Measuring the Volume of Logs: The Timber Contenting Slide Rule

James Bready and Bruce Babcock

In one way or another people have been measuring timber for as long as people have been measuring anything, except perhaps land. Loggers, timber merchants and carpenters have all needed to know not just the linear dimensions of wood, but the volume of standing trees, logs, or sawn lumber. Loggers needed to know so they could estimate how much finished lumber a given tree would yield, merchants so they could price their lumber, and carpenters so they could cost out their jobs. The most common unit for the volume of wood today is the board-foot (one board-foot = 144 cu. in., or a piece of lumber 12"x12"x1"), however, in the 18th and 19th centuries the cubic foot was used almost exclusively. Four methods for determining the volume of trees, logs, and finished boards have been used: log and board rules, books of tables, longhand calculation, and specialized slide rules. Log and board rules were specialized rulers with multiple scales for different lengths of logs or boards. The rule would be laid across the width of a board or log and the content, in board-feet, could be read directly on the scale that corresponded with the length of the log or board. There were numerous different patterns for the scales on log rules [1], and the accuracy of the answer varied with the pattern and size of log. Log and board rules are still sold today [2], in at least four different patterns. Books of tables [3,4,5] seem to have been very popular, and gave easy answers to problems involving squared timber. Unfortunately, the tables treated round logs exactly like squared timber. One fourth of the circumference was to be treated as the side of a square equivalent in cross section to the round log. In their favor, the books usually pointed out the error in this method and presented two different rules of thumb for the reader to choose from [3, also 5,6,7, and 8]:

> "To find the solidity of round Timber:
> Rule 1. Multiply the square of the quarter girt by the length, and the product will be the content, according to common practice.
> Rule 2. Multiply the square of one-fifth of the girt by twice the length, and the product will be the solidity, very near the truth."

"Girt" in this case meant the circumference, although the term was sometimes used to mean the quarter-girt. Measuring the content of a log using the tables went as follows: first, measure the circumference of the tree or log with a piece of string.[1] Fold the string into either fourths or fifths depending on which rule you're using, then look up that length in the tables opposite the length of the log to find the volume.

Rule 1 gives a volume 21.4% less than the actual volume; Rule 2 is surprisingly accurate with less than 1% error. Amazingly, Rule 1 predominated in practice. No doubt partly because it is easier to fold a piece of string into fourths than fifths (try it!), but also because of convention. According to Hawney in 1748 [9]:

> "This Error, though it has been so often confused, yet it is grown so customary in all Places, that there is little Hope of my prevailing with Men that are so wedded to it, to embrace the Truth: I shall therefore, in the following Examples, show how to work both the true Way, and also the false or customary Way."

Hawney's examples show two solutions, one using Rule 1, and another finding the volume of the log by applying a factor of .07958 to the circumference to get the area,[2] then multiplying by the length. Both of those examples are drawn out in longhand multiplication, but he also explains how to perform the same calculations "by scale and compasses" (Gunter's rule and dividers). Given the low standard of numeracy in Hawney's day, we doubt his methods for calculating the content of a log were very popular. He was, however, completely right when he said that there was little hope in "the Truth" prevailing over Rule 1. 95 years later Peddie noted [5]:

> "This way of calculating the content of round timber [Rule 1], gives the result less than the truth in the proportion of 11 to 14, or nearly one-fourth. No doubt a considerable part of what is under reckoned is lost in the squaring, and as the buyer and seller are both usually aware of the fact, the price is so arranged, that no great practical loss occurs to either

[1] Instead of string you could also use a "girt tape", which was a measuring tape marked at 4 or 5-inch intervals [6]. An improved form of the girt tape had markings at 3.14 inch intervals, making it a diameter tape, and an additional scale that gave the cubic content of the log per foot of length [10,11]. Although we've found no examples of girt tapes for sale today, diameter tapes - without the cubic content scale - are still sold by forestry supply companies[2].

