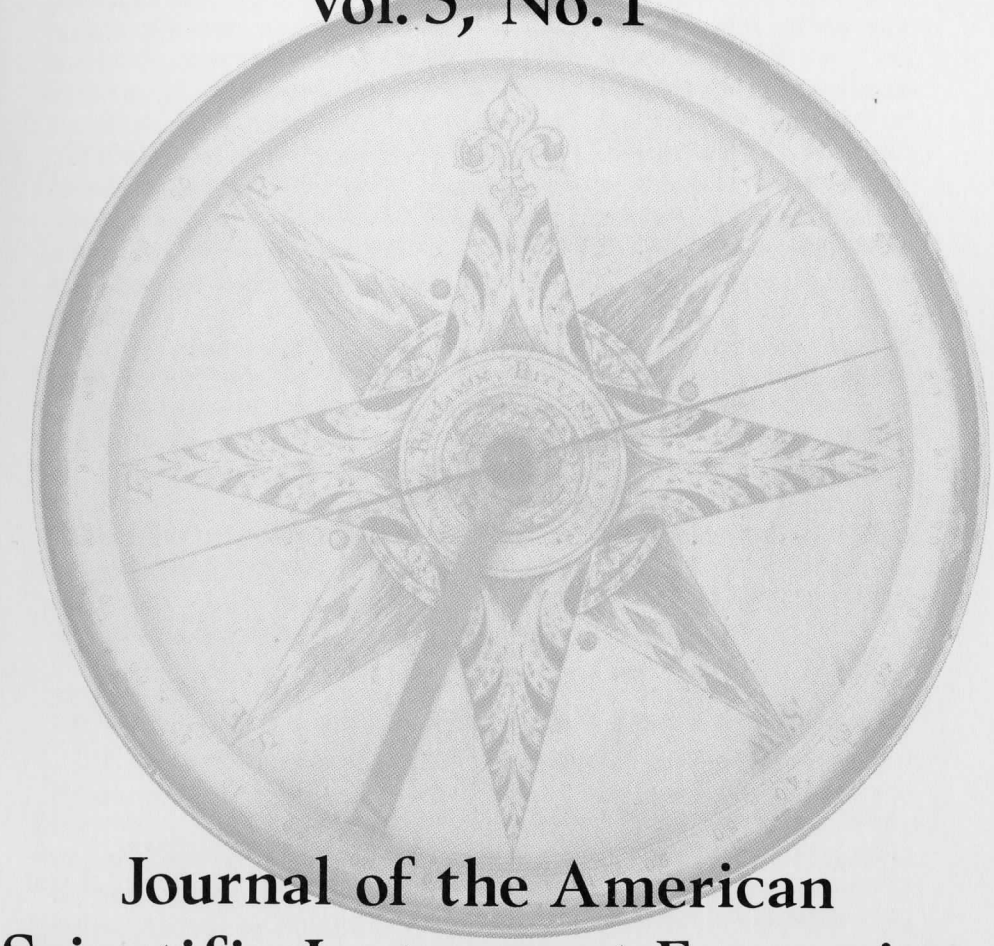
Vol. 5 November 1990 Issue 17

RITTENHOUSE

Vol. 5, No. 1



Journal of the American Scientific Instrument Enterprise

RITTENHOUSE

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Washington, D.C. 20560

Publishers

DAVID & YOLA COFFEEN
Tesseract
P.O. Box 151
Hastings-on-Hudson, NY 10706

RAYMOND V. GIORDANO
The Antiquarian Scientist
P.O. Box 367
Dracut, MA 01826

This JOURNAL aims to increase and diffuse knowledge about scientific instruments made and/or sold in the United States. The areas covered include mathematical, optical, and philosophical instruments, early electrical apparatus, sundials and globes.

Articles concerning instruments, instrument makers, or other aspects of the instrument enterprise, as well as book reviews and bibliographies, should be sent to the editor.

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DAVID RITTENHOUSE
COLONIAL SURVEYOR AND INSTRUMENT-MAKER

Francois D. Bud Uzes

David Rittenhouse (1732-1796) was a celebrated leader in several different disciplines. Although lacking a formal education, he distinguished himself as an astronomer, mathematician, surveyor, and maker of clocks and mathematical instruments. He also served as a legislator, administrator, financier, state treasurer, and the first director of the United States Mint. Along with his friend Benjamin Franklin, he is considered one of the leading American scientists of his time. He was a member of the Royal Society of London, and received a doctorate of laws from the College of New Jersey in 1789. Two years later he succeeded Franklin as president of the prestigious American Philosophical Society. Thomas Jefferson served as vice president of the Society under Rittenhouse, and succeeded him as president.

Numerous biographies of this distinguished Pennsylvanian have been published.[1] Because they all lack a surveying focus, they omit several significant details about his contributions to that profession. This article provides some of the little known yet important facts about that work, including a notable detail about a boundary survey. It examines improvements in the method of calculating land areas, and for the first time recognizes certain of the inventiveness and ingenuity in his surveying instruments. It also identifies which compasses were made by David Rittenhouse, and which were made by his younger brother, Benjamin.

