

# THE FIRST SCIENTIFIC EXPEDITION OF CHARLES MASON AND JEREMIAH DIXON\*

BY THOMAS D. COPE

University of Pennsylvania

**I**T WAS the year 1760 and a transit of Venus across the face of the Sun was due to occur—the first since 1639. The predicted date was June 6, 1761. The entire phenomenon would be visible throughout Asia, the Indian Ocean, the East Indies and western Australia, the North Polar Regions, and northeastern Europe. Observers within these regions would see the small black disk of Venus advance upon the limb of the Sun, touching it first on its eastern side well towards the south. Then for more than six hours Venus would creep across the solar disk in a direction slightly south of west, leaving it on the western side.

The exact projection of Venus upon the face of the Sun and the exact time occupied in transit would depend upon the position of the observer upon the surface of the Earth. If with the aid of his telescope and a carefully regulated clock the observer could record the instants, first when the disk of Venus appeared just to “touch” the solar disk, then when it was just wholly inside, then when it just began to move off the disk, and finally the instant when the disk of Venus was last “touching” the limb of the Sun, he could report the time occupied in transit as observed from his station.

If in addition he could measure from time to time during the transit the least distance in minutes of arc between the edge of Venus and the limb of the Sun this information would locate the path of Venus upon the disk of the Sun as viewed from his station. And if clouds or accidents of any kind should prevent his seeing the entire transit, then such observations as he could make, combined with a careful determination of his latitude and longitude, would locate Venus on the face of the Sun as seen from his post.

The beginning of the transit, but not its end, would be visible in California and Alaska and in the central and western parts of the

\*This is the second of a series of articles on Charles Mason and Jeremiah Dixon. The first of the series, entitled “The Apprentice Years of Mason and Dixon” was published in *PENNSYLVANIA HISTORY*, July, 1944.

Pacific Ocean. The end of the transit, but not its beginning, would be visible in western and central Europe, in Labrador and Newfoundland, on the Atlantic Ocean, and throughout the continent of Africa. Observers in these regions would need to determine their latitudes and longitudes for they could report observations of only parts of the transit.

If observations of the kind just described could be reported from stations widely scattered over the Earth, then astronomers could attempt to answer a fundamental question still open in 1760—"How far is the Sun from the Earth?"

Transits of Venus are rare events. They occur in cycles of four transits in two hundred and forty-three years. The last transit took place on December 6, 1882. A few oldsters will recall it. The next will fall on June 8, 2004. Many youngsters will live to see it. When Venus is in transit its black sphere stands out in space between Earth and Sun, and observers on the Earth see the black dot against an unusual background, the solar disk. Venus is then nearest the Earth, twenty-eight per cent of the way from Earth to Sun. An observer far to the south will see the dot more to the north against the face of the Sun than will a companion observer in high northern latitudes.

If these two observers know the length of the straight line that joins their stations, and if at the same instant of time each locates the black dot on the disk of the Sun as he sees it, then they know the base and the vertical angle of an isosceles triangle. Venus is at the distant vertex, the observers are at the extremities of the base. A bright schoolboy will answer the questions "How far is Venus from the observers?" and "How far is the Sun from the Earth?"

If the theory should appear to be simple it must be recalled that the actual labor of making the observations and of computing the distance of the Sun has taxed the ablest of men for generations. Both the Sun and Venus appear to shift as the observer changes his post. Venus and the Earth are not stationary—both move steadily forward. The Earth rotates and carries with it all the observers. The Earth is a sphere but not a perfect one. The angles to be measured are tiny ones—a few seconds and hundredths of seconds. And so on and on.

Long years of patient observing and intensive study have brought an answer to the question "How far is the Earth from the

Sun?" The distance accepted today is 93,003,000 miles. It is the fundamental distance that must be known if the universe is to be measured. Astronomers express this distance in terms of the angle that the equatorial radius of the Earth would subtend if viewed broadside from the distance of the Sun. This angle is called the Solar Parallax. Its accepted value is eight and seven hundred and ninety thousandths (8.790) seconds. In 1761, and again later, Charles Mason and Jeremiah Dixon contributed materially towards finding the distance from Earth to Sun.

