Mark John Skertich

Royal Society & MD Survey

MA 1993

"THIS PALPABLE DISREGARD OF THE PLAIN PROVISIONS OF NATURE:" THE ROLE OF THE ROYAL SOCIETY IN THE MASON-DIXON SURVEY

SUBMITTED TO
THE DEPARTMENT OF HISTORY
WEST VIRGINIA UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF ARTS
BY
MARK JOHN SKERTICH
APRIL, 1993

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INTRODUCTION

Writing in 1857, James Veech justified the study of the history of the Mason-Dixon survey by placing it the context of historical geography, a subject, he asserted, in which Americans were most deficient.

> If this unpretending effort to obtrude what some will regard as an effete, and what really is an almost forgotten subject, upon the public attention, be challenged with the inquiry--Cui bono?--I answer that I admit it does not come within the Baconian rules which have, perhaps, too much control over modern "progress." But I know of no more interesting, if not profitable field of historic research than that which takes in the boundary conformations of the several States of our Union. . . . We abound in histories of varied merit . . .; but we are singularly deficient in what may not inaptly be termed our Historical Geography. The neglect of this department of research is the more to be wondered at and regretted, because of its intimate blendings with, and elucidations of, all our other history, civil, political, social and religious.[1]

Veech, of course, wrote his history of the Mason-Dixon line prior to the establishment of history of science and technology as an academic discipline. Nevertheless, his fundamental insight regarding historical geography and its integration of civil, political, social and religious history is still applicable today. However, in the twentieth century we would expand his thesis and claim that the history of science and technology,

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[1]James Veech, Mason and Dixon's Line: A History (Pittsburgh: S. Haven, 1857), p.iv.

as well as historical geography, performs the same function.

The aim of this study is to situate the Mason-Dixon survey in a wider context than is usual, that is, to move beyond the usual political solution of a rather narrow, provincial border problem. Veech is correct; the Mason-Dixon survey can be discussed in a context of civil, political, social and/or religious history. All of these elements enter into our story; each can be pursued in depth. However, the specific goal of this paper is to view the labors of Mason and Dixon in light of the scientific milieu of the eighteenth century. More precisely, the investigation will focus on the scientific and technical work of the two astronomers/surveyors vis-a-vis the Royal Society of London. When analyzed from this perspective, the Mason-Dixon survey becomes a case study of how and why science was pursued in the eighteenth century. It becomes a study not only of issues internal to science and technology, but of the social history of science as well. To truly understand what the Mason and Dixon survey was all about, it becomes imperative to pursue the constellation of factors of which it was the result.

The Royal Society of London played a significant role in the survey of the boundary between Pennsylvania and Maryland. However, to focus only on the technical support provided to our two astronomers/surveyors, is to miss the greater part of our fascinating story. The Mason-Dixon survey can be appreciated only if it is viewed as one facet of the multi-dimensional interest of the Royal Society in the New World, as well as its concern with the "universe" as a whole.

We commence our study by briefly looking at the scientific interest of the Royal Society in the New World generally. This may, at first, seem extraneous, but it does provide the context for the support of the work of Mason and Dixon. Concurrent with incipient natural philosophy in the colonies, border problems were arising between Pennsylvania and Maryland. Although political history is not the primary concern of this paper, we are examining science and technology at its interface with politics. Therefore it is essential for our understanding to have some background of the major political developments and historical events which led to the selection of the team of Mason and Dixon. A summary of this material is be presented in Part II.

Through individual members of the Royal Society who were consulted by the Proprietors of the colonies, the Society exercised a real, but less direct, influence on the solution of the boundary problem. The role of the scientists, as well as that of important instrument makers, is explored in Part III.

The relationship of Mason and Dixon to the Royal Society began long before the two men came to Pennsylvania. In fact, it is because of their previous work for the Society that they were recommended and chosen as the chief surveyors for the project. This dimension of the interaction between Mason and Dixon and the Royal Society (and/or its members) is the focus of Part IV.

Only by comprehending the role of the Royal Society in this very broad context can we gain the insight needed for Part V, which examines specifically the actual survey of Mason and Dixon. It is here that all the background elements finally converge and provide a remarkable solution to a vexing problem.

The preeminent scholar of the life and work of Mason and Dixon, Thomas D. Cope, once wrote:

> The story of the work of Mason and Dixon in the Middle Colonies from 1763 to 1768 is largely a "lost chapter" of Pennsylvania history because writers have persisted in viewing it from an inappropriate frame of reference, the local or regional one, and in entangling it with border issues that are completely irrelevant. When treated in this way the significance of their work is masked and obscured.[2]

The primary purpose of this study is to rectify this shortcoming and to situate the survey in a more fruitful "frame of reference." When one does this, one finds that the role of the Royal Society of London was crucial to the endeavors of Mason and Dixon.

[2]Thomas D. Cope, "A Frame of Reference for Mason and Dixon," Proceedings of the Pennsylvania Academy of Science, 19 (1945), 80.

I. "WE HAVE TAKEN TO TASK THE WHOLE UNIVERSE": THE ROYAL SOCIETY AND COLONIAL SCIENCE

On July 9, 1662, six days before the Royal Society of London received its official charter, John Winthrop, governor of Connecticut, delivered his first formal paper to that nascent society about to receive Royal approbation. Winthrop provided the Society with a detailed description of a process of making tar from the knots of pitch pines.[3] What this seemingly incidental fact signifies is of great importance: from the very beginnings of both the Royal Society as well as Colonial natural philosophy, the two were involved in a mutual symbiotic relationship.

The Royal Society, or at least Henry Oldenburg, recognized that it had in John Winthrop a valuable correspondent. Oldenburg wrote to Winthrop on March 26, 1664, asking him to make astronomical observations of the conjunction of Mercury with the Sun, which was due to occur on October 25 of that year.[4] In 1665 Winthrop sent a shipment of New England specimens "for view of the Gentlemen of the Royal Society," but unfortunately, it

[3]Raymond P. Stearns, Science in the British Colonies of America (Urbana: University of Illinois Press), p. 122.

[4]Stearns, Ibid., p. 130

was lost at sea.[5] In fact, misfortune seems to have hampered Winthrop's activities on behalf of the Royal Society from the beginning. Letters were lost in transit, communications were received years after they had been written, shipwrecks appeared to be common. Because of the defective communications at the time, Oldenburg interpreted the lack of correspondence as neglect or inactivity on the part of Winthrop. In a letter of October, 1667, Oldenburg admonished Winthrop, "Sir, you will please to remember that we have taken to task the whole universe, and that we were obliged to do so by the nature of our design."[6]

The Royal Society had specific objectives and expectations from this charter member. In particular it sought knowledge of:

> the remarkables [of New England] than is any yet extant, concerning the mappe of the country, the history of all its productions, and particularly the subterraneous ones . . . likewise a relation of the tides upon your coast, together with the course of your rivers, but especially and above all, a full account of your successe [sic] in your new way of saltmaking, whereof we could not compasse the experiment here, as was much desired.[7]

Despite several setbacks in communications and shipments, Winthrop served as one of the most active colonial correspondents of the Royal Society until his death in 1676. Moreover, the Society eventually did receive a large shipment of "curios-

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[5]Ibid., p. 131.

[6]Quoted by Stearns, Ibid., p. 132.

[7]Quoted by Michael Kraus, "Scientific Relations between Europe and America in the Eighteenth Century," Scientific Monthly, 55 (1942), 261.

ities of nature" on February 10, 1669/70.[8]

> By virtue of his knowledge of alchemy, early chemistry, and medicine--as well as an enthusiasm for experimental philosophy as a whole--together with his wide travels and personal acquaintances, his warm personality, his moderate and sensitive spirit, and his flexible wide ranging intellect, John Winthrop, Jr., was well qualified to become the Royal Society's "chief correspondent" in New England.[9]

The presence of John Winthrop in America, however, not only ensured that the Royal Society would receive scientific data, observations, information, and collections. He would also be the vehicle by which the Royal Society would promote the new science in the New World. As Oldenburg wrote to Winthrop on March 6, 1670:

> I hope that the New-English in America will not be displeased with what they find the Old-English do in Europe, as to the matter of improving and promoting useful knowledge by observations and experiments; and my mind presages to me, that within a little time we shall hear that the ferment of advancing real philosophy, which is very active here, and in all our neighboring country, will also take in your parts, and there seize on all that have ingenuity and industry, for the further spreading of the honour of the English Nation, and the larger diffusing of the manifold advantages, and benefits, that must proceed from thence.[10]

That John Winthrop, Jr, was held in the highest esteem by the Royal Society is confirmed by a relatively little known fact. In an unusual departure from tradition, volume forty of

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[8]The list of items received by the Royal Society, excerpted from its Journal-Book, is published in Stearns, Science in the British Colonies, pp. 691-694.

[9]Stearns, Science in the British Colonies, p. 119f.

[10]Quoted by Stearns, Ibid., p. 135f.

the Philosophical Transactions is dedicated to an individual, Winthrop's grandson, John Winthrop, III. In the prefatory "Dedication," Cromwell Mortimer, Secretary of the Royal Society, wrote:

> In Concert with these [Boyle, Wilkins, Oldenburg] and other learned friends, (as he often revisited England), he was one of those, who first form'd the plan of the Royal Society; and had not the Civil Wars happily ended as they did, Mr. Boyle and Dr. Wilkins, with several other learned men, would have left England, and, out of esteem for the most excellent and valuable Governor, John Winthrop the younger, would have retired to his new-born Colony, and there have established that Society for promoting natural knowledge, which these gentlemen had formed, as it were, in embryo among themselves; but which afterwards receiving the protection of King Charles II, obtained the style of Royal, and hath since done so much honor to the British Nations.[11]

If the Royal Society anticipated much from John Winthrop, it expected the nearly impossible from Edward Diggs. Four pages of very detailed directives were given to this Virginia planter prior to his departure. As if the demands of colonization in terms of time, energy, skill and financial outlay did not exist, the Society requested that Diggs, among other things:

> [compose] a good History of the Virginian Plantation, concerning its Beginning, Increase, misfortunes and the present state thereof.
>
> *****
>
> What considerable Minerals, Stones, Bitumens, Tinctures, Druggs? To inquire after ye several sorts of iron-ore, to try wch of ym is kindest to make good and tough iron, and to encourage iron-mills for iron-work, for saving the wast of wood in England, fuell being much more plentifull and work much cheaper there, than here.
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[11]Cromwell Mortimer, "Dedication," Philosophical Transactions, 40 (1737).

> To keep a register of all changes of wind and Weather at all hours by night and day, shewing ye Point, ye wind blows from; as also the snows and ye Hurricanes, especially what season of ye year the latter happen most; and What are their prognosticks, concomitants, and consequences.
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> *****
>
> To Carry with ym good Scales and Glas-viols of a pint or so, with very narrow mouths, wch are to be filled with Sea-water in different degrees of Latitude, and ye weight of ye water to be taken exactly at every time, and recorded, marking wthall ye degrees of Long. and Latitude of ye place; and yt as well of water near ye top, as at greater depth.[12]

Oldenburg had claimed that the Royal Society had taken to task the whole universe, but in this particular case the Society wanted Diggs to take on the universe himself!

Nevertheless, during the Colonial era American natural philosophers made important contributions to the Royal Society as well as to science per se. Thomas Brattle's observations of Halley's comet in 1680 were used by Newton in the Principia.[13] Thomas Pownall, once governor of Massachusetts, contributed an important paper entitled, "Hydraulic Currents in the Atlantic Ocean."[14] Dudley submitted his four-year meteorological record, "the better to make comparative studies," and Isaac Greenwood proffered an annual meteorological account of New England.[15] A number of colonial correspondents sent to the Royal Society

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[12]Royal Society of London, "Directions and Inquiries Concerning Virginia recommended to Edw. Diggs, Esq. July 22.69." Printed in Stearns, Science in the British Colonies, pp. 694-698.

[13]Kraus, "Scientific Relations," p. 271.

[14]Michael Kraus, The Atlantic Civilization: Eighteenth Century Origins (Ithaca: Cornell University Press, 1949), p. 191.

[15]Ibid., p. 190.

descriptions of American moose, pigeons and whales. The Society had asked Cotton Mather for information regarding the relationship of winds to the migration of pigeons. Mather was also requested to send more information about the "mouse deer;" "what we have hitherto had being very imperfect and not to be depended on."[16] When John Woodward simply suggested that Mather might send information of "such subterraneous curiosities, as may have been in these parts of America," Mather responded with a total of eighty-two letters.[17] Botanical specimens and plants sent to England by Bartram, Catesby, Mitchell, Clayton, and lesser naturalists enriched the Sloane Herbarium as well as that of Joseph Banks (and ultimately the British Museum.)[18] By the end of the colonial era (1783) the Royal Society numbered fifty-three Americans among its members;[19] and 260 papers were published in the Philosophical Transactions by colonials.[20]

The preceding examples appear to pale to insignificance when compared with the magnitude of the Principia. The names of the natural philosophers in the Colonies are mere footnotes in the history of science and technology; they rarely occur in the standard texts. What is their position in the historical development of science? Are we able to make some generaliza-

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[16]Ibid., p. 175.

[17]Hindle, Pursuit of Science, p. 16.

[18]Ibid., p. 171.

[19]Stearns, Science in the British Colonies, p. 708ff.

[20]Ibid., p. 116.

tions?

First of all, colonial science, and the role of the Royal Society in supporting the endeavors of the Americans, manifests the explicit Baconian nature of the enterprise. In his Novum Organum Bacon wrote:

> Nor must it go for nothing that by the distant voyages and travels which have become frequent in our times, many things in nature have been laid open and discovered which may let in new light upon philosophy. And surely it would be disgraceful if, while the regions of the material globe; that is, of the earth, of the sea, and of the stars--have been in our times laid widely open and revealed, the intellectual globe should remain shut up within the narrow limits of old discoveries.[21]

From its very beginning, indeed even from the objectives of its immediate predecessors, the Royal Society had as its raison d'etre the accurate collection, classification, and interpretation of scientific information from around the world. In order to achieve this goal, collaborators and correspondents were absolutely essential. In fact the Charter of the Royal Society explicitly grants to it the right

> . . . to enjoy mutual intelligence and knowledge with all and all manner of strangers and foreigners, whether private or collegiate, corporate or politic, without any molestation, interruption, or disturbance whatsoever: Provided nevertheless, that this our indulgence, so granted as it is aforesaid, be not extended to further use than the particular benefits of the aforesaid Royal Society in matters or things philosophical, mathematical, or mechanical.[22]

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[21]Francis Bacon, Novum Organon, Aphorisms Book One: LXXXIV.

[22]Raymond P. Stearns, "Colonial Fellows of the Royal Society of London, 1661-1788," Notes and Records of the Royal Society of London, 8 (April, 1951), 179.

This program was made possible right from the beginning of the Royal Society by the unprecedented growth of English commerce, navigation, the colonies and wealth. For the first time scientific organizations, more specifically the Royal Society, were capable of making a concerted effort to implement the Baconian ideal.[23] As Stearns says so eloquently:

> Of equal importance, especially to the colonial scene, the Society succeeded in imparting its objectives, its experimental approach and its spirit to countless persons in the English colonies of North America. By its unrelenting promotion in the New World in the way of personal appeals, publications, patronage in a variety of forms, and constant encouragement, it went far to reproduce in the colonies men and women imbued with the spirit of experimental philosophy.[24]

Nevertheless, American science, (at least until the time of Franklin), appears to have been second-rate at best. However, even this mediocrity was of value in the development of the scientific tradition. As Whitfield Bell once remarked, "It is the large body of unimaginative, undistinguished men of the middle sort who keep alive the ideas that other men create. . . . They originate little; they transmit much."[25] This was the primary function of the early American natural philosophers. They made observations, contributed data and provided specimens which were then synthesized into "science" by the

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[23]Brooke Hindle, The Pursuit of Science in Revolutionary America (Chapel Hill: University of North Carolina Press), p. 15

[24]Stearns, Science in the British Colonies, p. 115f.

