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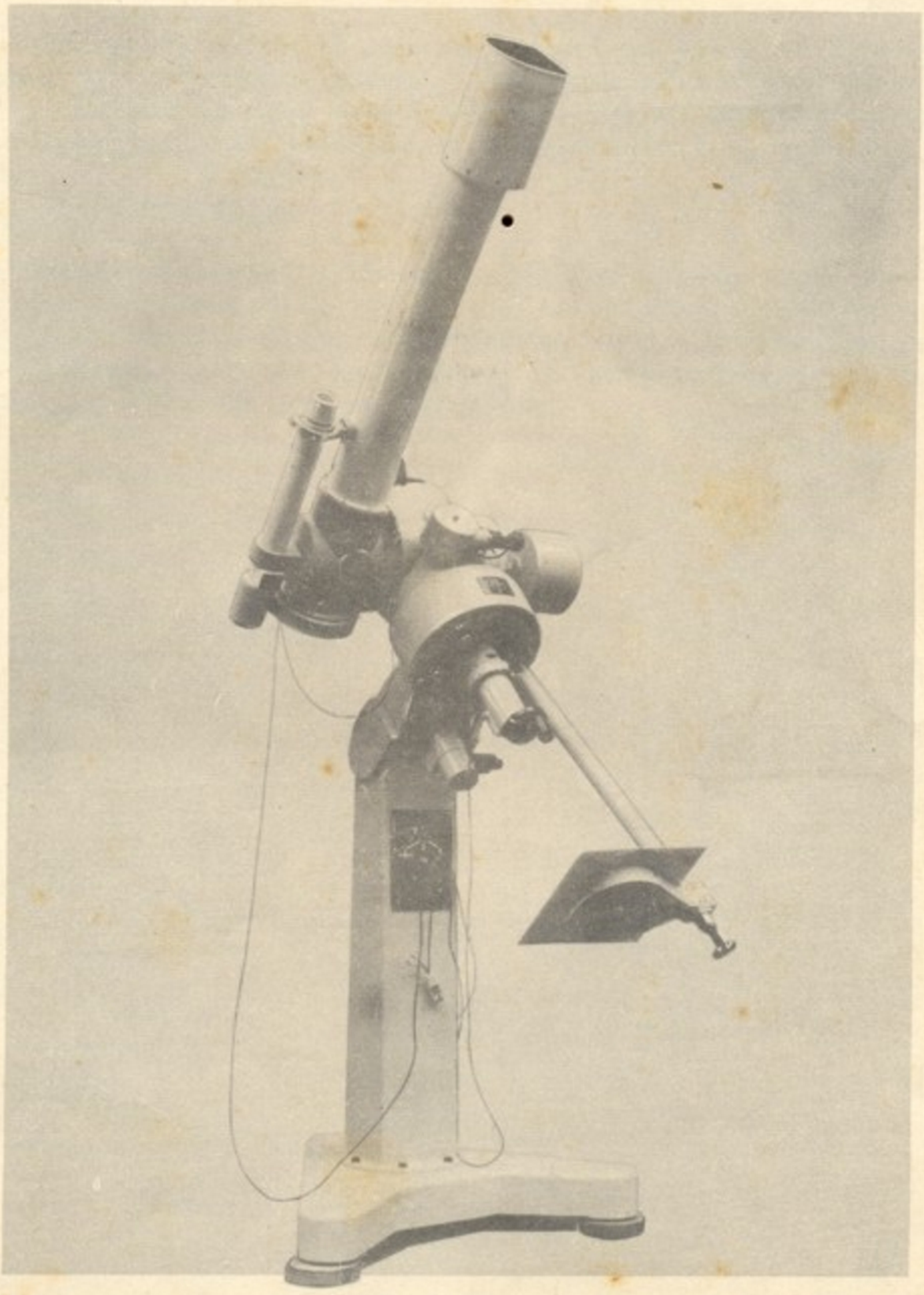

Coudé Refractor

The 150 mm Zeiss-Coudé-Refractor

1. Summary

The 150 mm Zeiss-Coudé-Refractor (see **cover** picture) is mounted equatorially. Owing to the special type of mounting of the Coudé-Refractor, it is impossible for its tube to hit the column during observation. Thus, uninterrupted observation is possible without reversing the instrument.

