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Dividing the Needle of a Colonial

In the American colonies during the 18th century, the construction of the surveyor's compass ranged from crude to sophisticated. Most New England instruments from this period were made primarily of wood and had printed paper cards for the divisions of the degrees. This article does not address the wooden compasses with engraved paper cards, but rather the means by which the colonial instrument manufacturers divided the needle rings for their manufactured surveying compasses prior to the introduction of a Jesse Ramsden-inspired dividing engine.

In order to accurately divide a needle ring of a compass into 360 degrees, accuracy would have been predicated on the abilities of the craftsman as well as the equipment available for such a procedure. The three most common methods of dividing the needle ring, from simple to complex, are by protractor, by dividing plate, or by wheel-cutting engine. A close inspection of a needle ring generally reveals the method by which the circle was divided. In some cases, however, the divisions are so irregular as to infer that they were carried out strictly by "eye," with minimal concern for uniformity of the divisions (**Figure 1**).

Protractor Method

Using the protractor method, the instrument maker would use a fairly accurately divided protractor, ideally larger than the needle ring to be divided. He first inscribed a circle on a piece of paper or vellum, slightly smaller than the inside diameter of the needle ring that he was dividing. Then, using his larger

Figure 1 David Main, dated 1800 (note birds in fleur de lis)

Ring Compass

>> By Jeffrey Lock

protractor, he first aligned the protractor center with the center of the circle he had marked out, and carefully marked on the paper or vellum each of the degrees for the circle. By working carefully with a ruler or straight edge, he connected the opposite degree marks to each other, being attentive to bisect the center of the circle, and repeating the procedure for each of the degrees (**Figure 2**). Next, he would cut out the appropriate diameter from the paper or vellum to match the inside diameter of the needle ring. The paper or vellum was then glued to a piece of wood the same thickness as the needle ring, which effectively placed his 360-degree "master" circle on the same horizontal plane as the needle ring, and affixed the two together with a pitch or tar material to prevent movement when the inscribing process commenced. He would then inscribe the needle ring by whichever means he was capable of, either incising it with a knife, punching it with a straight chisel, or engraving it with a burin, using this paper master as his guide (**Figure 3**).

