Building a Thacher

Bob Wolfson

My Dad was an engineer so there were always slide rules lying around the house and I learned the basics from him. I am old enough that slide rules were still taught in high school, but young enough that I bought and used a Commodore Minuteman 2 in a few classes before I graduated. Since then I have used calculators and computers, but I see them as simply progress in the science of applied math. In the spectrum from counting stones to cell phones, I find a unique elegance and advanced art in slide rules. They reveal the deep utility of even basic math and tie a purely abstract idea in a straightforward way to a physical instrument.

Thacher wanted a *long* scale to maximize the precision of calculation. He clearly realized that the surface of a cylinder offered a good Euclidean area to volume ratio. Now, in my mind, the simplest design choice would be to wrap a single scale helically around the cylinder and employ a "caliper" mechanism to build a binary device, like a Fuller Calculator.

However, Thacher decided to use two scales, requiring two cylinders. He also decided to lay out the scales longitudinally. His setup was a simple, horizontal 18-inch long, 4-inch outer diameter cylinder, snug but free to rotate and slide inside a cylindrical array of 18-inch parallel bars. He called the cylinder the "slide" and the bars the "envelope". He then took two parallel 30-foot long scales and chopped them into 20 segment-pairs. One half of each pair he glued to a bar, and the other half he glued to the outside of the cylinder in the gap between that bar and the adjacent bar below it.

Now he could move the slide with the envelope to align any pair of numbers on the two scales; thus, everywhere all the other numbers on the scales would be aligned in identical ratios. That is all that is required for usage. Almost.

Practically speaking, you cannot require the user of such a device to align a number at the far left of one scale with a number on the far right of the other; you cannot have the slide barely hanging into the envelope. That is why Thacher made the bars triangular.

When gluing the scale segments to the slide and envelope, he attached one half to the "upper" surface of a triangle-bar and the other half to the *lower half of the gap* between that bar and the adjacent bar above. When he was done, he had covered half the surface area of the envelope and slide. He then took a second pair of scales, offset them from the first pair by 9 inches and repeated the procedure using the lower surface of each triangle-bar and half the gap between the bar and the adjacent bar below it. That way, the user does not have the move the slide more than half-way out of the envelope.

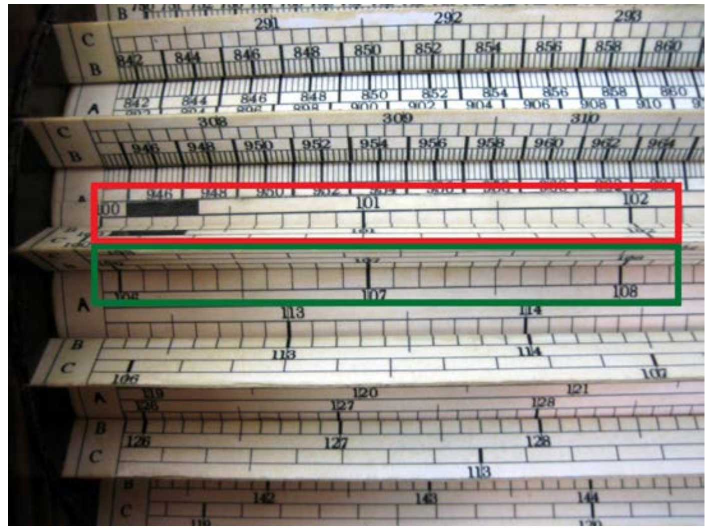

FIGURE 1.
Close-up of the leftmost 3 inches. In the red box, the top of a bar and half the gap above it bear a scale segment that goes from 100 to about 112. In the green box, the bottom half of the same bar and half the gap below it bear a scale segment that goes from about 106 to about 119.

Thacher called the slide scale (and its offset) *A* and the envelope scale (and its offset) *B*. On a regular slide rule they are called *C* and *D*. Finally, he squeezed in a little more information and added a *C* scale (normally called *A*) of squares above the *B* scale(s) at the apex of the triangle sides.

