This type of bearing is rapidly coming into use in England. The British Admiralty already have six warships fitted with Michell Thrust Bearings, and there are many more privately owned vessels also fitted.

Messrs. C. A. Parsons & Co., Ltd., have standardised this bearing as a part of their turbine to take up end thrust, and have abandoned the collar type of bearing. The large turbo generators now being built for the Melbourne Suburban Electrification by Messrs. Parsons, each 15,000-b.h.p., are all fitted with Michell Thrusts. Many other well-known turbine builders are also adopting it—one firm alone having about seventy machines so fitted.

In conclusion, it may be said that the field before this particular type of bearing is an exceptionally large one. It is cheap to construct, compact, the wear is negligible, and provided the lubrication is attended to regularly it should run for long periods without the necessity for examination.

It is hoped that these few remarks may have proved of interest to the members of the Association, as describing an appliance which is comparatively new to Australia. The author wishes to express his thanks to Mr. A. G. M. Michell for very kindly providing him with a quantity of most interesting and useful information on this subject.

Discussion.

THE PRESIDENT: Gentlemen, the paper is now open for discussion. It is an extremely interesting paper, and I am sure you will agree with me that it has been very lucidly put before us. There is a secondary reason why we should be very glad to have such a paper as this—apart altogether from the merits of the paper and the subject itself—and that is that we in Australia hear very little about Mr. Michell. Probably, in Melbourne, one hears more of him, but even there I doubt if he is recognised for his extraordinary ability. I have not found anybody from any part of the world possessing more ability. Taking his special type of centrifugal pump, it is well recognized that, in that, is another extraordinarily ingenious and scientifically designed piece of machinery.

I think it is very fitting that, in Australia, we should wish to hear more about what he has done. I do not know any more scientific engineer in any part of the world than Mr. Michell. He has a brother who is a well-known mathematician in England, and it seems to me that Mr. Michell (whose invention we are discussing) applies the same kind of acute reasoning and ability to the solving of machinery problems and engineering designs that his brother does to the transcendental problems of mathematics.

I think we should be very grateful to Mr. Taylor, not only for his paper, but for bringing Mr. Michell more prominently before us. (Applause).

Mr. Shirra said: I have listened with much interest to the paper describing this ingenious Australian invention. I understand it has been applied to the thrust blocks of many steamships, especially of the geared turbine type, but I have noticed that seemingly the thrusts of the two latest and largest geared turbine boats, the "Transylvania" and the "Tuscania," built last year by Messrs. Scott, of Greenock, and Stevens, of Glasgow, respectively, have the ordinary horseshoe type of thrust block. I think the author of the paper (Mr. J. A. Taylor) is rather hard on this type of block when he says it is a problem of great difficulty—i.e., lubricating the collars properly. It is quite true that the bearing surface to be provided must be sufficient to reduce the thrust pressure to 50 lbs. per square inch, or less, and this makes the block large and heavy for a high-powered and heavy steamer, but with well-designed oil grooves in the faces of the collars, and a suitable oil, such thrust blocks give no trouble, and have little wear. One serious objection to them not mentioned by the author of the paper is that collars of large diameter, relatively, to the shaft diameter, are usually provided to increase the bearing area without increasing the number of collars and length of block, but this evidently increases the mean rubbing speed of the opposing faces and the work lost in friction. A more serious objection is that the shaft is originally forged solid of the full diameter of the collars at the bearings, and then the recesses between these are cut out in the lathe—that is, the shaft is here reduced to less than half its forged diameter, the sound outer metal being cut away and only the possibly spongy and unsound central part left, leading to occasional shaft fractures in the thrust. For this reason the Board of Trade rules insist that the shaft diameter between the collars at the thrust bearing must be equal to that of the crank shaft, the rest of the thrust shaft, and intermediate shafting generally, being less in diameter than the crank shaft by some 5 per cent.

With the ordinary thrust shaft we have many instances where no cooling water is used, the oil bath sufficing to lubricate and cool the collars. The temperature does rise certainly, but seldom, I think, so high as the 180deg. F., allowed with the Michell thrust. This is with reciprocating engines, which, no doubt, are more favorable for allowing oil to introduce itself between the faces, owing to the varying torque they produce; in fact, when going "dead slow," with triple extension engines, I have noticed the whole shafting move fore and aft in its bearings as far as the clearance between the thrust collars would allow it, the propellor alternately pushing the hull and being pulled by it, as the speed of the engine momentarily varied—a condition evidently very suitable for the access of oil to the collar faces.

