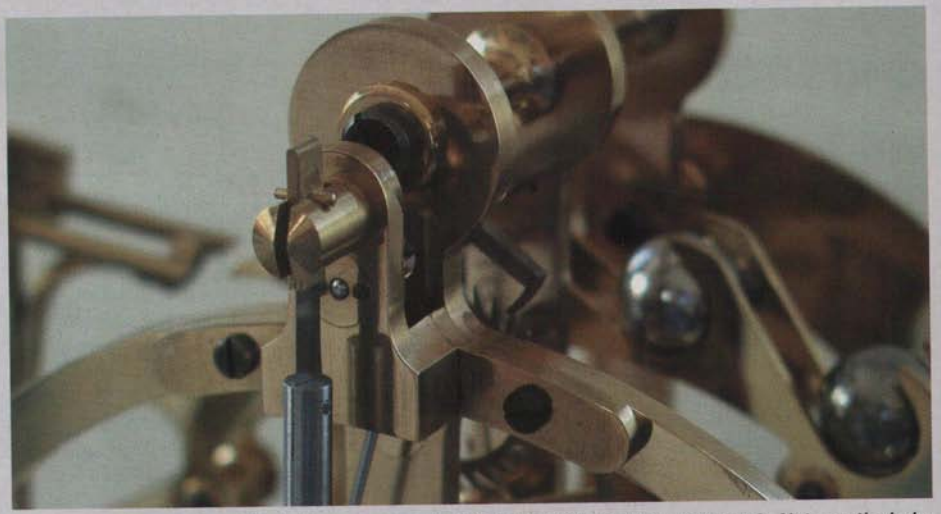
A FERRIS WHEEL CLOCK

Richard Stephen

describes the planting of the intermediate and escape wheels before dealing with the pendulum and back cock.

●*Part VII continued from page 176 (M.E. 4176, 23 August 2002)*



Some of the items referred to in the accompanying text are visible in this photograph. Note particularly the pallet arbor end cap, back cock, pendulum support and pendulum suspension spring.

The intermediate and escape wheels can now be planted in the train. The pivots on the two arbors still require to be reduced in length. The bushes should already have been correctly sized to take the pivots. Screw the end caps in place. The pivots are now ground to length using a carborundum grinding disc in the Dremel mini-drill. Hold the arbor in a collet or 3-jaw chuck in the lathe and grind a point on the end of the pivot, reducing the length at the same time.

The length of the arbors was made about 0.40mm less than the separation of the plates. Grind back the pivot until the shoulder is about 0.20mm clear of the surface of the bush. Now grind back the pivot at the other end of the arbor. Keep trying the arbor between the plates. You should aim to have just a slight amount of end shake when the plates are firmly assembled. If you grind too much off the end of a pivot, remove it and replace it with a new length of drill rod softening the Loctite with a little gentle heating.

The pinions and wheels can be fixed to the arbors using Loctite Screwlock. This will facilitate the removal of any wheel or pinion should this be necessary. The wheels and pinions will eventually be secured using Loctite high strength retainer.

It is now time to test the train. Before you assemble the train, the 3mm holes in the plates where the 3mm ball races have been fitted, i.e. at the Ferris wheel arbor and the centre arbor, should now be enlarged to 3.5mm. Assemble all the wheels including the Ferris wheel. If everything has gone correctly, the escape wheel should turn freely when one ball is placed in a slot at the '9 o'clock' position. If the train will not turn freely with just one ball there is too much friction somewhere in the train. Starting with the escape wheel, progressively remove wheels until the source of the friction is located.

The prototype train turned very freely even when a single ball was placed in a slot at the '11 o'clock' position.

Back cock

The dimensions of the back cock are shown in **fig 22**. It is best made from a solid brass block but it could be fabricated using scraps of 3mm engraving brass silver-soldered together. Personally, I find fabricating unsatisfactory as the silver-solder eventually tarnishes to leave a dark mark. The cock has a rather complicated form, the shaping of which, without access to CNC equipment, will have to be done by hand. The diagrams in fig 22 illustrate the steps I took making the cock. Unfortunately, there is no easy way to make it!

