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THE TERCENTENARY OF THE ROYAL OBSERVATORY AT GREENWICH

by D.H. Sadler

At 3.14 p.m. on 10 August 1675 John Flamsteed (1646-1719), the first Astronomer Royal, laid the foundation stone of the building that was to become the Royal Observatory at Greenwich, some 8 miles east of central London. (See figure 1). The tercentenary of this event is being celebrated this year both at Greenwich, where the old Royal Observatory is now a museum of astronomy and navigation, and at Herstmonceux, near Eastbourne, on the south coast of England (a few miles east of the Greenwich meridian), where the Royal Greenwich Observatory is now situated. (See figure 2). It is fully appropriate that those connected with the hydrographic sciences should recognise this historic event, even though modern astronomy may have little direct impact on their work. Apart from other considerations, the Hydrographer of the (British) Navy was administratively responsible for the Observatory from 1818 to 1965, when it was

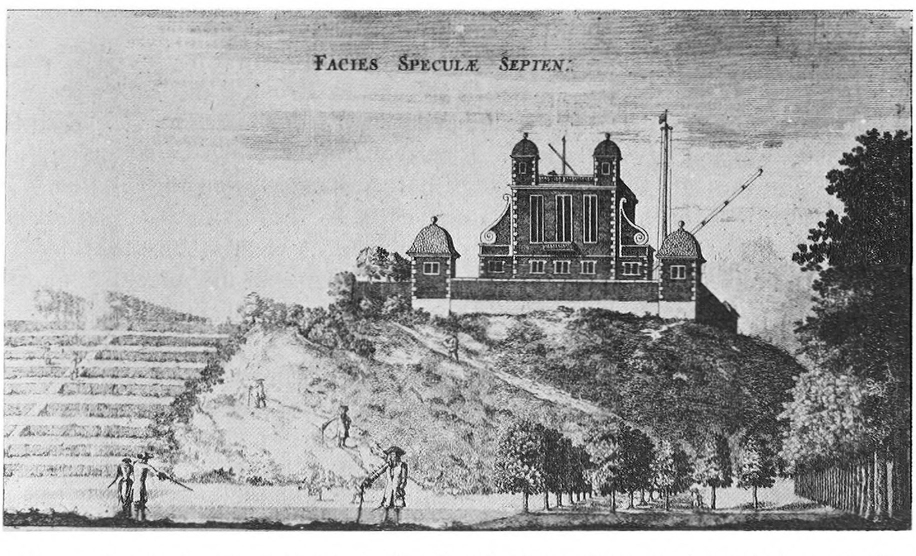

Fig. 1. — A contemporary view of the Royal Observatory at Greenwich as built in 1675/6 to the design of Sir Christopher Wren "for the observator's habitation and a little for pompe". Known as Flamsteed House, it is the main part of the present buildings.

FIG. 2. — Herstmonceux Castle, originally built in 1440 and restored to its original external appearance, which is now the home of the Royal Greenwich Observatory. Domes for the telescopes and buildings for offices, laboratories and workshops are situated in the extensive grounds.

transferred to the newly-formed Science Research Council; and some part of its work is still of vital importance to navigation.

The founding of the Royal Observatory by King Charles the Second was immediately due to the influence of his mistress, Louise de Kerouálle (Duchess of Portsmouth), who intervened in favour of a French claimant (who styled himself le Sieur de St. Pierre) for the award to be given for a practical solution to the problem of determining longitude at sea. The Committee appointed by the King to investigate the claim (to have discovered a method of finding longitude "from easy celestial observations" — equivalent to the already well-known method of lunar distances) demonstrated the then impracticability of the method, and humbly submitted a proposal that an observatory be erected to allow the positions and motions of the heavenly bodies to be determined with sufficient accuracy. The King accepted the proposal forthwith and, on 4 March 1675, appointed FLAMSTEED, by Royal Warrant, our 'Astronomical Observator with instructions "forthwith to apply himself with the most exact care and diligence to the rectifying of the tables of the motions of the heavens... ...for the perfecting of the art of navigation".

Even though FLAMSTEED and his successors as Astronomers Royal fulfilled their duties with great skill and almost unbelievable diligence, it was over 90 years before their labours were rewarded by a practical solution of the longitude problem in the form of *The Nautical Almanac and Astronomical Ephemeris*, published in 1766 for the year 1767. The method of lunar distances, proposed at the beginning of the sixteenth century and on many subsequent occasions, depends on the ability to predict (and to observe) the distance of the Moon from the Sun, planets and zodiacal stars to within one minute of arc ($\pm$ 1′); this precision corresponds to about half-a-degree in longitude on the Earth's surface. In 1675 this presented difficulties far beyond the capabilities of any one establishment, or individual — through limitations of theory, of equipment and techniques and, above all, of accurate recorded observations. It required the genius and application of many men, including Isaac NEWTON and his theory of universal gravitation, before Nevil MASKELYNE (1732-1811), fifth Astronomer Royal, was able to show how the seaman, with *The Nautical Almanac* and other available equipment (including a sextant), could determine his longitude at sea, certainly within a degree; he had himself demonstrated the practicability of the method during his voyages in 1763.

