A FERRIS WHEEL CLOCK

Richard Stephen

finishes the escape wheel and starts on the frames.

●*Part IV*

continued from page 398 (M.E. 4170, 31 May 2002)

The escape wheel should be crossed out at this stage. Titanium is quite easy to cut with a fine piercing saw, and to file, provided again one takes it slowly. The rim of the wheel can be made about 1.5mm thick, or less, with no danger of the wheel being too fragile. By now you will have discovered just how strong and rigid titanium is. You must finish the crossing out at this stage, including burnishing the spokes and the inside of the rim. The sides of the wheel can also be finished and polished. The wheel collet should also be made.

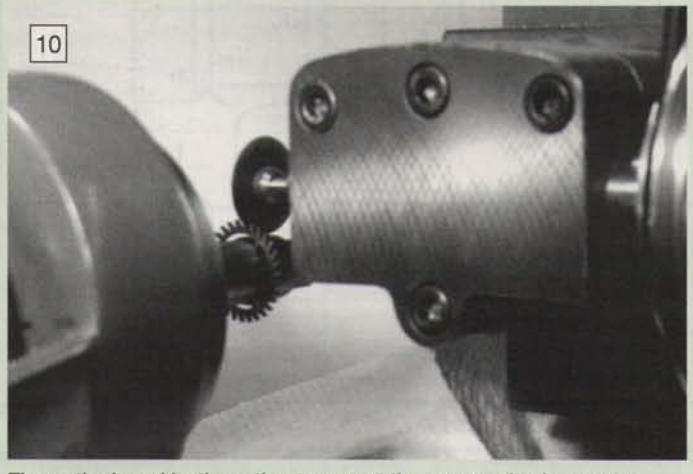
If you can find a scrap of 8mm titanium rod, use this for the collet, as any way of reducing the weight of the wheel will improve the escapement action. Fix the collet to the wheel with Loctite High Strength Retainer. Fix the wheel to a short length of 2mm rod (about 30mm long and perfectly true) using Loctite Screwlock. The wheel can then be removed easily at a later stage by heating the rod to break the joint.

Grinding the front faces of the escape wheel teeth

Fly-cutting the teeth of an escape wheel, whether the wheel is made of hard brass or, as in this instance titanium, produces some distortion of the teeth. In my experience it is almost impossible to prevent this distortion from occurring. The consequence of this distortion is that the spacing between successive teeth of the wheel is not exactly constant. Setting up the escapement then becomes a problem since in some positions of the wheel the escapement will hang up, in others the drop may be excessive, and in the rest it will be just right.

I like to have a maximum drop of no more than about 0.1deg., which translates to a clearance between the pallets and the escape wheel teeth of about 0.01mm. I have never been able to fly-cut an escape wheel to give me this degree of accuracy in my escapements. To achieve this degree of precision, the teeth of the escape wheel need to trued up. **Photograph 10** illustrates the set-up I use. Replace the fly cutter with a carborundum dental cutting disc. These carborundum cutting discs are readily available from dental equipment suppliers for which addresses and telephone numbers of a local supplier can be found in *Yellow Pages*. Alternatively, you can get them from Proops Bros. in the UK (see Part I, *M.E.* 4166, 5 April 2002).

A view of the Author's prototype Ferris Wheel Clock, showing the column of driving balls being lifted to re-enter the Ferris wheel and so drive the mechanism. The three frame members which hold the clock together are also apparent and are described in this article.



The method used by the author to correct the escape wheel geometry by means of a small carborundum cutting disc.

These cutting discs seem to work equally well on brass or titanium and, having many uses in the workshop, are quite invaluable. Return the escape wheel on its arbor to the set up used to fly-cut the teeth. Using a dial gauge, you must check that the arbor is running absolutely true. The escape wheel should first be ground true on its arbor. The crossing out, filing and burnishing may have slightly distorted the wheel. The diameter of the wheel also needs to be reduced to precisely 25mm. Bring the carborundum disc up to the tip of one tooth. Disengage the dividing or indexing attachment so allowing the lathe spindle to rotate freely. With the grinding disc rotating as fast as possible, rotate the escape wheel against the grinding disc. Reduce the diameter to exactly 25 millimetres. Re-engage the dividing or indexing attachment. Adjust the position of the wheel and the grinding disc so that the front face of a tooth is parallel to the face of the grinding disc. Bring the side of the disc up to the tooth face and grind approximately 0.02mm from the first tooth. Lock the disc in this position and grind all the front faces at this setting. Do not try to grind off too much at one time.

