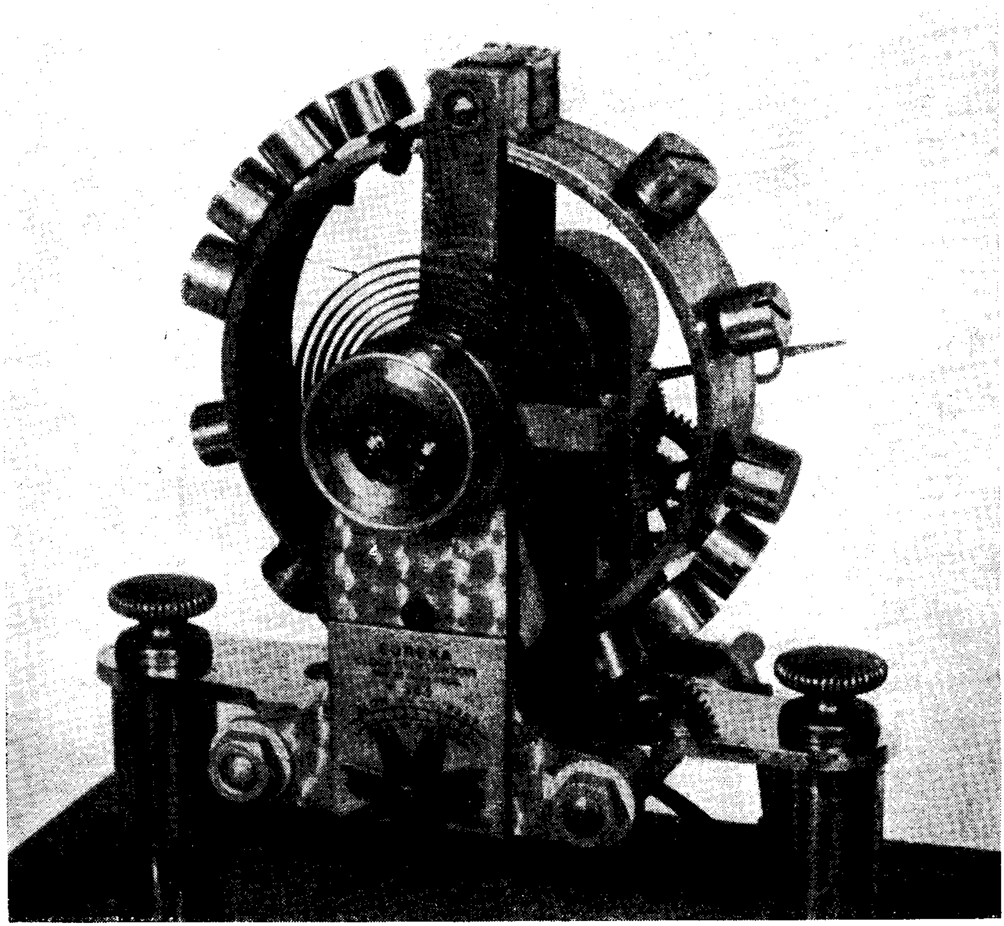
The " Eureka " Electric Clock

by " Artificer "

THE construction of electrically-driven clocks has always;been popular among model engineers, and at nearly every Model Engineer Exhibition, at least one or two specimens of these clocks are represented. But while the workmanship (and presumably, the performance) of these clocks is often extremelv good, and some of them exhibit originality and ingenuity in the details of design, there is comparatively little enterprise among constructors in exploring the broad principles of design, and in utilising the many possible forms of escapements and operating mechanisms which have been devised in the past. It is safe to say that about 95 per cent. of the electric clocks which have been built by amateurs have been either of the Hipp or the Synchronome types, with minor modifications in each case ; and while both these embody unquestionably sound working principles, and if properly made, work most reliably and keep accurate time, there is a strong case for going farther afield and introducing a little more variety in this branch of construction.

The obvious answer which many amateur constructors will make to this criticism is that the two types of clocks mentioned above are the only ones on which any detailed information on construction is available. This is-quite true ; of



The " Eureka " clock movement viewed from *the rear, showing regulator star wheel* two books on building electric clocks which the writer obtained some years ago, one described a number of different sizes and styles of clocks all using the Hipp escapement, while the other dealt with several Hipp clocks plus one Synchronome master and secondary clock. A third book described in detail the construction of a single

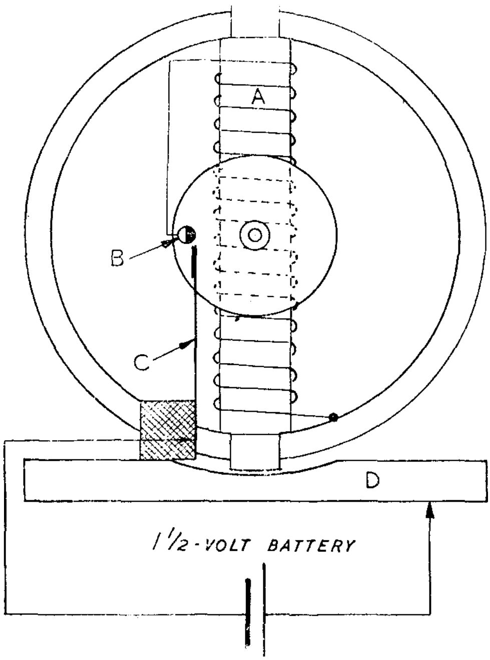


Fig. I. ***Position of balance wheel when at rest***

Hipp clock, while several articles published in THE MODEL ENGINEER and other journals played minor variations on the same old theme. It is in the hope of broadening general knowledge of the working principles of electric clocks, therefore, that the following particulars are given of a type of clock which is notably " different," and despite the fact that it is not claimed to be superior in any way to the popular types of electric clocks, is none the less interesting to the enterprising constructor.

It may further be noted that practically all the electric clocks built by amateurs-with the exception of a.c. mains synchronous clocks, which, one might argue, are ndt really clocks at all -have so far been pendulum clocks; and while there is nothing one can object to about such clocks from the timekeeping point of view, there is no doubt that they have their own particular limitations. The normal form of pendulum is impracticable in any type of portable clock, and if one had to rely exclusively on it, timekeeping at sea would be impossible unless the clock could be held steady by an elaborate gyroscopic stabilising device. While no form of balance wheel is quite equal in ***isochronous*** property to the best form of pendulum, it can be designed so as to show no perceptible inferiority in practice, and it can be compensated for climatic and other variations just as readily as a pendulum.

The balance wheel has been successfully applied to a number of electrically-driven clocks, including some small portable clocks such as those for use in cars or other vehicles. It may, however, be noted that most of the latter may be regarded as more or less normal mechanical spring-driven clocks, equipped with an electric impulse device to wind the spring at regular (and usually frequent) intervals; in other words, they come into a class termed "Remontoire" (self-winding) electric clocks, which present little real interest from the constructor's point of view.

There is, however, at least ***one*** notable example of a balance-wheel electric clock in which the driving impulse is applied directly to the balance wheel so that, like the pendulum of the Hipp and Synchronome clocks, it constitutes the actual driving " motor," and transmits power to the wheel train, which serves the function of an impulse counter and indicating mechanism, rather than a heavily-stressed transmission gear. Herein lies the great advantage of the true electrically-driven clock from the aspect of the amateur constructor; the pendulum or balance wheel, together with its escapement, instead of being a delicate and finely-poised piece of

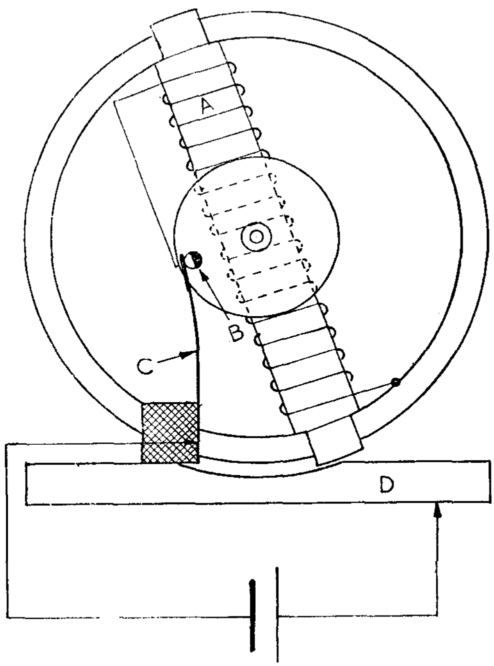
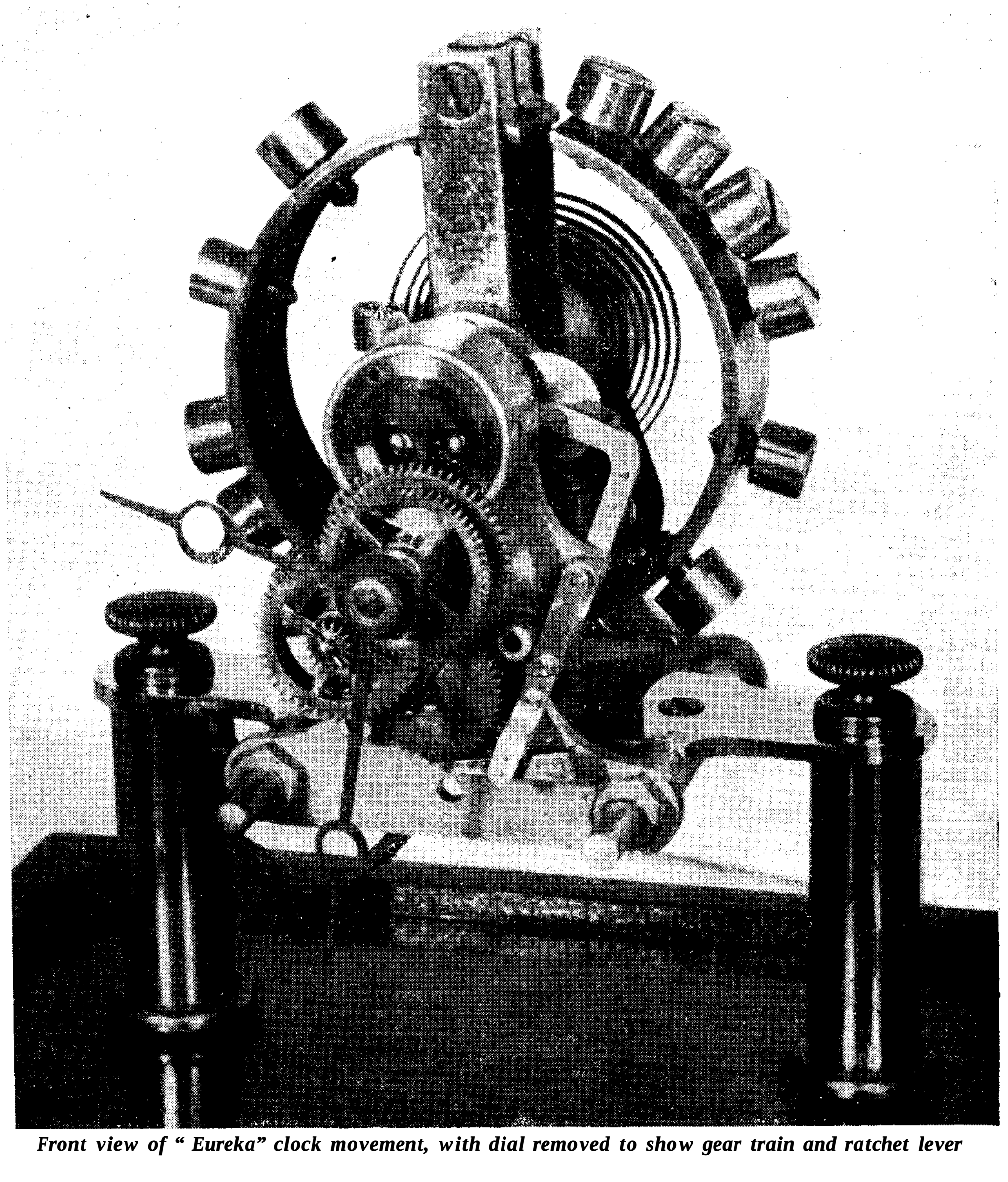