Thacher suspended the slide and envelope from brackets in such a way that both can be rotated separately or together. This allows the user to juxtapose any slide segment and any envelope segment in front of him and thereon align any *A* value with any *B* value to form a ratio. He can then rotate the slide and envelope together to find any other *A:B* combination that form the same ratio.

The result is a pretty substantial device that looks rather daunting for only having 3 scales! Two main versions were made, the difference between them being that one featured a sliding magnifier to help the user eke every bit of precision out of the machine. Good originals can easily command $1000 and up.

I decided to build a Thacher rather than buy one when I found Wayne Harrison's scales and David White's prototype on sliderulemuseum.com. I saw this information as my chance to play with a Thacher without having to pay for one. I actually underestimated the time required for construction and the cost of materials, but it still worked out to be a bargain and time well spent.

At the outset, I saw my immediate challenge was to design a rotating envelope held between brackets. I have never actually seen a Thacher in person, but the still pictures I have seen appear to show that the bar-ends are held in place with brass triangular clips. These clips appear to be forged to the inside of metal end rings, which then hang on mounts that are part of the metal end brackets.

I did not think I could readily build metal parts, so I tried to think of a way to make the end-rings and brackets out of wood. I settled on cutting thin rings of 3/16-inch high density fiberboard to set into circular grooves in 3/4-inch material.

