mitted to proper tests, and such tests, to my mind, must be carried out in a standard way. For instance, I cannot see how with the viscometer, as described by Mr. Tournay-Hinde, one could get results of the slightest value, because the shape of the orifice alone is of the utmost importance in determining the viscosity of oil; a hole punched in a tin can be hardly described as an accurate method. Castor oil undoubtedly is a useful lubricant, and I think that the explanation of its usefulness lies largely in the fact that its viscosity holds up remarkably well as the temperature increases, and thus, with a hot bearing, castor oil may be expected to maintain a film of oil between the metals even at high temperatures.

A great deal of trouble, in my experience, has arisen from want of rigidity in the structure of the bearing; and I have found that this has frequently applied to bearings of white metal, and this might explain such a case as has been described where the replacement of white metal by phosphor-bronze has given better results. Want of rigidity leads to overloading of the more rigid parts, with consequent overheating of those parts.

Referring back, for the moment, to the selection of oils, for many years I have supervised the testing of oils for the Western Australian Government. Standard apparatus was used throughout—the Redwood Viscometer, the Abel flash tester, and so on—and there is no question that the systematic testing of oils, where the amount of oil used warrants it, is of the utmost value, and is the only way by which one can really obtain real value for the money spent in lubrication. The improvements which were effected in the first two or three years after the testing was put into practice were of great value, and subsequently it has only been necessary to test, from time to time, the various samples submitted under annual contracts in order to see that the oils were up to sample, and met the particular requirements of each case. That is the only way in which one can

really, in a large undertaking, maintain an efficient lubricating system.

The much maligned oil-testing machines, or friction testing machines, undoubtedly, if not carefully used, give entirely misleading results; but, taking them in conjunction with other tests (and I have had three such machines for many years in operation) the data that one gets is extremely valuable, particularly in such a case as the testing of oils which have to be used under high superheat in steam practice. We used a machine of the modified Thurston or pendulum type, in which oils were tested up to 600° F., and in which the conditions of rubbing were made to approximate as closely as possible with the condition of the piston rings in the cylinder; and this machine we found to be of great service in weeding out many oils which appeared to be all right as to price and other physical conditions—viscosity and so on—but which failed as lubricants under the high temperatures in the engine cylinders. I think the intelligent use of such a machine, in large undertakings, is of very considerable importance.

Mr. Tournay-Hinde mentioned the question of the useful area of the bearing. I, personally, have always followed the practice of adopting the projected area, as I think it gives accurate results. I do not quite agree with the consideration of lubricants purely from the standpoint of avoiding hot bearing troubles. Undoubtedly troubles do arise, and it is necessary to know what to do when you get a hot bearing; but, after all, in a good system, this is really of small importance as compared with the necessity for selecting a lubricant which will enable one to ensure satisfactory running with a minimum of expenditure of power and lubricant.

Generally, one finds in practice a very marked tendency to use oils of too large a viscosity, which has arisen, I think, from the fact that such oils tend to minimise the noise aris-

ing from slack bearings; but the result is an enormous waste of power, due purely to the power wasted in overcoming the friction within the lubricant itself.

In small undertakings there is no doubt that the user of oil has to depend on his own experience and that of others, but in all undertakings involving the use of large quantities of lubricants, scientific testing and observation is the only efficient solution.

Mr. McEwin suggested (and I think rightly), therefore, that all large undertakings should be equipped with oil-testing apparatus of standard types.

The suggestion that the small users should depend upon the oil merchants for their information would, however, in my opinion, lead to disaster in many cases.

Some of the larger firms have experts attached to their staffs, from whom one can gain a very large amount of valuable data to assist one in selection of oils; but, generally speaking, the great majority of oil vendors push their oils with very little real knowledge of their real value, and generally also with still less knowledge regarding the apparatus for which the oil is required.

Mr. McEwin has given us a large amount of data to think about, and has put before us an interesting summary of the operations involved in the systematic testing of oil.

I have, therefore, very much pleasure in seconding the vote of thanks proposed by Mr. Tournay-Hinde.