Each of the Astronomers Royal (other than Nathaniel BLISS who died in 1764 after only two years in office) made substantial contributions. FLAMSTEED laid the foundation with his systematic observations, made with his own instruments with minimal financial support; the collected observations were published posthumously in 1725 as *Historia Coelestis Britannica,* which superseded the unofficial edition of 1712 issued despite FLAMSTEED's opposition. This publication forms a landmark in positional astronomy. FLAMSTEED was succeeded by Edmond HALLEY (1656-1742) who had already made outstanding contributions to science, including nautical science. He had played a leading part in the publication of NEWTON's *Principia,* and was largely responsible for the general acceptance of the theory of gravitation through his celebrated prediction of the return of the comet that bears his name. HALLEY laid the foundations of the scientific application of geomagnetism to navigation by his publication of his world-wide charts of the magnetic variation; and among his many other original contributions, he greatly improved the diving bell. At Greenwich he set himself the task of observing the Moon throughout the full 19-year cycle of the retrogression of the nodes of its orbit, necessary for a numerical gravitational theory of its motion; and, in spite of his then age of 64, he rarely missed a possible observation until ill-health forced him to stop after 17 years.

His successor James BRADLEY (1693-1762) had already made an enormous advance in positional astronomy by his discovery in 1728 of "aberration" — the apparent annual change (of about 20″, or 0′.3) in the position of a star (but not of the Moon) due to the combination of the finite speed of light and the motion of the Earth in its orbit round the Sun. At Greenwich he continued the observations of the Moon and the stars, with improved instruments and superlative techniques; he discovered the phenomenon of "nutation" (that affects the positions of all bodies by up to 0′.3 in periods of up to 19 years), due to the small oscillations of the Earth's axis of rotation. His observations, of exceptional accuracy for their time, made it possible for Tobias MAYER (1723-1762) to transform his numerical theory of the motion of the Moon (based on Leonhard EULER's theoretical work, as well as on that of NEWTON and others) into tables from which the position of the Moon could be predicted to within about 1′. It is pertinent to record that MAYER's interest arose from his work as a cartographer in Nuremberg in which he recognised the overriding importance of determining the longitudes of places on land. MASKELYNE used his manuscript tables during his early sea-trials and a corrected copy (sent to the Admiralty by MAYER's widow) as the basis for the lunar distances tabulated in *The Nautical Almanac.* (In 1765 Parliament made a grant of £3000 to Frau MAYER and £300 to EULER).

The application of this achievement to navigation would have been impracticable without the invention, and subsequent development, of the sextant. The basic principle, of allowing the reflected image of the Sun (or Moon or star) to be viewed simultaneously with the horizon (or another body), was first announced by John HADLEY in 1731 in describing his reflecting octant (often referred to as a quadrant); it was rapidly developed into an instrument, with a vernier, very similar to a modern sextant and capable of giving observations comparable in accuracy to that to which the position of the Moon could be predicted.

Simultaneously, the Yorkshire carpenter John HARRISON (1693-1776) was patiently constructing his series of marine time-keepers. In 1761-1764 the famous "Harrison No. 4" successfully completed the trials specified in the Act of Parliament of 1714 as necessary to qualify for the large prize offered for a practical solution of the longitude problem. Eventually, in 1773, he received essentially the full prize of £ 20 000 for this magnificent achievement — one that was for hundreds of years regarded as technically impossible, as contrasted to the merely difficult problem of the method of lunar distances. However, chronometers constructed on these principles were for many years expensive and rare; and they had to be set and rated by observations of lunar distances. Tabulations of lunar distances were thus continued in *The Nautical Almanac* until 1906, and the method of computing them until 1914, by which time radio was making time-signals available; but after the long 250-year development (1514-1767), the method served navigation for nearly 150 years !

With the completion of their first objective, the Astronomers Royal could turn to astronomical investigations, concentrating on positional work. Such was the success of the Royal Observatory in this field that it could be said, at the end of the nineteenth century, "that if this branch of astronomy were entirely lost, it could be reconstructed from the Greenwich observations alone". Inevitably the scope of astronomical research has widened and much of the current work of the Royal Greenwich Observatory is astrophysical. There are still departments concerned with positional astronomy, both on the meridian and by photography, but the only work now being done that is of direct relevance to navigation is that of Her Majesty's Nautical Almanac Office and the Time Department. The latter, which is responsible for the British time-service, may be said to stem from the testing in the Observatory of HARRISON's marine time-keepers though it was not formally set up until nearly 100 years later. The Observatory originated one of the first time-signals in 1833 with the time-ball on Flamsteed House which was, and still is, dropped at noon on each day. Until 1965 the associated chronometer department, which is responsible for repairing, checking and rating official-issue chronometers and watches was also part of the Observatory; but, although at Herstmonceux, it is still under the administration of the Hydrographer of the Navy. Similarly, the magnetics department (which might be said to stem from the researches of HALLEY), which is responsible for the geomagnetic information on British charts, is also at Herstmonceux, though now administered by the Natural Environment Research Council.

After many years during which observational work has been badly interrupted (due to the war and the move), the Royal Greenwich Observatory is now able to command the use of observing facilities comparable to those in countries geographically more favourably placed. In addition to the 2.5 m Isaac Newton telescope on the site, it has access to the 3.8 m Anglo-Australian telescope and the 1.25 m Schmidt camera in Australia; and it is taking a leading part in the design and procurement of such equipment as is approved for the Northern Hemisphere Observatory. In its tercentenary year it is certainly better placed to contribute to modern astronomy in its fourth century than it was in 1675 to contribute to navigational astronomy in its first century.