THE APPRENTICE YEARS OF MASON AND DIXON

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THE names Mason and Dixon hold a permanent place in American thought and speech. The boundaries that these two scientists surveyed and marked at the close of an era of dispute and turmoil have now remained unchanged, except in small details, for one hundred and eighty years. They are not political alone but social and cultural as well. The local surveyors who were engaged between 1760 and 1763 by the Baltimores and the Penns to survey and mark their boundaries have long been forgotten. Their names are recorded in the annals, while the names of Mason and Dixon are household words.

The writer was born and bred in the region where Mason and Dixon worked, and through the years he has come to appreciate the reasons why they are so well remembered. Charles Mason and Jeremiah Dixon, coming as they did from the scientific England of 1760, had drunk at the fountainhead. Mason had been trained in Greenwich Observatory, and he and Dixon had been sent to lands beyond the sea on scientific missions for the Royal Society. In their early thirties they were engaged by the Penns and the Baltimores to work on a problem in America the solution of which had proved to be beyond native talent. They spent five years in America, bringing with them the science, the skills, and the implements of Greenwich Observatory and of scientific London. After accomplishing their mission they returned to their places and parts in the English scene. There is in contemplation a series of articles on the Mason and Dixon survey as a scientific enterprise. The first article will consider "the apprentice years."

America's July 4 should be held especially sacred in Delaware, Maryland, and Pennsylvania, for it was on that date in 1760 that Frederick, sixth and last lord Baron of Baltimore, and Thomas Penn and Richard Penn, Esquires, sons and devisees under the will of William Penn, enrolled in His Majesty's High Court of Chancery an "Indenture of Agreement . . . putting a final and perpetual End forever to all disputes and differences between the parties to these presents, relating to the Extent, Bounds, and Limits of the said Province of Maryland, Province of Pennsylvania, and the Three lower Counties of New Castle, Kent, and Sussex on Delaware." The next day each party, as was provided in the agreement, appointed a commission of "seven impartial and Proper Persons, or any number of then~ not less than three, to mark, run out, settle; fix and determine all such parts of said Circle, Lines, Marks and Boundarys as are not yet compleated."

News that an agreement had been reached came to Phila-delphia on September 14, and on the following day Governor James Hamilton of Pennsylvania wrote to Governor Horatio Sharpe of Maryland announcing the Pennsylvania commissioner With his letter he sent a packet containing a copy of the agreement of July 4 and a commission from Lord Baltimore to Governor Sharpe and six other citizens of Maryland. During the autumn correspondence passed between the governors and between Governor Sharpe and Lord Baltimore. Finally on November 19 the commissioners met at New Castle on the Delaware in their first joint session, Governors Sharpe and Hamilton were both present as commissioners. Joint meetings were to continue at intervals until the survey had been completed almost a decade later.

On his return from New Castle to Annapolis, Governor Sharpe wrote to Lord Baltimore at length telling him of the meeting, of problems that had arisen, and of difficulties of a technical character that would have to be surmounted. Maryland's governor was an able and scholarly man, conversant with affairs of state and with the world of learning. His suggestions to lord Baltimore show that he had become keenly aware of the fact that the problem of running out, settling, fixing, and determining the boundaries had now passed beyond the realm of politics, lawyers, and courts into the world of science.

In the course of his letter to Lord Baltimore, Governor Sharpe wrote: "As I am apprehensive . . . that the Commissioners . . . may at times differ in Opinion about the best Mode of executing this or that particular part of the Work, I should be very glad if Your lop would submit some queries which I shall take the liberty to transmit & and such others as Your lop may think fit to the Consideration of some Gentlemen who have devoted a great part of their lives to the Study of Mathematics and whose Reputation is established. Such I presume are Doctor Bradley, Regius Professor of Astronomy at Greenwich, Mr. Senex the Map-Maker, and Mr. Cockayne who reads Lectures at Gresham College."