Fig. 2. ***Position of balance wheel at the point of making contact***

mechanism, the adjustment of which demands specialised skill, is heavy and robust, requiring comparatively little finesse in either construction or adjustment. This does not ***mean to say*** that there is not just as much scope for skill and care in the construction of such clocks as in those of the weight- or spring-driven type ; but it is a fact that some excellent results have been obtained with electric clocks of quite unsophisticated or even crude design and construction.

The "Eureka " electric clock, which forms the subject of these articles, was invented in 1906, and was put into production by the enterprise of the brothers Kutnow, of " Kutnow's Powder " fame. Its novel and somewhat spectacular design attracted a good deal of attention at the time, but it proved to be a nine day's wonder, and production was abandoned after about five years. There were possibly several reasons for this, not the least being that inevitable teething troubles were encountered in the early stages of production, and it is more than likely that when such faults as developed were referred to clock repairers, the unfamiliar nature of the mechanism prejudiced their chances of receiving conscientious attention. The examples of these clocks which have been encountered, or on which information is available, bear evidence of un-



Front view of " Eureka" clock movement, with dial removed to show gear train and ratchet lever finished design or tentative experiment, and there are certainly one or two points where the design or workmanship could be much improved. But the clock can at any rate be made to work well and reliably with a very low current consumption, and its inherent timekeeping qualities, though by no means perfect, are probably as good as those of most domestic and portable clocks of the normal type.

Some time ago, the writer was consulted about the repair and *restoration* of a " Eureka " clock 'which had been out of use for many years, and -thanks to the ministrations of someone who had tinkered with it at some time in the past -had several essential parts of the mechanism missing. There was, in fact, *no* visible link-up between the balance-wheel " motor " and the gear train, and though it was not difficult to reconstruct the general design of the missing parts, it was decided that it would be worth while to consult any available information on the original construction of the clock. In the course of this research, which entailed the consulting of all the books on electric clocks which could be unearthed (and incidentally some of them contained totally misleading information, worse than none at all !) and enquiries at South Kensington Museum (much more fruitful) a certain amount of data on this and other unusual types of electric clocks has been acquired. Some further advice has been given on this matter by Mr. F. Hope- Jones, who, as most readers are aware, is a world authority on electric clocks ; and as a result, the restoration of the clock in question has been very successfully carried out. In the hope that the matter will be of interest to many readers? an exact record of the design and working details of the clock in its restored form has been prepared, with some suggestions for possible improvement of the design and methods of construction.

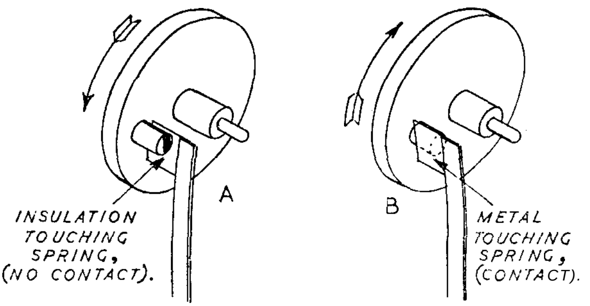


Fig. 3. Action of contact spring on both directions of balance wheel movement

Working Principle of the ," Eureka " Clock

The motive power of the clock is obtained from a large diameter oscillating balance wheel, the general form of which is similar to that of a watch balance on an enlarged scale, including the hair spring. This' wheel is kept in motion by an electro-magnetic device which operates on the same principle as that in any simple attraction motor. It may here be mentioned that in a clock having the motive power supplied by the pendulum or balance, a fairly substantial mass in the latter is most essential. In this case, the balance wheel is 12 oz. in weight, and the diameter over the rim is 2-7/8 in., the outermost diameter over the complete balance system being 3-3/4 in. The rim is of the bimetal compensated type, and fitted with poise screws ; the suspension of the balance is by extended pivots which roll on steel balls enclosed in an oil bath.

An iron bar, A, passes diametrically across the balance wheel, forming the " spokes " on which the rim is supported ; this is wound with a coil of wire so that it forms an electro-magnet when energised with current from a battery. The supply of current is controlled by a contact device which closes the circuit at the appropriate time. Below the balance wheel is a stationary iron plate, *D,* machined away in the centre so as to provide a fine clearance for the tips of the bar as the wheel oscillates.

When the clock is at rest, the bar assumes a perpendicular position relative to the iron plate, as shown *in Fig. 1.* The contact pin, *B,* in the cheek of the balance wheel is just clear of the contact spring, C, so that no current is passing, and the electro-magnet is inert. It will be noted that the contact pin, *D,* is composed of two half-round sections, the one on the left being of metal and the other of insulating material. The spring, C, has an attached tip of contact metal (usually gold-silver alloy), extending sideways, so that the end is shaped like an inverted L. It is adjusted in such a way that the contact pin passes on the right-hand side of it on the upwards swing (see Fig. 3A) and on the left-hand side of it on the downward swing as shown in Fig. 3B ; the spring being in each case displaced slightly in the opposite direction. The metal part of the contact pin forms the terminal point at one end of the magnet winding, the other being earthed to the frame of the wheel, and making connection with the main motion frame through the hair spring. Current is supplied from the battery by connecting one terminal to the base of the contact spring and earthing the other to the frame.

If the balance wheel is now set oscillating by hand, the first swing in the anti-clockwise direction will carry the contact pin past the spring with its insulated portion in contact, so that no current passes. But on the return (clockwise) swing, when the position shown in Fig. 2 is reached, the contact pin will again touch the spring, this time on the metallic side, so that a connection is established through the windings of the electro-magnet, which becomes strongly energised, just as its tip is approaching the concave portion of the iron plate. The result is to cause a powerful attraction of the electro-magnet to the centre of the plate, but by the time it reaches this point, contact will be broken between the pin and the spring, so that the balance wheel will continue to move under its own inertia until this is counteracted by the hair spring. This starts it on the return swing, and the cycle of

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Outside Help

There is no doubt that the key to good model making is knowing the right tools and knowing how to use them. Of course, methods will vary according to the facilities at hand, but the model engineer should not close his eyes to outside help. He may spend hours shaping parts which could be done much better and quicker if the right equipment was available, and this can often be had by joining or forming. an association and making use of a common workshop. The workshop would contain such items as a welding plant, and equipment for brazing and machining. Falling this kind of self-help? in most towns there are several small engineering concerns who would carry out welding and machining operations which are ***outside*** the scope of the individual.

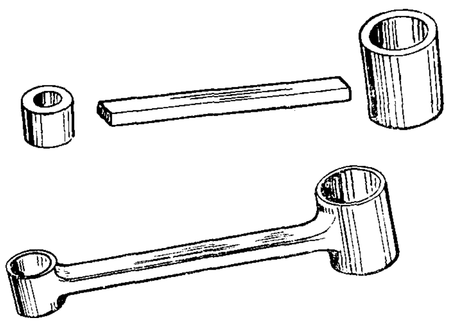

Fig. 10. A fabricated connecting-rod, made by welding steel tube to rod

The use of welding for the modelmaker should not be overlooked. Welding has made great strides in general engineering where parts which took many weeks to make, can now be made in a matter of hours. This is due to " fabrication." Take for instance a model connecting-rod ; instead of making this out of one piece, two short pieces of steel tube are welded to each end of a piece of steel rod, the ends then trued up and reamed. (see Fig. 10). This is a much quicker way and can be lust as good in every aspect. There are many parts which at one time had to be cast or forged and are now made by welding several pieces together. This method is invaluable in model making, for it often happens that it is a one off job, in which ***case*** pattern making and casting is a slow and expensive job.

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events is then repeated indefinitely, so long as current is available to energise the magnet.

