the principle of the action of bearing is such that when pivoted blocks are freely lubricated the oil pressure under each block is zero at the leading edge and twice the average pressure at the trailing edge. The oil is, therefore, free to enter and force the rubbing surfaces apart in the same way

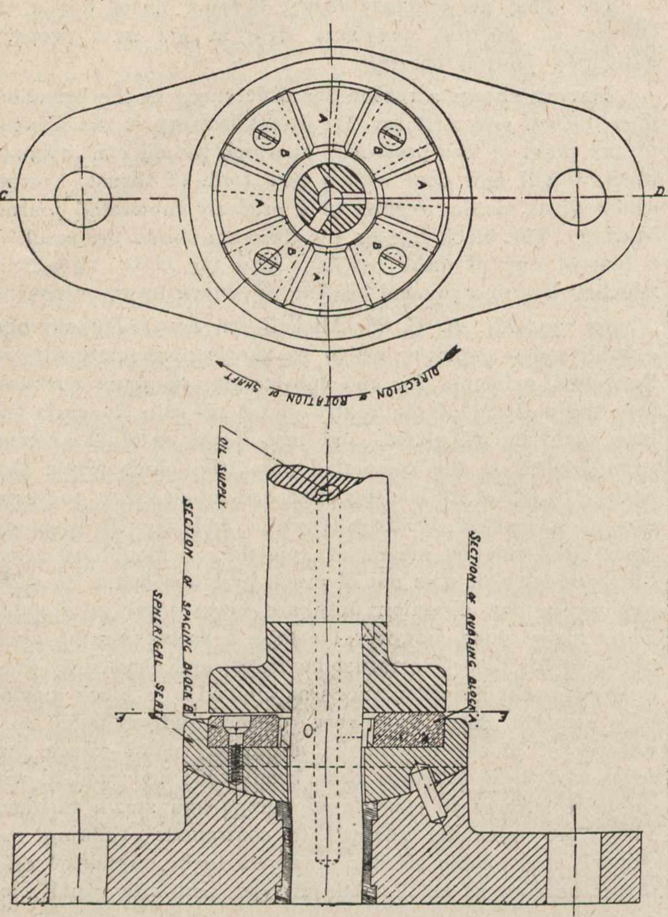

Fig. 4.—Special Design of a Michell Bearing Applied to a Steam Turbine.

as in a journal bearing, instead of being squeezed out under very moderate pressure as in a flat thrust bearing.

As shown by the diagram (which gives the results of actual tests) in place of the high friction loss of flat thrust bearings we get the same sudden drop in friction from that of metals in contact to that of simple oil shear when the speed reaches about ten feet per minute, as has been found by others to take place in journal bearings, and with this change we get the capacity to carry much heavier loads.

It should be mentioned that the importance of having a low co-efficient of friction is greater in the case of high-speed machinery than in that running at low speeds, because, supposing the co-efficient of friction is the same and the speed is doubled, then the work done in overcoming the friction will be doubled and the heat generated doubled.

As you all know, the mechanical equivalent of heat is 778 foot pounds of work; therefore, every 778 foot pounds of work done in overcoming friction generates enough heat to raise one pound of water one degree, and if the resistance offered to a shaft turning is a constant quantity the heat generated in the bearing increases directly as the speed. For example: Say, we have a shaft with 1,000-pound thrust and a collar one foot mean circumference. If this is an ordinary thrust bearing it will have a co-efficient of friction of about .075, and if it rotates at 60 revolutions per minute the work lost in friction will be—

$$1{,}000 \times .075 \times 60 = 4{,}500 \text{ foot pounds,}$$

and the heat generated will be enough to raise one pound of water nearly six degrees per minute, but, as it rotates at 600 revolutions per minute, the work is lost and heat generated will be ten times as much.

If, however, a bearing can be made with a co-efficient of friction of one-tenth of the ordinary thrust the heat generated at 600 revolutions will be the same as in the first case.

You will, therefore, see how important it is in these days of high-speed machinery to have bearings which will run with the very minimum of friction, not so much because of the coal which efficient bearings save, but because of the freedom from "hot bearings" which this efficiency gives, and in this connection it is well to note that the effect of heating in a bearing is cumulative, because as the heat rises it reduces the viscosity of the oil (in other words, makes it thinner) and more liable to be squeezed out and allow the metallic surfaces to come into contact with the usual attendant results.

I have shown you that the advantage of a ball bearing over a Michell thrust bearing is the very low starting friction which such bearings have as compared with oil-lubricated ones. But in comparing a ball thrust bearing with a Michell thrust one must remember that while ball bearings have attained a wonderful degree of perfection and are of great value for many purposes, they are in their very nature not adapted for carrying continuous heavy thrust loads at high speeds. Professor Stribeck, who has gone extensively into the subject of ball bearings, states that the capacity of the ball thrust bearing decreases as the speed increases, and that it is not possible to design a ball bearing within practical dimensions which will carry a heavy load for an indefinite time, as the continual overstressing of the material of the ball must ultimately result in failure, and the practical experience of many users has fully confirmed this opinion. This, however, is not the case with the flexible roller bearing, as has also been well proved. The usual method of failure in ball bearings is that the surface of one or more of the ball scales off, this abraided material getting between the ball and the race brings all the load on one

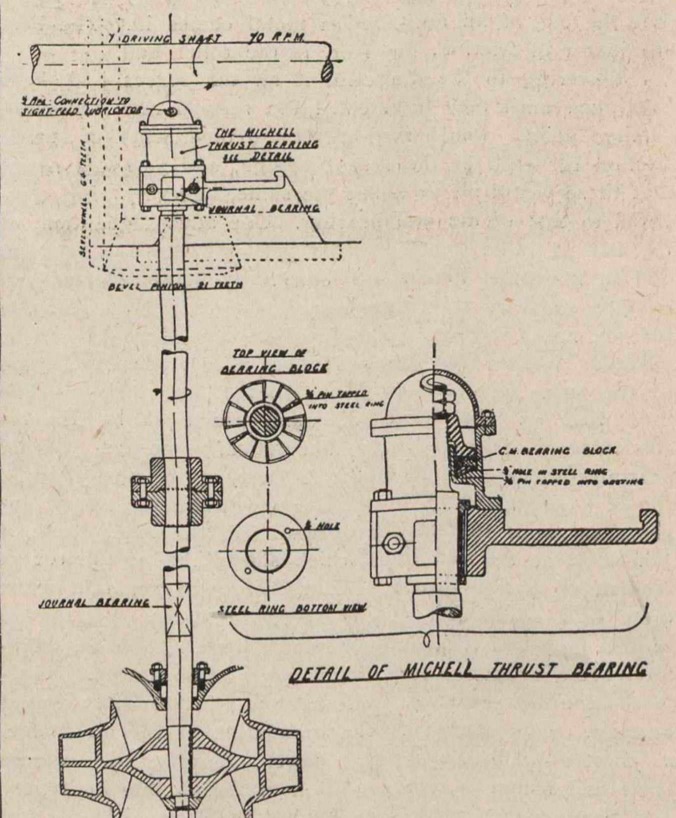

Fig. 5.—Arrangement of Michell Bearing as applied to two Large Vertical Type Centrifugal Pumps for the State Rivers and Water Supply Commission, Victoria, Australia.

ball, crushes it, and then produces a general destruction of the bearing.

I have now endeavored to show you:—

1st. That the chief advantage of a ball bearing is the very low starting friction which it has compared with an oil lubricated journal bearing, but that for heavy loads at high speeds it is not so reliable.