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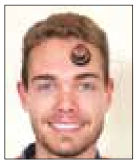
Screw Cutting Attachment for a D-bed Watchmaker's Lathe

A Novel Contemporary Design

Philip Kuchel FBHI  Lindsay Drabsch  Reuben Schoots 

Overview

Screw cutting (also called thread cutting) attachments for watch and instrument makers' lathes are valuable additions to the workshop. However, none was *ever* provided by manufacturers for the smaller D-bed lathes like the 6 mm and 8 mm versions made by Boley, Lorch Schmidt, Wolf Jahn etc.[1] Beginning in 1941, Louis Levin and his son Samuel in California began marketing watchmakers' lathes, and later added screw cutting capability.[2] However, only old stock is available today and Levin no longer manufactures the attachment. The highly informative book by the Levins on general watchmaking methods has a large section devoted to their screw cutting attachment and they provide detailed instructions on how to make the device, as if to invite competition for their sales.[3] We have also had the pleasure of a close-at-hand inspection of a complete Levin system owned by Eric Pearson, a fellow Member of the Sydney Clockmakers Society (SCS). **Figure 1** shows the general layout of the attachment shown in the Levins' book and also of Eric's version.

Previous efforts in fabricating one-off lathe-based screw-cutting attachments for watchmaking lathes of the Webster-Whitcomb (WW) bed pattern, by the Members of the SCS (notably Lindsay Drabsch and Peter Cassar), have paved the way for the latest challenge: to make a screw cutting attachment for one of our D-bed watchmakers' lathes.

The basic design was made by one of us (Lindsay Drabsch), while many of the finer details evolved as the attachment was constructed in a 'synthetic prototyping' approach; without using detailed design drawings. We are sufficiently satisfied with the final result that we thought other Members of the SCS, and the broader horological community, might be interested in taking up a similar challenge.

Fundamental Concept

A screw cutting (or self-acting) lathe is one in which, by mechanical means, a fixed relationship exists between the angle of rotation of the lathe-head spindle, which holds the work, and the axial position of the lathe's carriage or slide rest assembly that holds the cutter which in turn cuts the thread into the work. This connection is mediated by a wheel train whose ratios can be changed to give a specified pitch to the cut thread.

In the case of the Lorch Schmidt slide rest, the feed screw pitch is 0.75 mm per turn. This is inconvenient to use when selecting ratios in the wheel assembly to achieve a particular screw thread pitch. Hence an innovation was to have

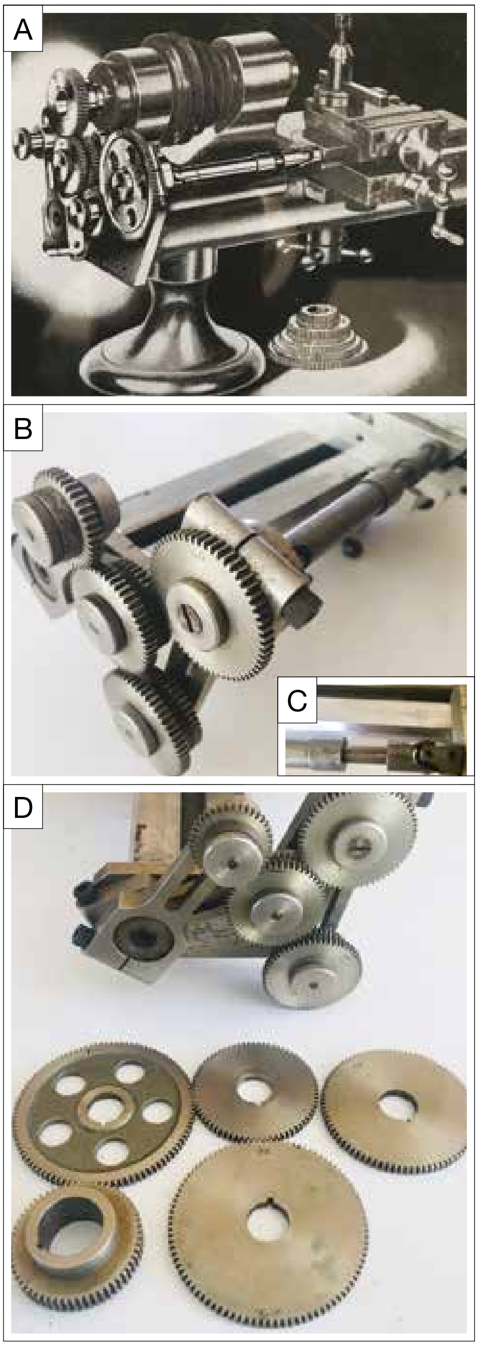


Figure 1. Screw-cutting attachment made by Levin. **A** *is a copy of Figure 94, p69 of the book by Levin and Levin showing their particular design attached to a WW bed lathe.[4]* **B** *is the particular example owned by Eric Pearson.* **C** *shows one of the universal linkages and the extensible shaft that connects the output gear to the feed screw on the slide rest.* **D** *shows some of the gears used to achieve the ratios to cut various thread pitches.*

Figure 2. Screw cutting attachment on the 8 mm Wolf Jahn watchmaker’s lathe.