SURVEYOR

David Rittenhouse made topographic surveys for roads and rivers, and he likely performed property surveys as well. He was the City Surveyor of Philadelphia for part of 1774. The most significant and widely known of his field work dealt with laying out boundaries between states. This work typically involved the ranging of lines of either latitude or longitude, according to positions determined from his astronomical observations.

Rittenhouse worked on jurisdictional lines involving Delaware, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, and Virginia. He helped run the 90-mile westward extension of the Mason-Dixon line and set the southwest corner of Pennsylvania. From this location, a party of four commissioners including David

Rittenhouse, Andrew Ellicott, and General Andrew Porter, together with 30 men, ran north in 1785 to establish the Pennsylvania-Virginia boundary. Along the way they set a post on the north bank of the Ohio River. That marker, described in the journal of General Richard Butler as "the post set up by Mr. Rittenhouse," was adopted later that year by Thomas Hutchins as the Initial Point for the survey of the Seven Ranges.[2] This post thus became the starting point for subdividing the public lands of the United States under the Land Ordinance of 1785.

COMPUTER

The Pennsylvania Method for calculating areas of irregular tracts by Double Meridian Distance uses only one column for the DMD portion of the calculations, instead of separating them into north and south elements, as was the former practice. It also makes the mathematics quickly self-checking, thereby saving valuable time when errors occurred. The Pennsylvania Method replaced the DMD procedure during the 19th century, and it survives to the present day. This writer used the Pennsylvania Method for over thirty years before getting a programmed computer.

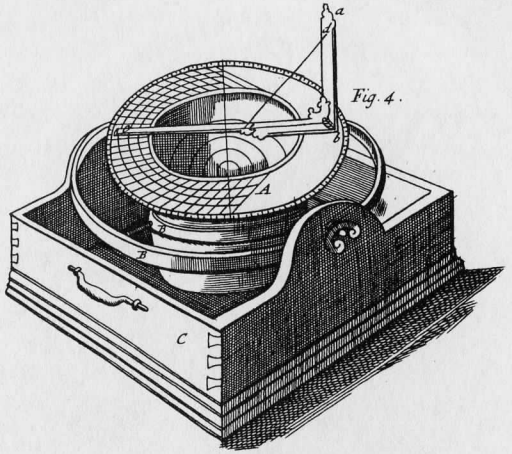
One source states that the method was used in the Surveyor General's Office in Philadelphia as early as 1785.[3] Another attributes the method to "Dr. Rittenhouse".[4] John Lukens, Surveyor General of Pennsylvania, was a close friend of David Rittenhouse. They worked together on several projects, including the 1769 observations of the transit of Venus. Whether or not Lukens learned the method from Rittenhouse is unknown.

COMPASS MAKER

David Rittenhouse, who had begun making clocks while in his teens, probably began making compasses in the late 1760s. We do not know where or from whom he learned to make these instruments, but the task would not have been difficult for one so mechanically inclined. Although he must have studied actual instruments--some brass compasses were in use in America, even though the metal was scarce--he probably gained important knowledge from Edmund Stone's English translation of Nicholas Bion, *The Construction and Principal Uses of Mathematical Instruments* (London, 1758). On 21 February 1767 Thomas Barton wrote to Rittenhouse, encouraging his brother-in-law to build an orrery, and urging him to purchase this

well-illustrated and informative book.[5] The fact that Rittenhouse built an azimuth compass mounted in a wood base, quite like the one pictured by Stone, suggests that he did in fact have access to the book.[6] So does the fact that Bion explains how to divide a circle into one-degree increments--the usual graduation found in Rittenhouse compasses.