Early in 1760 the Royal Society of London began to organize expeditions to observe the transit of Venus due to occur one year later. In July, 1760, president, council and fellows petitioned the Lords of the Treasury for a grant of sixteen hundred pounds sterling to be used in observing the transit. One-half of this sum was to be expended in sending an expedition to St. Helena where the end of the transit would be visible in the early morning. The rest would send an expedition to Bencoolen in Sumatra where the entire transit could be seen with the Sun high in the heavens.

The request was granted and the Royal Society chose Nevil Maskelyne, a well known young astronomer, assisted by Robert Waddington, to go to St. Helena. Charles Mason, who had assisted Dr. James Bradley, the Astronomer Royal at Greenwich, for the past five years, was chosen to go to Sumatra. Jeremiah Dixon, a surveyor and amateur astronomer well known in the county of Durham, was selected to accompany Mason.<sup>1</sup>

At the request of the Royal Society transportation was provided for the expeditions. Maskelyne and Waddington proceeded to St. Helena on the East Indiaman "Prince Henry." They left England on January 17, 1761, and arrived at their destination on the sixth of the following April.<sup>2</sup> Mason and Dixon embarked on the ship-of-war "Seahorse," that the Admiralty had provided, during December 1760. They arrived at the Cape of Good Hope on the twenty-seventh of April. War between England and France had delayed their voyage. During the whole month of January the "Seahorse" had been at Plymouth for repairs following an en-

<sup>1</sup> C. R. Weld, *History of the Royal Society*, Vol. 2 (London, 1848), pp. 11-15. H. P. Hollis, "Jeremiah Dixon and his Brother," *Journal of British Astronomical Association*, June, 1934.

<sup>2</sup> *Philosophical Transactions*, Vol. 52, part 1, page 26; Vol. 52, part 2, page 573. Mrs. A. W. Lane Hall, "Nevil Maskelyne," *Journal of British Astronomical Association*, 432, pp. 67-77.

gement in the Channel with the frigate "Le Grand." And in the Far East the French had taken Bencoolen. During their enforced delay at Plymouth a number of spirited letters passed between Mason and Dixon and officers of the Royal Society over a proposal made by the former that they proceed to a station in the Near East. Peremptory orders were soon issued that every effort be made to carry out the original plans.<sup>3</sup>

When the "Seahorse" brought Mason and Dixon into Sable Bay at the Cape of Good Hope on Sunday, April 27, 1761, the transit of Venus was only six weeks in the future. Bencoolen lay beyond the Indian Ocean, six thousand miles away—and the hostile French held it. Fortunes of war and of navigation had decided that the transit would be observed at the Cape. The scientific instruments were carried ashore and put under shelter and the erection of a temporary observatory was begun.<sup>4</sup>

The Royal Society had supplied Mason and Dixon with the following pieces of equipment:

a) Two reflecting telescopes made by James Short. Each was of two feet focal length, and magnified one hundred and twenty times. One of them was equipped with an "object-glass micrometer" of focal length 495.48 inches. Maskelyne describes it as "the curious object-glass micrometer adapted to the reflecting telescope according to Mr. Dollond's ingenious invention."<sup>5</sup>

b) An astronomical clock made by John Ellicott,

c) A quadrant of one foot radius made by John Bird, the personal property of the Earl of Macclesfield, president of the Royal Society.<sup>6</sup>

At the request of the Council of the Royal Society, Doctor James Bradley, Astronomer Royal, had drawn up instructions for the guidance of Mason at Bencoolen. Attached to the copy among Dr. Bradley's papers is the note:

These were the instructions that Dr. Bradley drew up at the desire of the Council of the Royal Society, relating to my observing the transit of Venus in the East Indies.  
C. Mason.

<sup>3</sup> C. R. Weld, *History of the Royal Society*, Vol. 2, pp. 16-19. *Philosophical Transactions*, Vol. 52, part 1, page 380. R. H. Heindel, "An Early Episode in the Career of Mason and Dixon," *Pennsylvania History*, Vol. VI, No. 1, Jan. 1939.

<sup>4</sup> *Philosophical Transactions*, Vol. 52, part 1, pp. 378-380.

<sup>5</sup> *Philosophical Transactions*, Vol. 52, part 1, pp. 197, 378. A. Wolf, *A History of Science . . . in the 18th Century* (New York, 1939), pp. 143-145.

