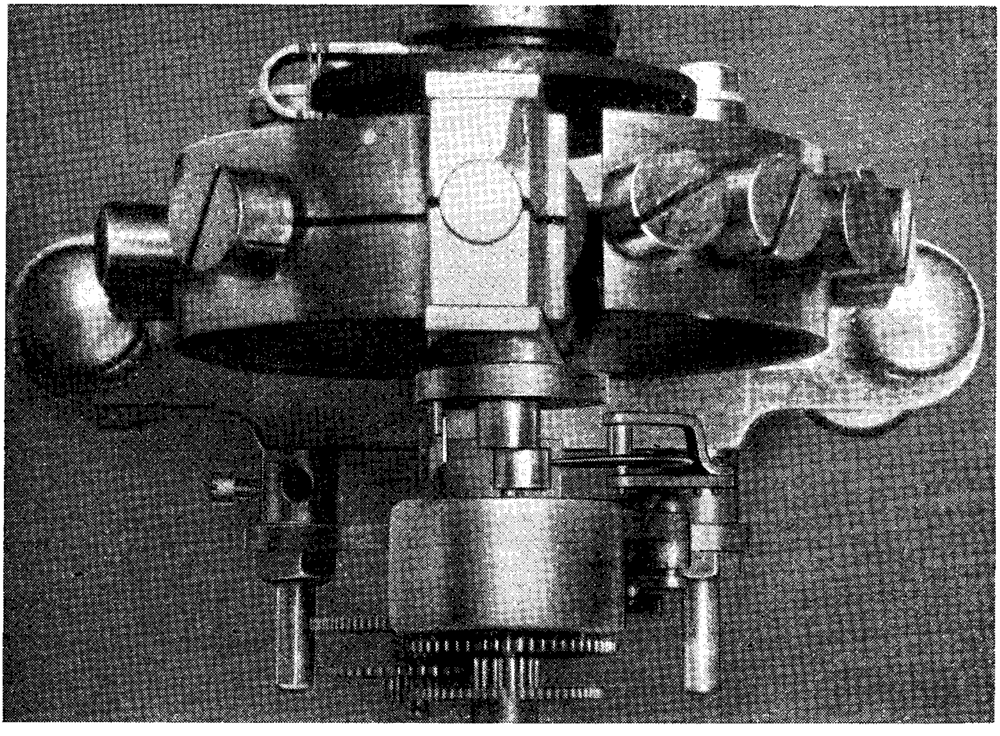
* The " Eureka " Electric Clock

by " Artificer"

FOR the benefit of readers who may wish to construct a clock of this type, or one working on similar principles, some details are given here of the essential working components, with main dimensions, and other useful data, though no attempt has been made to give working drawings which are complete in every respect. It is more than likely that any constructor who undertakes to build such a clock will wish to introduce minor modifications of his own design, or possibly to utilise existing material, such as gear wheels or other clock parts ; and so far as possible, advice will be given regarding the deviations from the set design which are permissible-or even, in certain cases, desirable.



Plan view of " Eureka "clock, showing eccentric and roller-operating ratchet lever

Balance Wheel

The balance mechanism of this clock is the heart of the entire functional system, and also the most difficult, or at least the most complex, part of the clock to construct. As the balance wheel contains the windings of the electro-magnet which provides its motive power, and it is not practicable to wind it in situ, it is necessarily a built-up structure, the several parts of which must be assembled in such a way that the whole runs truly on its pivots. This demands great care and accuracy in machining and fitting the parts.

As will be seen from Fig. 4, the main structural items comprise the round core and two flat side plates of soft iron, which pass across the centre of the wheel, and are joined at their outer extremities by clamp blocks, to which are attached the, two parts of the split bimetal rim. The pivots are mounted in flanged brass cheeks, attached by screws to the two side plates. It is recommended that the mechanical part of the structure should be completely built up and machined before dealing with electrical parts, the winding being done separately and fitted afterwards. This, of course, entails dismantling and reassembly of the wheel structure, but having once correctly machined and assured the true running of this component, it will not be too difficult to set it true on final assembly.

The side plates are 7/16 in. wide by 3/32-in. flat

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strip, and the core piece 5/16 in. diameter round bar, specified as soft iron, but as it may be somewhat difficult to obtain the Swedish " charcoal iron," which is generally represented as the ideal in the electrical text books, it may be mentioned that mild-steel has been found to work quite well for small electro-magnets in which high permeability and minimum retention of magnetism are essential properties. To ensure that it is as soft as possible, it is advisable to take the precaution of annealing it, which in the absence of a muffle or other heat-treatment equipment, is best done by packing the material inside a piece of iron pipe, in lime or ashes, with iron or clay plugs in the ends, and heating the lot up to a bright red, sustaining the temperature for several minutes and then allowing it to cool off naturally. The traditional use of the kitchen stove, and the all-night period of cooling, cannot be improved upon for this operation.