As you index the wheel around you will be aware that you are grinding more material off some teeth than others. The backs of the teeth now need to ground to reduce them to their final size. When finished, the witness should be about 0.15 millimetres. Because titanium is so much stronger than brass it is possible to make the witness much less than one would with a brass wheel.

It now time to begin setting up the escapement; the escape wheel will be matched exactly to the pallets and the pallet nibs ground to suit.

Fitting the escape wheel to the pallets

The drawing of the escapement, **fig 11a**, illustrates a tooth of the escape wheel having just dropped onto the left hand locking pallet face. The eighth tooth, counting clockwise around the escape wheel, has also just dropped off the right hand impulse pallet face. To understand the fitting procedure we need to consider the situation when an escape wheel tooth has dropped off the left hand impulse face and the eighth tooth clockwise around the escape wheel has dropped onto the right hand locking face of the pallets. This situation is shown in **fig 11b**.

To fit the escape wheel and pallets you will need the depthing tool made earlier. The advantage of this type of

depthing tool is that it allows detailed examination of the engagement of the escape wheel and the pallets. This is not possible using the conventional type of depthing tool. Fit the 10mm runner with a 2mm hole and the 3mm runner with the 2mm extension in the depthing tool. Place the pallets on the 2mm shaft and the escape wheel on its arbor in the 10mm runner. Using the screw adjustment on the depthing tool set the distance between the escape wheel and the pallets to correspond exactly to the position shown in fig 11b. Make the visible clearance between the tip of the escape wheel tooth and the right hand locking face (the drop) as small as possible. Likewise, the internal curved face of the left hand nib should *just* clear the back of the relevant tooth.

Rotate the escape wheel one tooth clockwise so that the next tooth has 'dropped' onto the locking face of the left hand nib. You will see that the external face of the right hand nib extends a little beyond the tip of the tooth of the escape wheel. This tooth had previously 'dropped' onto the locking face of the right hand nib. This is because earlier we did not reduce the width of the nibs sufficiently. Now is the time to reduce the width of the nibs. Grind down the external faces of the nibs, constantly checking the pallets against the escape wheel. The clearance at the external nib faces should be the same as that at the internal faces. It is better that the clearances are too tight, as these can be adjusted once the impulse or lifting faces are ground.

Grinding the impulse faces

The same set up as was used to grind the external faces of the nibs is used to grind the impulse faces. Position the centre of the 2mm peg in line with the grinding face of the lap. Advance the 2mm peg past the grinding face (i.e. towards the headstock) by the radius of the impulse circle of the pallets. For this escapement the radius of the impulse circle is 4mm. Simply hold the nib firmly against the lap and grind the first impulse face. To grind the second impulse face, retract the 2mm peg 4mm past the grinding face (i.e. towards the tailstock). Again simply hold the nib firmly against the lap and grind the second impulse face.

A constant check must be kept while grinding the impulse faces, by trying the pallets with the escape wheel. The impulse faces will have been ground back enough when a tooth sliding up an impulse face and just at the point of dropping off the nib, allows the tip of the opposite nib to just about clear the back of the relevant tooth. At this stage the pallets should just 'hang up'.

