Project 43 — Making a Crystal Wheel Skeleton Clock/Roger Adams

FIGURE 1—Roger's finished crystal wheel skeleton clock.

After a year or two of repairing watches, and in particular pocket watches, I decided to up my game a bit and committed to tackling making a clock from scratch, something I thought would be doable with time, patience, and money. The clock I opted to make was John Wilding's Crystal Wheel Skeleton Clock, the complete design for which I had at hand in his book of the same name. Wilding based his design on a design by Edwards of Stourbridge, England, in the early 19th century. This book was very well written, copiously illustrated, and mostly error free. The only issue I really had was that the drawings were mainly dimensioned in fractions of an inch so conversion into decimal inches was required to match the machine tools and measuring instruments I owned.

I had acquired a fair amount of watch and clock repair and fabrication tools by this time, a lot of it used but of good quality, and in good working order. What I didn't have were the machine tools required to manufacture every component of the clock from raw materials, which were mainly brass plate, brass round stock, and O1 plate and bar stock. This was critical as I had decided by this time that I was going to fabricate every part of the clock, except for the mainspring and chapter ring (dial).

After much research, I determined that the Sherline range of machine tools had the compactness (my workshop is tiny, actually being a converted walk-in-closet, and also serves as a furniture making shop), capacity, accuracy, accessory availability, and affordability that was needed to make this project feasible. Accordingly, I purchased a Sherline ultimate machine shop package, which included a 4400 series lathe, a 5400 series mill, and everything else required to get up and running. During the build, I acquired some additional accessories from Sherline, most notably a CNC rotary table, on an as-needed basis.

FYI, I was quite mechanically inclined to start with, and had some very limited experience with machine tools previously so it wasn't all completely alien to me, but for the most part, I learned "on the job," and by consulting the excellent resources available from Sherline itself, the internet, and several reference books.

One hurdle I encountered almost immediately, was the seeming impossibility of purchasing the gear cutters required to fabricate the cycloidal gear wheels, which are standard on a clock, unlike the more common involute gear form, for which gear cutters are much more readily available. This left no choice other than to make my own even though making gear cutters is no easy task. Fortunately, Robert D Porter's excellent "*The Clock and Watch Makers Guide to Gear Making*," a "fun" read of a mere 190 pages, came to the rescue. Following this, I was able to first make the lathe, and then other tools, required from his designs, to make other tools to enable me to machine the cutter blanks – yes, you must make tools to enable you to make other tools which in turn enable you to make the form cutting tools required to fabricate the cycloidal gear cutters.

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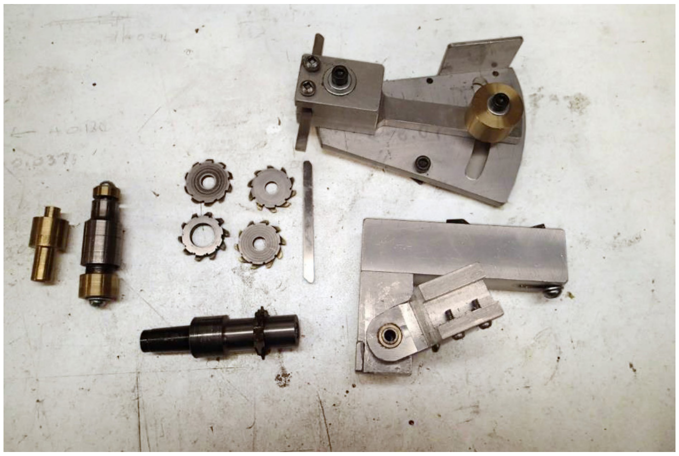

FIGURE 2—Gear Cutting Tools

Everything In the photo above is custom made, including gear cutter holders, gear cutters, sine bar tool lathe attachment, and the form tool grinding lathe attachment.

Following are two photos of some additional tools I made for this project, including a square broach, necessary to fabricate the rather substantial winding key.

