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A Helping Hand for Students 60

Adventures with a Unimat 3 – Part 3

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Examinations are approaching, and some readers may have entered Unit D2: Constructing Clock Components. Under current arrangements, the practical test piece consists of a component riveted to a collet, which turns on a post, an example is shown in **Figure 1**.

Recognising it is necessary for the student to practise the skills required to make the assembly, the Distance Learning Course (DLC) includes a section encouraging them to make a typical test piece prior to the examination. There are step-by-step diagrams showing the procedures to follow and detailed photographs for trickier aspects of the work. The practice test piece in the DLC is a crossed-out wheel turning on a post, typical of a longcase clock.

At first sight, this appears an excellent opportunity to ensure success: detailed instructions to make your examination test piece. Undoubtedly, the exercise is of considerable merit, but there is an assumption that particular items of equipment are available. For example, one diagram, in the DLC, similar to **Figure 2**, shows the post being held in a collet using a watchmaker's lathe; a double roller filing rest is shown to create the square.

The Unimat lathe purchased with our limited budget does not have collets, there is no opportunity to use a filing rest, and no facility to index the four positions for filing the square. So how can a candidate with a basic lathe achieve excellent results?

Figure 1. A typical examination test piece.

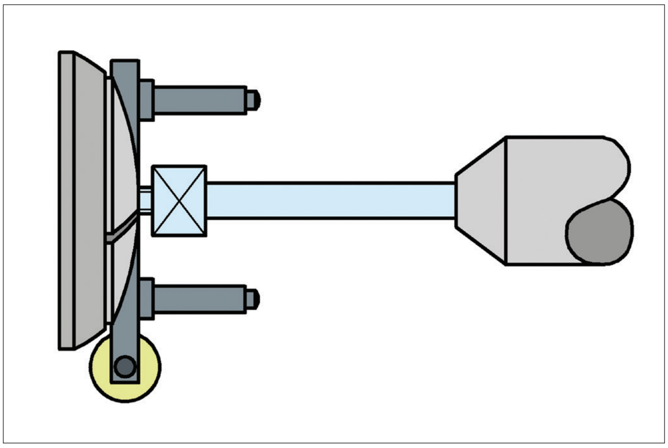

Figure 2. The DLC guidance suggests using a watchmaker's lathe with a collet, a roller filing rest and indexing the four positions for the square.

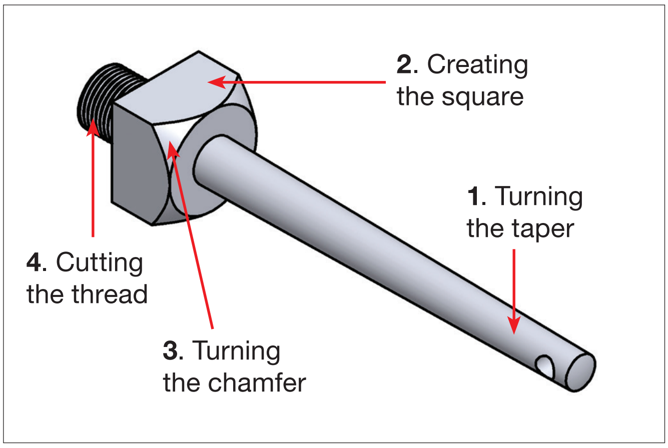

Figure 3. You will learn techniques to use a basic lathe for mastering these procedures.

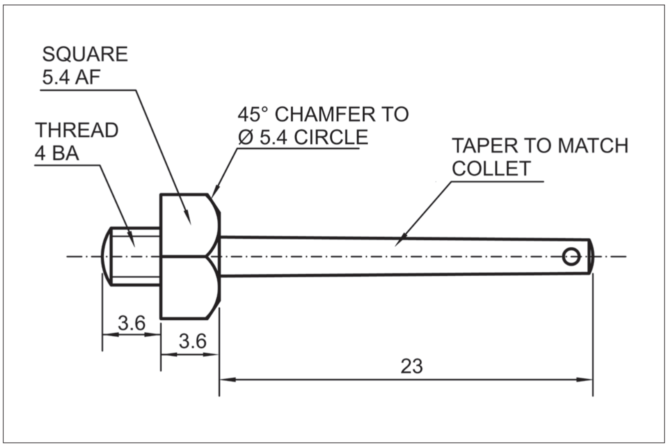

Figure 4. Dimensions for the post.

