Bull. Astr. Soc. India (1996) **24,** 67–72

Feasibility study for a polar disc mount

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Received 30 January 1995; accepted 26 May 1995

Abstract. A 61 cm Schmidt telescope employing a Yoke mount is being prepared for installation at Hanle, Ladakh district, Jammu and Kashmir. This paper studies the feasibility of an alternate type of mount viz. the polar disc mount, which is found to be superior in more ways than one, to the Yoke mount presently employed. It is felt that this type of mount may be considered for future telescopes to be installed at the same site.

Key words: polar disc mount—Hanle-telescope

Introduction

The design is centred around the bearing supporting the polar disc and the telescope tube assembly. The schmidt telescope is taken as the benchmark to work on and prove the feasibility of the mounting arrangement.

Telescope mounts : A telescope, it is said, is as good as its mount. A good mount should be sturdy and of light weight. The common type of mount employed for a telescope comes under the equatorial mount category. The various types of mounts under this category are Fork mount, English mount, Yoke mount etc. Fig.1 gives details of some equatorial mounts in use. Of late, with the advent of fast computers, alt-azimuth and alt-alt mounts have become popular.

Polar disc mount : It is an equatorial mount very much like a fork mount. The cantilever action is less as compared to the fork mount as the whole structure is supported on the bearing. Compared to the yoke mount, the weight and the number of parts are less. These factors enable easiness in manufacture, transportation and installation at site. Overall, the execution of the project within a short span of time becomes possible. Since the weight and moment of

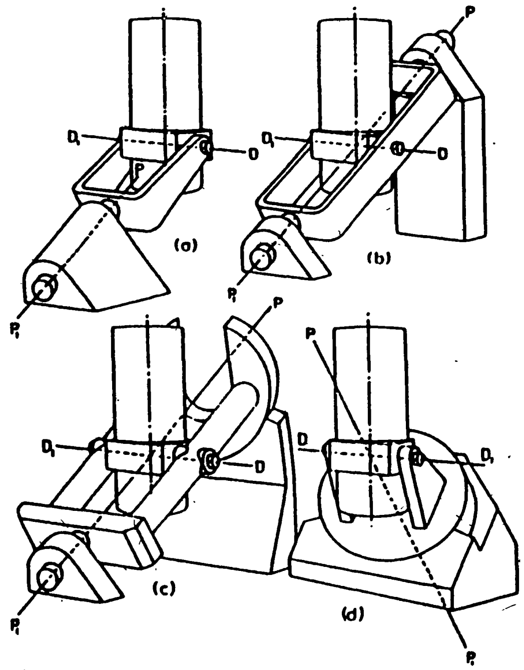

Fig. 1 Equatorial mountings. (a) Fork, (b) Yoke, (c) A variant of the horseshoe, (d) Polar disc.

The polar disc mounting is immensely rigid for a given weight and size. This enables one to obtain a high value for the natural frequency of the structure which is very much desirable from the point of view of the control system. Deflections are minimal and sky access is complete at north temperature latitudes, except for a small part of the southern horizon. But this can be corrected by suitably locating the declination axis on the telescope tube. This mounting is more suited for installation at high terrestrial latitudes than nearer to the equator, because in the latter case the upper edge of the disc tends to obstruct access to objects low on the horizon opposite to the pole (north or south depending upon hemisphere). These prove that it is quite ideally suited for the site under discussion viz., Hanle (Ladakh) in Jammu and Kashmir (Latitude 32° 47' N).

The 98 inch Isaac Newton telescope which was earlier installed at the Royal Greenwich Observatory at Herstmonceu (Latitude 50° 52' N) and presently installed at Canary Islands (Latitude 28° N) employs a polar disc mount.

Calculations

The total system is assumed to weigh 1000 kg.

Thrust load on bearing = 1000 Cos 32 = 848 kg = 1868.992 lbs.

Moment on bearing = $1000 \times \frac{1150}{1000}$ = 1150 kgm = 99787.402 lbs in.