<sup>6</sup> *Philosophical Transactions*, Vol. 52, part 1, page 394.

The instructions in brief were as follows:

Locate the observatory where there is a clear view toward the northeast, north, and northwest. Observe the first and second contacts of Venus with the limb of the Sun. Then measure the distance of Venus from the limb of the Sun to ascertain the nearest approach of Venus to the center of the Sun's disk. Measure the diameter of Venus.

Set up the clock so that the observers at the telescopes are immediately accessible to it. Observers must be careful not to prejudice one another in their judgments of events and times. Make a preliminary trial of the clock with its pendulum adjusted as it was at Greenwich to ascertain how much it loses in a sidereal day. Then adjust it to solar time. Keep a record of the temperature in the clock case. Record how much the pendulum must be changed in length to keep solar time at Bencoolen.<sup>7</sup>

When the sixth of June 1761 arrived the aged Doctor Bradley was so ill that he could not observe the transit at Greenwich. At his request Professor Nathaniel Bliss of Oxford University observed in his stead. John Bird and Charles Green assisted him. Doctor Bradley had trained Charles Mason in astronomy and had without doubt chosen him for the expedition to Bencoolen.<sup>8</sup>

From the day of their arrival, April 27, until the morning of June 6, when the Sun was due to rise at the Cape of Good Hope with the small black disk of Venus in front of it and near its southern limb, Mason and Dixon prepared to observe the event. On May 4th the astronomical clock made by John Ellicott "was set going, the pendulum having not been altered since it came from London." The quadrant was mounted, and on favorable nights observations were made on certain stars. Temperatures were recorded each morning, at mid-day, and in the evenings. The clock proved to be losing two minutes and seventeen seconds per day. On May 18th it was moved into the observatory, wound, and set "to nearly sidereal time." A total eclipse of the moon was observed on May 18th, and the times of "entrance into total darkness," "emersion," and "end of the eclipse" were recorded to the second by the clock.

<sup>7</sup> S. P. Rigaud, *Miscellaneous Works and Correspondence of The Rev. James Bradley* (Oxford, 1932), pp. 388-390.

<sup>8</sup> *Philosophical Transactions*, Vol. 52, part 1, pp. 173-177.

From the 18th of May until the evening before the transit cloudy weather prevailed. Then the skies became clear and observing was carried on continuously until the transit ended. The bright stars Antares in the Scorpion and Altair in the Eagle were observed repeatedly during the night at equal altitudes above the horizon in the East and in the West and the times recorded. The means for each star were highly consistent. These means were the times when the stars crossed the meridian of the observatory and served as corrections to the indications of the clock.

On the morning of June 6 "the sun ascended in a thick haze, and immediately entered a dark cloud." The disk of Venus against the Sun was not seen until half an hour after sunrise. Seeing continued bad for an hour. Then observations began again. With the "object-glass micrometer" attached to one telescope the angular diameters of the Sun and of Venus were measured to tenths of seconds. The path of Venus across the disk of the Sun was followed by measuring repeatedly the angular distance between the northern limb of the Sun and the southern limb of Venus.

Two hours after sunrise the disk of Venus was approaching the western limb of the Sun and was about to begin to leave it. Seeing became excellent, and both the internal and the external contacts of the disks were recorded by both Mason and Dixon independently. Dixon recorded the internal contact four seconds before Mason judged it to occur, the external contact two seconds earlier. The disk of the Sun was scanned for signs of a possible small satellite of Venus but none was seen.

During favorable weather through June, July, August, and September the times of astronomical phenomena and the positions of familiar stars were recorded to establish the latitude and longitude of the temporary observatory. Observations of Antares, Spica, Arcturus, Fomalhaut, Altair, and four other stars in the Scorpion and the Archer established the latitude as 33 degrees, 55 minutes, and 40.5 seconds south.

The longitude of the observatory was determined by recording the local times of sharply defined events in the heavens that were also being observed at the Royal Observatory at Greenwich by Mr. Charles Green and at "Mr. James Short's house in Surry-street in the Strand" by Mr. Short and Dr. John Bevis. The same Dr. Bevis two years later joined Daniel Harris in drawing up in-

structions to guide Mason and Dixon while surveying in America. These sharply defined events were eclipses of the satellites of Jupiter and occultations of stars by the Moon.