The naming of James Bradley at the head of the list of scholars to be consulted by lord Baltimore proves that Governor Horatio Sharpe knew his landmarks in the scientific England of 1760. Bradley, at that time sixty-eight years old, had for eighteen years directed Greenwich Observatory. He was the third of England's astronomers royal. John Flamsteed had been the first, Edmund Halley the second. By 1760 the services of the astronomers royal had spanned eighty-five years; King Charles the Second had founded Greenwich Observatory in 1675. James Bradley was one of the great astronomers of all ages and of all lands. Isaac Newton once called him "the best astronomer in Europe." When the third edition of Newton's *Principia* was published in 1726, twelve copies were printed on large thick paper with gilt edges and bound in red morocco, and one of these was presented to Bradley. Someone has called Bradley "the founder of modern observational astronomy," for his two major discoveries, the aberration of light and the nutation of the earth's axis, laid the foundation of the precise determinations of modern astronomy.

When the commissioners of Maryland and of Pennsylvania met at New Castle in November, 1760, they found themselves face to face with a project in surveying that called for precision work of a high order. Personnel and equipment for such work were not available in the colonies. Governor Horatio Sharpe grasped the situation and advised lord Baltimore to seek the advice of Doctor

Bradley. In the article now being written it is pr6posed to sketch Bradley's career and to show just when and where the men who furnished the science that was used in surveying and marking the boundaries between the lands of the Penns and the Baltimores came under his influence and tutelage. Among these men the most significant were John Bevis, Daniel Harris, John Robertson, Nevil Maskelyne, Charles Mason, and Jeremiah Dixon. Incidentally, the principal instruments used by Mason and Dixon in America were made by John Bird, who was instrument maker for Greenwich Observatory during the later years of Bradley's directorship.

At a later time we shall unfold the drama of surveying and science enacted from 1760 to 1768 on the Delaware-Maryland peninsula, in southeastern Pennsylvania, and along the border of Maryland and Pennsylvania. As our plans develop, each of the actors in the drama will step upon the stage at appropriate times. Perhaps we shall reach the conclusion that the Mason and Dixon survey succeeded as it did and became a lasting tradition of American life because the principals in the drama, Charles Mason and Jeremiah Dixon and those who served as their mentors and advisers, had caught the torch from the hand of James Bradley and had brought to American soil his passion for precise work, the techniques that he had taught them, and equipment of the grade that he demanded.

Bradley was an astronomer even in his youth. His maternal uncle the Reverend James Pound of Wansted, Essex, was a famous amateur with his own observatory. Pound was well known to both Isaac Newton and Edmund Halley, who often called upon him for aid in observing the heavens. During his student days at Balliol College, Oxford, Bradley spent all of his free time with his uncle, and thus began a comradeship and a partnership that lasted for fifteen years. After the death of his uncle in 1724 Bradley continued to live with the latter's family at Wansted and to use the Wansted observatory.

Scientific recognition came early to Bradley. By 1716 his observations had become known to Edmund Halley, who in the thirtieth volume of the *Philosophical Transactions* of the Royal Society praised his aptitude, ingenuity, and industry. In the thirty-first volume uncle and nephew jointly drew commendation from Halley for the exactness of their observations of Mars at opposition to the sun, from which reliable conclusions could be drawn about the distance from the earth to the sun.

Observations of the positions of the stars relative to one another and of the positions and the times of the eclipses of the moons of Jupiter engaged young Bradley's particular attention at Wan-sted. Together uncle and nephew determined with care the length of a pendulum that would "beat seconds." Isaac Newton, who was still alive and was near at hand, had shown the length of the "seconds pendulum" to be of major significance in finding the exact shape of the earth, a problem that was then in the fore-front of scientific interest All these matters continued to engage Bradley to the end of his career.

On November 6, 1718, the Royal Society elected Bradley to fellowship. He was then twenty-six years old and was in need of a source o5 livelihood. He had been educated for the church, and accordingly in 1719 he took orders and secured appointment to livings. One of his appointments was obtained for him by his friend, fellow astronomer, and coworker Samuel Molyneux, secretary to the Prince of Wales. Bradley continued to spend as much time as he could spare at the Wansted observatory. In August 1721, Dr. John Keill, Savilian professor of astronomy at Oxford University, passed away, and on October 31 Bradley was chosen to fill the vacant post. He was now free to devote his life to the science of his choice.