Static radial load on bearing = 1000 Sin 32 = 529 kg.

Dynamic radial load on bearing = $Mr\,\omega^2 = 1000 \times \frac{25 \times 2.54}{100} \times \left(\frac{1}{2}\right) \times \frac{1}{9.8}$ = 16.19 kg,

where M = Mass of system = 1000 kg

r = bore of bearing = 25"

ω = Maximum angular velocity = $1/2^c$ / sec

Net radial load = 529 + 16.19 = 545.19 kg = 1201.59 lbs

Torque required to drive the telescope in R.A axis = Moment of inertia x angular acceleration
$= m\gamma^2 \times a$

where m = mass of telescope = 1000 kg
γ= maximum radial distance from axis = 2 metre

The angular velocity of $\frac{1^c}{2}$/ sec is obtained in 2 secs,

Angular acceleration, $\alpha = \frac{1}{2} \times \frac{1}{2} = \frac{1^c}{4}/\sec^2$

Torque required at R.A. $= 1000 \times 2^2 \times \frac{1}{4} \times \frac{1}{9.8}$ = 102.04 kgm

Mass of telescope tube = 350 kg

Maximum radial distance γ = 1.5 metre

Angular acceleration, $\alpha = \frac{1^c}{4}/\sec^2$

Torque required to drive the telescope in declination axis $= I \times \alpha$

$= m\gamma^2 \times \alpha$

$= 350 \times 1.5^2 \times \frac{1}{4} \times \frac{1}{9.8}$

= 20.089 kgm

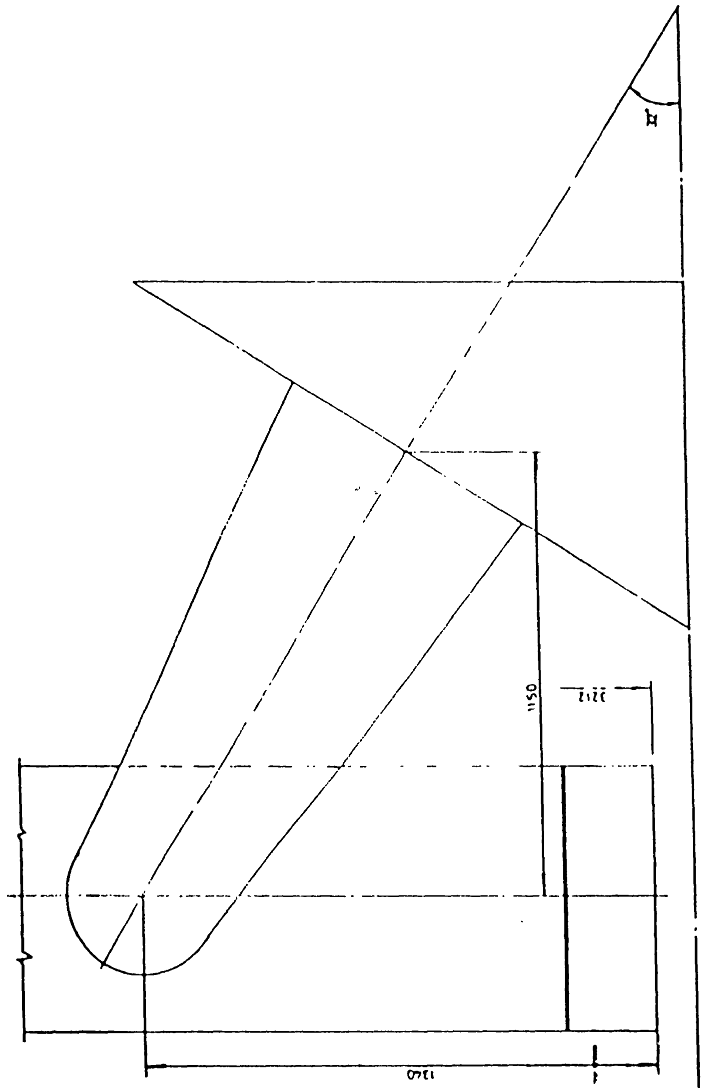

FIG. 3 MAJOR DIMENSIONS

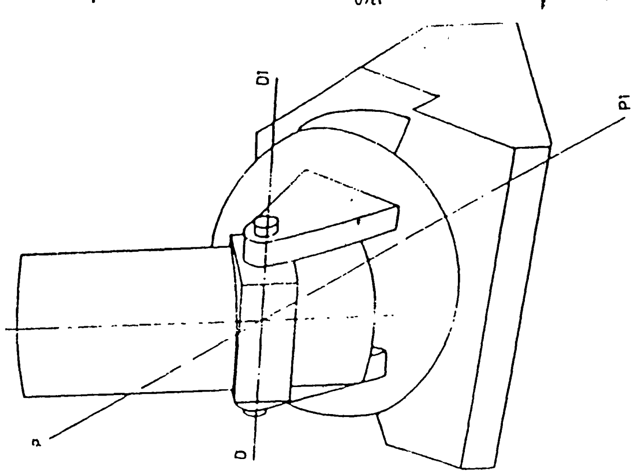

FIG. 2 THE POLAR DISC MOUNT

P P1 - Polar Axis

D D1 - Declination Axis

Selection of bearing : Since this particular type of mount gives all three types of loading i.e., radial, axial and moment, it is advisable to go in for a four point contact bearing which can withstand all three types of loading. A thin series bearing may be considered in order to reduce the bearing housing size and thus the weight. M/S Kaydon Corp., U.S.A. manufactures a popular brand of the bearing of the specifications given above. For the loads under consideration a suitable bearing is selected from the catalogue.

Specification of bearing selected : KG250XPO840

Manufactured by Kaydon Corporation, U.S.A.