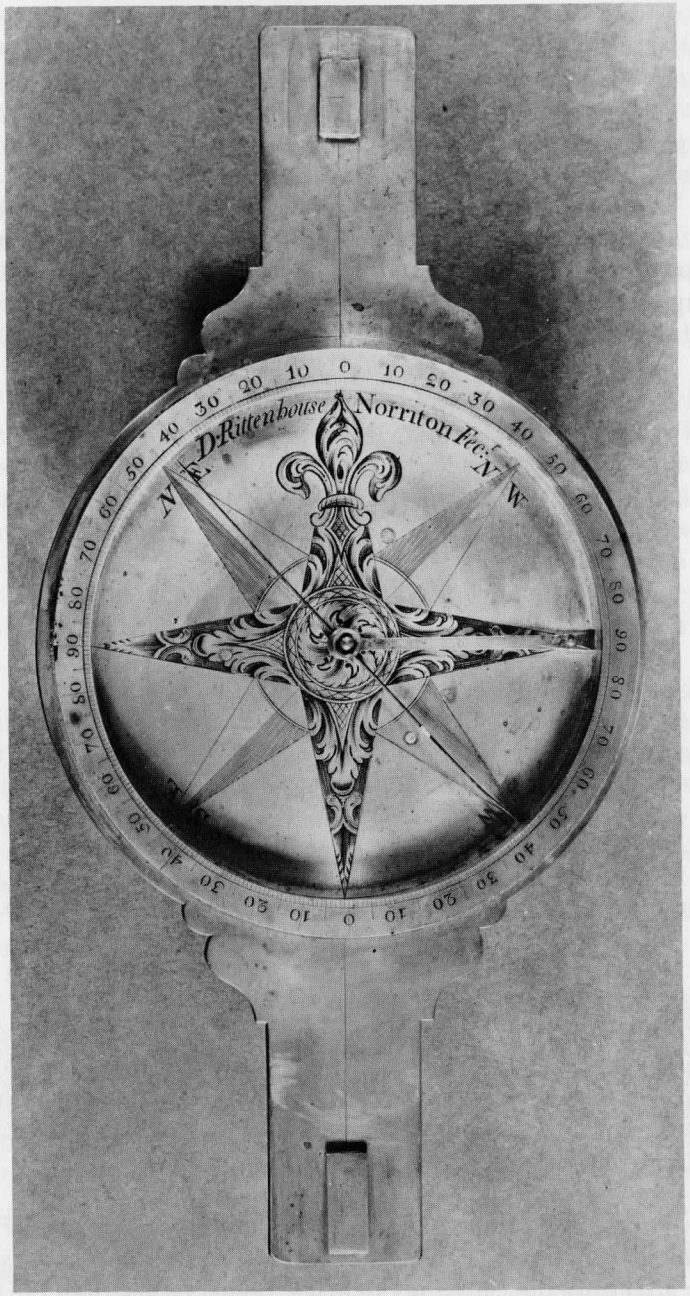
The Revolutionary War interrupted Rittenhouse's manufacturing, and afterward he engaged in other activities, including state boundary surveying. Nonetheless, he sought good optical glass for grinding telescope lenses in 1780, and he may have produced surveying instruments in the 1780's.



Azimuth compass. From Edmund Stone's edition of Nicholas Bion, The Construction and Principal Uses of Mathematical Instruments (London, 1758)

David Rittenhouse probably produced less than two dozen surveying instruments, and less than seventy-five clocks.[7] By way of comparison, Thomas Whitney advertised in 1820 that he had produced about 500 surveying compasses during the preceding thirteen years. David did not have a consistent instrument signature. Neither did Benjamin. The few surviving instruments which can unequivocally be attributed to David are:[8]

1. Surveyor's plain compass signed "D. Rittenhouse Norriton Fec^{t}" in the Historical Society of Pennsylvania at Philadelphia. This has raised lugs for attaching the (missing) sighting vanes, rather than the screws typically found on later instruments. This compass was probably made before Rittenhouse moved to Philadelphia in 1770.



Surveyor's plain compass signed "D. Rittenhouse, Norriton Fec^{t}."
Photo courtesy of The Historical Society of Pennsylvania.

2. Surveyor's compass signed "David Rittenhouse". Privately owned, this was exhibited at the State Museum of Pennsylvania at Harrisburg. It is unknown whether this is a plain or vernier compass. Its present location is also unknown.

3. Surveyor's vernier compass signed "DAVID RITTENHOUSE PHILAD^{A}". Privately owned. The vernier is on the south arm.

4. Surveyor's vernier compass signed "David Rittenhouse PHILADELPHIA" in the National Museum of American History at Washington, D.C. The Rittenhouse signature appears in slant letters, while the name of the city is vertical. The vernier here is on the rim of the compass box, rather than on one of the arms. This has screw holes for attaching the (missing) sighting vanes.

5. Variation compass signed "D. Rittenhouse Philadelphia" in the New York State Library at Albany. This was reportedly used by George Washington.[9] (This instrument is discussed below.)

6. Surveyor's 21-inch level signed "D. Rittenhouse" in the Historical Society of Montgomery County at Norristown, Pennsylvania.

Surveyor's level signed "D. Rittenhouse". Photo courtesy of James Bean and The Historical Society of Montgomery County, Pennsylvania.

These D. and David Rittenhouse instruments appear to be the work of several hands, suggesting apprentices and/or assistants. The engraved letters and numbers vary in quality, even on the same instrument. Some instruments are likely to have received more of Rittenhouse's personal labor than others. Those include the compasses with special devices like the rotating dial, vernier, automatic needle lifter, and solar device.

Some instruments are signed simply "Rittenhouse Philadelphia", but various styles of lettering are employed:

7. Surveyor's plain compass which David Rittenhouse reportedly gave to George Washington in 1782. The compass was donated to what is now the National Museum of American History in 1883.

8. Surveyor's plain compass in the Germantown Historical Society at Philadelphia.

9. Surveyor's plain compass, privately owned. This instrument has an automatic needle lifter (discussed below).

10. Surveyor's compass signed "Rittenhouse fecit for Tho^{s} Williams". It is unknown whether this privately owned instrument is a plain or vernier compass.[10]