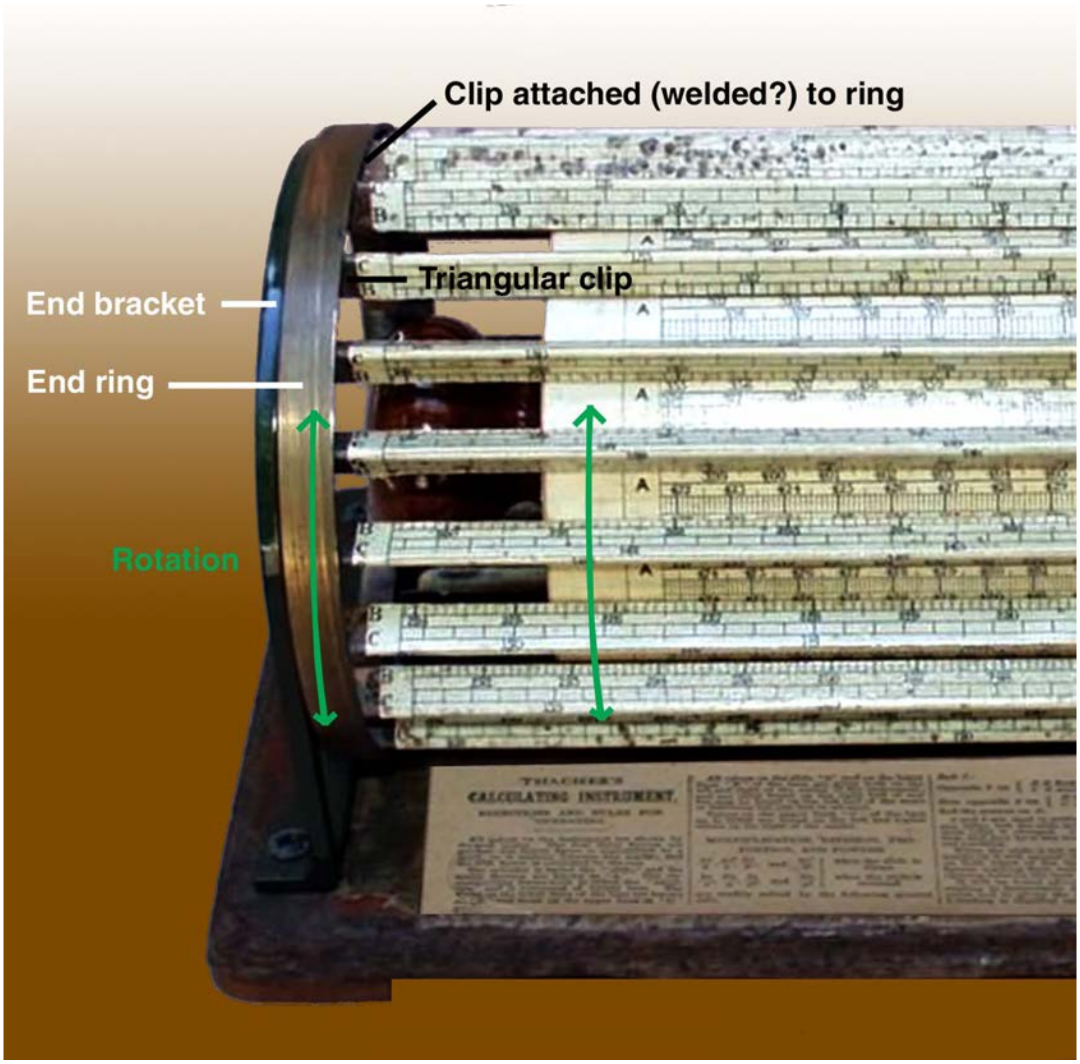

FIGURE 2.
The rotating envelope mechanism

FIGURE 3.
A prototype of a rotating ring

My drill press needed a special hole cutting jig for this – HolePro®, $85 with shipping, www.holepro.com.

FIGURE 4.
HolePro®

I made 4 rings and 2 brackets. The rings were $2\,{}^{1}/_{32}$-inch inner radius and $2\,{}^{25}/_{64}$-inch outer radius. I glued the pairs of rings back-to-back.

Next I needed triangular bars with a cross section ${}^{3}/_{8}$ x ${}^{1}/_{4}$ x ${}^{3}/_{8}$ inches. A carpenter cut these for me from red oak, but getting a straight, consistent result was hard. He cut about 70 bars and I culled the best 20 bars to use.

I had the bar scales printed on thick stock at a Kinko's. Their cheapest black and white wide-format printer could only print on thin stock and the lines were not perfectly straight. Their next-up color printer dithered the fonts so the numbers were not crisp. Their best printer was required: $30 for a set of scales.

FIGURE 5.
Triangular bars 3/8 x 1/4 x 3/8 inches

I cut out the bar scales and *very* lightly scored the paper to make the scales easier to fold over the triangles. Here I aimed to avoid cracking the paper at the fold so that later handling of the envelope would not split the paper scales. I glued each in place with thinned paper cement and then trimmed the bar ends to the edges of the paper.

Next, I measured out 20 equidistant points around the perimeter of each glued ring pair and cut ${}^{3}/_{8}$ x ${}^{1}/_{4}$ x ${}^{3}/_{8}$-inch notches out of each inner ring to form recesses into which the bar ends could fit. Each notched pair was one end ring.