The next few years Bradley spent in solving his first major problem. If the stars are scattered through space, some near, some remote, and if the earth swings round the sun in a vast orbit, as Copernicus taught, then the nearer stars should appear to oscillate past the more remote ones always in a sense opposite to the motion of the earth in its orbit, but on any given day the aspects of the stars should be the same from year to year. This shift from day to day in a yearly cycle, called annual parallax, had been looked for but had never been found with certainty, for its smallness defied its detection with the means then available. That very smallness indicates clearly, however, that even the nearest stars are far more remote from the earth than is the sun.

Molyneux owned a zenith sector mounted in his house on Kew Green. A zenith sector is a combination of telescope, graduated arc, and plumb line designed for measuring angles between the zenith and a star when crossing the meridian. Molyneux's sector was a very good one, one of the first ever built. It was made by George Graham, a famous maker of instruments, in 1725. With this device Molyneux and Bradley set about to look for annual parallax. They failed to find it. Instead they discovered a yearly oscillation in the zenith distance of every star that they measured as it crossed the meridian, amounting in some instances to forty seconds of arc. The motion was at right angles to that of the earth in its orbit, not opposite to it as annual parallax would require. To eliminate accidental effects Bradley secured from Graham a new and excellent zenith sector, which he mounted at the house of his Aunt Pound in Wansted. With it he repeated and extended all the observations made at Kew Green, securing complete confirmation of all that he and Molyneux had found. What was the origin of this newly discovered phenomenon?

Various hypotheses were tested by Bradley. Molyneux was unable to help, for he had been named a lord of the Admiralty and had little time for astronomical pursuits. His health declined, and he died before an explanation had been found. The tradition persists that the explanation occurred to Bradley while he was watching a pennant at the masthead of a sailboat The pennant changed its position as the boat tacked in the wind. This position was a result compounded from the wind and the motion of the boat. Might not the phenomenon that Molyneux and he had discovered result from the motion of light in space compounded with the motion of the earth in its orbit? A detailed analysis of their observations showed Bradley that they were completely accounted for by this hypothesis.. In January, 1729, he announced the new phenomenon to the Royal Society. It is called the aberration of light

During the 1720's and the 1730's Bradley worked on a number of problems that were to bear directly upon the subsequent work of Mason and Dixon in America. In 1726 he announced to the Royal Society the difference in time, and therefore in longitude, between London and Lisbon and between London and the Port of New York as determined by precise observations of the times of eclipses of the first satellite of Jupiter made at the three stations. In 1732 he went to sea at the request of the Admiralty to test the usefulness of Hadley's recently invented sextant as an aid in finding longitude at sea. Hadley accom-panied him. Their aim was to measure the angles between the moon and the sun and bright stars with the sextant and to use the results in calculating longitude. The report of its probable usefulness was most favorable.

The problem of the figure of the earth was commanding attention. In 1734 Bradley communicated to the Royal Society a paper on oscillations of the pendulum in different latitudes and on the figure of the earth, which might be deduced from them. Cohn Campbell, assisted by Joseph Harris, had taken a pendulum dock made by George Graham, who had regulated it against the stars at his house in London, and set it up in Jamaica with its pendulum unchanged and had determined the rate at which it lost time. Bradley discussed the significance of these obser-vations and advised gentlemen who might be taking pendulum docks to distant countries to make similar observations. He corresponded with Celsius at Upsala, Sweden, about the dif-ference between gravity at Upsala and at London as evidenced by the gain of time by a clock made by Graham for the observatory at Upsala and regulated to keep time in London. During the 1730's the French Academy of Sciences sent out two expeditions - one to Lapland and the other to Peru to obtain data for determining the figure of the earth. The Lapland party used a zenith sector modeled after the one made by Graham for Bradley's work at Wansted. Immediately on its return Maupertuis, its leader, submitted its findings to the Royal Society through Bradley.