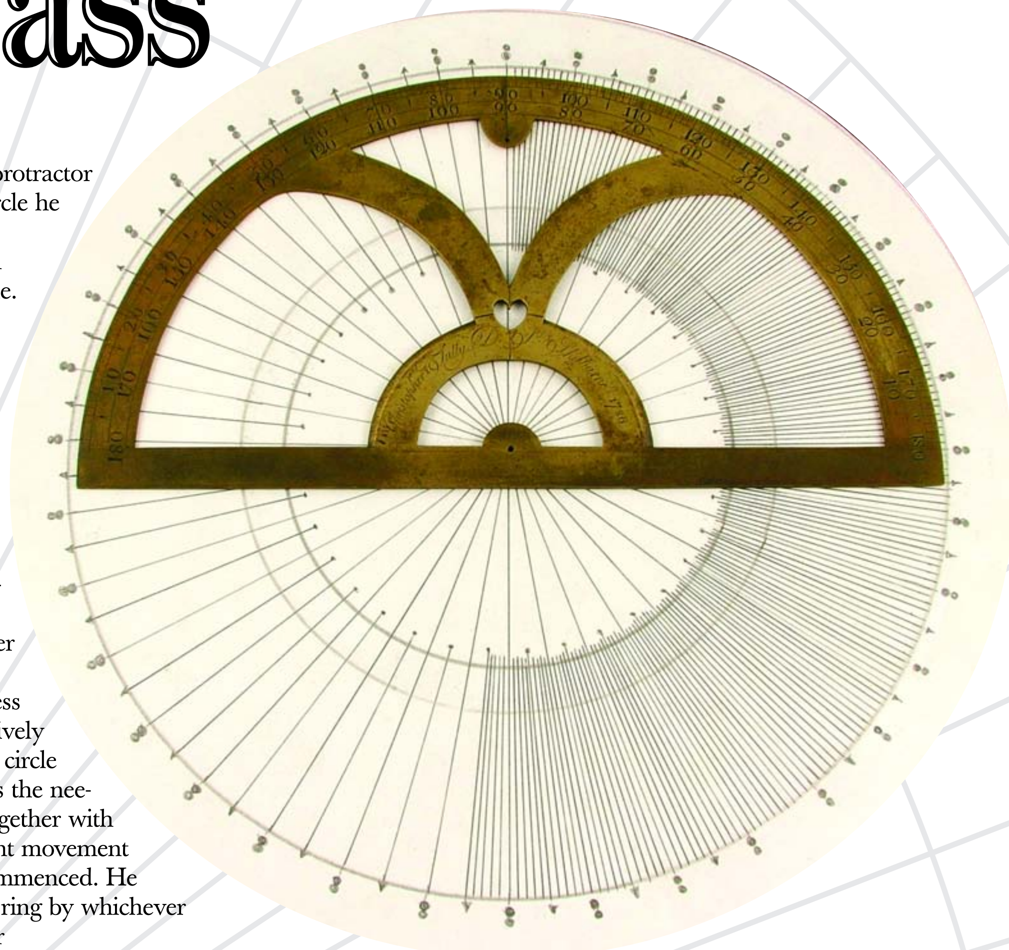


Figure 2 18th century protractor used to create master template

Dividing Plate Method

The second method of dividing could have a relatively high degree of precision directly proportional to the accuracy of the dividing plate being used. Dividing plates were originally constructed by clockmakers to accurately mark the divisions for the teeth of gears in clock mechanisms. Historical examples of dividing plates can be found illustrated in books such as *Horological Shop Tools, 1700 - 1900* by Theodore Crom. Upon studying a dividing plate circa 1565 which had an integral three-jaw chuck mechanism for holding the gear being laid out, I built a plate along the same design with four adjustable jaws that gives the ability to more quickly center the workpiece (**Figure 4**). The most time-consuming aspect of the construction of this plate was the accurate placement of the 360-degree holes. By keeping true to the time period I avoided using a mechanical dividing head and attempted to build this unit with the technology available in the 18th century. After