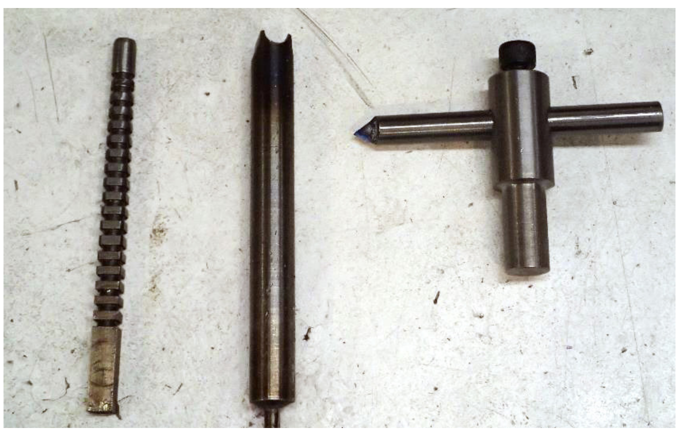

FIGURE 3—Square Broach, Pillar Form Tool, and Acrylic Engraving Cutter.

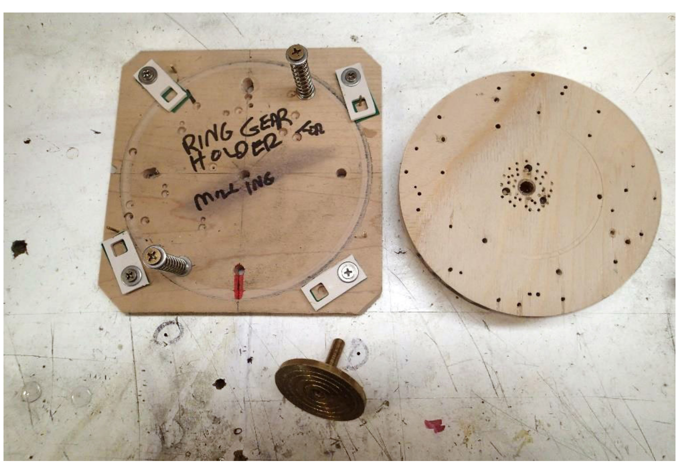

FIGURE 4—Sacrificial Work-holding Jigs.

The raw materials for this project were mainly brass plate and bar stock, and O1 flat and round bar stock. Sourcing presented quite a few hurdles, particularly acquiring a 2-3/4" dia. brass tube, or even a 3" solid round bar, for the mainspring barrel proved impossible as the only place I was able to find anything near to that was McMaster Carr, but, due to a tariff dispute between Canada and the U.S. at the time, there was an embargo on such an export believe it or not. I ended up sourcing a brass plumbing fitting locally that I was just able to fit on the lathe to turn down to size. The photo shows the brass fitting and the mainspring that would be fitted into it once it was machined to spec.

FIGURE 5—Plumbing Fitting for Mainspring Barrel

FIGURE 6—Mainspring Barrel and Frame

John Wilding's book is logically laid out and I followed the recommended sequence faithfully once I had the raw materials at hand. The lathe and mill were absolutely indispensable, although Mr. Wilding states that it could, at a push, all be machined with just a lathe, but the lathe would require an indexing head and a milling attachment at a minimum and, unless you already have these at hand, it would be far less expensive to acquire a dedicated mill and CNC rotary table, as I did from Sherline.

For every hour of actually machining a complex component, I probably spent 4 hours learning how to do it. There really aren't many components in this design that repeat, well other than screws, pillars, and collars, etc., most are one-offs that require a unique setup so no possibility of any time saving with a batch run of anything really. Which leads me to letting you know how long this project took, including sourcing materials, fabrication, assembly, polishing, adjusting, and fabricating a mystery box. I didn't actually clock the time it took but feel that it was probably around 1,000 hours of hands-on, give or take a couple of hundred. And of course, I didn't diligently work at this to completion, but rather in fits and starts as the mood took me, so the duration of the project was about a year. FYI, I'm retired so could afford to be kind to myself in this regard as some of the fabrication work could be laborious so I would pick away at it. This especially included cutting out the plates with a jeweler's fret saw and polishing components (a piece of advice to anyone contemplating taking on such a project – NEVER grip clock plates in the steel jaws of a vice unless you genuinely love polishing).

Making tools specific for the clock as you go is a definite requirement, and in addition to those illustrated above, there are also some that will serve you for any other clock you might fabricate in the future. These include a depthing jig and arbor adapters, as shown below, that are used to ensure the correct meshing of the gear teeth.