Some aspects of the work will require a different approach, and this article serves to explore alternative techniques for making the post. Although you may have only basic equipment, excellence is still within your grasp. However, don't forget that there is still a need to practise prior to the examination. There are many alternative methods that could be considered, but these illustrations describe one way to make the post using a Unimat lathe.

The design of the post varies: sometimes parallel, sometimes tapered. The example with a crossed-out wheel given in the DLC uses a tapered post that matches the broached hole in the 'gear'. We will focus on procedures to make the tapered post, see **Figures 3 and 4**.

Turning the Taper

The practice test piece in the DLC requires a slender tapered post to match a broached hole in the 'gear'. One of the Unimat accessories purchased is a top slide, **Figure 5**. Its function is to create tapered surfaces. The top slide is fastened to the cross slide and set at an angle to the axis of the lathe. The cutting tool will thus create a conical surface.

The taper of a cutting broach may vary; the example I measured was around 0.59° included angle, a slope of about 1 in 97. The graduations for setting the angle for the top slide are imprecise, with divisions at 5° intervals, see **Figure 6**. It is unlikely the correct angle can be achieved at the first attempt.

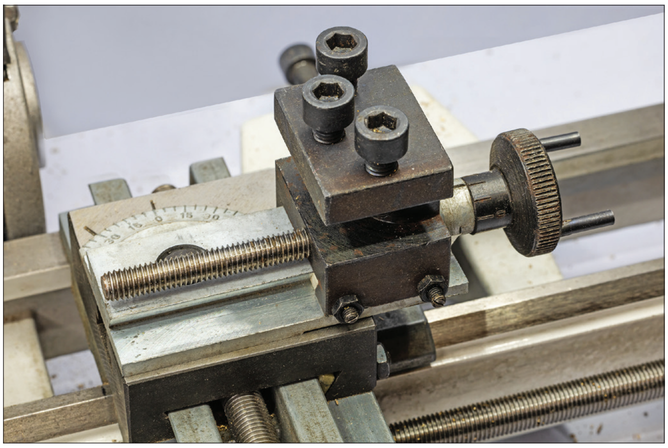

Figure 5. The top slide fastens onto the cross slide and can be positioned at an angle to turn a taper.

Figure 6. The graduations for the top slide are 5°. It is difficult (impossible?) to accurately adjust the slide to 0.295°.

To aid the process of adjusting the top slide to exactly the correct angle, a small brass 'gauge' will be made first. The length of the 'gauge' should be the overall length of the 'gear' specified in the drawing, in this instance 20 mm. The 'gauge' will initially be drilled with a 1.8 mm diameter hole and then broached to provide the taper.

After drilling the 1.8 mm diameter hole, the round portion of the broach is fitted to a Jacobs chuck held in the tailstock, which is then moved until the broach enters tightly into the hole.

To become aware when the hole being broached has reached the correct size, mark the broach at 20 mm, **Figure 7**. Broaching can then begin by turning the chuck backwards and forwards by hand until the mark reaches the end of the 'gauge', **Figure 8**. This brass 'gauge' will later be used to check the taper on the post and will also prove helpful when finally adjusting the top slide to the correct angle.

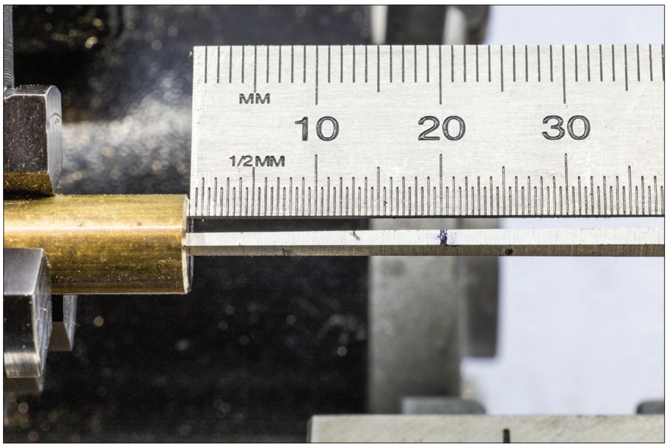

Figure 7. During broaching, the broach should move into the hole 20 mm. Mark the distance on the broach.