Key:

a: Double plain cone-bearing headstock
b: Headstock stepped drive pulleys
c: D-bed of the lathe, being 20 mm hard steel, milled flat at the back to give a depth of 17 mm
d: Lorch Schmidt left-hand slide rest
e: ‘Lantern’ tool post, with height adjustment of the tungsten-carbide tool by a knurled tapered ring
f: Bakelite knob of the draw bar
g: headstock spindle
h: Two tumbler wheels, the lower one of which engages with a 36-tooth wheel (see **i**).
i: 36-tooth wheel
j: Rocking platform; rocking this up or down changes engagement of one or the other tumbler wheels, thus changing the direction of rotation of the output wheel train
k: Knurled knob used to lock engagement of the top or bottom tumbler wheels with the main drive wheel, **g**. In addition, platform **j** can be locked in the neutral position with **k**, such that the drive to the slide rest is disengaged
l: Proximal (nearside) plate of the main assembly that supports the tumbler wheels on platform **j**, and the bearing **o** for the 6 mm diameter drive shaft, which carries wheel **i**
m: Main boss that holds the whole attachment on to the lathe via a recessed 9 mm socket-head cap screw with a hemispherical bottom that locks into the grooved centre of the flat of the D-bed
n: Distal (far-side) plate of the whole attachment that supports the output feed shaft and its attached banjo (see **u** below)
p: Boss that controls end-shake on the main drive shaft
q: Brass spacer
r and **s**: Exchangeable wheels, given positive drive by a 2 mm wide key seated in the shaft, and a corresponding keyway in each wheel
t: Hand crank to drive the thread-cutting process manually
u: Banjo with its central slot that enables adjustment of the longitudinal position of the stud (o.d., 4 mm) with its knurled locking nut **v**
v: Knurled locking nut which holds in place the changewheels
w and **x**: Changewheels, which are locked by a short keyed cylinder (o.d., 6 mm) that extends into their keyways
y: Wheel that engages with wheel **x** on the banjo and is keyed to the distal extension of the output feed shaft, and held in place by the knurled nut **z**
a’ Knurled screw that locks the banjo into such a position that all wheels are in correct engagement
b’ Distal universal joint and feed shaft with internal square
c’ Matching square shaft and proximal universal joint
d’ Collar of the universal joint that is clamped to the slide rest feed screw with a 3 mm socket-head grub screw
e’ Transverse feed screw with its scale indicating 0.01 mm

the main drive wheel of 48 teeth engaging with (via a tumbler wheel) a 36-tooth wheel, thus achieving an overall ratio of 4/3. This multiplied by the feed screw pitch of 3/4 gives 1. In other words, one revolution of the lathe spindle will advance the slide rest 1 mm if the intervening wheel train has a net ratio of 1.

The Device

Our complete screw-cutting attachment is shown in **Figure 2**. This is a top-down view of the 8 mm Wolf Jahn headstock to which the device is attached, its D-bed, the left-hand Lorch Schmidt compound slide rest, and additional components that make up the means of connecting the rotational motion of the headstock spindle with the axial motion of the slide rest. The various features of the attachment are identified by lowercase letters in **Figure 2**, and subsets of these letters are used on some of the figures that show close-up details.

The Components

8 mm Wolf Jahn Headstock

For both the 6 mm and 8 mm lathes, the height from the top of the D-bed to the spindle centre is 40 mm. Since the D-beds of both lathe-types are identical, attachments are interchangeable between them. While the original intention was to make the attachment exclusively for the 6 mm lathe, more convenience has been achieved by setting up a separate screw cutting lathe. Hence the main drive wheel on its boss was reconfigured for the Wolf Jahn headstock, **Figure 3**.

