everything that would serve the true interests of his profession.

ADJOURNED DISCUSSION

HELD AT

58, ROMFORD ROAD, STRATFORD,

ON MONDAY, JANUARY 11TH, 1897.

CHAIRMAN:

MR. S. C. SAGE (*Member of Council*).

The CHAIRMAN: We have met here to-night to discuss the paper read at a previous meeting by Mr. Dewrance on "The Bearings of the Marine Engine."

I was not here, unfortunately, when the paper was read, but I will ask now the members to continue the discussion, but before doing so, perhaps the author has something to add.

Mr. DEWRANCE : If I may be allowed, I would like to call attention to the hand machine on the platform, and say that at the last meeting it appeared to be thought by some members that the employment of a flat plate as a bearing on the wheel was not a satisfactory test. I have, therefore, since had a curved plate or round bearing fitted to the wheel, in the place of the flat plate, and members will observe that the action or effect is exactly the same as when the flat plate was used. The pressure gauge shows the pressure on the film of oil between the wheel and the plate. I employed a flat plate in the first instance because it enabled members to see better the action of the oil.

Mr. J. T. SMITH (Member of Council) : With regard to the white metals generally employed for lining engine bearings, I do not think that we are so much concerned with the wearing of the white metal as with the decay that takes place. There is a very great difference between the various alloys of white metals, and reference has been made to the information given in text books on the subject, but it is clear that we want something more than text books to guide us. I have here particulars of the composition of three different white metals. The first is composed of 1 per cent. of copper, 68 per cent. of tin, 30·5 per cent. of zinc, and ·5 per cent. of lead. The second consists of 8·5 per cent. of copper, 83 per cent. of tin, and 8·5 per cent. of antimony. The third sample is entirely different ; it consists of 4·4 per cent. of copper, 16·6 per cent. of tin, and 79 per cent. of zinc. Now, it would be very interesting if Mr. Dewrance would give us his opinion as to which of those three samples of white metal he would recommend. I have brought here to-night two pieces of metal which it will be observed are apparently very much decayed or corroded. Both pieces have been in use for about nine years, one in a crank pin, and the other in a guide shoe. The metal has proved a very good wearing material, and the piece taken from the guide shoe was found to be more decayed at the back, away from the rubbing surface, than at the front. We have had some specimens—some strips—of this same metal put in oil, and some in sea water and oil mixed. Some strips were cut off and suspended in vessels that were open to the atmosphere. The oil used was a very high class oil—a compound—with a good body, and it mixed very well with fresh water. It is an oil that does not attack the shaft. The shaft that runs with this oil is bright and polished, and the oil lubricates at a high temperature. Of course, we are all very interested in this question, because all the comfort of a voyage depends upon whether your bearings run well. With regard to this metal that was put in oil, and water and oil mixed, we did not find that it was perceptibly affected during a period of two years. At the end of that time it remained just the same as at the beginning, so that there was evidently something wanting to cause the decay to continue. Perhaps it was the absence of heat that made the difference. These strips were suspended by strings in glass jars, and while in the oil and oil and water the decay or corroding action was suspended. Can Mr. Dewrance tell us how to avoid the decay when the engine is at work? That is the main point.

The CHAIRMAN (referring to the two pieces of metals exhibited): Do you know whose metal this is, Mr. Smith? Do you know the component parts?

Mr. SMITH: I know whose metal it is, but I do not know the component parts.

The CHAIRMAN: It looks as if the basis was principally lead or zinc.

Mr. SMITH: There is one other question that I have been thinking about, and that is, as to the lubrication of the cross-head by Mr. Dewrance's method. We have not yet been able to learn how the oil would rise from the side to the crown of the cross-head.

Mr. DEWRANCE: I have a cross-head where the oil is admitted at the bottom and it is perfectly lubricated. It is a horizontal engine, and that is really the only satisfactory means of lubricating it.

Mr. SMITH: But the cross-head does not go round.

Mr. DEWRANCE: It is perfectly lubricated.

The CHAIRMAN: It has been my experience, with cross-heads especially, that white metal does not answer so well for a swinging movement—a swinging bearing —and it is possibly because the lubrication has not been perfect. In all the white metal lined top ends that I have seen, the swinging motion tends to cut the white metal very badly. I do not think that there are many of the smaller size engines which have white metal in the top ends.

Mr. SMITH: I cannot agree with the opinion expressed by the Chairman that white metal is not suitable for a reciprocating motion, because I have found it work well in beam links. I believe that it is the heat in the cross-head, and not the swinging motion which causes white metal to work badly in cross-heads.

Mr. DEWRANCE: The heat tends to hasten the the chemical action. If you have a white metal composed of zinc or lead it is absolutely impossible to run it in a cross-head, but if you have a metal sufficiently hard, my experience is that it will run better than brass. But in such a bearing you must have a white metal capable of resisting a pressure of several tons per square inch without yielding.

