ME JUBILEE ELECTRIC CLOCK

Completion of the contact unit

EDGAR T. WESTRURY
deals in this instalment with the completion of the contact and the making of the electro-magnet

Continued from 19 June 1958, pages 782 to 784

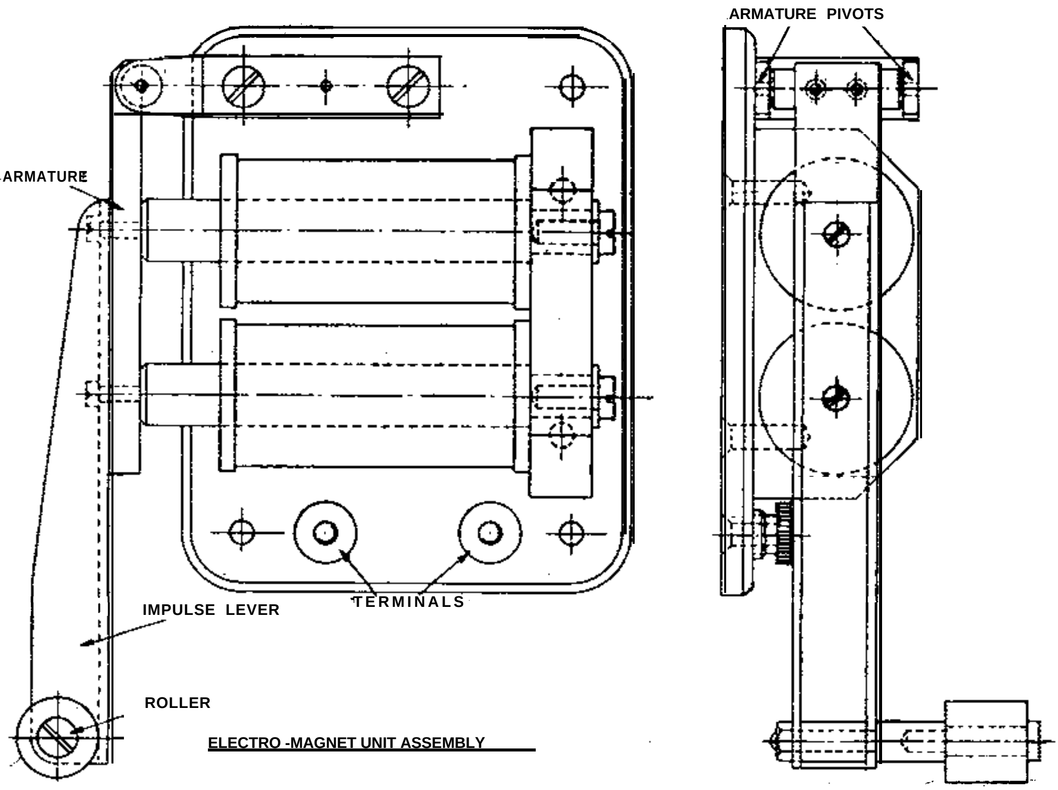
THE contact blade, in the form originally constructed, proved to be somewhat difficult to adjust, both vertically and laterally, so it has now been modified to incorporate a slotted slide and an adjustment screw, the actual blade being shortened to economise in. material and also to give a somewhat heavier loading without imposing too much friction on the wiper.

It will readily be understood that while it is desirable to avoid drag on the pendulum during the period of contact, a fairly firm pressure is necessary to establish a sound electrical connection.

As will be seen from the detail drawings in the last instalment of June 19 the blade is now attached by rivets or screws to a strip of 1/16 in. brass, bent U-shaped, and in its turn attached to a thicker strip which carries a knurled screw? and is also slotted to allow of a limited movement in the groove of the contact block. These two strips may be riveted or sweated together into an integral part if desired; I used 10 BA screws to attach the blade, as it was anticipated that it might be necessary to remove or replace it in the course of experimental work.

The best material for a contact of this nature is silver, or silver-plated bronze, but there is some difficulty in obtaining this and so far good results have been obtained with phosphor-bronze or beryllium-copper alloy. As the contact surfaces rub against each other, they are self-cleaning, so long as the current is not so heavy as to cause excessive sparking at the break.

The shape of the contact blade at the working end has been altered, in order to give a shorter period of contact, as a prolonged contact was found to be of no particular benefit, and tended to make adjustment more critical.



ELECTRO-MAGNET UNIT ASSEMBLY

Since the original article in the series was published, I have had some useful advice on the subject of contacts from a reader who is a specialist in electronics, and who has brought to my notice the availability of a ready-made contact device which should be applicable to this particular purpose. I am following this up closely and hope to be able to report on it in due course, as contacts have always been the " Achilles heel " of the electric clock and anything which can be done to improve them or make them more reliable deserves very careful consideration.

The adjustment screw, pressing on the lower limb of the bent strip, enables it to be sprung downwards, to adjust the tip of the blade to exactly the correct vertical position, and it is locked by the knurled nut. To adjust the timing of the contact, the blade assembly can be moved sideways in the groove of the block, and locked by the setscrew, which may also serve as a terminal; a hexagon-headed screw will be found more readily accessible here than one having a slotted head. Adjustment for the arc of pendulum swing is obtained by shifting the bracket which carries the detent-lever on the pendulum rod.

Electra-magnet unit

This is a relatively simple and robust unit,. which does not involve any very delicate machining operations or adjustments. The panel is identical in size and shape with that of the contact unit, and the fixing holes at the corners also correspond, so that as previously explained, the two panels can be bolted together and shaned at one ooeration.

In the magnetic circuit it is obviously desirable to use material of high permeability and low retentive properties-in simpler terms, easily magnetised and de-magnetised. Usually in such cases, soft or " Swedish" iron is specified, but it is not easy to obtain any special or unusual material nowadays; there is a very pure form of iron produced by electrolytic methods, known as Hecla, but I have not been able to trace the source of supply. It would also be possible to use laminations of magnetic alloy such as Stalloy, or Standynis, which would certainly have a high efficiency, but would tend to complicate construction.

A satisfactory substitute

It has, however, been found that ordinary mild steel, if well annealed by " soaking " at red heat in an enclosed box (to exclude carbon) for an hour or two, and allowed to cool very slowly, gives quite good results. This process should. of course. be carried out before machining or finishing to shape the essential parts, in case of scaling or distortion. There is no special need to machine or polish the outside of the cores, provided that they are chucked fairly truly for turning down the spigots, which should be a good fit in the holes in the yoke; the length should be the same for both cores.

Detachable cores

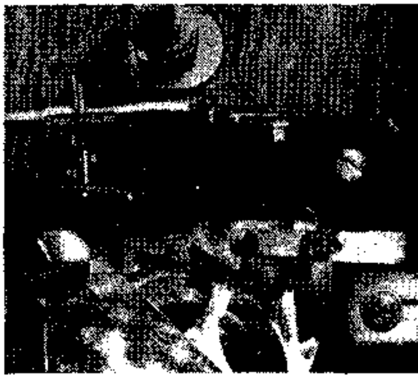
Although detachable cores are not an essential feature, and they may, if desired, be permanently pressed' or riveted into the yoke, it is an advantage to fit them, especially if the coils are wound directly on the cores to dispense with the need for bobbins; in the latter case. fibre cheeks should be made, a press fit for the cores, to locate the windings. When the cores are in place and the yoke secured to the panel, the pole faces should present a flat seating for the armature surface.

There is scope for experiment to find the most efficient winding specification for the particular conditions of working, and the supply voltage. In this part of the design, I have been greatly assisted by Mr J. W. Cooper, who has produced two sets of windings for the magnet, and has also helped me to explore further ideas in the development of the electrical parts of the clock. The most suitable winding so far tried is 1,600 turns (i.e. 800 per coil) of 26 s.w.g. enamelled copper, giving a resistance of 8.2 ohms, with 4-1/2 volts input; but both higher and lower voltages can be used successfully by suitable adjustment of the number of turns and gauge of wire employed, so that the wattage and ampere-turns remain substantially the same in all cases. The fitting of terminals is optional, but useful and convenient.

Swinging armature

The armature is of the same material as the magnet cores and yoke, in the form of a rectangular bar, 1/2 in. x 3/16 in.,suspended to swing freely from a cross pivot at the upper end. the latter being turned from 1/4 in. silver steel, taking the usual care to finish the working surfaces. It is attached to the flat bar in such a way that the pivot centre lines up with the inner edge of the bar, which can be done either by cutting a flat on the centre of the pivot? down to half its diameter, or groovmg the bar to the same depth. Either screws or rivets may be used for fixing the two parts together.

Two strips of brass. 3/8 in. wide x 3/32 in. thick, are used "to make the bearings for the armature pivot, the one at the back being flat and that at the front being bent twice at right



Contact blade as finally jitted to the experimental clock, shown at the instant of making contact. (Not identical with drawings which incorporate detail improvements)

angles to form a half-bridge, or " cock " as it is called, spanning the centre body of the pivot. In horological practice, a cock is usually made from a casting or cut from the solid, in either case producing neat sharp corners instead of rounded bends; but from the practical point of view there is no special advantage in this.

