Building a Thacher

My Dad was an engineer so there were always slide rules lying around the house and I learned the basics from him. I'm old enough that slide rules were still taught in high school, but young enough that I bought a Commodore Minuteman 2 and used it in a few classes before I graduated. Since then it's been 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 in 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, and 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[1].

Thacher, however, set himself to using two scales and hence two cylinders. He also decided to lay the scales out longitudinally. His setup was a simple, horizontal 18" long, 4" outer diameter cylinder, snug but free to rotate and slide inside a cylindrical array of 18" 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 he glued to the outside of the cylinder in the gap between that bar and the one below it.

Now he could move the slide with the envelope to align any pair of numbers on the two scales, and everywhere all the other numbers on the scales would be aligned in identical ratios. That's all it takes. Almost.

Practically speaking, you can't 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 can't have the slide barely hanging into the envelope. That's 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 one above it. When he was done, he'd 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" and repeated the procedure using the lower surface of each triangle-bar and half the gap between it an the bar below it. That way, the user doesn't have the move the slide more than half-way out of the envelope.

---

[1] I recently saw another binary cylindrical slide rule by Carbic on eBay. It was auction number 270524671762, and consisted of a single spiral scale on a 29cm cylinder. The device was marked GB patent number 778556 which can be found at http://www.wikipatents.com/GB-Patent-778556/improvements-in-or-relating-to-calculators It went for 222 GBP. I can find no mention of this device elsewhere.

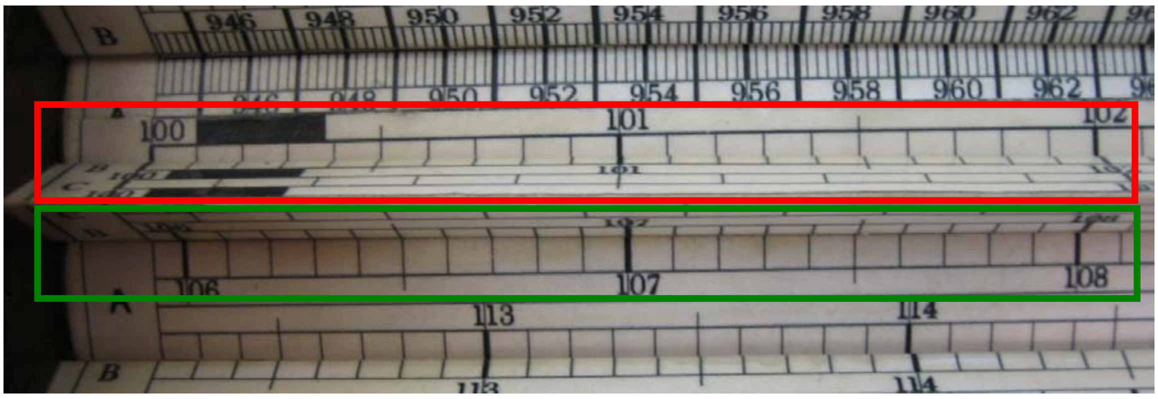


Figure 1 *Close up of the leftmost 3". In the red box, the top of a bar and half the gap above it bear a scale segment that goes from 100 to about 112. In the green box, the bottom half of the same bar and half the gap below it bear a scale segment that goes from about 106 to about 119.*

Thacher called the slide scale (and its offset) *A* and the envelope scale (and its offset) *B*. On a regular slide rule they'd be 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 the pair 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 an *A* value with a *B* value to form a ratio. He can then rotate the slide and envelope together to find any other *A:B* ratio.

The result is a pretty substantial device that looks rather daunting for all that it only has 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 it as my chance to play with one without having to pay for one. I actually underestimated the time it would take and the cost of materials, but it still worked out to a bargain and time well spent.

At the outset, I saw my immediate challenge was to design a rotating envelope held between brackets. Now, I've never actually seen a Thacher in person, but the still pictures I've seen appear to show that the bar-ends are held in brass triangular clips. Those 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.