[2] The multiplier for finding the area of a circle given the circumference, .07958, is derived earlier in Hawney's book. This interesting note is also found there: "The Proportion of the Diameter of a Circle to the Circumference was never yet exactly found, notwithstanding many eminent and learned Men having laboured very far therin; among which the excellent Van Culen hath hitherto outdone all, in his having calculated the said Proportion to 36 places of Decimals, which are engraven upon his Tomb-stone in St. Peter's Church in Leyden; which Numbers are these: Diameter: 1.00000.00000.00000.00000.00000.00000.00000 Circumference: 3.14159.26535.89793.23846.26433.83279.50288"

party in following this long established custom."

The first specialized slide rule for calculating the volume of logs was the Coggeshall slide rule. The construction and scales of this slide rule have been previously described by one of the authors in [12]. Briefly, the scales on the Coggeshall rule are labeled A, B, C, D from top to bottom, with B and C on the slide. A, B and C are identical 2-radius logarithmic scales, D is a single-radius logarithmic scale beginning at 4 and ending at 40. The D scale is labeled "Girt Line". Most instructions on the use of the Coggeshall rule start out with Rule 1, then quickly point out the error built into it. A good example of this is found in, of all places, a dictionary [13] which states:

> "The former method [Rule 1], is not quite just. To measure timber accurately, instead of the point 12 on the girt line, use another, viz. 10.635; at which there should be placed a center-pin. This 10.635 is the side of a square equal to a circle, whose diameter is 12 inches."

The "center-pin" referred to would be a small brass pin hammered into the wood flush with the surface, to serve as a marker for a frequently used number, just as Pi is invariably marked on modern slide rules. These brass pins are commonly called gauge points, although the term "gauge point" refers to the number, not the pin. Heather [7] mentions a gauge point at 10.63 on the Girt Line of the Coggeshall rule in such a matter of fact way that one must assume it was common practice to put one there, although Heather's own illustration does not show it. The authors have yet to see a Coggeshall type slide rule with a gauge point for round timber, although gauge points for wine gallons and ale gallons are common on older rules.

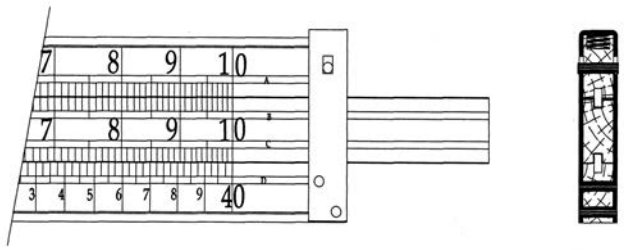


Figure 1. Construction of the Dring & Fage Rule

The timber contenting slide rule is an evolutionary device, building on the work that went before. It is a double-sided slide rule typically 2 or 3 feet long, 1.75 inches wide, and 1/4 inch thick. Boxwood is used throughout, with the upper and lower stocks usually joined by U-shaped brass end pieces. Figure 1 is a detailed drawing of one end of a timber rule, and shows how tension is maintained on the slide by means of a spring between the closed end of the brass U and one of the stocks, pushing the stock against the slide. The sprung stock has a pin that rides in a slot in the end piece, keeping that stock aligned with the fixed stock. The exact spring arrangement varied from maker to maker, with coil springs used by some (Dring & Fage, J. Tree) and leaf springs by at least one other (Dollond). The Thomas Aston rule shown in Figure 2 is the exception, using no tensioning springs at all. There is no indication of a runner on any of the timber rules we have examined.

