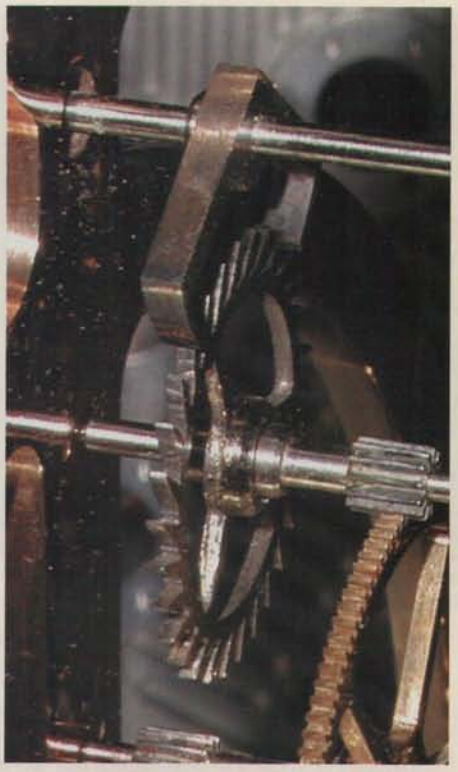

*A view of the tungsten carbide escapement of the Author's Ferris wheel clock.*

# A FERRIS WHEEL CLOCK

**Richard Stephen**

**makes a start on the escapement and describes a simple depthing tool and drilling jig.**

●*Part II continued from page 178 (M.E. 4166, 5 April 2002)*

The usual method of drilling pivot holes in clock plates is to mark the position of the hole using the scriber point on the depthing tool and a punch positioned by eye. The pivot hole is then drilled on a drill press holding the plate by hand. This method works perfectly well with large module wheels where there is considerable latitude in the depthing. This technique is simply not adequate for this clock since errors in the positions of the pivot holes will lead to increased engaging friction in the train and the likelihood of the clock not running properly.

I used my Wabeco mill with a digital readout and the centring microscope for precise drilling of pivot holes. If you do not have similar equipment you will need to make the combined depthing tool and drilling jig to drill your pivot holes sufficiently accurately. The tool shown in **fig 1** (see Part I, *M.E.* 4166, 5 April 2002) is a modification of the one described by John Wilding. The one I made for myself is only a depthing tool version. I find the screw adjustment very handy. The construction of the tool should present few problems. The drilling guides and runners for the depthing tool are illustrated in **fig 3**, here.

The drilling guides need to be securely fixed in the depthing tool; it is worth drilling a shallow 3mm hole in the side of each guide for the locking screw. These should be made from silver-steel, hardened and polished. The one 10mm guide with a 3mm hole has a 2mm grub screw to secure a 3mm runner. Access to this grub screw when the guide is fixed in place is through a 3mm hole drilled through the side of the depthing tool as illustrated. You will need several sizes of drill guides and these can be made as and when required.

## Escapement

We will begin the project by first making the escapement. This is possibly the part of the clock that most readers will find the most difficult to make. Once you have the escapement working satisfactorily the remainder of the clock is reasonably straight sailing.

The construction of a dead beat escapement has been discussed in numerous books on horology. Nevertheless, I would like to present the method I have developed over a number of years for making a dead beat escapement, which is rather different from any other method I have seen. In addition, it uses modern materials not generally employed in horology. The nibs are made of tungsten carbide. My friend, Peter Bradley, introduced me to tungsten carbide nibs several years ago. He had been using this material for his escapements for many years.