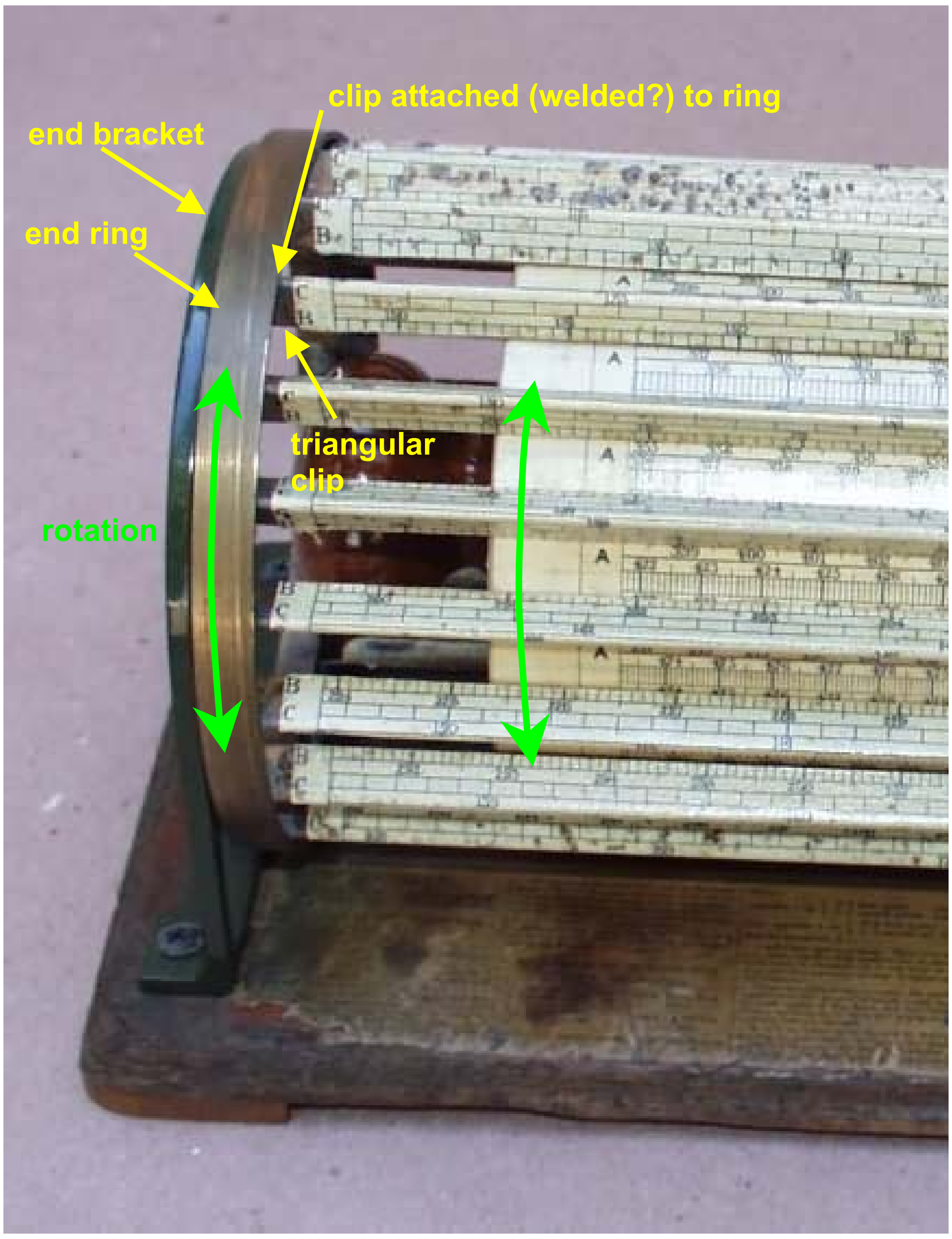


Figure 2 *The rotating envelope mechanism.*

I didn't 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" high density fiberboard to set into circular grooves in ¾" material.

