

XIII. NEUROPHYSIOLOGY*

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A. NEW MECHANICAL DEVICES

1. KINEMATIC THRUST BEARING

In Fig. XIII-1 we show a model of our new kinematic thrust bearing, for the case $N = 17$, there being 17 rings and 34 balls. The two end discs have a grooved raceway, the bottom disc is free to move on the $1/4$ " diameter shaft, and is restrained by a conventional thrust bearing. The configuration as illustrated is stable, and the device can be rotated at 500 rpm for an indefinite period.

The important feature of this bearing is that the forces are self-equalizing; that is, the device is kinematic. We contemplate application as a very high precision thrust bearing; in this case, the averaging or self-equalizing action will enable reduction of errors in axial positioning caused by oversized balls, irregularities of races, and so forth.

An interesting note concerning this geometry is that the configuration is stable only for odd values of N . If N is even, the lattice arrangement immediately collapses with rotation, alternate rings moving toward opposite ends of the shaft. An attempt to illustrate the kinematic behavior of the device by inserting a $1/32$ " oversized ball led to a similar collapse – such a deviation is evidently beyond the limits of accommodation of this device.

We are, at present, undertaking a computer analysis of these configurations, which will also enable us to explore the axial displacements (axial cam action) caused by radial and angular misalignments of the discs relative to the shafts. Preliminary results indicate that it will be possible, by these means, to realize a precision thrust bearing, which, when used in conjunction with a precision worm gear,

*This work was supported in part by the National Institutes of Health (Grant 5 PO1 GM14940-04), and by a grant from Bell Telephone Laboratories Incorporated.

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can be adjusted to compensate for the periodic errors that are almost always present in worm gear drives. Such an arrangement would have application to precision pointing of astronomical telescopes.

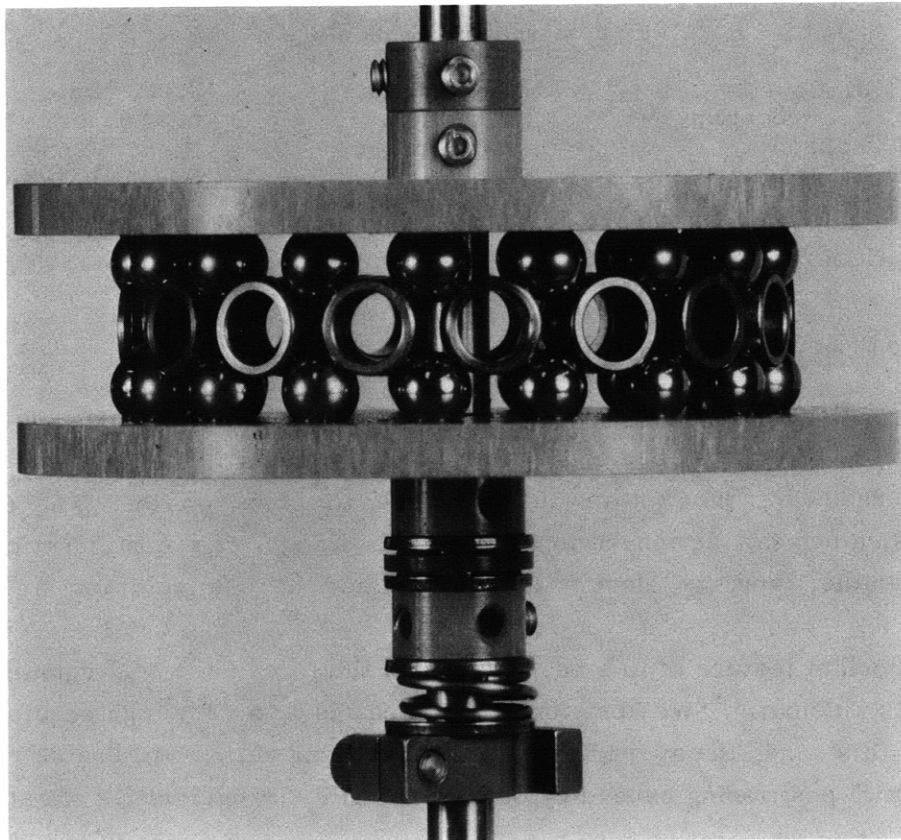


Fig. XIII-1. Kinematic thrust bearings for the case $N = 17$.

2. PRECISION ANGULAR TILT TABLE

In Fig. XIII-2 we show a drawing of an angular tilt table that has features of interest to the precision mechanic. The moving element is supported by a double row of balls, contained by two V grooves, and acted upon by a micrometer screw. The axis of the micrometer screw is laterally offset the amount necessary to provide rolling contact with the first ball. The arrows in the diagram indicate the approximate relative rates of motion of the balls. It will be appreciated that the contact between a ball and the sides of the V groove is rolling motion with a slight spin, and the contact between adjacent balls is rolling motion with a slight slippage resulting from their differing rates of rotation. The smooth action of the device depends on the fact that this slippage is absorbed by the concomitant rolling motion.