Dr. John Bevis has been mentioned as one who served along with Daniel Harris as adviser to Mason and Dixon at the be-ginning of their work in America. He was a physician by education, but his heart was in astronomy. In 1738 he built himself an observatory at Stoke Newington near Greenwich. An indefatigable observer, at times he assisted Edmund Halley, the astronomer royal. He extended the discovery of the aberration of light by showing from his own observations of the stars that aberration has an east-west component as well as the north-south component that Bradley and Molyneux had found. According to his biographer he was in constant and confidential communication with Bradley on astronomical questions. Throughout the pub-lished correspondence of Bradley there are letters to substantiate this statement. In them are discussed the moons of Jupiter, eclipses, comets, transits of the pole-star across the meridian, corrections to the instruments at Newington, Mars, astronomical tables, motion of the moon, and kindred topics. In 1737 we find the two men working together in observing a comet.

By 1740 Bradley was approaching his fiftieth year. Sir Isaac.. Newton had been asleep in Westminster Abbey for more than a decade. Edmund Halley's star was sinking to the horizon, for he was eighty-four years old and his life's work was done. George Graham was sixty-five, and his pupils John Shelton and John Bird were taking over his work of producing the world's finest precision instruments. Great days were ahead. James Bradley had more than twenty years of active life before him, and in England there were three small boys, each under ten, who in time were to come under his influence, Nevil Maskelyne, Charles Mason, and Jeremiah Dixon.

On February 3, 1742, Bradley was chosen as England's third astronomer royal, director of Greenwich Observatory, successor to John Flamsteed and to Edmund Halley. In June he changed his residence from Oxford to Greenwich. His first responsibility was the repair and renovation of the instruments at the observatory. Flamsteed, who had served England as astronomer royal for forty-three years on a salary of one hundred pounds per year, had supplied all his instruments. After his death these had been claimed by the executors of his estate, and therefore Halley had taken over an empty building. During the first five years of the latter's term the observatory had been equipped for the first time at public expense. By 1726 there had been provided clocks, telescopes, a transit instrument, and a mural quadrant by Graham. These had been purchased out of a grant of five hundred pounds from the public treasury. A board of visitors representing the Royal Society had recommended the addition of two hundred pounds for further equipment, but it was not until twenty-two years later that such a grant was secured. By the end of Halley's period of service (from his sixty-fourth to his eighty-sixth year) the instruments had fallen into bad adjustment and the building into disrepair. Bradley, Graham and Sisson therefore spent the entire summer of 1742 bringing the observatory into condition for use.

The first years after 1742 were devoted to a careful check of observations that had been made at Greenwich since the days of its foundation. The positions of the stars and of the sun, the moon, and the planets among the stars constituted the vast majority of the observations. But other fields were not neglected. Comets appeared and were followed from day to day and from hour to hour among the stars. The length of the "seconds pendulum" was determined with new equipment made by Graham. This problem, it will be recalled, had engaged the attention of Bradley and his uncle at Wansted. .

By 1747 Bradley's studies of positions of the stars had brought to light his second major contribution to science -the "nodding" or "nutation" of the axis of the earth. That some effect other than "aberration" was present had been apparent twenty years before during his observations at Wansted. At every opportunity Bradley returned to Wansted to use his zenith sector. In the course of years it became clear that this other effect varied in a cycle of about eighteen years. This period suggested as a cause the pull of the moon on the bulge of the earth at its equator, for the plane of the moon's orbit had been known for centuries to move around the plane of the earth's orbit in eighteen and six-tenths years. A careful check of this hypothesis against observations of several stars revealed a most satisfactory agreement. On December 31, 1747, Bradley announced his discovery to the Royal Society by letter addressed to his patron, friend, and fellow astronomer, George Parker, Earl of Macclesfield.