[25]Randolph S. Klein, ed., Science and Society in Early America: Essays in Honor of Whitfield J. Bell, Jr. (Philadelphia: American Philosophical Society, 1986), p. 11.

giants of thought. Indeed, a new country like America is conducive to Baconianism, where collecting and observing are relatively easy compared to learning advanced science and mathematics.[26] Moreover, the contributions of the colonists truly were valued by the British scientists.

One particular example stands out, that of John Bartram, whom Linnaeus himself regarded as the greatest natural botanist in the world.[27] An indefatigable collector of plants and seeds, he contributed more than anyone else to the advance of botany in this country. Moreover, the number of American plants which were cultivated in England more than doubled because of his contributions.[28] Nevertheless, Bartram did not classify the plants which he collected; nor was this necessary. As Hindle reminds us, "this could be done much more satisfactorily by the more erudite Europeans who were able to integrate Bartram's discoveries into the general body of Western Science."[29] Bartram himself was content with this arrangement, for in a letter to Collinson he wrote,

> To my friends Doctor Dillenius and M[ark] Catesby, I sent my observations on such things as will be proper materials to assist them in composing their fine histories, for which they promised me one of their

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[26]Susan Faye Cannon, Science in Culture: The Early Victorian Period (New York: Dawson and Science History Publications, 1978), p. 73.

[27]Dirk J. Struik, Yankee Science in the Making (Boston: Little, Brown & Co., 1948), p. 19.

[28]Hindle, Pursuit of Science, p. 27.

[29]Ibid.

books.[30]

That the English scientists needed and appreciated data from North America is attested to by the fact that Dillenius, a botany professor at Oxford, postponed the printing of History of Mosses until he received samples from the Americans: Bartram, Clayton and Mitchell.[31] More pertinent to our topic, as competent as Mason and Dixon were, it was Maskelyne who performed the final calculations of the length of a degree based on their data.[32] (One gets the impression from all of this that what is really going on is the scientific analog of mercantilism--the colonies exist to provide raw material for the mother country, which then exports finished products to the colonies.)

In order to promote science, as well as its vision of science, in the colonies, the Royal Society gave unstintingly of its resources. It provided books, instruments, directives, and even money to the natural philosophers in America. "No available opportunity was overlooked to seek to impart to the colonist the objectives of the work of the Society and to assist him in identifying himself with its vast program."[33]

As important as the support of the Royal Society was to

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[30]Kraus, "Scientific Relations," p. 264.

[31]Kraus, Atlantic Civilization, p. 167.

[32]Nevil Maskelyne, "The Length of Degree of Latitude in the Province of Maryland and Pennsylvania, deduced from the foregoing Operations; by the Astronomer Royal," Philosophical Transactions, 58 (1768), 323-25.

[33]Stearns, Science in the British Colonies, p. 116

American science, it was able to do so precisely because it was the Royal Society--a scientific society. What was the nature of a scientific organization, its role in promoting science, and its significance in the history of early modern science? The scientific societies promoted the best science by means of various organizational activities such as publishing journals, awarding prizes, and sponsoring scientific expeditions. In an era when science was not yet institutionalized in the universities, it was the scientific society which provided institutional affiliation for the leading natural philosophers.[34]

Perhaps more than anything else, scientific societies represent the "professionalization" of science. As McClellan states:

> . . . scientific societies were a separate and key stage in the professional development and the social definition of the man of science in the period form the seventeenth to the nineteenth century. . . . Careers in science could be pursued within the orbit of the scientific societies, and they did provide some paid professional positions. The scientific societies were the natural centers in which to work or to which work was sent. [A man of science] used his knowledge. More often than not a man's work was scrutinized and judged by his peers. Membership in scientific societies constituted entry into a professional cadre with its own standards and values. And in the positions of academician, F.R.S., or state employed scientific expert, society recognized well-established social roles.[35]

In terms of this study, Mason and Dixon were "English men

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[34]James E. McClellan, III, Science Reorganized: Scientific Societies in the Eighteenth Century (New York: Columbia University Press, 1985), p. xxi, xxvii.

[35]Ibid., p. xxv.

of science," as Thomas Cope called them, because they met all the criteria of the "professional" that McClellan delineates. They were recognized as competent professionals by the Astronomer Royal as well as by the Royal Society. They did earn their livings by utilizing their science. Being employed by the Penns and Lord Baltimore, (i.e., being "state employed scientific experts"), also validated their role in society. Moreover, because they were recommended by members of the Royal Society, and because the Society sponsored some of their work, the Royal Society represented the "science-society interface" which is so crucial to this study.[36]

As early as 1683 New Englanders attempted to emulate the example of the Royal Society. Their interest aroused by the comets of 1680 and 1682, they formed in Boston a scientific club, or as they termed it, a philosophical society. Although this "first child of the Royal Society of London" existed for only five years, it demonstrated the success of its "parent" in promoting science in America.[37] In 1736, Cromwell Mortimer, secretary of the Royal Society, invited Paul Bradley to establish in Boston "a Company here subservient to the Royal Society" and cooperating with it.[38]

Compared to the previous century when scientists basically worked alone, the scientific societies, especially the Royal

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[36]Ibid., p. xix.

[37]Stearns, Science in the British Colonies, p. 155.

[38]Ibid., p. 487.

Society of London, were primarily responsible for the considerable increase of scientific knowledge at this time. This was accomplished in several ways, but especially through their sponsorship of expeditions and projects.[39] How does all of this relate to the Mason-Dixon survey? Very simply put, "the Mason-Dixon Survey in America was intimately related to scientific projects which the Royal Society was undertaking during the middle years of the eighteenth century."[40]

In this section we have explored the interest of the Royal Society in North America in a wide context. This interest began with John Winthrop, Jr. reading a paper a week before the Society received its official charter, and it continued to the end of the colonial era, with the election of Benjamin Franklin to a seat on the Council. Because science was nurtured in America under the auspices of the Royal Society, it matured as the country did. In one of those mysterious coincidences of history, American science achieved independence precisely at the time that the nation did.

> It appears evident that this early eighteenth-century generation of New England scientists . . .reached new levels of accomplishment and sophistication in their scientific achievements. In their communications with the Royal Society they were no longer content to serve merely as field agents for their masters in the homeland. To the specimens, descriptions, and observations which they sent to the Royal Society, they added philosophical speculations, hypotheses, and

[39]McClellan, Science Reorganized, p. xxvii.

[40]Thomas D. Cope, and H.W. Robinson, "Charles Mason, Jeremiah Dixon, and the Royal Society," Notes and Records of the Royal Society of London, Vol. 9, No. 1 (1951), 55.

> scientific ideas, some of them founded upon scientific experiment and measurement. . . . They marked a growing independence of mind on the part of colonials, and they heralded a day, no longer far distant, when colonial scientists would be able to muster such a degree of self-reliance in scientific matters that they would dare to pit their knowledge against that of the mother country . . . .[41]

When Rittenhouse, Ellicott and their colleagues were commissioned in 1784 to continue the Mason-Dixon line to the western boundary of Pennsylvania, they needed no support from the Royal Society. Their astronomy was equal to, if not superior to, that of the "English men of science."[42] Additionally, the instruments constructed by Rittenhouse, especially his zenith sectors and telescopes, were as high a quality as anything which could be imported from Europe.[43]

During the time that science was growing in the American colonies, border problems were becoming a major concern between Maryland and Pennsylvania. This political issue ultimately would be resolved in the courts of England, but the implementation of the courts' decisions would be a scientific and technical problem. The Royal Society would play an active role in the solution. The next section gives an overview of the political dimension of the border problem.

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[41]Stearns, Science in the British Colonies, p. 486f.

[42]Brooke Hindle, David Rittenhouse (Princeton: Princeton University Press, 1964), p. 256.

[43]Cannon, Science and Culture, p. 100.

II. "NO IMAGINARY POINTS IN THE HEAVENS": THE CONFLICT BETWEEN PENNSYLVANIA AND MARYLAND

"Kings lacked competence in scientific matters and in the writing of their colonial charters made impossible geometrical specifications."[44] The colonial charter issued by Charles I to Cecilius, Lord Baltimore in 1632 entitled Baltimore to all of the Delaware peninsula north of a line drawn east from Watkins Point on the Chesapeake to the Atlantic Ocean south of the fortieth degree of latitude. Baltimore was also given the land west of the Chesapeake, south of the fortieth degree, bounded on the south and west by the Potomac. Also included in the royal patent was the land bordering the Delaware Bay "not yet cultivated" by a Christian people.[45]

Charles II, as payment of a debt owed to William Penn's father, granted William Penn a charter to the territory between Maryland and New York on March 4, 1681. Penn's colony was to be bounded on the north by the forty-third parallel, on the west

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[44] A. Hughlett Mason, ed., The Journal of Charles Mason and Jeremiah Dixon (Philadelphia: American Philosophical Society, 1969), p. 8. For another good summary of the historical background see also Mathews, "History of the Boundary Dispute."

[45] "Pennsylvania and Maryland Boundaries," The Pennsylvania Magazine of History and Biography, 6 (1882), 412. (This unsigned article is prefatory to Lord Baltimore's Narrative.)

five degrees from the Delaware.[46] The southern boundary was to be the fortieth degree of latitude except for that arc of a circle twelve miles about New Castle, and the eastern boundary was the Delaware River/Bay.[47]

Obviously there was much ignorance as to the location of the fortieth degree. When Baltimore's grant was issued it was assumed that the degree would cross the Delaware Bay, and on a map issued in 1635 it is much further south than its true location.[48] When Penn's grant was made the Lords of Trade believed that the line would intersect the circle around New Castle, whereas in reality the fortieth degree passes through Philadelphia.

Charles, Third Lord Baltimore,[49] was informed of Penn's charter on April 2, 1681, and the recommendation made that he and his representatives meet with those of Penn in

> making a true division and separation of the said Provinces of Maryland and Pennsylvania, according to the bounds and degree of Northern Latitude expressed in our said Letters Patents by settling and fixing certain Land Marks where they shall appear to border

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[46]A.H. Mason defines the boundary as a meridian five degrees west of the Delaware Bay. Other sources assert five degrees from the Delaware River.

[47]A.H. Mason, Journal of Mason and Dixon, p. 3.

[48]"Pennsylvania and Maryland Boundaries, " p. 412. The map is annexed to Pennsylvania Archives, Second Series, Vol. XVI, and is included in the inside back cover of this thesis.

[49]The title "Lord Baltimore" extends from 1624-1771, and denotes six different individuals: George Calvert (1624-32); Cecil Calvert (1632-75); Charles Calvert (1675-1715); Benedict Leonard Calvert (1715-1715); Charles Calvert (1715-51); Frederick Calvert (1751-71). See A.H. Mason, Journal, p. 2.

upon each other for the preventing and avoiding all doubts and controversies that may otherwise happen concerning the same.[50]

William Markham was William Penn's deputy governor, and therefore represented him in the new colony. Because of illness and difficulties in transportation, Markham and Baltimore were unable to meet until October, 1681. At this time is was discovered that the latitude of Upland was 39°47'5". One can imagine Baltimore's excitement as well as Markham's disappointment. Baltimore then wanted to go further up the Delaware River to where the fortieth degree crossed it, but as he himself states:

> [Markham] dissented on the grounds that everything along the Delaware from twelve miles North of Newcastle to the 43° had been granted to Penn, and as a loyal representative of Penn, he could not allow any pretence to the territory, and if the patents overlapped, the question must be referred to the king.[51]

The tension was increased when, on September 16, 1681, William Penn himself wrote to several prominent citizens in Cecil and Baltimore Counties informing them that, because they were residents of Pennsylvania, they were no longer required to

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[50]Quoted by Edward Mathews, "History of the Boundary Dispute between the Baltimores and the Penns Resulting in the Original Mason and Dixon Line," Report of the Resurvey of the Maryland-Pennsylvania Boundary Part of the Mason and Dixon Line (Harrisburg: Harrisburg Publishing Co., 1909), p. 125.

[51]Lord Baltimore, "A narrative of the Whole Proceedings betwixt the Lord Baltimore and Capt. Wm. Markham, Deputy Governor under William Penn, Esqr., as also betwixt the Lord Baltimore and the Said Penn, " The Pennsylvania Magazine of History and Biography, 6 (1882), p. 432.

pay taxes in Maryland.[52]

> From the fall of 1681 begins the series of mutual recriminations which mark the entire boundary controversy, lasting for nearly a century. . . . From this point to the close, the records become partisan with skillful omissions of essential details, or artful warpings of the actual facts, which obscure the truth and relative culpability of the contestants.[53]

Complicating the border problem at this time was the issue of the "Three Lower Counties." In 1664 Charles II granted to his brother James, the Duke of York, the land between the Connecticut and Delaware Rivers. The Duke immediately began a campaign to suppress the Dutch colonies in America, including those on the Delaware Peninsula (to which he really had no claim). After several years of war, the Dutch relinquished their claims and ceded all their territory to England. Eventually the Duke of York granted this territory to William Penn. Penn arrived in America on October 24, 1682, and immediately took possession of his colony as well as the three lower counties.[54]

On December 13, 1682 Penn met with Baltimore in an attempt to locate the southern boundary of Pennsylvania. He proposed measuring northward from Cape Charles, Virginia (thought to be 37°05'), using sixty statute miles as the equivalent of a degree. (One degree at this latitude is closer to 69.5 miles). This

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[52]Mathews, "History of the Boundary Dispute," p. 127.

[53]Ibid.

[54]A.H. Mason, Journal of Mason and Dixon, p. 3f.

would have given Penn about 28.5 miles south of the fortieth degree. Baltimore's alternative was much more scientific (and it would also favor his position): proceed up the Delaware River with a sextant and locate the fortieth parallel of latitude. This procedure was unacceptable to Penn, and so no progress was made at this time.[55]

The following April, 1683 Penn agreed to abide by Baltimore's charter boundary if Baltimore would sell him sufficient property so that Pennsylvania would have access to the Chesapeake. Baltimore refused, and negotiations were at a stalemate; the conflicting demands would have to be resolved in England.[56]

To avoid the morass of an enormous amount of detail, we shall simply state the decision of the King in Council, known as "The Decree of 1685." James II, (who thought well of Penn), approved the report of the Committee for Trades and Plantations, and divided the Delaware Peninsula into two equal parts north of Cape Henlopen to the fortieth degree. The eastern portion would belong to Pennsylvania, and the western to Maryland.[57] This decision represented a compromise between Penn and Baltimore. The question of the Three Lower Counties was settled in favor of Penn, while that of the northern boundary in favor of Balti-

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[55]Ibid., p. 4.

[56]Ibid., p. 5.

[57]Council Chamber, 7th of November, 1685, Pennsylvania Archives, Second Series, Vol. XVI, p. 406.

more.[58] Baltimore had his fortieth degree; he should have relinquished his claim to the Three Lower Counties and conducted a survey immediately, but because of his procrastination he eventually lost this northern boundary.[59]

Thomas and John Penn, commenting on this decision in the great Chancery Case of 1735, twisted the meaning of the fortieth degree in order to defend their position.

