THINKERS AND TINKERS

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Early American
Men of Science

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Illustrated with Photographs

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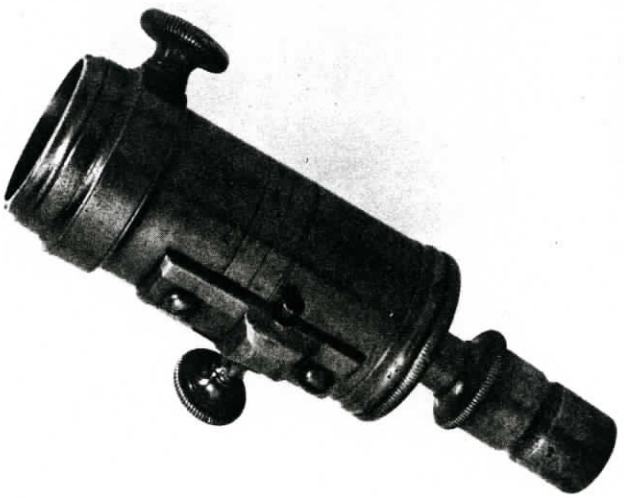
40 Vernier compass made by Benjamin Rittenhouse, with specially designed socket joint. Shown in the original field case.

41 Special socket joint developed and produced by Benjamin Rittenhouse for use with his plain surveying compasses to enable adjustment for declination.



the occasion of Mr. Baily's being introduced to the notice of the Philosophical Society. . . ." [20]

When the boundary established by Mason and Dixon, which came to be commonly known as the Mason and Dixon Line, was resurveyed in the twentieth century by a commission under the Superintendent of the Coast and Geodetic Survey, the work was found to have been accomplished with incredible accuracy and the latitudes determined by Mason and Dixon were only 2 or 3 degrees in error.[21]

In 1774 the Bird zenith sector, which Mason and Dixon left behind in Pennsylvania, was borrowed from the Proprietors by Samuel Holland and David Rittenhouse when they began the survey of the northern boundary of Pennsylvania, and was subsequently returned.[22] The instrument was stored at the Capitol in Harrisburg when the state capital was moved to that city after the War of 1812, and it remained there for most of the nineteenth century. It had been dismantled for cleaning at the time that the capitol building was destroyed by fire in 1897, and a report in 1909 stated that only a few parts of the instrument had survived. More recent research has failed to confirm the report or to locate the salvaged parts.[23]

Another instrument acquired by Thomas Penn in England for the boundary survey was an astronomical transit made by John Bird, which was to prove of considerable value later for colonial observation of the transit of Venus. Mason and Dixon frankly admitted that they preferred the Bird transit to one that belonged to John Bevis which they had brought with them to Pennsylvania. They considered the Bird transit a "less complex and more portable Transit Instrument" which would be more generally useful to them in running their lines.[24] The instrument was next mentioned as being loaned by the Penn family to the American Philosophical Society in 1769 for use at the observatory in Independence Square to observe the transit of Venus. At some time after these observations, which are described elsewhere, had been made, the instrument was removed to the tower of the State House in Philadelphia, where it was subsequently used to regulate the public clock in the tower. In 1912 it was discovered stored under the floorboards of a platform beside the old supports on which the Liberty Bell had formerly hung. The transit evidently had been mounted for many years on the heavy stone sill of the south window opening of the tower, in a position to take the meridian passage of the sun at noon, for regulating the tower clock. The instrument is presently owned by the City of

Philadelphia and is on loan to the National Park Service for display at Independence Hall.[25]

Meanwhile, the adventurous Jersey Quadrant, which had been set aside with the advent of the Bird zenith sector, had been returned to the Jersey Proprietors. It appears to have been borrowed again by the Proprietors of Pennsylvania for the use of David Rittenhouse for observing the transit of Venus at his observatory at Norriton in 1769; in his report of the observations he made, the list of the equipment in his observatory included "an Astronomical Quadrant two and one half f. radius, made by Sission [*sic*], the property of the East Jersey Proprietors; under the care of the Right Hon. William Earl of Stirling, Surveyor-General of that Province; from whom Mr. Lukens procured the use of it, and sent it up to Mr. Rittenhouse for ascertaining the latitude of the Observatory."[26] Thereafter the instrument was lost to record, and recent efforts to locate it have been without success.

The advent of these highly sophisticated astronomical instruments had a significant effect on the art of surveying, and Rittenhouse, for one, was inspired to duplicate some of them for use in his own endeavors as well as for the use of others. In due course he produced the most advanced scientific instrumentation achieved in America.

Following the completion of the Mason and Dixon survey and the observations of the transit of Venus, Rittenhouse moved his home and workshop from Norriton to Philadelphia, where he is known to have been at work in 1770. There he presumably achieved the first important modification of the plain surveying compass by inventing the form known as the vernier compass. The instrument was developed and first produced between late 1770 and the beginning of the Revolution.[27] Whether the invention is in fact rightfully attributed to David Rittenhouse cannot be documented, but the earliest-known examples of the new instrument are his work or that of his associates, including his brother Benjamin and Henry Voigt.