It will be quite clear that an essential feature in the function of the clock is that current must only be supplied during the time the magnet is approaching the centre of the iron plate? therefore contact must only be made on one direction of swing. If contact took place on the reverse swing, it would produce an impulse equal and opposite to the first, tending to stop the motion of the wheel. This point is emphasised because it has been stated by one writer in a published description of the '(Eureka" clock that impulse takes place in ***both*** directions of swing ; a statement which caused considerable perplexity when the working of this clock was first investigated by the writer, until it was proved that such action was quite impossible with the form of contact mechanism shown.

The strength of the impulse will be dependent on the e.m.f. supplied by the battery, so that any variation in the voltage, as caused by a gradual running down or deterioration will affect the applied power, and to some extent, the rate of the balance. But the isochronous characteristics of the latter will be similar to those of an ordinary watch balance, which tends to compensate variations of power by altering the arc of its swing, and timekeeping errors from this source are not serious, unless one insists on high precision standards. It would not be impossible, however, to improve on this detail, and introduce a constant-impulse form of contact device if so desired.

So far, only the operation of the balance wheel "motor" has been considered, but obviously some method of " counting " the impulses of the wheel and using them to drive the hands of the clock is essential. The gear train employed for this purpose differs in no practical respect from that of an ordinary clock, but what would normally be the escape wheel is in this case a ratchet wheel, which is fed one tooth at a time by a lever and pawl deriving its motion from the balance wheel system. This is done by providing ***an*** eccentric on the staff of the balance wheel, and a large diameter roller resting on the latter, and mounted on a pivot at one end of the lever. The ratchet mechanism is clearly visible in the photograph taken from the front side of the clock, with the dial removed ; this part of the clock is of course essentially similar to that of the Hipp, Synchronome and many other electric clocks.

The balance wheel is regulated by the usual method of controlling the free length of the hair spring, a rather elaborated geared quadrant being fitted for this purpose, and operated from a pinion with a star wheel on the outside of the motion plate, as seen in the photograph taken from the rear side.

(To be continued)

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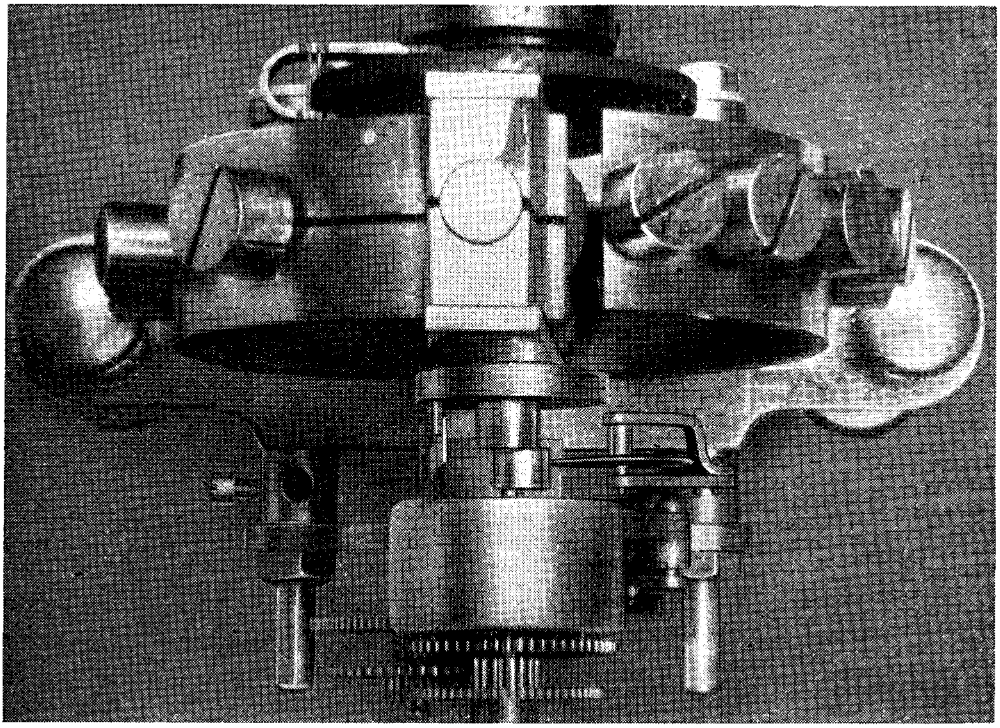
FOR the benefit of readers who may wish to construct a clock of this type, or one working on similar principles, some details are given here of the essential working components, with main dimensions, and other useful data, though no attempt has been made to give working drawings which are complete in 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.

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



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

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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, 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

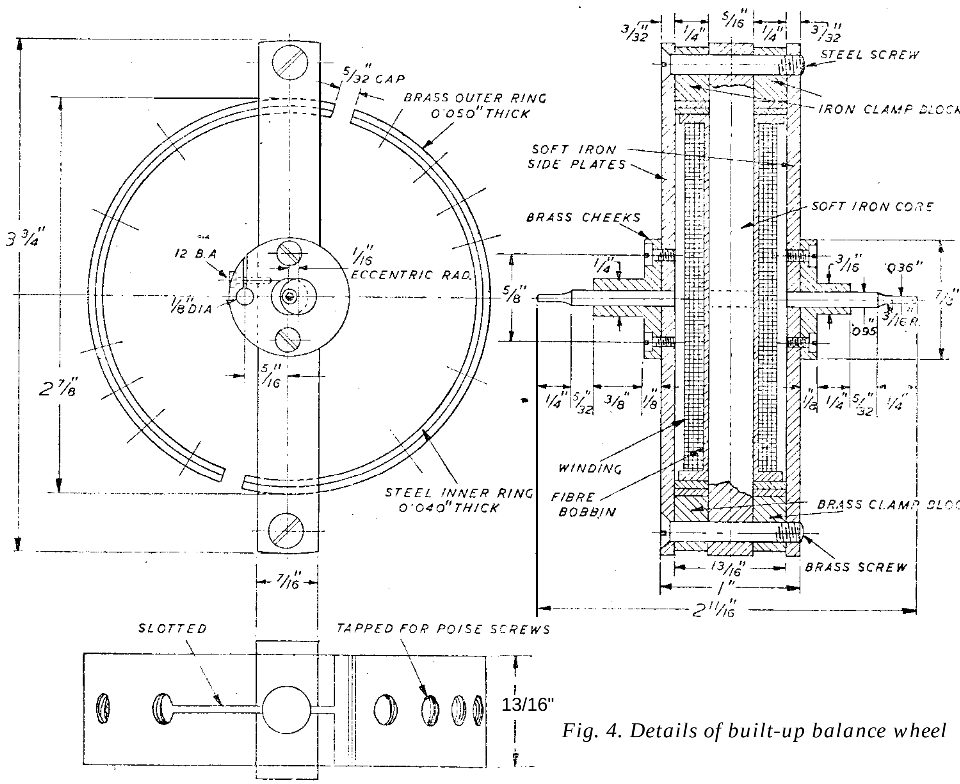

Fig. 4. Details of built-up balance wheel

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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)

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HAVING completed the building-up of the balance wheel, the electrical components incorporated in this unit may be considered. The contact pin assembly, shown in detail in Fig. 5, comprises a fibre or bakelite bush turned to fit the split clamp in the wheel cheek, and drilled 1/16 in. through the centre to take the half-round pieces of metal and insulating material, which should fit fairly tightly, but not so as to risk bursting the bush. A piece of 16-gauge silver wire is recommended for the contact pin, but if not available, nickel-silver (german silver) will give fairly good results. It should be carefully filed to a half-round section, using a micrometer to gauge when exactly half the diameter has been filed away.

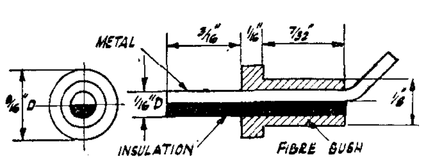


Fig. 5, Details of contact-pin assembly

A piece of glass or quartz rod 1/16 in. diameter is the most suitable material for the insulating side of the pin ; this may be 'obtained from a shop dealing in laboratory glassware, and after the required length is cut off by nicking with a file, it should be embedded in a pitch block and ground down flat on one side on a metal or glass lap charged with carborundum paste. As it may be difficult to gauge exactly how much material has been removed in this case, it may be advisable to do this before making the metal part, and adjust the thickness of the latter to sun. If vitreous material is considered too difficult to work, the next best substitute is a piece of hard plastic material, such as a knitting needle, which is first turned down to the required diameter and then filed half-round. Adhesion between the projecting ends of the metal and insulation can be obtained by the use of a. cement such as Durofix, or by melting in a flake of shellac. When fitted to the bush, and the latter clamped in place in the cheek of the wheel, the pin should be quite secure. The inner end of the metal portion should be bent outwards as shown to form a convenient solder tag for connecting the outer end of the magnet coil.

Winding the Coil

A bobbin for the coil should be prepared, preferably by turning from the solid in ebonite, fibre or bakelite, though it may be fabricated from tube, with end washers cemented on, if this is more convenient. The thickness of the tube and end cheeks should not be more than 1/16 in.; and the bobbin should be a free sliding fit on the core, its overall length being adjusted to fit neatly inside the rim of the balance wheel.

The magnet coil of the clock examined had a resistance of just over 20 ohms, which represents about four layers of No 24 gauge wire. In the writer's opinion, a coil of higher resistance would be an advantage, as the power obtained from the magnet on an input of 1-1/2 volts appears to be greater than is necessary to maintain the swing of the wheel, and is liable to affect the accuracy of timekeeping. The higher resistance would also improve economy of current consumption, with longer battery life and less variation of voltage. It will be noted that most battery-driven clocks in which the impulses are frequent, work best with magnets of high resistance. There is plenty of space in the balance wheel for considerably more turns of the same gauge wire, or, alternatively, a smaller gauge of wire may be used to increase the resistance.

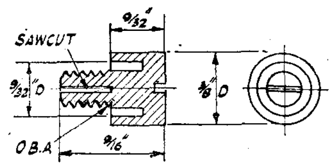


Fig. 6. Poise screws (12 off)

The wire may be either enamel, cotton or silk covered, and the process of winding it is quite simple ; it may be carried out either in the lathe, drilling machine, ***or on*** a hand-driven spindle. There are not enough turns on the coil to make winding tedious. Care should be taken in laying the turns so as to ensure neat and even winding, which, although not important from the electrical aspect, affects the balance of the wheel, as well as its appearance.