The CHAIRMAN: The heat undoubtedly has a great deal to do with it. Even in gun metal linings it is very seldom that you see one which is not a little bit cut up. It must be due to the heat, although gun metal ought not to be nearly so easily affected as white metal.

* Mr. W. J. NOWERS BRETT (Member): I had great pleasure in listening to Mr. Dewrance's paper read before the Institute. He has clearly and most ably placed before us a system for the proper lubrication of bearings, a most important consideration in the efficient working of machinery of every description, and doubly so when placed inside the hull of a ship. Marine engineers have been rather conservative when dealing with lubrication of bearings, mainly due, I think, to the fact that the principles of lubrication and friction have not been thoroughly understood. Mr. Dewrance, and I am sure all engineers, will agree with me in saying that great credit is due to Mr. Beauchamp Tower, of the Institution of Mechanical Engineers, for his experiments on friction, but I think Mr. Tower might even have carried his researches further, considering the great importance of the subject. Other gentlemen—Captain Galton, Mr. Westinghouse, and Professors Fleming, Jenkin, and Kimball—have, by their researches, enlightened us considerably upon this subject. I would also mention that more than once Mr. Macfarlane Gray has given some valuable hints on the subject of lubrication and friction. I think much remains to be done with regard to the co-efficients of friction of the different kinds of white metal now used by marine engineers. I am inclined to think that the varying proportions of tin, zinc, and lead used must have varying frictional values, and when we find that other metals are added in addition to these I think you will agree with me when I say we should have some fixed standard for white metal, so that we can form some idea of what we are using. At any rate, a better knowledge of the general behaviour of the different kinds of white metal from an experimental point of view would be most valuable to all engineers. With

* Read as received by the Hon. Secretary in the absence of Mr. Brett.

regard to the hammering of white metal, the only way of getting over the difficulty is by heating the bearing before running in the white metal, and so prevent the metal from shrinking too much when cooling, and becoming slack. But it is not always possible or desirable to heat a bearing to any great degree, and the only remedy that I can see is to use a softer metal, and tighten it by hammering. It would be well if we knew to what extent the heavier kinds of white metal would stand hammering without cracking. With journals and bearings we should aim at attaining two objects, viz, they should be pefectly true and smooth, and should be perfectly oil-borne. In a paper on "Friction," read before this Institute in 1890, I suggested that the oil should be led to the brasses at the extremities of the chord of contact, so that the lubricant should enter as a liquid wedge, and I also made the same remarks during the discussion on Mr. Ross's paper on "Lubrication." With the present method of lubrication a bearing will carry a much higher load when the pressure is intermittent, and I believe that is almost the only way most bearings receive the oil at all.

Mr. GODFREY ELLIOTT (Visitor): I do not know whether a non-member is permitted to take part in this discussion, but, if so, I should like to make one or two remarks. This system that is advocated by Mr. Dewrance seems such a radical change from the general practice in marine engineering at the present day, that I thought we should have had a very lively discussion to-night, and I came rather to hear the discussion than to take part in it. One of the principles upon which I believe most marine engineers insist is, that you want to air the bearings, get plenty of air in between the surfaces. Of course, Mr. Dewrance's system is entirely against that principle. In his method there are no means of getting air into the bearing, or circulating air through the bearing. Then again, marine engineers, in designing their bearings, very often put strips of white metal so that the bedding for the shaft is composed of long longitudinal strips of white metal, sometimes placed diagonally, sometimes in line with the bearing, and sometimes, as Mr. Flannery and Mr. Dewrance explained on the last occasion, in the form of plugs of white metal in the bearing. Mr. Dewrance advocates a bearing of white metal all the way round, and that seems to me a very feasible suggestion, because, as he explained, the wear of the bearing is owing to the corrosion of the bearing. If you get white metal and gun metal alternatively, and one corrodes more quickly than the other, then you get a bearing only on those strips which corrode the slowest, and these strips, instead of assisting lubrication, are merely scrapers to scrape the oil off the shaft, which is surely detrimental to the good running of the bearing.