> Another Matter which confined the Northern End to that dividing Line is very express and remarkable, and falls in exactly with our Construction of Lord Baltimore's Patent; for, that Dividing Line was, by this Order, to run from the Latitude of Cape Hinlopen to the 40th Degree of Northern Latitude; but not, through all that Degree, up to the 41st Degree. All the World understood this as a Judgment in the Favour of Mr. Penn . . .[60]

Penn's sons, in other words, were claiming that the fortieth degree really started at the end of the thirty-ninth degree complete. Moreover, they contend that "the whole world" understood this to be the case; they maintained this patently absurd position throughout the entire Chancery Case.

Instead of accepting the Decree of 1685, Lord Baltimore attempted to have the it annulled. In Council, on June 23, 1709, Queen Anne dismissed Baltimore's petition, ratified the

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[58]Mathews, "History of the Boundary Dispute," p. 144f.

[59]A.H. Mason, Journal of Mason and Dixon, p. 6.

[60]"The Breviate in the Boundary Dispute between Pennsylvania and Maryland." Pennsylvania Archives. Second Series, Vol. XVI (Harrisburg: E.K. Meyers, 1890), p.406. (Hereafter called "Breviate.")

decision of 1685, and ordered its immediate implementation.[61]

Charles, Third Lord Baltimore died in 1715; William Penn in 1718. Various changes in proprietorship in Maryland, and a contested title to Pennsylvania tended to place a moratorium on the boundary dispute for the time being, at least in the courts in London.[62]

Back home there was still controversy. For example, James Logan wrote to Thomas Grey on March 29, 1714, expressing his concern about Baltimore getting the fortieth degree. Logan questioned the validity of the observations of one Mr. Green, who concluded that Newcastle was at 39°29'17". If Baltimore's claim was upheld, then Philadelphia would belong to Maryland. In addition to the boundary question, Logan's letter demonstrates that observational astronomy was current in America.

> Should these observations happen to be discoursed of at London, and the declination tried there, it is to be remembered that the sun's declination on the 9th of March is 5 minutes more at London that day at Noon than it is here, because of the difference of Longitude, which we find by observations of eclipses, etc., is about 75 degrees or 5 hours, and the sun, when near the equator, varies his declination about a minute every hour. If this be not observed, what I have advanced will be thought wrong.[63]

The "Agreement of 1732" was the second major milestone in

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[61]Mathews, "History of the Boundary Dispute," p. 154.

[62]A.H. Mason, Journal of Mason and Dixon, p. 6.

[63]James Logan to Thomas Grey, March 29, 1714, Pennsylvania Archives, Second Series, Vol. VII, p. 47.

the ultimate solution of the boundary controversy.[64] The decision of 1685 failed to resolve the border issue between Baltimore and the Penns. Baltimore had not abandoned his claim the Three Lower Counties; consequently the residents of Delaware were not paying their rents to the Penns.[65] Both Baltimore and the Penns were suffering from a loss of revenue. Furthermore, the Penns were heavily in debt.

In 1731, Charles, Fifth Lord Baltimore, petitioned George II to order the Penns to meet with Baltimore in order reach a definitive solution to the problem. The petition was referred to the Committee for Trade and Plantations for consideration.[66] Meanwhile, Baltimore met with his long-time friend, Ferdinando John Paris, who was also the London agent for the Pennsylvania Assembly.[67] Because of his connection with both Baltimore and the Penns, he offered to serve as a mediator between the two parties. As a result of his efforts the Penns and Baltimore arrived at the famous Agreement of 1732. It was this document which specified the boundaries which would be the basis of the Mason-Dixon Survey. North of Cape Henlopen the Peninsula would be divided according to the decree of 1685: the eastern portion

[64]For a detailed account of the "Agreement," see Nicholas Wainwright, "Tale of a Runaway Cape: The Penn-Baltimore Agreement of 1732," The Pennsylvania Magazine of History and Biography, 87 (1963), 251-293.

[65]A.H. Mason, Journal of Mason and Dixon, p. 6.

[66]Ibid.

[67]Wainwright, "Runaway Cape," p. 253.

would go to Pennsylvania, the western to Maryland. The northern boundary of Maryland would be an east-west line fifteen miles south of the southernmost point of Philadelphia. The northern boundary of what is now Delaware would be a circle twelve miles distant from New Castle (but the center of this circle was not specified.) Commissions were also to be established for the purpose of carrying out the specifics of the agreement[68] (These Articles of Agreement were later printed by no other than Benjamin Franklin himself.)[69]

A communication to the Penns by John Senex, the London engraver of the map affixed to the document, dated April, 1732, provides us with insight into the opinion of astronomy at this time.

> This Division of the Countries in dispute, betwixt the Lord Baltimore, &c. as described in the Articles of Agreement, &c. Seems to be much more convenient and practicable, than any Division that can be made, by affixing the Longitude and Latitude of such Bounds-- Because, the Longitudes and Latitudes of Places are with great Difficulty made sufficiently exact, to determine the true Place of such Boundaries, within less than a Mile or two Miles, Whereas, this Method is easily practicable, and determines it to what Exactness is required. Moreover, in case any Dispute at any time arise, it may soon be adjusted, by any skilful [sic] Surveyor to the Satisfaction of each Party.[70]

The unnamed editor of Lord Baltimore's "Narrative" concludes from statements like these that when the boundary

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[68]A.H. Mason, Journal of Mason and Dixon, p. 6.

[69]Wainwright, "Runaway Cape," p. 260.

[70]Pennsylvania Archives, Second Series, Vol. XVI, p. 448f.

disputes were finally resolved, they were adjudicated on the principle that "when the well-known geographical points mentioned in the patents conflicted with imaginary lines, the former should take precedence."[71]

Regarding the line fifteen miles south of Philadelphia, most authorities (e.g. Wainwright) maintain that this was Baltimore's suggestion. In fact, the Penns were demanding the line be twenty miles south of the city, but Baltimore would not budge. Did Baltimore waive his right to the fortieth degree? He swore afterward that he did not "propose or consent to such limits, but always held that the northern boundary should be at forty degrees complete."[72] Perhaps this is another example of duplicity in this complex case.

According to Mathews, "the agreement of May 10, 1732, changed the entire aspect of the controversy and marked the beginning of the end in the long dispute between the successive proprietors."[73] However, it was a flawed beginning. The commissioners were unable to agree on the measurement of the circle around New Castle. Those from Pennsylvania maintained that the twelve mile circle about New Castle referred to the radius, while those from Maryland insisted that the circumference was meant. On November 23, 1733, the commissioners from

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[71] "Pennsylvania and Maryland Boundaries," Preface to Baltimore, "Narrative of Proceedings," p. 414.

[72] Mathews, "History of the Boundary Dispute," p. 164.

[73] Ibid., p. 163.

both Pennsylvania and Maryland signed a joint statement admitting that they were at an impasse.[74]

Complicating the issue was Baltimore's accusation of deception, his allegation that the map used in the agreement was fraud (it was his own map), and his subsequent abrogation of the Agreement. On August 28, 1734, while the Penns were back in America, Baltimore presented a petition to the King requesting that his charter be confirmed. The petition was referred to the Committee of Trades and Plantations who ruled in favor of Baltimore and recommended the case to the Crown and the Privy Council.[75] On behalf of the absent Penns, the mediator Paris presented a petition seeking dismissal of Baltimore's case, with the result that a postponement was gained.[76] The outcome of all these suits, countersuits, delays, etc., was that on May 16, 1735, King George II ordered that the

> consideration of the various petitions and reports should be adjourned to the end of Michaelmas term, and that either party might have opportunity to obtain relief in a Court of Equity.[77]

This order led to the famous "Great Chancery Suit" which began in 1735 and continued until Lord Hardwicke's final decision on May 15, 1750.[78]

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[74]A.H. Mason, Journal of Mason and Dixon, p. 6.

[75]Mathews, "History of the Boundary Dispute," p. 170.

[76]Wainwright, "Runaway Cape," p. 265.

[77]Mathews, "History of the Boundary Dispute," p. 170.

[78]Ibid.

The Breviate, as it is called, is our primary source for the Great Chancery Suit. This enormously long work contains depositions of the Penns, Baltimore, Pennsylvanians and Marylanders in America, and expert witnesses in London. It also contains the history of the controversy up until the time it was printed, and reprints verbatim the decisions of 1685 and 1732. Although portions of it are somewhat polemical in nature (most of the Maryland documents have been lost), it is still the standard source.[79]

The testimony in the Breviate with which we are primarily concerned are those statements which refer to science, especially astronomy, vis-a-vis the boundary problem. We have already referred to an opinion of John Senex which was included in the Breviate. Other statements reiterate this fundamental position, or when they do not, Richard Penn was quick to detect "flaws" in the reasoning. The issue of the fortieth degree was supposedly resolved in the Agreement of 1732, but the following testimony demonstrates that it was still a debated issue up until 1750.

For example, the Penns cross-examined Benjamin Eastburn, a witness for Baltimore and made some observations.

> [Benjamin Eastburn] has been informed, that some Persons, several years ago, made Observations in Philadelphia, in order to discover its Latitude. And this Affirmant has, likewise, made some Observations, for the same purpose. And, according to the best Judgment he can form from his Observations, he believes, that the Market-Street in Philadelphia, does not lie so far North as the Latitude of 40 degrees

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[79]The Breviate was printed in its entirety in Pennsylvania Archives, Second Series, Vol. XVI, 1890.

> compleat [sic], but near to the Northernmost Part of the said Degree. But, as Astronomers differ, among themselves, concerning the Places of the Heavenly Bodies, their Declinations, and the Latitude of the Stars, and proper Allowances for Refractions, it is almost impossible to determine the exact Latitude of any Place, with the best Instruments; And as the instruments, chiefly made use of by the Affirmant, on this occasion, were made by himself, and very imperfect, he cannot take upon himself to speack [sic] certainly of the Latitude of any Part of the Street aforesaid: And says, that he has heard, and believes, that the Surveyors, appointed by Commissioners, in pursuance of and Order of the King in Council, about the Year 1733, to lay out the Northern Neck in Virginia, did differ, about the Latitude of one Place in the said Neck, fourteen, about another, fifteen, and a third, seventeen, Geometrical Minutes [which is very near 20 Miles] And that his information was from John Warner, one of the Persons employed to make the said Observation.[80]

In his attempt to undermine Eastburn's credibility, Thomas Penn drew attention to the fact of the uncertainty of the observations; and also added, "What pretty Work this would make, in explaining the King's Grants by Degrees (especially when there are certain Landmarks in a Charter?)."[81]

Not only did the Penns question the accuracy of astronomical observations, they were intent on undermining the commonly accepted understanding of what the fortieth degree meant, and twisting the meaning to suit their own ends. For example, Thomas H. Wright, Esq., Deputy Surveyor of Queen Anne's County, testified that the fortieth degree must be applied only to the fortieth degree complete. The Penns replied:

> This Surveyor is a very bad Expounder of the King's

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[80]<u>Breviate</u>, p. 682.

[81]<u>Ibid</u>.

Charters; and he is, either a great Quibbler upon Oath, or else, a most wretched Mathematician; for, with his Leave, 39 Deg. 59 Min. is under the 40th Degree; and so is 39 Degrees 1 Minute; and every single Hair's Breadth, from 39 compleat [sic] to 40 compleat; altho' none of them are to the Extent of the 40th Degree compleat.[82]

Witnesses from Maryland continued to defend the fortieth degree (complete) as the Northern boundary of Maryland, while the Penns were just as adamant in their claim. Sometimes the latter bordered on the irrational. Commenting on the deposition of William Rumsey, another Maryland surveyor, the Penns wrote:

> And another particular Error of this Witness is, that he is looking to the 40th Degree as now known (108 Years after the Time of my Lord's Charter) whereas, if he were to go according to the Degree at all, it should be the Degree as then known.
> But the greatest Opinions have, unanimously, been, that my Lord's Charter is to be expounded according to the Landmarks, and not any imaginary Points in the Heavens, the Uncertainty whereof the Defendant himself has given such an Account of.[83]

Hugh Jones, BA, MA, a former professor of mathematics at William and Mary, and in 1732 a minister near Newcastle, provided the same basic testimony. The Penns reiterated their assertion that forty degrees had to be where it was thought to be in 1632, and added that if the witness were correct:

> His words carry a very clear Proposition in them, and necessarily imply another, more short and more clear, that the whole Space of the 40th Degree was granted to Lord Baltimore; which brings it to a Fact that the whole Degree was granted Lord Baltimore; whereas I contend, that it was not, it could not, and it was not intended to be granted to him, for it was, before,

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[82] Ibid., p. 683.

[83] Ibid., p. 685. See enclosed map for the supposed location of the fortieth degree in Baltimore's Charter.

most precisely granted to the Council of Plymouth for the ruling of New England.[84]

Not only was the witness in error regarding the fortieth degree, he could not be trusted; he had an ulterior motive. Because the Rev. Jones was a minister near Newcastle, with an allowance of forty pounds of tobacco per person within his parish, the county of Newcastle with 11,000-12,000 souls would greatly increase his income.[85] The Penns were stooping rather low in their polemics!

The great irony of all of this is that, regardless of how much the Penns attempted to discredit astronomical observations in ascertaining the boundary between Maryland and Pennsylvania, it was precisely because of astronomy that the Mason-Dixon survey succeeded.

In addition to Thomas Penn's denigrations of astronomy and distortion of the meaning of the fortieth degree, there is evidence of a different nature which indicates that deliberate deceit was involved. Two years after the Chancery Suit was resolved the great cartographer, Lewis Evans, published a map of the Middle Colonies of America; boundaries were in accord with the decision of Lord Hardwicke. In an earlier version of his map (1739) Evans had drawn the southern boundary at the thirty-ninth parallel, in agreement with what he believed was the

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[84]Ibid., p. 688.

[85]Ibid.

truth. This earned for him the good graces of the Penns.[86]

For unknown reasons Evans soon fell out of favor with the Penns. His interest in the case must have led him to become the first historian of the border controversy because he soon began to collect and investigate numerous documents associated with the case, and basically proved that the southern boundary of Pennsylvania was in actuality the fortieth degree of latitude.[87]

Apparently this turn of events occurred when Evans happened to come across some of the briefs prepared for the Chancery Suit. Among these was a document related to William Penn's application for his charter, in which it was stated explicitly "that the beginning of the 40th Degree is somewhere above Newcastle." Evans was convinced at that point that the beginning of the degree was truly at forty degrees, and not at thirty-nine as the Penns had been maintaining.[88] Furthermore, he also concluded that the Penns were not only "ungrateful, but untrustworthy," and proceeded to offer his services to the Baltimore.[89] The evidence for deception comes from Thomas Penn himself, who referred to this matter as "Lewis Evans's Discovery," and expressed concern that the document would fall into

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[86]Lawrence H. Gipson, Lewis Evans. To Which is Added Evans' "A Brief Account of Pennsylvania (Philadelphia: Historical Society of Pennsylvania, 1939), p. 21.

[87]Ibid., p. 42ff.

[88]Ibid., p. 41.

[89]Ibid.

the hands of Baltimore.[90]

The Chancery proceedings between Baltimore and the Penns took fifteen years. Finally on May 15, 1750, Philip Lord Hardwicke, Lord Chancellor of Great Britain, handed down his definitive decision. "The Articles of Agreement of the 10th May, 1732, are valid and obligatory . . . and that the said Articles ought to be specifically executed and performed."[91]

Immediately after Lord Hardwicke announced his decision, commissioners, agreeable to both parties, were named to survey and mark the boundaries.[92] However, some questions remained unanswered, and problems persisted. For example, John Watson, assistant surveyor to the Commissioners of Pennsylvania, remarked in his journal entry for November 17, 1750, that the Commissioners were still arguing whether the radius from New Castle should be measured in horizontally or superficial miles.[93] On March 1, 1751, three distinguished members of the Royal Society testified before the High Court that the circle should be measured by horizontal miles; and four weeks later the Lord Chancellor ordered the measurements to be made in this

[90]Ibid., p. 41, n. 12.