When you have completed stage A, the hole for the bush should be drilled and reamed 3.0mm. Assemble the back plate, middle bar and the pillars. Make sure the screws are tight. To fit the back cock in its correct position you require a 60mm length of 3mm dia. silver-steel rod. Check that the rod is perfectly straight by testing that it runs perfectly truly in the lathe. Pass the rod through the 3mm dia. holes in both plates. Check that you can turn the rod easily with your fingers. Now pass the rod through the 3mm hole in the back cock. Clamp the cock to the back plate with toolmaker's clamps. The centre line of the cock should line up with the centre line of the back plate. Check again that you can turn the 3mm rod easily with your fingers. If it is at all stiff, carefully adjust the position of the cock until the rod turns easily. The back cock is now correctly aligned with the holes drilled for the pallet arbor. Using the back plate as a template mark out the shape of the cock with a scriber.

The holes for the screws and the 1mm register pins can now be drilled using the scribed lines as a guide for their positions (see fig 22). With the holes drilled, reposition the cock and clamp it to the back plate. Check that the 3mm silver-steel rod still turns easily. Leave the cock clamped in place and disassemble the plates. Drill the holes in the back plate for the register pins. Insert the register pins in the cock. Reassemble the plates. Position the cock using the register pins and clamp with toolmaker's clamps.

Check once more that the 3mm dia. silver-steel rod still turns easily. Disassemble the plates and drill and tap the holes for the 2.5mm screws. Finally check that the scribed lines are still correct. The cock can now be finished off using a piercing saw and files, referring to fig 22 as a guide for the shape. When the cock is finally profiled, the recess for the end cap can be drilled using the 8mm dia. counterbore, and the end cap fitted in place. The hole for the pendulum support is drilled 8mm vertically above the pivot hole in the cock.

The dimensions of the pendulum support are also shown in fig 22. This should present no difficulties and when made can be screwed in place on the back cock.

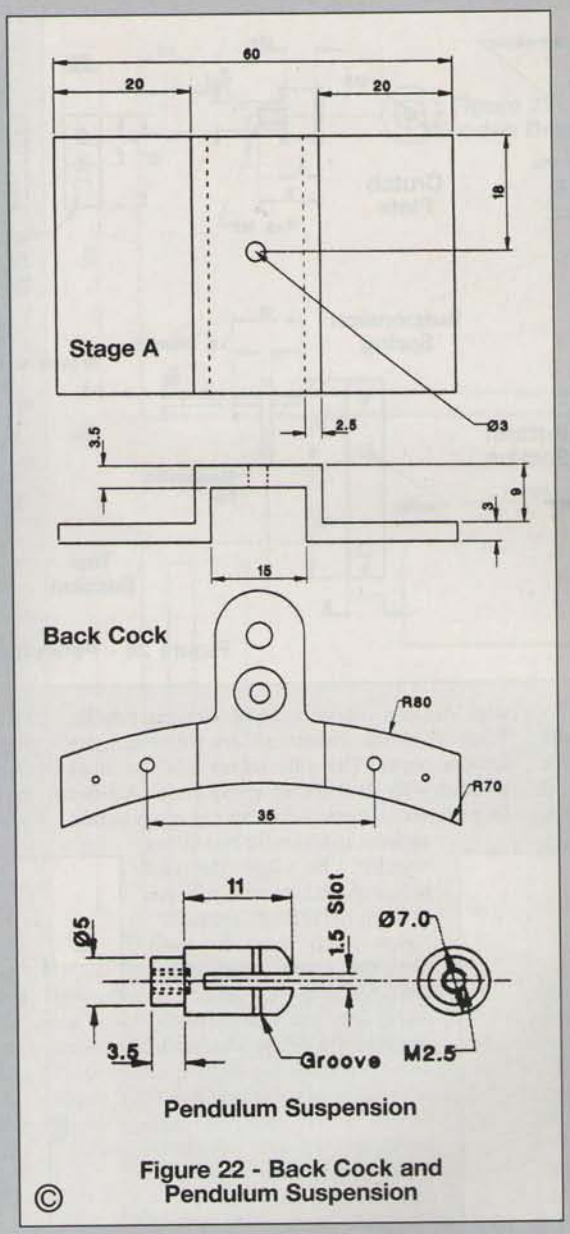


Figure 22 - Back Cock and Pendulum Suspension

Fitting the pallet arbor

With the back cock in position, the pallet arbor can now be made. Measure the separation between the middle bar and the back cock. Make the length of the arbor 0.40mm less than the measured value. The pallet arbor is best made from 2mm dia. blued steel or equivalent. If you have none, use silver-steel. If you use blued steel the temper will have to be drawn from the ends in order to drill the holes for the high speed steel pivots. The collar can be made of mild steel and fixed in place with Loctite.