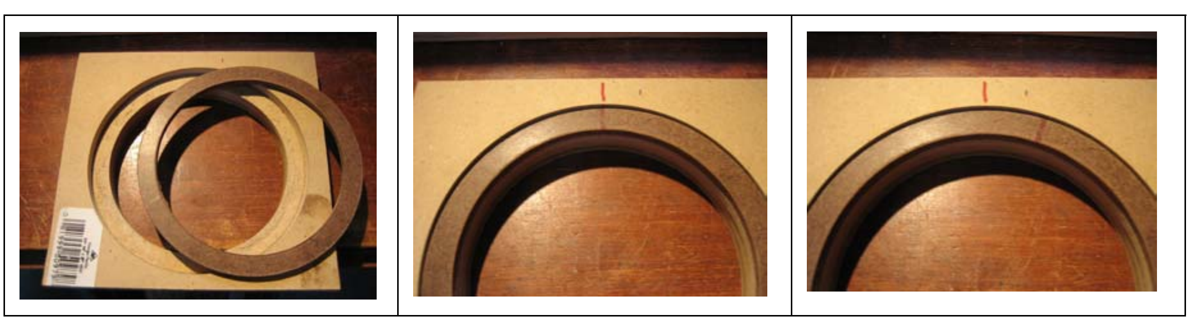


Figure 3 *A prototype of a rotating ring.*

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

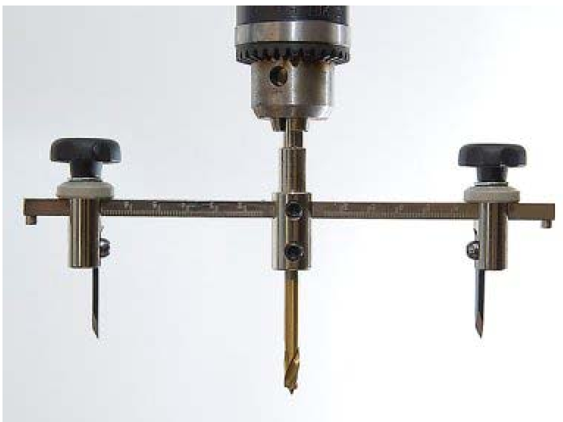


Figure 4 *HolePro®.*

I made 4 rings and 2 brackets. The rings were 2 1/32" inner radius and 2 25/64 outer radius. I glue pairs of rings back-to-back.

Next I needed triangular bars with a cross section 3/8 x ¼ x 3/8. A carpenter cut these for me from red oak, but getting a straight, consistent result was hard. He cut about 70 and I culled the best 20 from them.

Figure 5 *Triangular bars 3/8 x ¼ x 3/8.*

I had the bar scales printed on thick stock at a Kinkos. Results on their cheapest, B/W, wide-format printer could only be made on thin stock and lines were not perfectly straight. Their next-up color printer dithered the fonts so they did not come out crisp. Their best printer was required: $30 for a set of scales.

I cut out the bar scales and *very* lightly scored them to make them 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 it. 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 ¼ x 3/8 notches out of one ring to form recesses into which the bar ends could fit. Each notched pair was one end ring.