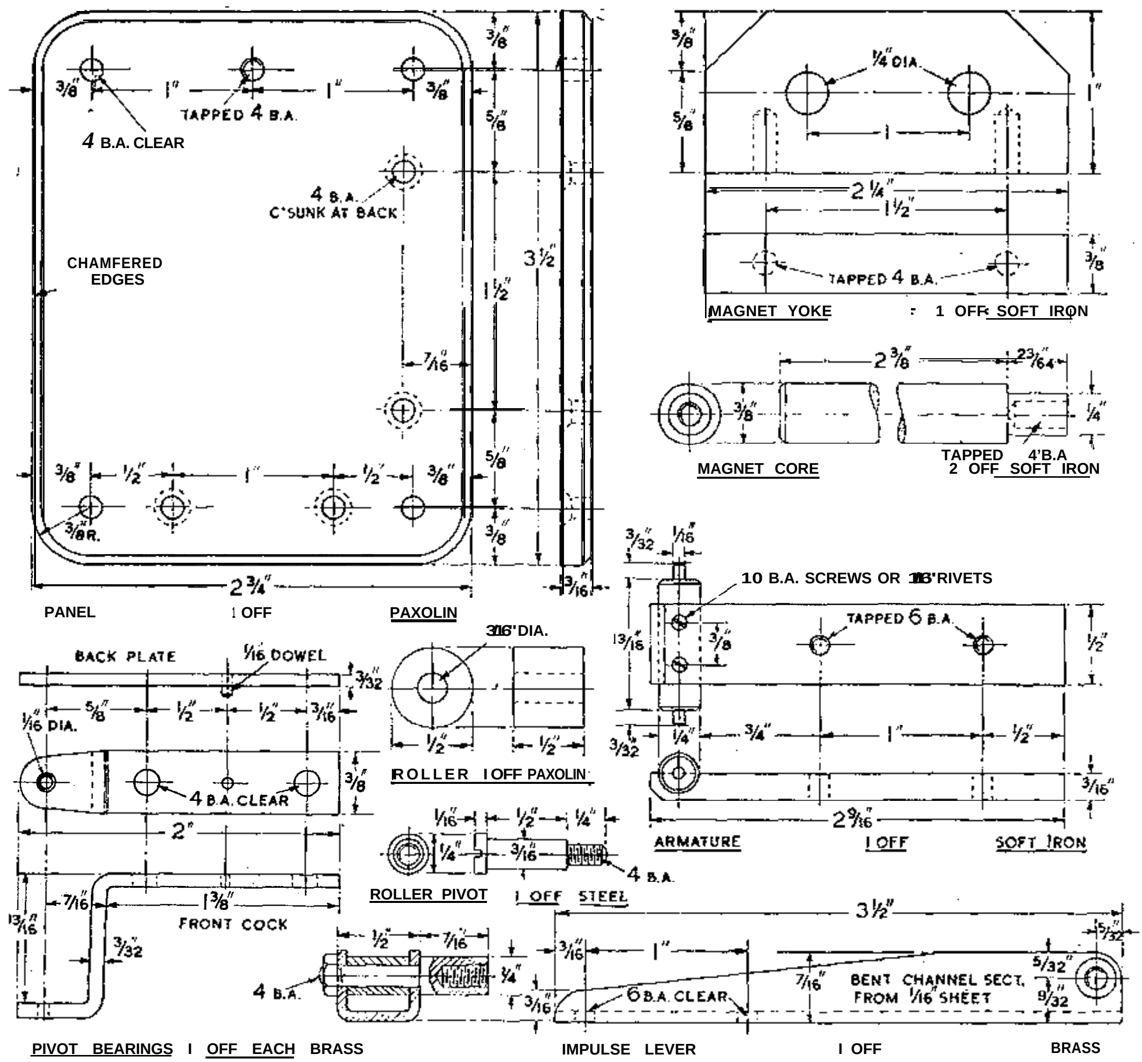
Bearing alignment

It is, of course, important that the pivot holes in the two bearings should line up squarely, and that they should be located so that the armature will seat truly against the pole faces of the electro-magnet. These positions can be ascertained by clamping the armature in this position, and after drilling the pivot holes, marking the fixing hole nearest the bend of the cock, from the corner hole in the panel. This is then drilled through both bearings, and they can be temporarily secured for checking position and locating the second fixing screw.

One or two dowels may be fitted to maintain the relative alignment of the bearings; only one is shown on the drawing, and this has been found sufficient, so long as the clearance of the fixing screws is kept to the minimum; but conscientious clockmakers would probably insist on more than one dowel to ensure correct dimensional accuracy.

The pivot bearings must be a good fit, with the least trace of end play, but must obviously work quite freely. Slackness would tend to cause noise when the impulse occurs. There might be some advantage here in fitting hardened cone pivots with end adjusting screws, but this has not been tried.

It is not desirable to make the impulse lever and roller any heavier



than is absolutely necessary, but it must be adequately strong and rigid to perform its function properly. A channel-section arm bent from sheet brass is specified, but aluminium alloy (not ordinary sheet aluminium) would probably be better. The boss to carry the roller pivot is made in the form of a bolt fitted across the lower end of the channel, with a bush between the inside surfaces to prevent crushing; alternatively, the boss itself may be a bush tapped right through, and secured by a long screw from the other side, plus the spacing bush.

In either case the assembly should be strong and rigid. The other end of the lever may be tapered off as shown, and is secured to the armature by two 6 BA screws.

The roller is made from hard plastic material and fitted to work freely on its pivot bolt. It should not be grooved to fit the contour of the pendulum rod, as this might tend to cause the latter to deviate from its natural path, and thereby set up a rolling motion. Like all other working parts, a slight amount of end play should be allowed on the pivot.

When the pendulum is at rest, the roller should only just make contact with it, the armature being also in contact with the pole faces. Any error in this respect can be corrected by packing or filing the face of the lever at the upper end. In experimental work, an eccentric adjustment of the roller position was tried out, but was not found necessary: the effect of varying length of the lever, also the use of a wooden lever to give resilience, led to no very conclusive results either.

It is always open to discussion as to which is the best and most efficient method of applying an electromagnetic impulse to the movement of mechanical parts which involve inertia. The impulse must necessarily be rapid and abrupt, and a heavy pendulum does not react favourably to this kind of treatment. From this it might be argued that there would be an advantage in applying electric drive to light, short-period pendulums or balances, which is true as far as it goes, but this also introduces the maximum interference with natural period, and thus departs further from the ideal of the " free pendulum."

The higher the frequency of the pendulum or balance, the more necessary becomes exact regulation of the strength of the impulse, and all adjustments, not to mention physical dimensions of essential parts, become more critical and delicate.

● *To be continued on July 17*

ME Jubilee ELECTRIC CLOCK

Continued from 3 July 1958. pager 8 to 10

Assemblyand adjustment of the electrical mechanism

By EDGAR T. WESTBURY

THE construction of the clock has now arrived at a stage where it is possible to assemble the electro-motive parts and set them working, and this will no doubt appeal to many constructors, who may be excused some natural impatience to prove that their work is yielding satisfactory results.

I know that I can never resist the temptation, as soon as essential working parts of a model are completed, to set up a "jury rig" which will enable preliminary tests to be made, without waiting till every last detail is completed.

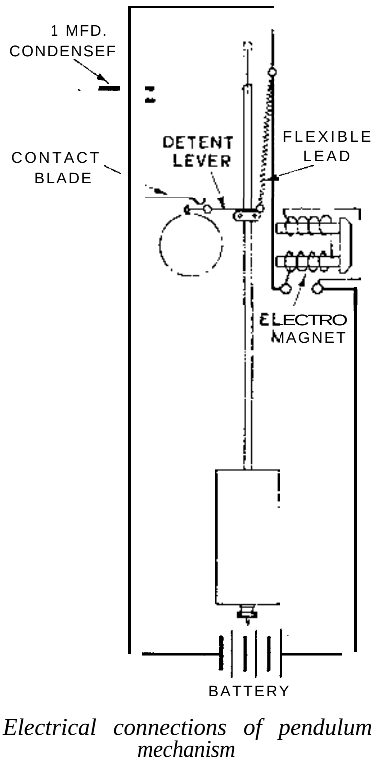
In any case, this part of the mechanism will have to be adjusted independently of the actual clock movement, so that it is just as well to do this now as later on. The chassis may be set up on a vertical board, or even on the wall of the workshop, so long as it is vertical both ways and steady enough to avoid inadvertent movement. After attaching the electro-magnet and contact units to their respective seatings, by four screws in each, the pendulum is hung from its suspension bracket and allowed to find its natural position before tightening the clamp bars.

Handling the pendulum

A word of caution about handling the pendulum may be advisable; it is obvious that the delicate suspension springs are liable to damage if roughly handled, and in manipulating the heavy pendulum into position, it is only too easy for them to foul other parts, thereby getting bent or distorted; such faults are very difficult to correct. and the cause should be scrupulously avoided.

The electrical connections of the clock are very simple, and can be neatly arranged; some constructors may wish to conceal them entirely by taking them through to the back of the mounting board, when the clock is finally erected, but for the present purposes, temporary wiring will be satisfactory. Single lighting flex will be adequate to carry the current, and I favour p.v.c. covering, which is neat and durable, and can be obtained in colours which harmonise with the wooden panel, in whatever finish may be selected, so that exposed wiring will not be obtrusive.

It will be seen that a flexible connection must be made to the detent lever, so that it does not impose any drag on the pendulum rod. While a loose piece of light flex, hung from a point as near the pendulum suspension as possible, would serve this purpose, it is much better to make a long coil of enamel-covered wire, about 24 gauge, by winding it on a 3/16 in. rod and pulling it out to the length required. An alternative and somewhat neater method would be to run a straight wire down the back of the pendulum rod, holding it in position by small clips, or bands of transparent adhesive tape, with a short flexible coil just behind the suspension.



Electrical connections of pendulum mechanism

Preventing radio interference

The object of the condenser, which is connected between the contact blade and the wiper, is to suppress the inductive spark which occurs when contact is broken, and incidentally to prevent radio and TV interference, though this should not be serious in view of the low voltage and current employed. In the former and primary function, the capacity of the condenser is not at all critical, and various sixes have been tried with very little difference in results; either the cylindrical " cartridge " type, or the rectangular "canned " type of condenser, is equally suitable.

One point to which attention may well be called is the necessity of checking insulation of the various components in the circuit. If the terminals of the electromagnet are in the form of countersunk screws from the back of the panel, as recommended, it is obvious that the heads must be well sunk so that they cannot touch the metal chassis; if in doubt, however, a slip of paper or cellulose tape will make this quite safe. For clocks in which a metal pendulum rod is employed,, the' flexible lead to the rod can be elnnintaed in favour of " earth return " through the chassis; but in this case, the insulation of the panel carrying the riding wheel and contact blade must be above suspicion.

When all parts are assembled, the first stage in the working adjustment is to locate the clamp of the detent lever so that the latter is parallel to the back panel, and at such a height that the detent can just drop to the root of the tooth in the riding wheel. The bent tip of the contact blade should be about 1/8 in. to the left of the wiper when the pendulum is at rest, and the impulse lever should just touch the rod, with the armature in contact with the magnet poles. It may be mentioned here that a slip of thin paper or tape interposed between these surfaces will not only reduce the risk of noise, but also eliminate " stickiness " caused by slight residual magnetism.

Pendulum arc

The pendulum is set swinging by hand, and the action of the detent lever in engaging the riding wheel may be observed. It will be seen that by moving the pivot plate of the lever to the right, the rod will have to travel further to pick up a full tooth of the wheel, and therefore this adjustment affects the arc of pendulum swing. For robust action with reasonable time-keeping accuracy, an arc of 4 to 5 deg. (inclusive) is recommended.