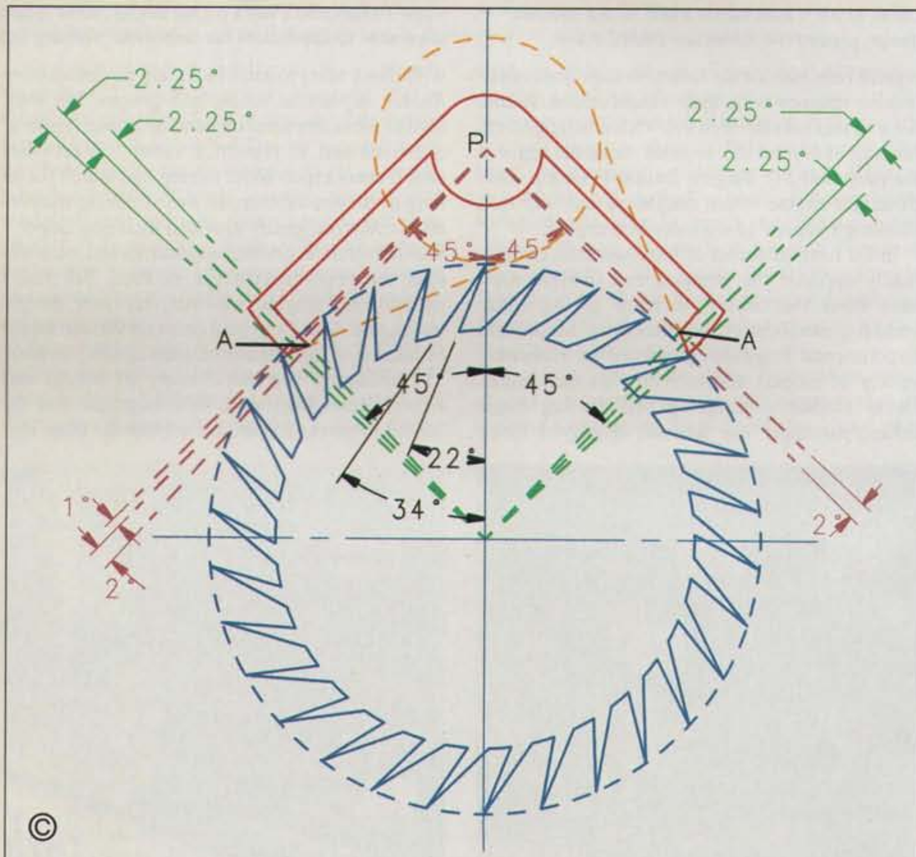


**Fig 2: To construct the escapement**

Draw a circle five times the diameter of the escape wheel, whose actual size will be 25mm diameter. Draw a vertical line through the centre of the circle and extend it upwards. With a protractor mark off lines at 45deg. each side of this vertical line. These lines will pass through the centre of the impulse faces of the pallets. Draw tangents to the circle at the points where the radial lines cut it. The intersection of these tangents on the vertical centre line will mark the centre for the pallet staff. The width of each pallet is equal to half the distance between one tooth and the next less 1deg. drop and 1/2deg. for the tip of the tooth, so set off 2 1/4deg. on each side of the radial lines i.e. 4 1/2deg. for the total width of each pallet. Now, from the pallet centre strike arcs that just touch the four radial lines. These form the circular locking faces and the backs of the pallets.

To form the left or outside impulse face, set off the pallet centre an angle of 1deg. inwards from the left tangential line. The point of intersection of this line with the outer arc is the locking corner. Now set off a further angle of 2 degrees. The point of intersection with the inner arc is the other corner. Join up these two points and thus complete the outside, impulse plane; strike a circle from the pallet centre tangential to an extension of this plane.

To form the right impulse plane, draw a line making an angle of 2deg. outwards from the tangent to the wheel circle. The point of intersection of this line with the inner of the two arcs is the locking corner. The exit corner is the point of intersection of the outer arc with the tangent to the wheel circle. Join up these two points to complete the impulse plane and extend the line. If the drawing is accurate both impulse plane extensions will be tangential to the same circle.

