Inside the Otis King Patent Calculator

Bob Wolfson

The marvelous "Otis King's Patent Calculator" is a wonderful addition to any collection. At only 6" long when collapsed and barely over 10" when fully open, it nevertheless boasts a 66" scale, providing tick marks to four significant digits at the low end of the scale, and to three at the high end.

The most commonly found Model K performs only multiplication and division. The Model L added a linear divided scale for calculating logs and powers. A fairly rare Model N handles British Sterling currency calculations.

All models have three main parts as depicted in Figure 1:

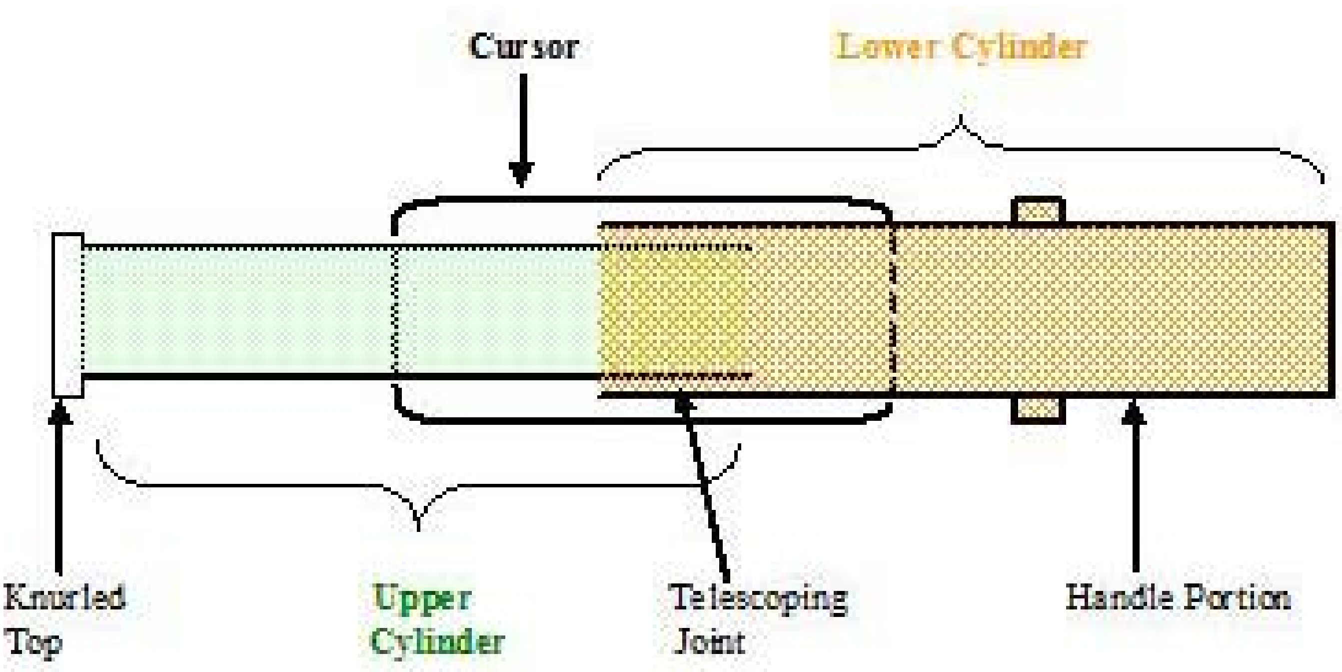

FIGURE 1. Schematic of an Otis King

1. The lower cylinder consisting of the handle and one logarithmically divided scale. The handle comprises the lower half of this cylinder, and the scale the upper half.

The scale is wound helically around the cylinder, with 1 at the lower end and 10 at the upper end. On this scale, the numerals are written below the line.

2. An equal-length upper cylinder with a knurled top that rotates and telescopes *within* the lower cylinder and bears a second logarithmically divided helical scale. Again, this scale begins with 1 at the lower end but repeats twice (on a model K). Numerals on this scale are written above the line.

3. The cursor is a cylindrical sleeve that surrounds and rotates, sliding *over* both the upper and lower cylinders and covers the telescoping joint. The cursor bears two vertically aligned marks, one on the lower rim and one on the upper.

You can use the device to perform any calculation represented by an equality of ratios:

$A/B = C/D$

You must always hold the device by the handle and perform all the mechanics with the other hand.

Begin by pulling the telescoping upper cylinder up to full extension. Then slide and rotate the cursor until the mark on the lower rim points to B on the lower scale. Friction between cursor and the lower cylinder must be low enough to permit the cursor to slide easily but high enough that the cursor will not drop from gravity or otherwise move without intention.