The astronomer locates objects in the heavens with reference to his meridian and his plumb line. He attaches this frame of reference to the revolving, rotating, slowly precessing, and slightly nodding earth. His instruments are mounted upon this moving platform. Both the plumb line and the meridian, when observations are carefully made and analyzed, show a complicated motion among the stars. The great phenomena that accompany the annual revolution of the earth about the sun and its daily rotation upon its own axis have been known from time immemorial. A less conspicuous phenomenon, the precession of the equinoxes, had been known to astronomers for twenty centuries. The axis of the earth moves slowly among the stars, completing a cycle in twenty-six millennia, and the plane of its equator accordingly moves around the plane of its orbit, the line of intersection changing in direction among the stars about fifty seconds of angle each year. Precession had been allowed for by astronomers for centuries, and Sir Isaac Newton had achieved the triumph of showing that the earth is probably flattened at the poles and bulged at the equator and explaining precession as arising from the pull of sun and moon upon the equatorial bulge.

During the last years of Newton's life and the twenty years that followed his death James Bradley had brought to light and explained two effects, hitherto unknown, of the motion of the earth. He and Molyneux discovered aberration, which results from the motion of light combined with the forward motion of the earth. Then Bradley discovered the cycle of nutation and showed it to be an effect of the moon's attraction upon the earth, which appears as a slight wobble in precession. These discoveries placed Bradley among the immortals of science. Furthermore, they materially increased the precision of astronomical determinations, for when corrections had been made for aberration and nutation, positions of stars could now be recorded to seconds and fractions of sec-onds of angle.

In a later article we shall learn that Charles Mason and Jeremiah Dixon came to America in 1763, sixteen years after the announcement of nutation by James Bradley. They came to carry out a survey that called for repeated determinations of latitude made by observing selected stars as they crossed the meridian. We shall note, as we study their work, that they corrected the positions of those stars they observed for precession, for aberration, and for nutation. Naturally they were among the first surveyors ever to make all these corrections, which, expressed in feet on the surface bf the earth, meant that each second of error eliminated thereby from their determinations of latitude removed one hundred feet of error from the position, northward or southward, of the boundary that bears their names.

By 1748 the science of astronomy and the art of observation had at the hands of James Bradley outgrown the equipment of Greenwich Observatory. Be it forever known to the credit of King George II that when it was recommended to him by the Royal Society and the lords of the Admiralty that Greenwich Observatory be thoroughly renovated, funds were immediately made available. New buildings were added to the observatory, the old instruments were repaired, and many new ones, made principally by George Graham and John Bird, were secured.

The zenith sector at Wansted, with which both aberration and nutation had been discovered, was moved to Greenwich Observatory in July, 1749.

About the middle of the 1750's two young men, both in their middle twenties allied themselves with Bradley. Nevil Maskelyne, as a Wiltshire lad who had taken his bachelor's degree at Trinity College, Cambridge, in 1754. He was educated for the church and had been ordained a curate. But the spectacle of a solar eclipse had made an astronomer of him. He took up the study of mathematics and about 1755 attached himself to the astronomer royal, learned his methods, and aided him in the study of corrections to observations occasioned by refraction of light in the earth's atmosphere. Ten years later Maskelyne was to succeed Bradley as astronomer royal. He was then to supervise and direct the scientific work done in America by Mason and Dixon for the Royal Society. Of his career during the decade from 1755 to 1765 we shall learn later.

Bradley was the first of the astronomers royal to have the services of a regularly employed assistant. His first was John Bradley, a nephew, who served from 1742 to 1756. His second was Charles Mason, who began to record observations in October 1756, and served until 1760, when he was succeeded by Charles Green. Of Mason's earlier life little is on record. The young man was twenty-six when he became Bradley's assistant. He found his chief in the midst of a program of observations with his recently acquired instruments, "that in point of accuracy may bear comparison with those of modern times." The records of Greenwich Observatory from 1750 forward "embody a collection of materials, which have almost exclusively formed the ground-work of every investigation undertaken in modern times, for the purpose of improving the solar, lunar, or planetary tables." "The Greenwich Observations for the twelve years (1750-1762) have been published, and occupy 931 large folio pages: their number cannot be less than 60,000." The problem of finding with accuracy the longitude of a ship at sea was still unsolved. Through its commissioners of longitude the British Admiralty was offering princely rewards for material contributions to the solution of "the problem of the longitude." It was necessary for the navigator to know both his own local time and the local time of Greenwich Observatory. The navigator of 1760 was equipped to find his own local time and had timepieces to carry it for a few hours or a few days. But to find the Greenwich time when far out at sea was a different matter. Modern chronometers, which for more than a century have carried Greenwich time to the ends of the earth, were just being introduced. Their inventor, "Longitude" John Harrison, was demanding recognition for them. In a few years he got it, but in the meantime the astronomers had other methods for finding Greenwich time far away from Greenwich. All such methods reduced themselves to a procedure simple in principle. Observe an event in the heavens that defines an instant of time sharply and whose Greenwich time of occurrence has been predicted and put in tables. Observe also the local time of this event. Then, after data have been taken from the tables and computations have been made, one has both the local' time and the Greenwich time of the event observed-hence the difference in time between one's position and Greenwich and hence one's longitude reckoned from Greenwich.

