**Richard Stephen**

**describes how to make and fit the front section of the centre arbor before continuing with further work on the motion, dial and hands.**

●*Part VIII continued from page 291 (M.E. 4178, 20 September 2002)*

*The centre arbor cock in position in the clock together with the respective wheels and pinions.*

*The dial and hands of the clock. The Roman numerals are best engraved mechanically.*

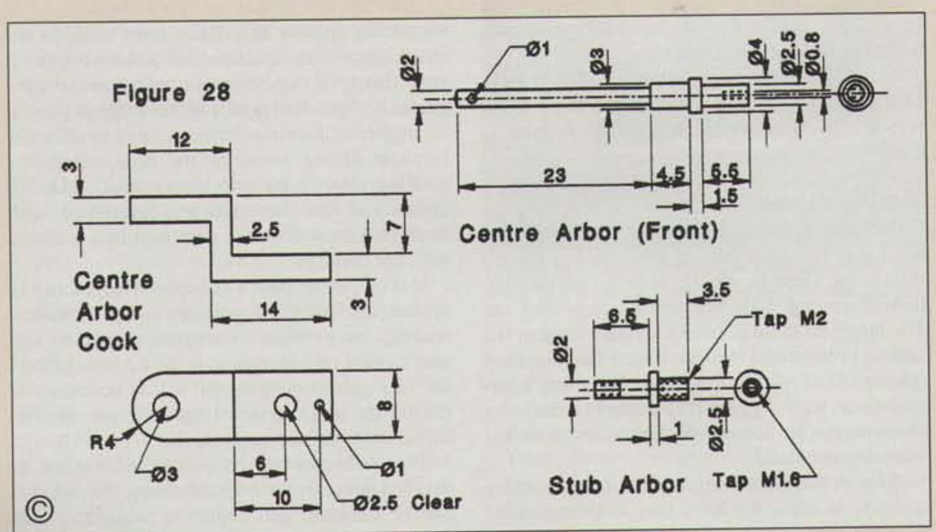
# A FERRIS WHEEL CLOCK

The front section of the centre arbor and the centre arbor cock are shown in **fig 28**. This section of the centre arbor should be made from blue pivot steel. I turned my arbor from a length of 4mm dia. steel. Blue steel turns quite easily with correctly ground tools, however most readers may prefer to fabricate the arbor. For this you will need a 30mm length of 2mm dia. blue steel or equivalent. Draw the temper from about 5mm from one end. This will make it easier to drill the 1mm hole for the pin.

Begin by drilling a 2mm dia. hole about 8mm deep in a scrap length of 6mm dia. brass rod. Insert the softened end of the blue steel rod and secure with Loctite screwlock. Cross drilling the 1mm hole will be much easier as the 6mm rod is easier to hold and there is much less likelihood of a small drill snatching as it breaks through the 2mm dia. rod. Gently heat the brass rod to remove the blue steel rod.

The remainder of the arbor can be made from EN1A mild steel as the arbor runs in a ball race in front and, as before, the pivot is 0.8mm dia. high-speed steel drill rod. Take a 15mm length of mild steel rod, face the end and drill and ream a 2mm dia. hole 8mm deep. Using Loctite high strength retainer, fix the blue steel rod into the hole. Allow the Loctite to cure. Very gentle warmth will accelerate the curing process. Hold the 2mm dia. rod in a collet or true chuck and machine the rest of the arbor. Drill a 0.8mm dia. hole for the pivot and secure the drill rod in place using Loctite. Cut off 3mm for the pivot and finally grind the pivot to its final length of 2.5mm.

The recess in the front bar for the 3mm ball race can now be counterbored as previously described, and the race fitted. Fit the arbor in the ball race and measure the distance between the surface of the front bar and the rear shoulder of the arbor. This measurement, plus 0.25mm, will be the height of the centre arbor cock. The remaining dimensions of the centre arbor cock are given in fig 28. The cock is best made from a solid piece of brass 8 x 12 x 35mm. Drill the holes for the 2.5mm dia. aluminium bronze bush, retaining screw and the 1mm dia. register pin.