Next, grasp the upper cylinder by the knurled top and, by both rotating and telescoping the cylinder downward; bring A on the upper scale to the cursor's upper mark. Friction between the cylinders must be sufficient to permit this easily while keeping them as positioned once you let go of the knurled top. Note that there must be *very little* friction between the cursor and the upper cylinder or this step will

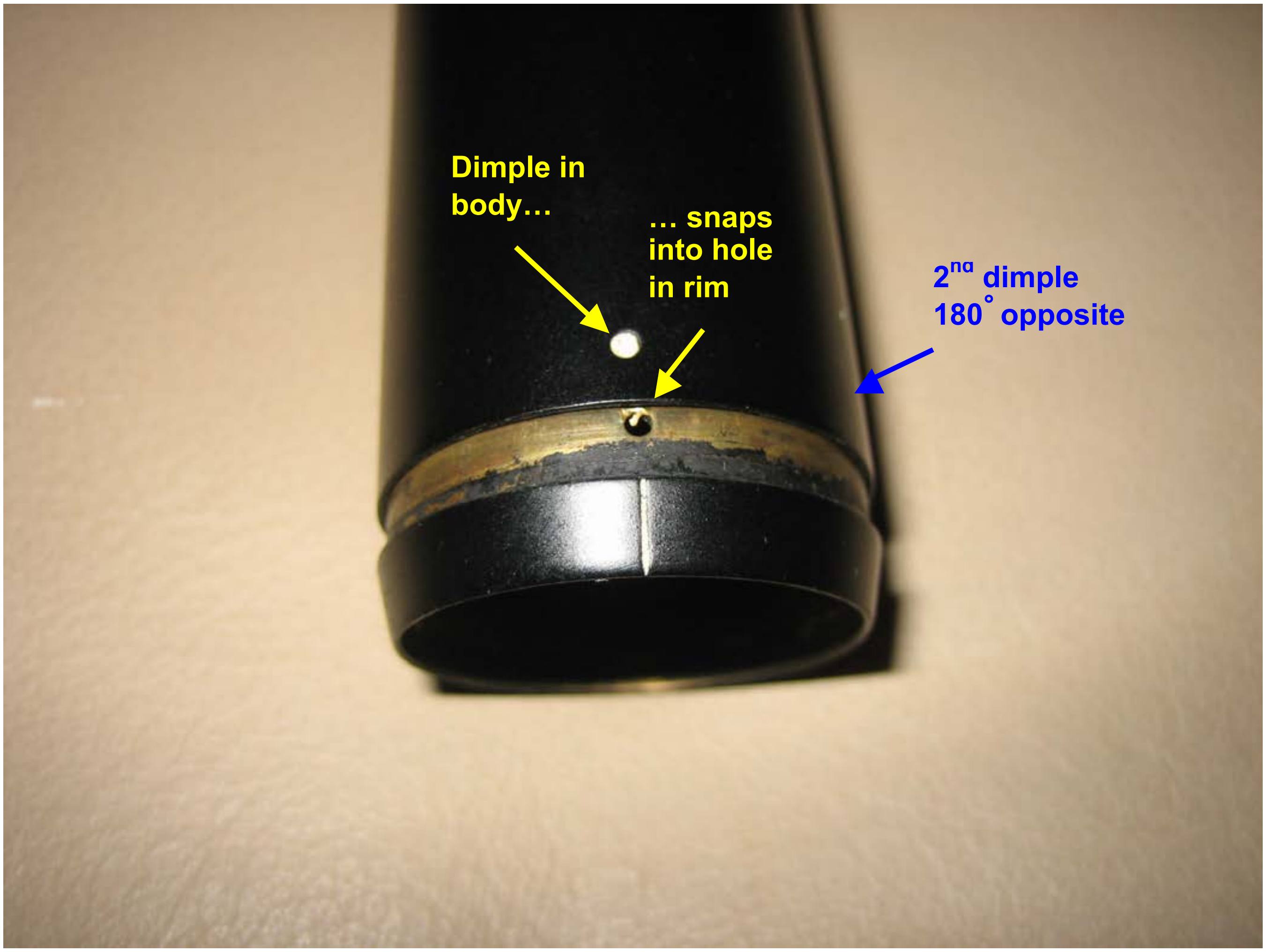

FIGURE 2. The Cursor's Two Parts

move the lower mark away from B.

Finally, you can move the cursor again to complete the calculation. Move the top mark to C on the upper scale and read D at the lower mark on the lower scale. Or move the lower mark to D on the lower scale and read C at the tip of the upper mark on the upper scale.

Why Disassemble an Otis King

There are two reasons to consider disassembling an Otis King calculator.

First, cleaning or fixing the calculator may be necessary if wear and accumulated soil make moving the parts too hard or too easy. There must be low friction between the parts so that they slide easily, otherwise aligning marks quickly and smoothly is too hard. But there must some friction to prevent unintended slippage.

Second, sometimes the scales get damaged and need to be repaired or replaced. At the moment I only know of one source for replacement scales. The International Slide Rule Museum has a PDF of Model L scales created by Peter Monta at http://sliderulemuseum.com/SR_Scales.htm#OK. These are not copies of the originals and so lack their hand-drawn appearance, but being computer-generated they are probably more accurate.