Figure 3. Wolf Jahn headstock **a** *with its drive pulleys* **b** *located between the plain cone bearings; and the* **g** *drive wheel (0.5 module, 48 teeth involute profile) attached to the boss with three blued screws that clamp onto the spindle; and* **f** *the Bakelite drawbar knob.*

Figure 4. 20 mm D-bed **c** *with the main boss* **m** *and its two attached mounting plates; the proximal one* **l** *supports the drive shaft bearing* **o***, while the distal one* **n** *supports the banjo and the feed screw shaft.*

D-bed

As noted above, all attachments are freely exchangeable between the two variants of the lathes (6 mm and 8 mm) because the D-beds are identical, being 20 mm in diameter, with a vertical flat on the rear giving a bed depth of 17 mm. A groove runs longitudinally along the middle of the flat. It is into this that the grub screw in the main boss (**m** in **Figures 2 and 4**) locks on to the D-bed. **Figure 5** gives a clearer view of the groove.

Main Boss and Two Support Plates

The main boss was fabricated from a bar of 38 mm diameter silver steel (high carbon steel). A blind 20 mm internal diameter hole was bored in it. The transverse set screw of 9 mm diameter was fitted, to fix the boss to the D-bed via the groove on its rear surface. This screw is set below the surface in a counter-bore. The two support plates of 2.83 mm blued steel were attached to the main boss by 3 mm socket-head cap screws, **Figure 6**. The set screw is shown in **Figure 7**.

Tumbler Wheels and Platform

The tumbler wheel assembly enables easy switching between cutting right- or left-hand threads. In addition, placing the wheels in the neutral position, disengaged from the main 48-tooth drive wheel, allows the lathe to be used in the normal way; for example, to cut a workpiece blank before screw cutting, without the subsequent need to remove the work from its collet. This ensures perfect concentricity of the final product.

Cross Slide

A lucky ‘find’ amongst my tools was a Lorch Schmidt D-bed cross-slide that is of the rarer left hand configuration, **Figure 2**. By using this, after removing the crank from the axial feed screw shaft, the shaft was conveniently in line, near the end of the headstock, for connection to the output shaft from the wheel train.

Banjo

This is the slotted arm that supports a single stud of 4 mm diameter, which in turn carries two wheels that are keyed together on a steel cylinder of 6 mm outer diameter. The latter fits the 6 mm central bore of the wheels.

Universal Joints

These were fabricated by Lindsay using precision milling methods (**Figure 2 b’, c’, d’ and Figure 11**). The internal square was cut into a drilled hole, using a hard square broach that had a ~3° face angle and which was applied in a rotational sequence after blows with a hammer. Each 4.7 mm square-cross-section hole is 40 mm long and took about an hour and a half to make (by Lindsay). This differs from Levins’ design (**Figure 1C**) which uses a simple slotted shaft.

Wheels (Gears)

These were generated by Lindsay on a home-built, numerically controlled machine, using a 0.5 module helical involute hobbing cutter. The engraving brass that was used was 4.76 mm (3/16 of an inch) thick. Each blank of a wheel was turned on a lathe to 0.05 mm oversize for the expected pitch-circle diameter. Then, when the blanks were hobbed, the cutting depth was increased by 0.025 mm so that that the tops of the teeth were trimmed. This specification was born out of experience with gear performance (Lindsay’s), as typically with gear cutting the blanks are made exactly

Figure 5. Back of the lathe's D-bed and the screw cutting attachment's proximal plate and main boss.

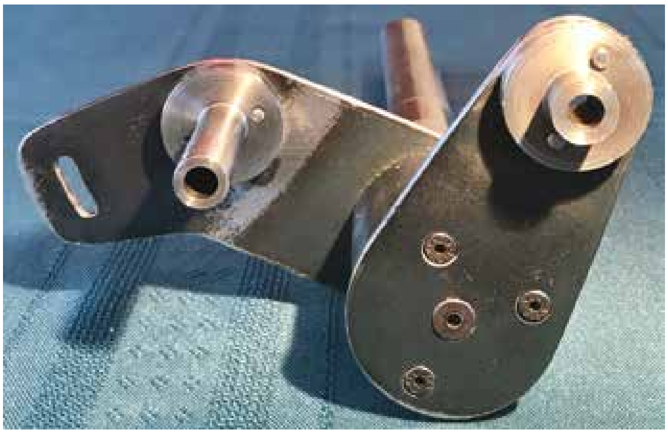


Figure 6. The two supporting plates attached to the main boss. The distal plate is fixed to the main boss by one central and three radially disposed 3 mm socket-head cap screws. The two bearings for the drive and lead-screw shafts are of cast iron, which has the excellent property of retaining oil in such bearings.