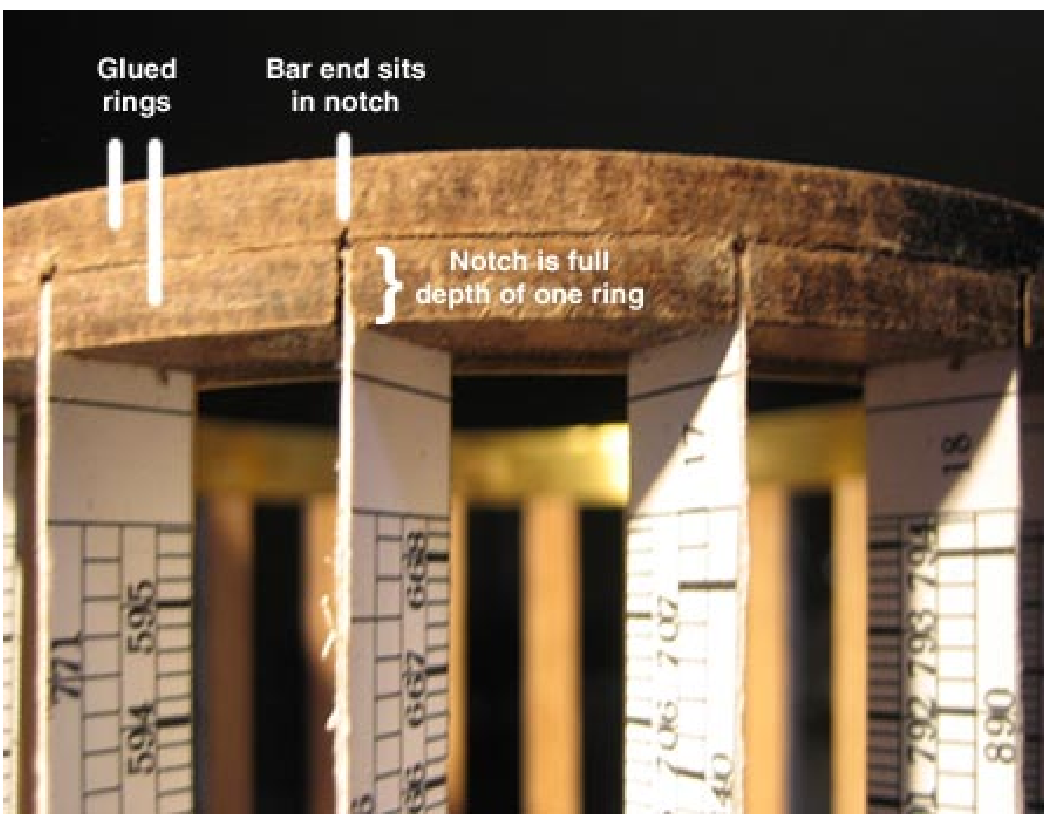

FIGURE 6.
An end ring of the envelope

Cutting the triangles into the fiberboard was the hardest part of this construction. Even after culling the best bars, not all ends were equal and I had to fit the 40 triangular cuts individually. On the other hand, I was able to achieve a very tight fit.

Now, when the slide is removed, something must prevent the bars from falling inward. So I had to choose whether to glue the ends into the rings or create some sort of lip to hold them. I opted for the latter, cut a strip from thin brass sheet, and glued the strip to the inside of each end ring to form a retaining collar.

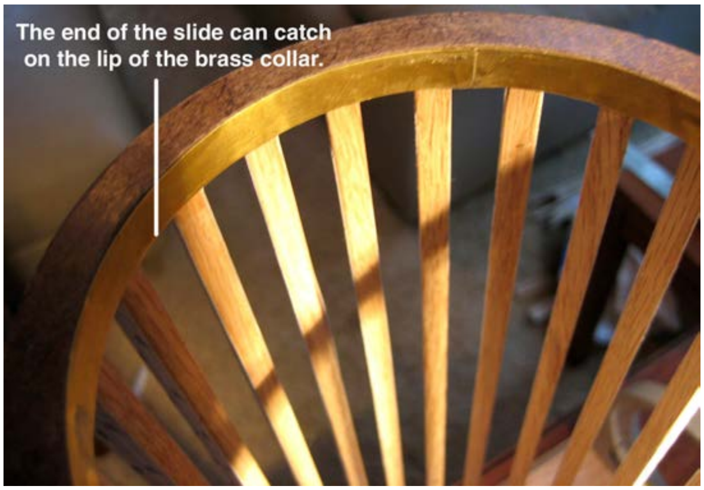

FIGURE 7.
A flat brass collar retains the bars.

My thinking here was to avoid gluing so as to leave room for a little lateral adjustment of the bars. The ends of the scales on them must line up exactly to make calculations accurate.

Ultimately, however, I found that turning the envelope in the end brackets exerted pressure on the end rings that kept changing the alignment anyway, so gluing was necessary. Furthermore, the inner edge of the brass collar creates a lip that can snag the end of the slide and/or the edge of the paper scale.

On the other hand, having some play was critical to being able to set the bars in both rings. To do so, I put one ring notches-up on the desk and set the slide cylinder vertically on the ring. I then inserted the bars in the notches and held their upper ends to the cylinder with a rubber band.

Then I slipped the other ring notches-down over the top of the cylinder (which was a little longer than the final length.) Since the bars were not glued into the lower ring, I could line up each bar in turn and raise it $^1/_{16}$ inch into the top ring notch without pulling the bar out of the bottom notch. Thus, when all bars were partially seated, I pressed both rings together to fully insert the bars into the top and bottom notches.