Follow the procedure previously described for grinding the pivots to length. Fit the pallets onto the arbor using Loctite Screwlock. Assemble the plates, back cock, escape wheel and pallets. If everything has gone according to plan, the escapement should function correctly.

Pendulum bob

The pendulum rod for this clock is made of carbon fibre and steel. No particular attempt has been made to compensate the pendulum for temperature effects. The temperature in most modern houses is relatively constant, which minimises temperature effects. Any reader who wishes to accurately compensate his pendulum should contact me (by telephone on 01572-770416 or by e-mail at dickstephn@aol.com) and I will explain how to do so using a carbon fibre rod.

The bob is prevented from rotating on the pendulum rod by a 1mm peg which slides in an internal groove in the bob (see **fig 23**). The only problem encountered when making the bob is cutting this internal groove. After trying several techniques with limited success I evolved the simple, if slightly unorthodox method which follows.

A length of 50mm diameter brass bar is required for the bob.

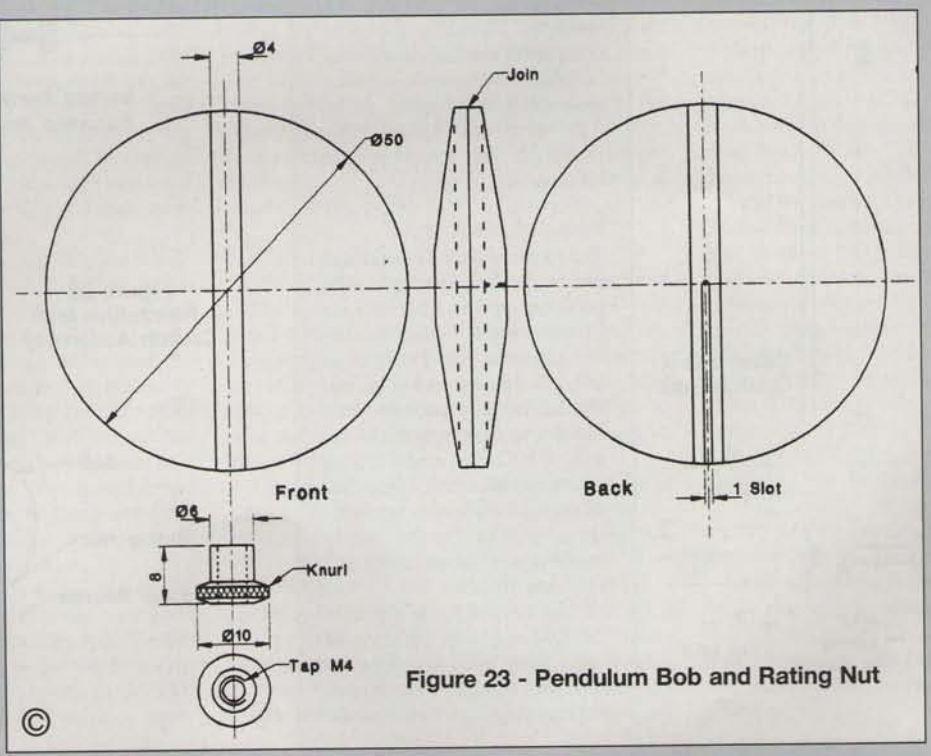


Figure 23 - Pendulum Bob and Rating Nut

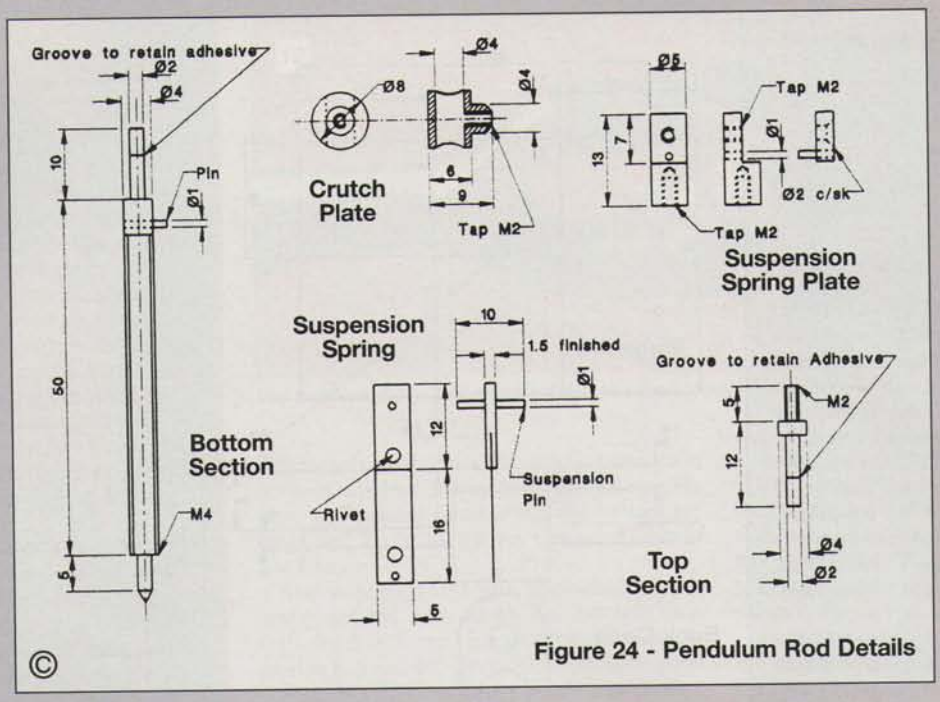


Figure 24 - Pendulum Rod Details