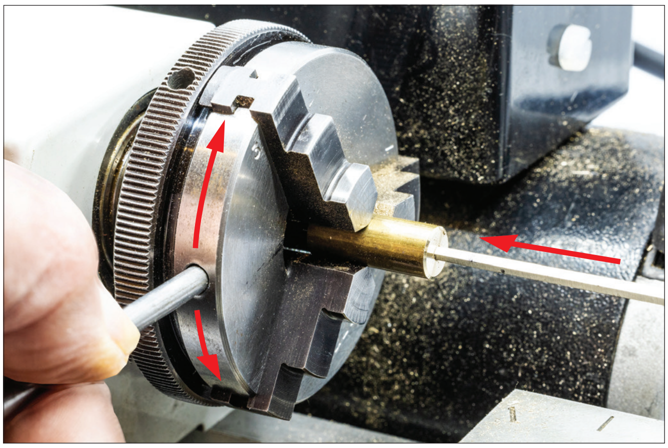

Figure 8. Gently press the broach into the hole. Move the chuck backwards and forwards until the black mark reaches the end of the 'gauge'.

Setting the Top Slide

A. Using a Dial Indicator

A dial indicator is a device used by engineers when operating a lathe or milling machine to determine deviations in the accuracy of components. A spring-loaded plunger rests against the workpiece and transfers, and magnifies, variations, which are shown on a dial. It is also very useful for clockmakers.

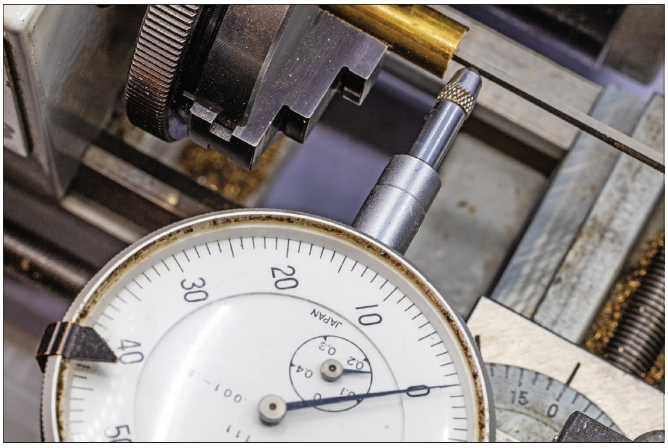

Figure 9. Using a dial indicator to check the angle of the top slide.

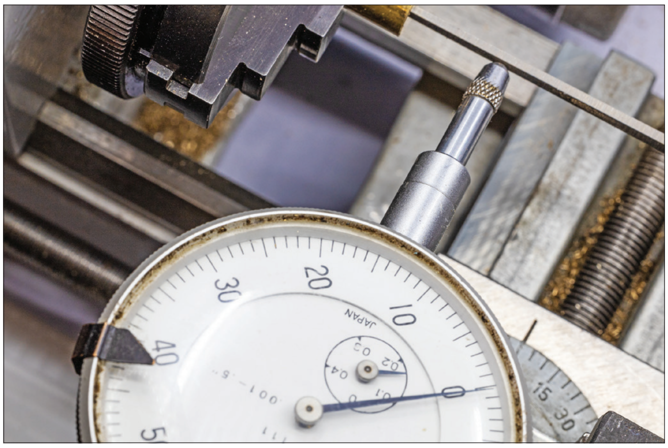

Figure 10. The reading should remain zero as the dial indicator is moved along the broach.

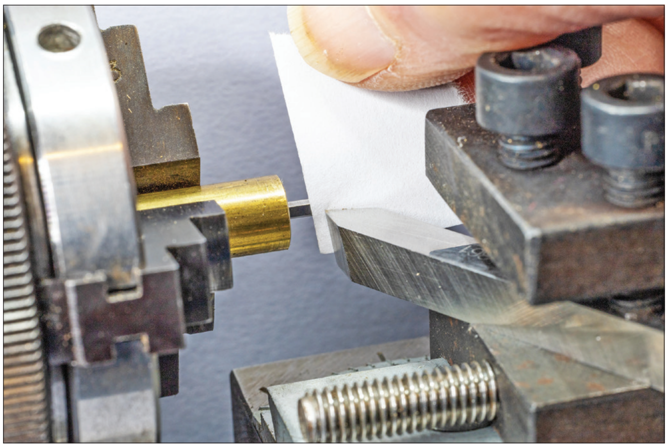

Figure 11. The cutting tool pinches the paper against the broach.