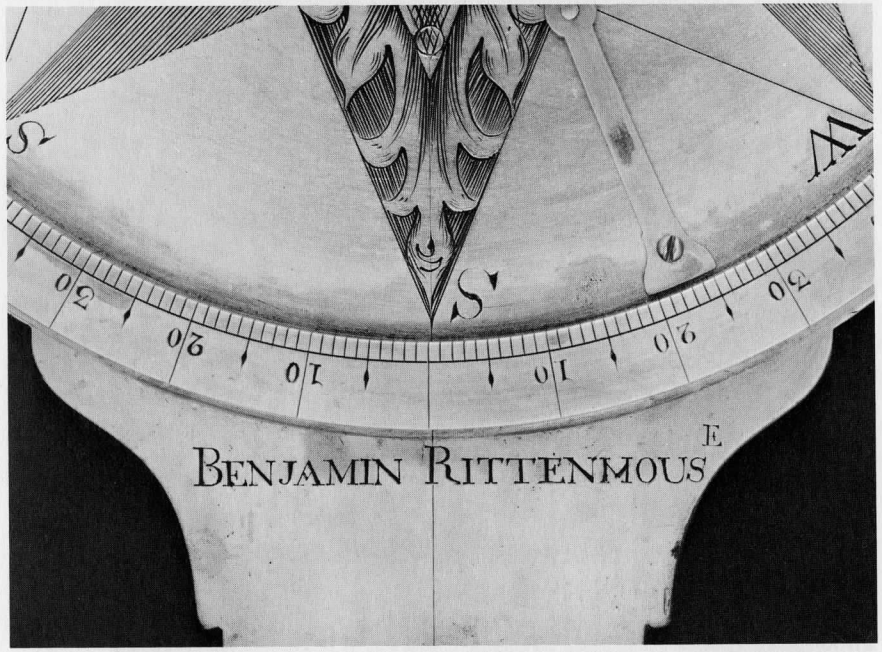
These "Rittenhouse Philadelphia" instruments are concluded to have been made by David. This is based, in part, on a comparison of the construction and engraving details. Since Benjamin served his apprenticeship under David, it is to be expected that instruments made by the two brothers would be alike in many ways.[11] There were, however, some distinguishing differences.

A. All three of the David Rittenhouse instruments checked have 8's with fully rounded tops, and flat-topped 3's. Compasses with block letters all have conventional H's with straight center bars.

B. All three of the Rittenhouse instruments checked have exactly the same pattern of 8's, 3's, and H's as those on the David Rittenhouse instruments.

C. Thirteen of the fifteen Benjamin Rittenhouse compasses checked have either flat-topped 8's, round-topped 3's, or block letter H's which look like M's. Several have two of these features.

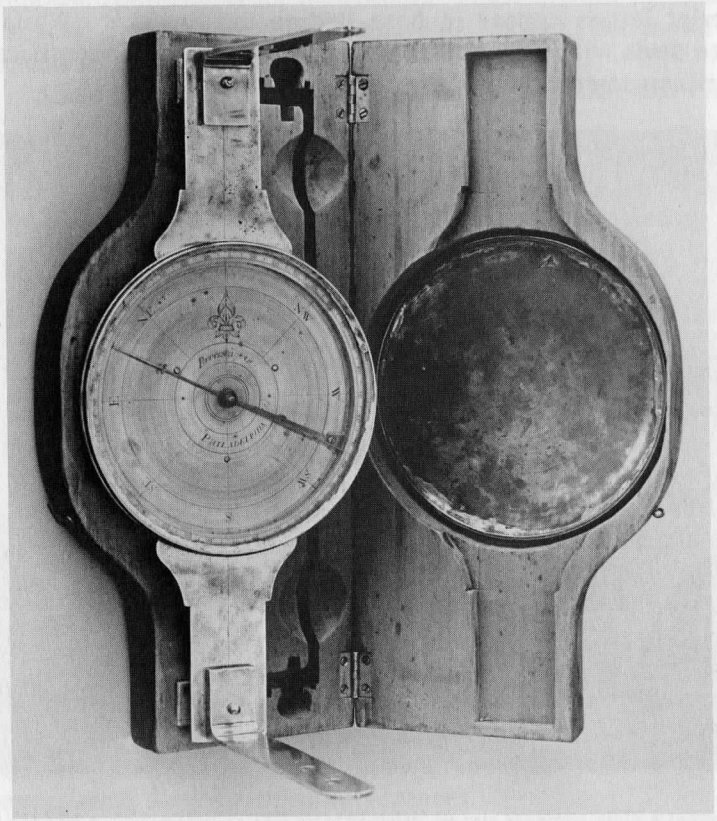
The conclusion of David being the maker is further supported by documentation concerning the "Rittenhouse Philadelphia" compass #7 listed above. Correspondence housed in the National Museum of American History indicates that David Rittenhouse gave this instrument to General Washington in 1782. Brief synopses of the original manuscript letters appear in both Bedini and Smart.[12] While this evidence deals with only one compass, it serves in the identification of other instruments having the same signature.



Surveyor's plain compass signed "BENJAMIN RITTENHOUS^{E}" in NMAH. Note the shape of the letter H, and the position of the final E.

A third argument is that David Rittenhouse was the oldest son in a family of European descent, a position which carries a privilege to the family name. He is thus more likely to have used just the family name on his instruments than was his younger brother. He may have discontinued using the "Rittenhouse Philadelphia" signature after Benjamin began making instruments for sale. It should also be noted that compasses were simple instruments compared with clocks and orreries, and they were never an important element of David Rittenhouse's business. It is likely that compasses played no significant role in David's personal identity, and so he felt no need to mark

them with a full signature. The same might not hold for Benjamin, who devoted himself to the manufacture of compasses for several years. Furthermore, it is unlikely Benjamin would use just the family name while having an older brother as an instrument maker.