Face the end of the bar and part off a disc 7mm thick. Face the end again and part off a second disc. Clamp the two faced sides of the discs together in the vice on the milling machine. Using the centring microscope, position the axis of the milling machine spindle on the join and a line passing through the centre of the two discs as shown in fig 23. Drill and ream the 4mm dia. hole. Separate the discs and, using a 1mm milling cutter, cut the groove for the peg in one of the discs as also shown in fig 23.

The grooved surfaces of the two discs must now be slightly roughened by rubbing them on a piece of 800 wet and dry abrasive paper placed on something flat. Thoroughly clean the surfaces with Vim or a similar domestic cleaning powder. Wash off all the cleaner and dry with clean, dry kitchen paper. The two halves will be stuck together with slow setting epoxy resin (Araldite for preference). Apply a thin layer of epoxy to both surfaces and press the two halves together. To align the two halves of the hole push a length of 4mm rod through the hole.

Now gently warm the metal until the epoxy turns liquid (about 60deg. C) and then clamp the two halves firmly together. Be sure to remove the 4mm rod before the epoxy sets, otherwise you cannot get it out! Scrape out any epoxy that has seeped into the slot. I prefer to warm epoxy resin to help it cure. If they aren't too big, I place items over gently boiling water in a covered double saucepan. This cures the epoxy completely in about 30 minutes.