The Michell thrust is fitted with water cooling, I observe, but it does not act directly on the bearing, but is employed to cool the oil. It is remarkable what a bad conductor of heat an oily copper surface is. In the trial referred to of thrust, shown in Fig. 2, we are told the oil was not water-cooled, as is commonly the practice in marine work.

I would like to know why, if cooling pipes were fitted, they were not used, and I would not be surprised to learn that it was because the water circulation made no appreciable difference. Of course, in ordinary marine work, the cooling water is applied directly to the metallic surfaces. The horseshoe collars may be cast hollow and have a water circulation through them,—or the lower part of the thrust block may be immersed in a water bath in which is a constant circulation of cool water, the favorite place with the old-fashioned thrust of semi-circular brass collars—but in many modern jobs no other water-cooling is provided than a water tap to drip on the shaft beyond the bearing which drip evaporates and carries away the heat generated. All this does not derogate from the ingenuity of the Michell thrust, which, no doubt, will find many suitable uses besides steamers' thrusts. For one thing, it is an object lesson to the ordinary fitter, to whom is often left the arranging of the oil holes and gutters in brasses. Every practical man knows the necessity of "eating off" the sides of a bearing—bearings would never run well if in continuous contact all round with the journal. The brasses of railway axles bear on less than one-fourth of the journal's circumference, and usually run well. If the rails and wheels were perfectly and mathematically smooth so that there was no jumping and jarring to let the brass and journal get out of contact momentarily, this cool running would probably cease.

S. Z. Ferranti patented a thrust block in which a collar or washer with radical grooves, having their leading edges eased off, is introduced between the faces; this allows the oil to flow freely in and keep up the supply as it gets squeezed out. The advantage of this continuity of the face in cross-head guards is well known—the cross grooves allow the oil to run in and the same is done in crank pin brasses and main bearings—at least when lined with white metal. This is a point I often have to emphasise in the verbal examination of marine engineers, many of whom were well posted in the elementary knowledge given in text books, but few seemed to have considered problems often unnoticed in books, but which obtrude on them every day of their working lives.

Mr. Michell seemed to have invented a very neat practical solution of thrust difficulties, one far superior to the use of ball bearings, which are often delusions and snares, as it is impossible that they avoid deformation and friction.

I have great pleasure in thanking Mr. Taylor for bringing the subject before us and explaining it lucidly to us. If he can inform us whether the very latest ships—the "Transylvania" and the "Tuscania" have the Michell bearing, it would be very interesting.

Mr. W. N. Grieve said: I have very much pleasure in seconding the vote of thanks to Mr. Taylor for his very interesting paper, but I have very little to add to the remarks which have been already made.

I think it will be admitted that it is physically impossible to efficiently lubricate two mathematical parallel faces. This fact has led to the multitude of unscientific oil ways of the ordinary horseshoe thrust block to lead oil actually on to the bearing surfaces, which is a very poor alternative to the natural lubricating properties of the journal bearing.

In 1912 I saw some experiments being carried out with this bearing for marine turbine purposes. The idea of one of the particular tests was to see what load the bearing would stand before heating or collapsing. Heating did not result, but the white metal face of the segmental block had become deformed with the great pressure exerted, showing the self-lubricating properties it possesses.

I should have liked Mr. Taylor to have given us more information with reference to the classic experiments of Beauchamp Tower, as we are apt to forget them, as the bearing under discussion is probably solely due to these classic experiments. Up to the time of these experiments of Beauchamp Tower engineers were very largely working in the dark on this most important part of an engine, and they erred on the side of safety, by making the bearing surface large and putting in oil ways where their judgment showed them to be necessary, and it can be readily understood that before Beauchamp Tower did demonstrate the self-lubricating properties of the journal bearing, these oil ways, were, in many cases, put in the wrong position, defeating the end that the journal itself would have naturally taken care of.

To my way of thinking, the Michell bearing is one of the most ingenious contrivances that has been invented out here, and I am very pleased that a paper has been read about it.