When picking up a full tooth of the wheel, the wiper should just pass under the contact blade as close as possible, but without actually touching it. As the arc of swing falls off, however, the detent will fail to clear the full tooth, and will ride in the notch, raising the wiper so that it strokes the contact blade and thus establishes electrical connection through the electro-magnet circuit, and provides the impulse to drive the pendulum. It is important that contact should be broken just before the pendulum reaches the centre or neutral point of its swing.

Interval between impulses

Some little patience may be required to adjust the mechanism to the best possible advantage, but when once this is accomplished, the action is very reliable, and will go on like the proverbial babbling brook. The interval between impulses will of course, depend on the energy applied, but I consider that nothing is really gained by putting too much power into the magnet so as to cause considerable variation in the arc of swing; lighter and more frequent impulses are more conducive to maintaining accuracy.

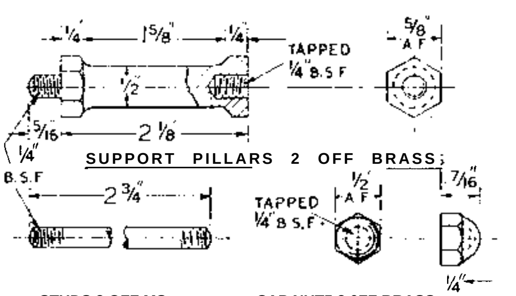
As explained in the first article in the series, it would be quite possible to employ this mechanism, as so far described, to serve as a master clock or " time transmitter," similar to the Synchronome, by fitting a contact device on the riding wheel arbor, to make contact once per revolution and feed current impulses to one or more secondary dials. This has been tried experimentally with success (in the photographs of the contact unit it is possible to see the ebonite disc of the contact-maker behind the contact wheel), but no doubt most constructors will prefer to make a self-contained clock with a mechanically-driven time train, which does not preclude the possibility of driving secondary dials as well, if desired.

The following part of the clock mechanism, therefore, is more or less orthodox clockmaking practice, in which the usual methods can be utilised, and it would in fact be possible in many cases to utilise or adapt the time train and dial work of an existing clock.

Supporting pillars

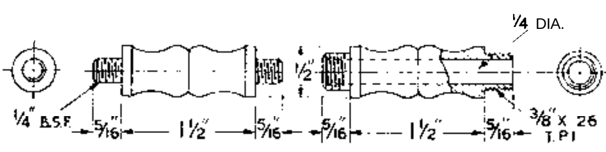
A somewhat unorthodox method of supporting the clock movement on the chassis is employed, with the object of making it as simple as possible to remove or replace the movement without affecting the rest of the mechanism. This consists of two rigid pillars screwed into the chassis casting and fitted with extended studs. The lower spacing pillars of the clock movement are made hollow to slide freely over these studs, and are secured by cap nuts. It would, of course, be possible to modify this arrangement to suit an adapted movement, including that of the English " grandfather," which is usually fixed by pulling down on to a flat platform or " seat board," by means of hook bolts engaging the spacing pillars.

Little comment is called for regarding the machining of the supporting pillars, which may conveniently be made from hexagon brass bar, and



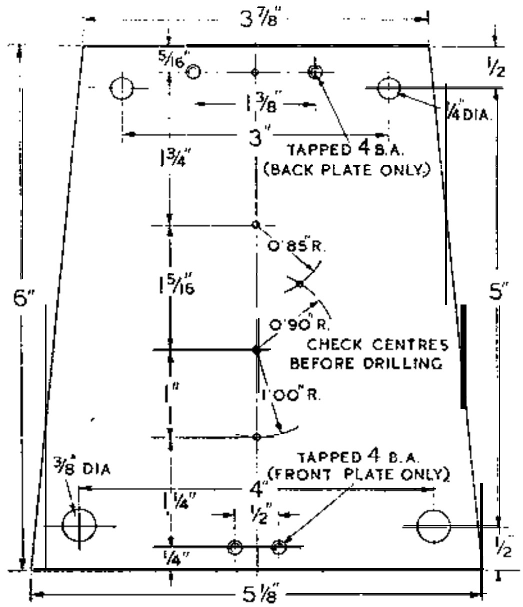
_STUDS 2 OFF MS

CAP NUT5 2 0FF BRASS BRASS



SPACING PILLARS 2 OFF EACH BRASS

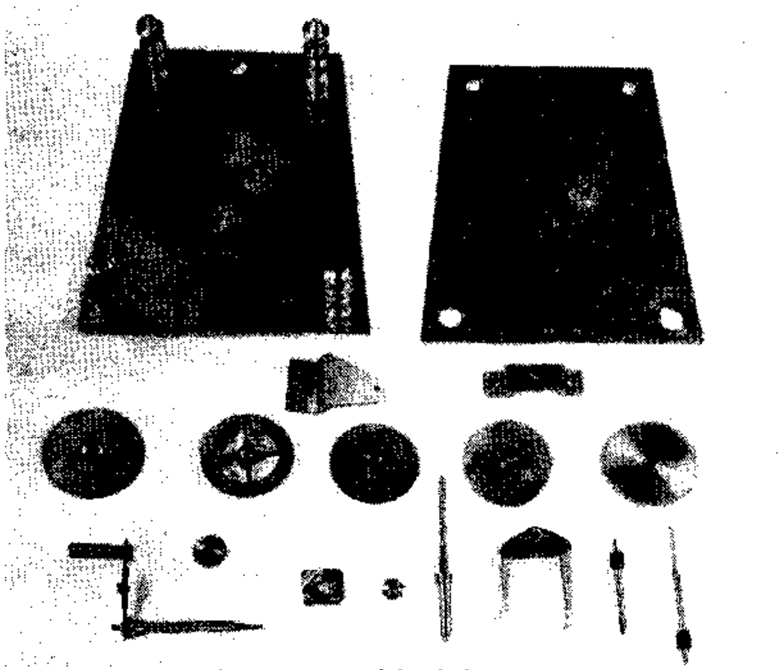
(HEX. NUTS, 1/8" THICK, FITTED EACH END)



MOTION PLATE 2 OFF BRASS

could be of more ornamental form than those shown. It is essential that they should be of uniform length, and the screwed and tapped ends true and concentric. Instead of turning the male end from solid, both ends may be drilled and tapped, and short steel studs inserted at one end; this would in fact increase strength and ensure that the pillars would seat properly against the bosses of the chassis. Cap nuts are optional, but they conceal the ends of the studs, and are thus conducive to neatness.

When fitted, the extended studs should be in exact parallel alignment both ways; if not, correction may be made by machining or scraping the faces of the seating bosses until proper alignment is obtained. The lower holes in the clock plates must, of course, be exactly the same distance apart as the studs, which is easily checked by measurement, and actual trial before opening them out to finished size.



The components of the clock movement

Clock plates

The clock plates are cut from 3/32 in. hard brass sheet, and the first essential is that they should be perfectly flat. It is, of course, possible to straighten bent and buckled plates, but it is by no means easy, and at best calls for a good deal of patience. In the absence of specialised experience, attempts to do so may make matters worse by putting stresses into the metal instead of taking them out. For this reason, it is advisable to get true plates in the first place, even if they cost more.

Metal merchants usually cut sheet metal of this thickness with a guillotine shear, which is quite capable of doing a clean job if the blades are keen and well-adjusted; but often they are not, and this causes considerable distortion. At best, the cut edges are usually burred or depressed, and for this reason, attempts to shear the plates to near-finished shape and size are not advisable. At the expense of some waste metal, larger plates should be obtained, and sawn to shape all round.

Having marked the positions for the corner holes as accurately as possible on one plate, undersize holes, say 3/16 in. dia., may be drilled in it, and it is then used as a jig for the second plate. I did all my marking out on the surfaces which eventually faced ***inward*** on assembly, as scriber marks are difficult to erase, and in this position they will not be readily visible. The plates may now be temporarily bolted together by close-fitting bolts, and trimmed over the outside edges to the finished shape. Mark the plates clearly to show front and back, and to distinguish inside and outside surfaces; the drilling of pivot holes may be deferred for the present, but in most cases the front plate can with advantage be marked out and used as a jig for drilling the other, when hole locations are definitely settled..

Spacing pillars

These are turned from 1/2 in. dia. brass rod, the upper pair having the ends screwed 1/4in. BSF, and the lower pair screwed 3/8 in. x 26 t.p.i. (brass pipe standard) or other convenient fine thread. Four nuts are required for each size of thread, all being 1/8 in. thick; convenient hexagon sizes are 1/2 in. and 5/8 in. across flats, respectively, but nearest available sizes may be used. The pillars must be all of uniform length between shoulders, and the ends true and concentric. I turned these pillars at a single operation from bar held in the chuck, with the outer end supported by the back centre; the lower pillars were drilled before parting off. It was, of course, impossible to screw the inner ends at the same setting, but this was done by a second operation, using a tapped piece of bar in the chuck to hold the end previously screwed. The holes through the lower studs may be drilled at either setting, and should be an easy fit for the supporting studs.

The " chair-leg " ornamentation of the pillars is, of course, optional, but is orthodox practice on most of the older types of clocks, and certainly looks better than plain parallel or waisted pillars; the particular shape varies, however, and constructors may exercise their individual taste in these matters. I strongly recommend, however, that if it is done at all, it should be done carefully and neatly, with nicely swept curves and a good finish free from scores. The use of hand turning tools will enable this to be done quite easily, and they are a delight to manipulate; no turner should consider himself a master of his craft unless he has acquired some proficiency in the use of hand tools. I am often horrified to see readers recommended to shape curved contours in the lathe with a file, when it could be done much quicker and neater by emulating the methods of an older, and in some ways more conscientious, generation of craftsmen.