Figure 7. The silver steel main boss of 38 mm diameter, which is clamped on the D-bed via a single 9 mm socket-head cap screw tightened on to the rear groove. The boss has a central blind bored hole of 20 mm that extends to within ~5 mm of the end of its 35 mm length.

to size. The wheels have tooth counts ranging from 25 to 95 in steps of 5.* The time efficiency for generating wheels this way is underscored by the fact that the 21 were completed in approximately eight hours.

Other Views

The general disposition of the various components, which should be familiar from **Figure 2**, can be seen in **Figures 11–13**.

Cutting Tool

The choice of cutting tool for forming screw threads has been the topic of debate in the SCS. Since several of us have moved to using tungsten carbide gravers for all our watchmaking turning tasks, it was convenient to shape such a graver for screw cutting. The results have been very pleasing.

Discussion

A key consideration at the start of the project was deciding on the means of attaching the screw cutting attachment to the D-bed. One approach would have been to emulate the means used for the headstock and other components, like the tailstock and cross-slide. This would require a lot of work, but a boss and grub-screw are relatively easy to make. This approach was made even more appealing by noting the axial groove in the middle of the flat at the back of the D-bed. The end of the hard-steel grub screw was made hemispherical to avoid bruising the D-bed.

The main boss and support plates for the wheel train were made in Lindsay's workshop, as were all the wheels. The keyways in the brass wheels were cut using a stepped keyway broach in a specially turned-and-slit guide that was fitted inside the 6mm hole of the wheel. The broach was pressed though a stack of five wheels using a manually operated 10-ton hydraulic press. If such a press is not to hand, keyways can be made by using a square file and a purpose-made guide jig; the keyway for the winding handle was cut this way.

* It is planned to add a 100-tooth wheel to increase the utility of the attachment, especially for cutting BA threads. The useful range would be further increased with the addition of wheels of 73, 66, 59, 53, 48, 43, 39 ,31 and 28, which would cover BA threads from 1 to 13.

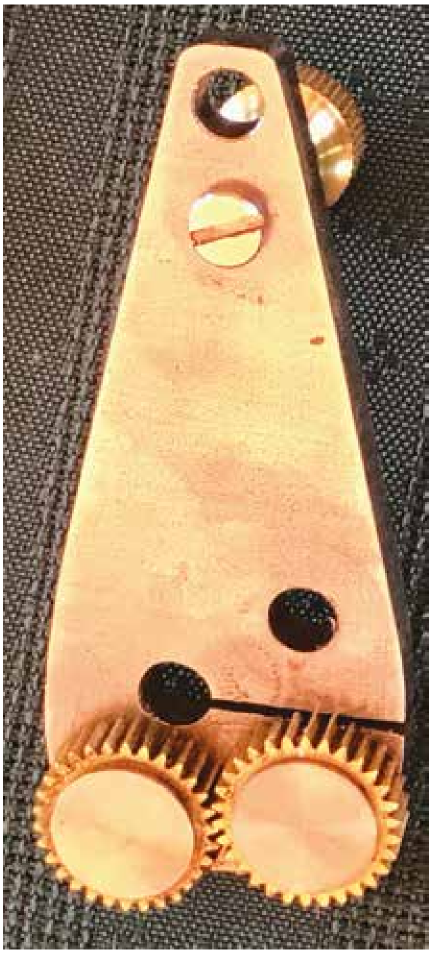


Figure 8. Tumbler wheels on their platform. Note the slit-and-hole used for fine adjustment of the depthing of the right-hand tumbler wheel with the 36-tooth wheel on the drive shaft.

Figure 9. Distal side of the tumbler platform, showing the 4 mm knurled nut on its stud, used for locking the platform, and hence the tumbler wheels, into selected positions (forward, neutral and reverse motion of the slide rest relative to the lathe spindle).

Figure 10. Banjo that supports the intermediate wheels. It fits, via the 11mm hole, on to the feed screw bearing (shoulder) and is clamped into position by the long knurled nut. The banjo was cut from 5.75 mm blued steel with a CNC mill using a 3 mm tungsten carbide end-mill.

Figure 11. Side view, showing the universal joints on the feed screw shaft.

Figure 12. End view showing the crank and wheel train in detail. Here it is set up with a 25-tooth wheel driving a 95-tooth wheel that is linked on the banjo to a 60-tooth wheel that in turn drives a 90-tooth wheel. This gives a pitch ratio of 0.175.

Figure 13. Close up of the tumbler (direction-reversing) wheels on their platform.

Figure 14. The cross slide with tool post and tungsten carbide graver sharpened to give the required thread profile on the cut screw.