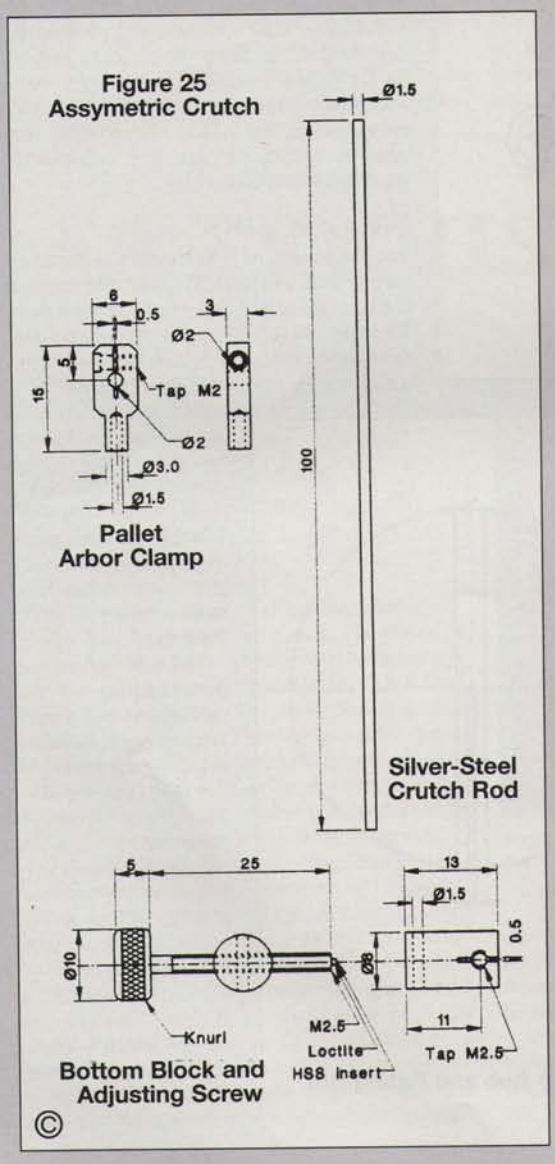
Allow the bob to cool before machining it to final shape. The rating nut is also shown in fig 23. This should present no problem.

Pendulum rod

The components of the pendulum rod are illustrated in **fig 24**. The pendulum rod is made from a 215mm length of 4mm dia. carbon fibre rod. The first part to make is the suspension spring. The top block is made of brass. The slot for the spring can be cut with a 0.075mm wide slitting saw if you have one. I find fine slitting saw blades frequently do not cut straight. This can lead to problems with the pendulum not swinging correctly.

I 'cut' the slot for the spring in the following way. A piece of 6mm thick brass bar approximately 20 x 50mm was clamped in the milling vice. Two opposite edges were machined flat and parallel. Using any convenient slitting saw (0.50mm is fine) a slot was cut to the depth required, about 2.5mm below one edge. A scrap piece of 0.075mm suspension spring was inserted into the slot and the brass hammered on an anvil to close the slot down onto the spring.

The brass above the slot was machined to 1mm. A cut 1mm below the slot was made using the slitting saw. The suspension spring was inserted into the slot; it was a nice tight fit. The 1mm hole for the suspension pin and a 1.5mm hole for the rivet were drilled. I use second-hand tungsten carbide printed circuit board drills for the purpose. A short length of 1.5mm brass wire was cut off for use as a rivet to rivet the spring



