A FERRIS WHEEL CLOCK

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completes the construction of the Ferris wheel and moves on to describe the assembly of the train.

●*Part VI continued from page 74 (M.E. 4174, 26 July 2002)*

The details of the spacers for the Ferris wheel are illustrated here in **fig 17**. The arbor for the wheel is also shown. Constructing these should present no problems. The arbor is made of brass with a 5mm steel central shaft. As the wheel runs on ball races there is no need for the pivots to be hardened. The fit of the pivots in the ball races should be similar to the fit one would aim at for any other clock pivot: the pivot should drop easily into the ball race.

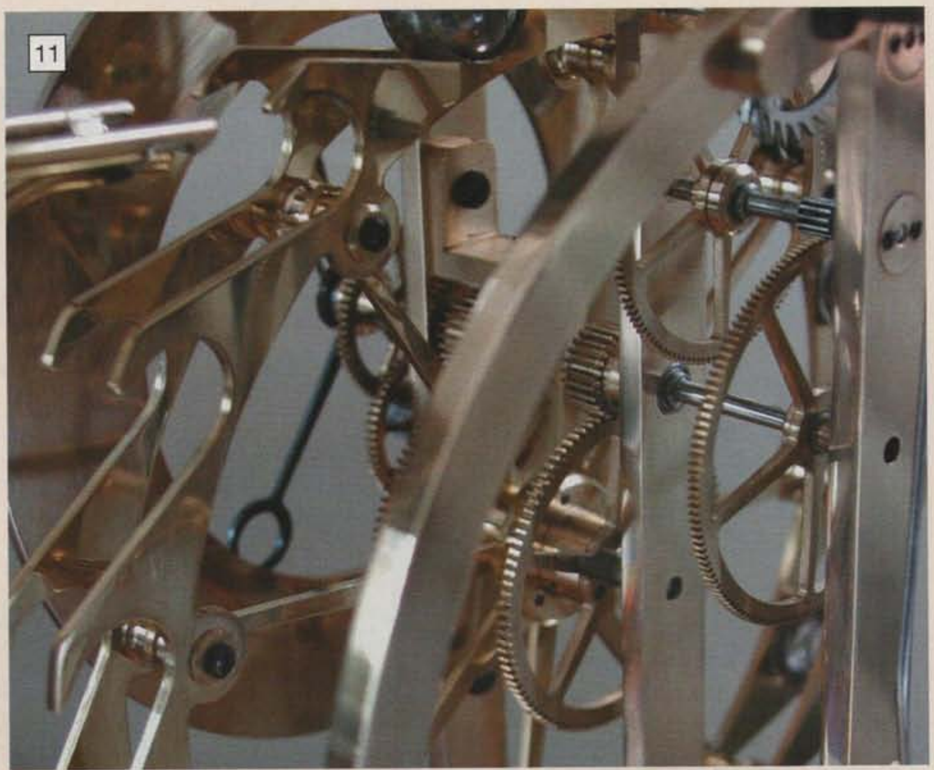
To complete the wheel, the spokes are attached to the flange on the arbor with three 2mm dia. screws positioned as illustrated in fig 17. The two drive wheels are also attached to the arbor using three 1.6mm dia. countersunk screws. **Figure 18** illustrates the countersink which I use to ensure that all the screw heads are countersunk to exactly the same depth. Nothing looks worse on a clock than badly fitting countersunk screws. The countersink is no more than a 2mm dia. 90deg. spade drill fitted with a collar to limit the depth of cut. If a suitable drill is not to hand, making one only takes a few minutes.

Cut off a 40mm length of 3mm dia. silver-steel rod. Face off both ends and reduce one end to 2mm dia. for 10mm length. File about 5mm on two sides to leave a thickness of about 1mm and form the cutting edges as shown in fig 18. To harden the countersink I find it best to grip the shank in the chuck of a cordless drill and, with the drill running, heat the end to a cherry red and quench in cold water. Temper to a pale straw colour and sharpen the cutting edges on an oilstone having bevelled the point of the drill as illustrated.