The first layer of a coil is always easy enough to lay evenly, but difficulty is often encountered with subsequent layers owing to the slipping of end turns. If this trouble arises, a layer of stiff paper or Empire cloth may be interposed between the layers of wire ; it should be cut to fit the length of the bobbin closely and with a moderate overlap, so that it can be cemented down with Durofix or shellac varnish. When the coil is completed, it should be well varnished externally, the object being not so much to improve insulation, which is not at all highly stressed, in view of the low operating voltage, as to fix the turns mechanically and prevent them moving afterwards. The end turn may be tied in place with silk or cotton thread.

****Continued from page 208, " M.E.," February 17, 1949.***

To assemble the wound bobbin in place, it is, of course, necessary to remove one side of the balance wheel and slide out the core piece ; if the pivot has been made in one piece to serve as a mandrel when building up the wheel, its centre must, of course, be cut out to allow the bobbin to be fitted. If there is any end play of the latter inside the rim of the wheel, paper washers should be cemented to the side cheeks to take this up ; no movement of the bobbin is permissible when the wheel is assembled. The inner end of the coil winding is connected, by soldering or other convenient method, to the wheel structure, and the outer end soldered to the bent inner end of the contact pin. The arrangement of the core piece and side plates, with a single iron clamp block at one end, and the wound bobbin on the core, constitutes a three-limbed or " trident " form of electro-magnet. Assuming the tip of the core, at the end remote from the iron clamp piece, to be a N pole, the adjacent ends of the side plates will both be S poles. This constitutes a highly efficient form of magnet, and when working in close proximity to the armature plate, as it normally should, the system is completely " ironclad," so that there is practically no stray field to reduce efficiency or cause trouble by magnetisation of the hair-spring. A test of the magnet, by connecting a single dry cell between the contact pin and the balance-wheel frame, should show a powerful attractive force when a piece of iron is held near the open poles, with a curent flow of about 75 milliamps at this voltage input.

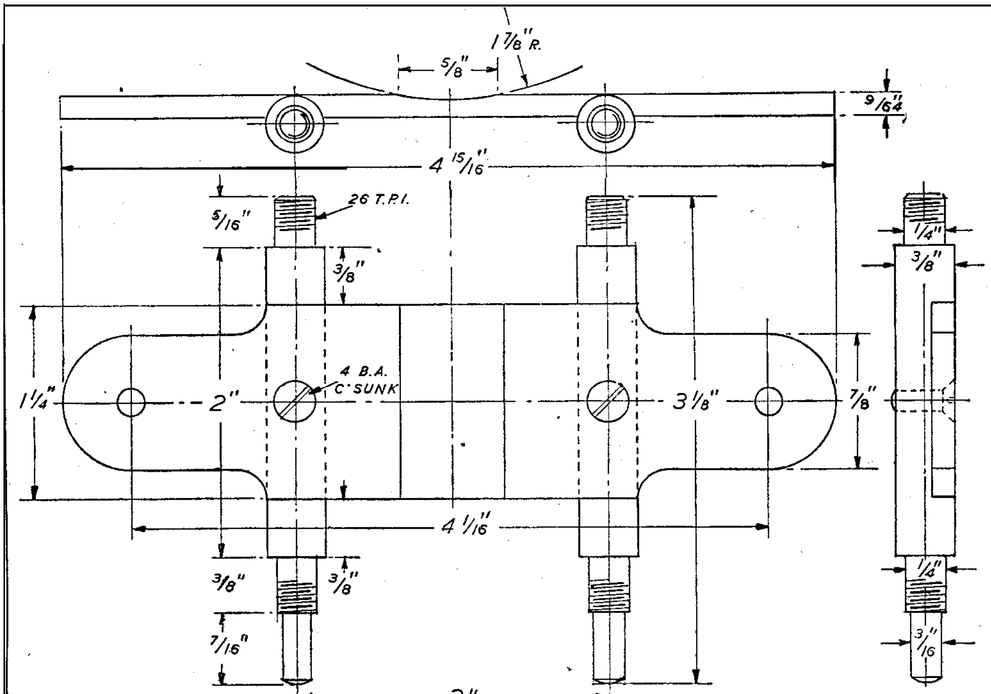


Fig. 7. Armature plate'

Poise Screws

When the complete balance wheel is assembled and spun on its pivots, it should run truly and be fairly well balanced. Any error in this respect should be corrected before going further ; assuming this is in order, however, the rim may now be split in two places, as shown in Fig. 4. The width of the gap is not critical, but the same amount of metal should be removed in each case, to maintain proper balance.

The fitting of poise screws is not absolutely essential, though it is usual in a compensated balance wheel. Both the balancing and the natural period of the wheel are influenced by the poise screws; they may be used to affect the rating or regulation of the clock, but their most useful function in the case of watches is the correction of position errors-that is to say, variation of timekeeping accuracy according to the position and angle of the watch frame. In the case of the " Eureka " clock, in which the position of the balance wheel axis is not likely to vary, this condition does not arise ; but the weight and location of the poise screws also affects the period in relation to the arc of balance wheel swing. Adjustment in this respect may be very useful, though not easy to apply in practice unless one is an experienced horologist.

It will be seen from the photographs that the poise screws are not screwed fully home against the rim of the wheel, and in view of the fact that the shanks of the screws are split to provide a friction grip in the tapped holes, it can be assumed that they were definitely intended to be adjusted in this way. This is, however, contrary to the best watch practice, where the screws are fully tightened, and adjustment of balance or moment made by filing the screw heads, or, conversely, fitting ballast washers under them.

The detail drawing of the poise screws, Fig. 6, shows that an annular groove is machined in the underside of the head, which may possibly have been intended for ballasting with lead or similar

either of brass or steel attached underneath. The latter have flats filed or milled to a depth practically equal to the thickness of the plate, and fitting tightly over the edges of it, so that one screw in each stud will hold it securely. At the ends of the plate, holes are drilled for the screws or studs which secure the vertical pillars by which the entire movement is mounted on its plinth or bedplate.

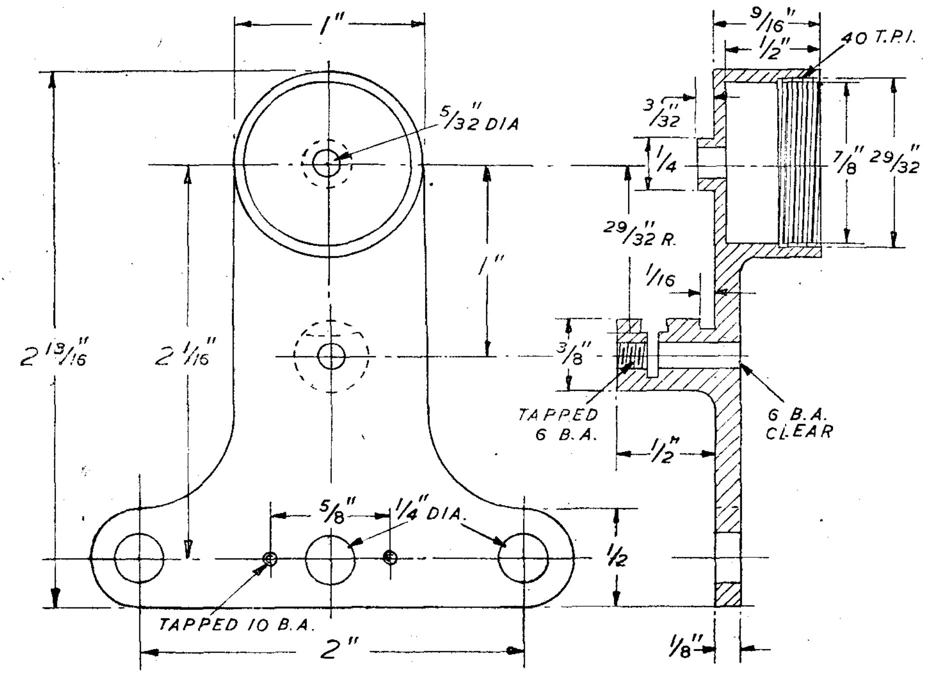


Fig. 8. Rear motion plate

material. As this groove will require a special tool to machine, it may be omitted and the screw head shortened to compensate for the increased weight. All the poise screws, twelve in number, should be of equal weight, and should be adjusted in the rim so that the balance wheel will rest in any position when poised on knife-edges.

The hair-spring may 'be made from a mainspring of a small watch. It consists of approximately 12-1/4 turns, the material being spring steel 0.096 in. wide by 0.015 in. thick. The centre of the spring is attached to a brass collet by swaging into a tangential sawcut, and the collet is mounted on the arbor with a 14-B.A. grub screw, which is convenient for setting the balance correctly in beat. If desired, however, the usual friction-tight split collet may be fitted.

Armature Plate

This is made from annealed iron or mild steel, and forms not only the armature but also the foundation plate of the clock movement. As shown in Fig. 7, it is 1-1/4 in. wide in the central portion, and 9/64 in. thick, with pillar studs made

It will be seen that the centre portion of the plate is machined to an arc corresponding to the radius of the balance wheel pole tips, plus clearance. This can be machined with a cutter held in a boring bar between lathe centres, the plate being clamped vertically to an angle-plate mounted on the lathe cross-slide, with its centre level with the lathe axis. In a small lathe, it will be found necessary to overhang the work to one side of the cross-slide to obtain necessary clearance.

The amount of metal to be removed here is quite small, and it is doubtful whether machining such a short arc has much effect on the magnetic efficiency as compared with a plain flat plate. In the event of difficulty in machining this surface, it is fairly certain that the clock will work satisfactorily with the plate left flat, so long as the working clearance of the pole tips of the balance wheel is suitably adjusted.