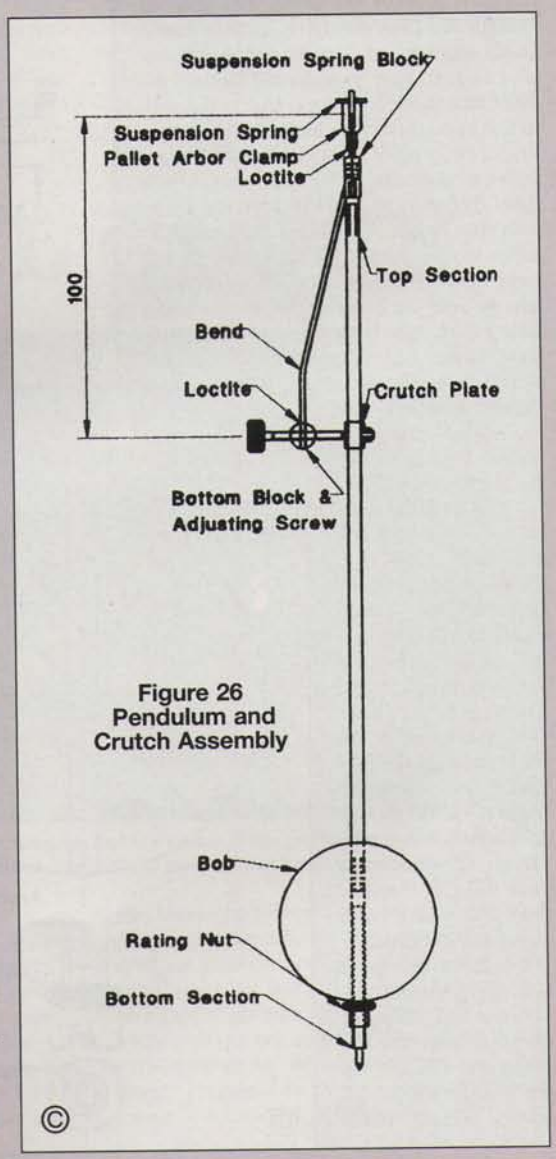


Figure 26
Pendulum and
Crutch Assembly

A view of the rear of the clock showing the carbon fibre pendulum rod and pendulum crutch assembly.

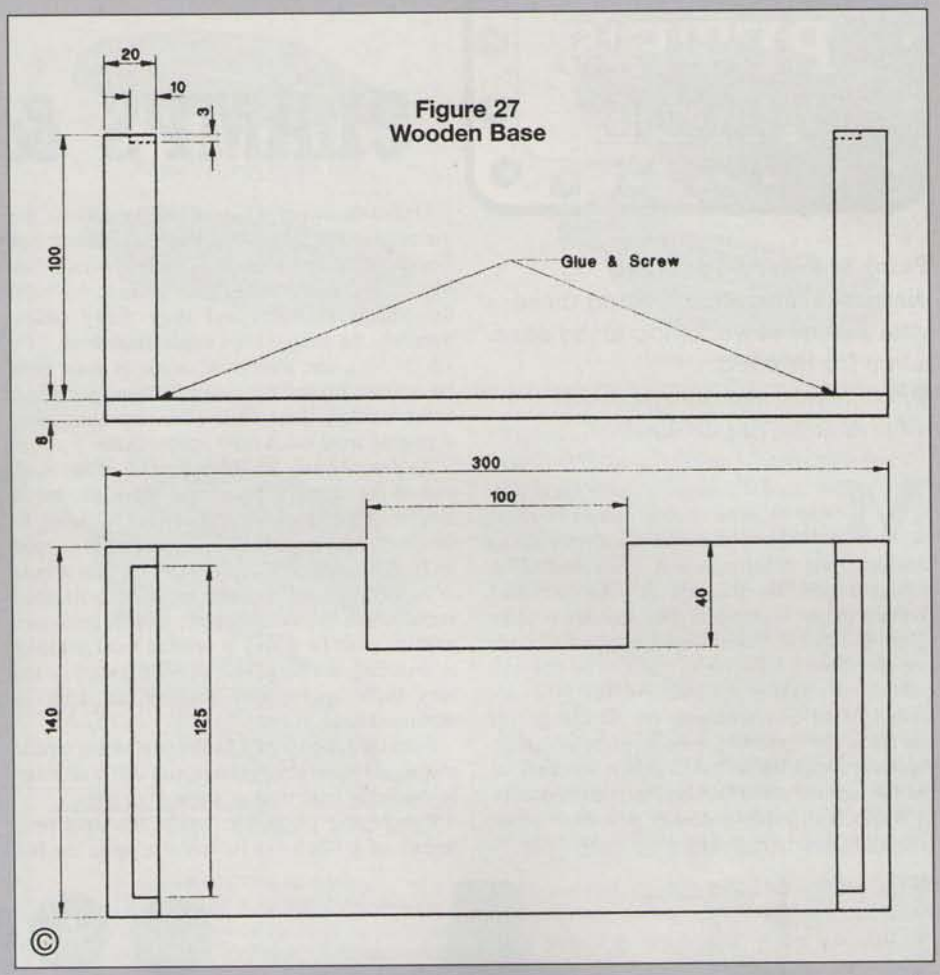


Figure 27
Wooden Base

into the block. The block was still too thick for the slot in the support. The thickness was carefully reduced by filing both sides until the spring block fitted snugly in the slot in the support. On no account must the spring block be able to rock sideways in the slot —if it does you should begin again.