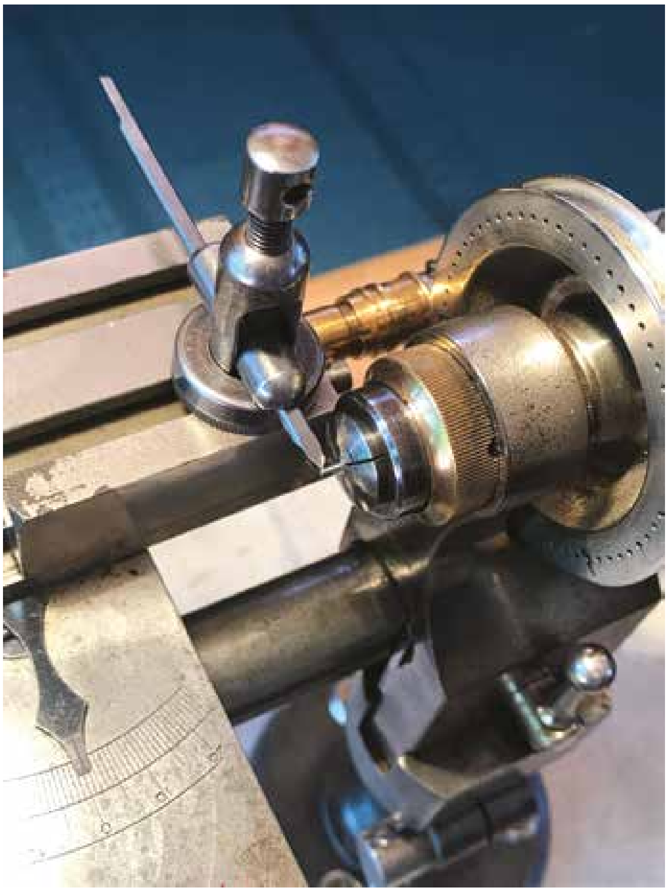


Figure 15. The screw was of 0.7 mm outer diameter with a pitch of 0.175 mm.

The keyseats in the shafts were cut with a 1.5 mm tungsten carbide slot drill on a CNC mill running Mach3 with a special 'Slot Wizard', while the keyed cylinder for the banjo was shaped by hand on a mill by Reuben.

When cutting screws, the threads are formed by several passes of the cutting tool, to minimise the amount of bending force that would otherwise be applied to the work, were the cut to be made to full depth in one pass. At the end of a cut, the tool is withdrawn from the work and returned to an axial position beyond the free end of the work by reversing the whole setup with the hand-crank. It is important to reverse further than the work and then drive forward in free air before recommencing the cut, thus taking up backlash. The transverse position of the cutter is advanced incrementally before each cut by means of the top slide crank using reference to the top slide micrometer collar, having first noted at the start of the work where the cutter just scratches the work. This is 'zero', and subsequent cuts are made incrementally deeper with respect to this point.

Conclusions

Overall, this project tested, and helped develop, many machining skills (such as wheel hobbing) for me and Reuben, under the watchful eye of Lindsay. The design of the attachment rapidly evolved after the decision had been made about the means of its attachment to the D-bed. In addition, having decided on the use of a left-hand cross slide, the rest of the design seemed to 'fall into place'. If a more conventional right-hand cross-slide had been used, a means of extending the feed screw back towards the headstock would have been required; in fact, this has been done by Peter Cassar on his version of a Levin-type attachment.

The screw-cutting attachment is valuable for cutting those left-hand threads that are often encountered in the keyless work of wrist and pocket watches. Also, left-hand taps are readily generated on this system. Of course, by the correct choice of wheel ratios it is possible to cut almost any metric thread, and importantly BA threads as well; these are still favoured by many model engineers, so our particular design of screw cutting attachment would be of interest to them too.

If your watchmaker's lathe is 'fully kitted out' like my 6 mm Lorch Schmidt lathe was (I thought!) and it begs to be even further enhanced, then this is a good project for you.

Acknowledgements

Thanks to Peter Cassar for insights and instructions into making screw-cutting attachments of the Levin type, and to Eric Pearson for information on, and photographs of, his Levin system. Thanks also to Mr Dale Waite, Manager, Louis Levin & Son, Inc. for approval to use the image in **Figure 1A**.

ENDNOTES

1. Donald De Carle, The Watchmaker's Lathe and How to Use It (Thetford, Norfolk: Lowe & Brydone Ltd, 1974)
2. Levin lathe at https://levinlathe.com/menu.htm (accessed 8 February 2021)
3. L. Levin and S. Levin, Practical Benchwork for Horologists: Revised Eighth Edition (Arlington, Virginia, USA: Arlington Book Company, 1988). pp62-80
4. Ibid.