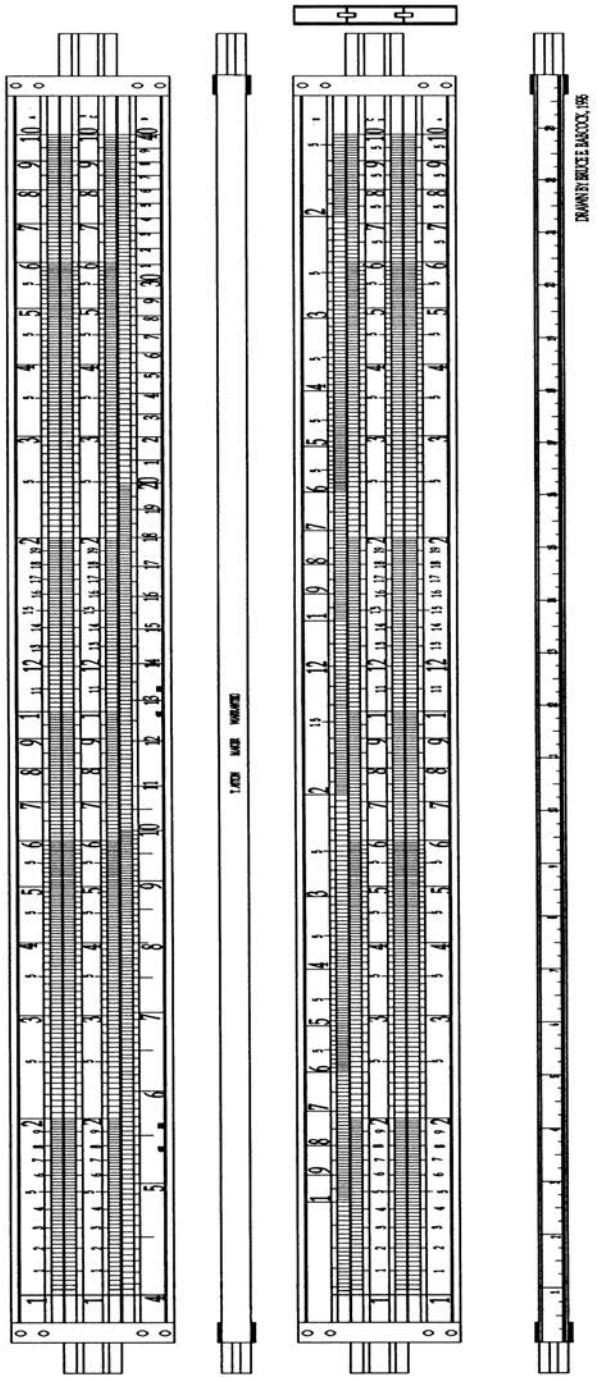


Figure 2. Timber contenting rule by T. Aston, Birmingham, ca. 1845

In the eight examples of timber rules we have exam-

ined, by four different makers, the scale layout is identical. Each side has four scales. The first side has the scales labeled A, B, C, and E from bottom to top, with A on the lower stock, B and C on the slide, and E on the upper stock. A, B, and C are identical 2-radius logarithmic scales reading from left to right and beginning and ending on 1. E is a 2-radius inverted logarithmic scale folded at 144. This side of the rule is used for calculating the content of sawn lumber. The dimensions of the lumber are always taken in inches for the width and thickness, and feet for the length. The width on C is placed opposite the thickness on E, and the volume in cubic feet can be read on B next to the length on A. The fold at 144 in the E scale neatly effects a division by 144 to convert the cross sectional area from square inches to square feet.

The second side of the timber rule is for round, 8-sided and 16-sided lumber. 8– and 16–sided lumber was an intermediate step in making ships masts [8, 18]. The scales on this side are labeled A, B, C and D from top to bottom, with A, B, and C once again being identical 2-radius logarithmic scales with A on the upper stock and B and C on the slide. D is a single-radius logarithmic scale, but it starts at 4 and ends at 40. The D scale is labeled the "Girt Line". If this side of the slide rule looks familiar it is because it is identical, with one important exception, to the scale arrangement on the Coggeshall rule. The exception is six gauge points on the D scale, three for diameter measurements (could the diameter tape have been invented around this time?), and three for quarter-girt measurements. Heather [14] explains their derivation:

> "In a square, the diameter, side, and quarter-girt are equal, and, if they each measure 1 inch, 144 such squares make a foot.[3] Consequently, the square divisor is 144, to be taken on A, and 12, the square root of 144, is the square-gauge point to be taken on D, to reduce to square feet the area of a square, the side of which is given in inches.
>
> If the diameter of a regular octagon be 1 inch, then 173.82 such octagons make a square foot. If, then, the diameter of a regular octagon be taken in inches, 173.82 is the divisor, to be taken on A, and its square root, 13.18, is the diameter gauge point, to be taken on D, to reduce the area of the octagon to square feet.
>
> If the perimeter of a regular octagon be 4 inches, so that the quarter-girt is 1 inch, 119.29 such octagons make a square foot: consequently 119.29 is the quarter-girt divisor, and its square root, 10.92, is the quarter-girt gauge point, for this figure."

Similar derivations yield the remaining gauge points for diameter and quarter-girt measurements of round and 16-sided logs. The gauge points are:

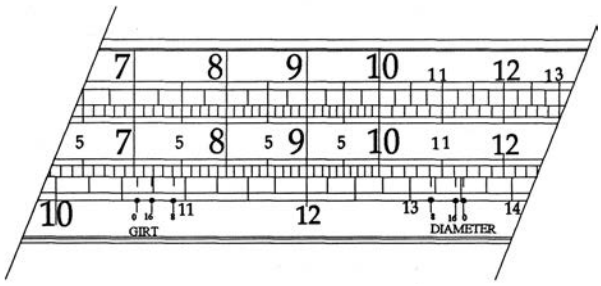


Figure 3. Guage points.

	Diameter	Quarter–Girt
Square	12	12
Circular	13.54	10.63
16-Sided	13.45	10.7
8-Sided	13.18	10.92

These gauge points may or may not be marked by brass pins. One Dollond timber rule has brass pins at all of the gauge points listed above, plus one at 20 on the D scale, and is the only timber rule we've seen with that point marked. Another rule (unnamed but almost certainly by Dring & Fage) has all the gauge points marked, but no pins. The rule by Thomas Aston is very unique in that it has no gauge points at all!

The A and B scales on this side of the slide rule appear to be for general calculating as they are not involved in timber contenting calculations. Measuring the content of round, 8-sided or 16-sided logs involves only the C and D scales. For example, to measure the content of a round log given diameter in inches and and length in feet: the length on the C scale is set opposite the gauge point at 13.54 (circular diameter) on the D scale, and the content is read on the C scale opposite the diameter in inches on the D scale. The gauge point 12 on the A scale is to facilitate the conversion of feet to inches and vice versa.

All of the timber contenting rules have rulers on the edges, usually one reading from left to right on one edge, with another reading from right to left on the other edge. The Aston rule is the exception with a ruler on only one edge. The rulers are typically divided into 1/4 inch parts, with the Aston rule again being the exception, using 1/8 inch divisions. This ruler would have been used to measure the girting string.

According to Heather [14], the E, C, and A scales on the first side of the rule should be divided in 1/4 parts to facilitate using measurements in inches and 1/4s, while the B scale should be divided decimally. We have yet to see a timber contenting rule that follows this pattern to the letter. Most rules stick to this pattern with the exception that the A and C scales are divided decimally from the 5 on the right hand side to the right end of the rule. The Thomas Aston rule is yet again an exception

[3] As pointed out by Knight [15], the term "foot" was frequently used to mean linear foot, square foot, or cubic foot, with the reader left to determine the intended meaning from the context.

in that it is divided decimally throughout. These divisions, and the lack of any gauge points, may mean the Aston rule was made to order for some other purpose, or that it was made before the final pattern for the timber rule was developed and adopted by all makers. Another possibility is that the rule is unfinished, but what maker stamps his name on an unfinished product?