The collar is best made of brass. Drill a 2mm dia. hole about 10mm deep in a piece of 3mm brass rod and part off the section of tube. Slip it over the drill. About 0.5mm of the shank of the drill should extend beyond the end of the collar. Secure the collar in place with Loctite high strength retainer.

Counterbores

The Ferris wheel and centre wheel both run on ball races, and the remaining wheels on aluminium bronze bushes fitted with end caps. The plates require counterboring for both the ball races and the end caps. The diameter of the counterbores for the ball races and the end caps are 7mm and 8mm respectively. If you have no suitable counterbores, you may choose to make them; details of the 8mm dia. counterbore are shown in fig 18.



This view shows some of the constructional details of the Ferris wheel clock and the arrangement of the train. Note the method of attachment of the Ferris wheel cages to the spoked support member.

The 7mm dia. counterbore is the same except for the diameter of the cutter. Cut a 70mm length from a piece of 8mm dia. silver-steel. Reduce a 50mm length to 6mm dia. to make the shank of the tool. Face the other end and drill and ream a 3mm dia. hole to a depth of 12mm for the guide pin. Using a hacksaw, cut away the material on either side of the 3mm hole down to a depth of about 8mm to form the cutting blade. Finish off the sides with a file. The blade should finish at about 2mm thickness. Form the cutting edges using a file; final sharpening being done after the counterbore is hardened and tempered. Hardening can be carried out in the manner described for the countersinks above. Harden and temper a piece of 3mm dia. silver-steel rod for the guide pin which should be long enough to protrude about 4mm beyond the cutting edge when in place. The guide pin needs to be removable so that the bore can be re-sharpened at a later date. The 7mm bore should also be made now.

The cutting edges are best sharped on a tool and cutter grinder. If you have no access to such a machine you can do so by hand but be careful to ensure that both cutting edges are the same height.

Assembling the train

With all the wheels and pinions now made, a start can be made on assembling the train (**fig 19**). Begin with the Ferris wheel which runs between the two time bars. Clamp the two time bars together with the register pegs in the pillar holes. Locate the centre of the middle time bar and drill and ream a 3mm hole through both bars. At this point it is worth clearly marking the two outside