Surveyor's plain compass signed "RITTENHOUSE PHILADELPHIA" with automatic needle lifter. The wood case may not be original. Private Coll.

Compass #9 signed "RITTENHOUSE, PHILADELPHIA" has an automatic needle lifter which mechanically guards the sharp center pin against wear during non-working conditions. A small lever protrudes downward from inside the unit's staff socket. Pushing up on this lever causes the compass needle to be lowered onto the pin. This occurs automatically when the instrument is placed upon a tripod or staff. When removed from the support, the lever returns causing the needle to be lifted off the pin. No earlier examples are known, and so it is possible that David Rittenhouse invented this device.

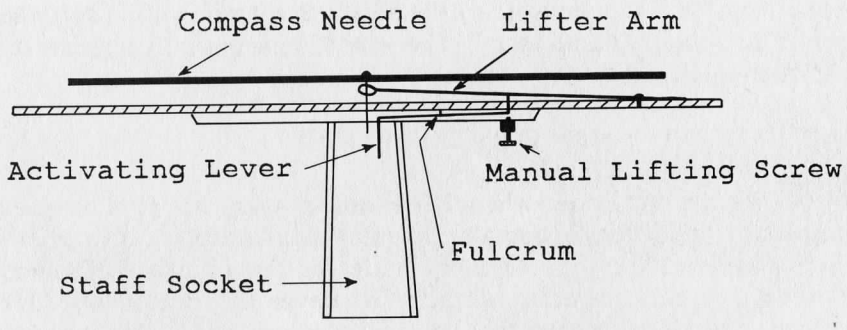


Diagram of the automatic needle lifting mechanism in the "RITTENHOUSE PHILADELPHIA" plain compass. Private Coll.

A vernier compass signed "Rittenhouse and Comp^{y}", said to have been used by Abraham Lincoln, is kept in the Lincoln Park Museum at Petersburg, Illinois.[13] One investigator suggests that this compass may have been made by Benjamin Rittenhouse and his son David.[14] That possibility has much merit. County tax records indicate David worked with his father from 1800 to 1802. The divided ring of this compass has the flat-topped 8's used by Benjamin. The instrument lacks the decorated compass rose typically found on Benjamin's instruments, but that might be expected on a piece made primarily by a young man whose skills were only moderately advanced. Signing the instrument David Rittenhouse would be misleading, as that would suggest it was made by young David's well-known uncle. Business use of the non-specific family name is compatible with the family succession concept, particularly as the elder David was then deceased.

Some compasses are signed "Rittenhouse and Potts", and some are signed "Rittenhouse and Evans". Although earlier scholars differ on whether this Rittenhouse was David or Benjamin, Bruce Forman has recently argued convincingly for Benjamin being the brother involved in these ventures.[15] Analysis of Benjamin's distinctive style supports his finding. The H on one "Rittenhouse and Potts" compass looks like an M, while the 8 is round and full. Another example, though, has flat-topped 8's. The H on one "Rittenhouse and Evans" instrument looks like an H, but the tops of the 8's are small and flat. On other instruments with these signatures, however, the H's and 8's are conventional in form.

Both William Lukens Potts (1771-1854) and Benjamin Evans (1776-1836) started working with Benjamin Rittenhouse in about 1796. That is the year David passed away. Potts was with Benjamin

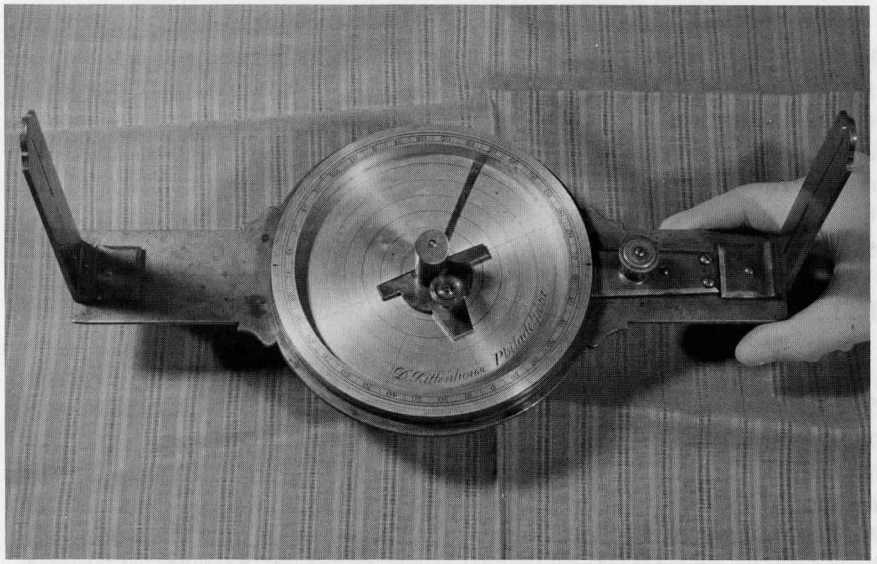
for about two years, then later worked independently. Evans, a nephew of the Rittenhouses, worked with Benjamin until 1801, the year of Benjamin's bankruptcy. The year 1796 reportedly appears on a "Rittenhouse and Evans" compass.