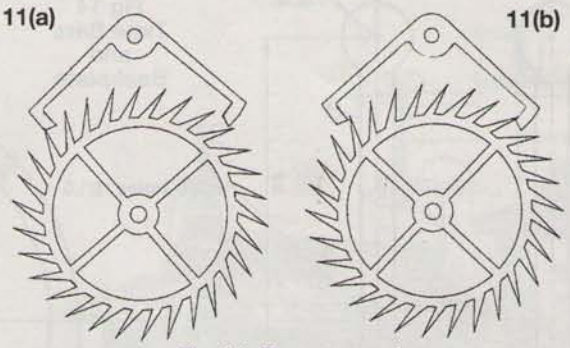


Fig 11. Escapement

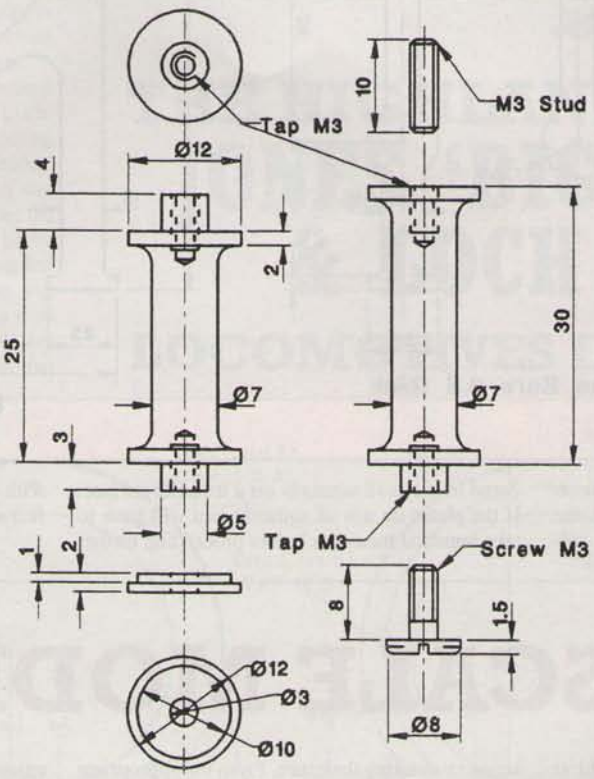


Fig 12. Brass Pillars, Washers, Steel Screws

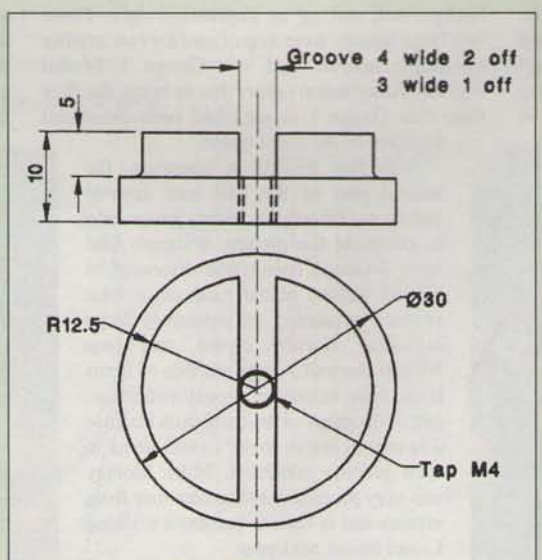


Fig 13. Brass Feet

The final adjustments are made using a 6 micron lap. Lap the external circular faces of the nibs and the impulse faces, constantly testing the escapement to see if it releases. It may also be necessary to adjust the separation between the arbors. If you find that the 'hang up' is caused by the internal edge of the left impulse face or the external edge of the right hand impulse face catching against the back of the teeth, then correct this by carefully lapping these sharp edges. This generally cures the problem and you will suddenly find that the escapement releases and 'works'. Finally, polish the faces with a 1 micron lap.

With care you should be able to produce an escapement with the absolute minimum of drop. Measure the spacing between the arbors using a micrometer and note it down.

Plates

Now that the escapement is made and working, a start can be made on the rest of the clock. The drawings for the back plate and the two time bars of the clock frame are given in **fig 14**. For the back plate you require a piece of CZ120 brass sheet 200 x 300mm, 4mm thick. For the middle and front time bars you require a piece of CZ120 brass sheet 300 x 100mm, 3.5mm thick. I cut out my plate and time bars using my Wabeco CNC milling machine which did a super job leaving me with little finishing work to do on the edges. How you cut out the plates will depend on the equipment you have available.

After cutting out the plate and time bars, the holes for the pillars should be drilled and reamed. Align the back plate and the two time bars and clamp them together. Drill and ream the first pillar hole. Fit one of the register pegs into the hole. Now drill and ream the hole for the second pillar.

Pillars

You will require a 180mm length of 12mm brass rod to make the four pillars. In addition you will need two 20mm lengths of 3mm (or the nearest BA equivalent, eg. 6BA) brass threaded rod. If you have no threaded rod, either make some or cut down a couple of screws of suitable length.

The dimensions of the pillars are given in **fig 12**. The rear ends of the two front pillars are tapped 3mm and a length of threaded rod inserted and secured with Loctite High Strength Retainer. Alternatively, you could thread the end of the pillar. I prefer to insert a length of threaded rod as this produces a perfectly square shoulder and allows the pillar to pull up squarely onto the middle plate.

The four pillar screws and the four brass washers should also be made. These are also shown in fig 12. The screws are made of ▶

8mm diameter EN1A (mild steel) rod. You could use any other mild steel, however you will find that EN1A threads a lot better than any other mild steel. The slots in the heads of the screws are best cut in the milling machine using a slitting saw of the appropriate thickness. Ensure that you cut the slots absolutely centrally as off-centre slots look awful.