Some vernier compasses were made by David Rittenhouse in partnership with W. L. Potts of Bucks County, Pennsylvania, and Potts also produced this type of instrument under his own name. Vernier compasses made of wood with metal components were produced by Benjamin Hanks of Mansfield, Connecticut, and possibly by other makers.

Because the invention of the vernier compass was ascribed to

David Rittenhouse, it became known also as the "Rittenhouse compass," and was produced by Benjamin Rittenhouse as well as by David. Confirmation of this association of the instrument with the Rittenhouse brothers exists in a letter of 1798 from the Surveyor-General of Ohio, Rufus Putnam, to Thomas Worthington, who was conducting surveys in Chillicothe. Putnam wrote: "If you are not already, you must furnish yourself with a compass having a moveable band (Mr. Rittenhouse, near Philadelphia, makes the best I have seen). Our compasses must all be rectified to one declination in order that our Surveys may be not only correct but uniform. But without having a moveable band those small variations between different compasses which frequently exist cannot be corrected to any considerable degree of certainty. A compass therefore with a moveable band cannot be dispensed with. . . ." Putnam was referring to Benjamin Rittenhouse; David had died two years previously.[28]

The use of the plain surveying compass, which was the practice during this period, was subject to two primary sources of error. One was the deflection of the magnetic needle by iron-ore deposits in the area being surveyed, and the other was irregularity in the behavior of the needle, possibly due to infinitesimal particles of iron accidentally embodied in the instrument during the process of manufacture. These defects could be detected only by comparing readings made of the same locality with different instruments and for different parts of the graduated circle.

That these difficulties continued to be experienced by surveyors was attested in a report made by William Nicoll and Gerard Brancker in 1773 on their survey of the boundary between New York and Massachusetts. When the instruments of the parties representing their respective colonies were compared, it was discovered that the instrument of the Massachusetts surveyor would run the line considerably more to the east than that of the New York surveyors, but it was agreed to use it. After having run a distance of about twenty-five chains the surveyors examined the course that had been run and discovered a defect in the Massachusetts instrument. They exchanged it for the New York instrument ". . . but finding the Needle frequently affected by Minerals, the Massachusetts Gentlemen expressed a doubt whether we had continued on the true Course, it was here tryed on low Land, where we did not apprehend there was any Attraction, and after correcting a Back Monument or two, and satisfying both Sides, it was agreed to run by Stakes and

sight to be correctly read when the instrument was held in the customary position with the South point toward the surveyor's body. The dual-purpose cards could not accommodate this practice.

The compasses made of metal provided other and different opportunities for decoration, but the colonial maker generally preferred the utmost simplicity. Decoration was reserved to the dial, which was customarily silvered and the compass points and decorative elements rendered in black for the greatest legibility. The many brass surveying compasses that have survived reveal that there were several distinctive schools of metal decoration prevalent in the colonies, which were geographically defined during the second half of the eighteenth and in the early nineteenth century, although not in the earlier period.

The most important school of instrument decoration flourished in Pennsylvania from the middle to the end of the eighteenth century and included the work produced by David and Benjamin Rittenhouse of Norriton and Philadelphia, George Hoff and Frederick A. Heiseley of Lancaster, W. L. Potts of Bucks County, and the partnerships of the Rittenhouses with David Evans and with Potts at various periods. The consistency of the types of motifs used identified them with similar motifs and styles prevalent in England and Europe in the same period.

The resemblance in artistic rendering among the works of a number of makers during the same period in the same region suggests that there may have been design books for engravers of instruments from which the designs were copied and modified. Such guides were quite common abroad and were widely used by silversmiths and engravers for many purposes, ranging from the decoration of watch cases to designs for book plates and trade cards. Further evidence of the possible existence of such guides in the colonies occurs in an advertising brochure or catalogue published for or by Jacob Gorgas, a watch and clock maker of Ephrata, Pennsylvania, in about 1765. Gorgas's father was a clockmaker and may have also taught watch and clock making to the Rittenhouse brothers, who were relatives and neighbors. The twelve pages of the Gorgas brochure contained a variety of elaborate motifs and designs printed from intaglio engravings for the use of clockmakers and engravers.[7]

The instrument makers of the Pennsylvania school, as well as others, generally utilized wide cardinal points (north, east, south, and west) in their design of the compass rose and filled the areas with

elaborate foliate designs in fine detail, with the subcardinal points (northeast, southeast, southwest, and northwest) generally reduced to four in number and cross-hatched or rendered in some other subtle manner. Some engravers made the central medallion the dominant feature. The style reflected an obviously traditional form, varied by the degree of detail and rendered almost identically with the decoration prevalent on the dials of surveying compasses produced by some English makers during the same period. As an example, the dial motifs of some of the surveying compasses made by Benjamin Rittenhouse duplicated in many details those produced by Benjamin Cole (2nd) of London during the first half of the eighteenth century.[8] The engraved compass dials made by Benjamin Rittenhouse were among the most attractive and elaborate produced in America, customarily featuring a well-proportioned design in which the eight cardinal points extended from the center to the edge of the graduated circle. A Tudor rose with elaborate foliation forming the standard central motif was enclosed in a riband in which his name was inscribed, often with the date of production. The four dominant points of the compass rose were featured with minutely executed foliation while the four remaining points were subdued.