VERNIER AND VARIATION COMPASSES

We do not know when Rittenhouse made his first vernier compass, or if indeed he actually invented this important instrument which enables a surveyor to compensate for the angular difference between true and magnetic north.[16] Whatever the case, nineteenth century Americans knew the vernier compass as a "Rittenhouse compass," or the "compass upon Rittenhouse's construction."[17] According to Abel Flint: "It was well known to the celebrated Rittenhouse that his compasses did not agree, and he was never satisfied as to the cause of it. To remedy this defect, if it can be called a defect, he constructed his compass with a nonius or vernier scale (as some call it) that all of them might be so regulated by a meridian as to agree. The meridian should be established by the motion of the heavenly bodies, and made permanent by durable monuments."[18]

Within a few decades of its introduction the vernier compass had become the basic instrument specified in the instructions for the surveys of the public lands of the United States. Its popularity declined in the 1840s after the introduction of Burt's solar compass, which was more reliable in areas with local magnetic attraction. Still, the vernier compass continued to be accepted for certain types of public work until 1894. Its use in non-government work continued much longer, with production by several major manufacturers continuing into the 1920's and 1930's. It still appeared in the 1949 edition of Gurley's *Manual*. Today its features appear in small forester's and geologist's compasses.

As a practical surveyor, David Rittenhouse was well aware of the problems of magnetic variation and how it changed over time and place. He researched the differences in needle readings between various compasses for the same alignment of the sights. He also made at least one instrument designed for measuring the earth's magnetic variation. This innovative instrument, which should probably be termed a variation compass, incorporates the mechanism of the vernier compass, perhaps without that result intended.[19] One wonders if it was a precursor of the vernier compass. An example is now owned by the New York State Library at Albany (#5 above).



"D. Rittenhouse Philadelphia" variation compass.
Photo courtesy of the New York State Library at Albany.

The variation compass has two unique features: several concentric circles cut into the compass face, and a small brass solar device which fits over the pin once the needle is removed. Accessories include a spirit level attached to a small straightedge, and a wooden case with adjustable brass legs for leveling.

The equal-altitude method of determining the magnetic variation is as follows. With the vernier reading 0° on the ring, align the sights in the magnetic meridian, and remove the glass cover. Replace the compass needle with the solar device. Sunlight will pass through the hole in the solar device, creating a spot on the dial. Wait for the spot to touch one of the concentric rings. Without disturbing the sighting alignment, rotate the dial so the image touches the north-south line. Read the arc value appearing opposite the vernier. Repeat the operation in the afternoon, when the light spot is in the same position relative to the concentric ring. Now rotate the dial until the spot just touches the opposite side of the north-south line. The line halfway between the two vernier readings is true north. The angular difference between that direction and magnetic north is the variation of the needle. If the sun's bearing is known, the variation can be determined from a single pointing. With his appetite for scientific experiment, it is likely that David Rittenhouse operated the

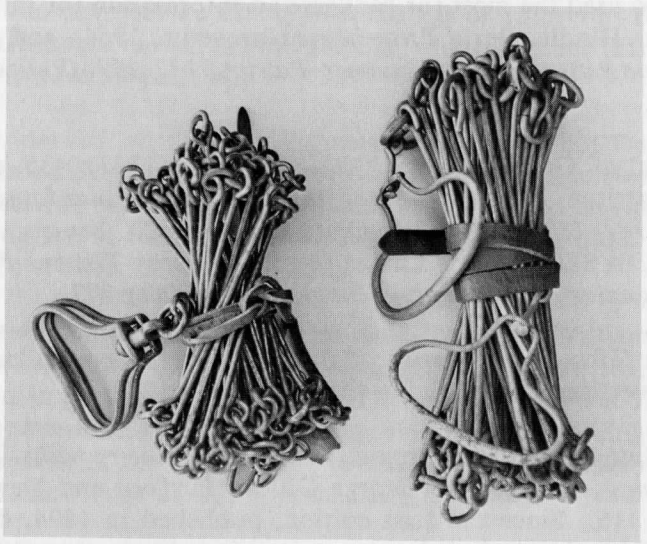
variation compass using both methods.

The graduated ring of the variation compass rotates a full 360°, and can thus accommodate the morning and afternoon values of the sun's bearing. The usual vernier compass, by contrast, has only enough adjustment for the range of the anticipated magnetic variation. For example, a circa 1815 Thomas Whitney vernier compass has a 20° reach from 10°E to 10°W. Built for surveys in the eastern part of the United States, it would not suffice in the west, where the variation can exceed 23°E.