I personally became interested in disassembling Otis Kings when I bought one with a loose cursor a few years ago. Mine is a type C (c.1970), per Dick Lyon's classification scheme at his excellent website, http://www.svpal.org/~dickel/OK/OtisKing.html. Wanting to fix mine, I searched the Internet for disassembly instructions. Finding none, I emailed Dick, who also could provide no help. Eventually I worked it out myself, and developed a detailed set of disassembly instructions I thought worth sharing in an article.

I passed an early draft by my friend Wayne Harrison, who replied that he owned an early Otis King–one that is similar to both, but not the same as either a type A or B per Dick's classification–that did not appear to be constructed at all like my later model. He wanted to take his apart to replace the scales, both of which were gone. He generously shipped it to me to see if I could figure out how it was assembled. I did, and so expanded this article to cover both varieties of construction.

I would be interested if, upon comparing their Otis Kings to

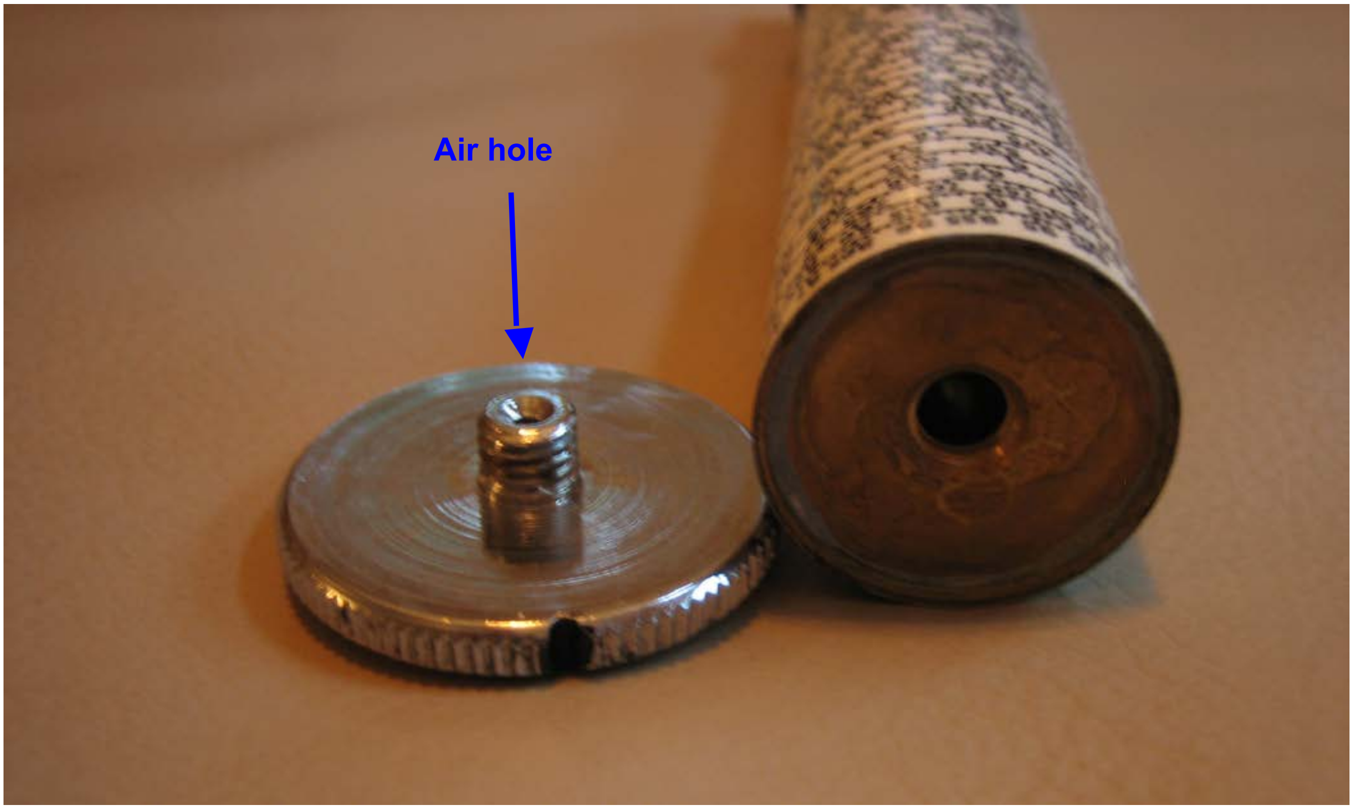

FIGURE 3. Removed Knurled Top

these descriptions, any readers find that there appear to be additional, substantially different designs.

Late Model – circa 1960/70 (Type C)

A key to the construction of this model is the 2-piece cursor. Look closely at the bottom lip of the cursor and note a seam there. The cursor comes apart into a main body and a separable lower rim as show in Figure 2. In some early models (type B per Dick Lyon's classification), the rim may be held in place by tiny screws. In my later model the two cursor parts are held together by friction and two "dimples" in the main cursor body that snap into holes in the rim. In any case, you need to separate the main body from the rim.

Before doing so, try to remove the knurled top from the upper cylinder. In my model, the top simply screws off, so open the device to the full extent, grab the upper cylinder firmly, and try unscrewing the top counter-clockwise. Figure 3 shows the removed knurled top.