Mr. D. F. J. Harricks said: Mr. Reeks called on him early in the evening and asked him to read the following notes, as he regretted that he would not be able to read them himself:—

I have listened with keen interest to the description of this exceedingly ingenuous Michell thrust block, for not only is it ingenuous, but it is scientifically correct. What a pleasure it is to come across an invention that has been primarily scientifically based, or, in other words, tackled from the right end, because however much we may flatter ourselves that we are promulgating new laws, expressing them in formula, and regarding them as our own, this wonderful thing we call "science" is just nothing more than a study of, a research into, Nature's methods, and their working in obedience thereto. No man has, strictly speaking, ever invented anything—the word "invention" is just a convenient way of saying that someone has dived a little deeper into Nature's hidden mysteries than others, thereby made himself better acquainted with her ways in that particular direction, and shaped his course accordingly.

Some people get inspirations, and claim to have invented something suddenly. I prefer those spelt with a "P." and called "perspirations"—they are more likely to be useful.

We have such a case in Mr. Michell—you can follow his line of thought quite clearly when he, having digested the results of Beauchamp Tower's investigations. and Osborne Reynolds' explanation, he set out with his mind definitely set on the one point of getting that little wedge of oil into the place where it would do most good. And on his having done so in such a simple and eminently practical way, we congratulate him.

On the result shown, one may safely specify a Michell thrust block for all marine purposes without hesitation. In the large ships thrust blocks of the collar and horseshoe pattern great length is required, 7 feet not being an extreme case, against which some comparative drawings published, but not to scale, the Michell blocks for equal power would appear to be about 2ft. 3in. over all. In our ferry steamers the blocks run from 21in. to 24in., and the forward one involves a pocket in the mid-ship bulkhead. There would appear to be some prospect of avoiding that pocket in future boats, and so save expense, or, at least, modifying it, and so get more room about the boiler backs—either or both are desirable.

I do not generally arrive at conclusions rapidly, but I certainly see in the Michell block a most desirable item in any or all marine sets.

Charles F. A. Fyfe, in his book on steamship co-efficients, speeds, and powers sums up the chapter on "Thrust Block Friction," as follows:—

> "Taking the first result as an average for ordinary marine engines we may say that one-twentieth, or 5 per cent. of the indicated horse power is lost in thrust friction."

Mr. Michell would appear to have put the decimal point on the other side, and we should now read .5 or ½ per cent. in practice—a negligible quantity."

Mr. Harricks (continuing) said: Personally, I should like to add my congratulations to Mr. Taylor for his paper, because I think it is some 5 or 6 years now since the Michell thrust block was invented. Being such an excellent device, it seems to me it is a great pity that it has been so long in coming into notice. I know that at the time it first came to my notice I was immediately struck with the thought that if this thrust block had appeared some 5 or 6 years previously it would probably have had an application in a line of engineering in which I am interested, viz., sugar machinery—and that is with regard to the bearings for centrifugal machines. The ordinary centrifugal sugar basket weighs about 7cwt. or 8cwt.; it revolves at the rate of from 800 to 1200 revolutions a minute, and, for many years, ordinary friction washers of one sort or another, were all that supported the suspended baskets. As one would expect, there was a great deal of wear. About 8 or 9 years ago, ball bearings bounded into favor. I am afraid, as far as the Michell thrust block is concerned, it will not get a look in now for that very reason. As Mr. Taylor has said, friction is a very important factor. When one realises that, in connection with a centrifugal machine, there is the starting, accelerating, maintaining speed, and discharging of its load—probably 6 or 8 times an hour—one would immediately realise the ball bearings as having a tremendous pull over any other form of thrust.

I think, with reference to Fig. 4, thrown on the screen, Mr. Taylor said he did not quite know what the design really applied to. It really approaches, to a great extent, in appearance, the thrust bearing or the bearing of a suspended centrifugal machine.

I have very much pleasure in adding my meed of thanks to Mr. Taylor.

MR. MCEWIN said: I should like to add my thanks to Mr. Taylor for his very interesting paper, the reading of which I have enjoyed very much. I had not much opportunity of studying it before coming here, and I am very glad to have the opportunity of hearing Mr. Taylor explain the diagrams. I think one of the most interesting parts of his paper is that in which he draws our attention to the Beauchamp Tower's experiments. I am afraid very few of us knew anything about those experiments, and I shall, for one, take the opportunity of looking up the proceedings and learning something more