[91]Wainwright, "Runaway Cape," p. 284.

[92]Thomas D. Cope and H.W. Robinson, "When the Maryland-Pennsylvania Boundary Survey Changed from a Political and Legal Struggle to a Scientific and Technological Project," Proceedings of the American Philosophical Society, 98 (1954), 435.

[93]John W. Jordan, "Penn versus Baltimore: The Journal of John Watson, Assistant Surveyor to the Commissioners of the Province of Pennsylvania, 1750," The Pennsylvania Magazine of History and Biography, 38 (1914), 390.

manner.[94]

Watson, who we will find to be a very competent surveyor, was also amused by the method used by the Maryland Commissioners to determine the center of New Castle.

> Note the Point in the Maryland Plan, mentioned in these Notes before and supposed designed to represent the Situation of the Court House, was since discovered to be intended for the Center of gravity of the Town of New Castle, which it seems the Maryland Surveyors and Mathematicians attempted to find in this ridiculous Manner viz.--having made an exact plan of the Survey of the Town, upon a Piece of Paper, they carefully pared away the Edges by the Draught, untill [sic] no more than the Draught was left, when sticking a Pin thro it, they suspended it thereby in different places untill they found a place whereby it might be suspended horizontally which Point or place they accepted as the Center of Gravity.[95]

It was eventually decided by mutual agreement that the spire of the courthouse would be designated the "center" of Newcastle.

Colonial surveyors also surveyed the transpeninsular line and marked the Middle Point in 1751. Their work was accepted by both the Penns and Baltimore as the "true east-west line," although the Middle Point (the southeast corner of Delaware) is about three-quarters of a mile north of the stone set up on Fenwick's Island.[96]

The death of Charles, fifth Lord Baltimore, brought the provincial survey to a standstill. Complicating the matter was

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[94]Cope and Robinson, "When the Boundary Survey Changed, " p. 435.

[95]Jordan, "Journal of John Watson," p. 401f.

[96]Cope and Robinson, "When the Boundary Survey Changed," p. 435.

the refusal of Frederick, sixth Lord Baltimore, to acknowledge the previous agreements between the Penns and the Calverts. Fortunately, Baltimore modified his position in 1734. Thomas Penn wrote to Richard Peters informing him that:

> My Lord Baltimore being weary of law has proposed to submit to the Decree against his father on the condition that we release him from the payment of our costs. This we have consented to on his agreeing to leave the line already run from Fenwick's Island to Chesapeake Bay [as] the south boundary of the Counties.[97]

On July 4, 1760, the "Indenture of Agreement" was signed between the Penns and Baltimore; and seven commissioners from each province were appointed the next day to supervise the running of the lines.[98] The agreement basically confirmed that of 1732, but some details were more clearly defined. The chaining would be horizontal, the center of New Castle would be the center of the tower of the courthouse, the width of the peninsula would be measured from the shore of the Atlantic to the shore of the Chesapeake, and that the north-south boundary between Maryland and the Three Lower Counties would be a line from the Middle Point tangent to the twelve mile circle about New Castle.

Word of the agreement reached Philadelphia and Annapolis in September. Immediately Governor James Hamilton of Pennsylvania and Governor Horatio Sharpe began corresponding about their new

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[97]Wainwright, "Runaway Cape," p.285.

[98]"Indenture of Agreement, &c, Between Lord Baltimore and Thos. and Rich'd Penn, Esqr's. 4th July, 1760," Pennsylvania Archives, Vol IV, pp 1-36.

joint responsibility. The two governors and the commissioners from both colonies convened for the first time on November 19, 1760.[99]

There was scientific talent in the two provinces which was utilized by Thomas Penn, Cecil Calvert, and their respective governors, Hamilton and Sharpe. Early in the survey Sharpe sent the mathematical scholar, the Rev. Barclay, to Williamsburg in order to induce Professor Graham, of the College of William and Mary, to be an advisor to the Maryland Commissioners. Later on, Barclay himself was nominated to fill a vacancy on the board.[100]

Sharpe recommended that the Rev. William Smith, provost of the College of Philadelphia, be an advisor to the Pennsylvania commissioners. Instead, Thomas Penn and Governor Hamilton selected the Rev. John Ewing, natural philosopher, mathematician, and astronomer, of the College of Philadelphia to fill a vacancy. This ultimately proved to be a stroke of genius. "No other American scientist of those days learned to know Mason and Dixon as persons and as scientists as did Rev. John Ewing."[101] In fact, it was to Ewing that Mason bequeathed his astronomical observations when he died.

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[99]Thomas D. Cope, "Mason and Dixon: English Men of Science," Delaware Notes, Twenty-second Series (Newark: University of Delaware, 1949), 13f.

[100]Cope, "English Men of Science," p. 16. See also Cope, "Some Local Scholars who Counselled the Proprietors of Pennsylvania and their Commissioners during the Boundary Surveys of the 1760's," Proceedings of the American Philosophical Society, 99 (1955), 268-276.

[101]Ibid., p. 17.

As the transpeninsular line was accepted as surveyed in 1751, the first task of the colonial surveyors was to run the tangent line. Their procedure indicates the relative competence of the American surveyors. First, they ran a line due north along the meridian from the Middle Point until it was near the twelve-mile circle about New Castle. Then a radial line was run from the courthouse until it intersected with the meridian line. From the distances and angles measured, trigonometric calculations showed that the tangent line would lie 3°32′05″ west of the meridian.[102]

Astronomical methods were used in running the meridian due north. Alioth (the first star in the handle of the Big Dipper) and Polaris were lined up with a plumb line and a lantern. However, during June and July Alioth and Polaris are in vertical alignment only during daylight hours. Watson, whom we have already met, recommended another method of determining the meridian. In 1761 Polaris moved around the pole in a circle of small radius. By using a telescope and plumb line the surveyors placed a lantern directly beneath Polaris when it was furthest east of the pole. From the angular radius of the circle circumscribed by Polaris, Watson calculated the angle between the meridian and their line of sight toward the lantern. This method failed to provide the needed accuracy and was eventually abandoned. Cope, however, reminds us that the method devised by

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[102]A.H. Mason, Journal, p. 7.

Watson for finding a meridian, i.e. finding the maximum elongation of Polaris and calculating the position of the pole, was still the standard practice in 1956.[103]

The American surveyors made two attempts at running the tangent line. During the summer of 1762, after running the line for 81 miles, 74 chains and 65 links, the tangent line intersected the New Castle radius 0.422 miles east of the calculated tangent point. The second attempt, completed in August 1763, passed 5 chains, 25 links to the west of the calculated tangent point.[104] Further calculations indicated a more precise direction for the line. However, before the line could be run Mason and Dixon were appointed the official surveyors for the project.

One must put in a good word for the colonial surveyors. Thomas Penn thought that their efforts were an exercise in incompetence.[105] He was amazed that "the surveyors were so ignorant as to run the Meridian Line with a wooden telescope that was left abroad in wet weather."[106] Penn didn't know the entire story. Watson, in the May 18, 1761, entry in his field book, tells us what happened.

The short telescope of Governor Sharpe's theodolite had

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[103]Thomas D. Cope, "When the Stars Interrupted the Running of a Meridian Line Northward up the Delaware Peninsula," Proceedings of the American Philosophical Society, 100 (1956), 563.

[104]A.H. Mason, Journal, p. 8.

[105]Kleber, "The Mason and Dixon Line," History Today, 18 (1968), 121f.

[106]Ibid.

been used in running the meridian line from the Middle Point to the Nanticoke River. At this point, during the first week of May, the surveyors found that the telescope was too short to discern both the plumb line, near at hand, and the top of a staff across the river. The surveyors improvised by constructing a support for the telescope which was four and one-half feet long when extended. This enabled them to view, in one field, both the plumb line and the tops of staves at greater distances. They not only used this device to measure across the river, but because it was so effective, they continued to employ it until May 16. On May 17 the surveyors were using the telescope and its wooden support in the rain, which eventually caused distortion in the images. Experiments with the telescope occupied the afternoon of May 18. Watson, Stapler, Garnett and Emory signed the entry in the field book. Thomas Penn, in England, heard only part of the story, rashly judged the surveyors, and reacted by soliciting assistance in London.[107] The Royal Society will once again come into our story.

The provincial surveyors were "able, conscientious, and responsible." But they were trying to solve a complex problem which was beyond their training and their equipment.[108]

> They brought to their work neither the training, nor the experience, nor the instruments, nor the volume of scientific and technological counsel that Mason and Dixon brought with them to Philadelphia in November, 1763. But they did bring to their work integrity,

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[107]Cope, "When the Stars Interrupted," p. 560.

[108]Cope, "English Men of Science," p. 22.

> sound technological instincts, and a goodly measure of genuine competence, as their field books show. They carried on and they did achieve results that stood up under scrutiny.[109]

In this section we have seen that on three different occasions, i.e., 1685, 1732, and 1750, the boundary controversy between Pennsylvania and Maryland had to be adjudicated in the courts of London. After 1750 the focus of the problem gradually shifted from the political arena to the scientific and technological. It is to this area that we now turn our attention.

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[109]Cope, "When the Stars Interrupted" p. 565.

III. THE INFLUENCE OF THE ROYAL SOCIETY: THE ROLE OF INDIVIDUAL MEMBERS

Thomas Cope once wrote:

> To comprehend Mason and Dixon one must place himself in the midst of the scientific and technological London from which they came to America in 1763 and to which they returned in 1768. Throughout their work in America, they were under the advice of this London. Lord Baltimore and Thomas Penn sought advice from this coterie in London . . ..
>
> As seen from the scientific London of the 1760's the work of Mason and Dixon in America assumes its true perspective and significance in the development of science and technology. This is lost to the historian who persists in viewing events in Pennsylvania only from a Pennsylvania frame.[110]

The purpose of this chapter, indeed the entire paper, is to situate the work of Mason and Dixon in its proper "frame of reference." The influence of the Royal Society of London on the work of Mason and Dixon is viewed from a twofold perspective. First, we shall investigate the role of the individuals who were members of the Royal Society, but were not acting on behalf of the Royal Society per se. Secondly, we will examine specifically the scientific and technical support given to Mason and Dixon by the Society itself. What emerges is a picture of the interrelationship of scientists, technicians and even political figures in a complicated network.

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[110]Thomas D. Cope, "A Frame of Reference for Mason and Dixon," Proceedings of the Pennsylvania Academy of Science, 19 (1945), 82.

Long before the provincial surveyors experienced difficulties in running the tangent lines, the Penns, Baltimore, and the Governors were seeking competent scientific assistance in London. On December 20, 1760, almost as soon as the survey began, Horatio Sharpe wrote to Lord Baltimore (in what must be a record for a run on sentence):

> As I am apprehensive from what passed between the Commissioners . . . that [they] 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 Lordship would submit some queries which I have take the Liberty to transmit and such others as your Lordship may think fit to the Consideration of some Gentlemen who have devoted a great part of their Lives to the Study of the Mathematicks 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, but as these Gentlemen may not be apprized of all the Difficulties which will attend running Lines on the Surface of the Earth some through a Forrest [sic], some over Boggs and Marshes and others over a hilly or mountainous Country and the Difficulties which will attend the measuring such Lines horizontally, your Lordship will not perhaps think it amiss to submit their Opinions or Schemes of these Gentlemen or any other Theorists whom you may be pleased to consult to the Consideration of some Person that hath been used to run and measure Lines on the Surface of the Earth, for oftentimes a Thing might appear very easy in theory which, the best Artist cannot carry into practice.[111]

Senex had died in 1740, Bradley was aged and infirm, and there is no evidence that Cockayne was ever approached for advice.[112] However, in addition to the request for scientific and technical counsel, Sharpe's letter reveals his basic

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[111]Cope, "English Men of Science," p. 14.

[112]Cope and Robinson, "When the Boundary Survey Changed," p. 437.

awareness of English scientific talent.

Although none of the persons recommended by Sharpe became scientific consultors of Baltimore, Sharpe's advice was, in principle, accepted by Baltimore. The Fellow of the Royal Society who did become the principal advisor to Frederick, Lord Baltimore, was John Bevis, a physician and distinguished astronomer.[113] Bevis, a friend and coworker of both Halley and Bradley, is referred to in sixteen letters of Gov. Sharpe, and in fourteen letters of Thomas Penn. Because Bevis is mentioned so frequently in official correspondence from the time that Sharpe suggested that Baltimore seek the advice of Bradley and others, Cope and Robinson conclude that perhaps Bradley himself endorsed Bevis as advisor to Baltimore.[114]

Bevis is important to the Mason-Dixon survey for one particularly important reason. Previously he had been part a surveying project of the Salisbury Plain which involved the running of a meridian as well as a parallel of latitude. During this survey Bevis used a new type of transit instrument made by James Short which was quite accurate in ascertaining the meridian as well as the latitude of a locality. Because of this experience, Bevis, along with Daniel Harris, was able to formulate the plans and suggestions for running the survey in America. These were the plans that the proprietors recommended

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[113]Thomas D. Cope and H.W. Robinson, "Charles Mason, Jeremiah Dixon, and the Royal Society," Notes and Records of the Royal Society of London, 9 (1951), 63.

[114]Cope and Robinson, "When the Boundary Survey Changed, p. 437.

to their commissioners and which Mason and Dixon brought with them to America.[115] Moreover, in a letter to Governor Sharpe, dated August 17, 1763, Cecilius Calvert forwarded Bevis's transit instrument via Mason and Dixon, a receipt for £71 for the transit, as well as Bevis's detailed plans for the survey.[116]

Thomas Penn, too, sought scientific advice even before the tangent lines were run. In his correspondence of April and May 1761 to Gov. Hamilton and Secretary Peters, Penn refers to Mr. Simpson. "[He is] second Master of the Academy of Woolwich . . .; he has been recommended to me as the fittest Person to give these directions." (The directions were from Provost Smith concerning the running of the east-west line fifteen miles south of Philadelphia.)[117] However, because Simpson was ill, Penn wrote instead to John Robertson, who was to become his principal scientific advisor.[118]

Actually Robertson first became involved with the Penns during the first attempted survey of 1751, when he was master of

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[115]Thomas D Cope, "Local Natural Philosophers Who counselled the Boundary Surveys during the 1760's," Proceedings of the Pennsylvania Academy of Science, 29 (1955), 42.

[116]Edward L. Burchard and Edward B. Mathews, "Manuscripts and Publications Relating to the Mason and Dixon Line and Other Lines in Pennsylvania, Maryland and the Virginias Involving the Charter Rights of Lord Baltimore and the Penns," Report on the Resurvey of the Maryland Pennsylvania Boundary Part of the Mason and Dixon Line (Harrisburg: Harrisburg Publishing Co., 1909), p. 342.

[117]Cope and Robinson, "When the Boundary Survey Changed," p. 440.