The suspension spring is fixed to the suspension spring block at its lower end. The dimensions of this part are given in fig 24. The top section of the pendulum rod screws into the suspension spring block and is made from a piece of 4mm dia. mild steel rod. The dimensions are given in fig 24. The 2mm grooved spigot is fixed into the end of the carbon fibre rod using epoxy resin adhesive. The bottom steel section shown in fig 24 is threaded 4mm for the rating nut. To prevent the bob from rotating on the rod a 1mm peg is set in the lower section. This peg slides in the groove cut in the bob.

The last component is the crutch plate which should be made from silver-steel. Cut off a 15mm length of 8mm rod. Drill and ream a 4mm hole about 3mm from one end. Face off the end of the rod and reduce the thickness between the edge of the hole and the face to 1mm. Slightly chamfer the edge and polish the face finishing with 1200 wet and dry paper. Now reduce the other end leaving about 5mm between the hole and the face. Drill and tap a 2mm thread in the end. The excess material can be machined away as shown in fig 24. Now harden and leave in a glass hard state, clean and polish.

The pendulum rod can now be assembled. Using epoxy resin, first glue only the lower section into place in the carbon fibre rod. The bob should be able to slide freely on the rod. Screw the top section into the suspension spring block. Slide the bob onto the rod as far as it will go. Apply some slow setting epoxy resin to the spigot of the top section and inside the carbon fibre rod. Insert the spigot into the end of the carbon fibre rod. Lay the pendulum bob on a flat surface and rotate the spigot until the suspension spring lies at right angles to the plane of the bob. Allow the epoxy resin to set before moving the pendulum.

Crutch

The crutch is illustrated in **fig 25**. Its construction should present few difficulties. The pallet arbor clamp and the bottom block are made of mild steel, the rod is made from a length of 1.5mm dia. silver-steel rod, and the knurled adjusting screw from brass. The polished domed end of the adjusting screw that rests on the crutch plate on the pendulum rod is made from a piece of 1.5mm dia. high speed steel drill rod. The parts are fixed together with Loctite.

Testing the movement

The movement is now ready for testing and should be assembled. At this point you will notice that the pendulum extends below the feet. This was quite intentional. The reason for this was to reduce the height through which the balls needed to be lifted. As it is, the ball lift has to raise thirteen 15mm steel balls each weighing 16 grams (total weight nearly 1lb.)

The pendulum in the finished clock swings in a recess in the base. The base houses the batteries, electronics and the motor that drives the ball lift. To test the movement, a base will have to be made on which to mount it. **Figure 27** shows a suitable design for a test base. This base has a dual purpose as, when used as drawn, the movement and base plate can be located in the recesses in the uprights. This will be useful later when, for example, testing the ball lift. Since we have not yet made the base plate, the test base can be inverted with the plywood uppermost and the movement screwed to it for testing.

The test base can be made from a piece of 8mm plywood and the side supports any available 20mm thick wood board. Mill out the recesses dimensioned 125 x 10 x 3mm and shown on the bottom of the side supports. For our initial trials, the movement needs to be firmly screwed to the plywood board. To mark the positions of the screw holes, three lengths of 4mm dia. steel, threaded rod 10mm long will be required. Turn a sharp point on the end of each piece of rod. Screw one into each foot with the point outermost. Position the movement so that the pendulum can swing in the recess in the base and press down firmly. The dimples in the surface should be easily visible.

Drill the holes for the 4mm screws. The three pointed lengths of threaded rod will be needed later to mark the positions of the screw holes in the brass base plate on which the movement is mounted. Secure the movement to the base with the three 4mm screws. Attach the pendulum. The crutch plate on the pendulum rod will have to be moved to its correct position. The domed high-speed steel point on the crutch adjusting screw has to rest at 90deg. to the face of the crutch plate. If it does not rest at 90deg. the pendulum will be caused to swing in a figure of eight pattern. To set the pendulum in beat simply turn the adjusting screw until the tick is perfectly even.

Place eight balls in the slots on the left of the Ferris wheel. If the escape wheel turned with one ball in a slot at the '9 o'clock' position the movement should run. My prototype ran immediately and has continued to do so ever since.

●*To be continued.*