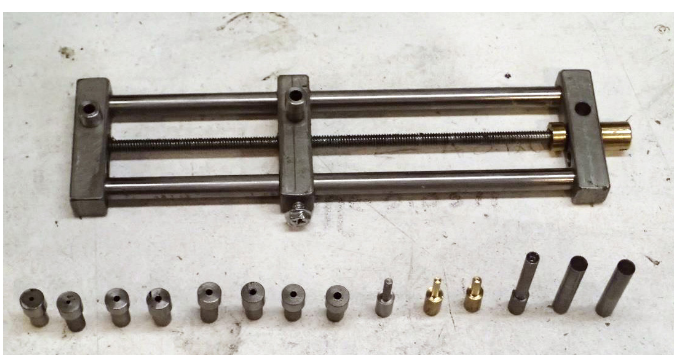

FIGURE 7—Depthing Tool and Arbor Adapters

Probably the most technically demanding part of the fabrication was cutting the gears, and to accomplish this, I first fabricated the tools, as detailed above. The actual cutting was done on the mill using the CNC rotary table, which proved to be highly accurate and repeatable. About the worst thing that can happen when cutting gear teeth is to find that the last tooth cut isn't the requisite spacing from the first. Being too close or too far will lead to incorrect meshing of the teeth and the clock simply won't run well, if at all, however the rotary table ensured perfectly spaced teeth without exception. The photo below shows the largest and smallest clock wheels, and the fabrication methods are identical for both despite the big size difference.

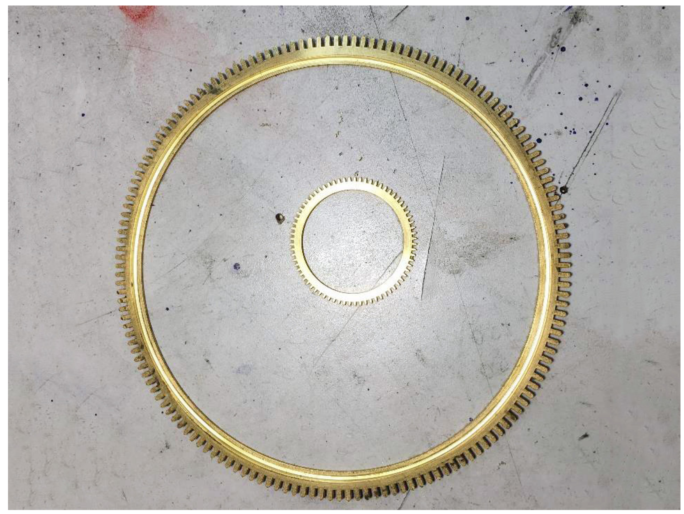

FIGURE 8—Largest and Smallest Wheels

The Sherline lathe didn't have sufficient clearance to cut the largest wheel from brass plate, but I was able to accommodate it on the mill, using the rotary table again. This proved much easier than I anticipated, and the video accompanying this article shows how this was accomplished; in this case it's cutting the recess that will hold the acrylic center.

FIGURE 9—Mill setup with CNC controlled rotary table. Centering the main wheel for the recess machining on the mill.

As can be seen in the photo below, the large wheel is attached to the "fusee," a device which compensates for the reduction in torque as the mainspring unwinds, and which also contains a ratchet mechanism, and which is, by far, the trickiest item to fabricate for the clock. The photo shows the completed assembly, including the etched acrylic center; each wheel gets such a center.

FIGURE 10—Mainwheel and Fusee

Following are photos of some of the more critical components.