[118]Ibid.

the Royal Mathematical School at Christ's Hospital (1748-55).[119] From 1755 to 1766, during the time presently under discussion, he was First Master of the Royal Naval Academy, after which he served the Royal Society in various capacities. He wrote several treatises on navigation and had nine papers published in the Philosophical Transaction from 1750-1772.[120] As principal advisor to the Penns, "John Robertson contributed in a major way to the organization of the survey in America by suggestions that he originated and by his criticisms and evaluations of the suggestions of other men."[121]

Fortunately for all involved, Bevis, chief scientific advisor to Baltimore, and Robertson, serving the Penns in the same capacity, collaborated with one another and worked well together when counselling the Proprietors about the survey.[122]

Co-author, with Bevis, of Hints for Running the Lines was Daniel Harris, F.R.S., who had succeeded Robertson at Christ's Hospital. When William Smith of the College of Philadelphia sent suggestions on running the lines to Thomas Penn, Penn solicited the advice of Harris (January 1761). Writing in March to Secretary Richard Peters regarding the running of the tangent line, Penn mentions a

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[119]Ibid., p. 434.

[120]Ibid., p. 437.

[121]Cope and Robinson, "When the Boundary Survey Changed," p. 437.

[122]Ibid.

Proposition from the Master of the Mathematical School at Christ's Hospital which requires finding latitudes and longitudes of New Castle and Fenwick's Island. We must not agree to it as we have been preaching about the uncertainty of celestial observations.[123]

Once again we see an example of Thomas Penn's attitude toward observational astronomy in determining the boundary lines between Pennsylvania and Maryland. However, he must have undergone a conversion experience, because by September 1763, he and Baltimore agreed that latitude should be "ascertained by distance of stars."[124]

Perhaps the consulter who helped change Thomas Penn's mind was John Blair, F.R.S. During May, 1762, Penn wrote to Gov. Hamilton, Secretary Peters, and to the Commissioners for Pennsylvania. In each of the three letters he mentions that their questions concerning the survey were referred to John Blair for study and comment. In a letter dated May 28, 1762, Penn informed the Commissioners that

> [Dr. Blair] approves making the Tangent Line by offsets from the Meridian; he thinks the parallel of latitudes can be most certainly done by observations made with the [zenith] sector which is now making [by John Bird]; he suggests that Dr. Bevis's transit instrument may be of use to compare with the other work, but I find that he does not depend greatly upon it; he thinks the instrument you wrote for will not now be of any use.[125]

Although Bevis, Simpson, Robertson, et al. were influential

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[123]Cope and Robinson, "When the Boundary Survey Changed," p. 439.

[124]Burchard and Mathews, "Manuscripts and Publications," p. 342.

[125]Cope and Robinson, "When the Boundary Survey Changed," p. 439.

and important scientific consultants to the Proprietors, we must keep in mind that "at the head of the list of advisors commended to Lord Baltimore by Governor Sharpe stands Reverend James Bradley."[126] Although Bradley himself was not part of the group of Fellows of the Royal Society who directly advised Baltimore or the Penns, his influence simply permeates the project. Because of the techniques, discipline, accuracy, perseverence and patience which Bradely espoused and communicated to Mason, the team probably owed more to Bradley than to any other individual scientist then living.

In 1725, when Samuel Molyneux was searching for stellar parallax in the position of the star Gamma Draconis, he was joined by Bradley, Savilian Professor of Astronomy at Oxford. Instead of finding the hoped-for parallax, the astronomers made the remarkable discovery of the aberration of starlight.[127] Bradley also formulated that "elegant rule" for determining the refraction of light as a function of zenith distance, temperature, and atmospheric pressure.[128] Continuing to make observations with his zenith sector, he discovered the nutation of the earth by 1747.[129] Based on the values Bradley obtained for the

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[126]Cope, "English Men of Science," p. 14.

[127]Thomas D. Cope, "Zenith Sectors and Discoveries made with Them, Linked with More Recent Events in Pennsylvania," Proceedings of the Pennsylvania Academy of Science, 18 (1944), 73.

[128]Robert Grant, History of Physical Astronomy (London: Henry G. Bohn, 1852), p. 484.

[129]Cope, "Zenith Sector," p. 73.

aberration of light and his theory of its cause, he was able to estimate that the speed of light is 10,210 times the speed of the earth in its orbit about the sun, a value which is in remarkable agreement with Roemer's.[130]

When Bradley was named the third Astronomer Royal of England and director of Greenwich Observatory in the summer of 1742,[131] he continued his series of remarkable observations. Robert Grant, in praising Bradley's labors, remarked that he was aided by only one (unnamed) assistant.[132] That man, of course, was Charles Mason. The last observation in the record entered in Bradley's hand is in September, 1756. Charles Mason's handwriting first appeared in October, 1756, and continued until he left in order to observe the transit of Venus in 1760.[133]

A. H. Mason states that we may assume that Charles Mason aided Bradley in his extensive astronometric work.[134] Surely this is an understatement. As Rigaud informs us, the meridian observation had to be carried out simultaneously at the quadrant and at the transit. This necessitated the use of an assistant.

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[130]Ibid.

[131]S.P. Rigaud, "Memoirs of Bradley," Miscellaneous Works and Correspondence of the Rev. James Bradley, D.D., F.R.S. Edited by S.P. Rigaud (Oxford: Oxford University Press, 1832), p. xcix, n. k.

[132]Grant, History of Physical Astronomy, p. 484.

[133]Rigaud, "Memoirs," p. xcix, n. k.

[134]A.H. Mason, "Charles Mason," Dictionary of Scientific Biography, Vol. IX. Edited by Charles C. Gillespie (New York: Charles Scribner's Sons, 1970), p. 164.

"But the assistant was trained by himself, and acted under his control; he was answerable for the performance of their duties, and he therefore had a right to connect their labors with his own."[135] Although never equal to Bradley, in one way Mason did go beyond him. From Bradley's 60,000 observations obtained between 1750-1762, Mason compiledd a catalog of 387 fixed stars which was added to the Nautical Almanac for 1773.[136]

By 1760, when the colonial survey was just getting underway, Bradley was old and in very poor health. Perhaps he could not advise Baltimore, but he could suggest Bevis as the best person to be of assistance. Furthermore, as a member of the Council of the Royal Society, and as the premier astronomer of the country, he was still in a position to name Nevil Maskelyne and Charles Mason as observers for the transit of Venus expedition. In fact, his last public paper was the instructions to Mason on the method of observing the transit of Venus.[137]

When Mason and Dixon came to America they brought with them Bradley's passion for precision, the techniques which they had learned from him, and the quality of instruments which Bradley had demanded.[138] Mason and Dixon's observations are replete

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[135]Rigaud, "Memoirs," p. xcii.

[136]Ibid.

[137]Rigaud, "Memoirs," p. c. The instructions are printed in their entirety in Bradley, Miscellaneous Works and Correspondence, pp. 388-90.

[138]Thomas D. Cope, "The Apprentice Years of Mason and Dixon," Pennsylvania History, 11 (1944), 158.

with corrections for refraction, precession, aberration, and nutation. They are, perhaps, among the first surveyors to compensate for these factors in their measurements. For every second of error eliminated in their determination of latitude, a linear error of 100 feet was also removed.[139] It is to James Bradley that Mason and Dixon owe their technique and precision.

If Bradley's celestial observations were of unprecedented accuracy, if he was able to discover the aberration of light and the nutation of the earth, we must be eternally grateful to his instrument makers. John Bird, F.R.S., in particular, plays an important role in our story. It was Bird who recommended his friend and acquaintance, Jeremiah Dixon, as a partner to Charles Mason for the transit of Venus expedition. And it was Bird who constructed the zenith sector which played such a crucial role in the Mason-Dixon survey.

Prior to the eighteenth century scientific instruments usually were constructed by those who intended to use them. However, a new profession was arising--that of the professional scientific instrument maker. It was in the eighteenth century that scientific instruments truly became instruments of precision; with earlier instruments it would have impossible to achieve the accuracy that Bradley, for example, attained.[140] But the scientific instrument makers were not simply craftsmen

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[139] Ibid., p. 164.

[140] Reginald S. Clay and Thomas H. Court, "English Instrument Making in the Eighteenth Century," Transactions of the Newcomen Society, 16 (1935-36), 53.

of exceptional skill and genius; they were also men of science, as indicated by their membership in the Royal Society.[141] The technical advances in science at this time were due in no small part to men of mechanical genius such as Graham, Sisson, Bird, the Dollands, and Ramsden.[142]

The preceding list of master craftsmen-scientists is in reality a continuous line of masters and apprentices. Graham, for example constructed the zenith sector which enabled Bradley to discover the aberration of light and the nutation of the earth. The clock at Greenwich was attributed to Graham, but Maskelyne informs us that it was made by Shelton under Graham's supervision because Graham was too old to do the job himself.[143] In John Bird, Graham "saw another artist rising to emulate his fame, and advance the improvements which he had made in the division of astronomical instruments."[144] In his book The Method of Dividing Astronomical Instruments, Bird himself said that he learned his skill from thirty-four years of experience and from the teaching of Sisson.[145]

When Flamsteed was Astronomer Royal, the government failed

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[141]Ibid., p. 45. Dr. Gregory Good suggests that perhaps the Royal Society simply had an appreciation for technicians as well as scientists.

[142]A. Wolf, A History of Science, Technology, and Philosophy in the Eighteenth Century (London: Allen & Unwin, 1952), p. 122.

[143]Rigaud, "Memoirs," p. lxxvi.

[144]Ibid.

[145]C. Doris Hellman, "John Bird (1709-1176) Mathematical Instrument-Maker in the Strand," Isis, 17 (1932), 145.

to equip Greenwich Observatory with the necessary precision instruments. Consequently Flamsteed provided for many instruments out of his own pocket. When he died his executors removed most of the instruments from the observatory. Perhaps this was a blessing in disguise. The government provided £1000 for new equipment and much of it was built by John Bird.

Bradley had Bird construct a brass mural quadrant of eight-foot radius, and a transit instrument of eight-foot focal length. With these instruments Bradley began the astronomical observations which were carried on by Maskelyne after Bradley's death. In 1776, Maskelyne commented on Bird's instruments.

> The exactness of the instruments is so great, and their rectification so nice, that the place of any heavenly body may always be found by them within ten seconds of a degree, both in Longitude and Latitude, and generally much nearer.[146]

The Records of the Royal Society show that Bird provided:

--an apparatus for trying the line of collimation
--an arch for the transit instruments
--a level
--a brass mural quadrant
--a movable quadrant
--a transit instrument
--a twenty foot refracting telescope
--a barometer and a thermometer
--various alterations to existing equipment[147]

Not only did Bird furnish many of the instruments for the Greenwich Observatory, but he also constructed an eight-foot mural quadrant for the Imperial Academy of Sciences at St. Petersburg, and a six-foot mural quadrant for the University of

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[146]Helllman, "John Bird," p. 135.

[147]Rigaud, "Memoirs," p. lxxiv.

Göttingen for Tobias Mayer.[148] Regarding the Mason-Dixon survey, Bird's most significant contribution was his zenith sector, which provided more precise measurements than the sector of Graham.

The first zenith sectors of superior precision were made by Graham for Molyneux (1725) and Bradley (1727).[149] Bradley described this instrument in great detail,[150] and his zenith observations are still extant.[151] Appended to his description of Graham's zenith sector is a commentary by Maskelyne:

> This instrument, constructed by that excellent artist Mr. Graham, with his peculiar elegance and accuracy, was fixed up at Wanstead in the year 1727, for the use of that great astronomer Dr. Bradley; who, from his first year's observations with it, discovered the apparent motion of the fixed stars, which he called the aberration of light, and settled the laws of it; and, from the same observations continued for a course of twenty years, discovered the nutation of the earth's axis: two discoveries so profound, and at the same time so useful and necessary to the improvement of astronomy, that they will ever do him honour, while accurate observations and astronomical speculations are held in estimation.[152]

Wolf describes the zenith sector as a "special type of transit circle intended for the refined measurement of small differences in the meridian altitudes of stars transiting near

[148]Hellman, "John Bird," p. 136f.

[149]Wolf, History of Science and Technology, p. 133.

[150]James Bradley, "Memoranda Respecting the Instrument at Wansted," Miscellaneous Works and Correspondence, pp. 194-200.

[151]Bradley, "Observations on the Fixed Stars Made at Wansted in Essex," Miscellaneous Works and Correspondence, pp. 210ff.

[152]Bradley, "Memoranda," p. 197f.

the zenith."[153] A zenith sector consists of a long telescope which pivots about an east-west horizontal axis located near the object glass; near the eyepiece is a graduated scale. A plumb line is suspended from the geometrical center of the arc, which lies in the axis of rotation. The plumb line crosses the scale and thus gives the zenith distance of the point on the meridian. Observations made with a zenith sector are the least affected by atmospheric refraction, and they are optimal for measuring the difference of latitude along a meridian of arc.[154]

For example, when Mason and Dixon were determining the latitude of the southernmost point of the city of Philadelphia, they used a zenith sector. By measuring the angle between their zenith and an observed star when it was precisely on their meridian, and knowing the declination of the star, they were able to calculate the latitude of the observatory.[155]

Maskelyne took a ten-foot zenith sector made for the Royal Society when he went to St. Helena for the transit of Venus expedition. In using it he discovered a fundamental flaw in its basic design: the way in which the plumb line was suspended introduced a significant error in the readings. Moreover, all zenith sectors up to this time suffered from the same fundamental fault. Maskelyne demonstrated this defect before the Royal

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[153]Wolf, <u>History of Science and Technology</u>, p. 132.

[154]<u>Ibid</u>., p. 133.

[155]Charles D. Leach, "Placing the Post Mark'd West," <u>Pennsylvania Heritage</u>, 8 (Fall, 1982), 8f.

Society on September 11, 1762.[156] And this is where John Bird made his contribution to the Mason-Dixon survey.

Seeking the best advice in England, Thomas and Richard Penn commissioned Bird to build the best zenith sector yet constructed. This new sector was the first ever built which incorporated Maskelyne's suggested improvement in design,[157] and it was the one used in the survey. "In its day it represented the ultimate that science and craftsmanship could produce."[158] Commenting on the quality of this precision instrument used in Pennsylvania, Maskelyne wrote:

> The astronomical observations had been taken with an excellent sector of 6 foot radius, constructed by Mr. Bird, the first that ever had the plumb-line passing over and bisecting a point at the centre of the instrument. The instrument was so exact, that they found they could trace out a parallel of latitude by it, without erring above 15 or 20 yards; . . .[159]

It is such a tragedy that this historic instrument was lost in the fire which destroyed the Pennsylvania Capitol building on February 2, 1897.[160]

One other instrument maker is important for this study. Previous mention was made of a clock at the Observatory attributed to Graham, but actually constructed by another master

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[156]Cope, "Zenith Sector," p. 74.

[157]Ibid.

[158]Ibid., p. 45.

[159]Nevil Maskelyne, "Introduction to the following Observations, made by Messrs. Charles Mason and Jeremiah Dixon," Philosophical Transactions, 58 (1768), 271.

[160]Cope, "Zenith Sector," p. 45.

craftsman, John Shelton. One clock in particular made by Shelton is symbolic of the scientific enterprise of the eighteenth century[161] (and in a way, symbolic of this paper). Cope summarizes the fascinating history of this timepiece, which we shall refer to as "Shelton's clock."

Shelton's clock was first set up by Bradley at Greenwich Observatory in 1760; here it was found to lose eleven seconds per day compared to sidereal time. Maskelyne used this same clock at St. Helena for his astronomical observations and gravity determinations in 1761 and part of 1762. Our Jeremiah Dixon took Shelton's clock to the Cape of Good Hope from October 28 to December 30, 1761, also for gravity experiments. When Maskelyne went to Barbados in 1763-1764, the clock was part of his scientific equipment. This famous chronometer, which was to travel around the world, spent 1766-1767 at the farm of John Harlan(d) in Brandywine, Pennsylvania, where Mason and Dixon continued to make observations for the Royal Society. The clock traveled around the world with Captain Cook, where it was used to observe the transit of Venus on June 3, 1769 (at Tahiti); and finally used for the great Schiehallien mountain experiment in 1774.[162] To this very day Shelton's clock still keeps time at

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[161]Cope, "A Clock Sent Thither," p. 267.