By heating the metal in an enclosed chamber so that it is protected from the atmosphere, little or no scaling or pitting of the surface should take place, but the metal should in any case be cleaned up, and trued if necessary, before proceeding further. It may here be mentioned that it would be an advantage, from the structural point of view to modify the shape of the side plates, making them at least as wide as the diameter of the brass cheeks (7/8 in.) in the centre, and tapering off to 7/16in. wide at each end. This would allow of using three screws for securing each of the cheeks. Better still, the plates may be made wider 'in the centre than the diameter of the cheeks, and thick enough to allow of turning a recess to register tightly over the latter, thereby improving the rigidity of the assembly considerably. Leave a small allowance on the length of the plates for finishing.

Mark out the positions of the centre pivot and the two clamping screws on one of the plates, taking great care to ensure symmetry in both planes, and drill undersize pilot holes ; the second plate is jig drilled from the first, and marked to show relative positions for subsequent location. Next make the two clamp blocks, one in iron and the other in brass ; their final dimensions are 3/8in. by 7/16 in. by 13/16 in., but they are best left oversize on all dimensions at first. Set up each in turn in the four-jaw chuck, crosswise, and drill and ream to a tight wringing fit on the round core piece ; if the only reamer available produces too easy a fit, it is worth while to make a slightly undersize D-bit from silver-steel for this purpose. Press both the blocks on to a mandrel, or on the core itself, and finish the end faces by filing or machining so that they are exactly parallel to the mandrel and equal in distance from it on each side.

The blocks should now be set in their correct positions *between the side plates, with the core piece in position and the holes for the clamping screw drilled through clamp blocks and core, but not to finished size at this stage. Remove the blocks, and tin one end face of each, also the mating surfaces on one of the plates, and sweat them in position ; note that this must be done on one plate only as the other must always be capable of removal. The assembly should be clamped together, with the core in place, and temporary screws or dowels in the holes, while this is being done.

Next dismantle the parts again, and set up the one side plate, with the blocks clamped thereto, on the faceplate for machining the inner concave surface of the blocks to fit the rim of the balance wheel. The centre hole in the plate, for the insertion of the pivot, must be set dead true, and to facilitate this, a temporary plug may be inserted in the mandrel socket and turned down in place to form a close-fitting pilot or spigot. If the sweated joint is relied upon to hold the clamp blocks, very light cuts should be taken on the latter to avoid the risk of their becoming detached ; but this risk can be very much reduced if temporary screws are used in the clamp screw holes, and further security may be provided, if desired, by dowelling the blocks in position as well.

The **Bimetal Rim**

As most readers with horological knowledge are aware, the object of using a split rim made of two dissimilar metals for the balance wheel of a clock or watch is to compensate for temperature errors in timekeeping. The principle is exactly the same as the bimetal strip used in thermostats and " biinkers " as extensively used in electrical apparatus, and it is probable that the idea of these devices was evolved from the methods which had long been used by horologists.

If the rim of a balance wheel is made of solid metal, it is, of course, subject to expansion and contraction with any change of temperature, and thus minute alteration of its diameter takes place, involving similar changes in its radial centre of gravity, or in other words, the moment of its mass. The ultimate result will be that an increase of temperature will tend to slow the clock down, and a decrease of temperature will speed it up. This effect might be very much reduced by making the rim of a metal having a very low coefficient of expansion, such as Invar steel ; but long before metallurgists had bit upon this solution, the problem had been dealt with in another way by the ingenious makers of clocks and watches.

In the normal " compensated balance." the rim is made of two metals which have definitely (not necessarily widely) different coefficients of expansion, the one having the greater expansion being on the outside. Brass and steel are common metals conforming to this condition, and are commonly used. The rim is supported by radial spokes, not more than two or three in most cases, and is split near each spoke, so that the composite rim is virtually in separate sections, each forming a curved strip of the two metals in close intimate metallic contact. When changes of temperature take place, expansion or contraction of the spokes of the wheel alter the moment of mass of the rim at the point of support, but this is counteracted by the behaviour of the bimetal rim sections, which alter their curvature by reason of the differential expansion of the two metals. As the spokes of the wheel expand radially outwards, the free end of the rim curves inwards, and if the wheel is suitably designed, the result is to produce a reasonably exact temperature compensation within the range normally encountered.