Mr. DEWRANCE: I cannot understand how the system of lining bearings with either strips or studs of white metal can prove beneficial, and it can only be applied to those bearings which have such a large excess of surface that you can afford to throw away considerably more than half of it. The pressure would have to be borne either by the strips or plugs of white metal, and if that is the case, you are certainly not getting the duty out of the bearing that you ought to get. If you want to get the maximum of duty out of a bearing, you must make it all of one uniform composition. By employing strips or studs of white metal, you not only get the decomposition of the two metals, but the two different surfaces of metal form a sort of voltaic couple which favours the chemical action or corrosion very much indeed. Several very interesting points are brought out in Mr. Brett's communication, read this evening. He speaks of the desirability of having standards of co-efficients of friction for all the different anti-friction metals in the market. Well, I am in this position: I am a maker of anti-friction metal, and I ought, perhaps, to make out that white metal will do a great deal more than it will do; but I do not think that that is desirable from my point of view, because I have quite sufficient claims to put forward which can be fully substantiated without having to cling to some of those false claims which I have seen put forward. The idea of an anti-friction metal is one that my father must have started, and it arose, I think, from an incomplete comprehension of white metal. There is no such thing as an anti-friction metal. White metal has its advantages, but not in the sense of being an anti-friction metal, because there is no metal that will run without oil or lubrication. The co-efficient of friction of any given bearing surface is exactly the same as the co-efficient of friction of any other surface. The friction is fluid friction, due to the film of oil between the surfaces. The whole thing resolves itself into this: that if the two surfaces are properly lubricated, the friction is lost in the oil. The co-efficient of friction is the same whether the surface be of bronze or white metal, or anything else. The advantage of white metal over bronze is that when properly composed it will resist chemical corrosion, and when lubrication fails it does not damage the shaft. With regard to the question asked by Mr. Smith at the commencement of the discussion this evening, my answer is that none of the samples which he gave us are good, but the one which contains the most tin, and which will bear the heaviest compression test, is the best. I have not the least doubt that these specimens of decayed metal produced by Mr. Smith will prove, on examination, to contain a very large proportion of zinc. From the way it is corroded it must contain zinc. The action of the bearing has decomposed the oil, broken it up into oleic acid, and that is the cause of this corrosion. That is my explanation of it, and I should very much like to have the opportunity of verifying my opinion by analysing the metal. Then with regard to the hammering of white metal, I must stick to my guns. Hammering is not only undesirable, but absolutely unnecessary. It simply breaks up the metal into a kind of mosaic, and the mosaic breaks up and gets loose, and gives rise to all sorts of trouble.*

* With the aid of a model of a section of a bearing, Mr. Dewrance explained a method of lining with white metal which he had found to completely remove any necessity for hammering. He had never found that the white metal, if poured in and treated as he explained, ever got loose or required hammering. But if hammering was found to be required, he recommended them to do the job over again.

Mr. DEWRANCE continued: In the course of a previous discussion on this subject Mr. Brett suggested that the oil should be taken into the brasses at the end of the chord of contact. I cannot accede to that. If you do that you get no inclined plane at all. It is better than the centre, but you must lead your oil in some distance away from where it is to do its work. You must lead the oil in at a point far enough away to give it a chance of getting a good inclined plane before it has to do its work. I do not claim to be the originator of this idea, and I fully recognise the credit that is due to Mr. Beauchamp Tower and others. Mr. Tower conducted a large number of experiments, the results of which were stated very fully in a scientific way, and many others have also devoted a great deal of attention to the subject, including Mr. Ross. Mr. Ross, in his paper, stated the actual fact which I wish to bring before you, namely, that by bringing in the oil at the side of the bearing you will get a better result, but he did not actually say why you should lead it in at the side. Something more should be said, however, as to why you should put the oil in at the side and to show the reasons for it. I wish to acknowledge most fully all that various experimenters have done in this matter before me, and I only claim a little credit for myself in having taken the idea from where they left it to a point where we can use it most effectively.

Mr. J. R. RUTHVEN (Member of Council): I can see that this is a valuable idea brought to a practical point, but the question is, how can it be applied to present bearings, which, of course, are not lubricated in this way? How can we improve the lubrication of our present bearings by the light of the knowledge obtained from Mr. Dewrance's experiments? As this inclined plane is one of the chief points of the system, it seems to me that if we could make a lot of inclined planes away from the channels in the present bearings, we might get some advantage. If it was clearly understood that the inclined plane was the chief feature, I think we might make inclined planes even by deducting from the surfaces. I think we are very much obliged to Mr. Dewrance for showing what accurate workmanship can do. Working on the principle that you cannot prevent friction altogether, his object has been to show how to reduce it as much as possible, by getting in the oil in this ingenious method.

Mr. DEWRANCE: There is no doubt that you could improve the present bearings by taking off the edges of the channels and making an inclined plane, but the difficulty is that these channels are mostly at the points of greatest pressure. My suggestion is that you should fill the channels up and then make your inclined plane.

Mr. RUTHVEN: When once the idea is grasped it can be modified to meet existing conditions very considerably.