MR. TOURNAY-HINDE: Before the debate closes, I would like to refer to Mr. Julius, who condemned the rough viscometer described by me, and waved it on one side as comparatively valueless. He is not the only person who has done so, for some of those who tendered under the specification I referred to were anything but complimentary concerning the same viscometer. It must be remembered, however, that the device is not put forward to supplement a

standard instrument. What I desired to call attention to was, that it was better to rely on even such comparatively rough tests and apparatus in selecting oils for purchase, than use none, or to merely go on rule of thumb or guess methods. I have not the slightest doubt when the matter is viewed thus, that Mr. Julius will be wholly in accord with me.

MR. D. F. J. HARRICKS: It is not my intention to enter into the discussion of Mr. McEwin's interesting paper, but merely to quote a little experience. In sugar factories a large part of the plant is of a very heavy, slow-moving type, and grease lubrication is very suitable. In the mills of the C.S.R. Co. grease is largely used, and although some oil is, of course, necessary in certain parts of the plant, the cost of lubricants per ton of cane crushed is very low.

When recently visiting a number of mills in an American territory I was somewhat surprised to find that, because oil was cheap, very little grease, and in some cases none at all, was used there; but the striking fact was that the cost of lubricants was from two to three times greater than with us. It seemed that the very cheapness of oil was blinding their eyes to the possibility of using other still cheaper and yet as effective lubricants for certain work in their factories. There certainly appeared no evidence to show that the lubrication therein was more effective, or, in other words, that the greater cost was reflected in reduced friction losses.

We are frequently reminded in engineering that the cheapest article is not always the best; but, nevertheless, it would be folly to imagine that the rule approaches infallibility, and the instance quoted above will serve to show that if, after careful tests, prolonged use, and intelligent observation, all of which seem especially necessary in dealing with lubricants, a cheap grease proved satisfactory for a certain class of machinery, it could quite likely be shown to be the best.

THE PRESIDENT: I think you will agree with me that we have had a very interesting paper from Mr. McEwin, and very interesting remarks from the proposer and seconder of the motion for a vote of thanks.

Anyone speaking at the end of the meeting has to face the position of having most of what he wished to say already touched upon by other speakers. There is, however, one matter to which, so far as I remember, no reference has been made. I refer to the dangers of over-lubrication.

A man in charge of a power station often doses an engine with too much oil, thinking that it will work better thus than with too little, and that at the worst he is only wasting a little oil, whereas he is actually defeating his own ends. If more oil is supplied to the cylinder of a steam engine than is sufficient for lubrication purposes, the balance of what is required will gradually drop to the lowest point. In the case of a vertical high speed engine, the oil will find its way down into the metallic packing, with the result that it will gradually form into a solid condition in the packing, and the piston rod may seize in consequence. This is more likely to happen in a low pressure cylinder than in a high pressure cylinder, owing to the fact that high pressure steam mixes better with oil than does low pressure steam.

Again, in the case of exhaust turbines working in conjunction with reciprocating engines, if too much oil is allowed to get into the cylinder of the reciprocating engine, some of this will eventually pass through to the turbines, with disastrous results.

Mr. McEwin has given us a list of suitable oils for different purposes, but he does not make any reference to the class of oil which should be used for reciprocating engines using super-heated steam. This information would be very valuable to many of us.

With regard to the lubrication of white metal bearings. If a white metal bearing gets hot, the blame in the first

place is put upon the oil, although the trouble may not come from the oil at all. It is possible that the pipes carrying the oil from the lubricator may be clogged up, or, if the pressure is too great in the white metal bearing, the channels in the bearing itself may have got squeezed out, and there is no way for the oil to be distributed over the journal. As in most things, the principle that "The best pays best," applies to oil, and if the proper class of oil has been selected for the bearing upon which it is to be used, then if trouble follows, we can reasonably look for another cause for the heating up than that the oil is not doing its work properly.

I think Mr. McEwin's paper is a splendid indication of how science may be applied to practical work. The application of science at the present time to industrial work is one which is receiving marked attention from a great number of our leading associations, and I think Mr. McEwin is to be congratulated in having placed before us a very interesting paper.

I have much pleasure in putting the motion to the meeting.

MR. J. G. MCEWIN, in reply, said: I thank you gentlemen who have moved, seconded and supported the vote of thanks for letting me down very lightly. Mr. Julius particularly is in a better position than anybody to point out the weak points of the paper; and he has been kind enough to pass them over.