Having explained the principle on which the rim is designed, we may now proceed to deal with its construction. The first thing to consider is how the two parts of the rim should be fastened together. Intimate and permanent contact are most essential, and it may be remarked that in the manufacture of precision watches, the normal procedure is to make the spokes and the steel inner portion of the rim in one integral piece,

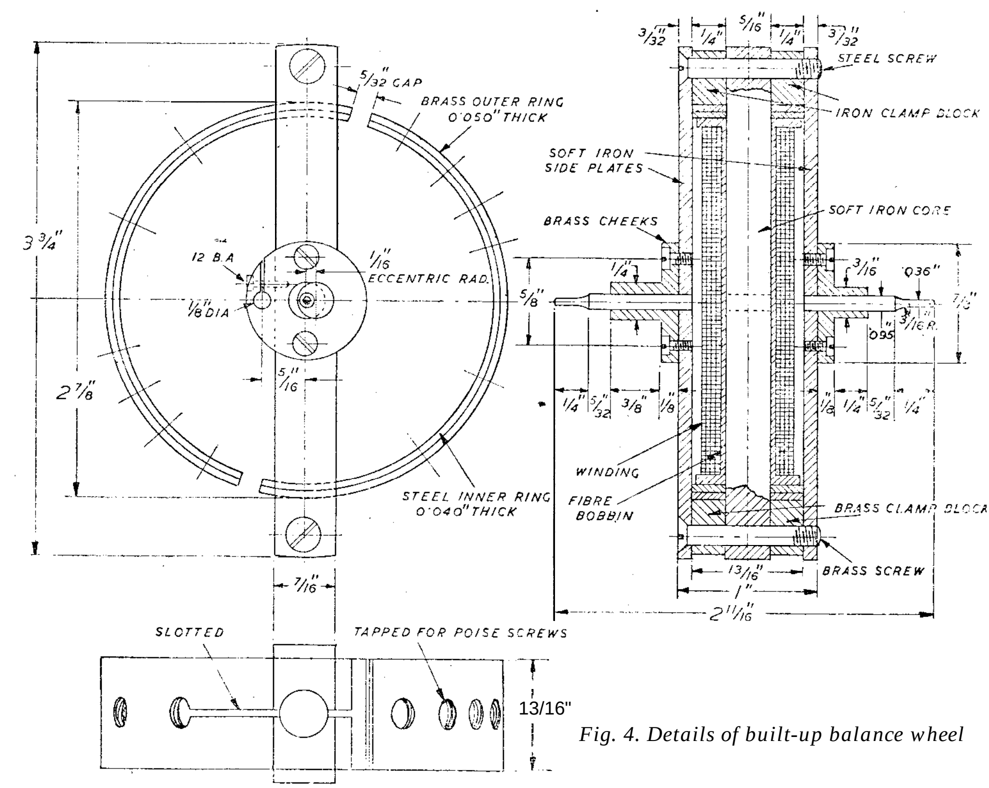

Fig. 4. Details of built-up balance wheel

machined from the solid, and fuse the brass rim on the outside of it. This virtually amounts to casting and brazing on the brass rim at one operation.

It is hardly practicable to adopt this procedure in so large a wheel as we are dealing with here, especially as the spokes cannot be made integral with the steel part of the rim. The next best thing to do is to turn up separate brass and steel rims and silver-solder them together, with allowance for finish machining on outer and inner surfaces respectively. It is essential that the solder should flow perfectly all over the joint surface and no gaps or faulty adhesion patches be- left ; this should not be difficult if sound methods are employed, but constructors who are not confident of their ability to carry out this work may be prepared to take a chance with soft soldering or "sweating " together of the rims. The surfaces should be very carefully tinned all over and the fit should be close so that little solder need be used.

Should the constructor be satisfied with the standard of accuracy obtainable without temperature ccmnensation, a solid rim may be used, preferably of steel having the minimum expansion coefficient, and in this case the subsequent splitting of the rim will not be necessary.

When finishing the machining of the rim, it is essential that the joint line should be maintained in concentric truth, so that the bimetal strips are of *even* thickness. The brass and steel rims, it may be noted, are of different thickness, and these dimensions, in conjunction with the length of the arcs of the rim, are presumably designed to give correct compensation. The completed rim is finally sweated in position between the clamp blocks, and the truth of the assembly checked. If possible, additional security of fixing should be provided by fitting screws or dowels. It will of course be necessary to follow through the radial holes in the clamp blocks, into the rim at each side, and ream right through to take the core. Do not cut the gaps in the rim at this stage.

