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HYDROSTATIC BEARING EXPERIMENTS

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HYDROSTATIC BEARING EXPERIMENTS

Anticipating an eventual increase in the accuracy requirements of rotating and sliding machine members, an investigation of the potential hydrostatic bearings might have for satisfying these requirements was started in 1964. The investigation was directed toward understanding the basic principles of hydrostatic design in order to be able to create suitable design criteria specifications and evaluate the resulting designs. It was felt that this could best be accomplished by actually designing, building and testing a simple hydrostatic bearing.

Toward this end a simple hydrostatic journal bearing was fabricated and evaluated. The 2-inch diameter journal was supported near each end by a ring of four pressure pads. Load was applied downward at each end of the journal shaft.

Load deflection curves obtained initially for this bearing were not in close agreement with theoretical predictions. At the maximum load point observed deflection was approximately 20 percent greater than that predicted by theory. Beam calculations on the journal shaft revealed significant bending upon being loaded which caused the journal surface to become slightly tilted with respect to the pressure pad surfaces. This condition in turn produced a non-uniform and reduced pressure distribution in the pads. Upon suitable revision to the theory to account for varying clearances, new theoretical curves were calculated and found to match experiment to less than 7 percent.

Several journal shafts of varying roundness were fabricated and placed in the bearing to study their affect on runout. It was found that the kind of unroundness was more important than the amount. That is, a two-lobed elliptical shaft of 50 microinches unroundness gave a maximum runout of 10 microinches while a three-lobed shaft of 30 microinches unroundness resulted in a runout of 15-20 microinches. The four pad arrangement of bearing design was apparently able to accommodate the two-lobed shaft better than the three-lobed configuration.

A second hydrostatic bearing was designed as the result of a concept for an ultra precision sweep gage. This design was a ring configuration with split pressure pad halves enclosing the rotor. The load faces were conical and at 45° to the rotation axis for combination radial and thrust loads.

Data collected from running this bearing indicated a runout sensitive to bearing temperature. Precision inspection of the bearing components separately and in assembly revealed eccentricities in the rotor conical faces and in the pad halves when assembled. Further data and conclusions await correction of these fabrication errors.

The value of these investigations does not lie in the fact that a more accurate design theory was derived or that an unusual configuration of hydrostatic bearing was designed. Instead, it lies in the realization that if hydrostatic bearings are to be expected to perform ideally in ultra-precision applications, meticulous

care must be taken in their specification, design and fabrication to insure that the ideal assumptions of the theory are closely approached. For example, the assumption of constant clearance implies infinite stiffness of bearing components, perfectly round or flat bearing infaces as the case may be, zero dimensional tolerance on critical parts and ideal alignment upon assembly. Hydrostatic bearings are able to perform well in spite of defects in design or manufacture. However, if they are to be expected to give the ultimate in precision and accuracy the same scrupulous care must attend as in the production of any precision instrument.

Certain demanding assumptions can sometimes be circumvented by novel design. Thus, the investigation of the journal bearing with different unround shafts suggests that the pads should be smaller and more numerous to be less sensitive to shaft unroundness.

Allowing the number of pads to increase without limit leads to the notion of a porous bearing. Simple experiments with small porous bushings and turned, unground shafts have indeed shown that the shaft need not be round to give impressive performance. Further work along this line is planned.