Rear Motion Plate

Both the motion plates of the " Eureka " clock are made from brass castings, but they may be fabricated by silver-soldering the bosses on to flat brass plates. The housings for the balance-wheel pivot bearings are integral with the plates, and the rear motion plate, shown in Fig. 8, also incorporates a pillar which serves to anchor the outer end of the hair spring. and also locates the regulator quadrant. A spigot is provided on the inner centre of the bearing housing for the quadrant to pivot on.

plate, 'already referred to, is drilled centrally to take a 6-B.A. screw, and cut about three-quarters of the way across, preferably with a circular slitting saw. The upper part of this slot is then stepped out wide enough to grip the edges of the hairspring; a slight undercut here will be desirable. By tapping the rear portion of the hole, and opening the rest out to clearance size, the pillar will act as a clamp to secure the spring when the screw is tightened.

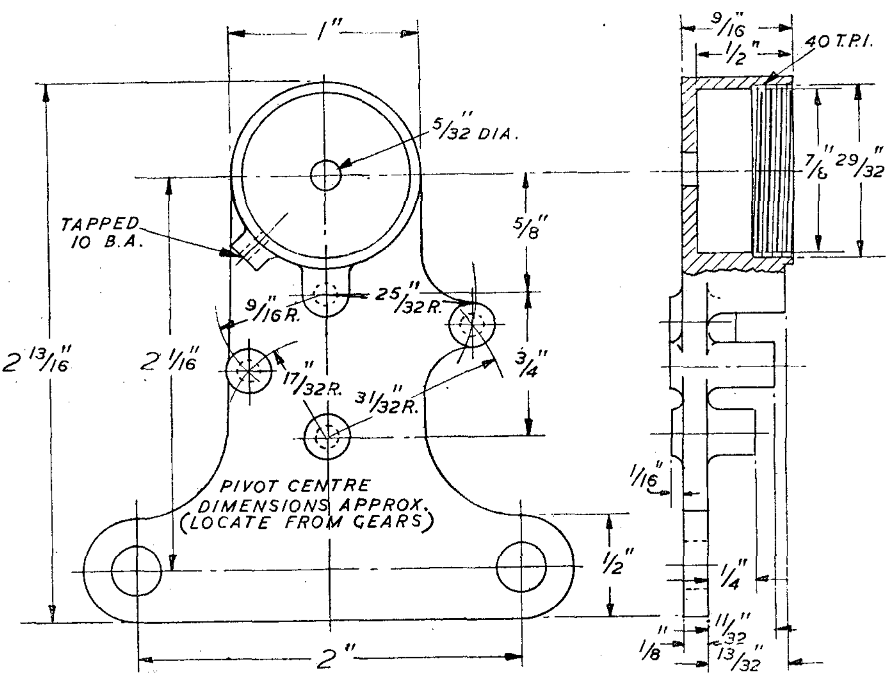


Fig. 9. Front motion plate

In machining the motion plates, the most important operation is the boring and screwing of the bearing housings; which may be carried out by clamping the plates to the lathe faceplate. It is advisable to take a skim over the face of the lower extremity of the plate, where the holes are drilled to fit the pillar studs of the *armature* plate, and afterwards reverse the plate, mounting the housing on a plug mandrel? to face the other and more important side of this surface. The object of this is to make certain that the two housings will be axially in line when the plates are assembled in position; but location in this respect is by no means as positive as it might be, and this feature constitutes one of the structural weaknesses of the clock. It is desirable to provide some means of clamping the plates together, with the housings correctly aligned, for drilling the holes for the pivot studs. The spigot on the rear housing is an obstacle to doing this, and, if desired, it may be made separately and screwed or sweated in afterwards, instead of being integral with the motion plate.

The pillar near the centre of the rear motion

Front Motion Plate

The bosses for the gear-wheel pivots are shown in their approximately correct positions (Fig 9), and whether the plates are cast or built up, this will be sufficiently exact for practical purposes, so long as the actual pivot holes are located by the usual horological methods when setting up the train. But it is extremely likely that some variation of the size or arrangement of the gearing may have to be made for the purpose of utilising existing or readily available gears ; in which case the pivot bosses may be set out accordingly.

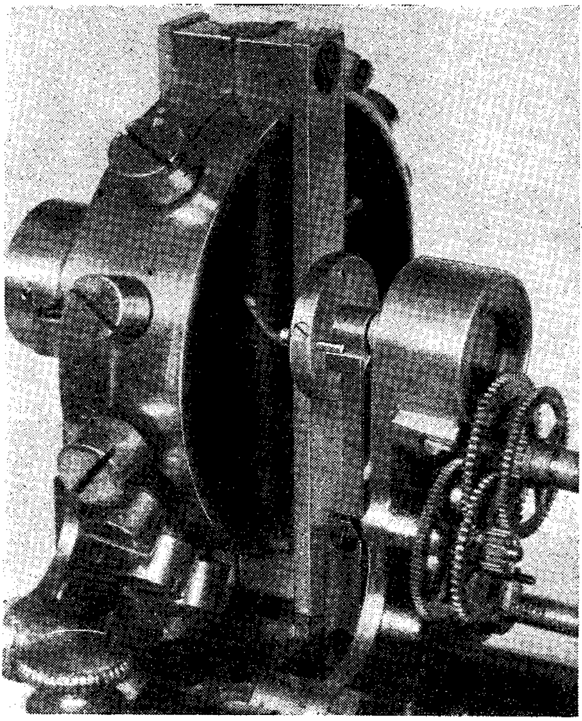
It will be seen that a boss is cast or otherwise permanently attached at an angle under the bearing housing for the anchorage of the spring which acts as the backstop of the ratchet wheel, and the position of this also may have to be modified to suit the gearing. In all other respects, the machining of this motion plate is the same as the rear one.

(To be continued)

*The "Eureka" Electric Clock

by "Artificer"

THE housings in the two motion plates contain the bearings for the balance wheel pivots, which are essentially identical for each side and are of rather unusual design. As will be seen from the bearing assembly design, the pivot rests on two large steel balls, which in turn roll inside a hardened ring or "race," in a very restricted orbit, the limits of which are determined by the holes in the plate which abuts against the outside edge of the race, and is held in place by a glass disc and a screwed retaining ring. The chamber enclosing the ball-race is capable of being used as an oil bath to keep the bearing well lubricated, so long as it is not filled above the level of the pivot clearance-hole, and the clock is not moved out of its normal vertical position.



A close-up of the clock movement, showing contact mechanism and gear *train*

It will be clear that this type of bearing is suitable only for a shaft having an oscillatory motion, as distinct from one which rotates completely and continuously in one direction ; and even then, the extent to which it can provide true rolling motion is very limited, as the balls tend to roll bodily within the race, which they cannot be allowed to do except to a very small extent. Should there be a tendency to exceed this, the balls will rub against the edges of the holes in the plate, causing some friction, and this may possibly be a deliberately designed effect to deter the balance wheel from swinging through too great an arc. To prevent the possibility of the balls becoming wedged in the holes, such as by inertia effects when the clock is moved violently, banking pins are fitted to the inner wall of the housing as an emergency limiting measure, and these also would cause friction if the balls made contact with them.

*Continued from page 253, "M.E.," March 3, 1949.

The endwise movement of the balls is prevented by the inner wall of the housing on one side and the glass disc on the other, and very little clearance should be allowed. It is possible to observe the rolling action of the balls through the glass disc, and also to see that the oil bath contains sufficient lubricant of the proper consistency and cleanliness.

Pivot Bearing Components

Details of the component parts of the bearing are given in Figs. 10, 11 & 12. The ball-race may be made either of silver-steel, hardened right out in oil, or mild-steel case-hardened.

If the pivot journals are made larger in diameter than the specified size, as suggested, it till be necessary to make the inside diameter of the race also larger, and in any case it will be desirable to "offer up" the assembly before hardening, or to make a dummy race to obtain the correct location of the pivots, as near as possible concentric with the housing, but at least close enough to avoid fouling the clearance holes in the latter. The inner surface of the race is parallel, without the concave track usually provided in standard forms of ball-races, and the width of the race is less than the diameter of the ball, by an amount approximately equal to the thickness of the abutting steel plate. After hardening, the race should be highly polished on its working surface.

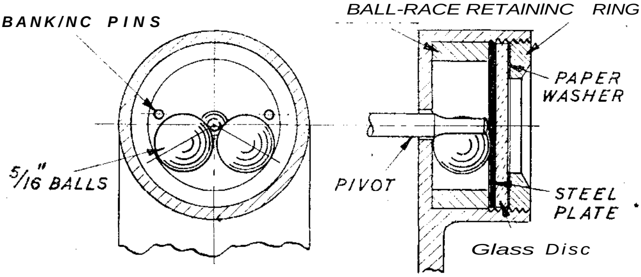
It will be seen that the steel plate is provided with a locating tab, which fits in a keyway or recess formed in the wall of the housing ; this does not extend to the outside of the threaded end, however, and is best formed by drilling, or chipping out with a small chisel. In order to ensure that the holes in the plate are symmetrical, relative to the vertical centre of the housing, it is advisable to locate the plate in this way before marking out and drilling them. Burrs must be carefully removed from the edges of the holes, and they should be polished with the rest of the surface on both sides of the plate, -after hardening. As the plate is thin, case-hardening is not very satisfactory, and it is better to use thin carbon-steel gauge plate or " pen steel " for making it.

There may be some difficulty in cutting or obtaining small glass discs, and the possibility of using a plastic substitute such as Perspex or cellulose acetate may be considered ; but it should be noted that these discs act as end-locators for the steel balls, and it is therefore desirable to use as hard a material as possible. A useful tip for cutting glass circles is to use a chip of tungsten carbide set in a radially adjustable holder like a washer cutter or trepanning tool ; it may be run either in the lathe or the drilling machine.

Should the end clearance of the balls be insufficient to allow free movement, a paper washer similar to the one outside the disc, but having a hole 11/16 in. diameter, may be used between it and the steel plate. It seems obviously desirable to fit a washer in this position, but it was not done in the clock examined. The screwed retaining rings for the housing may be machined in one piece from brass rod, and their, fit in the housings tested before parting off. They each have two blind holes drilled diametrically opposite to each other for the application of a pin spanner. A trace of varnish on the paper washers, and on the threads of the rings, will assist in ensuring oil-tightness of the housing.

