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GREENWICH MERIDIAN OBSERVATIONS

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Abstract. Meridian observations at the Greenwich Observatory have been made since 1851 with the Airy transit circle. This instrument falls short of modern requirements in several respects, though the long continuity of observations with the same instrument has been of special value. A new reversible transit circle by Cooke, installed shortly before the war, has been thoroughly investigated. A special feature of this instrument is the use of glass circles. It is shortly to be transferred to the new site at Herstmonceux. Alternative designs of meridian instruments, likely to be less affected by systematic errors than the conventional transit circle, have been considered.

Meridian observations have been made continuously at the Greenwich Observatory with the Airy transit circle since its installation in 1851. These observations have throughout been fundamental. The sun, moon, and planets have been systematically observed and there have been day-time observations of bright stars. The last two programmes with the instrument have completed the observations of all stars in the northern sky down to limiting magnitude 7.5, together with many fainter stars. Stars in the fundamental catalogues have been well observed. Determinations of the proper motions of the stars in the various observing programmes have been made.

The Airy transit circle does not meet modern requirements. It is non-reversible and it is not provided with azimuth marks; its site is such, in fact, that meridian marks cannot be installed. It is housed in a pavilion which has buildings in contact with it on either side. The shutters are narrow and the observing chair is in a pit. Thus refraction anomalies are to be feared. The observations with this telescope have a special value, however, from their long continuity. More transits have been observed with this telescope than with any other meridian instrument ever constructed. It is still in use for observations of sun, moon, planets, fundamental stars and certain asteroids, but these observations will be terminated when the removal of the Observatory from Greenwich to Herstmonceux has been completed.

The Airy transit circle has earned the right to be pensioned off. The objective is made of glasses of not very high stability. It has twice been refigured; it needs refiguring again, but the lenses are too thin for this to be done. The divisions of the circle have become faint through frequent cleaning; some had entirely disappeared and have had to be recut. The instrument will remain permanently at Greenwich, marking the zero meridian of longitude. The other historic instruments belonging to the Greenwich Observatory, including Halley's transit instrument and Bradley's zenith sector, will also remain at Greenwich. The old buildings, including Flamsteed's Observatory, will be taken care of by the National Maritime Museum, which is at the foot of the hill on which the Observatory stands, and will form an annexe of astronomy and navigation. This is particularly appropriate, as the Greenwich Observatory was founded in the first instance in the interests of navigation.

One fact about the Airy transit circle may be mentioned as illustrating the vagaries to which telescopes are liable. When Airy designed the instrument he made no provision for adjustment of level or azimuth because, as he said, none would ever be required. For 70 years this proved correct: there were appreciable annual variations in level (probably due largely to the two piers not being of the same type of stone), but the mean level remained very steady. Then, in 1921, following an exceptionally dry summer, the east pier started to move downwards and this movement has continued up to the present time, so that since 1921 the east bearing has had to be packed up almost every year. The reason for this downward movement of the east pier is not known.

Before the war a new reversible transit circle by Cooke was installed. It has an aperture of 7 inches and a focal length of 8 feet. The two collimators have the same aperture and focal length as the telescope: they are housed in separate buildings outside the transit circle pavilion. The instrument has no azimuth marks. Its general design follows closely that of the Cape reversible transit circle. A novel feature of the instrument is that the circles are of glass, with etched graduations which are excellent for setting the wires of the micrometers on.

The instrument has been subjected to a very thorough series of tests. At the outbreak of the last war, the graduation errors of the main circle had been very accurately determined, the pivots had been figured to an accuracy of a fraction of a micron and their errors investigated. Observations of transits had a high accuracy, but a drift

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of collimation error with changing temperature had proved troublesome. Observations of collimation proved to be difficult except under cloudy conditions.

Soon after the outbreak of the war these investigations had to be discontinued. The objectives of telescope and collimators and the micrometer eye-end were dismounted for safety. After the end of the war, the decision to move the Observatory from Greenwich was reached. As it was not advisable to start an observing programme with the telescope pending its removal, it was possible to make further investigations of the instrument.

These showed that the changes in collimation error correlated closely with rate of change of temperature. When this effect was allowed for, the dependence of collimation on temperature was just about what was to be expected from the coefficients of expansion of the materials of which the eye-piece micrometer is made. It appears that there is a slight warping of the telescope tubes with change of temperature, due presumably to the tubes not being of uniform thickness throughout. It has fortunately been found possible to fix the tubes in such a position that their effects cancel each other, leaving practically no effect depending upon rate of change of temperature.

A new building has been designed for housing this instrument at Herstmonceux. The telescope and the two collimators will be contained in this building and will be supported from one massive concrete pier, 5 ft. 6 in. in depth, which in turn is supported by 12 reinforced concrete piles, going down to a depth of 34 ft. 6 in. The reinforcing rods of these piles are bent over at the top and integrated with the pier. The site selected has uniform conditions to north and south, with a slight fall of the ground in both directions. Azimuth marks are to be installed, which can be viewed through the telescope at angles of depression of about 2° to 3°.

The right ascension micrometer is motor-driven. The declination micrometers are being fitted with cameras for photographic recording. With the motor-driven micrometer, there is a risk that the observer may make a bisection at the commencement of the transit and be satisfied with it throughout the transit, in which case the whole of the observation is affected with the accidental error of a single bisection. The practice has therefore been adopted of the observer making six independent bisections during the transit: by means of a loud speaker in the dome, the observer knows when contacts are made and is able to make a new bisection between contacts.

The new observing pavilion has been designed to have good thermal insulation but low heat capacity. Good ventilation beneath the floor has been provided. The piers and the tube of the telescope, when re-erected at Herstmonceux, will be well insulated so as to minimize the effects of temperature differences and temperature changes.

The azimuth marks will not be of the very high stability of the Cape marks, which are fixed below ground to the virgin rock. At Herstmonceux there is no rock. The azimuth marks will be used to control the change of aximuth of the instrument during the course of a night's observations, the stellar determinations of azimuth through the night being combined to fix the azimuth of the marks.

The Cooke transit circle will be used for fundamental observations, the sun, moon and planets being observed, as well as stars in the day-time. It is convenient to have a second transit circle for differential observations. For this purpose the Melbourne reversible transit circle will be used. This telescope was constructed by Troughton and Simms for the Melbourne Observatory, which was closed some few years ago. When I was in Australia in 1947 I expressed an interest in the telescope and it was presented to me by the Government of Victoria for the Greenwich Observatory. The pavilion which at present houses the Cooke R.T.C. at Greenwich will be moved to Herstmonceux and re-erected with some alterations as a pavilion for the Melbourne instrument. The collimators, which are of smaller aperture and shorter focal length than those of the telescope, can be fitted inside this pavilion by bending them. There might perhaps be objection to this procedure in the case of a meridian telescope to be used for fundamental observations, but there can be none in the case of one to be used only differentially. The observation of collimation takes but a few minutes; it is only for this short time that there needs to be stability in the mounting of the reflecting mirrors in the collimators.

No decision has yet been reached about the first programme of observations with the Cooke R.T.C. after its installation at Herstmonceux has been completed. The fundamental stars will of course be observed. The observation of the AG reference stars seems to me perhaps more im-

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