If the top does not turn easily you must be careful. The cylinder is hollow and thin-walled, so be sure not to squeeze the cylinder out of round while you torque the top. To loosen the threads, try turning the calculator upside down and squirting a little WD40 *up* into the air hole in the middle of the knurled top, hoping for the fluid to cascade down onto the threads. Also, try rapping the top with a wooden mallet.

If the top just will not turn, do not worry–removal is not essential.

Next separate the lower rim from the main cursor body. First, note that with the device fully opened the cursor only slides upward about half-way before it comes to a hard stop, catching on something internal. You are going to take advantage of that.

Grab the handle in one hand, move the cursor to the bottommost position with the other hand, and then slide the cursor *sharply* upward until it slaps hard against the catching-point. Repeat this a few times and you should begin to see the seam between the rim and the body start to open up. The amount of force needed will almost certainly vary from one case to another, so start gently and increase as needed. Avoid trying to pry the rim off as this will certainly leave marks/scratches on the cursor. Figure 4 shows the separated cursor.

If you were able to remove the knurled top, you can now slide the main body of the cursor off the top end of the calculator. If not, just slide the cursor up above the telescoping joint.

As shown in Figure 4, you should see some felt around the top of the lower cylinder. This is what provides the friction between the lower cylinder and the cursor.

This felt is glued to the top of a brass ring that threads onto the top of the lower cylinder. Note how the ring is what prevents the cursor from sliding up all the way; i.e., this is what the lower rim was slamming into when you were separating the cursor parts.

Unscrew this ring in order to pull the upper cylinder out of

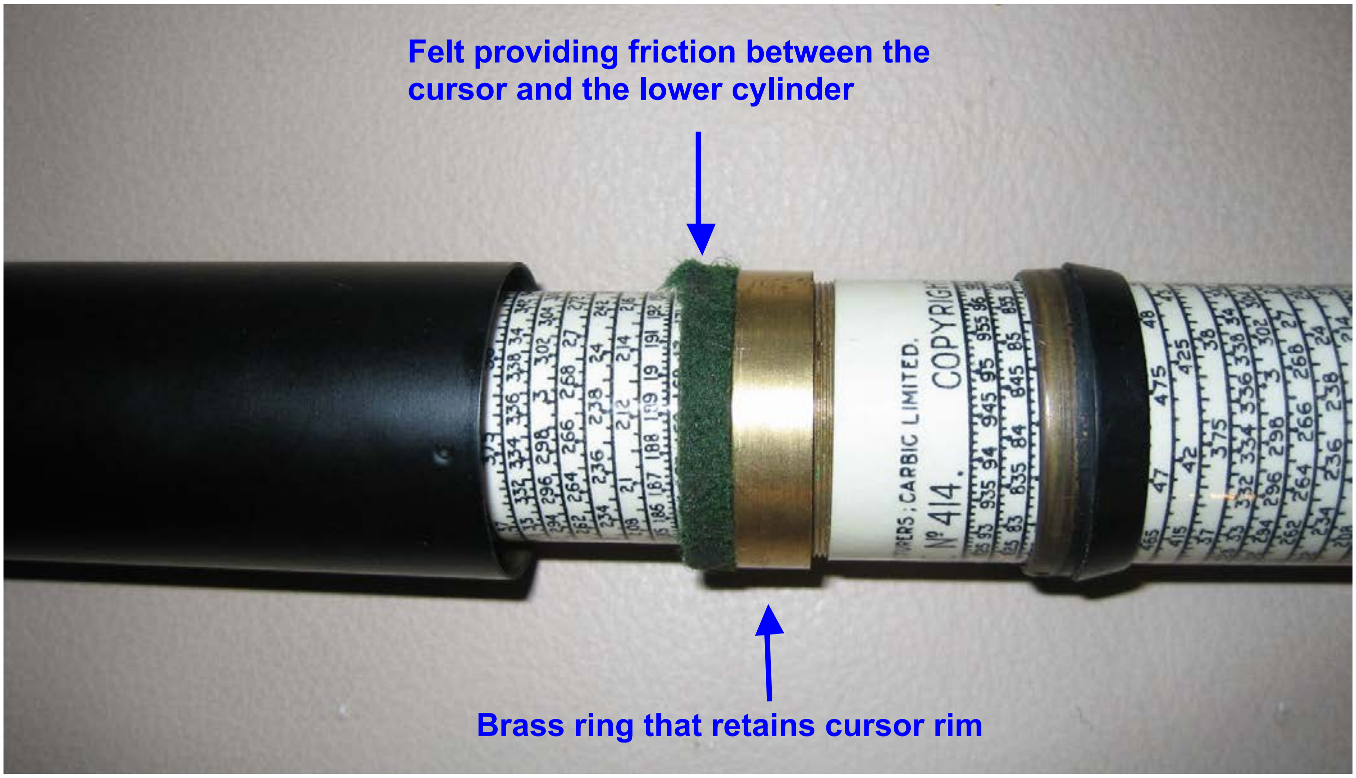

FIGURE 4. After Separating the Cursor's Parts

the lower cylinder as shown in Figure 5. This will also allow you to pull the lower rim of the cursor off the lower cylinder. And, you can remove the brass ring over the top of the upper cylinder if you were able to remove the knurled top.