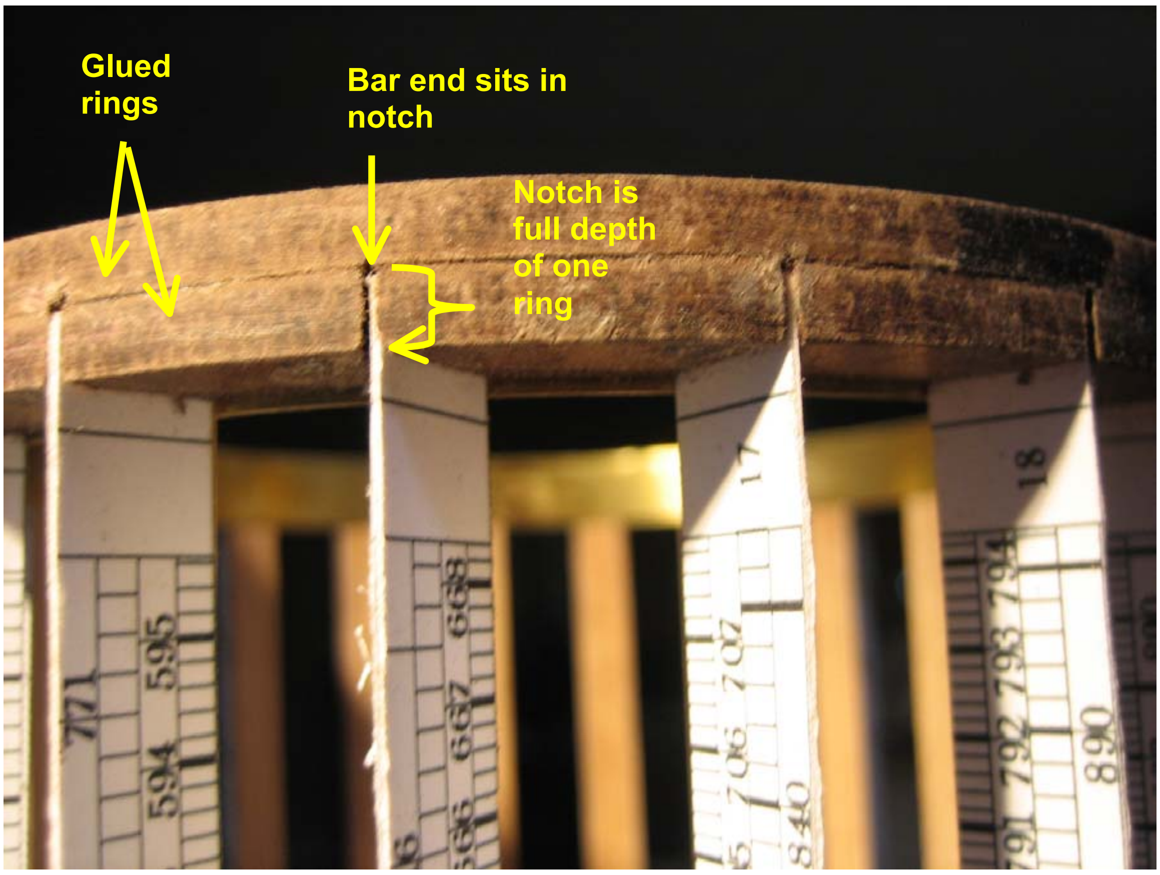


Figure 6 *An end ring of the envelope*

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 it 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. Further, the inner edge of brass collar creates a lip that can snag the end of the slide and/or the edge of its 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 in it. 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 yet a little longer than 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" into its top ring notch without pulling it out of the bottom notch. When all were thus partially seated, I pressed both rings together to bottom the bars into top and bottom notches.

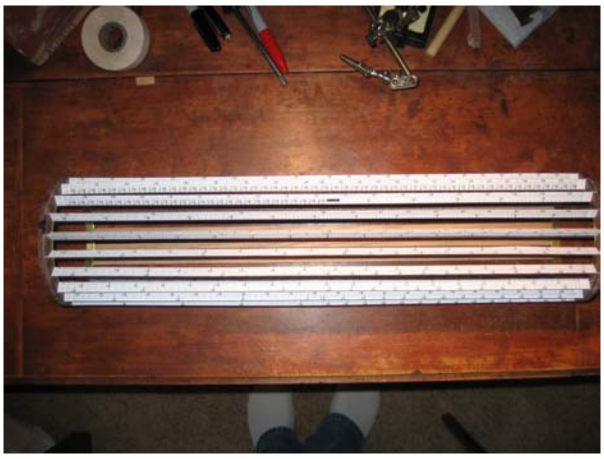


Figure 8 *The envelope*

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 them to help reduce turning friction on the end rings.

