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REMARKS

Dr Fricke: The catalogue Pu α 1 will be used for the systematic revision of the FK3 if forwarded to the Astronomische Rechen-Institut before July 1956. As to a remark by Dr Nemiro that Pu α 1 is in good agreement with N30, attention is drawn to the differences $\Delta\mu_\alpha$ when comparing Pu α 1, N30 and FK3. These differences show that the accidental and systematic deviations of Pu α 1 from N30 and FK3 are remarkably large.

3. MERIDIAN WORK AT THE ROYAL GREENWICH OBSERVATORY

By H. SPENCER JONES

The fundamental meridian work at the Greenwich Observatory during the past century has been undertaken with the Airy transit circle, which was installed in 1851. This instrument, designed in all its details by Airy, is a massive non-reversible instrument with an 8 in. objective. Though in advance of its time when it was designed it does not meet modern requirements, but the long series of observations made with the same instrument have made an important contribution to fundamental positional astronomy.

The housing of the instrument, in a pavilion with buildings on each side and in which the observer is in a pit, is such that refraction anomalies are to be expected. The telescope was provided with a movable mercury horizon so that stars at various altitudes could be observed by reflexion, as a control on instrumental flexure. Many papers were written on the discordances between direct and reflected observations, and it is certain that refraction anomalies were an important contributory factor to the (R–D) discordances.

The telescope was supported by its pivots in two long bearings, the bearings being carried by stone piers. No adjustments for level and azimuth were provided: Airy stated that none would be needed. In 1921, after a very dry summer, the east pier started to sink relatively to the west pier. This sinking has since continued at a fairly uniform rate, and it became necessary to pack up the east bearing each year. The bearings were modified in 1923 as it had proved impossible to maintain precise alignment of the original long-bearing surfaces.

Observations were made at first by the hand tapping method; the relative personal equations of the observers were determined and the observations of transits were reduced to the system of a standard observer. In 1915 a hand driven travelling wire micrometer was substituted and it was then found that transits were recorded about 0·25 sec. early by the standard observer.

The site of the instrument was not ideal. The ground falls away steeply to the north and less steeply to the south. It was thus not possible to provide azimuth marks for the control of changes in azimuth. About 1830 an azimuth mark on the Bradley meridian (19 ft. to the west of the meridian of the Airy transit circle, which defines the zero meridian of longitude) had been erected at Chingford to the north of London. This mark had long been unobservable, but recently it was observed for a period with the Airy instrument by placing a light on it, and the observations have shown that the Airy instrument has an appreciable diurnal variation of azimuth.

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The need for a more modern instrument having for some time been felt, the construction of a 7 in. reversible transit circle by Cooke, Troughton and Simms was commenced in 1931 and the instrument was installed in 1936 on a site in Greenwich Park where the ground both to north and south is level. The design was based on Gill's design for the reversible transit circle at the Cape. The piers, which are hollow, of cast iron and filled with water, are supported by a massive base plate whose level and azimuth can be adjusted; these adjustments do not alter the bearing of the pivots in the supporting Y's. The instrument is provided with a motor-driven impersonal micrometer and a novel feature is the employment of glass circles; the graduations, which are etched on the glass, are permanent and of excellent quality.

Before being brought into use the instrument was subjected to an exhaustive investigation. The pivots were given a final figuring on site, using a Zeiss mikrotast gauge to test their cylindricality and equality of diameter. They do not depart anywhere from a correct cylindrical figure by more than about 0·2 μ. The division errors of the fixed circle were determined with high accuracy by a long series of measurement, the error of each graduation being derived.

The collimators were housed, as at the Cape, in small buildings to the north and south of the transit circle pavilion. The observation of collimation proved to be difficult except under cloudy conditions. Series of observations of collimation and level errors were made and showed that there was a drift of collimation with change of temperature, which for some while was puzzling because for a given change of temperature the change in collimation was different from night to night. Eventually it was found that the change in collimation was correlated with the rate of change of temperature. It is caused apparently by a slight warping of the telescope tubes and it has fortunately proved possible practically to eliminate the effect by suitably rotating the tubes relative to the central cube.

These investigations had not been completed by 1939; after the outbreak of war the objective and the micrometer end were dismounted and stored in a safe place to avoid risk of damage from bombing, which was very intensive around Greenwich.

The transit circle has now been installed at Herstmonceux and the opportunity has been taken to make various modifications. A new pavilion has been erected at Herstmonceux to house the two collimators as well as the transit circle. A massive concrete foundation supports the transit circle and the two collimators, and is further stabilized by twelve reinforced concrete piles going to a depth of 36 ft. It was not possible to provide azimuth marks at Greenwich, but marks are being provided at Herstmonceux. These marks will not have the high stability of the Cape azimuth marks, which are fixed to the basic rock, but they will control the diurnal and other short-period changes in azimuth. The piers will be insulated to reduce the effects of rapid temperature changes, and magnitude screens will be provided as a control on magnitude errors. Cameras have been fitted to the circle microscopes for recording the circle readings and thereby saving time during observations. A photo-electric measuring machine for measuring the camera films is being designed, as measurement by normal methods is time consuming.