The observations for longitude were reduced by Mr. Short who found the observatory at the Cape to be one hour, 13 minutes, and 33 seconds of time east of the Royal Observatory at Greenwich, and by Professor Hornsby of Oxford University who found the difference to be seven seconds of time less.<sup>9</sup>

At St. Helena Maskelyne and Waddington had not been so fortunate. Clouds had prevailed for a month before the sixth of June and had prevented any satisfactory observing. When the Sun rose on the eventful morning they had only occasional glimpses through rifts in the clouds of Venus "as an intensely black spot upon the sun's body." They took advantage of their few opportunities to measure the position of the planet upon the disk of the Sun and to record the time.<sup>10</sup>

Fortunes of war had obliged Mason and Dixon to observe the transit of Venus at the Cape of Good Hope rather than at Bencoolen in Sumatra. Adverse weather deprived Maskelyne and Waddington of any valuable observations of the transit at St. Helena. So war had conspired with weather to assure at least one set of good observations from the region of the southeastern Atlantic Ocean.

Mason and Dixon made their last observations at the Cape of Good Hope on Sunday, September 27, 1761. Then they packed their instruments and put them on board the ship "Mercury" that was lying in port, Captain Harrold commanding. On the following Saturday they sailed for St. Helena where they arrived on October 16. There they joined Nevil Maskelyne in an ambitious program of astronomical research that kept them employed well into the following year. Immediately upon their arrival at St. Helena, Mason and Dixon began to take observations of eclipses of the moons of Jupiter.<sup>11</sup>

The report of Mason and Dixon to the Royal Society of their work at the Cape of Good Hope from April to October, 1761, was read to that body on April 22, 1762. The daily record of

<sup>9</sup> *Ibid.*, Vol. 52, pp. 2, 612; Vol. 53, p. 481.

<sup>10</sup> *Ibid.*, Vol. 52, part 1, pp. 196-201.

<sup>11</sup> *Ibid.*, Vol. 52, pp. 1, 393; Vol. 54, p. 370.

this work is published in *Philosophical Transactions* for the year 1761.<sup>12</sup>

Observations of the transit of Venus of June 6, 1761 were reported by one hundred and seventy-six persons from one hundred and seventeen stations widely distributed over the Earth. Reports to the learned bodies of Europe came from stations throughout Europe and Asia, from islands of the Indian Ocean, from the Cape of Good Hope and St. Helena. The only report from the Western Hemisphere was made from St. John's, Newfoundland, by Professor John Winthrop of Harvard College who had been sent to this post by the Colony of Massachusetts Bay. He observed the last phases of the transit on a Sun that had just risen.<sup>13</sup>

The observations of the transit made at the different stations spread over the Eastern Hemisphere and at Winthrop's lone post in Newfoundland were analyzed at once in various ways by astronomers of Europe with outcomes ranging from 8.5 to 10.5 seconds as the size of the angle subtended by the equatorial radius of the Earth when viewed from the distance of the Sun. The question "How far is the Earth from the Sun?" appeared still to be only approximately answered. But another opportunity was coming. Venus would again cross the disk of the Sun on June 3, 1769. Preparations began at once to observe the coming transit and to profit by all the experience of 1761.<sup>14</sup>

Perhaps a look into the future may reveal the significance of the work done at the Cape of Good Hope. Their selection to observe the transit of Venus of 1761 introduced Mason and Dixon to professional work that was to engage them at intervals for the next fifteen years. Between 1760 and 1775 they were sent on scientific missions by the Royal Society, sometimes together, at other times separately, to South Africa, and to St. Helena,<sup>15</sup> to Pennsylvania, Maryland and Delaware,<sup>16</sup> to North Ireland,<sup>17</sup> to Hammerfest, Norway,<sup>18</sup> and to northern England and Scotland.<sup>19</sup>

<sup>12</sup> *Ibid.*, Vol. 52, part 1, pp. 378-395.

<sup>13</sup> R. A. Proctor, *Transits of Venus* (London, 1883), p. 51. *Philosophical Transactions*, Vol. 54, pp. 277-283.