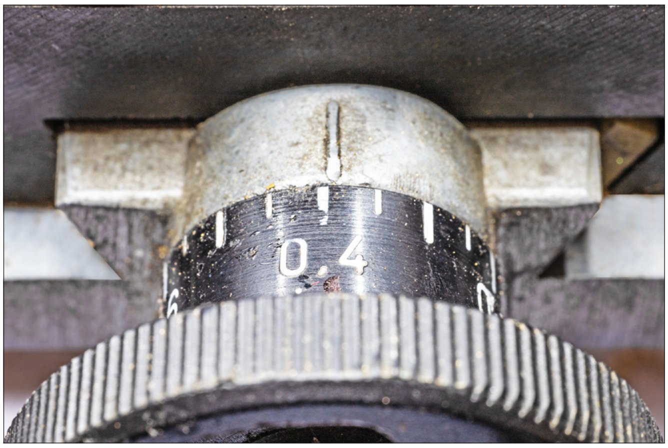

Figure 12. Note the reading on the cross slide.

The dial indicator can be fitted firmly to the tool post using a bolt tightened through the lug at the back of the gauge.

One end of the broach is held in a Jacobs chuck in the tailstock; the other fits firmly into the hole in the 'gauge'. The dial indicator is carefully aligned with the tip of the plunger against a flat on the broach. If the angle of the top slide is set correctly, and the dial indicator is moved along the broach, the reading, given in millimetres on the dial indicator, will not change.

Figure 9 shows the dial indicator close to the 'gauge'; the reading has been zeroed to 0 mm. As the plunger on the dial indicator is moved along the broach, the reading should remain zero, **Figure 10**. If the dial indicator moves from zero, the angle of the top slide must be changed. The top slide should be loosened, adjusted, re-tightened and the test repeated until the reading is constant.

B. Checking With a Cutting Tool

If you do not have a dial indicator, a similar approach can be followed by using a cutting tool brought close to the broach. If a thin piece of paper is placed between the cutting tool and the broach, as the cutter is advanced towards the broach, the paper will be 'pinched' between it and the tool. The cutter will be very close to the broach, just the thickness of the paper away, **Figure 11**.

The reading on the cross slide should be noted, **Figure 12**. On more expensive lathes, the collar showing the graduations can be rotated as it is held in position by friction. This enables the collar to be set to zero to avoid confusion.

It is easy to make a mistake, but to safeguard against error, a narrow strip of masking tape can be attached over the graduations and the zero position marked with a pen, **Figure 13**. The tape can be unfastened and re-positioned during the process of aligning the top slide with the broach. Using this technique will take time, but the tool should give the same amount of 'pinch' with the broach, both near to the brass 'gauge', see **Figure 11**, and when it is 20 mm away, **Figure 14**.

Although we have taken great care to ensure the top slide is set at exactly the correct angle to produce a taper on the post that matches the broached hole, a chance of error remains. Inaccuracy may arise because broaches are not always straight, or the brass 'gauge' may not be held in the three-jaw chuck with the hole absolutely concentric with the axis of the lathe. Once the brass 'gauge' is complete, work can commence to turn the post. A more cautious student might also create a larger 'gauge' made using a bigger section of the broach.

You are now ready to begin turning the post. Use silver steel, 8mm in diameter, held in a four-jaw chuck. This holds the material more securely than a three jaw self-centring chuck, and it will also enable you to easily index the four positions for the square. The chuck jaws will be used in a simple, precise technique to create the flats for the square, **Figure 15**.

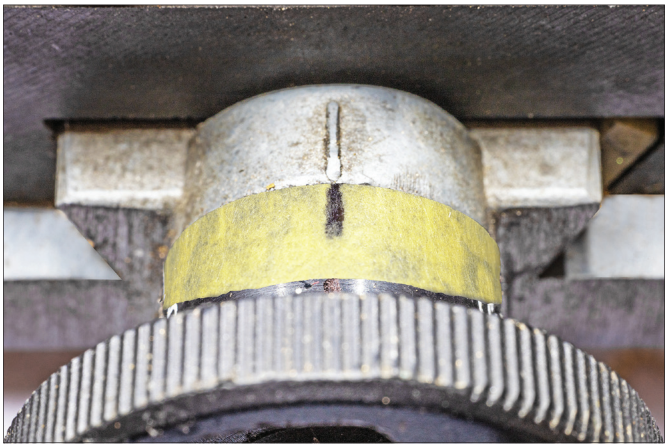

Figure 13. A strip of masking tape can help to avoid mistakes.