[162]This was an experiment to determine the deflection of a plumbline due to the gravitational attraction of a mountain in Perthshire, Scotland.

the Royal Society.[163]

> John Shelton's Astronomical Regulator is the symbol of an era two centuries ago when geodetic and geophysical inquiry was first reaching out from London to the far corners of the Earth and was linking those corners together.[164]

This is also the precise context of the Mason and Dixon survey vis-a-vis the Royal Society.

In this section we have investigated the impact of the Royal Society as it relates to the Maryland-Pennsylvania boundary conflict. The influence up to this point was indirect. Individual members of the Royal Society, rather than Society itself, provided scientific expertise as well as instruments that the Penns and Baltimore would use. What we have observed is that there was a "scientific network" which was functioning in the eighteenth century--a network centered in the Royal Society; a network to which Mason and Dixon belonged.

> In brief there were serving Baltimore and the Penn brothers a coterie of astronomers, mathematicians, authorities on navigation, and makers of instruments in England and the leading scientific minds in the Middle Colonies in America. All of this coterie knew about the expedition that the Royal Society was sending to St. Helena and to Sumatra. Some had supplied instruments, others were cooperating as observers in London.[165]

Cope is referring to the highly anticipated Transit of

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[163]Thomas D. Cope, "John Shelton's Astronomical Clock used by Mason and Dixon at Brandywine," Proceedings of the Pennsylvania Academy of Science, 18 (1944), 83ff.

[164]Thomas D. Cope, "A Clock Sent Thither by the Royal Society," Proceedings of the American Philosophical Society, 94 (1950), 267.

[165]Cope, "English Men of Science," p. 17.

IV. MASON, DIXON AND THE ROYAL SOCIETY

A transit is a passage of an inferior planet across the disk of the sun at the time of an inferior conjunction. Normally Mercury or Venus appear to pass north or south of the sun, but a transit is seen if the inferior conjunction occurs when the planet is near one of the nodes of its orbit--the points where it intersects the ecliptic.[166]

Transits of Venus are extremely rare because between two transits there must be an integral number of synodic periods of Venus, and there must also be an integral number of periods in which the planet has returned to the node. Transits of Venus take place in pairs, separated by eight years, with pairs occurring more than 100 years apart. The transits of Venus in 1761 and 1769 were literally the astronomical opportunities of a lifetime. Another pair would not be visible until 1874 and 1882.[167]

During the summer of 1760, while Baltimore and the Penns were completing their "Indenture of Agreement," the scientific community was preparing for the transit of Venus. From the data gathered, scientists had hoped to determine the dimensions of

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[166]George Abell, Exploration of the Universe (New York: Holt, Rinehart and Winston, 1964), p. 214.

[167]Ibid.

Venus expedition of 1761. It was this astronomical event which first brought Mason and Dixon together as a team under the aegis of the Royal Society: Charles Mason was recommended by his colleague Nevil Maskelyne; Jeremiah Dixon by his old neighbor John Bird. Their relationship with the Royal Society, which continued after the Transit of Venus expedition, will be an important factor in their work in America.

the solar system. More specifically, they hoped to determine the length of the astronomical unit; there was no acceptable value at that time.[168] This concern "brought more interests to a single focus than any other scientific problem in the Age of Reason"[169] The Royal Society, naturally, could not ignore this rare opportunity to observe the transit of Venus. Obviously, however, it did not have the financial resources available to support the expeditions which would be required for optimal observations. The crown itself would have to subsidize the work of the Society. When the Royal Society approached the Lords of the Treasury for funds, it stressed not only the scientific merit of the undertaking, but also the competitive and national image. This may have been a reference to the Seven Years war then in progress, or it may have been the correct psychological approach to the Lords of the Treasury. Nevertheless, the fact that the French and other countries were sponsoring astronomical expeditions did cause concern about national prestige.[170]

The British began their preparations rather late in comparison with other countries; the Royal Society had to move quickly. The Council of the Royal Society met on June 26, 1760, with Lord Cavendish presiding. It was determined that "it was both proper and expedient for the Royal Society to direct the

[168]Cope, "English Men of Science," p. 13.

[169]Harry Woolf, The Transits of Venus: A Study of Eighteenth Century Science (Princeton: Princeton University Press, 1959), p. viii.

[170]Ibid. p. 81.

observations."[171] At the same time the Council chose the sites for the observations of the transit. Based on a paper by Halley, published in the Philosophical Transactions in 1716, and corrected by the Delisle Memoir, the first choice went to St. Helena in the South Atlantic; the second choice to Bencoolen on Sumatra.[172]

The Council met again on July 14, 1760. At this meeting it was resolved that Nevil Maskelyne would be the principal astronomer on St. Helena, and that Charles Mason, Bradley's assistant, would accompany Maskelyne as second astronomer.[173] One week later, on July 21, Council petitioned the Admirality on behalf of a second expedition to Bencoolen; on August 5 Council was informed that a ship would be provided for the voyage.[174]

That the second expedition was going to Bencoolen required a change in personnel. This was discussed at the Council meetings of September 11 and September 25, 1760, when Bradley indicated that Charles Mason was willing to go to Sumatra. The issue must have been discussed previously, because it was immediately agreed upon. Also at this meeting it was proposed that Jeremiah Dixon, a surveyor and amateur astronomer, be asked to accompany Mason in a secondary or subordinate position.[175]

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[171] Ibid., p. 74.

[172] Ibid.

[173] Ibid., p. 84.

[174] Ibid., p. 85.

[175] Woolf, The Transits of Venus, p. 86.

One should recall that Dixon was an acquaintance of John Bird, both being natives of Bishop Auckland in Durham. It is quite plausible that Bird was responsible for Dixon's appointment.[176] And so, it was the transit of Venus of 1761 which brought together that most famous astronomical team of Mason and Dixon.

Accompanied by the last public paper of James Bradley, the instructions for observing the transit, and a clock made by John Ellicott, as well as other instruments provided by the Royal Society, Mason and Dixon departed for Bencoolen, Sumatra. But because their ship was damaged by a French man-o'-war and had to return to port for repairs, Mason and Dixon never arrived at their destination. Due to the delay of their departure, they were forced to settle for the Cape of Good Hope where they observed the transit of Venus. Prior to the transit, Mason and Dixon first determined the latitude of their observatory. These measurements were so precise that Maskelyne was able to write that, "it is probable that the situation of few places is better determined."[177]

Mason and Dixon's observations of the transit need not detain us, but what is important is their accuracy. Andrew Planman calculated the solar parallax from thirty-two observations of the transit. He concluded:

> The medium of all these means gives 8".49 for the sun's parallax. And if we reject all the parallaxes

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[176]Whitfield Bell, "Jeremiah Dixon," Dictionary of Scientific Biography, Vol. IV, p. 131.

[177]Quoted by Woolf, The Transits of Venus, p. 132.

> which result from the comparisons of the Peking observations on account of the uncertainty in the longitude of that place, there will result for the sun's parallax 8".29 being the medium deduced from the observations made at the Cape of Good Hope.[178]

One suspects that because of their precise observations of the transit of Venus, Mason and Dixon would have been guaranteed a place of honor, albeit minor, in the history of science even without their work in America.

The transit of Venus expedition not only created the team of Mason and Dixon; it also added to our astronomical knowledge. There was a more important benefit, however, from the scientific enterprise.

> Geography, navigation, natural history, and even national pride gained. But what was more important, the confidence of the scientists in their capacity to work cooperatively with one another and with their governments was immeasurably increased.[179]

This same cooperative effort among science, scientists, scientific institutions and government was also reflected in the Mason-Dixon survey. What we have, then, is another illustration of science and its relation to society in the eighteenth century.

During the fall of 1761, while Mason and Dixon were on their way to the Cape of Good Hope, the Survey Commissioners of Pennsylvania wrote to Thomas Penn describing the difficulties

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[178]Andrew Planman, "A Determination of the Solar Parallax attempted by a peculiar Method, from the Observations of the last Transit of Venus," Philosophical Transactions, 58 (1768), 526.

[179]Harry Woolf, "British Preparations for Observing the Transit of Venus of 1761," William and Mary Quarterly, 13 (1956), 518.

the local surveyors were having in running the lines.[180] Recall that it was during the previous May that Thomas Penn heard about the provincial surveyors using the telescope which was damaged by rain. Also, we have seen that as early as 1760, Governor Sharpe wrote to Lord Baltimore suggesting that he seek the advice of the best mathematicians and astronomers for assistance with the survey. As early as 1762 Thomas Penn informed his Commissioners that he was planning to send competent personnel from England, along with instruments that John Bird was making for him.[181] However, Mason and Dixon were not named at this time, nor was the Royal Society even alluded to.

Robert Harrison, an assistant secretary of the Royal Society many years ago, once made a diligent search of all Council minutes from 1760-1765 in an attempt to determine the function of the Royal Society in recommending, nominating or appointing Mason and Dixon as the principal surveyors for the Maryland-Pennsylvania border. His search was unsuccessful; there is no record of direct involvement of the Royal Society with the project.[182] This leads to the conclusion that Mason and Dixon were employed in a private capacity by Baltimore and/or the Penns. Mathews is of the opinion that they were referred to the Penns by Maskelyne,[183] whereas A. H. Mason

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[180]Mathews, "History of the Boundary Dispute," p. 185.

[181]Ibid.

[182]Mathews, "History of the Boundary Dispute," p. 185.

[183]Ibid.

believes that they were named by Astronomer Royal Nathaniel Bliss.[184]

There exists, however, a letter from Charles Mason to James Bradley, dated June 6, 1763, in which Mason thanks Bradley for his kind wishes in the "North American affair." Mason mentions that he has been in contact with Thomas Penn, and that when Lord Baltimore returns from the continent, Bradley's recommendation will be of great value.[185] Perhaps, then, it was the aging Bradley who suggested Mason and Dixon at the request of the Calverts and Penns. Another possibility is that Mason, aware of the need for an astronomer/surveyor in North America, actively sought Bradley's assistance in obtaining the position.[186]

The Penns and Baltimore decided upon Mason and Dixon on June 20, 1763.[187] Recall that at this time the surveyors in America were in the process of running the tangent line for the second time which they completed in August. This would indicate that Mason and Dixon were not chosen because of the failure of the surveyors to run an accurate line. As we have seen, Thomas Penn had decided the previous year to utilize English surveyors for the project.

On July 20, 1763, the proprietors of the two colonies

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[184]A. H. Mason, "Charles Mason," Dictionary of Scientific Biography, Vol. IX, p. 164.

[185]Burchard and Mathews, "Manuscripts and Publications," p. 340.

[186]I thank Dr. Gregory Good for this insight.

[187]Mathews, "History of the Boundary Dispute," p. 185.

agreed to pay Mason and Dixon 10sh. 6d. each from June 26, to the day that they land in America, and up until they once again return to England. They also consented to pay them £1 1sh. for the time necessary to complete the work, plus an extra 10sh. 6. for each day of their return trip. Additionally, Penn and Baltimore agreed to share the expenses of the survey, and provisions were made for the allotted amount of time to complete the work.[188]

Thomas and Richard Penn wrote to Governor James Hamilton and the Commissioners on August 4, 1763, stating that they have engaged

> two persons who, they have the greatest reason to believe, are well-skilled in astronomy, mathematicks and surveying, of great integrity and totally unbiassed and unprejudiced on either side of the question to go over to America.[189]

The Penns also wrote to their provincial secretary Richard Peters on August 10, 1763 and informed him that

> Mr. Mason and Mr. Dixon have taken their passage with Captain Falconar . . . and they have with them the fine Sector, two Transit Instruments, and two reflecting Telescopes, fit to look at the Post in the line for ten or twelve miles.[190]

When Mason and Dixon sailed to America they also carried with them the "Hints for Running the Lines" by Bevis and Harris, and most important their knowledge, skills, techniques and meticulous precision that they had learned at Greenwich, the

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[188]Burchard and Mathews, "Manuscripts and Publications," p. 340.

[189]Ibid., p. 341.

[190]Cope, "English Men of Science," p. 22.

Cape, and St. Helena. They brought to America the years of experience gained from association with the great masters--Bradley, Maskelyne, Bird and others.

Apparently the Royal Society was not directly involved in the selection of Mason and Dixon for the boundary survey in America, nor was the survey itself a specific project of the Royal Society. However, many individual Fellows of the Society left their mark on the project. Members of the Society proffered their expertise on conducting the survey, provided instruments, recommended Mason and Dixon, and most importantly, imparted to them the astronomical and surveying skills and techniques which were crucial to the survey. Mason and Dixon demonstrated their competence in the transit of Venus expedition which was sponsored by the Royal Society. The Royal Society would assume a more active role in the survey when the opportunity arose to measure a degree of latitude, and consequently determine the shape of the earth. This was one of the most significant international scientific projects of the eighteenth century.

V. "RESTLESS PROGRESS IN AMERICA": THE MASON-DIXON SURVEY

A. THE SURVEY OF THE PENNSYLVANIA-MARYLAND BOUNDARIES

Mason and Dixon arrived in Philadelphia on November 15, 1763. Their first few weeks in America were spent meeting with the Commissioners from both provinces, setting up and testing their instruments, and having an observatory built at the southernmost point of Philadelphia.[191] The work of Mason and Dixon was to consist of four components: 1) determine the latitude of the southernmost point of Philadelphia; 2) ascertain a point thirty to thirty-five miles west of Philadelphia having the same latitude as the southernmost point; 3) measure precisely fifteen miles south of this second point--this is to be the latitude of the boundary between Pennsylvania and Maryland; 4) run the tangent line from the "Center Point" to the tangent point twelve miles distant from New Castle.[192]

Ultimately, however, Mason and Dixon surveyed five lines. In addition to the tangent line and east-west line, they also ran the "East Line" from the Northeast corner of Maryland to the

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[191]A. Hughlett Mason, ed., The Journal of Charles Mason and Jeremiah Dixon (Philadelphia: American Philosophical Society, 1969), p. 31.

[192]Hubertis M. Cummings, The Mason and Dixon Line: Story for a Bicentenary, 1763-1963 (Commonwealth of Pennsylvania: Department of Internal Affairs, 1962), p. 1f. See accompanying map.