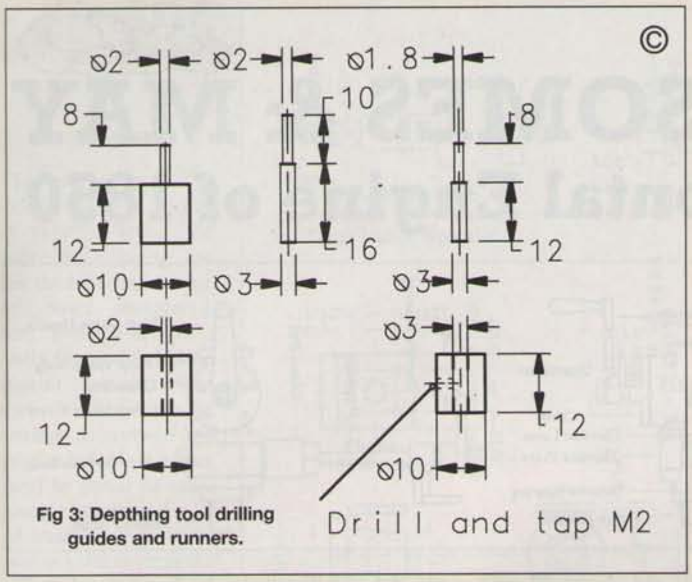

Fig 3: Depthing tool drilling guides and runners.

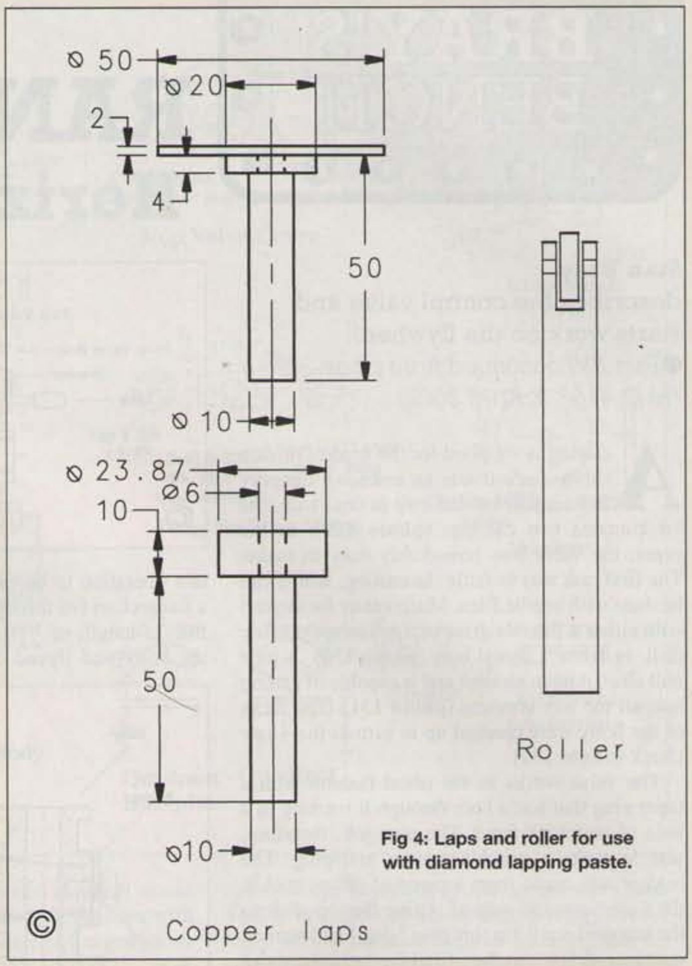

Fig 4: Laps and roller for use with diamond lapping paste.

In our opinion tungsten carbide is the ideal material, it is exceedingly hard wearing, very strong, takes a high polish and can be silver-soldered to the ends of the pallet arms.

A possible reason why tungsten carbide has not been more widely used is that many horologists and model engineers may be under the impression that it is almost impossible to work the material. This is simply not the case. Diamond tooling and abrasives are now widely available at very affordable prices allowing tungsten carbide to be worked with little difficulty.

Illustrated in **fig 2** is the theoretical diagram of a dead beat escapement with pallets spanning 7.5 teeth of a 30 tooth escape wheel. Before proceeding any further, a careful drawing of the escapement should be made on a sheet of stiff white paper at least 5 times the size of the final escapement. The procedure for making a drawing of a dead beat escapement is given in many books; the description in *Watch and Clockmaker's Handbook* by F. J. Britten (Baron Publications Ltd.) is as good as any. Alternatively you could enlarge the drawing in *Clock and Watch Escapements* by W. J. Gazeley to 3 times its size using a photocopier. Make a few copies of the drawing while you are about it, as they soon become unusable after exposure to the workshop!