<sup>14</sup> Simon Newcomb, *Popular Astronomy* (New York, 1892), pp. 181-182.

<sup>15</sup> *Philosophical Transactions*, Vol. 52, part 1, pp. 378-395; part 2, pp. 534-542.

<sup>16</sup> *Ibid.*, Vol. 58, pp. 270-335.

<sup>17</sup> *Ibid.*, Vol. 60, pp. 454-496.

<sup>18</sup> *Ibid.*, Vol. 59, pp. 253-261.

<sup>19</sup> *Ibid.*, Vol. 65, part 2, pp. 500-542.

In June, 1769, Nevil Maskelyne observed the transit of Venus at Greenwich Observatory where for four years he had been serving as Astronomer Royal. Charles Mason, in the service of the Royal Society, observed the transit at Cavan, near Strabane, in the County of Donegal, Ireland, and Jeremiah Dixon, in the same service, observed it at Hammerfest, Norway. Five of the years that had intervened between 1761 and 1769 Mason and Dixon had spent in Maryland, Delaware, and Pennsylvania in the service of Lord Baltimore and the Penns, and also of the Royal Society. During those five years they wrote their names on the heart of America.<sup>20</sup>

The mills of the gods of science grind slowly. The observations made on June 6, 1761 and on June 3, 1769 continued to be studied and studied again. By 1835 the German astronomer Encke had reviewed all the data found on those two days and had concluded that the Earth is 95,370,000 miles from the Sun. This result was accepted until the middle of the nineteenth century. By 1854 long continued studies of the motion of the Moon had made it clear that the Sun is nearer to the Earth than Encke had concluded. And new opportunities were coming. Venus would again cross the disk of the Sun on December 9, 1874, and on December 6, 1882. World-wide preparations were begun to observe these rare phenomena.<sup>21</sup>

Preparations to observe the transits of 1874 and 1882 included exhaustive reviews of the records of earlier transits. In a study of the records Professor Simon Newcomb of the United States Naval Observatory became convinced of the great scientific value of the mass of data that had been accumulated in 1761 and 1769. Accordingly, he made a thorough restudy of the transits of 1761 and 1769 and published it in 1891, one hundred and thirty years after the expeditions to the Cape of Good Hope and to St. Helena. To the observations made by Mason and Dixon in 1761 Professor Newcomb assigned weights that were among the very highest that he allotted.<sup>22</sup>

<sup>20</sup> *Ibid.*, Vol. 58, pp. 270-355, 355-365; Vol. 60, pp. 454-496; Vol. 59, pp. 253-261.

<sup>21</sup> Simon Newcomb, *Popular Astronomy*, pp. 183-185.

<sup>22</sup> Simon Newcomb, "Discussion of Observations of the Transits of Venus in 1761 and 1769." *Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac*, Vol. II (Washington, 1891), pp. 259-406.

This review of the careers of Mason and Dixon has reached the autumn of 1761, and it may prepare the mind for later events to make a concise summary of what took place during 1760 and 1761. On July 4, 1760, Lord Baltimore and the Penns signed an agreement in London to survey and to mark the boundaries between Maryland and the Three Lower Counties and Pennsylvania. During that same month the Royal Society of London applied to the Lords of the Treasury for funds to send expeditions to St. Helena and to Bencoolen. In November, 1760, the commissioners selected by Lord Baltimore and the Penns to carry out the agreement of July 4 held their first joint meeting at New Castle on the Delaware. A few weeks later Nevil Maskelyne and Robert Waddington, and Charles Mason and Jeremiah Dixon sailed from England on scientific missions. During the following April Maskelyne and Waddington landed on St. Helena and Mason and Dixon went ashore at the Cape of Good Hope. On the Maryland-Delaware peninsula during April, 1761, the surveyors, whom the Commissioners had chosen from Maryland and Pennsylvania, were beginning their attempt to run a meridian northward from the "Middle Point" of the peninsula. To this undertaking they were bringing the best in the way of science and skills and instruments of precision that the Colonies possessed.

All during the summer and autumn of 1761 Maskelyne and Waddington at St. Helena and Mason and Dixon at the Cape of Good Hope were applying the science and the skills of Greenwich Observatory and were using instruments made by the ablest craftsmen of the world.