● ***To be continued on July 31***

ME Jubilee ELECTRIC CLOCK

Components of the clock movement

By EDGAR T. WESTBURY

Continued from 17 July 1958, pages 67 to 69

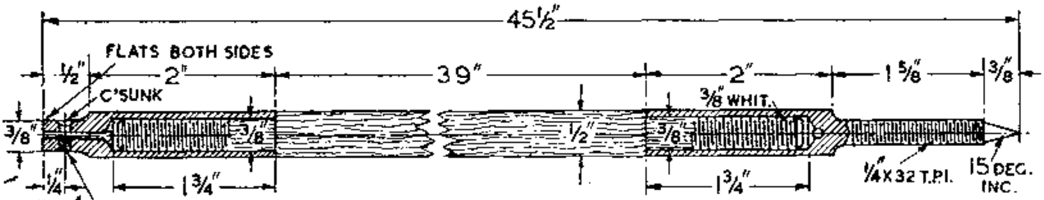
BY one of those mischances which occur even in the best-regulated offices, an important drawing was omitted from an earlier article in this series, namely, the details of the pendulum rod and bob, which should have accompanied the description of these items in the May 15 issue. I must admit that I had not noticed this omission until my attention was called to it by several readers. However, no harm has been done, as the drawing was soon found. It is reproduced here, with apologies for getting it out of normal sequence.

Pallet bridge

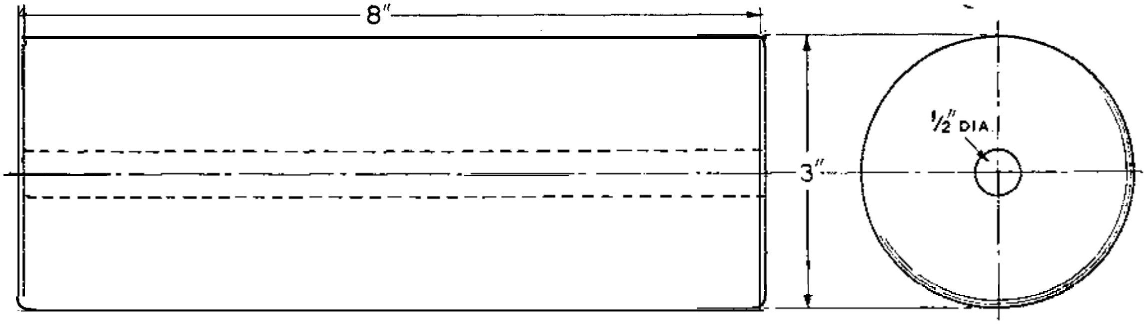
The fittings for the clock frame should next be made; the most important are the two outboard bearing brackets for the motion pivot and pallet arbor respectively. They follow normal horological practice in design and fitting; brackets of this kind are generally termed "cocks," though when the bracket extends both ways from the pivot centre, and is secured at both ends, the term " bridge " is more appropriate. They are usually made from castings, or cut from the solid; bent-up brackets, although serviceable, are liable to look rather slovenly, and are not favoured in any but the cheapest clocks.

In my case, the pallet bridge was machined from a piece of 5/8 in. x 3/8 in. brass bar, 1-3/4 in. long, and most of the unwanted material was removed in the lathe, by holding it crosswise in the four-Jaw chuck, set up symmetrical to the centre both ways, at two separate settings for inside and outside surfaces respectively. The squaring-up of the gap, inside and out, was done by milling. It is possible to dispense with this further work if curved surfaces are not objected to, in which event the ends should be similarly finished by turning, so that they harmonise with the other curved surfaces. But this is not in keeping with orthodox clock practice, and I thought it best to conform with it by keeping to square edges. Needless to say, whatever design or methods of construction are adopted, the flat seatings of the bridge must be true and the pivot hole exactly square with them; finally, the fixing holes are drilled in the positions shown.

As the centre of the pallet arbor (so-called, as there are no pallets, in the true sense of the term, in this clock) does not bear any fixed relation to the gearing, the pivot holes may be drilled in the main clock plates in the position indicated, using the front plate as a jig for the other, as already described. To locate the bridge in its correct position for pivot alignment, a



PENDULUM ROD 1 OFF HARDWOOD WITH BRASS FERRULES



PENDULUM BOB 1 OFF IRON OR STEEL

straight piece of silver steel rod 1/16in. dia. may be passed through the holes in the two plates and the bridge, which is then held in position by clamps while spotting the -tapping holes in the rear plate.

The fitting of dowels to ensure accurate location of the bridge is optional; I do not consider it necessary as the screws locate it near enough for practical purposes, so long as the clearance holes are not made unnecessarily large. Finally the hole in the rear clock plate is opened out to 5/16 in. dia. to give ample clearance for the pallet arbor.

It may be remarked that this bridge might be dispensed with by pivoting the arbor in the two main plates, and extending the pivots on both sides as required. This, however, would not be very good practice, for two reasons; first it would entail tight fitting of both the crutch and the rocker on the outside of the plates, making assembly and dismantling more difficult, and second, because less adequate support to the crutch would be provided.

Motion cock

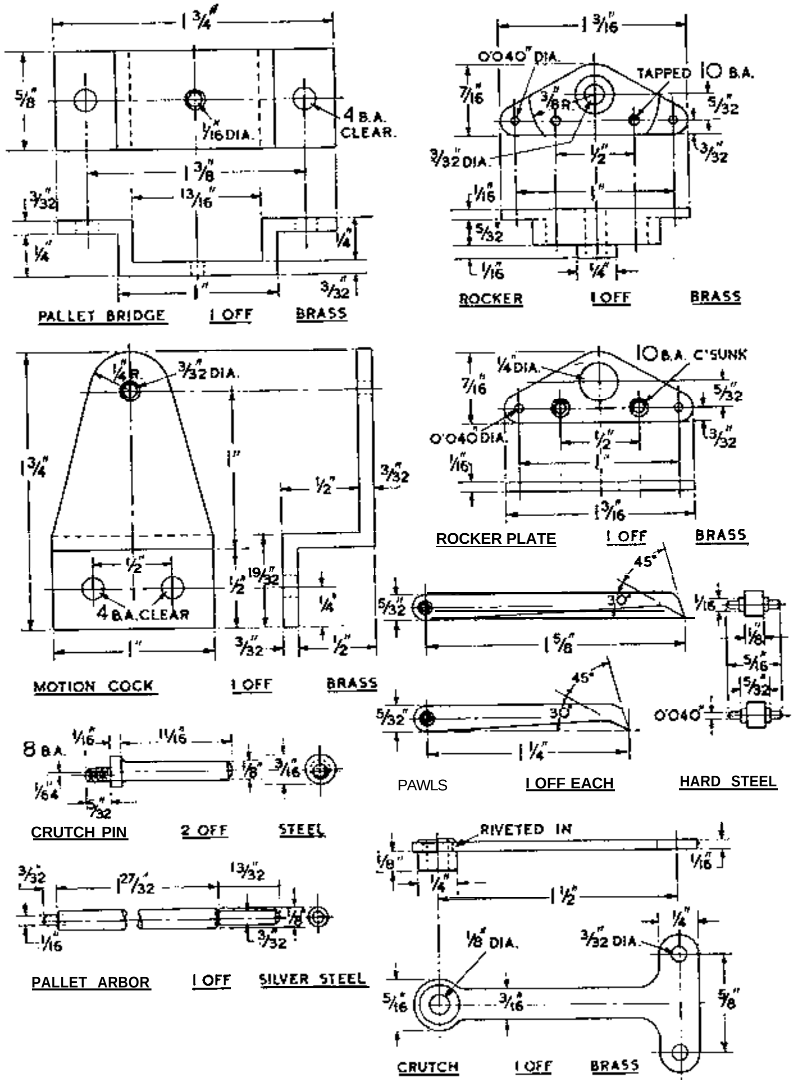
The motion cock was made by building up from 3/32 in. hard brass sheet, by silver soldering, as machining from the solid would entail a good deal of waste metal, and in any case no material of large enough section was readily available. In order to hold the three pieces of brass together during the brazing operation, both the vertical pieces were made longer than required, and the horizontal piece was provided with two dowels or tenons (filed from the solid) at each end; holes were drilled in the verticals to correspond, and the tenons, after insertion, riveted in. After brazing, the unwanted end projections were cut away and the job generally cleaned up.

As the pivot hole in this cock must line up with that in the front clock plate, the location of which depends on the meshing of the gear wheels, the cock cannot yet be fixed in position, though the fixing holes may be drilled in the foot, ready for spotting the tapping holes in the plate.

Rocker

This component carries the two gravity pawls which propel the ratchet wheel, and both accuracy and free workmg are highly important. It can be machined from a piece of 1-3/4 in. x 7/16 in. brass bar, which should be long enough to hold in the four-jaw chuck, the position of the hole being marked out and set to run truly. The machining of the spigot, pivot lugs, and drilling of the centre hole can then be carried out at this setting.

Before removing the job from the chuck, it is a good policy at this stage to mark out the holes for the pivots and the fixing screws. The chuck may then be removed bodily and laid on the drill table, and the holes drilled, taking them 1/4in. or so deeper than would normally be necessary. The pivot holes are, of course, left undersize **for final** finishing. If desired, the outer contour of the rocker may be shaped by milling or filing while still held in the chuck.



The rocker may now be parted off with a keen parting tool. If drilled as directed, the rocker plate can also be produced, by opening out the centre hole and parting off a 1/16 in. slice, with the pivot and fixing holes all ready drilled. After opening up and countersinking the latter, and tapping the holes in the rocker, the two parts may be fixed together, and a" reamer-bournisher," made as previously described, run through the pivot holes at both ends of the rocker assembly.

Pawls

These may be made either of silver steel, hardened throughout at the engaging end, or of mild steel case-hardened; either will give good service for quite a long time, but in the event of any subsequent refitting of the pawls entailing grinding or honing, it would be necessary to renew the " case "of the latter. If silver steel is used, it should be quenched in water, polished up, and held by the tip end in tongs or pliers, for letting down the other end and most of the shank to a dark purple or blue, before re-quenching. The colouring enhances the appearance of the pawls and may be protected by a thin coat of lacquer, but this must be kept away from the tips and the pivots.