Mr. F. COOPER (Member): Mr. Dewrance gave as the rule that we should let in the oil at the point of least pressure and not let it escape at the point of greatest pressure. I presume that that refers only to circular bearings, because one of the bearings that gives us great trouble is the guides; and that is one of the bearings where the oil is introduced at the point of least pressure, and it hardly ever gets to the point of greatest pressure. The best guides that I have sailed with have been lubricated with oil cups that led into the very centre of the guides. Again, Mr. Dewrance says that pure oil is a better lubricant than oil and water, always. I think a good many of us have found that in thrust bearings a mixture of a certain kind of oil and water gives a better lubrication than the oil itself will give. It must be clean water put in along with the oil, but I think it has been the experience of more than one here to-night that a mixture of fresh water with oil is a better lubricant than pure oil alone. I think we are very much indebted to Mr. Dewrance for his explanation of the co-efficient of friction. He tells us what I have often thought myself, that so long as you can keep the surfaces away from each other, so long as they do not rub they cannot wear; it does not matter what the two surfaces are so long as you keep them apart by oil, and a bearing that is perfectly lubricated will run for ever without wearing at all.

Several questions was then asked by Mr. McLAREN and others as to certain details of the drawings exhibited by the author, especially as to the most effective method of lubricating the guides; and reference being made incidentally to the fact that oil supply pipes often get "furred up," Mr. McLaren observed that this was frequently due to the inferior quality of the oil supplied by shipowners.

Mr. DEWRANCE: I think that owners ought to be brought here to listen to these papers. They would have more regard for their engineers, and for the oil they have to use. What they think is cheap oil is very far indeed from being the cheapest. Bad oil has often caused accidents which have cost more than the oil bill for a year or two.

The CHAIRMAN: I should like to ask Mr. Dewrance whether he has made any experiments as to the quantity of oleic acid contained in mineral and vegetable oils.

Mr. DEWRANCE: The largest amount is in olive oil, which contains an average of 10 per cent. Mineral oil does not contain oleic acid; that contains mineral acids. Rape oil contains 8 or 9 per cent. of oleic acid, and castor oil contains a good deal. I cannot help thinking that if engineers would only use a pure hydro-carbon oil in their engines they might put as much as they liked into their cylinders and on their rods without doing the boilers the least bit of harm. I believe you could use 5 per cent. of such oil in the water in the boilers without any damage resulting. It would simply go the round and lubricate the steam without doing any harm at all.

The CHAIRMAN: There has been a great amount of discussion and controversy upon that very subject, because it has always been impressed upon us to use as little internal lubrication as possible because of the amount of harm that accrues to the boilers. I have known lots of accidents through the use of a cylinder lubricant, but I did not know that it was impossible to deposit any portion of a pure hydro-carbon.

Mr. DEWRANCE: I believe it is chemically impossible.

The CHAIRMAN: There have been instances where furnaces have collapsed from some such cause. It is a most interesting subject, and I only wish that I could have been present at the last discussion, because the use of white metals, or so-called anti-friction metals, is no new thing. I remember being in a ship built in 1860, and that vessel had white metal in every one of her bearings; and, of course, it was all right so long as you did not let them get warm. In those days we used rape oil for lubrication, and we never got a bright bearing. Although it ran smoothly, and without friction or heating, it showed the action on the component parts of the white metal; and that was due, probably, to the insufficient lubrication. I notice that you recommend in the paper that bearings should be ground and faced to a perfect bearing. I have known cases where the crank shaft of a vessel, after being scraped and bedded, was run with the donkey engine, and fairly ground with oil and powdered emery. We afterwards cleaned the emery off, and I thought we should find that the emery would remain in the pores of the metal and cause trouble, but it did not. We know that if we had the highest skill which engineers could develop, we should be able to do and to save a good deal; but it is all a question of pounds, shillings, and pence; and if white metal can be obtained at 9d. per pound, that is the metal which is used in 99 cases out of a 100 in preference to metal at 1/4, although that at 1/4 may in fact be the cheapest for all concerned. I do not think that there are any people who charge less than 1s. 4d. for white metal; 1s. 6d. is a common price for filling bearings, and when the metal has a basis of 80 per cent. of lead I should think it is a very profitable transaction.

Mr. DEWRANCE: None of it, in the class referred to, ought to be so much as 9d. per lb.

The CHAIRMAN: I should like to know if any of our members here have had experience in the use of solidified lubricants such as the Axiom system, whereby the grease is forced through the pipes by pressure. I have used solidified oil for the tunnel bearings, and found it better than liquid oil, but to apply it to the crank pin and main bearings you require a pretty steady pressure. I believe, however, that the system is working satisfactorily in a good many ships.