The drawing will be valuable for checking measurements and angles. The lengths of the pallet arms can be measured or calculated from **fig 2** which includes details of how to construct this drawing. Referring to the figure, if R is the radius of the escape wheel and d the width of the nib, then the total length of the pallet arm, PA, is given by:

$PA = R - (d / 2)$

The space between each tooth for a 30 tooth escape wheel subtends an angle of 22deg. at the centre of the wheel. If a drop of 0.50deg. is allowed then each nib subtends an angle of 5.50deg. at the centre of the escape wheel. Expressing this angle in radians, the width of the nib is given approximately by:

Nib width = 0.096R.

Using this value for the nib width gives the length of the pallet arm PA as:

$PA = R ( 1 - 0.048 ) = 0.95 R$

## Diamond abrasives

If you do not have a diamond saw and diamond abrasive pastes, you will need to purchase these. Readers, I suspect, will have visions of these items costing a great deal of money. A small diamond saw can be purchased from Shesto Ltd. for about £10. Diamond pastes can be purchased from Marcon, most lapidary suppliers, or J&L.

The pastes are available in grit sizes from 50 micron down to 0.5 micron in 1 gram tubes costing about £10 per tube. A 1 gram tube lasts a very long time as very little is needed to charge the small copper laps needed to grind the nibs.

Many readers may be wary about using diamond abrasives on their lathes. With a little care and using plenty of paper towelling to cover sensitive parts of the machine, grinding on the lathe, or any other machine, with diamond abrasives will cause no more problems than polishing with wet and dry silicon carbide paper.

Before commencing the construction of the escapement, it is necessary to make copper laps for rough grinding and polishing the nibs. The dimensions of the laps are shown in **fig 4**. Their shanks are made from mild steel and their construction should present no problems. The surfaces, which will later be charged with diamond, should be absolutely true and as smooth as possible as this makes charging the surface easier and wastes least diamond paste.

The roller I use for pressing the diamond grit into the copper surface is also shown in fig 4. The roller disc is made from glass hard carbon steel, 15mm in diameter and 3mm thick. The arbor is also made from carbon steel and glass hardened. To charge a lap, smear a small quantity of diamond paste over the surface of the lap with your finger. Run the roller all over the surface applying very firm pressure. Some of the paste will collect on the edges of the roller. Carefully scrape this off and apply again to the lap and re-roll the surface.

The cylindrical laps are best charged on the lathe. Smear the paste over the surface; firmly pressing the roller against the lap, rotate the spindle by hand. Any paste accumulating on the edges of the lap or the roller is again smeared on the lap and the surface re-rolled. Use a different roller for each grade of diamond paste to avoid contaminating the lap surface, and don't forget to clearly mark each lap with the grit size used.

Marcon Diamond Ltd. and lapidary suppliers also stock diamond lapping sheet which is available in a variety of grit sizes. This is the same material used in commercial diamond hones; the only difference is the price: the lapping sheet costs about £1 per square inch. It can be stuck to a suitable backing using Superglue.

## Preparing the tungsten carbide blanks for the nibs

We are now in a position to begin making the escapement. The diameter of the escape wheel will be 25mm and the pallets span 7.5 teeth.

We begin by partly making the pallets. The first things to make are the nibs. For these you will need two pieces of tungsten carbide 2.5mm thick approximately 6mm long and about 2.5mm wide. A useful source of tungsten carbide is new or used (cheaper) replaceable lathe tool bits. To hold the tungsten carbide bit for sawing, silver-solder it to the end of a scrap of 3mm (1/8in.) brass sheet the same width as the tool bit and approximately 100mm (4in.) long.

Hold the piece of brass in a vice mounted on the vertical slide. Spray the lathe bed and slides liberally with WD 40 and cover everything with kitchen paper. The diamond saw must be kept well lubricated; use water to which a good squirt of washing-up liquid has been added. The water can be applied either with a small mop brush or dribbled on to the saw blade using a squeeze bottle. The kitchen paper will absorb most of the water and the WD 40 will prevent any excess getting into the lathe. The best speed for the saw is about 1500rpm and not the high speeds often recommended for diamond sawing. Use a very slow feed and light pressure and your saw blade will last a long time.

Haste will only ruin the blade.

● *To be continued.*