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PIVOT ERRORS

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Resumo. É descrita a determinação da seção dos munhões do círculo meridiano AM-190, por meio da leitura dos círculos graduados. A seção é circular, com uma precisão de 0.1 μm.

Abstract. The determination of pivot errors for the AM-190 transit circle is described. The method rests on readings of the graduated circles. The measured cross sections are circular within 0.1 μm.

Key words: pivot errors, transit circle.

1. THE METHOD

The quality of right ascension instrumental system of transit circles depends crucially on the knowledge of pivot errors. The determination of the shapes of the axles and their departure from strict cylinders of revolution is certainly a difficult problem. The required accuracy is of the order of about one tenth of a micron.

At this level, not only measurements are difficult, but their significance must be carefully established. Deformations of various origins - thermal, elastic, viscous - and possibly dependent on time and environmental conditions, may easily reach the above limit, both in the pivot-bearings system and in the measuring device.

Recent methods (Loibl 1978, De Concini and Zanzu 1980) make use of linear displacement transducers or indicators, assembled in such a way as to read radius variations along a vertical direction, while the pivot is turned. V-shaped bearings of more than one angular aperture are needed to obtain full determinacy.

In the most frequent situation, the pivots rest on 90° V-shaped bearings, so that irregularities in the contact points produce orthogonal - hence independent - displacement components. For this reason, it seems more natural to make the measurements in the directions perpendicular to the bearings arms.

Of course, if the measurements are performed in this way with the help of displacement meters in contact with the pivot surface we cannot get but diameter errors. However it was pointed out long ago (Chauvenet 1863, Vol. II, Art. 33) that the actual displacement of the pivot center is present in the circles readings.

If the microscopes pairs lie in diameters parallel to the bearings arms, the difference of the readings of opposite microscopes is, apart from an unknown constant, proportional to the pivot displacement in the direction orthogonal to the measured diameter.

The unknown constant depends on the micrometers index positions, on the pivot mean radius and, unfortunately, on the errors of the individual circle divisions. If, however, a second measurement is taken after a half turn of the pivot and circle, the division error term changes sign and we can get, at least in principle, the pivot diameter error, apart from a constant origin. This is, in essence, Chauvenet's method.

2. MEASUREMENTS AND RESULTS

The AM-190 transit circle from Zeiss Oberkochen of the University of São Paulo "Abrahão de Moraes" Observatory at Valinhos (λ=3h07m52s W, ϕ=-23°00') has hardened steel pivots, which rest on bronze V-shaped bearings of 90° aperture. The pivots diameter is 100 mm and the net force against the bearings is about 5 kg. The manufacturer specifications state that the pivots are cylinders of revolution to within 0.1 μm.

Four measuring microscopes are available on each pier. They read perpendicular diameters parallel to the bearings arms. The graduated circles have a diameter of 400 mm, so that 1" corresponds to a linear displacement of 1 μm.

The original visual micrometers at the western pier have been replaced by photoelectric scanning micrometers from Watts Prototype. This system is a property of the U. S. Naval Observatory and was kindly lent to the University of São Paulo.

All the measurements have been conducted at the western pier with the photoelectric system, because of its superior accuracy over the visual system. The repeatability of the scanners readings is 0".07, equivalent to 0.07 μm, for each micrometer.

Six independent series of measurements were performed on each pivot. A series comprised nineteen settings of the circle, at 20° intervals. The last setting reproduces the first one, so that eventual drifts could be detected and accounted for.

The completion of a series takes about half an hour. During this interval the room temperature was kept nearly constant, to minimize thermal deformations.

Since the bearings touch two points at right angles, we get independent and simultaneous results for two perpendicular pivot diameters. The combination of both yielded an actual sampling at 10° intervals.

The averages of the six series are displayed in Fig. 1 and 2, for pivots 1 and 2, respectively. The abcissae are the position angles counted from the telescope optcal axis. The ordinates are one half of the diameters deviations from the mean value.

The full line is a sine function fitted to the points. It represents the pivot ellipticity. The amplitudes for both pivots are 0.1 μm, in agreement with the manufacturer's specification. The similarity between the pivots is striking.

The residuals from the sine curve are scattered at random. They are due to experimental errors and their rms is 0.05 μm. This figure is taken as representative of the overall accuracy.

3. CONCLUSIONS

The present method yielded results of very high accuracy. Systematic accuracy is also probably good, since the similarity found between the pivots is likely to be real, as a consequence of identical manufacture procedures.

We should stress that such good performance has been atained with a great economy of means and very simply.

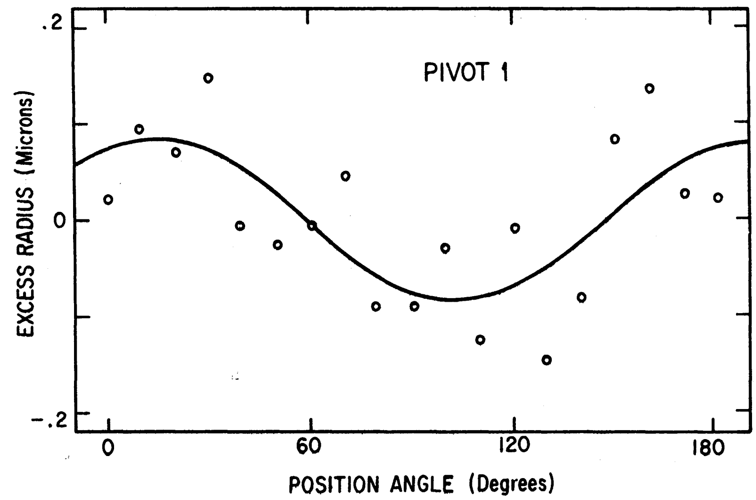

Fig. 1. Pivot 1: one half deviations from mean diameter.

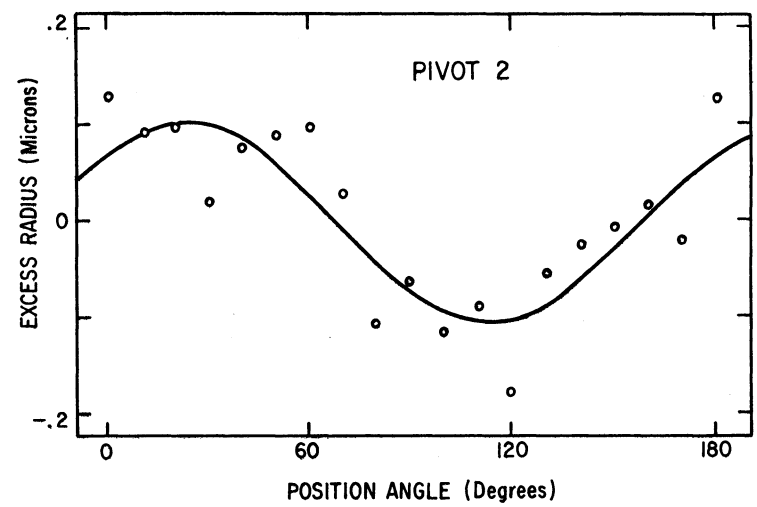

Fig. 2. Pivot 2: same as Fig. 1.

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