The dimensions of the three feet for the plates are shown in **fig 13**. The feet are silver-soldered to the plates. If you have any, silver-solder shim is the easiest material to use here. If you have no shim, then hammer flat a length of silver-solder wire. Assemble the plates and pillars. Check that the assembled plates sit squarely when placed on a true flat surface. Cut off three lengths of silver-solder shim sufficient to cover the bottom of the grooves milled in the feet. Liberally apply flux and insert the plates into the grooves of the three feet. Place on a flat fireproof surface. Heat each foot until the solder flows. You may have to apply a little extra solder if necessary. Leave in position and allow to cool. Clean off any excess solder with a fine file and finish with wet and dry paper. Again check that the assembled plates with their feet now silver-soldered in place sit squarely on a true flat surface. If the plates do not sit squarely you will have to take remedial measures before proceeding further with the construction. The screw threads in the feet may have to be cleaned out with a tap.

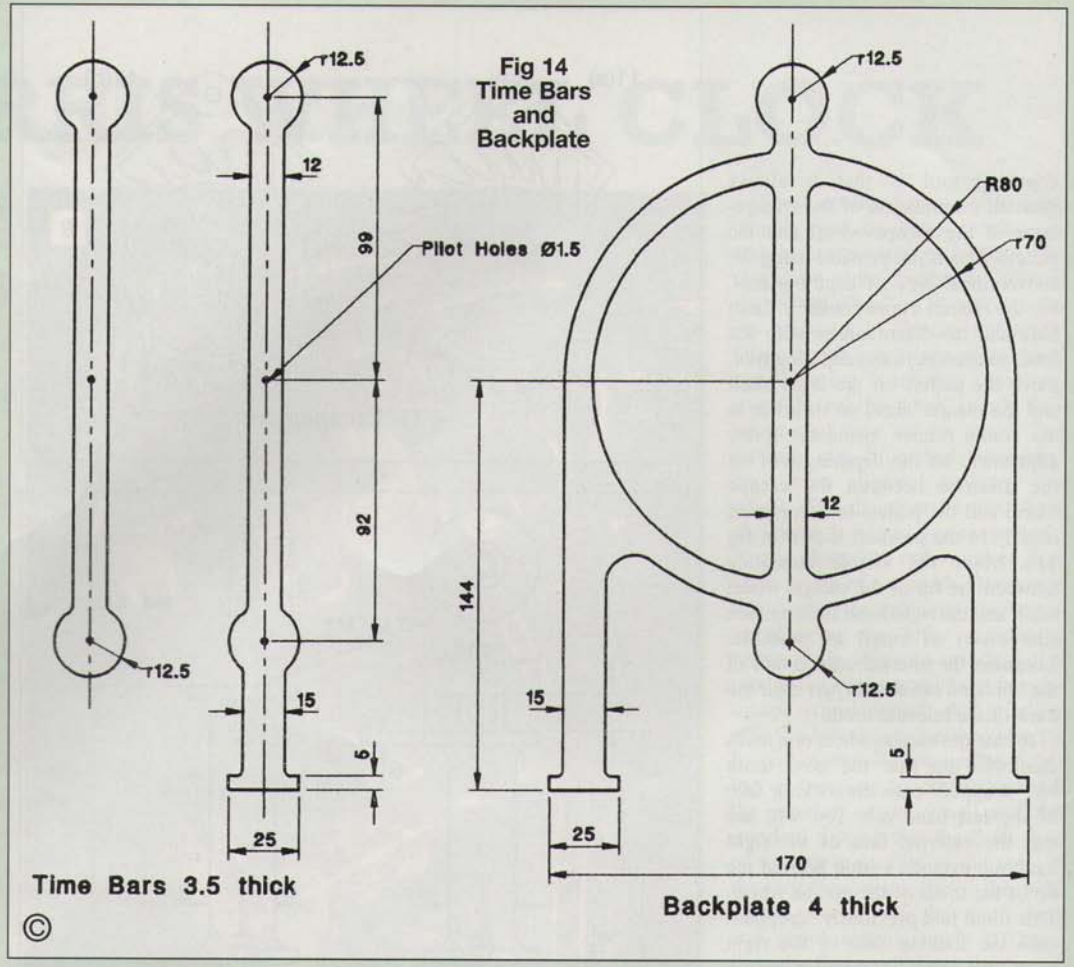


Fig 14
Time Bars
and
Backplate

●*To be continued.*