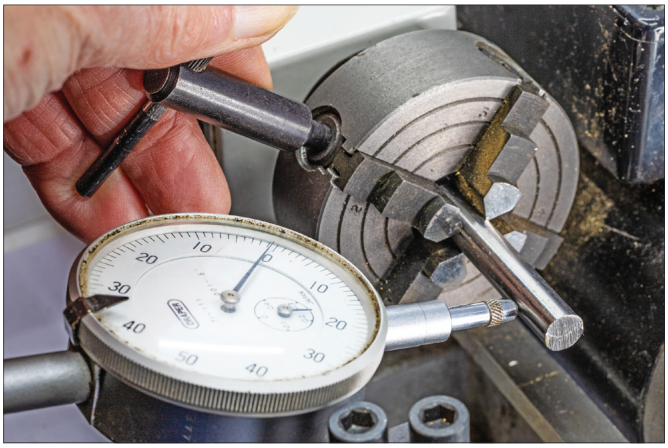

Figure 15. With practice, work can be quickly centred when using a four-jaw chuck. Tighten or loosen opposing jaws to achieve concentricity.

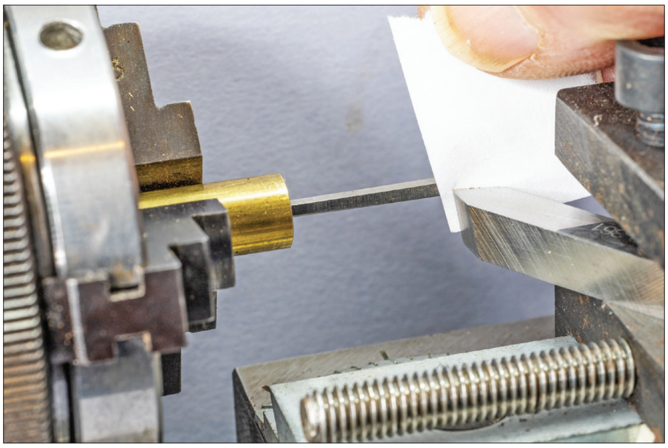

Figure 14. The cutting tool should 'pinch' the paper against the work at any place along the length of the broach.

Figure 16. Always lock the carriage when it is not being moved. This gives greater rigidity.

When fitting the silver steel in the four-jaw chuck, tighten the chuck jaws to hold the steel as centrally as possible with around 35 mm protruding. This may be more material projecting than is desirable, but it will allow the square, the threaded section and a little beyond to be machined without removal from the chuck. The circles on the chuck will help you to initially position your work in the chuck. If the lathe spindle is rotated by hand and a dial indicator used to check concentricity, errors will immediately become apparent. Guided by the readings from the dial indicator, jaws should be tightened, or loosened, to move the work to a more central position.

At the start, compare readings for two opposing chuck jaws and adjust as necessary, then use the other pair of jaws. Continue until the work is close to centre. For the final stage it will only be necessary to loosen one jaw very slightly and tighten the opposite jaw until the material is central. Before starting to turn the post, check the tightness of each jaw.

When you first attempt to use a four-jaw chuck, centralising the material will take some time, but practice makes perfect (assuming you are following a logical approach!). The level of precision that can be achieved is far greater than using a three-jaw chuck and, with practice, accuracy will be reached in two or three minutes.

With the silver steel now held centrally in the four-jaw chuck and the top slide adjusted to the correct taper matching the broach, turning the taper will be routine. The cross slide and the top slide will be used to control the tool to turn the taper: the cross slide determines the depth of cut and the top slide moves the cutting tool along the length of the taper. The carriage should be locked to give greater rigidity, **Figure 16**.

You will be able to achieve a finer finish if you use both hands when using the feed wheel to move the cutter. Instead of just using the handle, which tends to give a jerky movement, use both hands. One hand will start to move the feed wheel and the other should take over to continue a smooth rotation. The original hand can then continue, and so on until the cutter has moved the required distance.

The end of the taper is very slender; it is better to turn from the larger end towards the smaller. Successive cuts will reduce the post to a dimension approaching the diameter of the hole in the 'gauge'. When the post begins to enter a little way into the hole in the 'gauge', start checking whether the taper on the 'gauge' matches the taper on the post – it should fit snugly without wobble.