With respect to Mr. Tournay-Hinde's remarks, I expected that the criticism of this paper would be the most valuable part of the evening's work. Mr. Tournay-Hinde's remarks have been very valuable, as they were in his criticism of Mr. Sinclair's paper recently. It is true that there does not appear to be any good practical treatise on lubricating; the reason of that probably is that every machine presents almost a different problem. One reason why the

mechanical testing of lubricants has not given the results expected when it was first introduced, is that it is impossible to find a basis for experiment that will have a universal application in practice.

With regard to hot bearings and other practical problems which have been referred to, I am in the same difficulty as other people who have written on the subject. I found it impossible to come down to practical cases because the problems are so varied, and, as I say, every machine is practically a different proposition.

The remarks I have made at the end of the paper with respect to the selection of lubricating oils for various purposes can only be of a very general nature—I was not able to refer to any particular cases there.

With respect to Table 1, to which Mr. Tournay-Hinde referred, giving the pressures on bearings, it must be remembered that these are merely relative values tabulated to show the relative performances of various metals in bearings when in contact with other metals of a different nature to themselves. No speed of revolution was given with the original table.

The question has been answered by Mr. Julius as to what part of the bearing bears the load. If the lubrication is perfect, and the oil film is formed, the pressure must be distributed over that part of the bearing covered by the film.

Figure No. 2 in the paper was referred to. The actual bearing I had in my mind—I served my apprenticeship at locomotive engineering—was the driving axle of a locomotive, but I think it will also apply to any vehicle under traction. If lubrication is perfect the oil wedge will be formed, and the pressure of the vehicle on the axle will be transmitted through the film of oil. In the bearings of ordinary vehicles it is to be expected that there is frequent

metallic contact, and in any case the pressure wedge only forms when the speed reaches a certain point. In all the diagrams, which are conventional figures, the thickness of the oil film is very much exaggerated.

Mr. Tournay-Hinde's remarks about testing are very interesting. The difference between sperm-oil and whale-oil appeared to be due to the part of the whale from which the oil is taken. I understand that sperm-oil is taken from a cavity in the head of a particular whale, whereas whale-oil is made from blubber.

The same gentleman's remarks about the varying viscosities of different oils were very apt. While rape oil is the usual standard, it is quite true that water is apparently the only fluid from which we can get constant results. As to variations in the flashing points of oils, those variations can be got over by means of a certain rather expensive apparatus which is an efficient testing instrument. It is actuated by clock-work, and the arrangement for applying the flame is necessarily exactly the same with every oil tested. This refinement is hardly necessary in connection with lubricating oils.

As has been remarked, we turn to castor oil in a time of trouble. There is no doubt about the value of this oil in heavy bearings at ordinary times, but, as has been stated by Mr. Julius, the efficiency of castor oil is due to the high viscosity which it maintains at a pretty high temperature. As a result of this high viscosity, castor oil has a very high fluid friction, and its use for comparatively light bearings is not advisable.

Mr. Harricks' remarks about economy in lubricating oil were interesting, but I think that this is a point which may be stressed a little too much. In any organisation such as the Colonial Sugar Company, which has a number of mills of somewhat the same type, comparisons may be made; but sometimes, where there is economy in lubricating oils, there

is apt to be an increase in the coal consumption. As Sir Boverton Redwood points out, engineers sometimes save gallons of oil at the expense of tons of coal. I am not asking anybody to draw an inference with respect of the Sugar Company, but this state of things sometimes obtains in institutions of a similar character. For instance, tallow may be used in high-class engine cylinders in order to save a little cylinder lubricating oil. There is always a danger of that sort of thing happening.

I was glad to hear the President's remarks in confirmation of a point in my paper, which he illustrated by his sketch. There was an instance where two gentlemen constructed a dynamo, and led an oil pipe to the point of negative pressure in the bearing from a container six inches below the bearing. The bearing had thus to draw its own oil supply from the container, but perfect lubrication was maintained in the bearing without difficulty under these circumstances. In many bearings, if a knife edge, on a light spring, be brought up against the journal to collect the oil at a point slightly beyond the range of the oil wedge, and ducts be led from this point to the point of negative pressure, a constant circulation of oil would be kept up by the bearing itself, and perfect lubrication would be achieved.

I thank the various speakers very much for the remarks that they have made, which have been helpful to me, and I thank the meeting for the way in which those present have received my paper.