Mr. JAMES ADAMSON (Hon. Secretary): In the absence of Mr. Brett I should like to say, after what has fallen from Mr. Dewrance on the subject, that I do not think Mr. Brett had any thought of suggesting that Mr. Dewrance was overlooking or ignoring the researches of others in the matter of friction and lubrication. In mentioning the names of Mr. Beauchamp Tower and others, I think Mr. Brett's only desire was that their names should be placed on record in our transactions in connection with this discussion for purposes of reference. I am very glad that Mr. Dewrance has referred to the paper that was read before the Institute on this subject by Mr. Ross. He has supplemented Mr. Ross's paper, and he has been able to give a reason to Mr. Ross for the faith that was in him. With reference to the cross-head brasses, I think that most engineers are agreed that white metal does not answer so well there as in the other parts of the engine. I do not know if Mr. Dewrance has had experience of white metal in cross-head brasses, but in our former discussions we have mostly agreed that it is not so suitable for the cross-head as for the main bearings and the crank pin. There is an intermittent pressure on the cross-head brasses, and perhaps that fact will explain some of the points that have been raised. It has already been urged and emphasized that cheap oils may prove very expensive in the end. With reference to hydro-carbon oil, I know several steamers where hydro-carbon oil has been used with very satisfactory results on the bearings, and I agree with Mr. Dewrance in considering such oil to be most suitable, from experience of its use, thus adding the complement to Mr. Dewrance's view as to a hydro carbon oil being probably preferable for white metal as a lubricant, in much the same way as Mr. Dewrance has added the complement to the view of Mr. Ross in respect to the method of lubricating. On white metal thrust bearings rangoon oil is frequently used with satisfactory results. A good, carefully made solidified oil, in the tunnel bearings especially, if not cut too low in price, does very well in many steamers. In the course of a former discussion on this subject I referred to eccentric straps fitted direct with white metal. After considerable trouble had been experienced with brass, the white metal has given every satisfaction, and is working better than did the brass. There is another interesting point to which I would direct attention. When the oil comes out highly discoloured after passing through between the bearing and the shaft, there is a point of discolouration at which it is shown that the lubricant is carrying away a part of the white metal by its acidity, or otherwise, and that fact throws us back on the consideration—are we using the most suitable kind of oil for our particular class of white metal? Given the constituents of the white metal and the constitution of the oil, if we find that with a particular kind of white metal we get the best results by using a particular class of oil, we may be enabled to form a standard. Certainly, with a certain class of white metal, a good hydro-carbon oil gives the best results. We hear of white metal main bearings which have had to be lifted and lined up within a couple of years, and of others running eight and even 14 years without lining up. Why is it that these white metals do not give the same results, even when the metals are equally good? That is, price and constituents may seem to show that they are all of equally good quality, with the names of good makers at the back of them, who do not din the market, and dun desirable customers with excess of zeal and display. It seems to me that the solution lies in the adaptability of the lubricant to the particular class of white metal, and this applies to all classes of oils and grease, including the Axiom with its special system of automatic lubrication referred to by the Chairman.

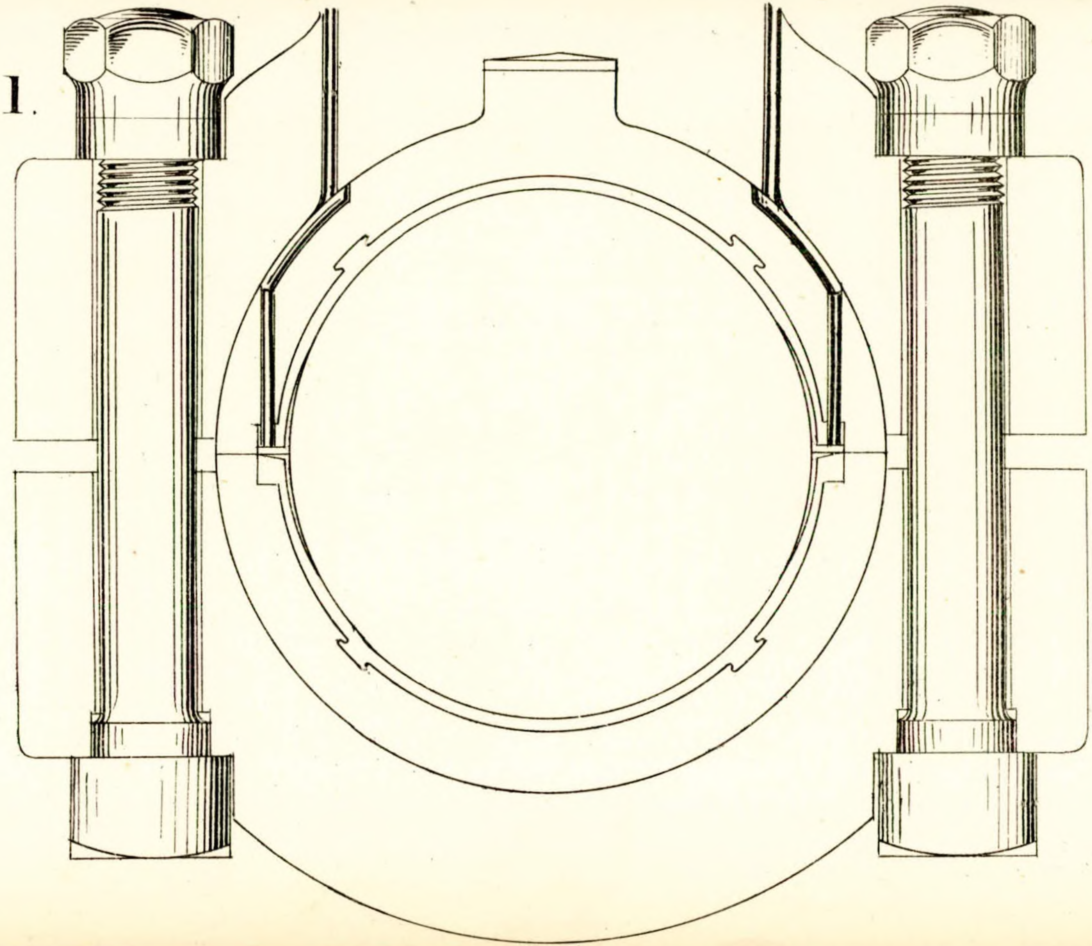
Mr. DEWRANCE: With regard to cross-head brasses, I cannot agree with Mr. Adamson. The cross-head is the most severe bearing you have in the engine, and while a large number of white metals would answer the purpose for the other bearings it is only one particular class of white metal that will answer for the cross-head. If you use a proper class of white metal, that is to say, a white metal containing not less than 80 per cent. of tin, it will show the same advantage in the cross-head that it does in the other bearings.