Figure 3 Degrees on an unsigned colonial compass, circa 1750

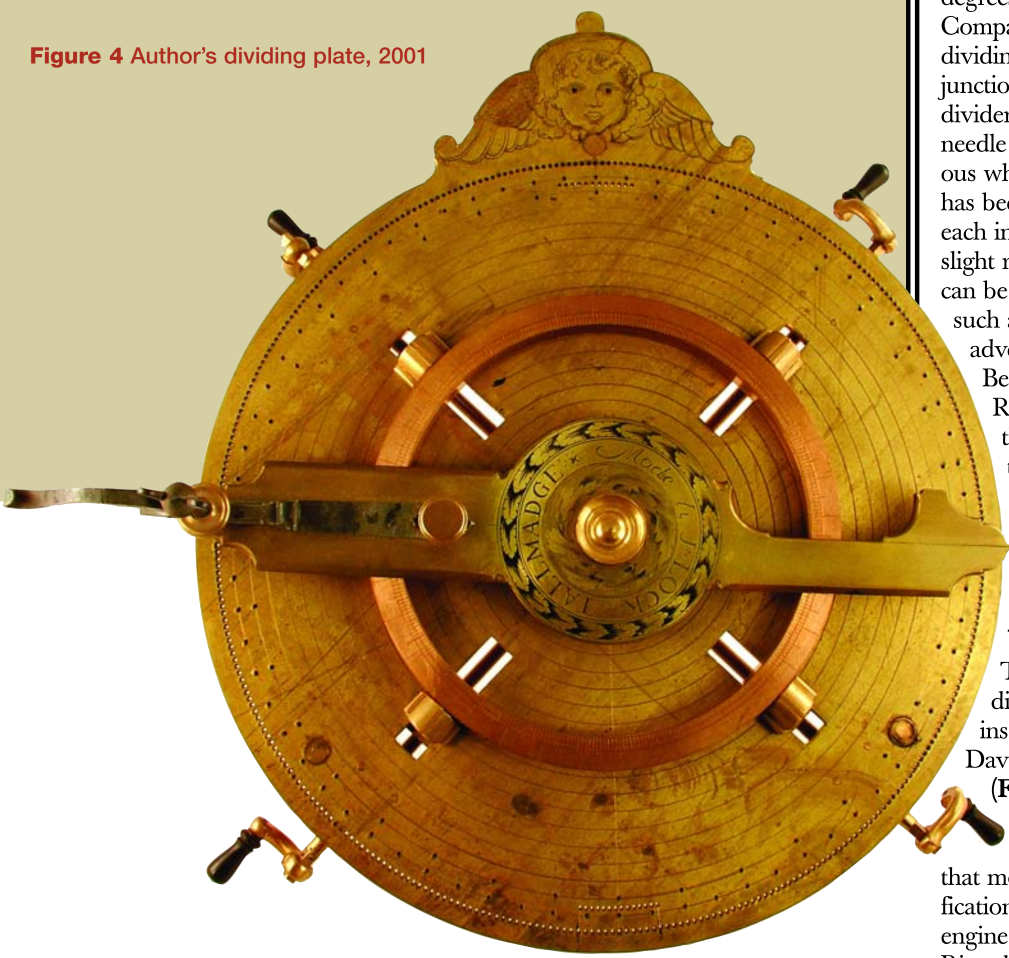


Figure 4 Author's dividing plate, 2001

experimenting with several division methods and referring to Allan Chapman's book, *Dividing the Circle,* I chose to use Graham's method of using beam compasses for bisections, trisections, and quinquesections. After much work under high magnification, I was satisfied with the accuracy of the 360 holes I had made in the dividing plate. I also chose to install a center axle about which an indexable alidade would rotate, dropping a pin into the corresponding hole in the dividing plate. Integral to this alidade was a fiducial centerline that acted as a straightedge to guide the dividing knife (**Figure 5**). This dividing knife acts as a miniature plow, accurately forming a groove in the brass similar to an engraved line, but instead of peeling out the brass like an engraver's burin, it literally plows a furrow in the brass, similar to a farmer's plow in the earth. These raised lips are then removed with a wet stone, leaving an extremely accurate straight line (**Figure 6**). Various early compasses can be found with quite accurate divisions despite their early dates of construction (**Figure 7**).

One of the distinctions between the protractor method and the dividing plate method is the uniformity of the radial degree lines. Using the protractor method, the uniform, radial aspect of the degrees is very difficult to accomplish. Compare Figure 3 with Figure 7. The dividing plate can also be used in conjunction with a beam compass or pair of dividers to mark out the degrees of a needle ring (**Figure 8**). It is very obvious when inspecting a needle ring that has been laid out using this combination; each individual scribe line will have a slight radius. Examples of this method can be found on compasses by makers such as Lewis Michael (**Figure 9**), who advertised that he was trained by Benjamin Rittenhouse. None of Rittenhouse's needle rings show this radius marking, therefore it is to be assumed that Lewis Michael collaborated with Rittenhouse but did not have access to Benjamin's equipment on his earliest compasses.

Wheel-Cutting Engine

The highest level of needle ring divisions can be found on the instruments of makers such as David and Benjamin Rittenhouse (**Figure 10**). Their scales, studied under magnification, show a level of accuracy and sophistication that most likely was the result of a modification to a clockmaker's wheel-cutting engine. When the inventory of David Rittenhouse's estate is reviewed, one of the most valuable items listed was his wheel-cutting engine as found on pp. 167/168 of *The Origin and History of the Rittenhouse Family* by Daniel Cassel. The "clock engine" was inventoried at 22 pounds, 10 shillings, equal in value to