The compass dials of instruments produced by David Rittenhouse ranged from the utmost simplicity to elaborate detail, in which they resembled those produced by Benjamin and the dials may have in fact been his work. Several instruments signed by the partnerships of Rittenhouse and Potts and Rittenhouse and Evans have the same detailed elaboration as the work of Benjamin Rittenhouse, suggesting that the partnerships may have been with Benjamin and not with David.

Distinctive decorative features became identified with specific makers and their imitators. Benjamin Rittenhouse and some of the other Pennsylvania makers of his time employed elaborately decorated compass roses, while Richard Patten of New York City featured a heavy leafy garland around the dial, and Goldsmith Chandlee of Winchester, Virginia, incorporated circular motifs that readily identified his instruments. The metal surveying compasses produced by New England makers in general had minimum decoration, if any at all, but their proportions gave them an attractive simplicity.

While the production of navigational and surveying instruments showed a remarkable development in the colonies during the first

half of the eighteenth century, optical instruments and others requiring the use of glass were another matter. Thermometers and barometers were imported from England and France until after the Revolutionary War. England in particular had developed as a center for the production of these items, which were for the most part used for scientific purposes or sold to gentlemen amateurs of the sciences, and not for general domestic use. Italian glass workers had emigrated to England in great numbers in response to the demand for the production of scientific glass, and English makers found a ready market in the colonies where these instruments were imported by stationers and booksellers in the larger cities. George Washington and Thomas Jefferson purchased such instruments from the stationer John Sparhawk of Philadelphia. Franklin in 1754 received from Peter Collinson of the Royal Society a number of scientific items, including "3 Barometers, two of which came safe, but the Ball of the third broke to pieces and the Mercury gone." [9] Thermometric and barometric instruments were also stocked by some of the more prominent colonial instrument makers.

Occasionally American makers attempted to produce these glass instruments, but usually for experimental purposes rather than commercial sale. David Rittenhouse was greatly interested in the use of these instruments and experimented with their development. In about 1762 he made a finely graduated thermometer on which he engraved, at a mark at 22 below zero on the Fahrenheit scale, a reminder of an unusual event, "Jan. 2, 1762—Great Cold In Pennsylvania." [10] Although his biographer William Barton stated that this was a reference to an entry in the daily journal maintained by the surveyor Charles Mason which recorded that this was the degree of cold registered in the forks of the Brandywine River on the date noted, the date was obviously in error, since the observation was made at another time.[11]

Early in 1767 Rittenhouse designed and constructed a special thermometer which was based on the contraction and expansion of metals by heat and cold and had a glass-covered dial graduated with a semicircle. The degrees of heat and cold marked on the dial corresponded with those of the Fahrenheit scale and were designated by an index moving from the center of the arc. The thermometer was square or parallelogrammatic in form, flat, thin, and small in size, so that it could be readily carried in the pocket. Rittenhouse presented one of these to Richard Peters, secretary to the Pennsylvania Propri-

etors, in June 1767, and another which he had made for himself was subsequently used by William Barton. Barton tested it at Lancaster and later returned it to the maker.[12]

In the summer of 1771, Rittenhouse received from Barton a tube for a barometer which had been made for him at the Glass House, a manufactory operated at Mannheim, Pennsylvania, by Henry William Stiegel. "I am obliged to you for the glass tube," he wrote, "it will make a pretty barometer, though the bore is somewhat too small. I have compared it with an English tube, and do not think the preference can, with any reason be given to the latter." He then asked Barton to "procure for me from the glass-house some tubes of a size fit for spirit-levels. . . . The bore must be half an inch in diameter, and from four to eight inches in length; as straight as possible, and open at one end only." [13]

The Glass House subsequently changed hands several times, and there is reason to believe that at some time after 1778 Rittenhouse leased it to produce scientific vessels and glass required for his work.[14] It was not until after the war, however, and then at a manufactory in Maryland that optical and scientific glass was commercially produced in America.[15]

Optical instruments were imported, almost without exception, until the middle of the nineteenth century. Telescopes and telescopic elements of other instruments were occasionally made for specific uses by Rittenhouse and a few others, but even in such instances the lenses had to be imported because neither skills, equipment, nor materials were available to grind them in America.

The art of lens grinding was slow to develop even in Europe, despite the ever-increasing demand for telescopic and microscopical lenses throughout the seventeenth and eighteenth centuries. The techniques of the mirror polishers of Murano, Italy, which provided the first lenses for Galileo's telescopes, were gradually replaced by a series of improved lens-grinding lathes borrowed from the traditions of the lapidary workers, first in Italy and Holland, then elsewhere in Europe, and finally in England. The best optical glass was first produced at Murano and even late in the seventeenth century France, Holland, and England sought vainly to develop facilities for the production of glass of matching quality. It was not until the development of flint glass that England moved to the forefront with a number of individual improvements of techniques as well as materials.[16]