Mr. KIRKWOOD (Member): I quite agree with Mr. Dewrance in his idea as to the application of this system to main bearings, but I do not believe it would answer at all for a reciprocating motion.

After some further conversational discussion the CHAIRMAN proposed a vote of thanks to Mr. Dewrance for again attending for the purpose of assisting them in the discussion on his paper, and was sure they had all been very much gratified and instructed by the manner in which he had explained the various points of the system he advocated and had demonstrated.

The motion was seconded, and carried by acclamation, and Mr. DEWRANCE having briefly acknowledged the compliment, a vote of thanks to the Chairman for presiding concluded the meeting.

No. 1.



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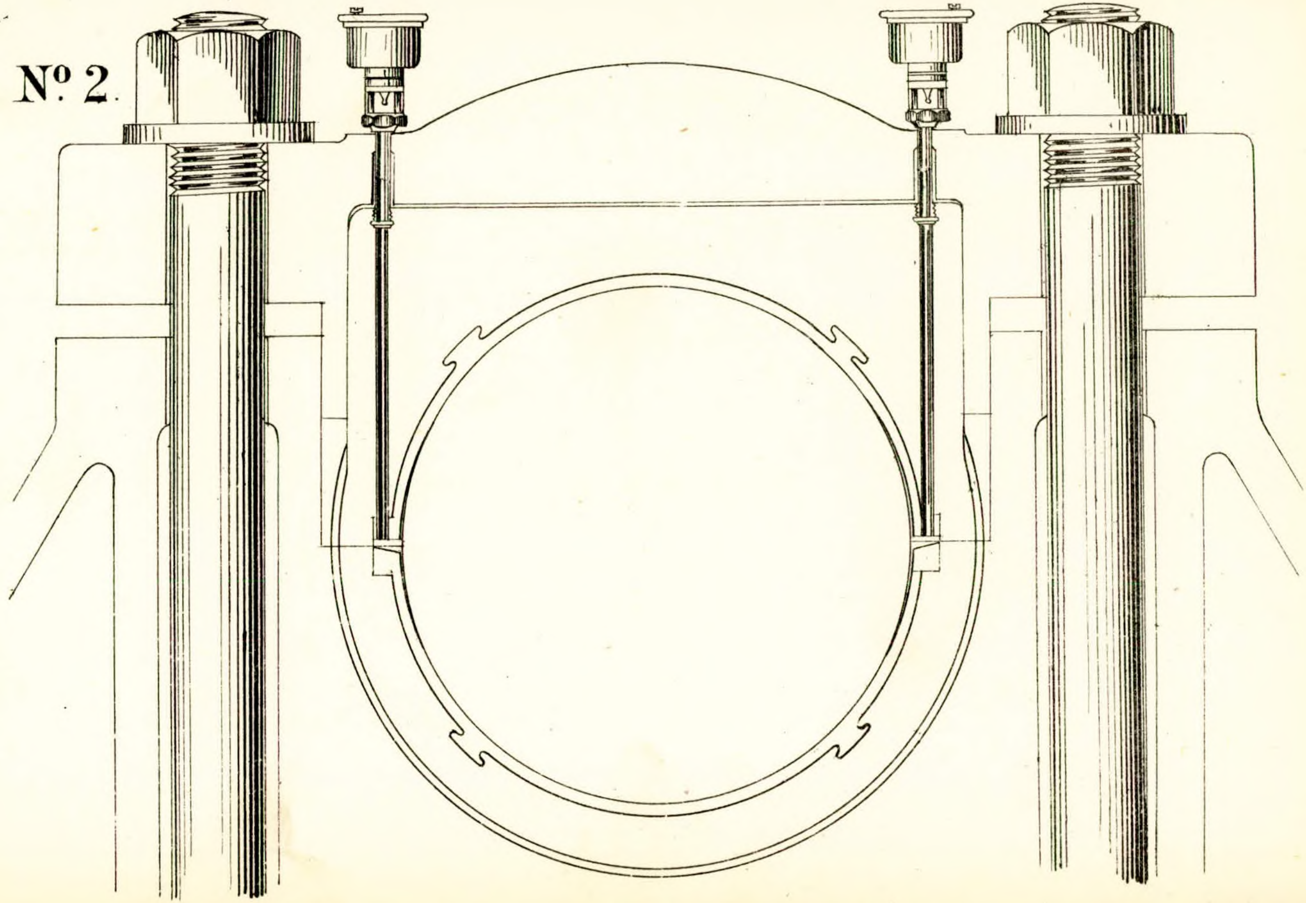

