IMPERSONAL TECHNIQUES OF TRANSIT CIRCLE OBSERVATIONS.
"The Carlsberg Automatic Meridian Circle".

L. Helmer
Copenhagen University Observatory
Brorfelde
DK-4340 Tølløse

ABSTRACT.

The conventionel reversible meridian circle of Copenhagen University, has over the last years been fully automated, and equipped with a new photoelectrical transit micrometer and a revised photoelectric circle recording system. Setting, observation and data recording is completely controlled by two minicomputers, therefore the presence of an observer is needed only for emergency situations, and for the reduction procedure. The telescope has been succesfully tested over a two year period in Brorfelde, resulting in two published catalogues with mean errors similar to those previously obtained with the photographic micrometer. The magnitudes were also measured and the limiting magnitude in Brorfelde was $m_v = 12$.
In the autumn of 1983 the telescope was moved to the Canarian island La Palma, where it is currently being installed.

INTRODUCTION.

The 7" meridian circle of Copenhagen University was built by Grubb Parsons around 1950, and erected in Brorfelde 60 km west of Copenhagen in 1953. In the mid-sixties it was equipped with a photographic transit micrometer and photoelectrical scanning micrometers for reading the glass circle. (Laustsen 1967). Still an observer was needed for selecting the stars to be observed and for setting the telescope. Another laborious job was to measure the exposed plates on an x-y measuring machine. The observations were also limited to nighttime star observations.

In the early seventies it was decided to built a new type of photoelectrical transit micrometer based on the principle of, and experience with the micrometer on the Hamburg meridian circle stationed in Perth, Australia. The micrometer was basically designed by E. Høg and built in the observatory workshop in Brorfelde.

With this micrometer being completely controlled by a computer, it

H. K. Eichhorn and R. J. Leacock (eds.), Astrometric Techniques, 429–433.

https://doi.org/10.1017/S0074180900076877 Published online by Cambridge University Press

was decided to automize the rest of the instrument, thus removing the observer completely from the telescope, and from any influence on the observations.

Effects such as heating the instrument or parts thereof from the observers sheer proximity to the telescope, missettings of the circle and misreadings of the meteorological data and last, but not least the personal influence on measuring the photographic plates, are completely eliminated. Finally the pure financial aspect. For about 1/3 to 1/4 of the manpower involved as compared to manual operation one can aquire several times as many observations in the same time and of an even quality.

SYSTEM HARDWARE DESCRIPTION.

The setting of the telescope is performed in four steps. First two DC slewing motors, attached via gearwheels to the big counter-weight opposite the glass circle and mounted on a diameter to produce torque only, drives the telescope, with a maximum slewing speed of 15°/sec to within 5' of the wanted setting. This is performed with a servo loop in the control computer, which receives the telescope position with an accuracy of 1' from a Heidenhein incremental encoder attached to the same big gearwheel. After that the telescope is clamped using a small DC motor, and the fine motion, driven by a step motor, brings the telescope within 1' of a neighbour division line on the glass circle. In the third step the circle illumination comes on and, while the fine motor drives the telescope, a scan of the division line is performed using all six micrometers and applying diameter corrections. Having thus established the position of the telescope to within 0".1 the final setting to an accuracy of about 1" is performed with the fine motion utilising that 1 step corresponds to 1". This whole process takes on average 10 sec. for angular distances up to 90° to be covered.

The glass circle is illuminated via flexible light guides and is scanned photoelectrically with six micrometers, each having a slit on a carriage driven by a stepping motor. The output signal is fed through amplifiers directly into a plug-in A/D converter in the control computer, where the reduction is performed and the diameter corrections applied. The control computer also monitors the quality of the circle reading during each scan of the circle.

After the setting of the telescope there is a dead period of at least 2 sec's before the observation begins, which allows the control computer to initialize the various instrument drivers. During this period a reading of the meteorological sensors is performed by the control computer and the obtained values are used for calculating the refraction.

For the recording of the transit of celestial objects an impersonal photoelectric moving slit micrometer is used. The slit plate containing various slits and pinholes for viewing different objects such as nadir, planets, stars and the sun is mounted on a carriage driven by a stepping motor. Each step by the motor corresponds to a movement of the slitplate by 0".155. During observation this slitplate is driven forwards and backwards across the image of the star at a constant speed of 38".75/sec.

https://doi.org/10.1017/S0074180900076877 Published online by Cambridge University Press