## Fitting the centre arbor cock

Begin by facing off a short length of 15mm dia. brass or steel rod. Drill and ream a 3mm dia. hole through the piece of rod. Using Loctite screwlock, fix the length of true 3mm silver-steel rod into the hole with about 25mm protruding from the faced end. Pass the 3mm dia. rod through the 3mm dia. hole for the centre arbor in the front bar and thread on the centre arbor cock. Clamp the cock in position on the front bar. The cock will be correctly positioned when, with the faced end of the 15mm rod pressed against the front face of the front bar, the 3mm rod can be easily turned with the fingers.

Drill the 1mm dia. hole for the register pin. Insert the register pin in the cock and reposition the cock using the register pin to locate it. Check that the 3mm dia. rod still turns easily, clamp in position and drill and tap the 2.5mm dia. hole for the retaining screw. The aluminium bronze bush can now be made and fitted in the cock. Insert the ball race and the arbor and fit the cock in place. The arbor should spin freely with a small amount of end shake.

## Motion work

The motion work used in the clock is unusual in that it uses large count pinion wheels. Instead of the usual 6 tooth minute wheel pinion, the motion work for this clock uses a 16 tooth minute wheel pinion. The details of the motion work are given in **Table 2**. The cannon pinion and minute wheel pinions can be made either of steel, hardened and polished, or from hard brass. The dimensions of the wheels are shown in **fig 29**.

Cut the teeth in the wheels and the two pinions not forgetting to cut a couple of spares of each while everything is set up. Before crossing out the minute and hour wheels don't forget to polish the teeth as previously described. Holes will need to be drilled in the pinions when you have finished cutting the teeth. Drill a 3.5mm dia. hole in the cannon pinion to fit on the minute pipe. The cannon pinion is 3.5mm long. The minute pinion is turned down to 4mm dia. for 2.5mm, and a 2mm dia. hole drilled. The minute pipe, hour pipe,

Table 2

| | No. of teeth | P.C.D (mm) | Full dia. (mm) |
|---|---|---|---|
| Minute wheel | 60 | 24.0 | 25.1 |
| Hour wheel | 64 | 25.6 | 26.7 |
| Cannon pinion | 20 | 8.0 | 8.64 |
| Minute pinion | 16 | 6.4 | 7.04 |

All wheels and pinions 0.40 module

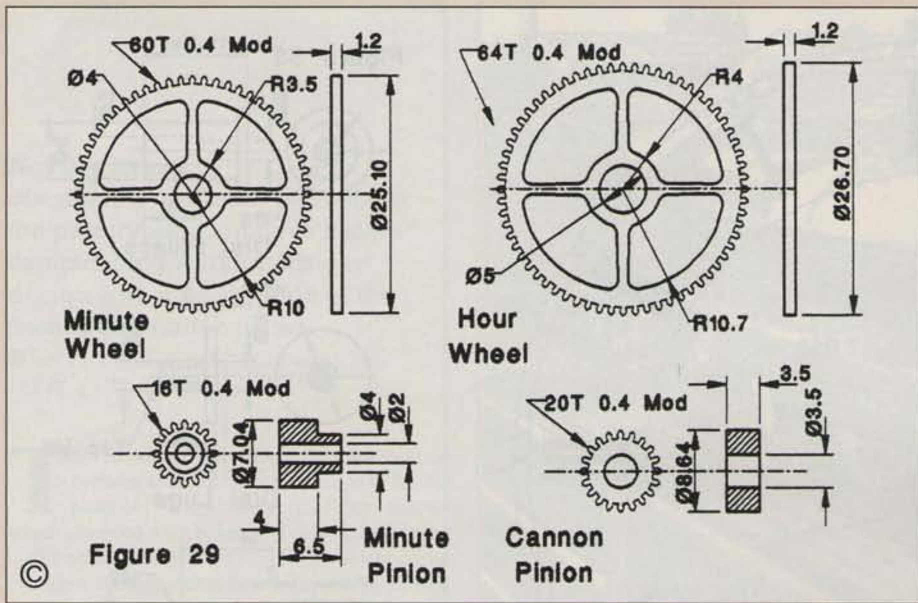



Figure 29

hour hand collet and the washer for the front of the minute hand are shown in **fig 30**.