The brass cheeks for mounting the pivots may now be turned up and drilled through the centre at one setting, then parted off and set up on a pin mandrel to face the inner side of the flange. Note that one of the cheeks has an eccentric machined on its hub, but if desired, this may be made as a separate piece, grub-screwed to the

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A 1/4in. B.S.F. has 26 threads per inch, therefore one thread = 0.0384 in. But one turn of the adjusting-screw will only advance the tailstock 5/1+6 in. or 0.0384, which equals 0.012 ;therefore 1 flat of the adjusting-screw = 0.012 / 6 = 2 thou.

This saves a lot of bother if the tailstock is to be set over a definite amount, i.e., if the tailstock is to be set over 25 thou., the adjusting-screw is turned two complete turns and half a flat.

(8) Carefully draw file and finish with emery cloth one of the machined faces of the tailstock-this is to provide working clearance, as otherwise it will be found that when the guide-strips are tightened hard against the soleplate the tailstock will be locked solid.

(9) Chamfer the ends of two 1/4in. B.S.F. bolts at the same angle as the adjusting slots for use as adjusting-bolts.

NOTE.-Although I have used commercial bolts, I suggest that special bolts be made. These bolts should be slightly oversize so that they move stiffly in the guide-strip. With commercial bolts, all the looseness and backlash has to be taken up before they start moving the tailstock.

(10) Assemble, oil and see if the adjusting-screws move the tailstock, if they do not, more clearance will be required between the tailstock and the guide-strips.

Although this is written as a means of improving a popular type of lathe, the idea could no doubt be adapted to fit a soleplate to a fixed type tailstock so that it could " set over."

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shank of the pivot after assembly, and this may even be an advantage, as it provides some adjustment of timing, which may be useful, in getting the clock to work efficiently. This cheek also has a hole drilled to take the insulating bush of the contact pin, and a sawcut is taken from this hole, tangentially out to the edge of the flange, and fitted with a clamping screw. If it is found difficult to obtain or fit a screw as small as 12 B.A., the flange may be made thicker to permit the fitting of a larger screw, say 10 B.A., or 1/16 in. It may also be noted that the pivot shank, specified as 0.095 in. dia., or 3/32 in., may be increased in diameter with advantage from the structural aspect.

The pivots are made of silver-steel, and it is recommended that they should be made in a single piece for the purposes of initially building up the wheel, the centre part being cut out afterwards ; or better still, a temporary mandrel with the true point centres may be used. Chuck the steel truly, in a collet chuck if available, or failing this, by any method which wiil ensure true running to the closest possible limit, and turn down the ends. In this case also, some increase in the diameter is permissible, indeed advisable, and 1/16 in. or 0.0625 in. is a suitable dimension. The pivot shank registers in the centre holes of the side plates, and locates the cheeks in position on them ; the screw holes for securing them can then be drilled and counterbored, and the screws permanently fitted. In order to allow the pivot shank to pass through the complete wheel assembly, a clearance hole is drilled diametrically through the centre of the core piece, and it is important that this should not bind on the pivot shank or it may spring the wheel out of truth. The shank should be a press fit through the cheeks and side plates, and before fitting it, the ends may be hardened and tempered, and polished, taking great care to ensure a high finish on the radius. When the assembly is put together and spun between centres, it should spin practically dead truly, and if this condition is obtained, the clamp screw holes should be opened out to a dowel fit for the screws-which it will be noted, are screwed only for a sufficient length to engage the tapped holes in the one side plate-and the latter. fitted. In the event of any bad errors in the truth of the wheel, the cause must be sought in inaccuracies of workmanship, in locating or aligning the holes, or the position of the clamp blocks.

At this stage, the end faces of the side plates and the core may be finished by taking a skim over them, but it is not advisable to do this by mounting the wheel on its fragile pivots. It is better to hold one of the cheek flanges by its rim in the three-jaw chuck, assuming the latter to be at least reasonably true, and steady the projecting pivot by a hollow centre in the tailstock. The holes for the poise screws in the rim may be marked out, drilled and tapped ; it will be seen that these are not equally spaced, the four at the free end of each arc being closer than the other two at the fixed end ; but their positions are not critical. Rather large screws, with shanks tapped o B.A., are used, but this feature also is optional, and smaller shanks may be used if desired. The slots for clamping the rim and the blocks securely to the core can most readily be cut by using a small circular saw in the lathe, the core piece, of course, being removed during this operation.

(To be continued)