A better approach to test the taper is to use a felt-tip pen to mark along the length of the taper, **Figure 17**. If the 'gauge' is fitted firmly on to the taper and twisted, you'll be able to see the points where the gauge touches the taper as they are smudged. Engineers' blue, a blue grease used for checking 'high spots', is an alternative, but not marking out fluid.

If you proceed cautiously, the emerging taper can be corrected by slightly altering the angle of the cross slide. The correction will be tiny, and a dial indicator can be used to help

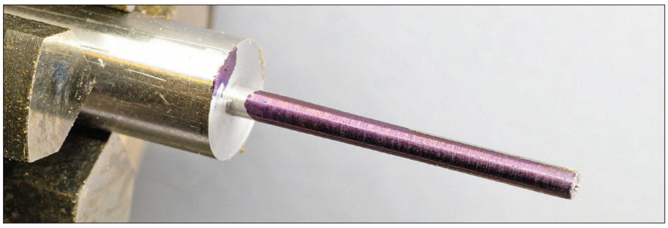

Figure 17. To check, a felt tip marker is used along the taper.

make precise changes. Alternatively, try using the technique with a piece of paper, as described in **Figure 14**. Bring the tool towards the taper until the paper is held firmly, remove the paper and adjust the angle of the top slide until the tool just touches the taper you are machining. The object is to create a long taper on the steel, which perfectly matches the taper in the hole of the 'gauge'.

For the final check, a felt tip marker can be used along the taper, **Figure 17**, and the 'gauge' fitted on to the taper and turned backwards and forwards, **Figure 18**. The mark from the felt tip will be rubbed away where the 'gauge' touches the taper. When the 'gauge' is removed, there should be bright patches along the full length of the taper, **Figure 19**.

Filing the Square

A watchmaker's lathe generally has a series of small holes drilled into the end of the pulley, and a small detent engages these holes to provide a simple arrangement for indexing. A dividing attachment is available for the Unimat lathe. It will aid the construction of this exercise, but the range of numbers is not particularly useful for clockmaking: 24, 30, 36 and 40.

It is possible to improvise. Two short pieces of wood can be placed between the lathe bed and the jaws of the four-jaw chuck, **Figure 20**. The length of the wood is not critical, but the chuck jaws should be approximately horizontal. To ensure each position can be precisely repeated, first locate the piece of wood between the jaw at the back of the lathe and the flat part of the bed. To avoid a mistake, this piece of wood is marked. The wood at the front can then be inserted at a slight angle and gently pushed to an upright position to hold the chuck firmly. If necessary, a small piece of cardboard can be fitted between the bed and the wood to ensure it is absolutely tight.

A double roller filing rest simplifies accurate filing to make the square but, again, it is easy to improvise. A piece of silver steel held in the tool post provides support for the file,

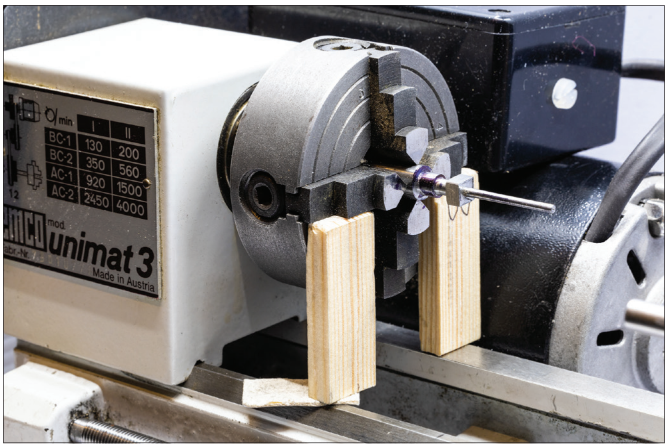

Figure 20. Two pieces of wood can be used to index the chuck to four positions.

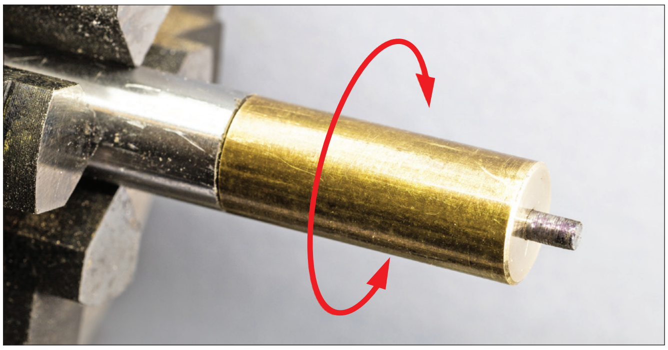

Figure 18. The gear is turned backwards and forwards on the tapered post.