RITTENHOUSE CHAIN

On 18 May 1796 Congress passed "An Act providing for the Sale of the Lands of the United States, in the Territory north-west of the River Ohio, and above the Mouth of Kentucky River." This Act specified that "All lines shall be plainly marked upon trees, and measured with chains, containing two perches of sixteen feet and one half each, subdivided into twenty-five equal links, and the chain shall be adjusted to a standard to be kept for that purpose."[20] Although this standard chain does not seem to have survived, it is reasonable to assume that it was a common Gunter chain with either 50 links in 33 feet (like those to be used in the field) or 100 links in 66 feet. Many 18th century surveys used linear and square perches (or poles, or rods) as the units of measure. Benjamin Rittenhouse, who was employed to make this standard chain, did the work with dispatch, and by the following May the chain had been sent to the Surveyor General, Rufus Putnam.[21]

The Gunter chain was not the only type of chain used in America at that time. John Gummere, the author of a popular surveying textbook, called attention to the use of 80-link chains.[22] The English surveyor Vincent Wing had introduced the 80-link chain during the second half of the 17th century.[23] He argued that his chain was better than the Rathborne and Gunter varieties, as it simplified calculations of area when land was measured in perches.[24] Dunbar Scott, the principal author of a significant historical treatise on surveying instruments, introduced some confusion when he asserted that a "chain of Rittenhouse, which comprised 80 links or 66 feet, was quite generally used in American mines until Eckley B. Coxe and others started a reformation, some twenty-five years ago, in favor of the steel band." Benjamin Smith Lyman challenged this unusual statement.[25] Similar doubt is expressed here. David and/or Benjamin Rittenhouse could have made 80-link chains, but this design should not be identified with them as if it were their invention.



A pair of two-pole (33 feet) link chains. On the left is a Gunter chain with 50 links, each 7.92 inches long. On the right is a Wing chain with 40 links, each 9.9 inches long. Private coll.

CONCLUSION

David Rittenhouse made several significant contributions to the surveying profession. They showed the same inventiveness, skill, and dedication that were proved in his other pursuits. It is unclear whether he was the originator of the several progressive items credited to him. For some, he may have been the first to apply them in America. In any event, he markedly advanced the practice of surveying. His surviving instruments are visible testimonials of that fact.

David Rittenhouse made the compasses signed D. Rittenhouse, David Rittenhouse, or Rittenhouse. All other instruments bearing the Rittenhouse name came from Benjamin's workshop.

Acknowledgements: Robert C. Miller of New Alexandria, Pennsylvania, provided much useful information, and Deborah Warner helped in the preparation of this article. Bryant N. Sturgess of Sacramento, California provided valuable aid in the analysis of the variation compass.

1. The two used the most for background information for this article are Brooke Hindle, *David Rittenhouse* (Princeton, 1964), and Edward Ford, *David Rittenhouse, Astronomer-Patriot, 1732-1796* (Philadelphia, 1946).

2. "Journal of General Butler," *Olden Time* 2 (1847): 435, cited in William Pattison, *Beginnings of the American Rectangular Land Survey System, 1784-1800* (Columbus, Ohio, 1970), p. 128. See also William A. Porter, "A Sketch in the Life of General Andrew Porter," *Pennsylvania Magazine of History and Biography* 4 (1880): 277.

3. Robert Gibson, *A Treatise of Practical Surveying* (Philadelphia, 1785), advertisement following title page and p. 219.

4. Abel Flint, *A System of Geometry and Trigonometry with a Treatise on Surveying*, enlarged by George Gillet (Hartford and New York, 1835), p. 116. Since the first edition, published in 1804, does not mention Rittenhouse in this connection, it is likely that Gillet was responsible for the information.

5. Quoted in William Barton, *Memoirs of the Life of David Rittenhouse* (Philadelphia, 1813), reprinted in part in Howard C. Rice, Jr., *The Rittenhouse Orrery* (Princeton, 1954), p. 29.

6. Illustrated (as rebuilt by W. & L. E. Gurley Co.) in Charles Smart, *The Makers of Surveying Instruments in America Since 1700* (Troy, N.Y., 1962), p. 140.

7. George H. Eckhardt, *Pennsylvania Clocks and Clockmakers* (New York, 1955), p. 35.

8. Numbers 1 (incorrectly identified as a vernier compass), 5, 6, 7, and 8 are listed in Smart, op. cit. Deborah Warner provided information on numbers 2, 3 (illustrated in *Rittenhouse* 1 (1987): 66), 4 and 10. Supplemental data was obtained from owners or custodians of some of the instruments. There is also a "D. Rittenhouse Philadelphia" azimuth compass designed for navigation in the Gurley Collection at Troy, New York.

9. A label inside the compass box reads "The instruments contained in this box...were the property of General Washington and used by him when a very young man." Middle-aged would have been a better choice of words. Washington, who was the same age as Rittenhouse,

is known to have been a surveyor at the age of 15 or 16. But by the time Rittenhouse moved to Philadelphia, where he made this compass, both men were 38 years old.

10. The identity of Thomas Williams is unknown, but David's and Benjamin's mother was born Dorothy Williams. Two uncles lived for some period at the Norriton farm, and the one named David Williams left young David Rittenhouse a box of tools when he died. The first name of the other uncle is not known.