Among events that define instants sharply are the disappearance of the moons of Jupiter into its shadow and their reappearances. James Bradley had studied the eclipses of Jupiter's moons from his youth onward and had made tables of the times of their occurrence. He was an authority on the moons of Jupiter. Charles Mason, using Bradley's tables, observed eclipses of these moons throughout his sojourn in Pennsylvania for the purpose of finding the longitudes of his stations. On a voyage to the Barbados in 1763 Nevil Maskelyne tried to observe eclipses of the moons of Jupiter from the deck of his ship in the hope of thus finding the longitude, but the pitching and the rolling of the vessel made his telescope unmanageable.

Another celestial phenomenon that defines an instant of time is the position of the moon as it moves among the stars. when the angles between the moon and neighboring stars had been measured or the angle between the moon and the sun obtained, approximate Greenwich time could be calculated from lunar tables, and the difference between it and the local time of the observations gave a fair value of the longitude of the observer. The prediction of the place of the moon among the stars and the preparation of a set of reliable lunar tables had been a major responsibility of astronomers for generations. A number of such tables had been constructed, none of which were satisfactory.

In 1755 Professor Tobias Mayer, director of the observatory at Goettingen, Germany, sent to London a set of tables of the moon that he had developed, entering it in competition for an award from a sum of twenty thousand pounds that had been posted by the commissioners of the board of longitude for improvements in the determination of longitude at sea. Mayer's tables were submitted to the astronomer royal for a check against Greenwich observations. As assistant observer Charles Mason had a large share in the work of checking Mayer's tables. These, while they proved to be extraordinarily accurate, could be modified and improved through the use of the data at Greenwich. Work on Mayer's tables of the moon continued to engage Mason at intervals for the rest of his life. When Mayer died in 1762, his widow was awarded three thousand pounds by the board of longitude. For his improvements to the tables Mason was ultimately awarded one thousand pounds.

Nevil Maskelyne was the perfecter of the method of lunar distances for finding longitude; Charles Mason developed into a leading proponent of this method. In order to understand fully the acts and words of these men it is necessary to keep in mind always the intense rivalry that existed between them and "Longi-tude" John Harrison for recognition by the commissioners of longitude. In the end, while all were still alive, Harrison at the age of eighty won the battle. King George III became con-vinced of the merits of Harrison's chronometers and came to his aid. Parliament, then favorable to the king, voted Harrison 8,750 pounds in 1773, bringing the total of all awards to him to the sum of 22,550 pounds. Old "Longitude" celebrated his triumph by flaying all obstructionists in a pamphlet published in 1775, the year before his death. Its title begins as follows: "A Description concerning Such Mechanism as will afford a nice, or true Mensuration of Time; together with. . .”

From his knowledge of the motions of the sun, the moon, the earth, and other planets and their satellites and in some instances of comets the astronomer is able to predict spectacular events in the heavens. As 1760 approached, two major events, foretold long before, were due to occur. First, Halley's comet was expected. A comet had appeared in August 1682. Edmund Halley, then a young man, had computed its orbit and found it to be identical with that of the comet of 1607 as descried by Johann Kepler. A review of the past revealed that at intervals of seventy-five and one-half years comets of exceptional brightness had appeared. Halley inferred that they were all the same comet and predicted a return in 1758. The mathematician Clairaut computed the orbit with care, using Newton's *law* of gravitation and allowing for the attractions of the major planets. He estimated that it would be nearest the sun in mid-April of 1759. It passed through perihelion on March 12 of that year. The comet returned again to perihelion on November 16, 1835, and once more on April 19, 1910. Those now beyond their middle thirties will remember it in the eastern sky at daybreak in early May, 1910, and in the western sky after sunset a few weeks later.