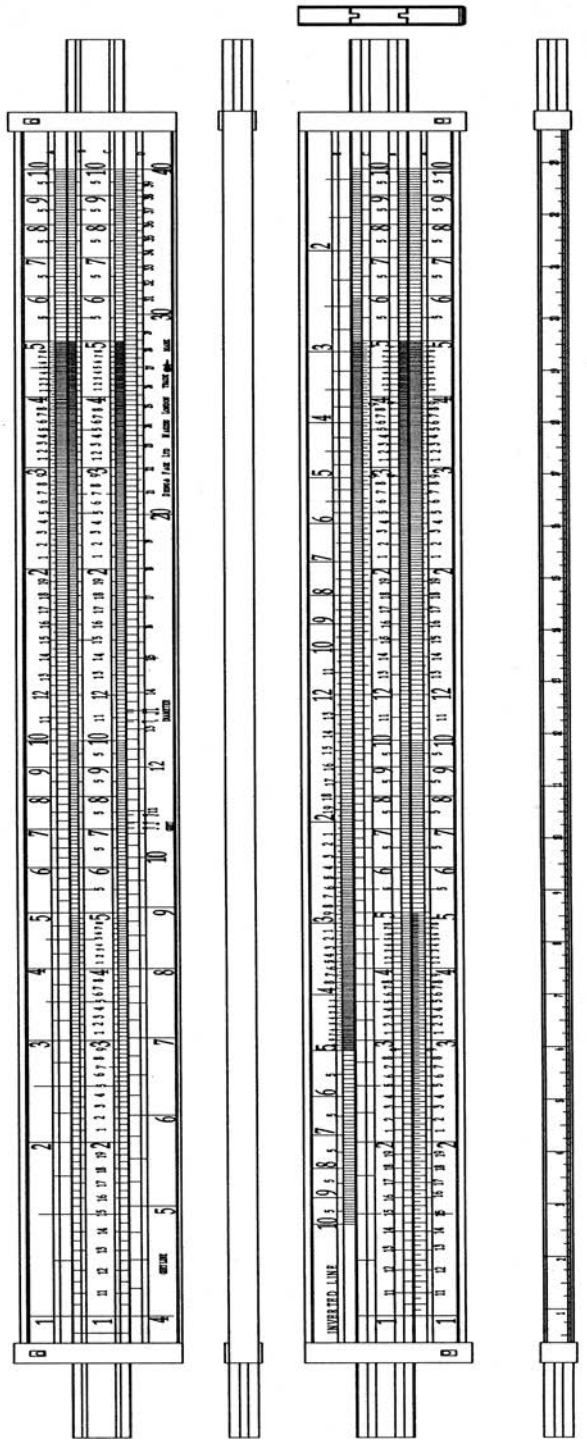


Figure 4. Timber contenting rule by Dring & Fage, makers London

Figure 4. is a drawing of a 2-foot Dring & Fage timber contenting slide rule. This appears to be identical to one in the Science Museum's collection, item 97 in [16]. On the actual rule, the brass ends are completely black with oxidation but the wood is clean, the scales and numbers crisp, and the corners and edges of the rule sharp and undamaged. It appears to have had very little use. The rule is hand stamped, as are all timber rules. One might think, quite reasonably, that all hand-stamped slide rules are very old because we're so used to seeing machine divided and stamped slide rules. However, according to the last managing director of the company [10], Dring & Fage were hand stamping wooden slide rules right up until they closed in 1972. Many of their trade-specific rules were produced in very low volume and didn't justify the cost of purpose-made stamping dies. This particular rule is marked "Dring & Fage Ltd.", which indicates it was made some time after 1938.