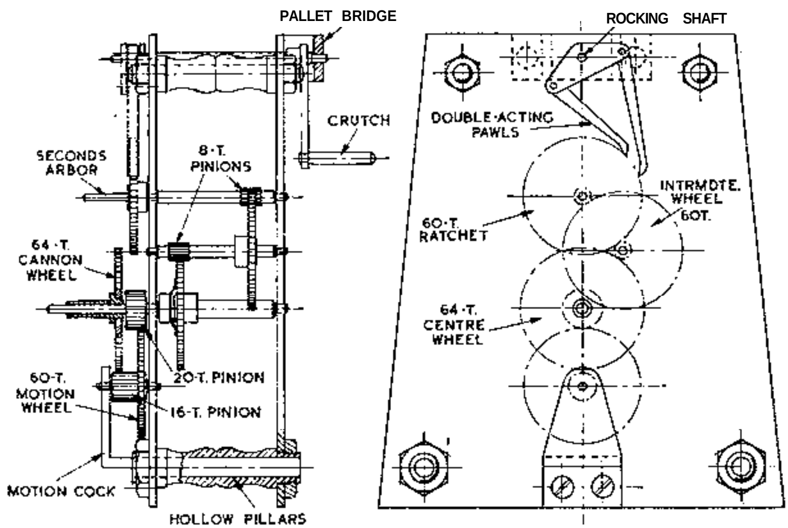
The pawls of electric clocks are often pivoted on fixed pins; but while this works fairly well in most cases, much better results are obtained by fitting double-ended pivots to the pawls, with bearings both sides. As shown, it is recommended that the pivots should be pressed into the pawls, and shoulders be provided to prevent the latter from rubbing on the sides of the bearing lugs. This form of pivot may be a little moredifficult to make than the other,. but it works with less friction and is adequately supported. The accurate chucking and turning down of two tiny pivots may be too much like watchmaking for some constructors; I find the best way is to turn them all over from larger material at one setting, using a narrow pointed tool, and polishing the pivots before finally parting off.

Crutch

The crutch is cut to shape from in. hard brass sheet, the eye being drilled 3/16 in. to receive a shouldered collet, which is then riveted in, the hole being left slightly undersize for fitting. At the fork end, two steel crutch pins are fitted; it will be seen that the screwed ends of these are eccentric to the shanks, so that they can be adjusted exactly to fit the diameter of the pendulum rod, after which they are locked by 8 BA nuts. Note that if a metal pendulum rod is employed the design of the fork end will have to be moditied to suit the different diameter.

The crutch is a press fit on the pallet arbor, in such a position that when the latter is assembled, it swings just clear of the back frame plate, allowing for the projecting crutch pm nuts. It is permissible to make the seating on the arbor slightly taper -not more than about one thou in its length-to facilitate fitting, and the same applies to the extended front end, which carries the rocker. The latter should not be too tight a fit, as its relation to the crutch must be capable of adjustment when setting up the clock ; a tight wringing fit should be quite sufficient. Some constructors mav nrefer to use an easier fit, providing a setscrew for locking it when adjusted.. These fitting operations call for some delicacy of touch, but they are common to all horological work. and the required skill can only be obtained by practice.

Some pains have been taken to work out the simplest possible combinations of wheels for this clock, not only to facilitate the work of those who undertake cutting their own gears, but also to improve the chances of being able to obtain suitable gears ready-made. As the loading of the gears is very light, and all motion is from a higher to a lower ratio, involute form gears, with which all



Generalarrangement of clock movement

engineers are familiar, are quite appropriate, though there is no objection to cycloidal or other recognised horological tooth forms. By adopting 40 diametral pitch, it is possible to use gears of very convenient size, and relatively small numbers of teeth, while the calculations for pitch and outside diameters are simplified, enabling round decimal figures to be used in all cases.

The ratios

The gear ratio of 1:60 from the " minute " wheel-in this case the ratchet wheel-to the centre wheel is obtained in two stages, namely $\frac{8}{60} \times \frac{8}{64}$ or 7-1/2 to 1 x 8 to 1 reduction.

A further two stages provide the ratio of 1 : 12 for the "motion " train which drives the hour hand, namely $\frac{60}{20} \times \frac{16}{64}$ or ***3*** to 1 x ***4*** to 1 reduction.

Thus the complete wheelwork system involves the use of a minimum number of different gears, the full set (not counting the ratchet wheel) being two 60 t two 64 t, two 8 t pinions, and one each of 20 and 16 t. The pinions may conveniently be made from pinion wire, which is now obtainable in very accurate form, and thus it is only necessary to cut the 60 t and 64 t gears, which may be dealt with in pairs, so that only two separate operations are involved. For those who are not prepared to cut their own gears, I confidently expect' to be able to announce that a full set of ready-cut gears will be available very shortly.

As the wheels and pinions, together with their arbors and pivots. follow normal clock practice, it 'is not considered necessary to describe them at great length. The articles on wheel cutting, by Mr J. C. Stevens, in the issues of ME 29 January, 5 and 12 February 1953, together with Mr C. B. Reeve's more recent articles on the ME Musical Clock, deal 'with these subjects far more competently than, with my limited experience of clockmaking, I could ever hope to do.

I would, however, encourage constructors to try their hand at wheel cutting, which is by no means as difficult as some of them believe, especially as in this particular clock, everything is of robust dimensions, and the extremely high precision required on many types of mechanically-driven clocks is not essential to a moderate degree of success, when electricity is used for motive power.

For those who do not wish to undertake this work, however, I have been able to get a stock of wheels cut to order and hope to arrange for their distribution through the model supply trade in the near future.

● ***To be concluded on August I4***

ME Jubilee ELECTRIC CLOCK

Continued from 31 July 1958, pages 134 to 136

Pinions, motion train and final assembly

By Edgar T. Westbury

THE pinions, owing to their small size in relation to the arbors, cannot be made separately and mounted thereon; it is thus necessary either to machine them from the solid or make use of pinion wire, the latter being obviously simpler as it avoids the need for cutting the teeth. In obtaining suitable pinion wire of a high degree of accuracy, I am indebted to the advice and assistance of Col Taplin, who in addition to being a keen model engineer, is a specialist in the production of precision-drawn metal sections.

Details of the tooth form of the 60 t ratchet wheel are given for the benefit of those who wish to cut this wheel, which can be done by the same general methods as illustrated for the 15 t stepped ratchet on page 783 of the June 19 issue. The cutter recommended is one having an included angle of 60 deg., though this is by no means critical; to produce the rake angle of about 1 deg., the front edge of the cutter is advanced about 1/32 in. beyond the centre line of the work, i.e. the lathe axis, as explained in the same issue.

Methods of mounting wheels on collets, etc., have also been described in previous issues; in the detail drawings, the riveted-over end of the collet has been exaggerated for purposes of clarity; in practice, only a very slight projection is necessary for riveting if the fit is good, and internal bevelling of the end face avoids the risk of burring the centre hole. When mounting the ratchet wheel, make certain that the teeth face the right way, but if a mistake has been made, it does not matter greatly whether the collet boss is at the front or back so long as the end location of the wheel on the arbor is suitably adjusted.

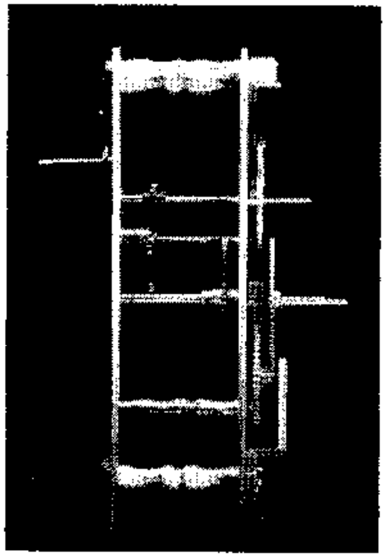
Many constructors will no doubt prefer to use spoked wheels, and unless pierced blanks can be obtained -1 was not successful in this respect -this calls for a fretting operation, which should be done before the wheels are mounted on the collets. While spoked wheels undoubtedly improve the appearance (if the job is neatly carried out) they obviously have no effect on the working of the clock, and blank discs are less liable to become distorted, though this risk should not arise if due care is taken in mounting them.

Machining the pinions

The obvious way to mount pinion wire for machining is in a collet chuck, but some caution is necessary in this respect, as the standard form of collet, which is split three ways, does not provide the ideal bearing for an eight-leaved pinion, and there is a possibility that it may not be held perfectly truly, even though the collet is true in itself.

In the absence of' a collet chuck, the four-jaw chuck can be used, and in this case the jaws will bear evenly on four of the teeth; only light pressure should be applied, to avoid damage to the tips, unless the part held in the chuck is subsequently to be machined away. It will be necessary to set the pinion up very carefully, using a dial test indicator or similar aid to accuracy, as eccentric pinions cannot be tolerated in any clock.

To avoid what many may consider to be a very tedious operation in setting up each pinion separately for operations on each of its ends, the alternative is to use a chucking bush, and personally I consider this to be a more reliable method, in respect of accuracy, than using a collet chuck. The bush should not be more than 3/8 in. dia., preferably with a shoulder on the outside for end location; it is held in the self-centring chuck and bored out in position to a tight push fit for the pinion wire. I do not split the bush_, as this entails removal and re-chuckmg, but simply tighten the chuck jaws a little further when

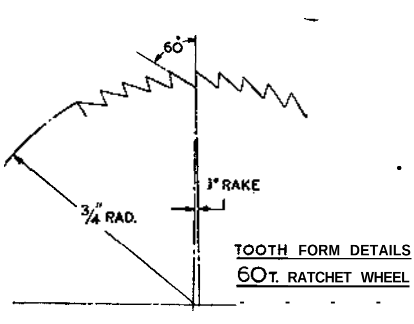


the wire is in position; this holds it quite securely and truly.

I do not recommend machining all the arbor and pivot surfaces while the work is chucked; it is best to turn the pivot ends only and bevel them carefully with a hand graver, then mount the arbor between hollow centres for the remaining turning operations. The standard form of hollow centres are too clumsy for this work (I am assuming that most constructors do not possess watchmakers' lathes) but it is easy enough to make a pair of special centres with small diameter conical extensions, drilled with the smallest size centre-drill. The rear or "dead" centre must, of course, be hardened.

While the arbor is between centres, the truth of the pinion teeth can be checked, and if any inaccuracy is detected, it is not too late to correct it by bending, but do not do this in position, as the pivot ends, being the weakest part, would bend first. Turn down the unwanted metal on the arbor as much as permissible, and lay it in V-blocks for the bending operation.

All this, however, is in the nature of an emergency measure, which should not be necessary in the normal



TOOTH FORM DETAILS 60T. RATCHET WHEEL

way. The shank of the arbor is finally turned and finished to a suitable degree of accuracy; in the case of the intermediate wheel, the collet is a press fit on the arbor,.whereas on the minute arbor the ratchet wheel collet fits outside the pivot bearing; this projecting end of the pivot is slightly tapered so that a seconds hand can be fitted if required.