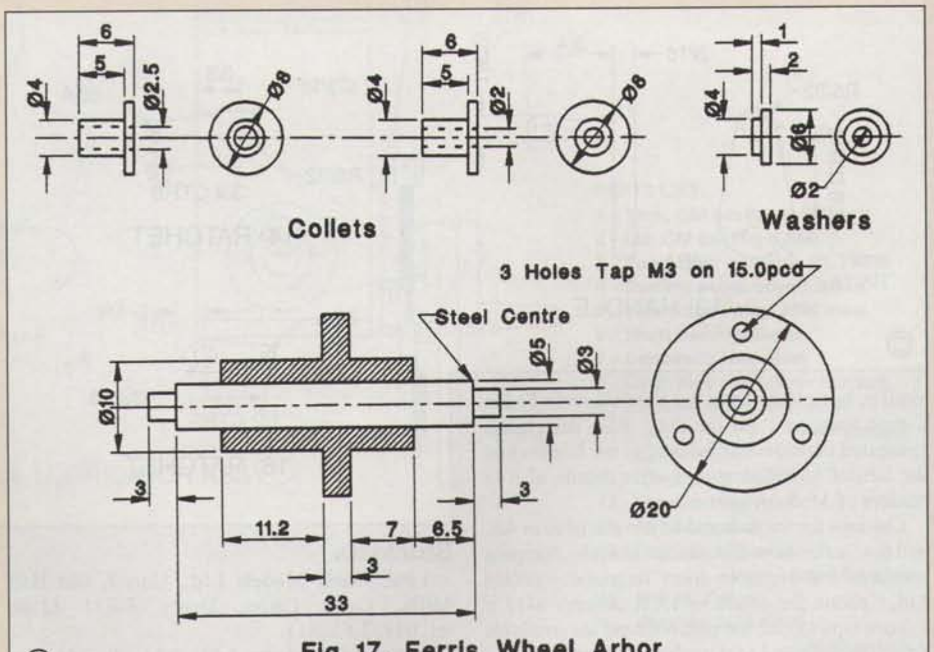


 Fig 17. Ferris Wheel Arbor

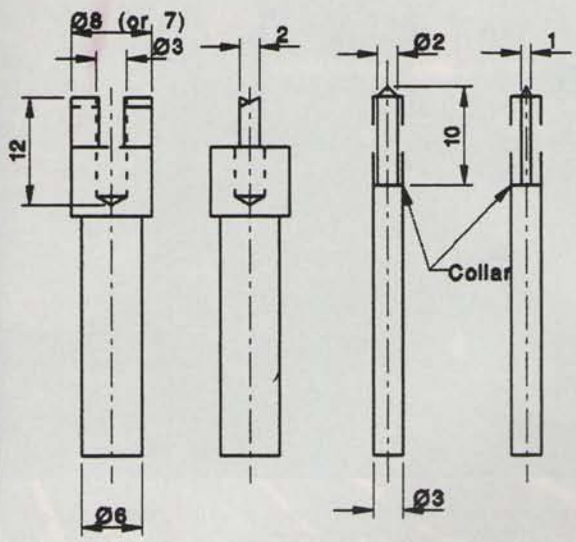


Fig 18. Counterbore Countersink

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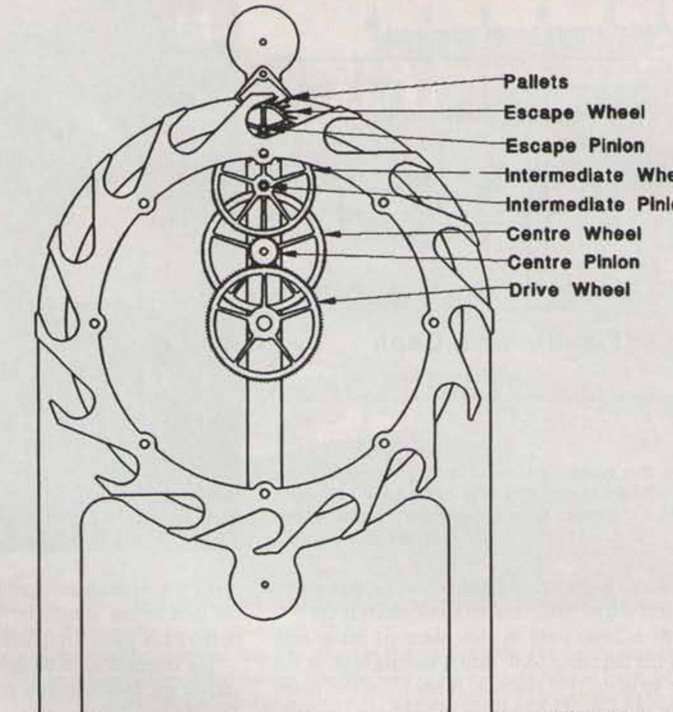

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Fig 19.

faces of the two time bars. It is remarkably easy to get the two faces confused and to subsequently make a mistake. The ball races can now be fitted.

Before using your 7mm counterbore on the job, it is worth checking that it cuts a hole which is concentric with the 3mm pilot hole. Drill and ream a 3mm hole in a scrap of 4mm brass sheet. Now drill a hole 2.5mm deep using the counterbore. Turn a scrap piece of brass bar to the diameter of the hole drilled by the counterbore, then reduce 3mm at the end of the bar to 3mm diameter. Check the fit of the end of the bar in the counterbored hole and the pilot hole. If the counterbore has drilled a truly concentric hole the end of the bar should be a snug fit in both holes. If you are satisfied with the counterbore then bore a hole 2.5mm deep in the two inside faces of the two time bars.

Fitting the ball races

The counterbored holes in the two time bars need to be sleeved to take the ball races. Turn down a piece of brass bar to snugly fit the counterbored hole in each time bar. Drill and ream a 6mm hole in the end and check the fit of the ball race in the hole. The ball race should be a snug sliding fit requiring very little force to push it into place.

Part off a piece 2.6mm long to form the sleeve. Fit it into the counterbored hole in the time bar and then fit the ball race which should still be a snug sliding fit. If it is, remove the ball race and secure the sleeve in place using Loctite high strength retainer. The sleeve should be slightly proud of the surface; remove the surplus with a fine (No. 6 cut) flat file.