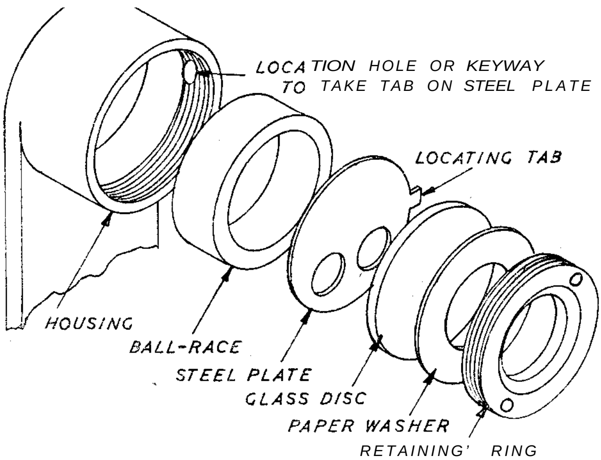
When the motion plates are fitted to the studs of the armature plate, and the balance wheel assembled in place, the pivots should have just perceptible end shake between the steel plates in the two housings. Adjustment of end play can be obtained either by fitting shims on the armature studs or machining back. the shoulders of the studs as required.

Should the construction of this rather elaborate form of pivot bearing be objected to by constructors, an alternative would be to use the smallest obtainable standard ball-race, or better still, one of the tiny Swiss ball-races specially made for instrument work. A cup-and-cone form of bearing like that of a cycle hub, the cone being formed on the pivot and a carefully machined and hardened cup fitted to the housing in place of the parallel ring, is also a possibility, but it should be noted that ball-bearings of this type require close end adjustment to work satisfactorily. Workers who have experience with fine horological work may be able to fit jewel bearings and endstones to the pivots in such a way as to produce little, if any, greater friction than a ball-race.



Left-Fig. 10. Pivot bearing and housing assembly

Below-Fig. 11. Exploded view of bearing assembly



Contact Spring Assembly

This is shown, together with details of the components, in Fig. 13, and it will be seen that the spring is held by means of two 6-B.A. screws, to the vertical edge of a block of ebonite or other insulating material, which in turn is attached to the back of the front motion plate by a single 6-B.A. screw. The contact spring itself is backed up by a check spring of the same material and thickness, to prevent excessive flexure near the root of the free end, and a further backing is provided by a rigid plate of 1/8in. brass strip. All these components are of a simple and straightforward nature, the only point which calls for detailed comment being the tipping of the contact spring with a small L-shaped piece of silver or gold-silver alloy. Both in obtaining the material, and in attaching it to the spring, some constructors may experience difficulties, but in such cases it is probable that nearly any working jeweller would be able to assist in both respects. Silver is quite a satisfactory metal for a contact of this type except for its tendency to tarnish, especially in an atmosphere containing sulphur compounds, as in industrial towns ; but as there is wiping contact of the conductors, they are

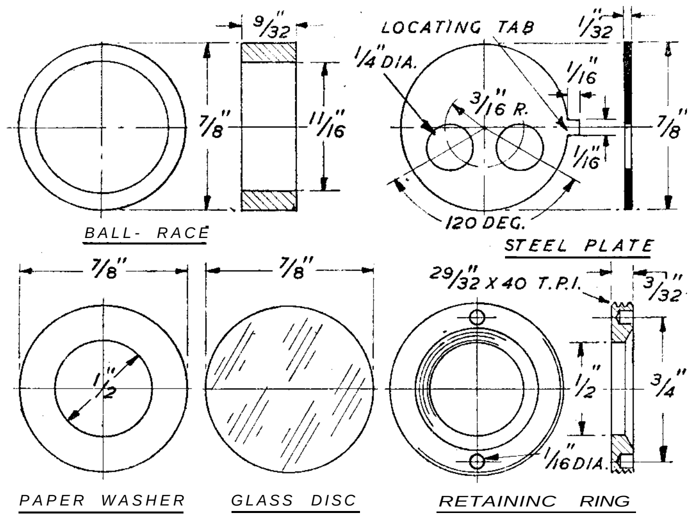


Fig. 12. Components of pivot bearings (less steel balls)

largely self-cleaning when kept in continuous use. The silver-gold alloy, however, does not tarnish, and being slightly softer than the silver or german-silver contact pin, acts as a lap to improve its polish.

The best material for the contact and check springs is a clock suspension spring strip of approximately the specified thickness. This material although finely tempered, can be cut quite easily with sharp shears, and also filed ; drilling, however, may present more difficulty, but it may be accomplished successfully with a glass-hard spear-point drill, made from silver-steel and hardened right out in water at the extreme tip ; it should be run fairly slowly and lubricated freely with turpentine. It will be noted that the screw holes in the contact spring are elongated to allow of slight vertical adjustment ; in this detail, some liberty is taken with the original design, as the actual clock examined had no provision of this kind, but it appears to be highly desirable in order to enable exact adjustment of the contact timing to be obtained.

A small hole is drilled at the extreme -lower end of the contact spring to assist in soldering the lead to it, but this is not absolutely essential, and it may be preferred to drill and tap the backing place and fit a small terminal screw, which would avoid the necessity for a soldered connection, and would be quite satisfactory from the electrical aspect if due care is taken in the metallic contact of the parts.

When the springs are mounted on the block and the latter attached to the motion plate, it is possible to adjust the block by pivotal motion on its single screw, so that the correct action of the contact gear is obtained ; in other words, that the contact pin touches the spring on its metallic side on the clockwise swing, and on the insulated side of the return swing. This action should be possible

(Continued on page 331)

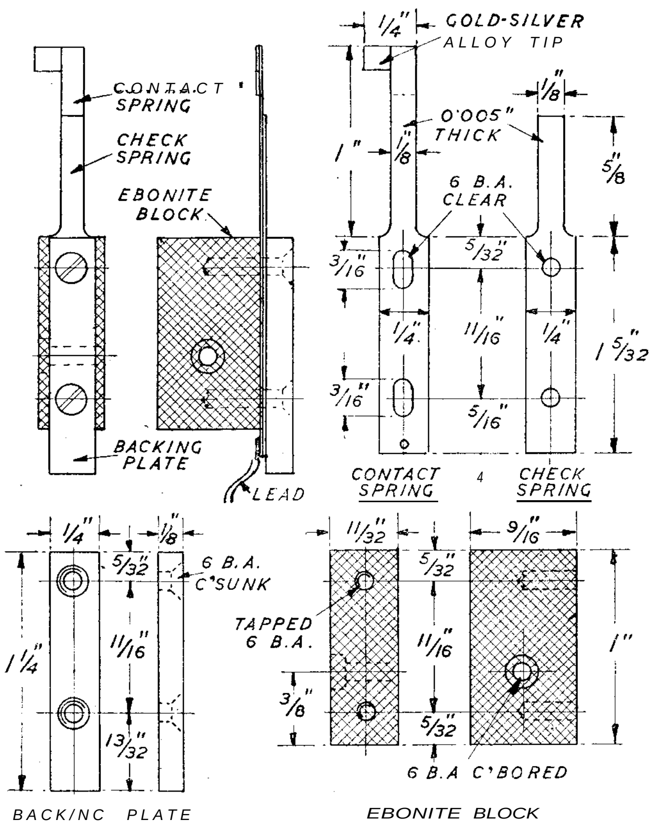
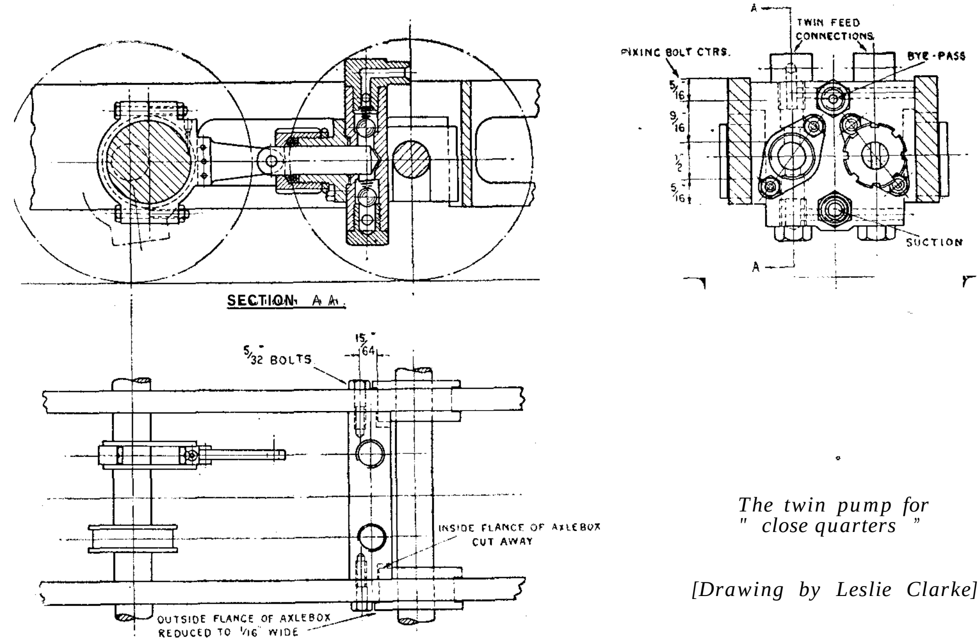


Fig. 13. Details of contact spring assembly



The twin pump for " close quarters "

[Drawing by Leslie Clarke]

practically explains itself. The valve chambers and waterways are all drilled in a very substantial cross-stay, which is set back close to the coupled axle by removing the inside flanges of the axlebox on each side. The pump barrels, which have external glands, are made separately, and attached to the cross-stay by oval flanges, with nuts and studs, as shown in the end view. The two eccentrics are set at 180 deg. or exactly opposite, so that the flow is practically continuous; and the method of drilling the waterways, calls for only one feed-pipe and one by-pass. Two deliveries are shown for clacks on each side of the boiler, but these could be combined into a single delivery if the design of the engine called for it.