11. Benjamin's apprenticeship is mentioned in William Barton, *Memoirs of the Life of David Rittenhouse* (Philadelphia, 1813), p. 138, reprinted in part in Daniel Cassel, *A Genea-Biographical History of the Rittenhouse Family* (Philadelphia, 1893), p. 221. William Barton was a nephew of the Rittenhouse brothers, and in a position to have personal knowledge of this apprenticeship.

12. Silvio Bedini, *Early American Scientific Instruments and Their Makers* (Rancho Cordova, Cal., 1986), pp. 142-145. Charles Smart, op. cit., pp. 139-140.

13. Sworn statement of John B. Gum, 13 November 1865, reprinted in Adin Baber, *A. Lincoln with Compass and Chain* (Kansas, Ill., 1968), p. 149.

14. Bruce R. Forman, "The Worcester Workshop of Benjamin Rittenhouse," *Rittenhouse* 2 (1988): 83. Bruce R. Forman, "A Guide to the Historical Society of Montgomery County's Clock Collection," *Bulletin of the Historical Society of Montgomery County* 26 (1988): 192.

15. Bruce Forman, "The Worcester Workshop of Benjamin Rittenhouse," op. cit., p. 82.

16. Deborah Jean Warner, "The Surveyor's Compass," *Rittenhouse* 1 (1987): 66-67.

17. W. & L. E. Gurley, *A Manual of the Principal Instruments Used in American Engineering and Surveying* (Troy, 1869), p. 22. Abel Flint, op. cit., p. 80. Edward Tiffin, *Instructions for Deputy Surveyors* (1815), p. 5. James Mansfield, "General Instructions to Deputy Surveyors" (1804) reprinted in C. Albert White, *A History of the Rectangular Survey System* (Washington, D.C., 1983), p. 237.

18. Abel Flint, op. cit., Appendix p. 95.

19. Although this Rittenhouse instrument uses the sun's position to determine the direction of true north, its operation is quite different from the more practical instrument introduced by Burt. Burt originally called his a variation compass, but soon changed the name to solar compass. See John S. Burt, *They Left Their Mark. A Biography of William Austin Burt* (Rancho Cordova, Cal., 1986), p. 37.

20. *The Laws of the United States of America* (Philadelphia, 1796), vol. 3, pp. 293-301.

21. Joseph Nourse to Rufus Putnam, 8 May 1797, Letters received by Surveyors General NW of Ohio River, 1796-1806, National Archives, RG 49. Also Rufus Putnam to Oliver Wolcott, 1 June 1797, Letters received by Secretary of the Treasury and Commissioner of General Land Office from Surveyors General NW of Ohio River, RG 49. Note that Silvio Bedini in *Thinkers and Tinkers* (New York, 1975), p. 317, contends erroneously that the standard chain Benjamin Rittenhouse produced for the U.S. Land Office had 80 links in 66 feet.

22. John Gummere, *A Treatise on Surveying*, 8th ed. (Philadelphia, 1833), p. 81.

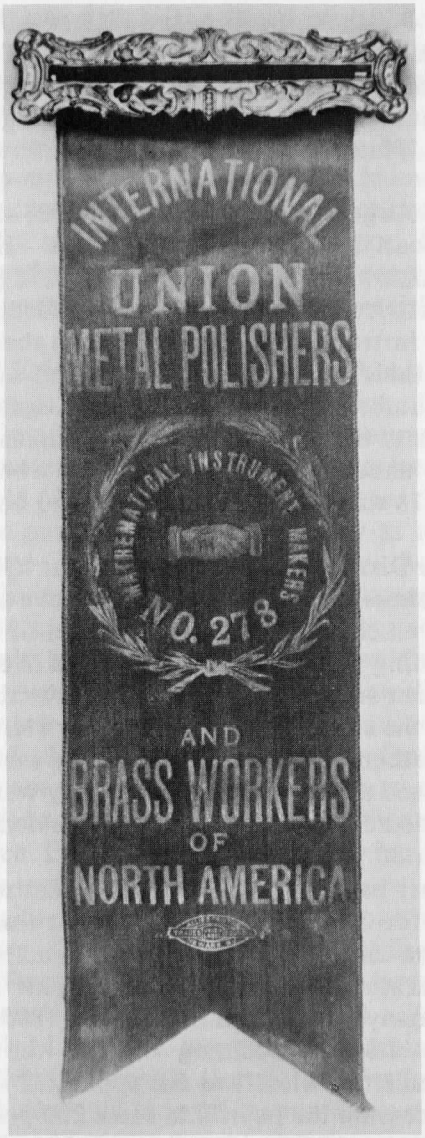
23. John Wing, *The Art of Surveying: Formerly Published by Vincent Wing, Math* (London, 1700), p. 170.

24. The Rathborne decimal chain divides each perch into tenths, called primes. It further divides each prime into tenths, called seconds. Thus, there are 100 seconds for each perch, or 400 seconds per 66 feet.

25. Dunbar D. Scott and others, *The Evolution of Mine Surveying Instrument* (New York, 1902), pp. 32 and 283.

INSTRUMENT MAKERS ORGANIZE

Deborah Jean Warner



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