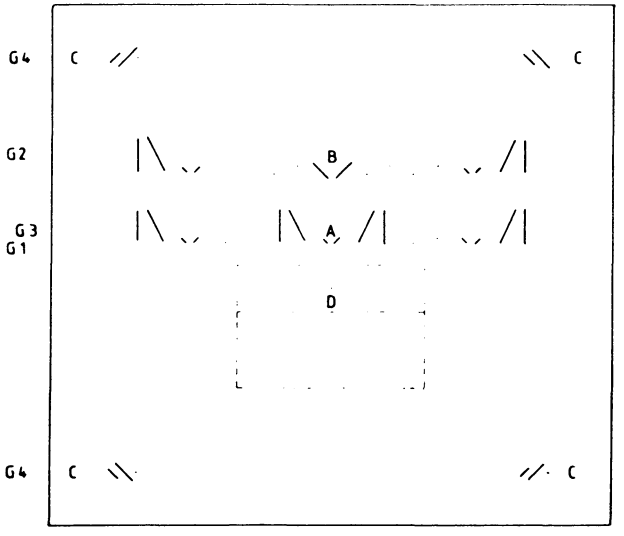

Fig.1. The slit plate. The slits marked A are used for starlike objects, B for outer large planets and C for the Sun. For Mercury and Venus the pinholes are used, and D is the virtual pinhole for observing nadir.

Just behind the slitplate the detectorbox containing a diaphragm, a filterwheel and the photocell is mounted on a separate carriage driven by a step motor. During observation the diaphragm is positioned over the slit that the star is crossing, and thereafter rapidly shifts position to the other slit. The light then passes through the filterwheel onto the photocell which in turn is connected to a photon-counting system.

On the side of the slit-plate facing the objective a small prism is cemented. When light is shone through a pinhole and through this prism, the optical distance is so, as if the pinhole was situated in the focal plane. This light can after reflection from a mercury surface be used for determining the nadir point. The mercury surface being 0.3mm thick is held in a sealed container that opens automatically. It is also kept in an atmosphere of dry nitrogen, and the same surface can be used for up to six months.

On the north collimator another photoelectrical micrometer is mounted in order to allign the collimators and measure the residual misallignment.

For further details of the telescope installation see Helmer et al. 1983, 1984II.

THE COMPUTER CONTROL SYSTEM.

Directly interfaced to the telescope is a HP-21 E-type minicomputer. This computer derives its timing from an external quartz-clock interrupting the computer at a frequency of 500 Hz siderial. The software for the control computer was written by the meridian staff in

https://doi.org/10.1017/S0074180900076877 Published online by Cambridge University Press

Brorfelde and consists of about 30 K words of data storage and 28K words of program. The program is divided into a series of instrument interrupt drivers, and interrupt clock driver and an overlaying control program. The control program is written in ALGOL whereas the remaining subroutines and drivers are written in machine language.

Once a process has been decided by the control program and all parameters sat up and drivers initialized, control is taken over by built-in counters in the clock driver. The remaining sequence of events is then controlled completely by the clock driver.

Because each single step order to any step motor is issued in real time by the clock driver, a firm relation between the position of all moveable parts of the telescope and time is established.

All data from the instrument are read into this computer, but only some of these data, f. ex. the circle reading and met. data, are completely reduced here. The remaining data, the result from the reduced data and all communication is transmitted via a fast 16 bit by-directional binary computer link to the main computer, a HP 21MX F-type with disc, nine-track magnetic tape station, printer and terminals. This computer is controlled by a modified RTE-IV operating system, to make it run on siderial time. Programming on this machine is done in FORTRAN and programs for automatic selection of objects for observation as well as programs for complete differential reduction and catalogue formation exist. Also the on-line reduction program for the micrometer readings and a number of utility programs including plotting facilities are implemented on this machine. For further information on this last subject I shall refer to the paper by Mr. L.V. Morrison from RGO.

CONCLUDING REMARKS.

The entire system has been tested during two years of operation at Brorfelde from mid 81 to mid 83, resulting in two differential catalogues, Helmer et al. 1983, 1984I. These catalogues will also be discussed in details by Mr. Morrison. The number of observations included in the two catalogues is about 20.000 and the obtained mean errors are:

$$\varepsilon_\alpha \cos_\delta = 0\overset{s}{.}014$$
$$\varepsilon_\delta = 0''\!.22$$
$$\varepsilon_m = 0\overset{m}{.}12$$

The faintest star observed was $11\overset{m}{.}98$

During late summer and autumn 83 the telescope was dismantled and transported to the Canarian island La Palma, where it is now erected. It will be operated here as a joint project between the meridian departments of Royal Greenwich Observatory, England, Instituto y Observatorio de Marina, Spain and Copenhagen University Observatory, Denmark. The telescope is expected to start operating on La Palma in spring 1984.

REFERENCES.

Helmer,L., Fabricius,C., Einicke,O.H., Thoburn,C.: 1983; Astron. Astrophys. Suppl. Ser. 53,223.
Helmer,L., Fabricius,C., Einicke,O.H., Thoburn,C., Morrison,L.V.:1984I; Astron. Astrophys. Suppl. Ser. 55,87.
Helmer,L., Fabricius,C., Thoburn,C.: 1984II in preparation.
Laustsen,S.: 1967; Publ. Mindre Medd. Kbh. Obs. 190.

Discussion:

TELEKI: What can you tell me about the meridian marks at La Palma?

HELMER: Right now there are no marks, but eventually we will have a south- and north mark.