Ordinarily, the instrument is equipped with a 150 mm AS objective of 2250 mm focal length. In accordance with the Coudé principle, the beam path is deflected twice by means of 2 plane mirrors. At both ends of the hour axis stationary focal planes are available which may be observed alternatively.

The hour angle drive of the instrument is operated by a synchronous motor. Servomotors and manual electrical potentiometers are provided for a continuous fine speed control. Visual and photographic observation is rendered possible by supplementary equipment.

2. Optical Construction

The Coudé principle, although known for a long time, has hitherto chiefly been used with reflecting telescopes. Since we have developed highly reflecting aluminium coatings with a protective layer effective even against tropical influences, we have successfully used the Coudé principle with the 150 mm Refractor.

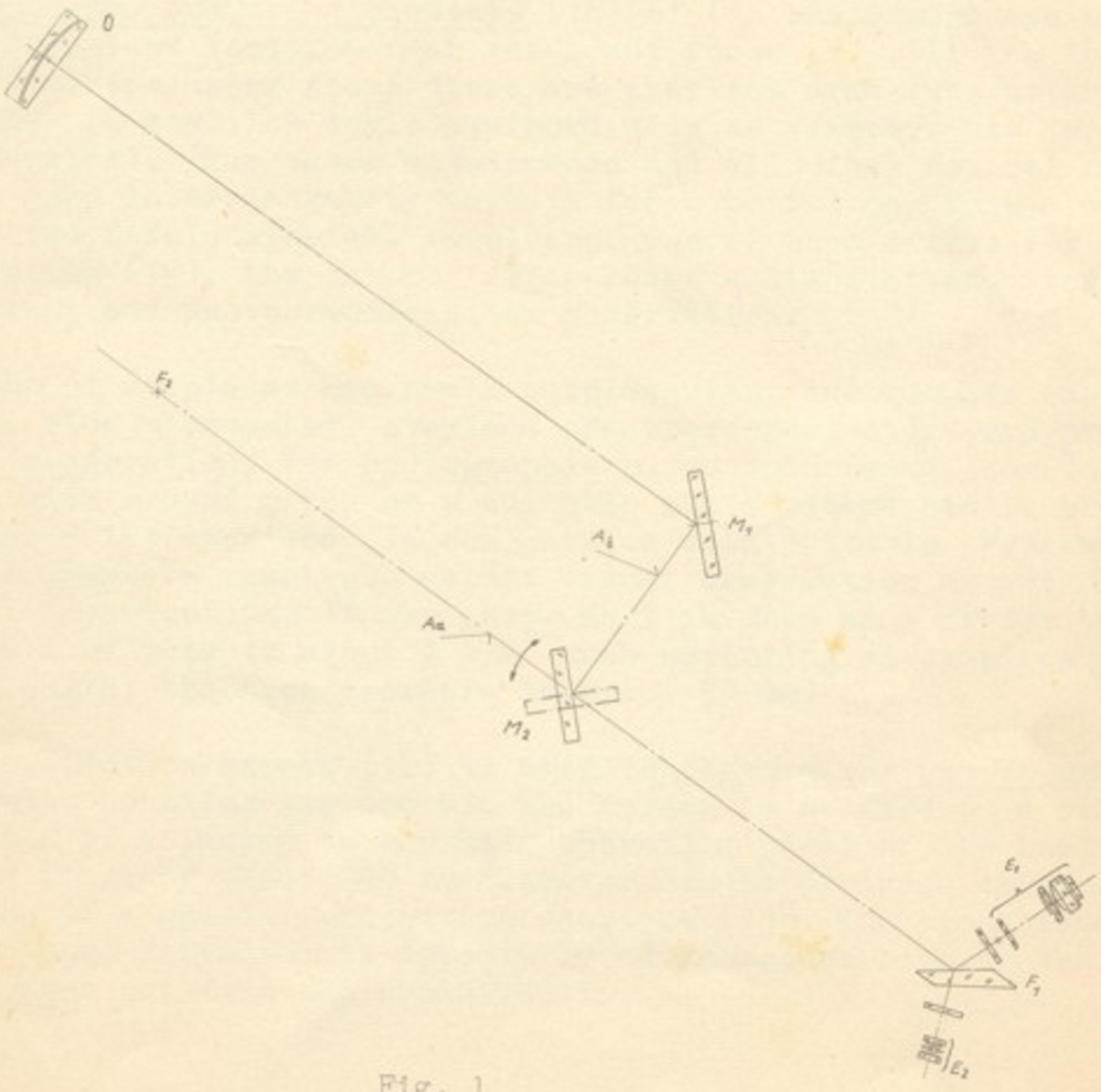

Fig. 1

The beam path is shown in fig. 1. The beam coming from objective O is directed by two plane mirrors M_1 and M_2 through the hollow declination shaft A δ and through the hollow polar shaft A α . Accordingly, the focus F_1 of the objective and, in consequence, the location of the eyepiece remain fixed, no matter to what part of the sky the objective is pointed. The expression "coudé", meaning "broken", refers to the deflected path of rays.

The advantage of the Coudé principle compared with conventional telescope mounts lies in the fixed place for the observer. Whilst the instrument follows the diurnal motion, the image and the eyepiece tube turn around the polar axis simultaneously, with no relative motion. Thus, measurements with a filar micrometer in the focal plane are possible without any restriction.

Within the hollow polar shaft A α the beam can be directed either to its lower or to its upper end where observations can be made at the Coudé foci F_1 or F_2. For this purpose the plane mirror M_2 is rotatably mounted in the point of intersection of declination and hour axis. By means of a crank (20) the mirror can be tilted to two positions spaced from each other by 90°. The two positions of the mirror are secured by positive precision stops. (Fig. 2 and 3).