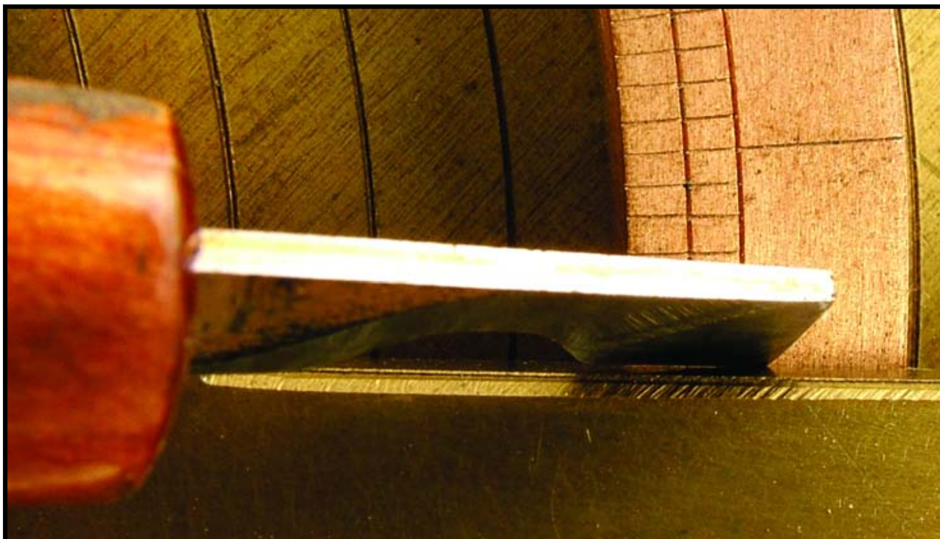


Figure 5 Dividing knife scoring along fiducial edge of alidade

Figure 6 Final divisions inscribed with dividing knife
Figure 7 (Below) Degrees on a signed colonial compass, dated 1733

the important transit instrument also listed. When compared to one of his clocks being evaluated at 10 pounds, the wheel-cutting engine's importance is put into its proper perspective. Keep in mind that the appraisals of Rittenhouse's instruments were carried out by none other than Andrew Ellicott.

Upon studying many 18th-century clockmakers' wheel-cutting engines, I have found that many contain an indexing ring of 360 holes, which corresponds directly to the division of a compass needle ring. The question to consider is how to harness the accuracy inherent in the wheel-cutting engine to mechanically divide the needle ring into 360 equal divisions. The suggested modification to the wheel-cutting engine would allow the scribing action to be directed horizontally onto the needle ring.

The first step to consider is the accurate placement of the needle ring and to allow the indexing capabilities of the divided circular plate to be utilized for the accurate division of the needle ring (**Figure 11**). In an attempt to reconstruct a manner in which an 18th-century clockmaker's engine could be modified to accurately scribe the divisions of a compass needle ring, I have constructed on a large 18th-century clockmaker's engine a rotating platform capable of holding a blank needle ring and use a hardened scribe to mark the degree divisions (**Figure 12**). The needle ring is securely held and centered to the plate by four bracketed thumbscrews that allow both the needle ring and plate to revolve as one unit (**Figure 13**). The horizontal motion of the screw-driven cutter platform allows the needle