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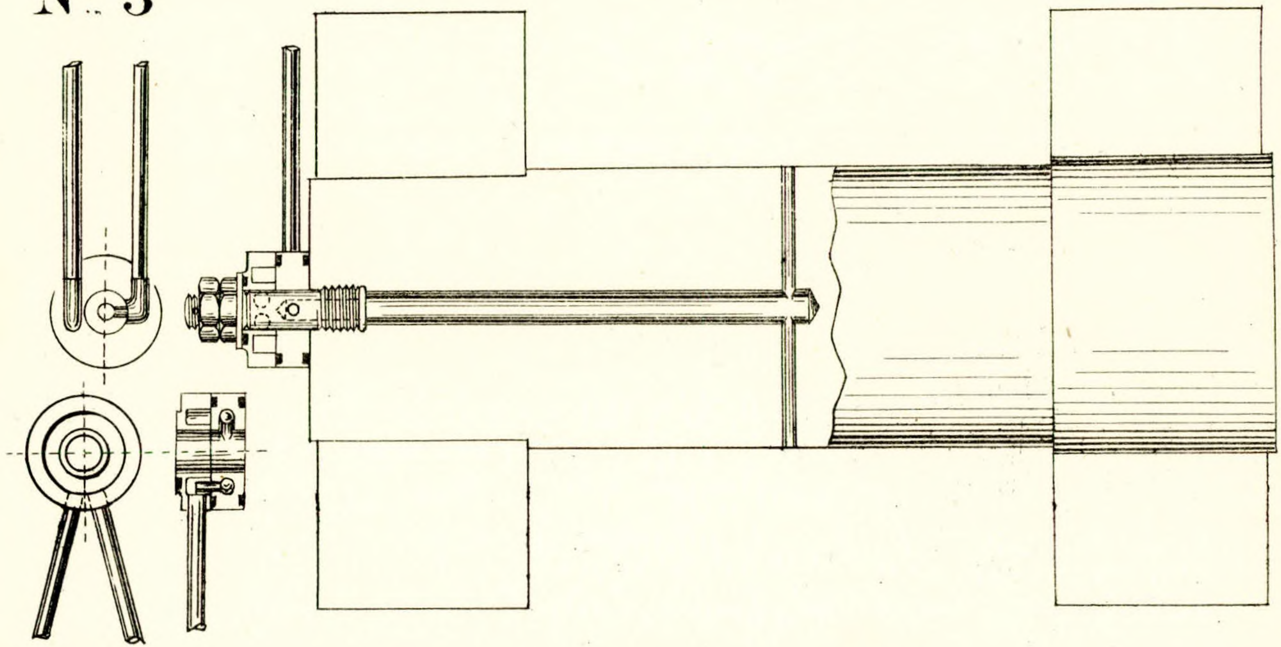
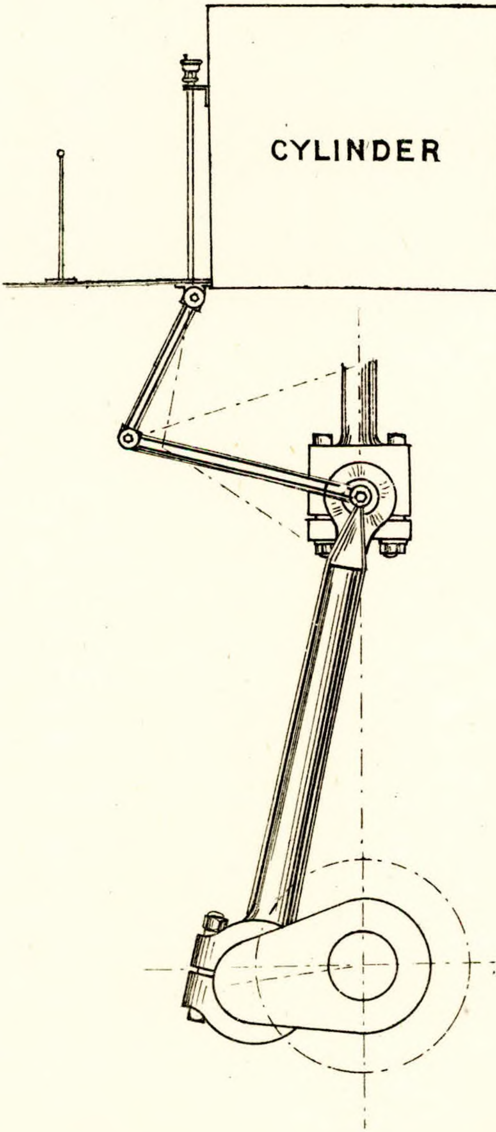