The standard-type refractor is equipped with an AS-objective (10) of 150 mm diameter and 2250 mm focal length. Exceptions to the standard accessories are listed under item 6.

The principal operating elements (18) of the instrument are situated in a convenient location near the lower focus (F_1). At the lower as well as at the upper focus there are eyepiece draw-tube attachments rotatable in position angle equipped with an adapter. The two adapters are identical. Thus these attachments and all other optical accessories can be used interchangeably in both focal positions. This also applies to the two 2-fold eyepiece revolvers. One of them serves for stellar observation (15), the other (14) includes a light-attenuating device for visual and photographic solar observation.

A number of eyepieces and small supplementary instruments (colour filter, ring micrometer, eyepiece spectroscopes, etc.) are provided for visual observation. For photographic purposes a Zeiss Ikon Contarex camera with ground glass or a suitable plate camera can be attached instead of the eyepiece. In conjunction with suitable eyepieces the twofold eyepiece revolvers permit visual observation as well as guiding without interruption. If the instrument is used as a finder telescope, the field of view is about $1\ 1/2^{\circ}$ when employing an eyepiece of 63 mm focal length; the free aperture is about 50 mm.

A sun projection screen (12) is used to observe the sun in projection (e.g. when counting sun spots). The screen is mounted on a rigid rod which can be attached to the main operating panel of the instrument. A solar image of about 250 mm diameter can be produced on the screen by means of a special projection eyepiece (13). Sun projection by means of the Coudé-Refractor is especially advantageous because the projection screen does not face the sun directly.

At the upper focus F_2 supplementary equipment can be used at the observer's choice (e.g. star photometer, spectrographs, H-alpha-monochromator, etc.).

It is of particular advantage that these instruments can remain fixed at the upper focus while observation independent thereof is possible at the lower focus.