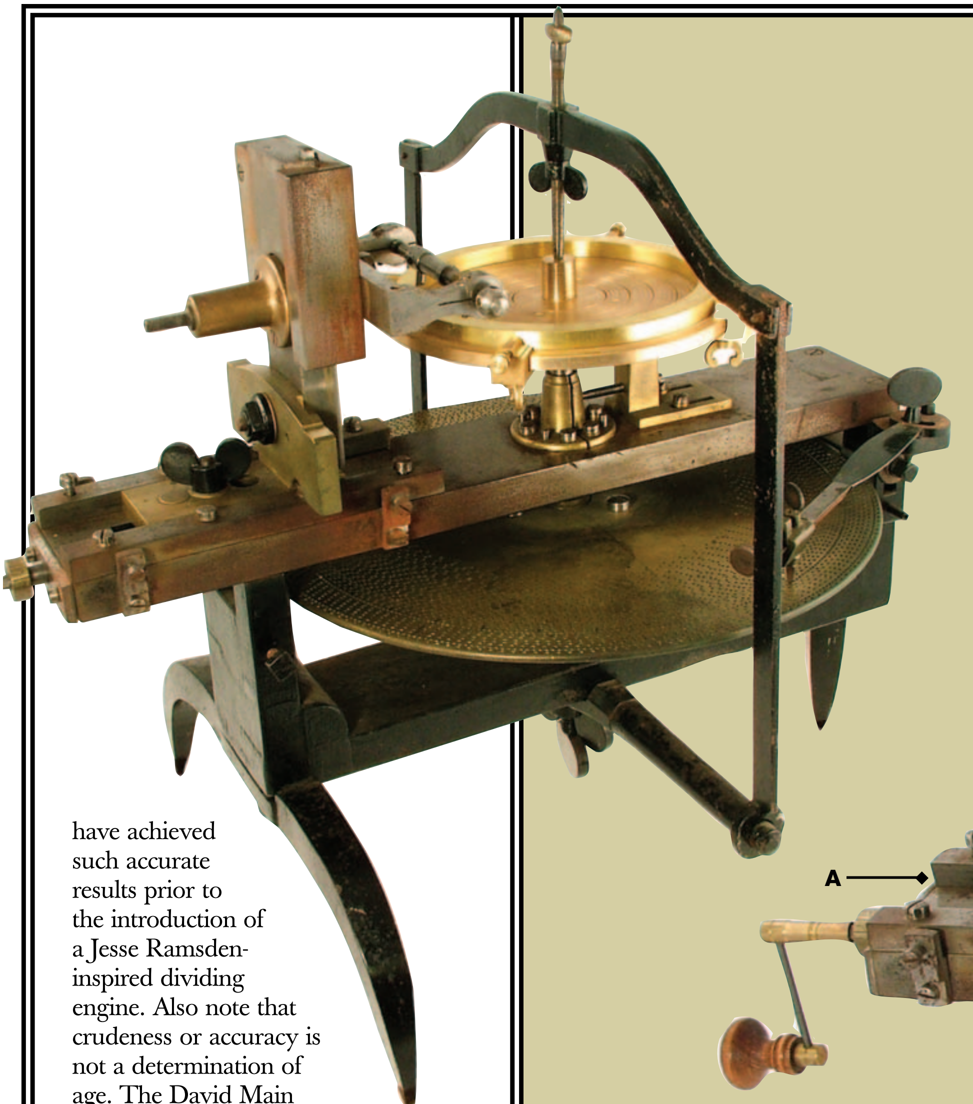
Figure 8 (Left) Dividers used to inscribe degree marks

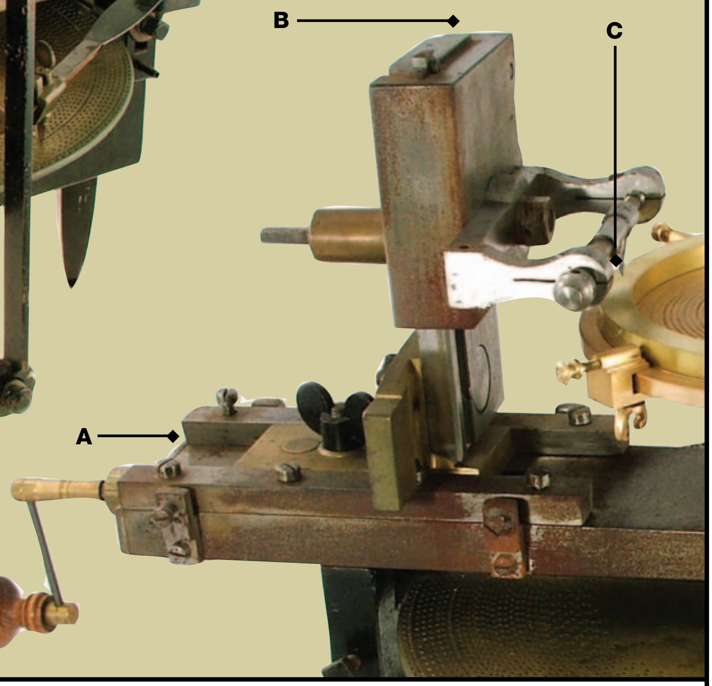
Figure 9 (Top) Degrees on a Lewis Michael compass, circa 1770

Figure 10 (Bottom) Degrees on a Benjamin Rittenhouse compass, circa 1780

ring to be engraved accurately. Due to the high level of craftsmanship in such a machine, I found that the horizontal run-out of the needle ring being divided was less than .010, which is easily shimmed to zero run-out, guaranteeing equal depth of cut for each of the scribed degree lines.