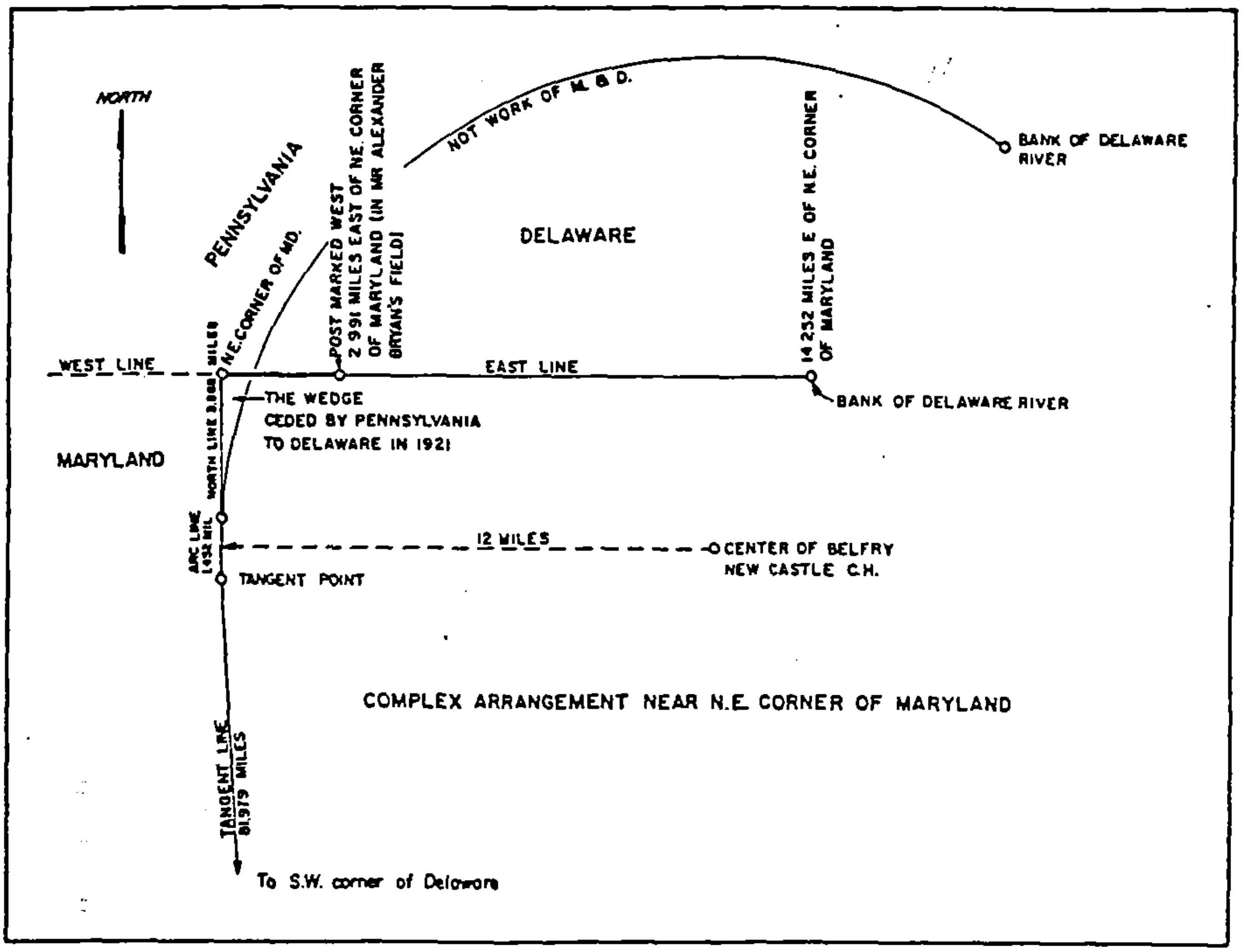

Figure 1 From A. H. Mason, Journal, p. 10.

Delaware River. The length of this line was important because the western boundary of Pennsylvania was to be five degrees west of the Delaware. The "Arc Line" which followed part of the twelve mile circle for a very short distance was also surveyed. The fifth line was the "North Line" from the tangent point to the Northeast corner of Maryland, less that portion which was part of the "Arc Line."[190]

[190]Charles Mason and Jeremiah Dixon, The Journal of Charles Mason and Jeremiah Dixon. Transcribed from the Original in the United States National Archives by A. Hughlett Mason. (Philadelphia: American Philosophical Society, 1969), p. 24f.

Because the Royal Society was not directly involved in the running of these lines, we shall simply summarize some of the more interesting results of Mason and Dixon's work. The latitude of the southernmost point of Philadelphia was found to be 39°56'29.1",[194] which differs from the modern accepted value by only 2.5".[195] January and February of 1764 were spent at Harlan's farm, at the Forks of the Brandywine, and the latitude determined. The two surveyors began surveying the due south line on April 2,[196] and on June 12, a historic date as far as the survey is concerned, placed the "Post Mark'd West" in Mr. Bryan's field.[197] This celebrated post became the reference point in Mason and Dixon's Journal for all measurements along their famous line.

The position of the "Post Mark'd West" was actually 400 feet further south than fifteen miles exact. This error, probably due to faulty equipment, ultimately cost Maryland some 9500 acres.[198] However, in the process of surveying the fifteen mile line and measuring the zenith distance from Philadelphia, Mason and Dixon corrected the accepted value of the length of a degree. In calculating the location of Harlan's farm, they

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[194]Mason and Dixon, Journal, p. 37.

[195]Charles D. Leach, "Placing the Post Mark'd West," Pennsylvania Heritage, 8 (Fall, 1982), 9.

[196]Mason and Dixon, Journal, p. 46.

[197]Ibid., p. 57.

[198]Leach, "Post Mark'd West," p. 12.

assumed 69.5 miles to a degree.[199] But the "Post Mark'd West" was 13'10.9" south of Philadelphia, and therefore 68.277 miles was the equivalent of a degree at that latitude.[200]

The summer and autumn of 1764 were spent running the tangent line. This line ran from the center of the east-west transpeninsular line (the center point) to a point tangent to the circle of twelve miles radius from New Castle. Mason and Dixon recognized that the provincial surveyors had calculated precisely the position of the tangent point, and were thus able to run an accurate line. However, it is interesting to note that their first attempt, completed on August 27, deviated westward from the tangent point by 22.51 chains, whereas the last tangent line run by the local surveyors was off by only 5.26 chains.[201]

The Journal of Mason and Dixon indicates that they began preparations on March 1, 1765, for the most important part of their work--running the Western Line; the actual survey beginning on April 5. The work continued throughout the summer and autumn of that year, and resumed the following spring. Running the boundary line continued until October 9, 1767, when

> the Chief of the Indians which joined us on the 16th of July informed us that the above mentioned War Path

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[199]Mason and Dixon, Journal, p. 44.

[200]Ibid. p. 57. Cf. Leach, "Post Mark'd West," maintains that the difference in latitude was 13"11.5", and a degree would therefore equal 68.223 miles. These are not the figures in the Journal.

[201]Mason and Dixon, Journal, p. 60; 62.

> was the extent of his *commission* from the Chiefs of the Six Nations that he should go with us, with the Line; and that he would not proceed one step farther Westward.[202]

Moving only three chains further west, in order to be on top of a ridge, Mason and Dixon made the last of their observations on October 18 and set up a post--"233 Miles 17 Chains 48 Links from the Post marked West in Mr. Bryan's Field."[203]

B. THE PROJECTS CONDUCTED FOR THE ROYAL SOCIETY

Mason and Dixon's Journal begins with the November 15, 1763 entry, "Arrived at Philadelphia." Relentlessly, it continues for almost two years with records of astronomical observations, mathematical calculations, mention of meetings with the Commissioners, daily progress of the lines, and an occasional comment on the view or the scenery. We learn precious little about Charles Mason and absolutely nothing about Jeremiah Dixon. We stand in awe of their competence and precision, but wonder why they don't take time to celebrate Christmas. Then, totally unexpected, there is the first mention of the Royal Society on October 1, 1765.

Mason and Dixon received a letter from the Pennsylvania Commissioners on September 27, requesting their attendance at a meeting on October 28. Mason mentions the letter and its contents in the October 1st entry:

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[202] Ibid. p. 187.

[203] Ibid., p. 190.

> In the letter mentioned last, the Commissioners informed us, they had no objection of our employing the interval of time to the 28th Instant, in executing our instructions from the Royal Society of London; towards determining the Length of a Degree of Latitude (of which Instructions the commissioners of both Provinces had received notice from the Honorable: the Proprietors: To whom we wrote in June 1765 for leave to use their Instruments; and the indulgence to do it in their Provinces.) Accordingly from this information, we this day set out with the Sector etc. for the Middle Point, or south end of the Tangent Line; To execute the following Instructions from the Royal Society.[204]

Suddenly our perspective changes. Mason and Dixon are not only executing work commissioned by the Penns and Baltimore, but they have been in contact with the Royal Society. Establishing boundaries is not their only work; we hear for the first time something about the length of a degree. Our horizon has broadened.

Some background to the problem is presently required. One of the more pressing scientific questions of the eighteenth century was the shape of the earth. Originally the significance of the problem lay in its power to confirm or disprove Newton's theory of gravitation. According to Grant, the shape of the earth was the one subject discussed in the Principia which was first undertaken by geometers.[205] Neither Newton nor Huygens provided an a priori demonstration that the earth might be an oblate spheroid.[206] By the time of Mason and Dixon the shape of

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[204]Mason and Dixon, Journal, p. 133.

[205]Grant, History of Physical Astronomy, p. 66.

[206]Ibid., p. 68.

the earth had become an interesting problem in its own right.[207]

There are three different methods by which the ellipticity of the earth may be determined. The simplest of these, at least in principle, is by measuring two arcs of a meridian lying in different latitudes. Secondly, one may measure differential gravitational forces by means of pendulum experiments. The third, and probably most difficult, is observing the effects of the ellipticity of the earth on the motions of the moon. If the results of all three methods agree, then there is a powerful argument in support of Newton's theory of gravitation.[208]

Isaac Todhunter relates an early Arabian account of an attempt to determine the length of a degree of latitude, published in Philosophical Transactions, March 25, 1675.

> . . . a Station being chosen, and thence Troops of Horsemen let out, that went in a straight line, till one of them had raised a degree of Latitude, and the other had deprest it; at the end of both their marches, they who raised in, counted 56 2/3 miles, and they who deprest it, reckon'd 56 miles just.[209]

Naturally we would not call this a precise scientific experiment, but it does reflect a very early concern with the problem. Another incident reveals not only the importance of the scientific problem, but something very notable about the Royal Society as well. From 1733-1744, Don Antonio de Ulloa, an

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[207]Dr. Gregory Good, Personal Communication.

[208]Grant, History of Physical Astronomy, p. 68.

[209]Isaac Todhunter, History of the Mathematical Theories of Attraction and Figure of the Earth, Vol. I (London: Macmillan, 1873), p. 40.

astronomer, and later governor of Louisiana, served in a joint expedition sponsored by the Kings of France and Spain to measure the length of a degree near the equator. Again, the purpose was to determine the shape of the earth by comparing the length of a degree in various parts of the earth. On his return voyage he was captured by a British man o' war, and taken to England as a prisoner. His papers eventually were shown to the Royal Society, and because of the significance and quality of his work, he was elected a Fellow on December 11, 1746, despite the fact that he was a prisoner of war.[210]

Mason and Dixon would have been aware of the scientific expeditions which had taken place, or were in progress, regarding the shape of the earth. In fact, we have already mentioned that Dixon took Shelton's famous clock to the Cape of Good Hope during the autumn of 1761 for a determination of gravity. As no data had been gathered from North America, Mason and Dixon seized the opportunity.

Surprisingly, the first suggestion for measuring the length of a degree of latitude was proposed by the Pennsylvania Commissioners to Thomas and Richard Penn in a letter dated May 10, 1762.

> Before we set out for Newcastle the Jersey Quadrant was brought hither from New York. . . . It would have given us some satisfaction to have known by means of good Observation taken with such an Instrument the true Latitude of the Beginning and End of the Meridian

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[210]Raymond P. Stearns, "Colonial Fellows of the Royal Society of London, 1661-1788," <u>Notes and Records of the Royal Society of London</u>, 8 (April, 1951), 180, n. 5.

> Line, which has been run from the Middle Point and measured (as we believe) with a good deal of care; there having never yet, that we have heard of, been any attempt to determine the measure of a Degree of Latitude on the Earth's surface in North America. We should be the better pleased with an opportunity of determining this matter as we imagine it may come in Question in some of our future operations respecting the West Line. When that line comes to be run this Quadrant, or some of equal goodness will, we conceive be necessary.[211]

However, it appears that the recommendation of the Commissioners was never acted upon.

Although the first mention of the Royal Society in the Journal is under the October 1, 1766 entry, Jeremiah Dixon had written to his old friend John Bird from Philadelphia on February 24, 1764. On June 28 of that year, Bird read Dixon's letter to the Council of the Royal Society. The letter mentioned the opportunity that Mason and Dixon had of measuring the length of a degree of longitude (not latitude) along a parallel at Philadelphia. No action was taken at that time, but the letter was read again at a Council meeting on October 24, 1764. The President announced that

> Mr. Penn had made an offer to the Society directing Messrs. Mason and Dixon . . . to measure a degree of Longitude, upon a parallel of latitude between Maryland and Pennsylvania without any Expence [sic] to the Society if the Society would direct the method of doing it.[212]

Penn's offer was accepted, the Society's gratitude was extended to him, and a committee was named to direct the project and

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[211]Cope, "Some Local Scholars," p. 274.

[212]Cope and Robinson, "Charles Mason, Jeremiah Dixon, and the Royal Society," p. 66

select the instruments, but for whatever reason the project was never implemented.[213]

Thomas Cope situates Dixon's letter to Bird in a wider frame of reference.

> To scientific London of 1764, Greenwich, St. Helena, Sumatra, the Cape of Good Hope, and the Middle Colonies of North America were all parts of "one small world." Its projects radiated to all of them. Charles Mason and Jeremiah Dixon were the tried and trusted agents and allies of scientific London. Wherever they went the thoughts and the projects of London were with them.[214]

Nevil Maskelyne was appointed Astronomer Royal on February 20, 1765. Upon hearing the news, Mason and Dixon offered their congratulations in a letter dated June 20, and once again presented in great detail their proposal for measuring the length of a degree of latitude as well as longitude. A copy of the letter was also sent to John Bird[215] (The Journal entry for June 20 mentions that Mason and Dixon wrote to the Proprietors; there is no reference to Maskelyne.) Mason and Dixon's letter was read at a Council meeting on October 17,[216] and the resolutions passed by Council a week later were inserted by Mason into his Journal when he received the letters from London on September 27, 1766.

The Royal Society, acting on the advice of Maskelyne,

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[213] Ibid.

[214] Cope, "English Men of Science," p. 23.

[215] Cope and Robinson, "Mason, Dixon and the Royal Society," p. 66.

[216] Ibid.

agreed to sponsor the measurement of a degree of latitude. The Council also communicated its reasons for supporting the project: 1) it was a work of great use and importance; 2) the abilities of Mason and Dixon were well known; 3) Mason and Dixon had excellent instruments; 4) the terrain was relatively level; and 5) the crew of assistants was also qualified and competent.[217] (Reasons why the Royal Society was not interested in the degree of longitude study were not given.)

It was also resolved by the Council to pay Mason and Dixon £200, provide some needed instruments, have Maskelyne draw up detailed instructions for the project, and request permission from the Proprietors to use their instruments which were already being used in the survey.[218] Lord Baltimore and Thomas Penn were cooperative enough to allow their instruments to be borrowed.[219] Of course, the commissioners from Pennsylvania had no objection to Mason and Dixon performing work for the Royal Society, but they were expected to be at a meeting at Christiana Bridge on October 28, 1776.[220]

The question may arise as to why correspondence dated October and November, 1765, was received by Mason and Dixon a year later. The original letters from the Royal Society, Penn,

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[217]Mason and Dixon, Journal, p. 133.

[218]Ibid.

[219]Copies of their letters to the Royal Society were sent to Mason and Dixon and are included in the Journal with other correspondence from London after the October 1, 1776 entry.

[220]Mason and Dixon, Journal, p. 138.