Fitting the centre wheel

The centre arbor is divided in two by the Ferris wheel. The rear drive wheel drives the train and the pendulum, and the front drive wheel drives the motion work and the hands. This may seem somewhat complicated but was the only way of designing a movement that ran for 15 minutes for each ball.

Remove the ball races fitted for the Ferris wheel, fit the register pegs in the pillar holes of the back plate and the two time bars, and clamp the three firmly together. Using the depthing tool, depth one of the drive wheels and one of the centre pinions. Fit the 3mm dia. drilling guide in the depthing tool and secure it firmly into position. Fit a 2.5mm dia. runner in the guide and the 4.0mm dia. runner. The 3mm dia. section of the 4mm dia. runner extends 6mm below the bottom of the depthing tool. The theoretical spacing between the arbors for these two wheels is 25mm. Set the arbors to this distance apart and try meshing the wheel and the pinion. Adjust the arbor spacing until you are satisfied that the wheels are meshing smoothly, then lock the depthing tool at this spacing using the knurled locking nut.

Remove the 2.5mm dia. runner from the drilling guide. Fit the end of the 4mm dia. runner extending below the depthing tool into the existing 3mm hole in the front bar. Position the centre of the 3mm dia. hole in the drilling guide over the line joining the centres of the pillars (i.e. the centre line of the front bar). Using a drill which is very sharp and properly backed off for drilling brass, drill a 3mm hole through the two bars and the ▶

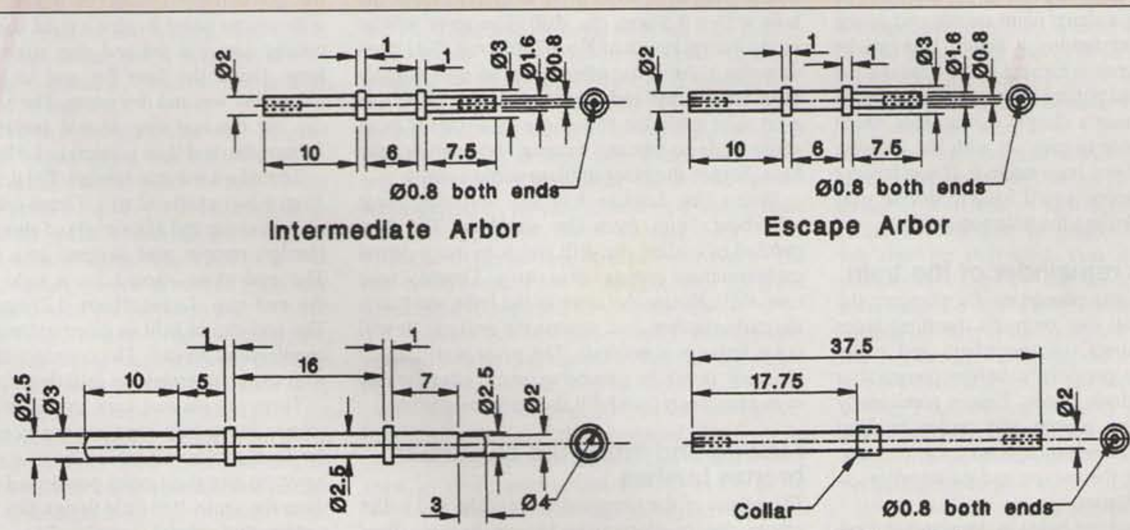

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Fig 20. Centre Arbor (Rear)