Determination of horizontal flexure of the instrument is made in the normal way with the aid of the collimators. It is then assumed that flexure varies with the sine of the zenith distance, an assumption which is not necessarily correct. An attempt was made at Greenwich to investigate the flexure of the Airy Transit Circle by the method devised by Bonsdorff and used at Pulkovo. But the results were inconclusive, as it was not certain that the apparatus behaved in accordance with the theory of its design, the effect of small constraints in the bearings of the mirror support being apparently comparable with the effects of telescope flexure. The flexure of the Cooke transit circle is to be investigated by the use of a pentagonal system, employing two optical flats of fused quartz, placed in front of the objective, so that for the same setting of the telescope stars at two different zenith distances can be observed.

There is a division of opinion whether a pavilion for housing a transit circle should be designed to be of low thermal capacity, so as to maintain as nearly as possible equality

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between internal and external temperatures, or whether it should be well insulated, so that the temperature inside the pavilion is maintained at or near the night temperature. With change of air temperature there is an appreciable lag in the change of temperature of the telescope and its piers. The pavilion at Herstmonceux is well insulated so as to prevent the interior temperature rising too much during the day; the pavilion is open during the day for short intervals only, for the observation of Sun, planets and bright stars. Air circulates freely under the floor of the pavilion to prevent heated air being trapped. Fans are provided so that, when desired, a rapid exchange of air within the pavilion can be effected.

A second transit circle which is to be installed at Herstmonceux is the Troughton and Simms reversible transit circle, which was formerly in use at the Melbourne Observatory. A pavilion, essentially similar to the one housing the Cooke transit circle, is to be built, the instrument and the two collimators being again mounted on a massive stabilized concrete foundation. This instrument will be used for differential zone observations, the Cooke instrument being reserved for fundamental observations.

Systematic differences between the positions of stars derived with different transit instruments are undoubtedly caused in large measure by small instrumental effects. These systematic instrumental effects should be appreciably reduced if the moving parts of the instrument are reduced. Consideration has therefore been given to the design of a mirror transit circle, stimulated by the pioneer work in this direction at Pulkovo. By employing two fixed horizontal telescopes in the meridian and a mirror of fused quartz, carried by two pivots and provided with graduated circles, the moving parts are reduced to a minimum. Possible small displacements of objective and eyepiece micrometer parts are eliminated, and flexure effects are likely to be negligible. Telescopes of longer focal length than convenient for a conventional transit circle can be used and they can also serve as collimators. The construction of a mirror transit circle for Herstmonceux is under consideration, but no actual work has yet been carried out.

The time service of the Greenwich Observatory is based entirely on quartz crystal clocks, which are free from the frequent small erratic changes of rate to which pendulum clocks are liable. The uniformity of time-keeping of the quartz crystal clocks is of distinct advantage for the determination of right ascensions by the observation of meridian transits.

The Cooke transit circle will be used for the fundamental observations of the positions of the Sun, Moon, planets, fundamental stars (clock stars and azimuth stars), and stars in the FK 3 catalogue, including the supplementary stars. Frequent observations of the instrumental errors of adjustment will be made to control their changes. The determinations of collimation are greatly facilitated by having the collimators in the pavilion with the instrument. Azimuth determinations will be based on observations of the double azimuths of circumpolar stars and also of single observations of azimuth stars in conjunction with observations of equatorial stars. The astronomical determinations of azimuth will be used to fix the azimuths of the azimuth marks, while observations of the azimuth marks will provide a control over the changes of azimuth of the instrument during the course of the observations. The first large programme of observations to be undertaken with the Cooke R.T.C. will be the observation of the reference stars for the AGK 3 programme, contained in the Scott list. The observations will be made concurrently with observations of FK 3 stars and of the Sun and planets; the positions of the stars in the FK 3 system and also their positions on the instrumental system will thus be derived. These observations will extend from about 1956.5 to 1960.5.

The question arises whether, in view of the Markowitz moon camera programme, there will be a continuing need for meridian observations of the Moon. The photographic observations of the Moon's position are likely to be of higher accuracy and to be less affected by systematic errors than the meridian observations. It seems to me desirable that meridian observations of the Moon should be continued for the present and until a satisfactory comparison between the meridian and photographic positions can be made; the ultimate decision whether there is any need for the meridian observations to be continued will depend upon the results of this comparison.

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