The centre arbor does not carry a pinion, and can be made from 1/4 in. silver-steel rod, which may be chucked in the same bush as the pinion wire and turned in the same way. Note that in this case the wheel collet is not a press fit, but should work freely on the reduced diameter of the arbor; the collar adjacent to it, however, should be a press fit, and the easiest way to attain this is not to pass the reamer right through it when machining the bore. This leaves it slightly tapered, and the arbor can be eased off with a dead smooth file to correspond.

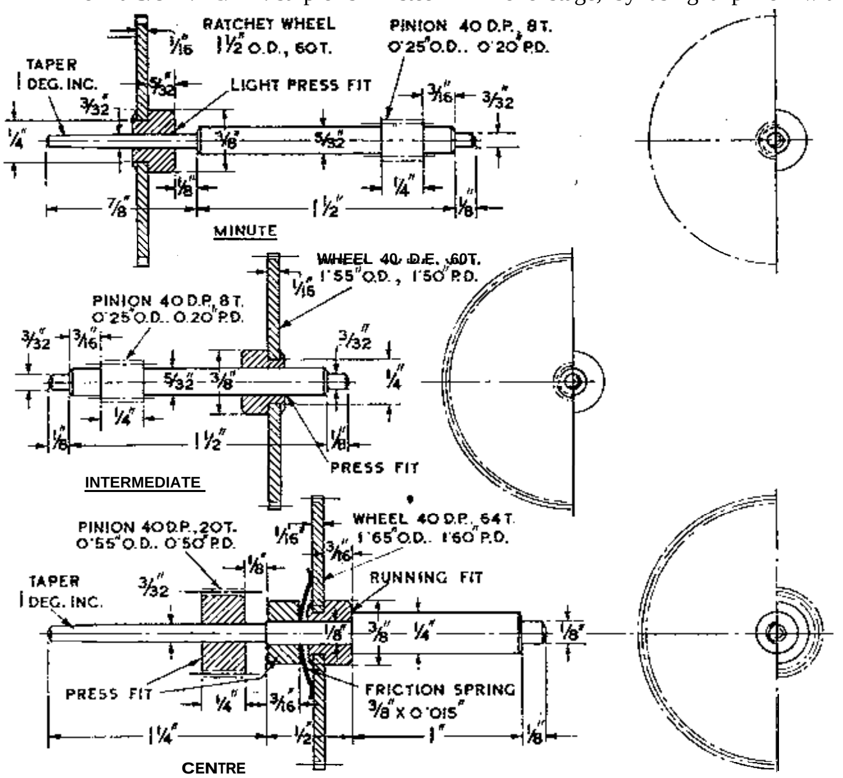
A friction spring is interposed between the collar and the wheel, the object being to allow the hands of the clock to be set without turning the entire wheel train-this, of course, is a common arrangement in all types of clocks. The spring can be made from a 3/8 in. x 3/4 in. strip of shim steel or hard brass., bent as shown and drilled 1/8in. dia. in the centre to fit the arbor; tension is adjusted by the position of the collar.

As in the case of the minute arbor. the projecting end of the front pivot is slightly tapered for fitting the minute hand. I may mention that this is not the orthodox method of fitting, as it is more usual, at least on high-class clocks, to square the end and broach the collet of the minute hand to fit, retaining it in place with a washer and cross pin.

But I have found friction fitting of both the hour and minute hands quite satisfactory, and see no practical advantage in the more elaborate fitting. The degree of taper. should be the same as a standard clock broach, if available, or if not, a broach may be made to a 1 deg. included taper, as specified, for reaming the hands.

The motion train

This is the term used for the 12 : 1 ratio reduction gear which drives the hour hand, and the particular arrangement employed to enable the latter to be co-axial with the minute hand is sometimes known as a "reverting" train. In some of the older clocks, the actual reduction is accomplished in one stage, by using a pinion with the smallest permissible number of teeth, meshing with a wheel having 12 times as many; the reverting pair of wheels then have an equal number of teeth.



MAIN WHEELTRAIN DETAILS I OFF EACH BRASS & STEEL

It is generally more convenient, however, to use two stages of reduction, to make the train more compact, and in this case the ratio is 3:1 x 4:1, obtained by using a 20 t pinion meshing with a 60 t wheel and a 16 t pinion meshing with a 64 t wheel. Whatever arrangement is employed, however, an essential condition is that the appropriate numbers of teeth in all cases must be selected so that the gear centres for the two stages are identical.

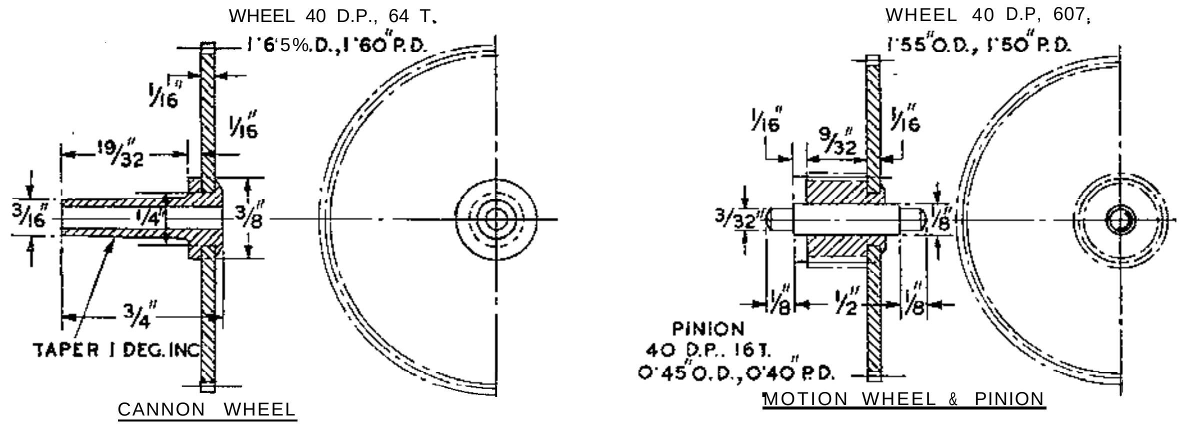
The 20 t and 16 t pinions can be made in pinion wire, either steel or brass being suitable in view of their light duty, or cut from the solid. In the first case, the pinion is pressed on the projecting end of the centre arbor after it has been assembled in the front plate. The 16 t pinion, if made of brass, is fitted to a steel pivot as shown, but if of steel, the pivot ends can be turned from the solid; in either case, however, the pinion is shouldered down to form a collet, to which the 60 t wheel is riveted.

The cannon wheel is so called because instead of being fitted to an arbor it is mounted on a "cannon" or tubular centre, which is a running fit on the centre arbor, and is tapered on the outside for fitting the hour hand. In all pairs of wheels and pinions used in this clock,, end locations are by no means critical,. as the pinions are made of ample width to give plenty of latitude, or to enable the wheels to be shifted after wear has taken place, though this should not be necessary for a very long time.

Meshing the gears

In the details of the clock plates it was specified that the gear centres should be checked before drilling the pivot holes; this is most essential to ensure sweet running and efficiency. If involute gears of the sixes and pitch as specified in the drawings are employed, it should be possible to work to "dead reckoning," or in other words to the exact measurements stated, but in other types of gears dimensions may not be quite so definite, and in any case it is better to check up before drilling than to wish you had afterwards.

Clockmakers use what is known as a "depthing tool" to check gear centres; it enables the arbors, with their wheels and pinions, to be temporarily mounted between running centres and their distance apart adjusted until they run smoothly. This distance can then be marked out on the clock plates by scriber



MOTION TRAIN DETAILS   I OFF EACH   STEEL & BRASS

points on the ends of the running centres. Mr C. B. Reeve has described this tool, which is a relatively expensive one to buy, but it is not beyond the ability of the amateur to make for himself.

There are, however, other means of checking centres which entail less elaborate apparatus. I have used several devices for the purpose, but the simplest method I know is to mount one of the gears, preferably the pinion, in the lathe so that it runs quite truly. The other is held, either on its own arbor between centres. or on a dead running shaft which can be set up on the lathe cross slide, parallel to the lathe axis.

With the cross feed, the distance apart of the gears is adjusted till they run quite freely but without excessive backlash; the noise, or rather absence of it, when the lathe is running at high speed, is a very good guide to correct meshing. The distance apart of the gear arbors is then measured, allowance made for their radius in both cases. and this dimension transferred to the clock plates with dividers.

Should an error in the pivot hole positions be made,. it is possible to correct it by openmg out the holes and fitting eccentric bushes, but this is not considered quite the thing in the best horological circles. The holes should be reamed as described in previous issues, and countersunk to retain oil, the final fitting and polishing of the pivots then being carried out.

In the case of the motion cock, the exact oosition can onlv be found after the gear centres have been checked; the cock is then clamped in position to ensure that the outer pivot is properly lined up, after which the fixing screw holes can be drilled and tapped, and if desired, one or more dowels can be fitted to ensure positive location.

Assembly of clock movement

There is nothing that calls for any special comment in this part of the work as all parts should go together without any difficulty if made as described. A spot of clock oil should be applied to each of the pivots before assembly, but excess should be scrupulously avoided. When all the gears are assembled, the train should run without friction or tight spots; light finger pressure on the centre wheel should be sufficient to spin the ratchet wheel at high speed. The complete movement may now be placed in position on the chassis by sliding it over the two studs, the pins being adjusted so that they embrace the pendulum rod without lost motion.

With the normal working swing of the pendulum, the pawls should feed the ratchet wheel forward one tooth per half-swing; there is an apparent paradox here, as each of the pawls will appear to gather two teeth each time. This may call for some adjustment of the rocker on the pallet arbor, as the maximum stroke is obtained when both pawls are disposed as near as possible to the tangential position to the ratchet wheel.

Dial and hands

I do not propose to say much about this, as there is considerable scope for individual taste and ingenuity in the design of the dial and hands. The dial fitted to my clock is of “ traditional ” design, with engraved figures; it was made for me by Mr C. B. Reeve, and is up_ to his usual high standard of workmanship. Attachment is by three sheet metal brackets at 2, 6 and 10 o’clock respectively, bent inwards and screwed to the front clockplate.

Some constructors may wish to adopt a more modern type of dial, such as a transparent glass or Perspex plate with metal figures or dartheads mounted on it. Complete dials of various kinds are obtainable ready made in the clock trade, but I have not been able to find one which appeals to me as in complete harmony with the rest of the design. Fretted Roman or Arabic figures, for mounting on dials, are also available for those who wish to fabricate them.