The tension spring is unusual in that it is a 2mm I/D compression spring fitted inside the minute hand pipe. The spring presses against the shoulder on the center arbor which extends through the front bar. Peter Bradley introduced me to this method for tensioning the minute hand several years ago since when I have found it superior to the more usual leaf spring. The stub arbor illustrated in fig 28, on which the minute wheel and pinion runs, is made of silver-steel and hardened and tempered.

## Planting the motion work

Set the motion work up on the depthing tool. A long 2mm dia. runner will be needed for this. The theoretical arbor spacing for the motion work is 16mm. Set the arbors at this spacing and position the wheels. Check that the motion work runs smoothly. Remove the runner from the drilling jig and insert the 3mm dia. end of the other runner into the 3mm dia. centre arbor hole. Position the jig centrally below the centre arbor and drill a 3mm dia. hole through the front bar.

This hole must now be expanded to 3.5mm dia. to take the end of the stub arbor. The safest way to expand the hole without accidentally shifting the centre is to drill it on the milling machine. I have a 50mm length of 6mm dia. silver-steel with one end ground to make a centre. Fix the centre in the drill chuck, locate the hole in the front bar and press the bar firmly against a drilling board. Clamp firmly in position. Remove the centre, fit a 3.4mm dia. drill and expand the hole, finishing with a 3.5mm dia. reamer.

Assemble the centre arbor and the motion work and check that it still runs smoothly. The 3mm dia. centre arbor hole in the front bar should now be expanded to 3.5mm diameter.

## Dial

The dimensions of the dial for the clock are given in **fig 31**. Unfortunately, apart possibly from the hands, the dial is the one (and in my opinion the most important!) part of the clock, about the making of which I can offer little advice. There are four options:

1: Hand engraving,
2: Chemical etching,
3: Machine engraving,
4: Getting someone else to make it.

If you are an expert with a hand graver there is no doubt that a hand engraved dial is by far and away the most stylish and best choice.

Chemical etching involves the use of corrosive chemicals best kept well clear of the workshop. With care, etched dials are good, provided CZ108 brass is used.

For most amateur clock makers the last two options are possibly the only practical ones but for myself, I do not like asking someone else to make the one part of a clock which everyone looks at.

This leaves machine engraving as the final option. If you have access to a pantograph engraver and the appropriate copy, this a viable option. The dial for the prototype was engraved on my Wabeco CNC mill. If you are heavily into clock making it is almost worth retro-fitting a CNC set-up on your milling machine simply to make dials. The cost of the CNC would be soon recovered with the saving on dials.

Fitting a poor dial to a clock you have possibly spent months making is a complete waste of time.

## Hands

The design of the hands which I made for my clock is shown in **fig 32**. I have tried many different designs for hands but always revert to the Brueget style which I consider to be both simple and elegant.

The best material I have found for hands is the steel from a cheap cross-cut wood saw blade which is a little less than 1mm thick. The steel is rather hard and a bit difficult to work but this disadvantage is more than offset by the stiffness of the steel which enables very delicate hands to be made without sacrificing strength. When finished, the hands must be brought to a high polish, carefully degreased and then remain untouched by bare fingers until they have been blued.

The spring collet for the hour hand is illustrated in fig 30. The only tip I can offer when making the collet is to leave the diameter well oversize when you cut the slits with a slitting saw. If the diameter of the collet is reduced to its final thickness before slitting there is a danger of the teeth of the saw snatching. Once the slits have been cut, the diameter can be reduced to its final size, the collet being supported by inserting a length of 5mm dia. rod and taking very light cuts with a very sharp tool.

Use Loctite to retain the hour hand securely on its collet and then rivet the hand firmly in place, using an old lathe back centre.

## Fitting the dial

The dial is attached by two screws which pass through the front time bar, through two spacing pillars and screw into two lugs soft soldered onto the back of the dial. The dimensions of these parts are given in **fig 33**. The height of the pillars is best determined when you are fitting the dial in place as this depends on the final positioning of the hands.