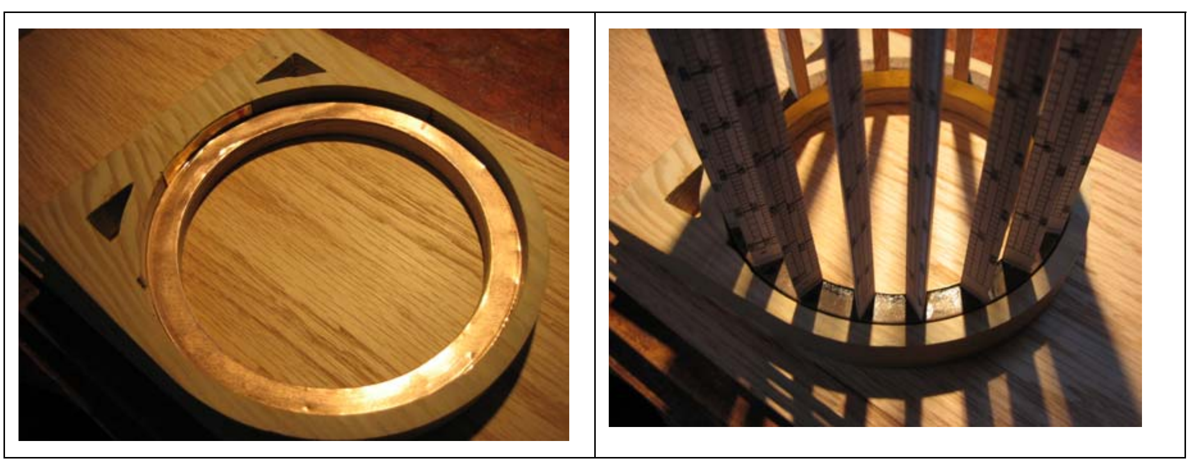


Figure 9 *And end bracket and the envelope sitting in it.*

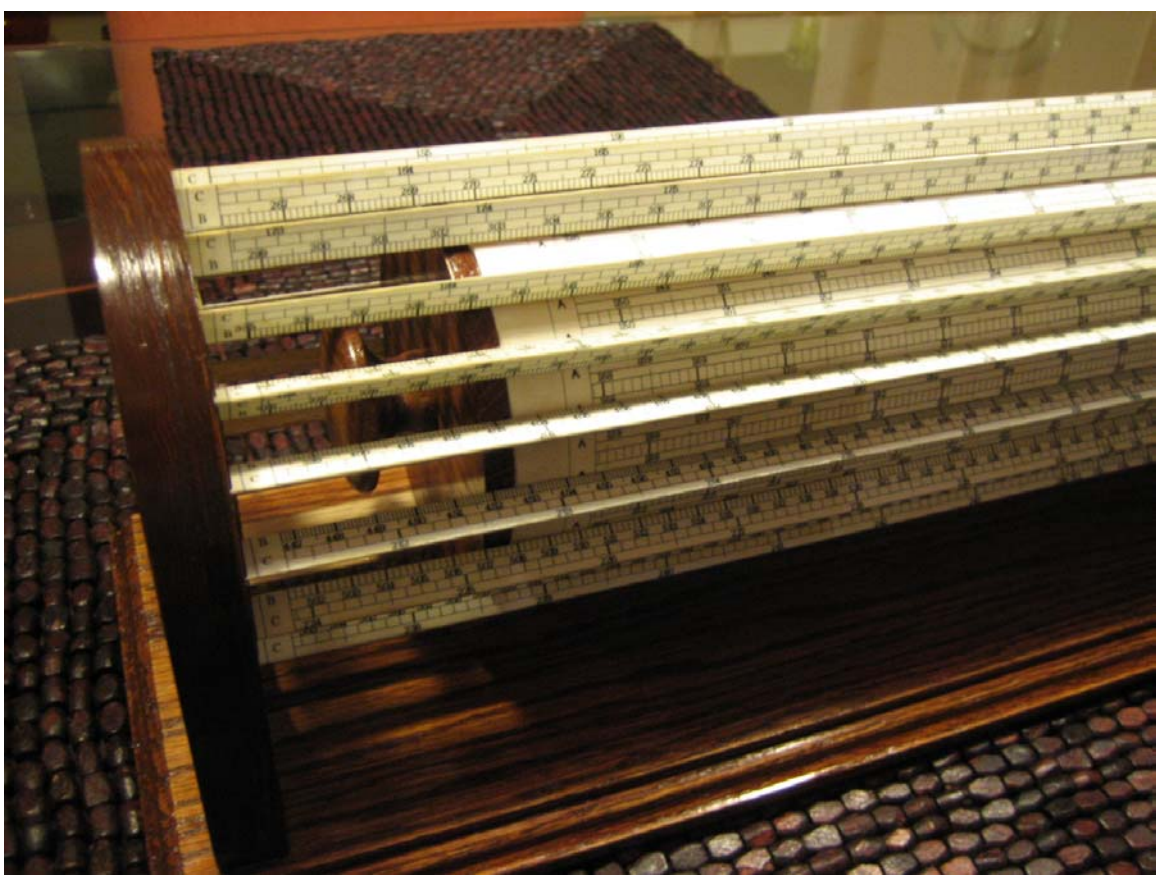
I cut the 6½" x 21 3/8" base from 8" wide oak plank, added an ogee edge, and drove screws from the bottom to secure the brackets. Oak costs about $4.50 / foot at Home Depot and their smallest plank was 6'.