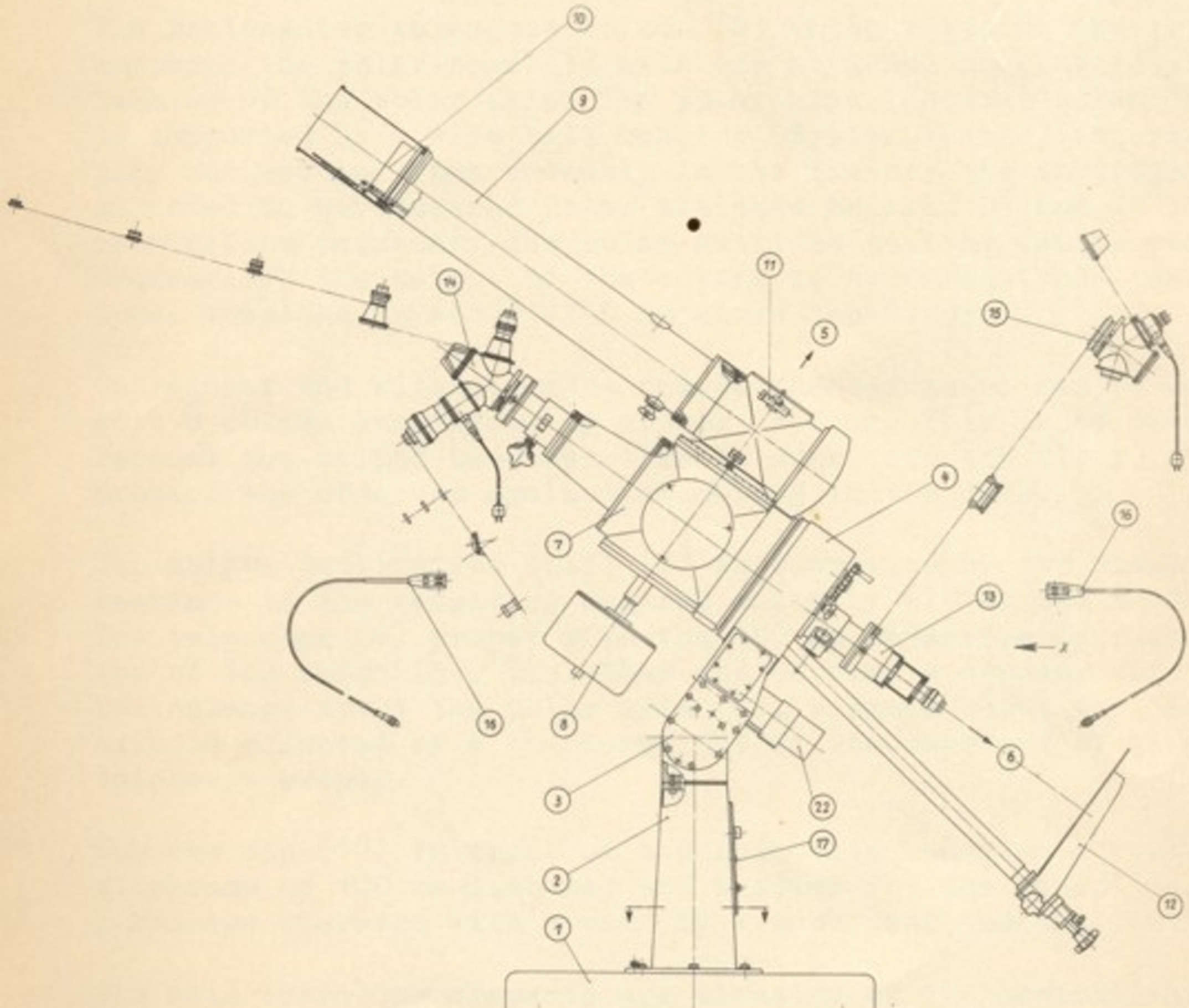

Fig. 2

3. Mechanical Construction

Figs. 2 and 3 are general views of the 150 mm Coudé-Refractor.

Like any parallactically mounted telescope, the Coudé-Refractor, too, consists of three principal assemblies:

a) the stationary assembly: tripod, column, polar head with bearing support

b) the central assembly which turns about the hour axis;

c) the tube which is supported in the central assembly and turns around the declination axis.

The rectangular telescope column (2) which rests on the tripod (1) supports the polar head (3) with the attached housing (4) for the bearing of the polar axis. The polar axis (central assembly (7)) is supported by a wire ball bearing (System Franke) ensuring minimum play and wobble. Upon assembly in the factory the instrument can be adjusted to any desired polar altitude between 0° and 70°. Although very seldom necessary the polar altitude setting can be changed. Ordinarily, the height of the column is so dimensioned that the lower eyepiece is about 1150 mm above the floor.

On request and without extra charge the refractor can be supplied with a column lengthened by approx. 350 mm. This is of advantage because the tripod base can then be sunk into the floor in order to protect the observer against stumbling in the dark.