Figure 19. The felt tip is rubbed away at points along the length of the taper.

Figure 21. This approach could be improved by fitting a roller on the rest, but, to prevent the file cutting the silver steel, it is sufficient to attach masking tape to the underside of the file. The masking tape rubs against the silver steel.

In use, firm downwards pressure is applied between the work and the silver steel while the file is moved backwards and forwards, **Figure 22**. The file must always be kept in constant contact with the silver steel.

The technique is clear, but there are still little details to consider, and a close look at **Figure 21** reveals the section of the post between the taper and the chuck has been modified:

A. The part that will be threaded has been turned to the outside diameter for a 5BA thread. This shoulder determines the thickness of the square, 3.6mm, and reduces the amount of filing required.

B. There is another, larger portion that has been turned to Ø 5.4 mm, the distance of the square across flats. This will act as a guide to show when the filing of each flat is complete – the file will touch and mark this surface.

C. Close to the chuck, the steel is Ø 8 mm, the original diameter. The small shoulder prevents the file rubbing against the hardened jaws of the chuck.

D. The diameter of the part to be filed has been reduced from 8 mm to 7.7 mm, the diameter of a 5.4 mm square.

The turning of these diameters can be undertaken using the parting tool set at a slight angle to the work. The dimensions are shown in **Figure 23**. Filing the square is a slow process, but with patience and care, a precise result can be achieved. Always ensure the file is pressed down firmly at a point between the work and the silver steel held in the tool post. If the masking tape begins to wear, it should be replaced. The tolerance for this exercise is ± 0.1 mm. Ensure there is an allowance for polishing and check dimensions frequently using a micrometer. At this stage, the square should measure 5.55 mm across flats, **Figure 24**, and this distance should be equal in both directions. Select which flat should be filed to correct any errors.

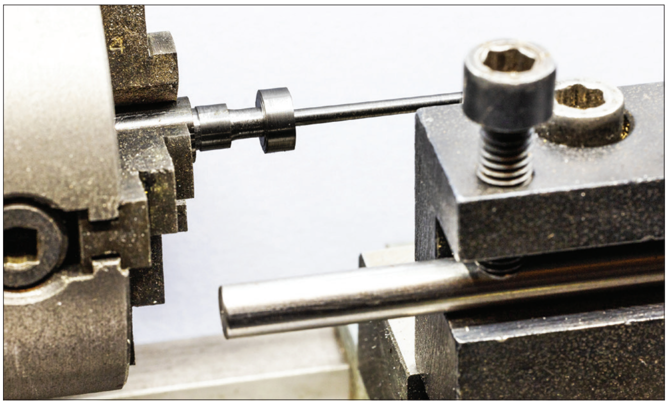

Figure 21. A piece of silver steel held in the tool post is a substitute for a double fining rest.

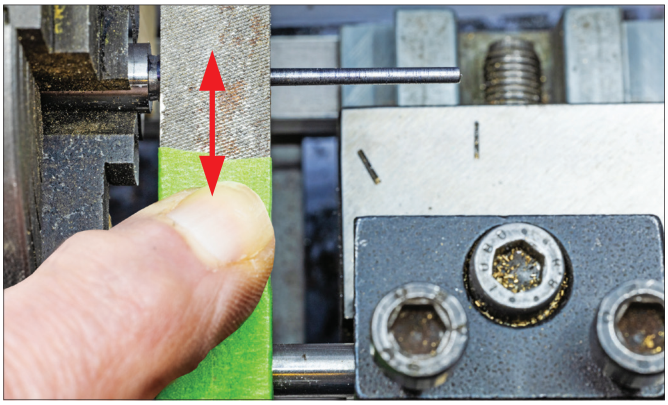

Figure 22. The file bridges from the work piece to a piece of silver steel held in the tool post.