The " Eureka " Electric Clock

(Continued from page 313)

without the need for setting or bending the springs themselves, which is not advisable, though a slight twisting of the contact tip may be permissible. Note that very little effort should be needed to flex the spring to the extent of just over 1/16 in. at the tip, as required to operate the contact ; the lightest possible action consistent with just enough contact pressure to conduct the necessary current, will give the best results.

It is now possible to get the balance wheel impulse motor working, though not to get it properly rated at this stage. A hairspring of appropriate length and strength to produce a losing rate should be fitted, and the spring collet adjusted to put the balance " in beat " (i.e., with the core vertical) when at rest. Not more than 1-1/2 volts should be used to energise the motor. Adjust the position of the spring so that contact is established at about 15 to 20 deg. to the right of the dead centre, and broken exactly at dead centre. This will call for careful and possibly patient, manipulation of the spring and mounting block.

When properly adjusted, the action of the balance wheel should be healthy and vigorous, and the current consumption low, so that only a very minute spark, if any, is perceptible at the contacts. The motor may be left running while the rest of the clock-virtually no more than a counting and indicating gear-is completed. Its movement, however, is so fascinating to watch that it may prove to be a distraction if set up in the workshop ; it is best to put it in some other part of the house, where it serves the purpose of a decoy for those admiring but often embarrassing friends who are always " dropping in " when some particularly delicate job is in progress !

(To be continued)

*The " Eureka " Electric Clock

by " Artificer "

A READER has pointed out a rather serious oversight in the details of the balance wheel which were described in the February 17th issue. It will be noted that the soft iron portions of this wheel are arranged to form a three-limbed electro-magnet, the limbs being connected by an iron clamp-piece at the top end, and by a brass clamp-piece at the lower end, so that the magnetic circuit is left open, except for the proximity of the armature plate below the wheel.

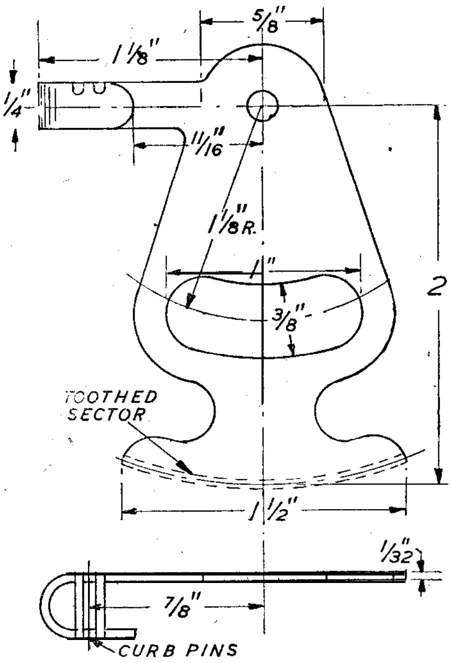


Fig. 14. Regulator quadrant

The object here, of course, is to produce the maximum attractive efficiency between the magnet poles and the armature, and to avoid the stray field which would be caused by an " open" magnet. This is all right as far as it goes, but the correspondent referred to has pointed out that when the bimetal rim is fitted to the balance wheel, the inner (steel) component of the rim will short-circuit the open poles of the magnet and cause a serious loss of efficiency.

As the clock which was restored is not now available for further examination it is impossible to-say how this factor was dealt with in practice ; there is a possibility that the steel part of the rim was made of a non-magnetic alloy, or that a section of non-magnetic material was brazed in at the point adjacent to the lower clamp. It may be found rather difficult to obtain a suitable piece of non-magnetic steel to make the rim, but fortunately there is a much simpler method of eliminating the short-circuit, which will considerably reduce the loss of efficiency from this source, and can be applied even if the wheel has already been fabricated.

The remedy consists in counterboring or trepanning away the portion of the rim surrounding the core at the lower end, to a diameter of. 5/8 in.,which will leave a clear gap of 5/32 in. all round the core. This operation can be carried out by means of a cutter mounted on a 3/16in. bar by a grubscrew, and does not necessitate dismantling the wheel, except for the removal of the core and the exciting coil. As the removal of this metal will affect the balance of the wheel, it may be replaced by a washer of brass or other non-magnetic materia!, which need not be positively fixed in place so long as it is prevented from rattling about when fitted.

Regulator Gear

In principle, the regulator of the " Eureka " clock is identical with that of any ordinary watch or balance clock, consisting of a quadrant mounted concentric with the balance wheel pivot, and capable of partial rotation around it, having an arm fitted with curb pins which control the motion of the hairspring near its fixed end,

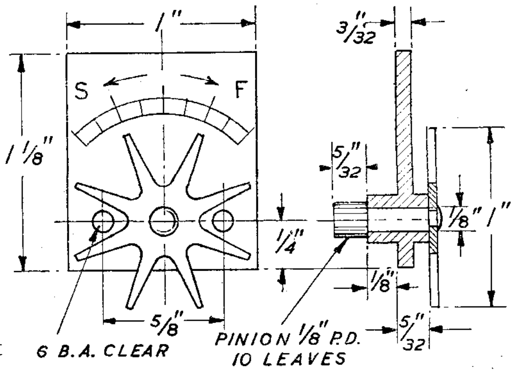


Fig. 15. Regulator pinion, star wheel and rating plate

and thereby influence the rate of vibration. The effect is virtually the same as altering the length of the hairspring, which could not be done in practice without putting the balance "out of beat."

The details of the " Eureka " clock regulator are given in Figs. 14 and 15, but it is considered

*Continued from page 331, " M.E.," March 17, 1949.

that they are needlessly elaborate, and confer no practical advantage over the simpler form of regulator as fitted to a cheap alarm clock. Only if it is desired to construct a faithful replica of the original clock is it considered worth while to follow these details exactly. It will be seen that the regulator quadrant is equipped with a toothed segment, engaging a pinion carried in a plate attached to the rear motion-plate of the clock, and fitted with a star wheel on the outside, by means of which it is operated. The quadrant plate has a 1/4 in. pivot hole which fits over the spigot of the rear balance pivot housing, and is retained in place by fitting a washer over it and lightly burring over or expanding the end of the spigot, so that it moves with some friction. A curved slot is cut in the lower end of the quadrant, which is located by springing it into a slot at the root of the boss which clamps the end of the hairspring, and this boss also limits the motion of the quadrant, preventing the sector from moving far enough to get out of mesh with the pinion.

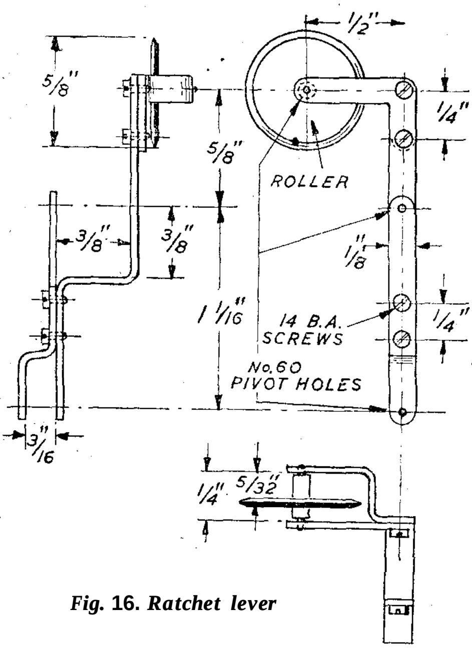


Fig. **16.** ***Ratchet lever***

The arm extending horizontally from the quadrant is bent U-shaped at the end, and notches are cut across the span, into which brass curb pins approximately 1/32 in. diameter are sweated. Under working conditions, these allow a little play for the hairspring, which passes between them, and should touch each of them in turn as it expands and contracts with oscillation of the balance wheel. By moving the quadrant towards the anchorage of the spring, its effective free length is increased and the clock is slowed down ; movement in the other direction has the reverse effect and increases the working rate.

If it is decided to simplify the regulator, it is suggested that the pinion, pivot plate and star wheel may be entirely omitted, also the toothed sector of the quadrant, but the latter should then have a second arm extending upwards for operating purposes. A rating plate may be fixed to the pivot housing to indicate the position of the arm, and show the direction in which it must be moved to produce a faster or slower rate.

Ratchet Lever

As already mentioned, this component was entirely absent when the clock was submitted for restoration, and has been produced from first principles, so there is no guarantee that it is identical with the one originally fitted. The form in which it is made is somewhat elaborate, involving the use of three separate parts held together by 14-B.A. screws, and a simpler construction, with the parts fabricated by sweating or riveting would serve just as well, but it should be noted that the construction was experimental and tentative, and several alterations were called for before it produced the desired result, so that a method of construction which conferred some measure of mutability was clearly indicated. (Fig. **16.)**

The top end of the lever is extended at right angles to its main length and carries a large diameter disc roller, which is reduced to a narrow rounded edge and polished to reduce friction when in contact with the eccentric on the balance staff. This may be turned from the solid, as the more orthodox horological method of making it separate, fixing it to a brass collet, and mounting the latter on an arbor, confers no practical advantage, and entails much more work. Mild-steel, case-hardened on the working surfaces is a suitable material and easier to machine than a carbon steel which could be hardened and tempered. The pivots should be highly polished and made a little larger than the holes in the lever, which are broached to a working fit ;

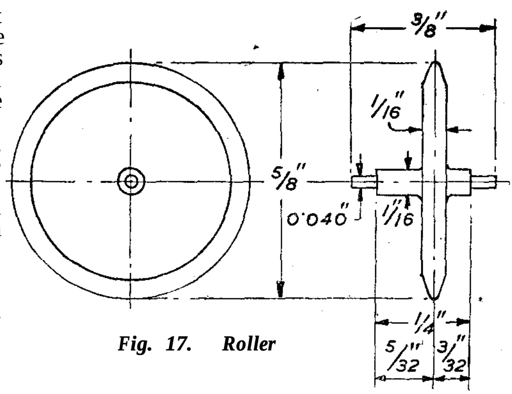


Fig. 17. Roller

this applies also to the other pivot holes for the feed pawl and the lever itself. (Fig. **17.)**

Case-hardened mild-steel may be used also for the pawl, similarly turned from the solid, complete with its pivots, and filed to the shape shown. Before hardening, it should be tried out in position to check up on the shape of the point, which should fit the ratchet wheel teeth when at the end of its working stroke. The lever pivot is a double-ended arbor which is, a press fit in the boss of the front motion-plate, so that the lever straddles the plate when in position. Note that the feed pawl must be made tail-heavy, so that it is kept in engagement with the ratchet wheel by gravity. (Fig. 18.)