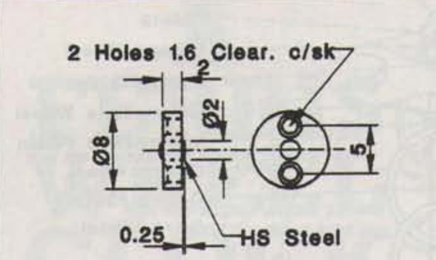

Fig 21. End Caps

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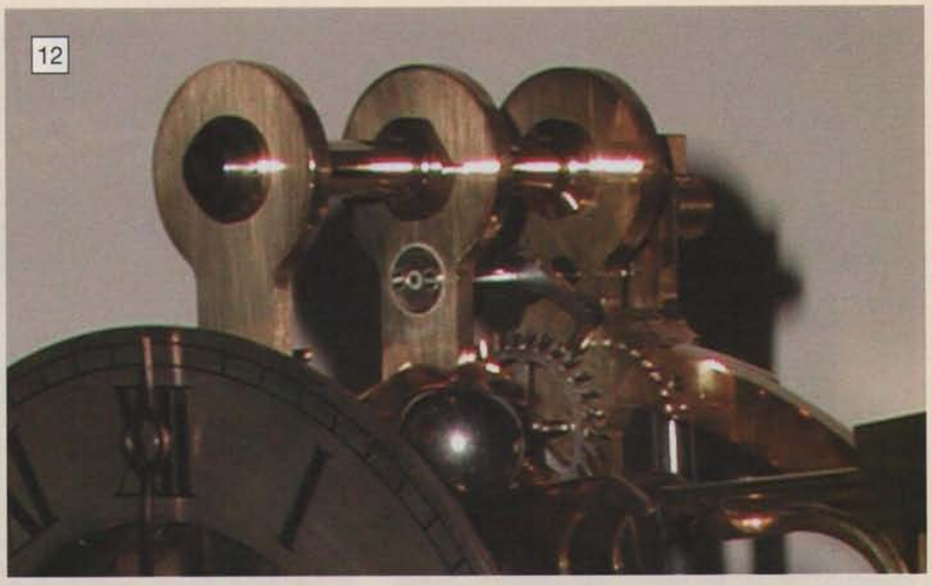

Right: this close up view of the top portion of the clock shows the time bars, back plate and pillars. Note the end cap, visible in the centre of the photograph.

back plate. Before drilling this hole I suggest that you drill a trial hole in a scrap of 4mm brass.

Drill a 3mm hole in this piece of brass and, using the depthing tool, drill a second hole at the arbor spacing. Fit the two runners in the holes and fit the wheel and pinion. Check the meshing of the wheels. If satisfactory, proceed with drilling the hole for the centre arbor. Once a hole has been drilled incorrectly in the plates, the plates will probably be destined for the scrap box. Before doing anything on any part of the plates, or for that matter on any part of the clock, carefully check before you do it. Mistakes are easily made and difficult to correct.

Fitting the centre arbor

Just like the Ferris wheel arbor, the centre arbor also runs in ball races. The front section, which drives the motion work, runs in a 3mm race while the rear section, which drives the train, runs in a 3mm front race and a 2mm rear race. All three races are of 6mm outer diameter. Fit the races in the middle bar and back plate, at this stage following the same procedure as previously described.

The dimensions of the rear section of the centre arbor are given in **fig 20**. As the pivots are running in ball races the arbor can be made from EN1A. The rear centre pinion is attached to the arbor with a 2mm dia. grub screw. To prevent the pinion from turning on the arbor, the end of the grub screw is reduced to 1mm dia. and a 1mm dia. hole drilled in the arbor. The 1mm dia. hole in the arbor can be located by filing a sharp point on the end of the grub screw before turning it down. This can be done while the screw is turning in the lathe. Fit the pinion in place and tighten the screw. The point on the screw will make a dimple in the arbor which you should be able to pick up with the centring microscope — if you have made it. If you haven't made the microscope you'll have to devise your own method of drilling the hole accurately.

Planting the remainder of the train

Following the same procedure for planting the centre wheel, drill the 3mm dia. bushing holes for the intermediate, escape wheel and pallet arbors. Check as previously, before committing the drill to the clock plates. This is particularly important for the escape and pallet bushing holes. With a well-made escapement, the tolerance in the spacing of the escape and pallet arbors is no more than 0.02mm.

With all the bushing holes in the plates drilled, the recesses for the end caps should be drilled using the 8mm dia. counterbore. The recesses in the middle bar should be 1.5mm deep and those in the back plate 2mm deep.