To fit the dial correctly in position you will need a 125mm square piece of 1.5mm thick Dural or other aluminium alloy sheet, or any other sheet metal which happens to be to hand. Mark the centre, scribe two circles equal in diameter to the inside and outside diameters of the dial and mark a line to pass through the centre (**fig 34**). Now drill two 1mm dia. holes on the line midway between the two circles (fig 34) and a 3mm dia. hole in the centre.

Fit the front section of the centre arbor and the front arbor cock in position on the front bar. Pass the centre arbor through the centre hole in the Dural sheet and align the centre line (uppermost) on the Dural sheet with the centre line of the front bar. Clamp the Dural sheet to the front bar. Mark the positions of the two 1mm dia. holes in the Dural sheet on the front time bar using a 1mm dia. drill.

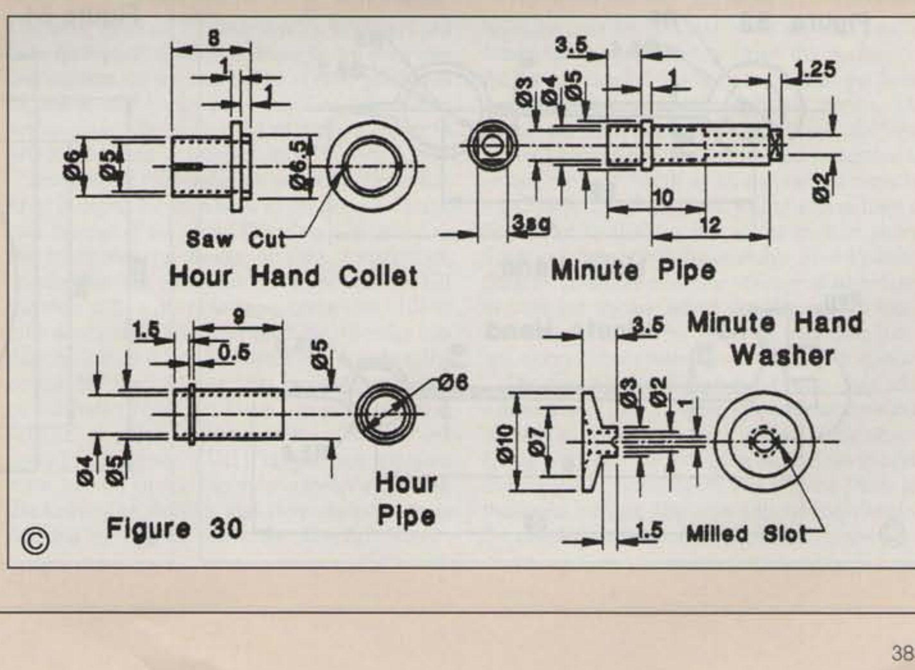



Figure 30

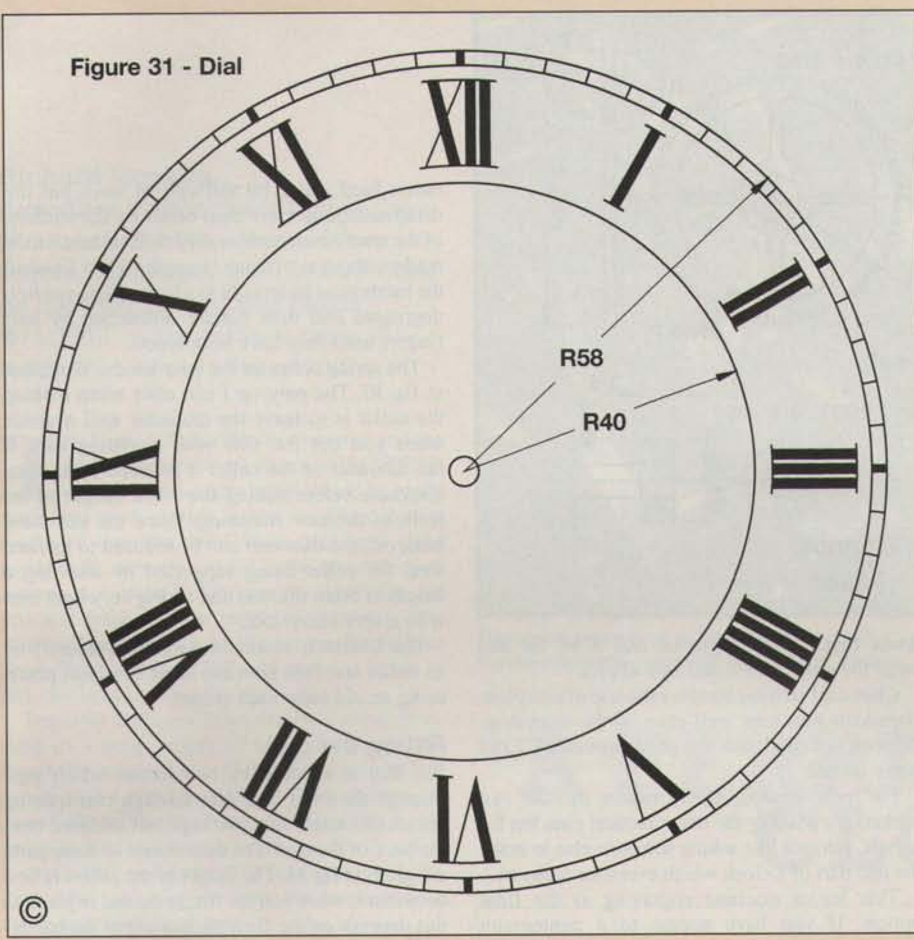


Figure 31 - Dial

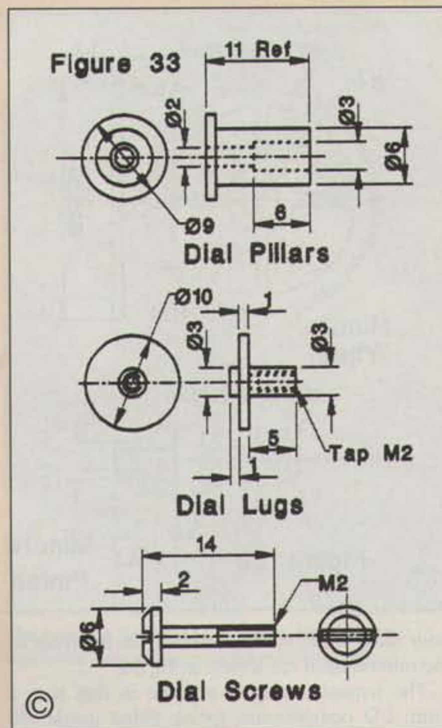


Figure 33

Hold a scrap of sheet metal in a candle flame until a good deposit of soot appears on the metal surface. Allow to cool. Mix some slow set epoxy in the middle of the soot and incorporate the soot into the mixture. Smear the mixture into the engraving and warm the dial very gently until the epoxy runs. This will ensure that the epoxy thoroughly penetrates the engraving. Leave overnight to allow the epoxy to fully cure.

Excess epoxy can be removed with 500 grit wet and dry abrasive paper. This is best done in warm water to which a squirt of washing up liquid has been added. The surface of the dial can now be grained using 1200 grit wet and dry abrasive paper. Wash off the dial, dry with paper towel and silver immediately. Finally lacquer the silvering and the back of the dial.

Assemble the entire movement and run it for as long as you can be bothered to keep replacing the balls as they drop off the wheel. My movement will run with two balls in slots close to the '9 o'clock' position. With all eight balls in place there is plenty of power to spare!

●*To be continued.*

Remove the Dural sheet from the front bar and place the dial on top of the Dural sheet, lining up the 12 and 6 with the scribed line and the outside and inside circumferences of the dial with the scribed circles. Clamp the dial and the Dural sheet firmly together. Mark the positions of the two 1mm holes on the back of the dial, again using a 1mm drill.