The backward movement of the ratchet lever, and the depth of " bite " of the pawl, are limited by banking pins fitted to the front motion plate ; in the former case, the pin prevents the roller following the eccentric right to the bottom of its stroke, so that under conditions of variable balance action, the length of stroke of the pawl is fairly constant, or at any rate, never sufficient to enable it to gather 'more than one tooth of the ratchet wheel. But if, for any reason, excessive swing of the lever takes place, the second banking pin over the pawl prevents it rising too high so as to gather a second tooth or jam through engagement at too steep an angle. As it is very difficult to determine the exact positions of the banking pins beforehand, they are-located as close as possible to their presumed positions and adjusted by bending.

The ratchet wheel is prevented from moving backwards, on the return swing of the ratchet lever, by a simple backstop spring, which, as already mentioned, is anchored by a screw to a lug cast on the motion plate, below the pivot bearing housing. This spring should be very light, or it will be noisy in action and also cause unnecessary friction in operating the ratchet wheel. A piece of pendulum suspension spring, bent at the end to the shape shown in Fig. 19, may be used for this purpose, and the hole for the anchoring screw may, with advantage, be elongated so that the spring can be adjusted to a nicety, to drop lightly into engagement with the teeth of the wheel as the ratchet lever comes to the end of its stroke.

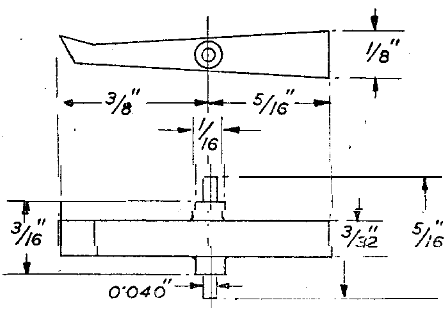


Fig.* 18. *Feed pawl

Wheel Train

The method of fitting the train of wheels in this clock is unusual, and it avoids the necessity of providing a pair of motion plates to accommodate both ends of the arbor pivots ; but in other respects it is of dubious advantage, and probably causes more friction than the normal arrangement of wheels on arbors pivoted at both ends. As it is more than probable that any readers interested in the construction of such a clock will either utilise an existing wheel train, or have their own ideas on its arrangement, it is not proposed to devote much space to its description, but the spacing and numbers of teeth in the wheels and pinions are illustrated in Figs. 19 and 20, the latter being in the form of a diagram in which it is assumed that the pivots are in line vertically for the sake of clarity.

A rather peculiar, and in some respects inconvenient, feature of this wheel train is that the pitches of the wheels and pinions are not all the same ; this has no doubt been done in order to

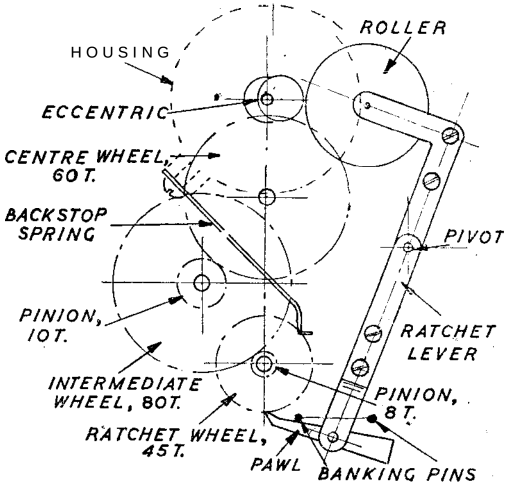


Fig. 19. Arrangement of ratchet* gear and *main wheel train

enable the "motion " wheel and pinion (that is, the intermediate element of the compound train required to reduce the speed of the hour wheel to 1/12 that of the minute wheel) to run on the same. arbor as the intermediate wheel of the main train. But here again the advantage is questionable, and it probably would be much simpler, particularly for readers who have to collect suitable gears or cut their own, to avoid the use of " mixed " pitches. 'The intermediate motion wheel and its pinion would then have to be fitted on a separate fixed stud, as it is in most normal types of clocks. Apart from the motion work, which must obviously provide a 12 to 1 reduction, it is not imperative that the reduction ratio of the main train should be the same as that specified, providing that the number of teeth in the ratchet wheel is modified to produce the correct " count," and drive the train at the correct rate for accurate timekeeping.

It may be remarked that some " Eureka" clocks have been made with the gearing and motion work disposed differently to that of the example shown, and in this respect, constructors may exercise their own fancy or preference. The example dealt with has an open dial, fitted with two sockets which push over the spigot extensions of the armature plate studs, and are secured with grubscrews. The entire movement is mounted, by the lugs of the armature plate, on two vertical pillars, which are in turn bolted to the top of a hollow plinth which houses the battery-a' large capacity single dry cell. A domed glass case is presumably intended to be fitted to protect the mechanism from dust, though this was missing in the particular specimen.

Supporting Pillars

These are shown in detail in Fig. 21, and it will be seen that they are of composite form, and one of them is devised to form a conduit for the battery supply lead, so that the latter can be kept invisible, or at least unobtrusive. This is

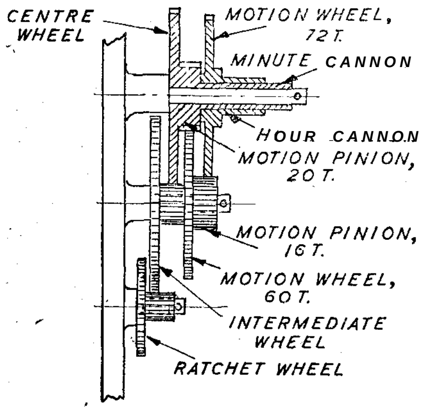


Fig. 20. Diagrammatic side view of wheel train

another optional feature, but many constructors would consider it simpler to machine the pillars from solid brass-with or without a drilled passage for the lead. Alternatively, one of the pillars, or its centre bolt, could be insulated and used as a lead-in conductor. The other terminal of the battery is of course " earthed " to the frame of the clock, and polarity of the connections is of little importance.

In the description of this unique and interesting type of clock, the writer has attempted to furnish sufficient data to enable the intelligent reader to build a clock working on similar principles, if not identical in detail. Many thanks are due to several helpers in this research, including Wing Commander J. Fitzpatrick Lewis, who first introduced the particular example to the writer's notice ; to Mr. F. Hope-Jones, of the Synchronome Co., and the staff of the South Kensington Science Museum, for technical and historical data ; and last but not least, to Mr. J. Message of the " M.E." Workshop, for assistance in the practical work of restoration, and preparation of notes and sketches.

Readers' Comments

Due acknowledgments are made to the many readers who have written to the writer or the Editor on the subject of the " Eureka " or other unusual types of electric clocks. Some of the letters express an adverse opinion of the clock or criticism of its design, but in nearly all cases they show real interest in the subject, and ask for further articles on similar topics.

It is not possible to publish all these letters in detail, or even to quote from them, but one or two have been selected by the Editor as containing matters of general interest, and will appear in the Practical Letters columns of THE MODEL ENGINEER in due course. One rather incoherent correspondent, however, has accused the writer of " cheap sneers " at the constructors of Hipp or other simple pendulum clock, though such a thing was certainly never implied or intended. It is true, as he points out, that such clocks are easy to build with simple equipment, and perform accurately and reliably; but this fact, so far from being denied by the writer, was clearly stated and indeed emphasised in the introductory article on the "Eureka" clock, together with the motives for bringing the latter to the notice of readers.

Another reader asks " what 'is the significance of the title ' Eureka' applied to this clock?" That is a matter beyond the cognisance of the writer, and might be answered by another question-what's in a name ? But from hazy recollection of ancient history, the name recalls the legend of old man Archimedes tearing through the streets of Athens in nudist uniform, leaving a trail of soapsuds, and yelling " I have found it ! " -on the memorable occasion when he hit upon the method of finding the specific gravity of metals. By inference, one may suppose that the emotions, though probably not the actions, of the

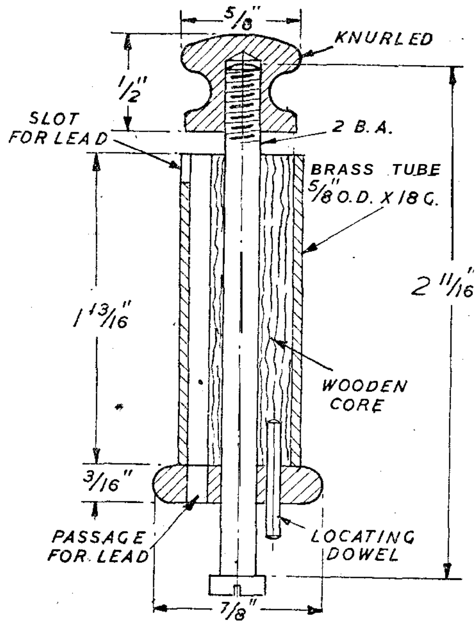


Fig. 21 Supporting **pillars, 2** ***off (one only drilled and located to form lead conduit)***

inventor of this clock were similar-in other words, he must have believed that he had really " got something." But carrying deduction still further, it is possible that after the disillusionment caused by the abortive efforts to exploit the commercial production of the clock, he may have had another search through the Greek dictionary to find the appropriate term for that much sadder phrase " I have had it ! "