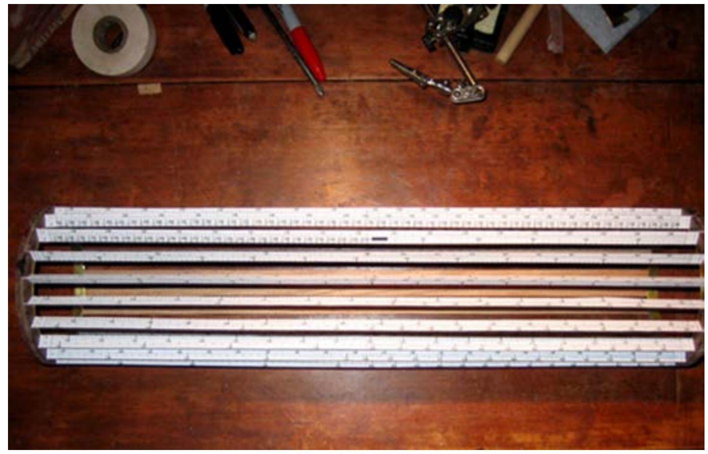

FIGURE 8.
The envelope

Next I cut and grooved end brackets from oak. I cut a strip of brass, used my hole cutter to make copper washers, and added the washers on the end rings to help reduce turning friction.

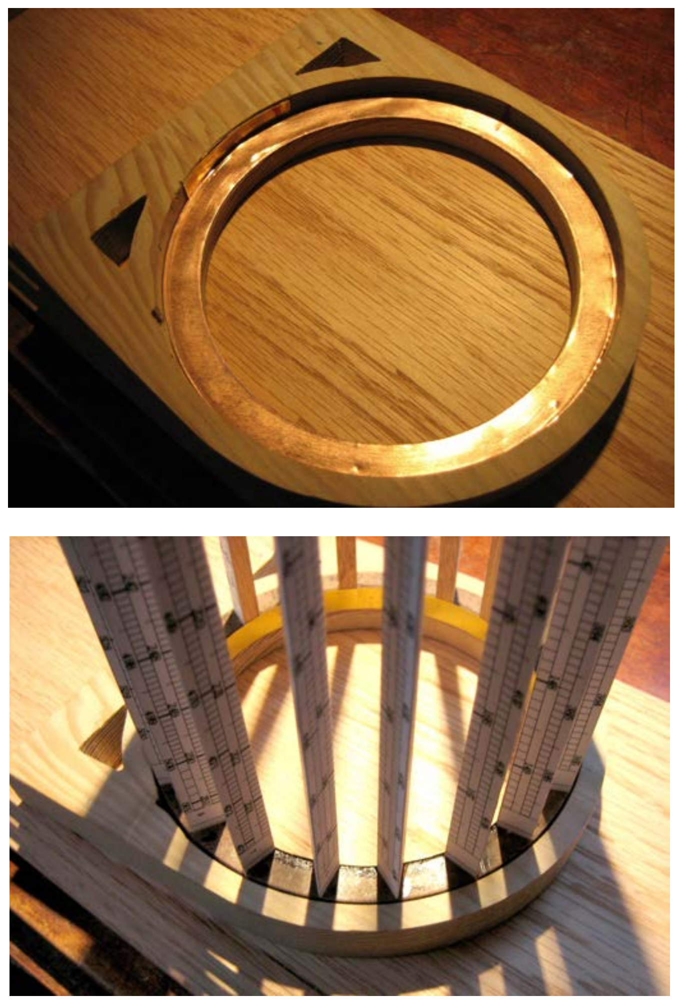

FIGURE 9.
And end bracket and the envelope inserted into the bracket

I cut the $6\,{}^{1}/_{2}$ x $21\,{}^{3}/_{8}$-inch base from an 8 inch wide oak plank, added an ogee edge, and drove screws from the bottom to secure the brackets. Oak costs about $4.50/foot at Home Depot and their smallest plank was 6 feet long.