With the upper cylinder removed, you will see felt glued to the lower end. This provides the friction between the upper cylinder and the lower one. If you were unable to remove the knurled top, you can detach this felt and then pull the brass ring and the body of the cursor off the bottom of the upper cylinder.

Finally note in Figure 5 a flat, oblong aluminum "key" stuck through a slot in the lower end of the upper cylinder that prevents the upper cylinder from being pulled past the brass ring when the device is assembled.

At this point you have fully disassembled your Otis King.

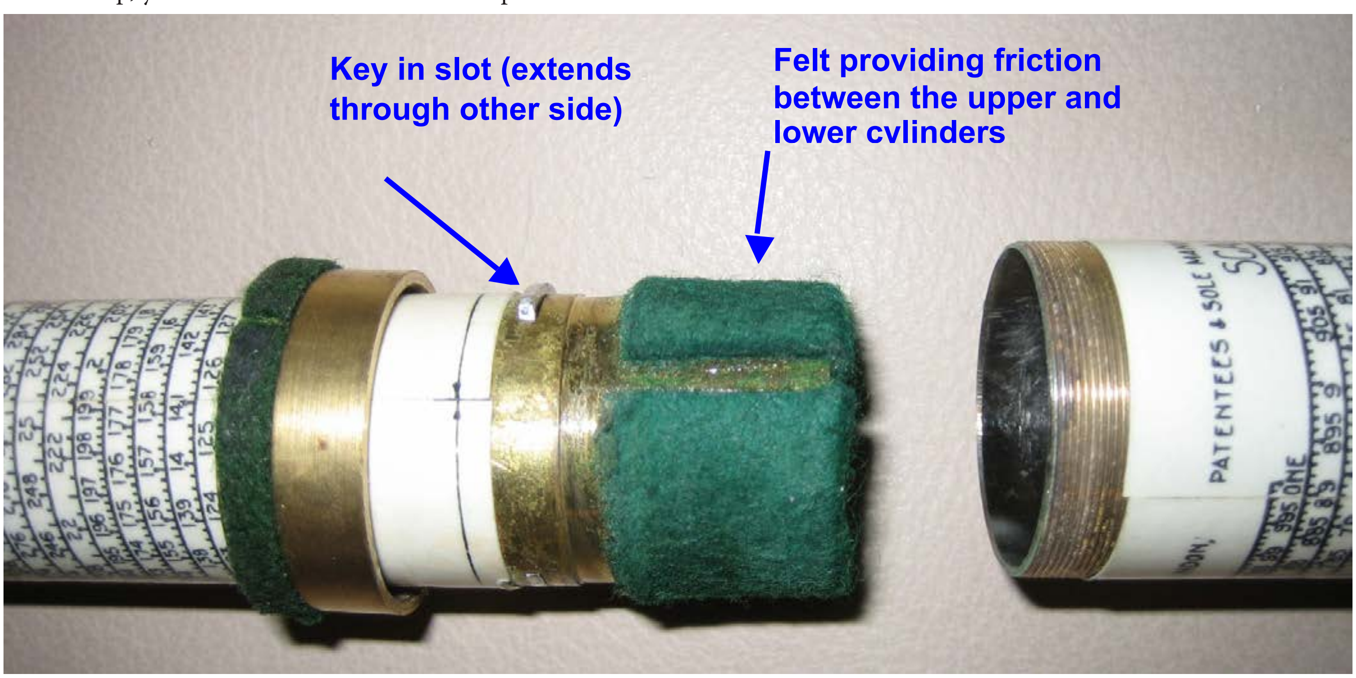

FIGURE 5. After Unscrewing the Brass Ring

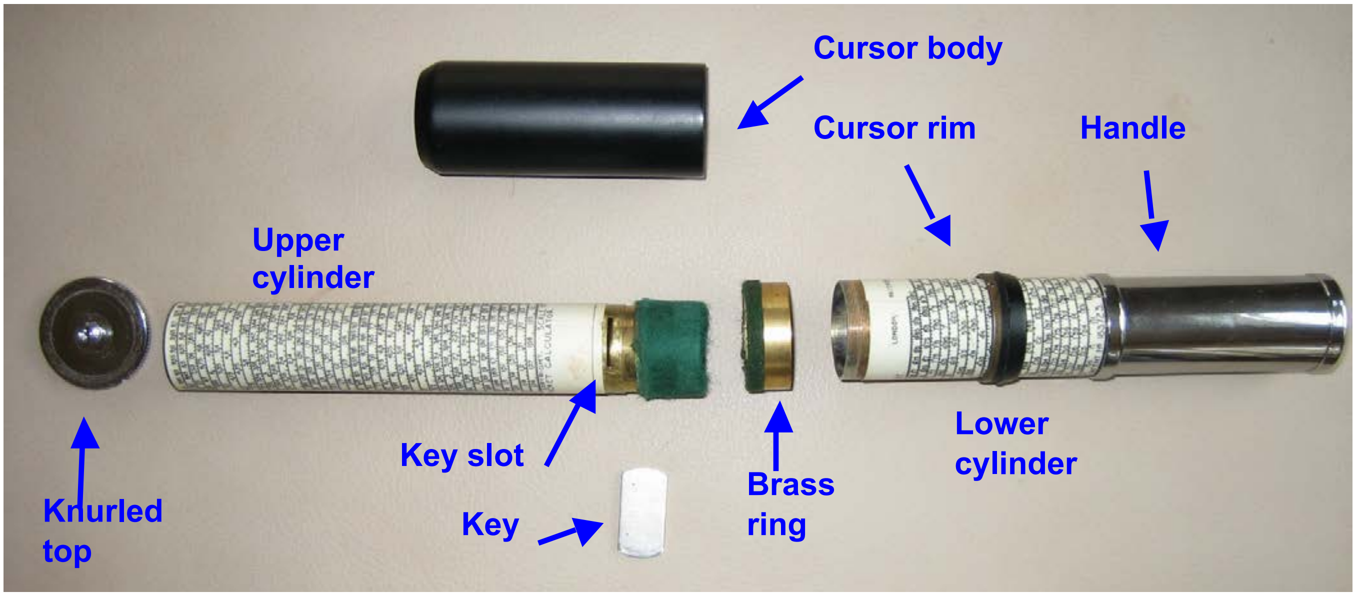

FIGURE 6. All the Parts

Figure 6 shows all the parts laid out. You can replace or clean the felt and/or the scales as needed.

To reassemble the unit, put the lower rim of the cursor on the lower cylinder. Stick the key in the slot and push the felted end of the upper cylinder into the lower cylinder. Slide the brass ring over the top of the upper cylinder (assuming you removed the knurled top) and tighten the brass ring to the lower cylinder. Slide the cursor body over the top of the upper cylinder (ditto the assumption above), line up the dimples in the cursor body with the holes in the lower rim, and press them together by pushing down against the handle. Screw the knurled top back onto the upper cylinder, and you are done!

Early Model - circa 1925?

A key indicator of this construction is the one solid piece cursor. There are no screws or dimples or indeed any visible clues to its construction–which turns out to be much simpler than the later models.

This variety of Otis King only has three parts–the upper cylinder, the lower cylinder, and the cursor–as shown disassembled in Figure 7. Unlike the later model, the knurled top is soldered, not screwed, to the upper cylinder.

The parts are assembled by slipping the cursor onto and to the top of the upper cylinder, pushing the bottom of the upper cylinder into the top of the lower one, and then sliding the cursor down over the telescoping joint.

Holding the assembly together are spring tabs cut into the two cylinders – see the close-up in Figure 8.

Three outwardly bent tabs cut into each cylinder do double duty. First, they provide friction–the ones on the upper cylinder press against the insides of the lower cylinder, and the ones on the lower cylinder press against the insides of the cursor. A strip of felt (blue) glued to the bottom of the upper cylinder provides additional friction. Second, they lock the assembled pieces together owing to a lip carved into the inside of the top rim of the lower cylinder, and another likewise around the inside of the bottom rim of the cursor. Once a spring tab has been pushed past a lip, it expands and cannot be pulled out again. This prevents the upper cylinder from