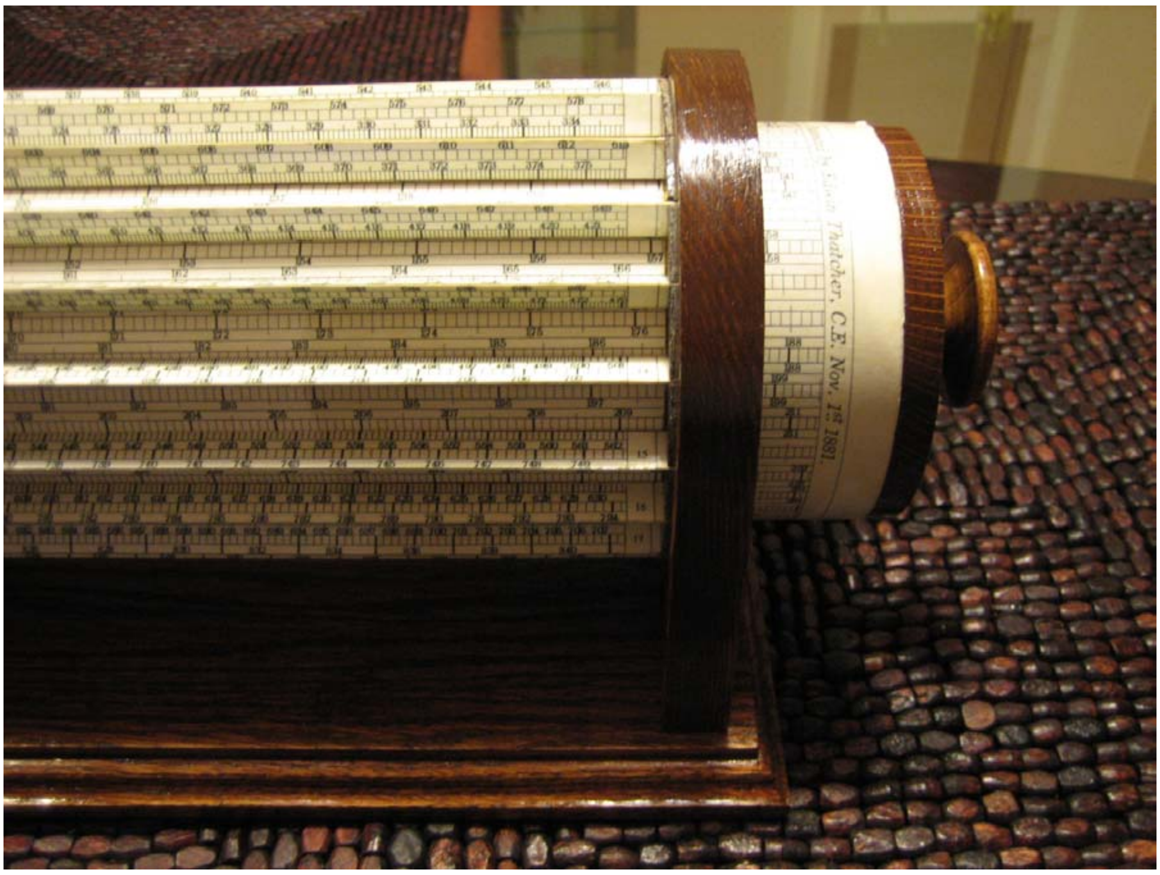
I really wanted to use a paper tube for the slide, but I could not find stock of exactly 4" outer diameter on the internet. Instead, I found clear acrylic tube, from Outwater Plastics and also Midland Plastics. It runs about $35 (plus $20 shipping) for a minimum 6' length. 4" OD stock pipe of various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