I have, I trust, now given sufficient information on constructing all the essential parts of the clock, up to the stage of development the design has so far reached. Once again I would emphasise that this clock is intended to provide some variety in the methods of applying electricity to the pendulum mechanism and in common with all experimental designs, is undoubtedly capable of further development but it works quite well in its present form, and is relatively easy to construct. As soon as circumstances permit, I intend to explore the possibilities of increasing its efficiency by improving the electro-magnetic and contact units, and to pass on the results in due course.

Meanwhile I am now handing the job over to Mr A. L. Headech, who designed and built the very handsome case for the clock and will describe its construction in detail.

For the benefit of those who wish to “ re-cap,” as they say on the BBC, the previous articles on the clock mechanism were published in the following issues:

(1) May 1: introduction and working principles; (2) May 15: chassis and pendulum; (3) June 5: pendulum suspension and detent lever; (4) June 19: contact unit; (5) July 3: electro-magnet unit; (6) July 17: assembly of electrical components; and (7) July 31: clock mechanism. *

A CASE

For the ME Jubilee Clock

A. L. HEADECH designed this handsome case, a compromise between traditional and modern cabinet-making, the construction of which should be within the capabilities of the model engineer

I GAVE the design of this case a lot of thought, for among the readers of MODEL ENGINEER there must be craftsmen who differ greatly in their knowledge and skill of cabinet-making.

To please the older, practised craftsman a period piece would have appealed no doubt, but our good friends the metalworkers, with little experience of woodworking, would have found that veneering, inlaying and turning not at all to their liking.

As you will see I have tried to achieve a happy medium between an historical piece and the ultra modern style of strips, nails and glue. I felt that the basic construction should be not only traditional and well balanced, but fit to encase a movement made and designed by E. T. Westbury.

The case is made from a mixture of Japanese and Jugoslavian oak and as the timber had a good figure I finished the work in a natural shade, which enhances the beauty of the oak and keeps the case modern in colour.

The glass panels are rebated into the frames and beads are used on the outside. Should the glass get broken, it is much more easily replaced with the beads outside. The moulding, standing proud as it does, gives a pleasing break and interest to an otherwise plain frame. The plinth is built out from the main frame and encased by oak-faced plywood, mitred, pinned and glued into position. Simple mouldings serve to set off the plinth top and bottom. The base, I feel, gives a sense of weight and solidity to offset the movement above it, and also keeps the centre of gravity of the case low.

Construction

Before I describe the setting out and making of the case perhaps readers would like to have a list of the necessary fundamental tools required. Where the correct tools are already possessed I hope the constructor will see that they are properly ground and sharpened in readiness. Nothing makes for poor workmanship and spoiled timber more than badly sharpened tools.

A stout bench and woodworker's vice are necessary. Sufficient space will be needed to get around the bench to clean up the framing after it has been glued. These tools will be required: two or four sash cramps and C-cramps (these are essential for gluing the framing); a 9 in. Stanley or Record smoothing plane; jackplane; 12 in. tenon saw; Record Duplex rabbet plane, No 078; 12 in. and 6 in. trysquares; marking gauge; marking knife; mortise gauge; 5/16 in. mortise chisel; ¼ in., ½ in., and 1 in.

CUTTING LIST

No.	Description	Length in ft and in.	Width in in.	Thickness in in.
2	Rear styles	5′ 1½″	2	⅞
2	Front styles	5′ 1½″	1⅛	⅞
2	Door styles	4′ 1½″	1⅛	⅞
2	Side top rails	5½″	2¼	⅞
2	„ middle rails	5½″	5	⅞
2	„ bottom rails	5½″	2½	⅞
1	Top rail (door)	11¼″	2	⅞
1	Bottom rail (door)	11¼″	4	⅞
1	Top	1′ 2¼″	8½	¾
2	Scotia strips (one piece)	9″	1⅜	⅞
1	„ „	1′ 2″	1⅝	⅞
1	Back strip (top)	11″	1	⅞
4	Cross bottom rails	11½″	2¼	⅞
2	Front pieces (glued)	13″	⅞	⅞
2	Plinth corner strips (front) ...	11¼″	2	⅞
2	„ „ „ (rear)	11¼″	¾	⅞
2	Base rails (side)	9¼″	3	⅞
1	„ „ (front)	1′ 3¼″	3	⅞
1	„ „ (back)	11″	2	⅞
2	Plinth capping mouldings (side) ...	9⅛″	1⅜	⅞ (or one piece)
1	„ „ „ (front) ...	1′ 3″	1⅜	⅞
1	Plinth facing (plywood) oak ...	2′ 9″	12	⅛ single face
1	Backboard (plywood) oak	5′ 1″	11⅜	¼ single face
1	Loose shelf (plywood) oak	10⅛″	6	⅜ single face
1	Bottom shelf (plywood) oak ...	10⅛″	5¼	⅜ single face
2	Shelf bearers	5¾″	½	⅜
1	Oak strip for beads	3′ 8″	3¼	5/16

turner's chisels; mallet; rebate plane (a steel carriagemaker's rebate plane will do all the necessary work here and is admirable for shooting shoulders as well); cabinet scraper; screwdriver; bradawl; small hammer; nail-punch—fine; and mitre block or box. The use of a ¼ in. bead plane and ½ in. round plane will be necessary for the mouldings. These last tools may perhaps be borrowed for the occasion.

Cutting list

This list gives lengths, widths and thicknesses and is for machine-planed timber. I would not advise readers to plane up their own from rough as the labour could be far better spent in making the case.

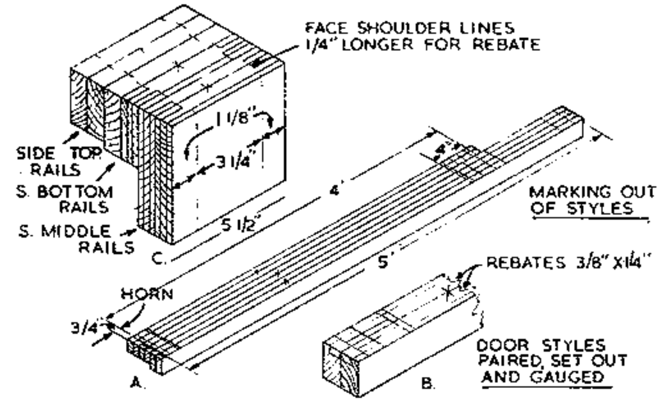


Fig. 2

Main frames and door

The front and side elevations of the case are shown in Fig. 1. These give overall dimensions and a general idea of the construction. It will be seen that the framing which holds the glass panels appears to finish at the top of the plinth. This is not so, as reference to subsequent drawings will prove. The side frames continue down behind the plinth and terminate at the top surface of the base moulding.

The first job to do is to make these side frames or ends, and as the door is in line with these, it can be set out at the same time.

Now refer to Fig. 2. Assuming that all the necessary timber is at hand it is a good plan to select the face sides and edges and pencil on the customary marks which are of vital help later in making sure that members which are paired are left that way during the whole of the construction. The way of the grain is also important when applying these marks, care being taken to see that it flows in the direction of the rebate planing later on. Lack of thought here can produce a poor result through timber being torn up badly, particularly where mouldings are concerned.

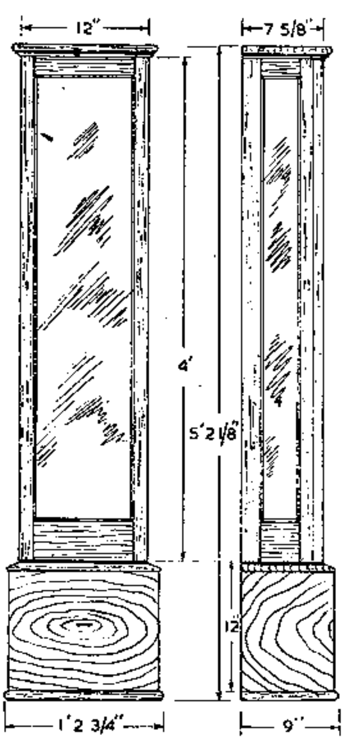


Fig. 1

Use of marking knife

The four frame styles and the door styles should be paired and placed together in a vice or between cramps and marked out as at *A*. The extra 1½ in. in the cutting list is to allow for the horns at each end of the styles. The lines shown should be cut lines done with a marking knife. If you have no such tool one can be made from an old table knife, suitably shortened, ground and sharpened. Many joiners and craftsmen I have met used a knife of this type in preference to the bought type. My own is at least thirty years old and still as good as ever.

Mark a line across all six styles ¾ in. from the left-hand end and from this measure 5 ft on the four frame styles and 4 ft on the door styles. Next mark the inner line or "wood line" on the latter, 4 in. in, cutting this line right across the six pieces. From this line mark another one a ¼ in. to the right to allow for the wood removed later in rebating for the glass.

Mark the wood lines for the top rails which will be 2 in. down from the first line marked on the left. Again mark in a ¼ in. for rebating. Now mark up 1½ in. for the mortises and square across all styles. To complete this end add on a ¾ in. to the four frame styles with a line which indicates the top surfaces of the wider top rails required here. The reason for this will be clear later (Fig. 6).

The rest of the setting out for the remaining mortises can now be done. At the extreme right end of the larger styles mark up 2½ in., square a line and from this mark another 1¾ in. to the right for the mortises in the bottom ends of the styles. It now remains to mark the mortise lines for the middle and bottom rails of the door.

On the four styles mark along 5 in. from the "wood line" already there and square across the four pieces only; mark back 1½ in. and 1¾ in. respectively and square across. The four frame styles are now ready for gauging. To complete the door styles mark up ¾ in. from the length line and then divide the remainder into three 1 in. spaces. You will now have two mortises of 1 in. width, and two haunchings.

Setting mortise gauge

Set a mortise gauge to a ⅜ in. or $\frac{5}{16}$ in. mortise chisel so that the points of the two spurs exactly span the width of the chisel blade. By trial and error set the spurs to come exactly in the middle of the face edge; when this is so only two dots will be visible instead of four. With the gauge firmly held against the face sides, gauge all styles, marking carefully between the limiting lines of the rails. Fig. 2 *B*.