Equivalent radial load for the bearing, $P_\gamma = \dfrac{1.2M}{PD\ \mathrm{Sin}\theta} + 0.75F_\gamma + 0.9F_t$

where F_γ = radial load = 1201.59 lbs

F_t = thrust load = 1868.992 lbs

M = Moment load = 99787.402 lbs in

PD = bearing pitch diameter = 25 inches

θ = Bearing contact angle = 30° (for standard bearing)

$$P_\gamma = \frac{1.2 \times 99787.402}{25 \times \mathrm{Sin}30} + 0.75 \times 1201.59 + 0.9 \times 1868.992 = 12162.876 \text{ lbs}$$

Data on bearing :

Dynamic Capacity of bearing :

Radial = 13400 lbs = 6079.85 kg

Thrust = 33700 lbs = 15290.381 kg

Moment = 174200 lbs in = 2007.56 kg m

Temperature range of standard lubricant : –26°C to 121°C

Bearing diametral clearance = 0.0011 inch = 27.94 micron

Limiting speed of bearing = 16 rpm

Bearing axis deviation :

Axial deflection for the axial load being applied = 17 microns

Radial deflection for the radial load being applied = 3.81 microns

Moment deflection for the moment load being applied = 0.0002 radian = 41.25"

Conclusion

Considering the factors of simplicity in fabrication, transportion and erection at site, keeping in view the harsh conditions at site and ability to convert to an alt-azimuth mount easily, this mounting is strongly recommended for future telescopes to be located in the Himalayan region.

If the polar axis of a polar disc mount is made vertical it gets converted to an alt–azimuth mount. This involves only civil work as the mechanical structure remains the same. This is very beneficial from the point of view of future developments. Care has to be taken to see that the tube along with Cassegrain instrument, if any, goes in completely between the declinations axis supports.

References

Barlow B.V., 1975, The Astronomical Telescope, London, Wykeham Publ.

Catalog 300 (Reali-slim Ball and Roller bearings) - Kaydon Corporation, 2860, McCracken street, Muskegon, Michigan 49443, U.S.A.