The dimensions of the arbors for the intermediate and escape wheels and the pallets are given in fig 20. The intermediate and escape arbors can also be made from EN1A mild steel. The pallet arbor is made from a length of 2mm blue steel if you have some. If have no blue steel, silver-steel will do.

The pivots for all three arbors are made from lengths of high-speed drill blank inserted into the ends of the arbors and secured with Loctite high strength retainer which, I appreciate, is not the traditional method of making pivots. The traditionalists would still have us turning pivots by hand using a graver but I feel engineering has moved a bit beyond hand turning! There are several definite advantages of HSS inserted pivots. First, HSS is significantly tougher than carbon steel. Secondly, the drill blanks come highly polished and are made to a very close tolerance. Thirdly, the shoulders of the pivots are absolutely square. And finally, the arbors are a lot easier to make.

Before making the arbors, assemble the middle bar and the back plate with the pillars. Measure the spacing between the plate and the bar. The length of the intermediate and the escape arbor should be about 0.4mm less that the space between the plate and bar. Making the pallet arbor can wait until the back cock has been made. Having made the arbors, drill a 0.75mm dia. hole to a depth of about 4mm in the end. Open the hole with a 0.80mm dia. drill. The pivot will be made from a length of No. 67 drill rod (0.812mm diameter.). As drills often seem to drill slightly oversize, the drill rod should be a good fit. If it is a bit tight grind the end of the drill rod off at an acute angle to create a reamer and open out the hole. Secure the pivot in place using Loctite.

When the Loctite has set, cut the pivot off about 3mm from the shoulder. The best method of cutting the drill rod is to use a dental carborundum cutting disc in a Dremel type mini-drill. Rotate the arbor in the lathe and touch the carborundum disc against the drill rod. It will cut it through in seconds. The pivot is still much too long; it will be ground to length after the end caps have been fitted. Fit the remaining pivots.

Making and fitting the aluminium bronze bushes

The pivots of the intermediate, escape and pallet arbors run in aluminium bronze bushes. Turn down a piece of aluminium bronze bar to 3.02mm diameter. Slightly chamfer the end to make it easier to press the bush in place. Drill a 2.5mm dia. hole 1.8mm deep in the end. Using a 0.75mm dia. drill, extend the hole for a further 2mm. Part off 3mm from the end. The final length of the bush is 2.5mm. Face off the parted end to this length. Press the bush in position flush with the surface of the plate. Using a tapered broach open the hole in the bush so that the 0.8mm dia. pivot just enters. Final burnishing of the hole will slightly increase the size.

Sewing needles make excellent burnishers. Use one with a shank slightly larger than the hole. I put the needle in a Dremel mini drill and, using a spot of oil, burnished the pivot hole from both sides until the pivot passed easily into the hole. The hole is the 'right' size when, with the pivot in the hole, the arbor can rock sideways about 10deg. with little resistance. Assemble the arbor in position between the front plate and the front cock. There should be a small amount of end shake.

End caps

The end caps are illustrated in **fig 21**. Six of these required. The three for the middle bar are chamfered, as these end caps stand slightly proud of the surface. The end caps should present few problems. The end stop is made from 2mm dia. high-speed steel drill rod.

Using the face of a carborundum cutting disc in the mini-drill, round off the end of a length of drill rod. Polish the end using fine wet and dry finishing with crocus paper to give a good shine. Using the cutting disc, cut the end stop slightly over 2mm long. Grind the face flat and to length. Polish using fine wet and dry paper. The hole in the end cap for the end stop should initially be drilled 1.9mm dia. and then reamed to 1.97mm diameter.

To make a suitable reamer, file down a piece of 2mm silver-steel rod to 1.97mm dia. in the lathe and grind the end at an angle of about 30 degrees. Harden, temper, and sharpen on a fine oilstone. The end stops should be a tight press fit in the end cap. Leave about 0.25mm protruding. The end cap is held in place by two 1.6mm dia. countersunk screws. The countersinks are drilled with the countersinking drill described earlier.

There are six end caps in the clock. If all the screws in the end caps are positioned randomly the final result will look a bit of a mess. Decide how you like the screws positioned and do all of them the same. It is little things like this that give a clock that special something.

●*To be continued.*