SECTIONAL PLAN.

No. 4.



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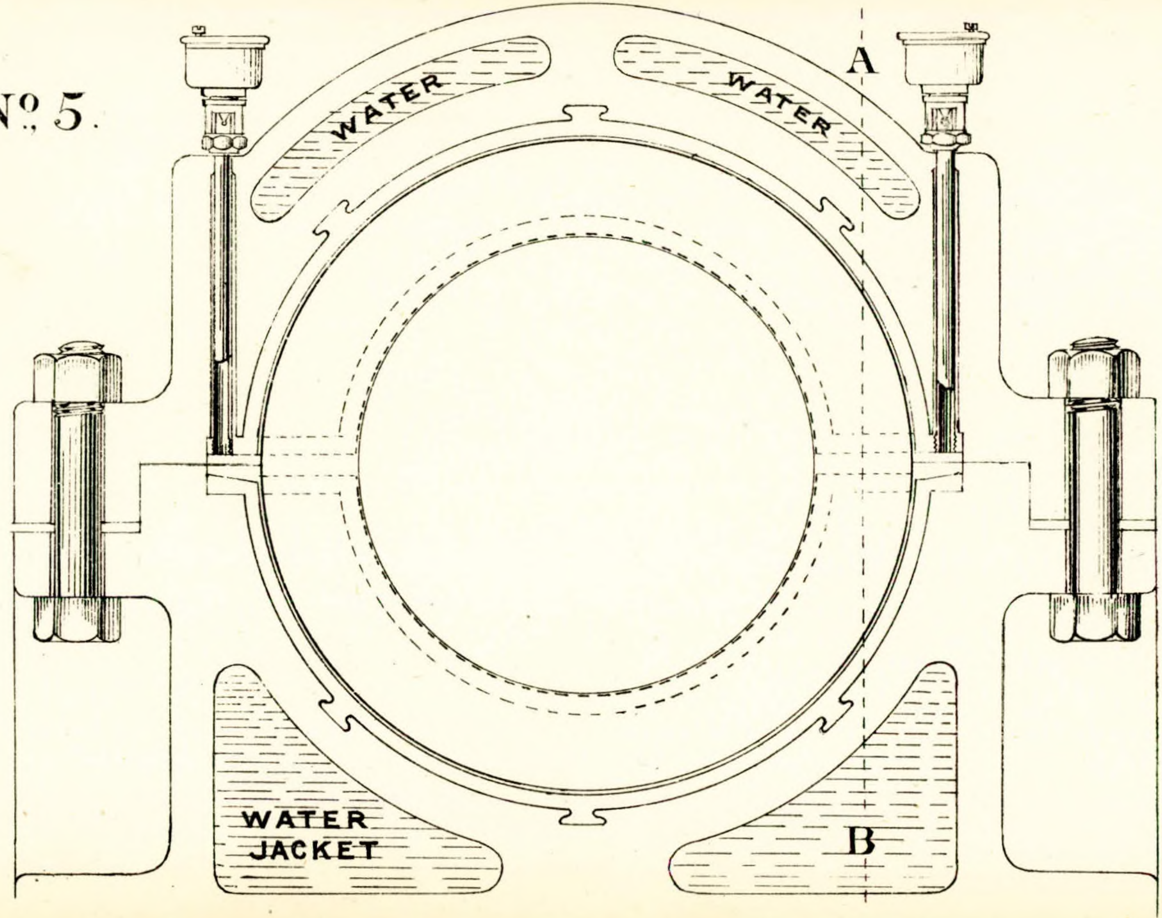

No. 6