Clamp the dial on a drilling board onto the table of the milling machine and locate one of the 1mm holes marked on the back of the dial using the centring microscope. Drill a 2mm dia. hole *1mm* deep in the back of the dial. Replace the drill with a 3mm dia. slot drill and expand the hole to 3mm diameter. Pick up the second hole and drill it. *Take care not to drill through the dial.* Check that the dial lugs fit snugly into the holes drilled.

Tin the area around the holes and the lugs with soft-solder. Smear a little flux on both tinned areas; locate the lug and heat with a small flame until the solder melts. Repeat the process for the second lug. Carefully remove any solder that is visible and wash off any remaining flux using detergent and hot water.

Drill the 2mm dia. holes in the front bar using the milling machine, using the centring microscope once more to locate the positions of the holes. The dial can now be screwed in position. The final height of the dial spacers can be determined when the hands are fitted. A 1mm separation between the dial face and the hour hand and between the hour hand and the minute hand is about right.

With the dial fitted, the engraving on the dial can be filled. The best filler for dials is slow setting epoxy, coloured black with candle black.

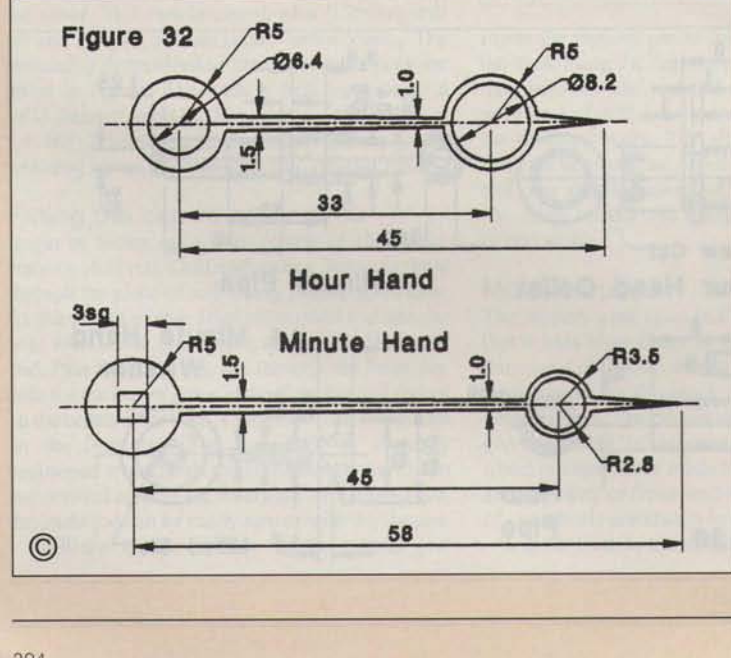


Figure 32

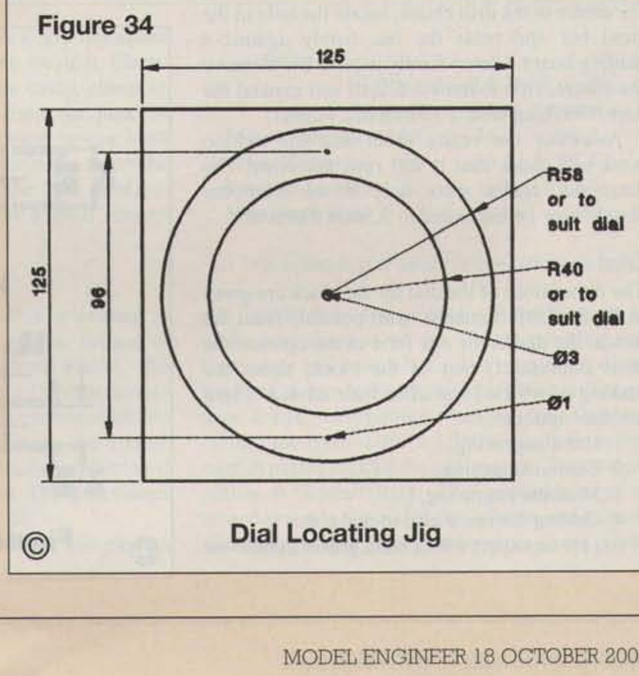


Figure 34