The hollow declination shaft (5) is supported by two standard ball bearings in the revolving central assembly (7) of the instrument. The telescope (9) proper with the 150 mm objective is flanged to one end of the shaft (5). The other end carries a counter weight (8) for balance about the polar axis (6). Balance about the declination axis is effected by a counterweight at the rear end of the telescope proper.

The dew cap (10) in front of the objective contains a removable sun diaphragm of 100 mm diameter and a cover for the objective. Both parts are operated with a gear by a knob near the declination axis.

The main operating elements are situated on the central assembly on the side of the lower focus: handwheels for the coarse motion (19) in hour angle and declination, the associated clamps, the focussing device (21), the reversal of the mirror (20) and the hour angle scale. The declination scale is arranged directly on the declination shaft. When the instrument settings in hour and declination are clamped, the electrical fine motion (16) for these two co-ordinates can be operated. For this purpose, one hand-operated potentiometer each (cf. item 4) is suspended by flexible connections at the lower and upper focus.

For adjusting the refractor in polar altitude and azimuth after assembly, three adjusting screws are provided in the tripod of the column and an azimuth screw at the lower end of the column.

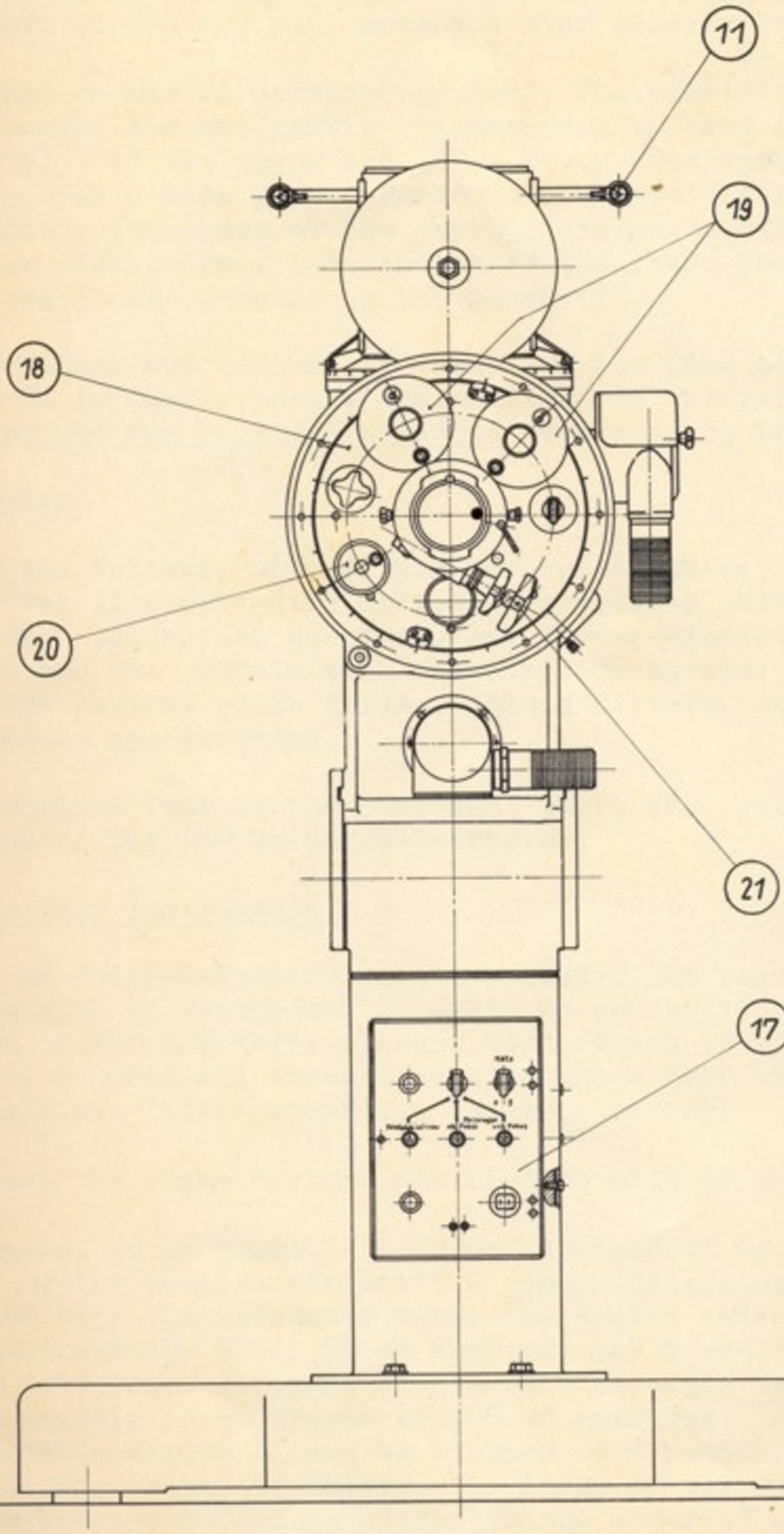

Fig. 3

4. Drive

The hour-angle drive of the instrument is operated by means of a synchronous motor (an additional control by quartz clock can be provided if the line frequency is not constant enough). A three-speed gear shift allows for sun, moon and star observation.

Coarse motion can be effected by hand. The electrical fine motion in hour-angle and declination is actuated by hand control (potentiometer (16)) at the upper and lower focus. The speed is continuously variable over a wide range. Servomotor control is employed for the fine motion. The speed of the appropriate motor is regulated by one amplifier each, widely independent of the load. The electrical control elements are mounted on the panel (17).

The electrical and mechanical layout of the fine motion drives is so devised as to easily permit the addition to the refractor of a photoelectric sun guiding telescope developed by CARL ZEISS.

5. Accessories

Besides the integral optical and mechanical parts, a number of accessories is supplied: 5 different eyepieces calibrated in diopters, including a projection eyepiece, one finder eyepiece calibrated in diopters and one reticle with illuminating device, one pointing eyepiece, one neutral glass filter, colour filters, one ring micrometer and eyepiece spectroscope.