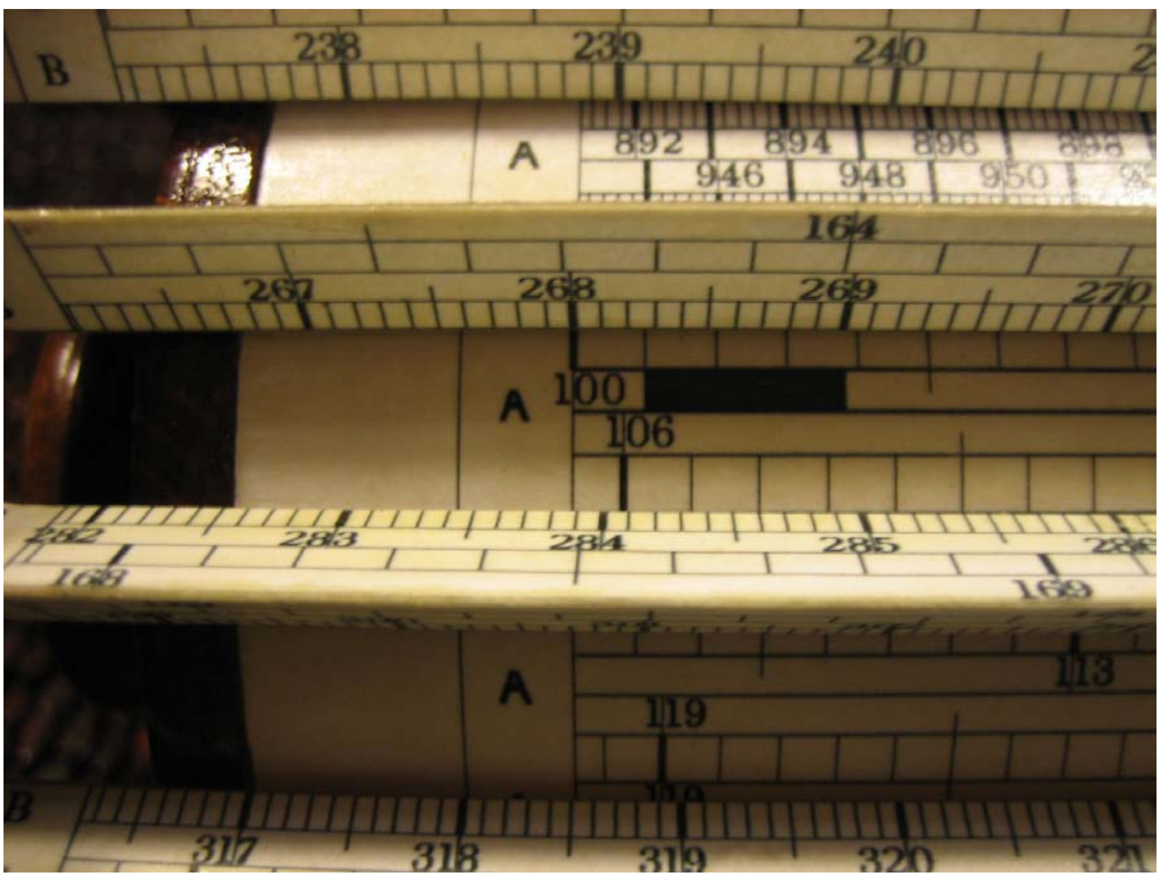
I used my hole jig to cut caps out of oak, and cut a length of tube so that the cap ends would be even with the outer sides of the end brackets. I bought large wood knobs at Home Depot, $1.25 each.

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 it 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'm 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.







Whew! Quite a lot of work went into this and I'm somewhat glad it's over. On the other hand, I've 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've got 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