A second phenomenon - a transit of Venus across the face of the sun-was due to make its appearance on June 5, 1761. This rare event occurs four times in every two hundred and forty three years at intervals of a hundred and five and one-half years, eight years, a hundred and twenty-one and one-half years, and eight years. Johann Kepler had predicted that it would come on December 6, 1631, but circumstances had been unfavorable and no one had observed it. The next transit had fallen on December 4, 1639. It had been foretold by Jeremiah Horrox, a young clergyman-astronomer of Hoole, a village of Lancashire, and observed by him and by his friend William Crabtree, the first persons, so far as records go, to see a transit of Venus.

In the twenty-ninth volume of *Philosophical Transactions,* published in 1716, Edmund Halley had brought the next transit, still nearly half a century in the future, to general notice in such a vivid and effective way that the scientific world has not yet forgotten his counsel. Halley knew, as did his contemporaries, that a transit of Venus might be used to settle the vexatious and open question as to the distance from the earth to the sun. He had the advantage of experience gained in observing a transit of Mercury while he was on a scientific mission to St. Helena in 1677. After putting all available information together he pointed out that precise observations of the times of the beginning and of the end of the transit made by reasonably competent people stationed at well-selected posts over the face of the earth and equipped only with simple telescopes and reliable timepieces could furnish all the data necessary for computing the distance from the earth to the sun. He predicted that the next transit of Venus would occur on May 26, 1761, and would be visible throughout the eastern hemisphere and the Arctic zone. He made an urgent appeal that the astronomers of Europe who would then be alive take advantage of the golden opportunity. As the years passed, more accurate knowledge of the positions of the sun, the earth, and Venus advanced the predicted date to June 5.. Months before this time the governments of France, Denmark, Sweden, Russia, and Great Britain organized scientific expeditions to various parts of Europe, Asia, and Africa to observe the event. The Royal Society initiated its plans a full year before the expected transit. In July, 1760, the president, council, and fellows of the organization addressed a memorial to the lords of the treasury asking for a grant of eight hundred pounds to be used in sending two observers with the necessary instruments to St. Helena and for an additional eight hundred pounds to send two other observers with instruments to Bencoolen in Sumatra. Their lordships were humbly begged, "to intercede with his Majesty, that he would be most graciously pleased to enable them to carry the said design into execution." Both requests were granted, and the council of the Royal Society proceeded to engage observers, to secure the necessary instruments, and to petition the admiralty to supply transportation to St. Helena and Sumatra.

The hand of the astronomer royal is seen in the selection of observers. Nevil Maskelyne, assisted by Robert Waddington, was chosen to go to St. Helena, and Charles Mason, assisted by Jeremiah Dixon, was selected for the expedition to Sumatra. Better choices could not have been made. Maskelyne and Mason were well known to the astronomer royal as able young astronomers. Dixon was brought to general notice by his selection to assist Mason. He had previously been prominent in his native county of Durham as a surveyor and amateur astronomer. There is some evidence that a neighbor and fellow amateur named Emerson had persuaded him to apply for appointment to one of the expeditions.

Bradley's last known publication is his letter of directions to Mason for observing the transit It was written probably dur-ing October, 1760. The great master made his last observation at Greenwich on September 1, 1761. After months of illness he passed away at Chalford in his native Gloucestershire on July 13, 1762, at the age of seventy.

Their years of apprenticeship over, Nevil Maskelyne, Charles Mason, and Jeremiah Dixon as mature and responsible scientists in the service of the Royal Society soon began their journeys to distant lands on scientific missions. Further articles now in preparation will review the events that took place at the Cape of Good Hope, on St. Helena, in London, on the Barbados, and in the three lower counties of New Castle, Kent, and Sussex before they set foot on Pennsylvania soil three years later.