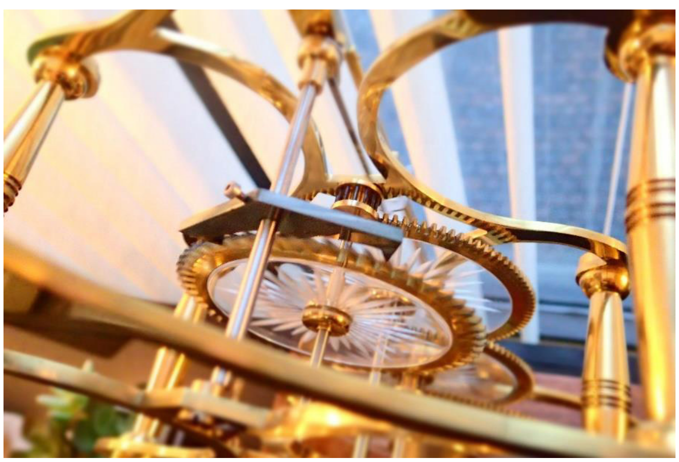

FIGURE 11—Escapement and Wheel

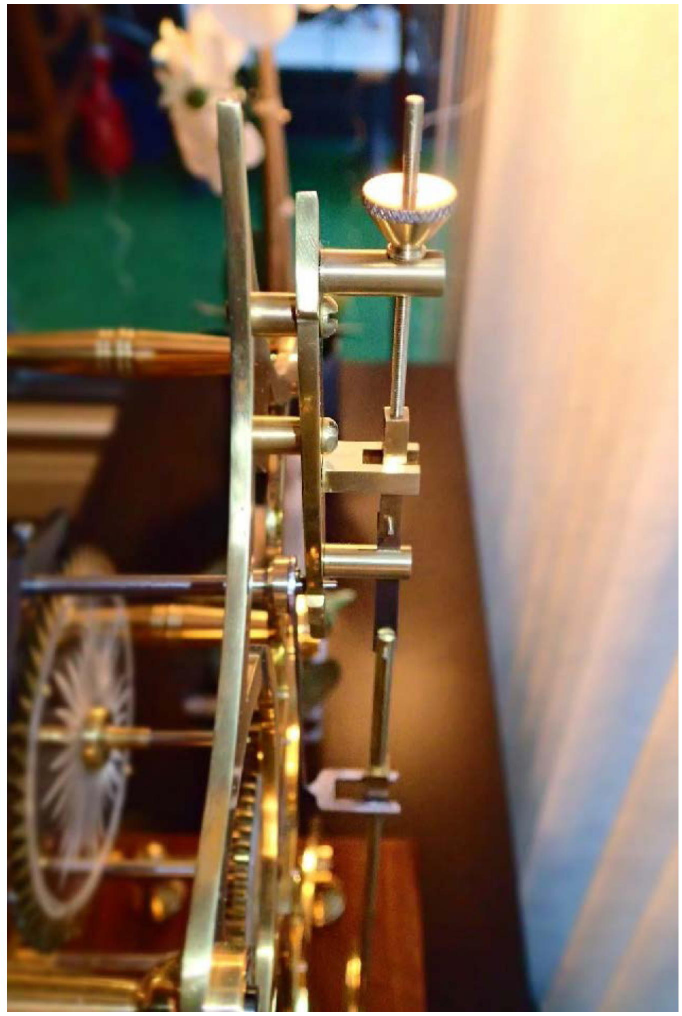

FIGURE 12—Pendulum Attachment and Regulator

Besides the obvious requirement of making all the individual parts, certain other skills needed to be acquired, and these included heat bluing (all steel screws are blued), hardening and tempering of steel parts, single-point threading on the lathe, and most especially, mastering the jeweler's fretsaw. While John Wilding apparently purchased his frames pre-made and rough polished which required little finishing, I was not nearly so lucky however and found the frame cutting, and subsequent polishing, to be by far the least pleasant part of this project, and probably spent 40 plus hours on this alone. A power fretsaw would have made this part of the job go much faster, and probably would have resulted in nicer cuts, and ditto for the polishing, however my budget wouldn't stretch that far so much manual cutting and polishing ensued, with decent results I believe.

I am also a woodworker and was able to fabricate the box without too much trouble. This was made from walnut, and I applied several coats of polymerized Tung Oil as a finish.

I also opted to coat the brass part with Renaissance Micro-Crystalline Wax Polish, which is very expensive but a little goes a long way, and I do believe it makes a positive difference.

The clock is not enclosed as I couldn't find a reasonably priced bell jar so it's in the open and thus subject to accumulating dust, however I haven't had a stoppage for that reason for the several months it's been running, though I'll probably clean and re-lubricate it annually as a matter of course.

Lest I forget, the final assembly and running adjustments went suspiciously well as I was expecting to spend a lot of time fiddling around with escapement corrections, frame spacing, pendulum adjustment, etc., but it went really smoothly, which may be more of a tribute to Mr. Wilding's excellent design and fine book, than to my skills as a clockmaker.

Overall, the project was very enjoyable, and I would encourage anyone with an interest in tackling something complex like this to give it a go. It's not rocket science, and anyone with a modicum of mechanical aptitude should be able to master the necessary skills. As I mentioned in the beginning, all it really needs is time, patience, and money.

Thank you,
Roger Adams

FIGURE 13—The power to drive the clock is from a mainspring hidden in the base. The front cover of the base is removable, should the need arise to access it.