FIGURE 7. Three Parts of an Early Otis King

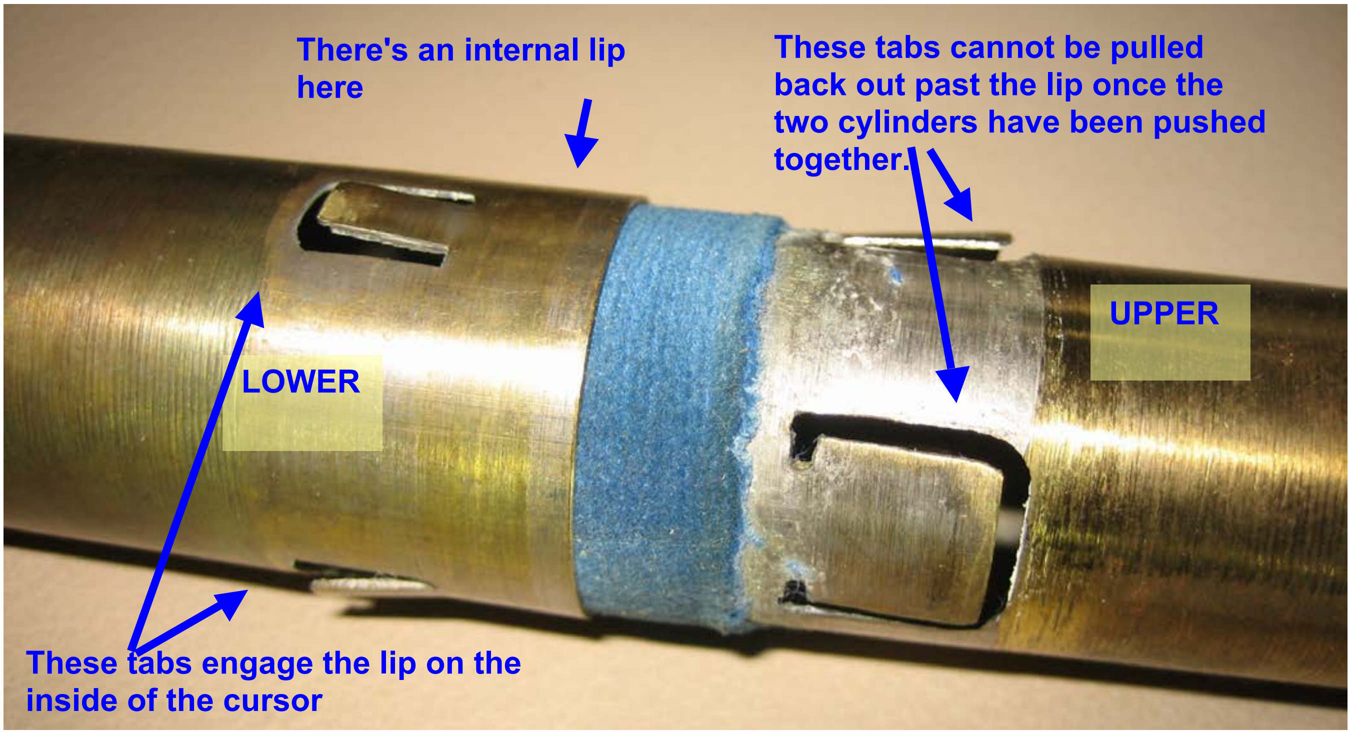

FIGURE 8. Clips and Lips

being pulled out of the lower one and prevents the cursor from being pulled above the telescoping joint.

This simple arrangement makes assembly a breeze, but makes disassembly quite hard. Once the cursor has been slid past the clips on the lower cylinder it covers the telescoping joint and all the clips, making them hard to reach and impossible to see.

Thus, to take the Otis King apart, you have to fashion three metal, L-shaped shims, thin enough to slide between the cursor and the lower cylinder. Working by feel alone, you have to slide the shims over the tabs in the lower cylinder so the tabs cannot engage the lip on the lower rim of the cursor as you pull it up and off the lower cylinder. Figure 9 illustrates how to use the shims.