I really wanted to use a paper tube for the slide, but I could not find stock of exactly 4 inches outer diameter on the internet. Instead, I found clear acrylic tube, from Outwater Plastics (also Midland Plastics). It runs about $35 (plus $20 shipping) for a minimum 6' length. Four inch OD (outside diameter) stock pipe of various metals was also available, but I did not think I could easily cut metal precisely.

I used my hole jig to cut caps out of oak and cut a length of tube so that the cap ends would be even with the outer sides of the end brackets. I bought large wood knobs at Home Depot for $1.25 each.

I stained the wood with Minwax English Chestnut, about $4 for a small can. And finally I varnished all the paper with some old spar urethane that gave the paper an older yellow look. This tended to glue the envelope's bars into the end-rings as well.

My result is a not-quite Thacher, but I think the attractiveness of his design comes through. The one thing I am still missing is the instruction label to attach to the base, but Wayne Harrison has promised to make one for me that matches the original fonts.

FIGURE 10.
The finished Thacher replica, overall view

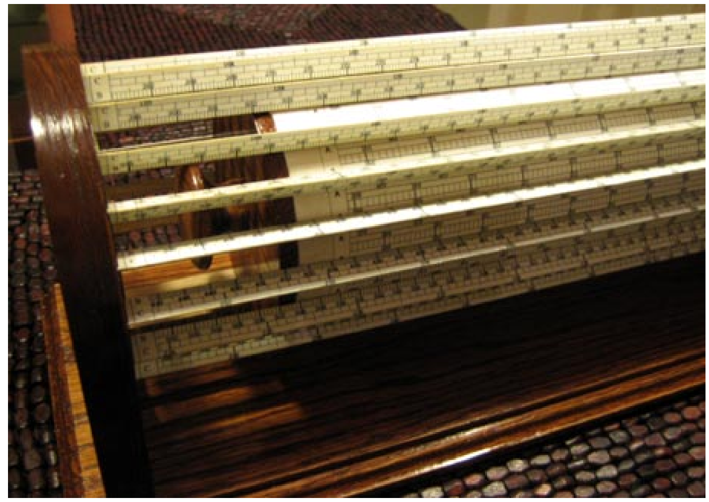

FIGURE 11.
The finished Thacher replica, left and detail

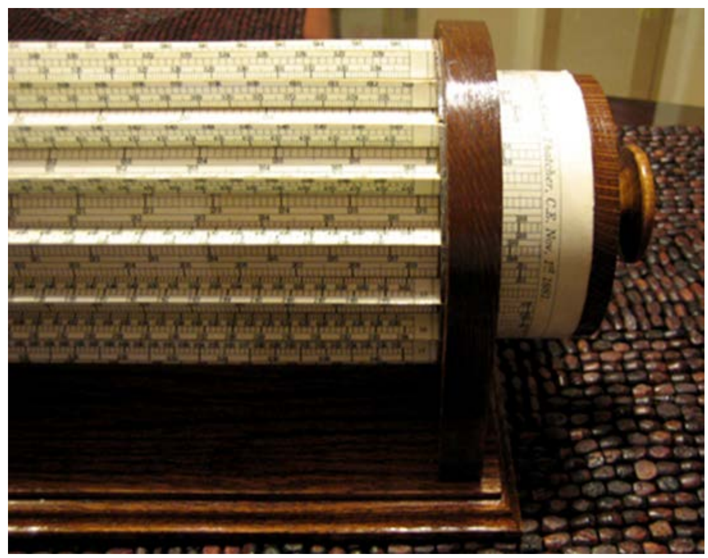

FIGURE 12.
The finished Thacher replica, right end detail

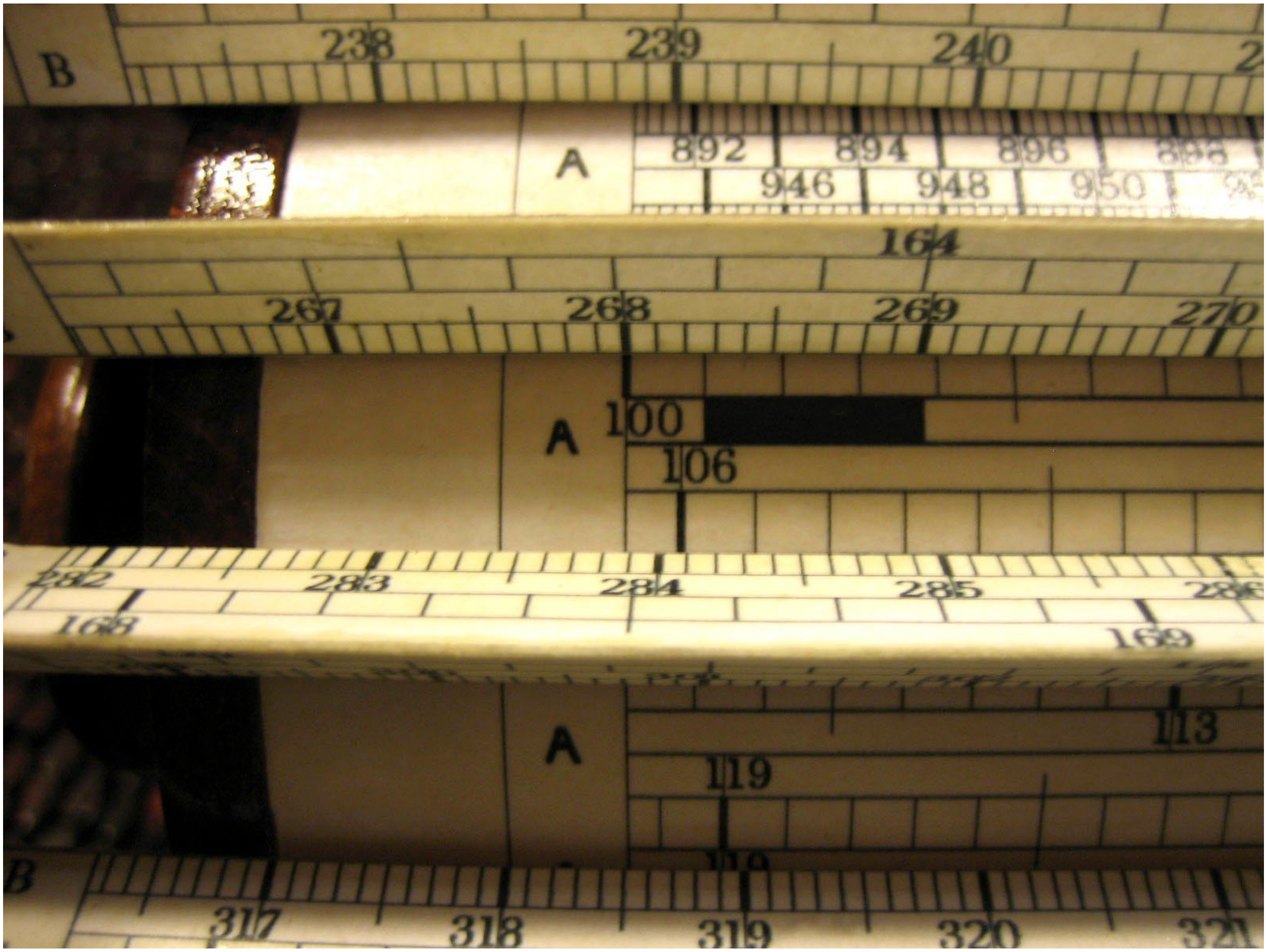

FIGURE 13.
The finished Thacher replica, scale detail

Whew! Quite a lot of work went into this and I am somewhat glad that the job is finished. On the other hand, I have learned a lot and had some ideas along the way. In particular, now I think I see how I can make a version with metal end rings and clips, much more like a real Thacher. And since I have materials left over …!

Cost Breakdown

Hole saw	$85
Other misc. tools	$15-ish
Fiber board	$10
Scales	$30
Oak	$27
Acrylic tube	$55
Knobs	$2.50
Stain	$4
Time	40+ hours
Other materials	on hand leftovers from other projects
TOTAL	~$230 + sweat