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ZENITH SECTORS, AND DISCOVERIES MADE WITII THEM. LINKED WITH MORE RECENT EVENTS IN PENNSYLVANIA

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The zenith sector was a fundamental instrument of astronomy and geodesy a few generations ago. It was used to measure the angle between the zenith and a star as it crossed the meridian. The instrument was mounted to rotate about both vertical and horizontal axes. A telescope attached to a sector of a vertical circle with a graduated limb was trained upon the star as it came to the meridian. A fine plumb-line hanging past the center of the sector and its limb served as a reference for the reading of angles in the plane of the meridian.

The first zenith sector of high quality was made in 1725 by George Graham for Samuel Molyneux, an amateur. It was mounted in Molyneux's house on Kew Green, just south and west of London. With it Molyneux sought for Annual Parallax in the position of the star Gamma Draconis. He was joined in the search by his friend James Bradley, Savilian Professor of Astronomy at Oxford University. They failed to find an Annual Parallax. Instead they discovered the Aberration of Light.

To make sure of their observations Bradley bad Graham make for him an equally good but smaller zenith sector which he mounted in the house of his Aunt Pound at Wansted in Essex. With it he confirmed and extended all that had been observed at Kew. And the explanation occurred to him that the effect is due to the motion of the Earth combined with the motion of light in space. From his results he calculated the speed of light in space. Molyneux had died in the meantime. In January 1729, Bradley announced the discovery to the Royal Society of London.

From the constants of Aberration and from his theory of its origin, Bradley was able to estimate that the speed of light in space at 10,210 times the speed of the Earth in its orbit as it moves around the Sun. This value agreed well with an estimate made fifty years before by Roemer from his observations of the eclipses of the moons of Jupiter. And it agrees still better with all subsequent determinations of the speed of light, which began more than a century later, in 1849, and have continued until the present day. AII of them are based upon phenomena confined to the surface of the Earth.

Bradley continued to observe the zenith distance of stars with his sector as they crossed the meridian at Wansted. By 1747 his observations had revealed that the axis of the Earth nods and wobbles slightly in a cycle of eighteen and six tenths years.

This famous old instrument, which for two centuries has been one of the treasures of Greenwich Observatory, James Bradley who owned it and observed with it, and the discoveries he made with it are recalled at this time and this place because they are linked with places and events in this part of the world in a way of which few persons are aware. In 1742 James Bradley was chosen director of Greenwich Observatory, the third of England's Astronomers Royal. In 1749 he moved his zenith sector from Wansted to Greenwich Observatory. About I755 two young men in their early twenties entered the Observatory as assistants. One of them, Nevil Maskelyne, was a volunteer. Ten years later he became the fifth Astronomer Royal and served in that post for forty-six years. The other assistant, Charles Mason, was employed by the Observatory. Together Maskelyne and Mason assisted James Bradley at Greenwich for five years.

In 1760 the Royal Society of London equipped two expeditions to go overseas to observe a transit of Venus across the face of the Sun, which was to occur early In June 1761. Maskelyne was selected to take one expedition to the island of St. Helena. Charles Mason, assisted by Jeremiah Dixon, was sent to Sumatra. Owing to war with France, Mason and Dixon were obliged to observe the Transit at the Cape of Good Hope Instead.

Among the instruments that Maskelyne took to St. Helena was a ton foot zenith sector made for the Royal Society for this expedition. In using it Maskelyne discovered a fundamental fault in design to which all zenith sectors previously made had probably been subject. The manner of suspending the plumb line introduced an error of many seconds of angle. Maskelyne proved his point to a committee of the Royal Society In an exhibition which he made before them at the British Museum on September 11,1762.

On their return voyage from the Cape of Good Hope, Mason and Dixon had landed at St. Helena and had worked with Maskelyne on his scientific projects for several months during 1761 and 1762. In 1762 the survey of the southern boundaries of Pennsylvania was under way and was not making progress owing to unskilled surveyors and inadequate equipment. Accordingly Thomas and Richard Penn, proprietors of Pennsylvania, with the best of advice engaged John Bird, pupil, former employee, and business successor of George Graham, to build for them the best zenith sector yet made, for use in the survey. Bird built for the Penns the first zenith sector to possess Nevil Maskelyne's proposed Improvement of design. In the words of Nevil Maskelyne

"Mr. Bird has contrived one of six foot length, for settling the limit, between Pennsylvania and Maryland, in which the plumb line is adjusted so as to pass over against, and bisect a small point at the center of the instrument"

And one year later, early in 1763, Thomas and Richard Penn and Frederick Lord Baltimore jointly engaged Charles Mason and Jeremiah Dixon to bring the sector and other instruments to America and to make the survey. The southern boundary of York County was established by these men using Bird's sector for determining latitudes.

If noble blood ever runs In the veins of a scientific instrument the zenith sector that John Bird built for the Penns surely had it The noble instrument was lost in the fire that destroyed the Capitol at Harrisburg on February 2, 1897. In Its day It represented the ultimate that science and craftsmanship could produce. Graham, Sisson, and Bird were master instrument-makers of the middle years of the eighteenth century. Graham had made zenith sectors for Molyneux and Bradley and others. Sisson made the sector for the Royal Society, which Maskelyne took to St. Helens. Bird built the sector for the Penna.
The Royal Society's sector was used again by Maskelyne thirteen years after his expedition to St. Helena. The fault in the suspension of its plumb-line was corrected, and the instrument was taken to Perthshire, Scotland, in 1774 where It was used In the famous Schehallien experiment which determined the deflection of the plumb line by the mountain.

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