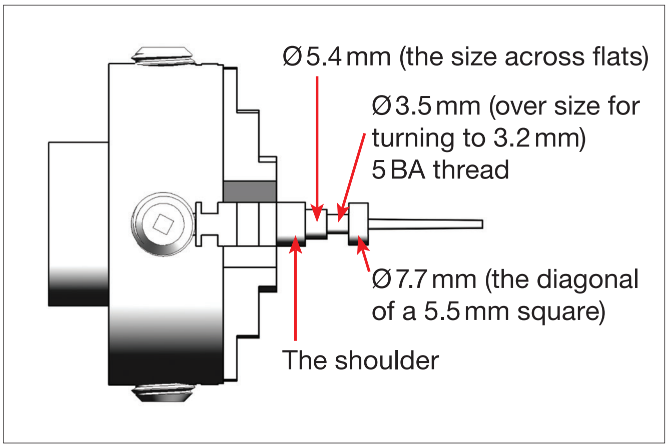

Figure 23. The dimensions before filing.

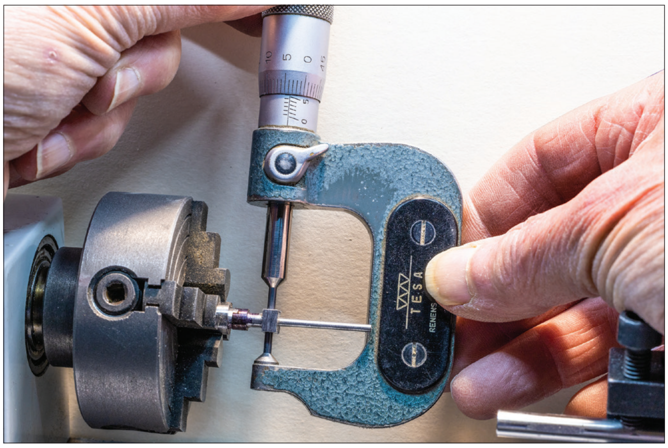

Figure 24. Measure the distance across flats in both directions and check whether the flats meet at the corners.

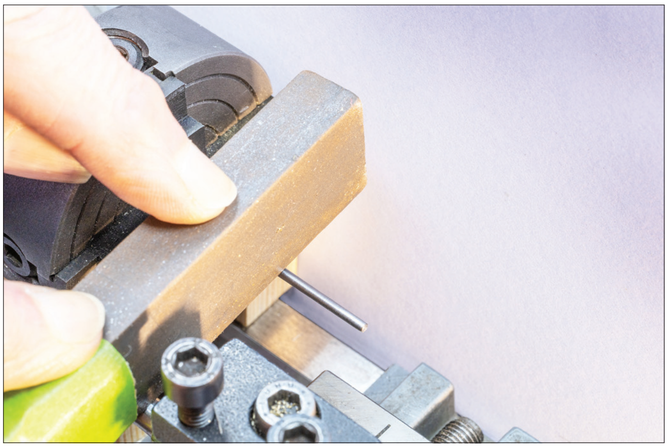

Figure 25. Ensure the oilstone is pressed firmly against the square and the silver steel held in the tool post.

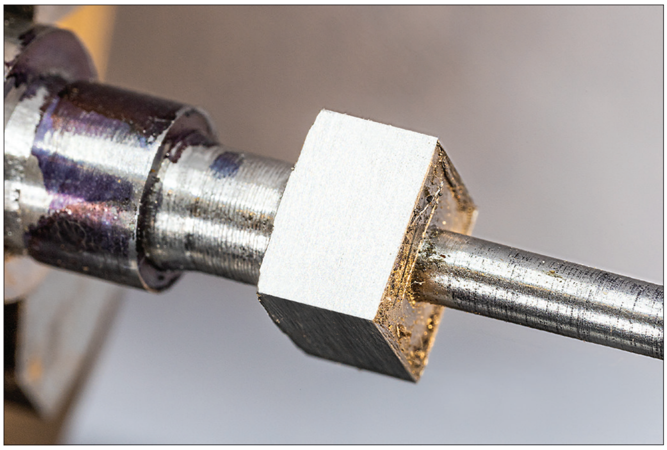

Figure 26. Burrs may remain, but the square is almost finished.

Once the filing is complete, an oilstone can be used to improve the finish. Use a similar technique with the filing rest: place the oilstone against the silver steel in the tool post and the work to ensure the oilstone is flat against each of the facets of the square, **Figure 25**. If the indexing is accurate, very little material need be removed from the square to leave a smooth finish, **Figure 26**. The square now requires a little further finishing.

Next Issue
In the June edition of the *HJ* there will be guidance for the last stages in making the arbor for the Technician Grade examination.