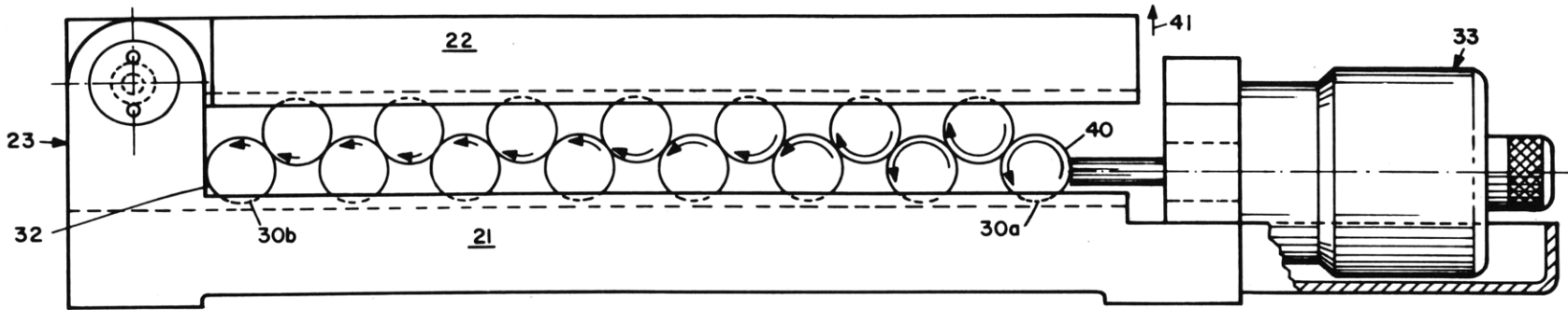


Fig. XIII-2. Diagram of the precision angular tilt table.

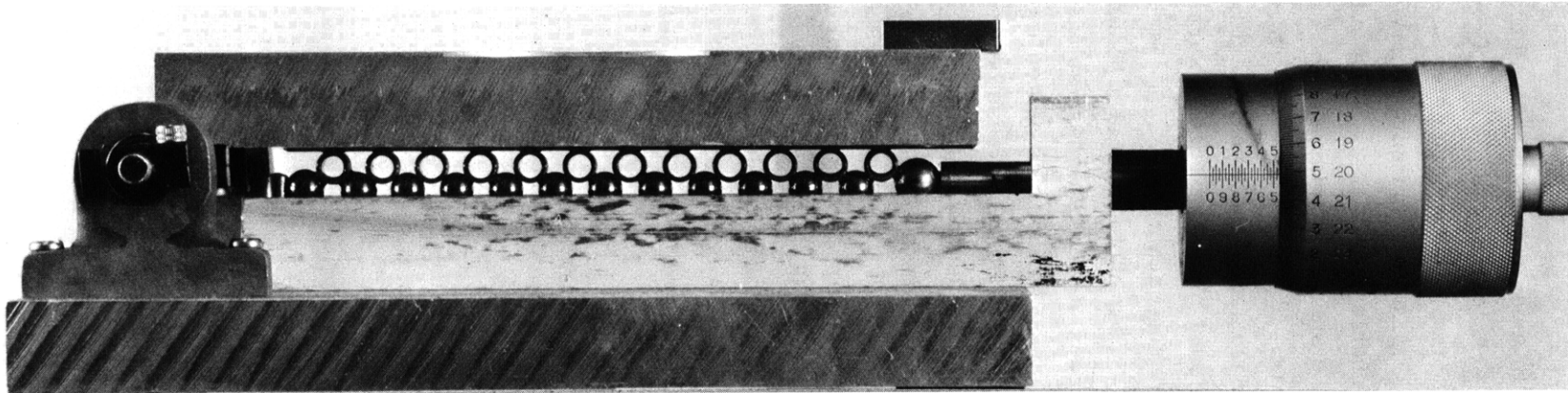


Fig. XIII-3. Photograph of a modified angular tilt table, with rings substituting for the upper set of balls.

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A model of this device was machined from aluminum alloy and fitted with 29 steel balls, and was then tested with the aid of an electronic gauging system. The reduction ratio, that is, motion of the micrometer screw vs the moving end of the platform, was approximately 15:1 in this configuration. We found that the action of the device was very smooth, no mechanical hysteresis being evident. The angular increment of tilt corresponding to the smallest division of the micrometer, 0.0001 inch, was approximately 0.2 second of arc. After wide excursions, readings were regularly repeated to approximately 1 second of arc, the errors evidently being due to tolerances in the hinge bearings. Our next model will use flexural hinges, and will be machined of steel for greater load bearing capability.

Figure XIII-3 is a photograph of a second configuration, in which a set of rings, here defunct inner races of ball bearings, substitutes for the upper set of balls. The rings ride on a steel shaft, which is cemented into the top V groove. The object of this exercise was to reduce the contact stress between rolling elements; the greater conformity of contacting surfaces has this effect. The performance was much the same as before; the reduction ratio was approximately 10:1.

The principal disadvantage of the present device is its inherent nonlinearity, which amounts to several per cent of the total motion. A parabolic fiducial mark on the micrometer scale can be used to correct for this effect; however, more accurate settings would require the use of a correction table. In certain applications, as, for example, servomechanisms, this nonlinearity is of little importance, and the inherent smoothness of operation, essentially free from mechanical hysteresis, could be used to advantage.

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