For a complete list of the component parts cf. list of the standard equipment of the 150 mm Coudé-Refractor.

6. Supplementary Instruments

The 150 mm Coudé-Refractor can be extended. On request it can be supplied with an apochromat 150/2250 mm or 150/1650 mm. The secondary spectrum of our new three-element apochromats (F-objectives) is considerably reduced and these objectives have very small Gauss and zonal errors and are little sensitive to de-centering.

On request the plane mirrors can also be made of quartz.

Furthermore, it is possible to mount instead of the counterweight at one end of the declination shaft a second telescope mechanically connected with the refractor tube. The second telescope could be a Cassegrain system, with 300 mm aperture and a small refractor as a guiding telescope. It could either be a straight Cassegrain system or a Cassegrain Coudé system of 400 mm aperture. In the latter case, the rotatable mirror M_2 can be stopped in 4 positions instead of two. Hence it is possible to observe the image of the refractor or the Cassegrain-Coudé-telescope either in the lower or in the upper focus.

It is also possible to choose as a second telescope one of short focal length, small f-number and wide field, e. g. a Schmidt telescope.

As mentioned under item 4, it is possible to mount on the refractor a photoelectric sun guiding telescope which has been developed by Zeiss. This instrument eliminates to a high degree disturbing influences of refraction and mechanical inaccuracies by utilizing precise guidance through the sun.

Please write for our special offer if you are interested in the supplementary instruments listed under item 6.

7. Dome

The minimum diameter for a dome for the Coudé-Refractor described above is 3 3/4 m. Although we do not make observatory domes, we shall be glad to offer our advice.

Explanation of the notations in Figs. 1 - 3

O Objective
M_1 45° plane mirror
M_2 Tiltable 45° - plane mirror
Aδ Declination axis
Aα Polar axis
E_1 Finder eyepiece
E_2 Observation or guiding eyepiece
F_1 Lower Coudé focus
F_2 Upper Coudé focus

1) Tripod
2) Column
3) Polar head
4) Support of polar axis
5) Declination axis
6) Polar axis
7) Central assembly
8) Counterweight
9) Tube
10) Objective with dew cap
11) Coarse view finder
12) Sun projection screen
13) Extension for sun projection eyepiece
14) Twofold eyepiece-revolver for solar observation
15) Twofold eyepiece-revolver for stellar observation
16) Hand control for electrical fine motion
17) Control panel
18) Operating elements
19) Coarse motion in right ascension and declination
20) Mirror tilt
21) Focusing
22) Synchronous motor