Keep in mind there is no written documentation that states how the 18th century instrument makers divided their scales. Therefore I must emphasize to the reader that, as an instrument maker, the suggested modification to a wheel-cutting engine is my concept of how makers such as the Rittenhouse brothers could





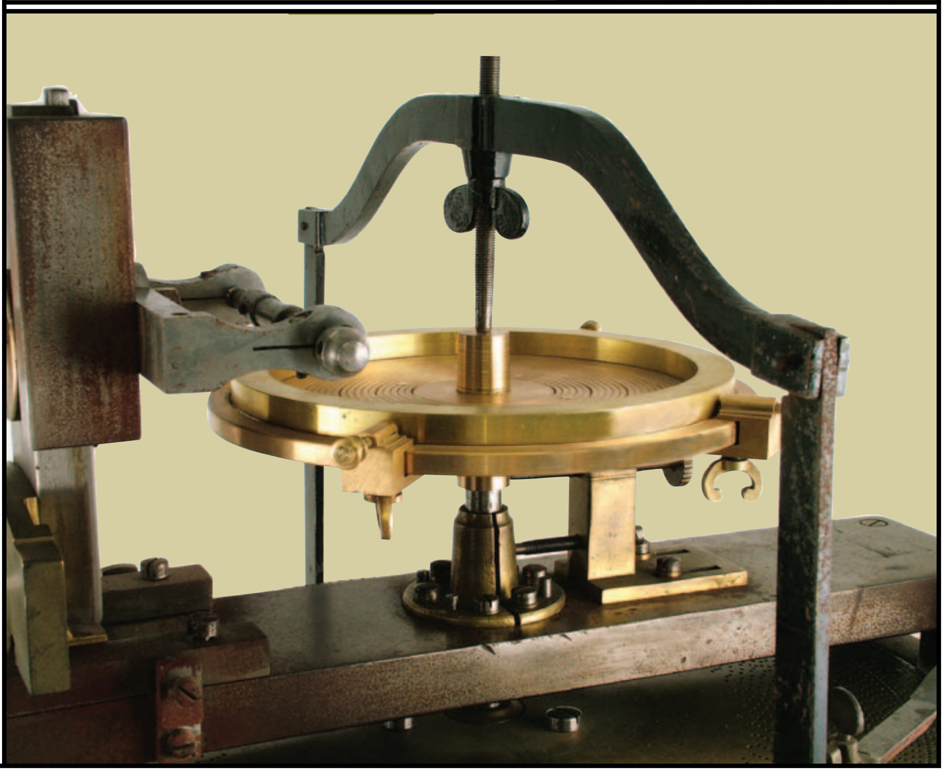


Figure 11 (Top) 18th-century clockmaker's wheel-cutting engine with author's indexing table

Figure 12 (Middle) Close-up of original horizontal (A) and vertical (B) screw-driven dovetailed slides. (C) denotes hardened scribe.

Figure 13 (Bottom) New indexing table with adjustable thumbscrew blocks for accurate centering of the needle ring.

have achieved such accurate results prior to the introduction of a Jesse Ramsden-inspired dividing engine. Also note that crudeness or accuracy is not a determination of age. The David Main instrument is crudely hand-divided, as seen in Figure 1, but is dated 1800. The much earlier colonial instrument, as illustrated, is signed and dated 1733. The accuracy of the divisions is determined by the dedication and craftsmanship of the individual maker. Further accuracy reaching mechanical perfection is achieved with the combination of craftsmanship in conjunction with a mechanical aid such as a dividing plate or modified clockmaker's wheel-cutting engine. It is always a challenge to allow the instrument maker's finished product to suggest the unspoken words of instruction that a student of this field so eagerly desires. However, instead of having the luxury of their personal instruction, we must attempt to uncover their methods by functioning in a working environment similar to theirs.

Additional articles and examples of the author's work can be viewed at www.colonialinstruments.com.