Once the cursor has been slid off the lower cylinder and fully

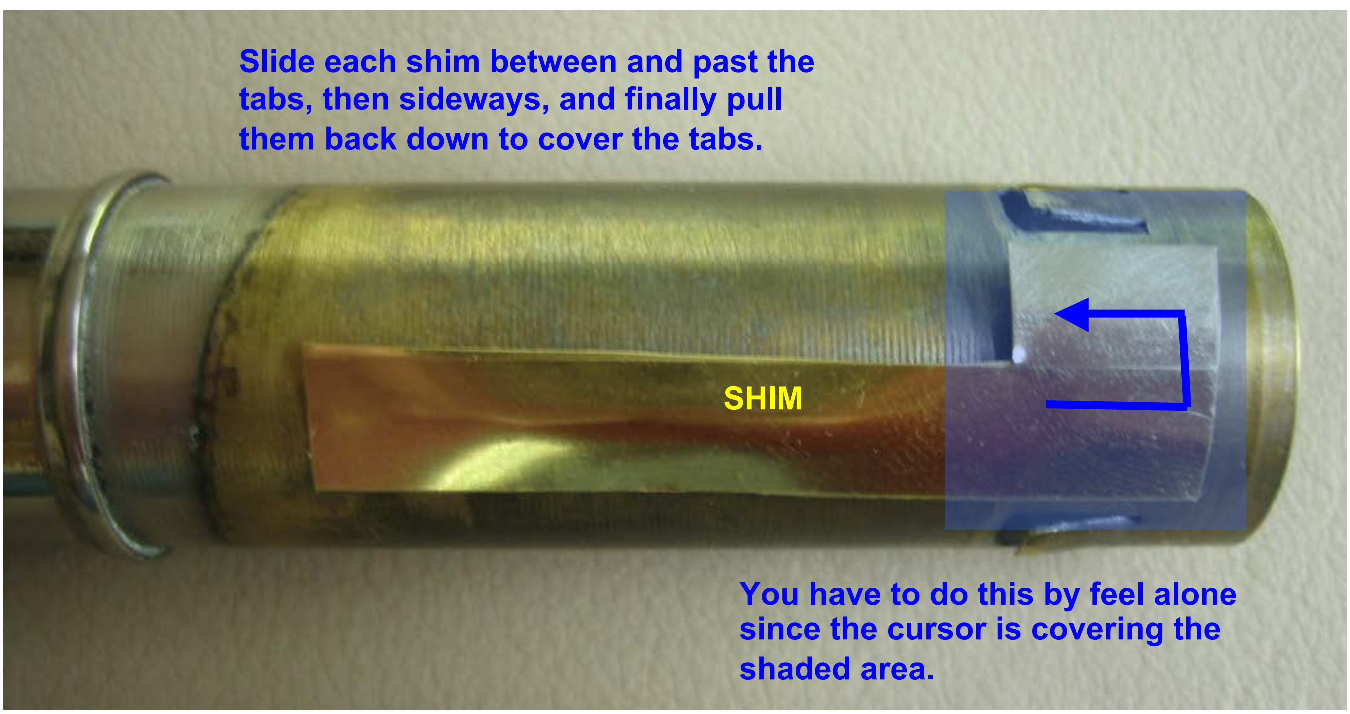

FIGURE 9. Shimming the Tabs

onto the upper cylinder, the telescoping joint is exposed. You can then similarly slip the shims between the lower cylinder and the upper cylinder tabs, and pull the two cylinders apart.

Why Different Constructions?

Given the simplicity of the older construction, I am inclined to wonder what prompted a change in design. We may never know, but I speculate the following two reasons.

First, if there was much need to take an Otis King apart, for cleaning or scale replacement, the greater difficulty presented by the older construction is a negative. On the other hand, repetition eases the process, so maybe this reason can be discounted.

Second, the older model involves metal-to-metal friction. The mechanics are consequently scratchy where the later model's friction is all felt-to-metal and the action is smooth. That yields a more comfortable user experience, which may have justified the design change.

Wichman "Aristo" P.A. 44

Determining True North from the Azimuth of Polaris

Richard Smith Hughes

The P.A. 44 is not a true slide rule, not having the multiply, divide, or find trig functions. The P.A 44's function is to locate the azimuth of the pole star; the horizontal angle of Polaris to true north, at the observer's longitude, latitude, month and day, and time of day from 1944 to the end of 1948.

Figure 1 illustrates the daily rotation of Polaris around true north (with a radius of 1° 02.5′). Assume Polaris is sighted with a "transit"; a telescope mounted on a horizontal plate with very accurate horizontal and vertical angle scales.

When Polaris is at position A or B (lower and upper culmination), the "transit" telescope is horizontally aligned towards true north. (see example 3). If the "transit" is pointing at position D (west elongation), move the horizontal angle 1° 02.5′ to the right and the telescope will be pointed towards true north (see example 4). If Polaris is sighted at an arbitrary position C, to determine true north your longitude, latitude, date, and time of day must be accurately known. Celestial navigation tables (which are published yearly) in conjunction with five place log and log trig tables must be used to calculate the azimuth of Polaris to true north.

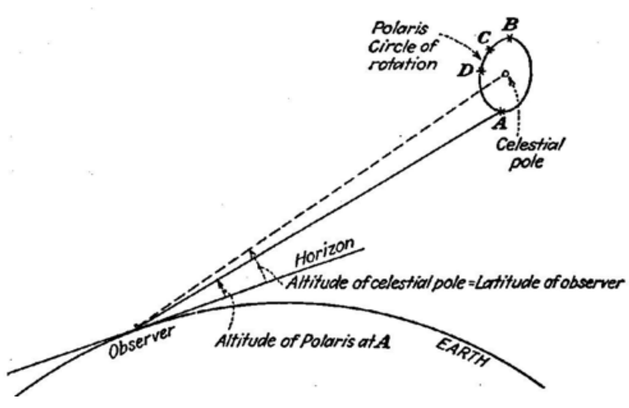

FIGURE 1. Polaris's path around true north

Although not a formidable task, the task must be repeated every time your location, date, or time changes. The P.A. 44 easily removes the need for celestial navigation and log tables, at least from 1944 to 1948. The P.A. 44 presents, in a graphical (front side) and tabular (back side) format true north for the observer's position, date, and time in World War II Germany, from 1944 to the end of 1948.

The P.A. 44 would have saved the user much calculating time and the need to carry celestial navigation and log tables. Certainly the data could have been given in printed tables but this would have required some sixty-seven million entries! The P.A. 44, Figure 2, is easy to use, and provides an advertised +/- 1 Mil accuracy. The following is a brief discussion of the history, operation, and examples. The bibliography lists several articles and books for those interested.

Firing long range artillery requires exact pointing directions from a known reference; typically true north. Artillery personnel use a 6400 Mil circle (1 Mil = 0.056250° {degrees} = 0.033750′ {minutes} = 0.06250^g {grads}). Gary LaPook (see the Bibliography) discusses two methods for determining true north used by the U.S. Army in artillery laying. One uses the celestial position of the Sun, the other the azimuths of the star Kochab (in Ursa Minor-the little dipper) and Polaris, also in Ursa Minor.

The P.A. 44, produced in Germany during World War II (probably in 1944), for the German army takes a different approach; determining the azimuth of Polaris to true north using the observer's known position, day/month, and time of day.

The position of celestial objects, planets, and stars, change (for a given position and time) from year to year, necessitating publishing celestial navigation tables every year. How-