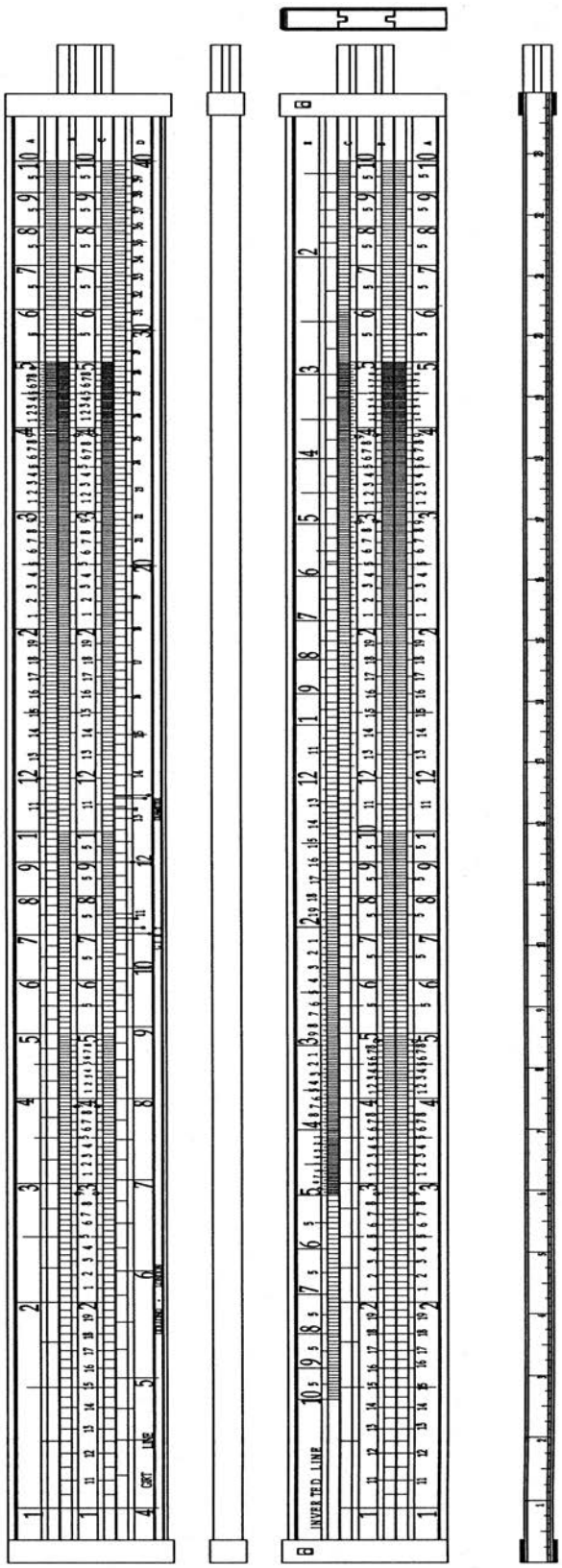
The date of the Dollond rule, Figure 5, is also hard to pin down, but for a different reason. The rule is marked only "Dollond London", and there were many instrument makers in the Dollond family, all of them in London. A careful inspection of Gloria Clifton's excellent reference [17] reveals that most of the family made optical instruments, with only two members producing mathematical instruments: John Dollond (worked 1766-1804) and George Huggins Dollond (worked 1804-1852). The style of the numbers on the rule indicates that it was probably made in the latter half of that time span, by George or one of his apprentices.

Finally, the date of the T. Aston rule, Figure 2, must also be imprecise. Thomas Aston (I) worked from 1818-1850, and Thomas Aston II from 1841-1862. There is no information on the rule that would indicate which Aston made it, although that lack of identification may indicate it was made before 1841, when there was only one Thomas Aston making rules in Birmingham.

The exact origin of the timber contenting slide rule is unknown to the authors. The earliest examples we've seen are early to mid 19th century. References that mention the timber rule are very limited [14, 16] and offer no hints as to origin. If the T. Aston rule is indeed an early example of the timber rule, then we would suggest 1818-1841 as a likely period in which the rule was invented.

Ironically, while the timber contenting slide rule may have been state of the art in finding the volume of boards and logs, its answers were probably too accurate for its own good. In the real world logs have bark, branches and defects, all of which affect the timber yield. In the sawmill, the conversion of rough logs into finished lumber involves wastage from squaring the log, the width of the saw blade, and the mix of board sizes being cut from that particular log. The log rule, essentially a yardstick with fancy scales, is probably still the best all around estimator, which may be the reason it alone survives today.

Figure 5. Timber contenting rule by Dolland



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