Baltimore, instructions from Maskelyne, as well as equipment, were lost when the Egdon was shipwrecked. Duplicates of the letters were sent on August 8, 1766, but Mason and Dixon were advised to use the instruments which were already at their disposal; only a little silver wire for the plumb line was provided.[221]

Included in all this mail was a six-page letter from Maskelyne detailing the procedures to be followed in measuring the lines. The distance to be measured was from the Middle Point to the observatory at Harlan's farm. Although Mason and Dixon had chained these lines previously, the Royal Society directed them to remeasure them accurately with twenty-foot fir rods, compared frequently with a brass standard.[222] Incidentally, the five-foot brass standard and the twenty-foot brass-tipped rods were made by John Bird.[223]

Surprisingly, the latitude of the Middle Point had never been determined. On October 1, 1766, Mason and Dixon set out for this point, taking the sector with them, in order to carry out the instructions from the Royal Society.[224] They observed the stars until the 19th, packed the next day, and left the Middle Point on October 21 in order to meet with the Commission-

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[221]Mason and Dixon, Journal, p. 135.

[222]Mason and Dixon, Journal, p. 133.

[223]Cope and Robinson, "Mason, Dixon, and the Royal Society," p. 67.

[224]Mason and Dixon, Journal, p. 133.

ers a week later.[225] Work for the Royal Society was suspended until December when, back at Harlan's farm, they remeasured zenith distances of several stars in order to determine the difference in latitude between Brandywine and the Middle Point.[226] Although the precise measuring of the distance by the rods would not occur until the spring of 1768, Mason and Dixon made a preliminary determination of the length of a degree based on their previous survey. They concluded that one degree was equal to 68 miles 64 chains and 91 links.[227]

It was only after Mason and Dixon had completed all of their work for the Proprietors and Commissioners that they resumed measuring the length of a degree on the Delmarva Peninsula. Their Journal indicates that they scrupulously followed Maskelyne's instructions to the letter, and actually measured the entire distance with the 20 foot measuring rods, or more specifically, with the levels constructed to contain the rods.[228]

What impresses the reader of the Journal is the meticulous care taken to note the change in the length of the brass-tipped rods and the brass standard as a function of temperature. In fact, Mason and Dixon were measuring and noting differences of

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[225]Ibid., p. 147.

[226]Ibid., p. 149ff.

[227]Ibid., p. 169.

[228]Ibid., p. 196. Presumably, triangulation was used to measure across rivers, etc.

only .01 inch. Throughout the entire process they were continually concerned about standards of length. For example, they record that on April 9, 1768, they compared Bird's five-foot brass standard with a one-foot sector made of ivory by Mr. Bennet, and "found it wanting 0.15 of an Inch in 5 feet."[229] Again, on July 8 they compared the five-foot standard with the brass yard of the six-foot sector, and consistently found the standard short by .015 inch.[230] When Mason and Dixon published their observations in Philosophical Transactions the length of the brass standard was corrected to 62°F.[231]

On June 21, 1768, Mason and Dixon informed the Commissioners that they had completed their work for the Royal Society. One finds it rather strange that despite all the work of Mason and Dixon in measuring the distance between two points as well as the celestial arc, it was Maskelyne who finally calculated the length of the degree. His initial value for the degree was 363,763 feet;[232] but when Bird's five-foot sector was compared with the standard of the Royal Society, and the wear taken into account, the "true length of a degree" was equivalent to 363,771

[229] Ibid., p. 203.

[230] Ibid., p. 210.

[231] Charles Mason and Jeremiah Dixon, "Observations for Determining the Length of a Degree of Latitude in the Province of Maryland and Pennsylvania," Philosophical Transactions, 58 (1768), 313.

[232] Maskelyne, "The Length of a Degree," p. 323.

feet, or 68.8960 English statute miles.[233] Simply for comparative purposes, by converting Mason and Dixon's length of 68 miles 64 chains 91 links found by chaining,[234] their value of 68.830 miles differs from Maskelyne's by 348 feet. (The currently accepted value, according to Cope, is 364,233 feet, or 68.984 miles.)[235]

Measuring the length of a degree, as we have seen, is only one of three ways of determining the size and shape of the earth. The other method which would have been accessible to Mason and Dixon involved pendulum experiments to discern variations in gravity. In order that Mason and Dixon could determine the force of gravity by this method, Maskelyne sent John Shelton's clock belonging to the Royal Society. The clock would also be available to them for any other astronomical observations.[236]

Shelton's clock was set up at Harlan's farmon December 11, 1766.[237] Following Maskelyne's instructions to "always fix the clock up firm," the clock was attached to a piece of timber 5 1/4 inches thick and 22 inches in breadth. It was then set four

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[233]Ibid., p. 326. On comparing instruments with a standard in London see Cannon, Science in Culture, p. 99.

[234]Mason and Dixon, Journal, p. 169

[235]Cope and Robinson, "Mason, Dixon, and the Royal Society," p. 69.

[236]Mason and Dixon, Journal, p. 137.

[237]Mason and Dixon, Journal, p. 149.

feet into the ground, resting on firm, dry, hard clay.[238] For comparative purposes the Proprietors' clock was also used, to which Mason "applied a Pendulum made with Walnut that had lain dry for about 40 years."[239] Maskelyne had directed that the pendulum be adjusted to a particular scratch against the index, so that the length would be equal to that which kept sidereal time at St. Helena. This procedure was followed on December 15.[240]

Throughout the winter of 1766-67, Mason and Dixon utilized the clock in timing the transit of stars across the meridian, noting the times of the eclipses of Jupiter, and comparing Shelton's clock to that of the Proprietors. Based on the apparent times at Paris of eclipses of the satellites of Jupiter, they calculated their longitudinal distance from Paris: 5h 12min 59sec.[241] (The modern value is 5h 12min 17sec.)[242] They observed that the pendulum swung eight minutes more to the east than to the west. This was attributed to settling after an extreme cold spell. (It was 22° below zero on January 1.) On February 28 the clock was dismantled and packed up.[243]

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[238]Ibid., p. 159.

[239]Ibid., p. 149.

[240]Ibid., p. 150.

[241]Ibid., p. 158.

[242]Cope and Robinson, "Mason, Dixon and the Royal Society," p. 70.

[243]Mason and Dixon, Journal, p. 153; 157.

Mason and Dixon published their data in Philosophical Transactions in 1768. However, because the spring from which the pendulum was suspended was broken during shipwreck, Maskelyne regarded the results as invalid. Consequently, no inference or conclusions were drawn regarding the force of gravity.[244] (How fortunate for history, however, that the clock itself was not lost.) Therefore we would have to disagree with Hindle, who states that, "this work was of more scientific value than anything else that grew out of the surveys of provincial boundaries."[245] It could have been a contribution to science, but because of the damage it was not.

On May 24, 1767, Mason and Dixon received a letter from Maskelyne informing them that the Council of the Royal Society requested that they return the clock immediately, "as we hear it has received great damage and must be put in order directly for the ensuing transit of Venus over the Sun."[246] Shelton's clock was shipped that very day to Wilmington, and on to Philadelphia, where it arrived on May 28.[247]

It is not inappropriate to mention that Maskelyne did not simply request that Mason and Dixon return the clock belonging to the Royal Society. He included the Nautical Almanac for

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[244]Mason and Dixon, "Astronomical Observations, made in the Forks of the River Brandywine . . .," Philosophical Transactions, 58 (1768), 329-330.

[245]Hindle, Pursuit of Science, p. 176.

[246]Mason and Dixon, Journal, p. 173.

[247]Ibid., p. 172.

1767, as well as a set of tables for computing the distance of the moon from the sun. He also shared with them news of the scientific world: the method of finding longitude by lunar observations is coming into vogue; Mayer's tables are not yet completed; John Bird has received £500 from the Board of Longitude for his method of constructing and dividing instruments; and Dolland's telescope is second to none.[248]

What Maskelyne's letter signifies is that Mason and Dixon were not isolated in America. They had been in continual communication with the scientific world, or at least with scientific London. Throughout their Journal there are a number of entries informing the reader that they wrote to Maskelyne, Morton, Bird, and Katy (Secretary of the Royal Society). Moreover, Maskelyne explicitly desired information about the work of Mason and Dixon, especially regarding the measure of a degree.[249] Benjamin Franklin, a member of the Council, also would have heard of their work.[250] Even Thomas Penn wrote to Mason and Dixon, complimenting them on their work for the Royal Society, (but questioning the value of running the east-west line to the Delaware River).[251] What emerges, then, is a picture of the scientific world of eighteenth-century London, and in particular, of the Royal Society. Maskelyne's letter

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[248] Ibid., p. 173.

[249] Ibid., p. 173.

[250] Cope, "Contacts of Franklin," p. 234.

[251] Mason and Dixon, Journal, p. 194.

represented a program which can be traced all the way back to John Winthrop, Jr. and the founding of the Royal Society.

Recall that in Jeremiah Dixon's letter to John Bird, dated February 24, 1764, he proposed measuring a degree of longitude along a parallel at Philadelphia, but for unknown reasons the Royal Society never acted on this proposal. In their letter of congratulations to Nevil Maskelyne on his appointment as Astronomer Royal, Mason and Dixon once again presented their proposal for measuring a degree of longitude as well as latitude. The Royal Society, however, was interested only in the length of a degree of latitude.

Cope states that Mason and Dixon never measured a degree of longitude while in America.[252] Technically, he is correct; a degree of longitude was *not* measured in the way that the degree of latitude was. However, on December 26, 1767, the Commissioners had asked Mason and Dixon for the length of a degree of longitude along the West Line. They gave the value, but with a caveat:

> By comparing our mensuration of a Degree of the Meridian with that made under the Arctic Circle, supposing the Earth to be a Spheroid of a uniform Density: a Degree of Longitude in the Parallel of the West Line is 53.5549 Miles. But the Earth is not known to be exactly a Spheroid, nor whether it is everywhere of equal Density; and our own experiment not yet finished: We do not give in this as accurate.[253]

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[252]Thomas D. Cope, "Westward Five Degrees in Longitude," Proceedings of the Pennsylvania Academy of Science, 22 (1948), p. 147.

[253]Mason and Dixon, Journal, p. 194.

Numerous opportunities existed for ascertaining the longitude of various locations. It has been noted that Mason and Dixon calculated the longitudinal distance of Harlan's farm from Paris by observing eclipses of Jupiter's satellite. Any sharply defined astronomical event, if properly timed, would have sufficed for measuring longitude. Solar and lunar eclipses, as well as occultations of stars are recorded in the Journal; the data easily could have been translated into longitude if compared with the time of the event at Greenwich, for example.[254]

On June 17, 1767, Mason and Dixon were instructed by the Commissioners to extend the West Line to its limit of five degrees from the Delaware River.[255] However, the refusal of the Indians to grant permission to cross the War Path precluded the completion of the line. It would be the task of the American astronomers to extend the Mason-Dixon Line to five degrees from the Delaware, a task accomplished with remarkable precision.

Mason and Dixon met with the Commissioners for the last time from August 25-27, 1768. Accounts were settled, certificates of completion issued, the work was entirely finished. The last entry in the Journal, September 11, reads, "At 11h 30m A.M. went on Board the Halifax Packet Boat for Falmouth. Thus ends

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[254]The specific instances are discussed in Cope, "Degrees along the West Line," pp. 127-33.

[255]Mason and Dixon, Journal, p. 177.

my restless progress in America."[256]

A few days prior to their departure, on August 20, Baltimore and the Penns petitioned the King for his approval of the boundaries separating Pennsylvania and Maryland. On November 11 the boundaries as defined by Mason and Dixon were established by the Commissioners of both provinces. Finally, on January 11, 1769, the King in Council officially ratified the boundary between Maryland and Pennsylvania. The boundary conflict, which began in 1681, was finally resolved.

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[256] Ibid., p. 211.

CONCLUSION

In his history of the Mason-Dixon Line, James Veech asked: "Whence came . . . this palpable disregard of the plain provisions of nature and science for the divisions of dominion?"[257] In this study we have attempted to provide an answer to his question. Part of the "disregard" was rooted in ambiguous expressions in original charters and in geographic ignorance. Differing interpretations of defined boundaries also caused some problems. William Penn's refusal to acknowledge the fortieth degree, which was readily measurable, while maintaining twelve miles about Newcastle, added to the controversy. Charges, counter-charges, royal favor, court cases, compromises, even deceit and lies, make for a fascinating history. The solution, while primarily the result of the famous Chancery Case, was also scientific in nature.

In this paper we have investigated the role of the Royal Society in the solution to the boundary controversy between Maryland and Pennsylvania. Initially, it was my hope to discover that the Mason-Dixon Survey was a direct undertaking of the Royal Society. However, the evidence does not support that premise. Nevertheless, the Royal Society had a significant impact on the survey.

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[257]Veech, The Monongahela of Old, p. 207.

In the broadest context, from its very beginning the Royal Society had a keen interest in the curiosities of the New World. To satisfy the desire for knowledge Henry Oldenburg and succeeding secretaries established a network of correspondents who supplied data and information regarding natural philosophy in the colonies. In many ways the work of Mason and Dixon, especially their work on the length of a degree, was a continuation of a program begun with John Winthrop.

Regarding the political dimension of the boundary controversy, the Royal Society was also influential, albeit indirectly. It was to individual members of the Royal Society to whom the Penns and the Baltimores turned for scientific expertise. Their scientific advisors were all Fellows of the Society. It was these men who formulated the methods of running lines, who constructed the equipment, who persuaded Thomas Penn to allow astronomical observations in the survey. Most important, it was the members of the Royal Society who recommended Mason and Dixon to Thomas Penn and Lord Baltimore.

The role of the Royal Society became more focussed when we considered Mason and Dixon. The former was trained by Maskelyne; the latter was a friend of Bird. Together for the first time as a team, Mason and Dixon worked explicitly for the Royal Society during the Transit of Venus expedition. It was the quality of their work which commended them for the boundary survey.

Two projects which were sponsored explicitly by the Royal

Society and undertaken by Mason and Dixon in America were the measurement of a degree of latitude and the determination of the force of gravity. With instructions from the Astronomer Royal and equipment from the Royal Society, Mason and Dixon completed these assignments when not working for the Proprietors. Throughout their sojourn in America, Mason and Dixon were in constant communication with Maskelyne, Bird, and other members of the Royal Society. They kept Maskelyne informed of their progress, and published the results of their work in Philosophical Transactions. And so, we can validly conclude, that although the Mason-Dixon Survey was not a specific project of the Royal Society of London, it was part of the English astronomical program of the eighteenth century. As such it was greatly influenced by the Society and its members.

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ABSTRACT

This study investigates the Mason-Dixon Survey from the perspective of the Royal Society of London. From early colonial times the Royal Society had a scientific interest in the New World, an interest which enabled them to support some of the work of Mason and Dixon. Moreover, it was to members of the Royal Society that Thomas and Richard Penn, as well as the Lords Baltimore, turned for scientific advice. Members of the Royal Society drew up the instructions for running the lines, and other Fellows constructed the precision equipment which was used. Mason apprenticed under Astronomer Royal Bradley and worked with Nevil Maskelyne; Dixon was a friend of John Bird. Working explicitly for the Society, Mason and Dixon journeyed to the Cape of Good Hope for the Transit of Venus expedition of 1761. Because of the caliber of their work, members of the Royal Society commended them to the Proprietors for the survey. During their sojourn in America Mason and Dixon were in constant communication with the Society and a number of its members. Specifically, Mason and Dixon measured the length of a degree of latitude for the Society, and attempted to measure the force of gravity. Although the Mason-Dixon Survey was not a project of the Royal Society *per se*, it was greatly influenced by the Society. The work of Mason and Dixon is seen as part of the world-wide scientific program of the Royal Society during the eighteenth century.