Set a marking gauge to come in line with the far gauge line of the mortise seen from the face side and gauge the whole length of all styles keeping the gauge on the face side always. Reset the gauge to ¼ in. and gauge the depth line on the face sides, *B*. The styles are now ready for mortising.

A look at Fig. 2 *C* will show the general idea for marking out the rails accurately. The three rails at the back of the sketch show the preliminary lines on the face edges, the other rails showing the squaring round of shoulders and the gauging with mortise and marking gauge. The side bottom rails do not require gauging for rebating as a glance at Fig. 5 will prove.

The six rails can either be paired up and placed on the bench above one another for marking out, or if the woodwork vice is large enough they may be held between the jaws firmly. This mass-production method should always be carried out if possible, as it makes for speed and accuracy in setting out. The door rails are shown at Fig. 3 joined up and marked out. When using the mortise gauge on the end grain, make sure a very firm and clear line is shown, because a feint, indistinct mark will be difficult to follow when tenon cutting.

Cutting the mortises

Those fortunate people who have access to a chain or bit mortising machine will make short work of this job and I shall not describe their work; but those of us who will have to do the mortising the hard way may profit by a word or two of explanation. With small mortises like we have here it is a waste of time to attempt to drill or bore out the core, for a smart craftsman can chop out a mortise cleanly while another is laboriously boring a chain of holes between the gauge lines.

Place the six styles on the bench as they are in Fig. 2 *A* and take up a seat on top of them! This may sound a lazy way of doing it and those who prefer to stand all the while are perfectly at liberty to do so. By sitting on the work a position is taken up directly behind the chisel and mallet and one can readily check if the tool is being held upright.

To gauge the depth of cut for these stub mortises, make a pencil mark from time to time on the chisel blade to the depth required, or paste a strip of paper around the blade above the line. The first method is less troublesome. Starting in the middle of the top mortises, hold the chisel vertical and give a good solid blow with the mallet. The face of the chisel should be adjacent to the next cut—up or down. Having made the blow, push the chisel over slightly to release the chip and move the tool forwards or backwards a $\frac{1}{16}$ in. and hit again. Carry on this work until the chisel has reached to within $\frac{1}{8}$ in. of the intended line and then lift out the chips, and start again from the centre and go deeper.

I found that for a mortise of one inch or so in depth two traverses had to be made to get down to my line on the mortise chisel blade. When the mortise is down to the correct depth, cut the remainder neatly back to the finishing line.

The job of mortising is the most tedious of the whole work, but certainly one of the most important and time and care spent here will amply reward the diligent worker. If these mortises are cut out of square or the vertical, great difficulty will be experienced later on in the fitting up. A through mortise is not so difficult as an approach is made from each edge of the style and the result is usually parallel.

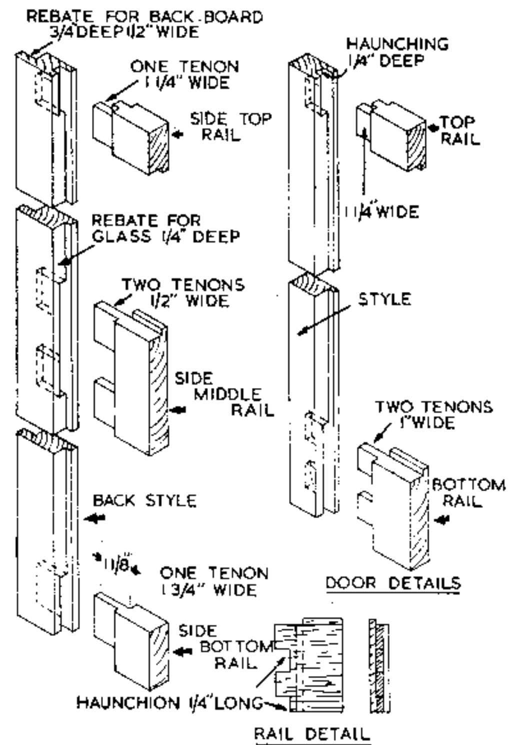


Fig. 4

Tenon cutting

Place two or more rails in the vice (Fig. 4) and with a sharp tenon saw start cutting from the top corner as shown. By this method one can see both lines—those on the end grain and those on the edge—and a truer result will be obtained. Try hard to leave half the V of the gauge line on the side of each tenon. No one cuts in the gauge line and no one should cut a $\frac{1}{16}$ in. or so outside the line as this makes more work in paring down later when fitting up.

A well-cut tenon should go into the mortise first time with the minimum of easing. Saw diagonally each way as shown and then cut vertically down nearly to the shoulder line. No shoulders must be cut at this stage of the work.

To be continued on September 11

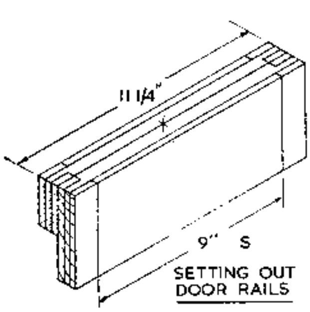


Fig. 3

A CASE for the ME Jubilee clock

Continued from 28 August 1958, pages 262 to 264

This, the second article in the short series by A. L. HEADECH, deals with the fitting up and general assembly of the case

SHARPEN and set the Record rabbet plane so that the side cutter rests in the gauge line on the face edge and the depth stop is set to a bare ¼ in. Place the style in the vice and support the other end with a block screwed or nailed to the side of the bench.

I never worry about fixing a job to the bench as it is made to work on and not to keep as a french-polished showpiece, as can happen in handicraft rooms in some schools. A glance at the benches in a joiner's or cabinet-maker's shop will prove what I mean.

Young people are shown unconventional ways of cutting joints just to prevent the benches being marked or sawn. This is a great pity, as traditional methods are lost, and indifferent craftsmen become the result.

However, let us return to the rebating of the styles. Make every effort to keep the fillister plane level and held tightly against the side of the work. Plane the part of the style nearest to the vice, with long strokes and only move backwards when the tool has stopped cutting. Now finish off the rebate from the far end, coming up to the vice at the end of the stroke. If the result is not quite as one would like and a shaving or two needs removing, use the steel carriage-maker's rebate plane to true up.

Rebating the rails

The rails can be done easily in one action using the vice only. Here one can start at the rear end of the wood and work smoothly backwards and forwards. Accuracy in the rebating is very important as the subsequent fit of the shoulders depends on the rebates being the correct depth. Having completed the rebating we can now turn our attention to the cutting of the shoulders on the rails.

Here again the tenon saw should be placed on the waste side of the shoulder line allowing possibly a 1/64 in. extra on the length when cut. After the shoulders are sawn a few strokes across them with a steel rebate plane or shoulder plane set very fine will leave a perfect surface to ensure a good fit against the style.

We now have six rails with tenons cut to thickness but not to width. Reference to Fig. 5 will give the necessary dimensions showing tenon width, length and depth of haunch as well. The spaces are made by sawing down the tenon at right angles to the bench vice. These lines may be pencil and should be marked with a trysquare blade held against the shoulder. The piece is removed by sawing across the haunch portion with a coping saw. Any roughness can be carefully removed with a paring chisel. As the joints are all stub mortises and tenons, we are not concerned with making wedges. A point to remember if wedges were required is that they are usually cut from the waste pieces before they are removed from the tenons.

Fitting up

Theoretically, if the joints are carefully prepared beforehand, the framing should go together easily first time, forming a well fitting construction, true and "out of winding." Often there is some easing to do where tenons are too tight or where some warping of the styles has occurred.

Place the style of one of the end frames in the vice and support the other end on the block used for rebating. Now take the top rail and fit it into its mortise and tap down gently with a mallet. The tenon should just be able to be pressed down by hand and not be a knock fit all the way by mallet. If one shoulder is off when the other is touching, it may be that it is a little long or, perhaps, the rebate is not exactly the right depth. Always ease the offender, never make two wrongs into a right!

Test with straightedge

As soon as the shoulders touch, test with a trysquare between rail and style to see if the rail is square and vertical. Also test with a straight edge—steel rule will do—from the face of the style to see if the rail is upright and in line with the face surfaces. When all these tests are true we can fit the bottom rail in place. Use the same method as before and look down the framing to see if the rails are in line.

Finally fit the middle rail to be upright, square and agree with the top and bottom rails. Now do the same with the opposite stlye in the vice and fit the other ends of the rails into their respective places. This completed, the frame may be assembled again and checked both sides. Stand the frame on its "horns" and turn your attention to the other one, which, when assembled will make the pair to form the sides of the clock case. The fitting up of the door is the same as before, particular care being needed to see that it is perfectly flat. A door which " winds " is an eye-sore and a perpetual nuisance for evermore ! As soon as the inner edges are cleaned up with a smoothing plane the frame can be glued together.

Gluing up

This is one of the periods during construction when a good clean up is necessary. Put away bench tools, brush down, and lay the sash cramps across the bench in a position which conforms with the centre of the rails of the frame. Now bend down and look along from one cramp to the next to see that they are lying perfectly flat on the bench surface and that the top edges are parallel. See that the shoes are already set to the width of the framing plus a space for a spare piece or block each side of the frame. These pieces will protect the square edges from damage by the cramp shoes on tightening up.

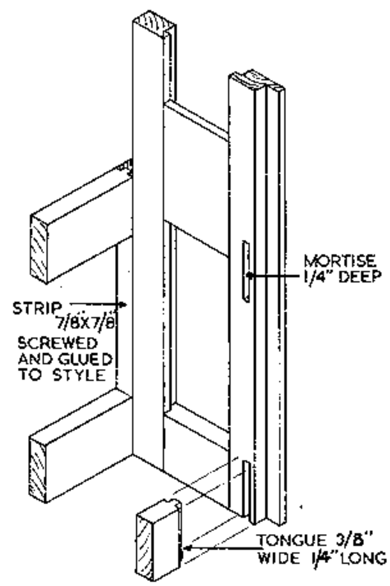
Where only two cramps are used, have one at the top rail and the other set between the middle and bottom rails with a wide piece of hardwood, some two inches or more, each side between the shoes and the frame. This will spread the pressure evenly and if the shoulders were really well fitted, be quite adequate to force out excess glue and air from the joint and hold the work till the glue sets. I like to leave work of this kind at least 24 hours.

Some people have a preference for the modern quick drying glues but I have always worked with the old fashioned Scotch glue which can be bought in a granulated or pearl form. This needs only the addition of water and heating in the usual way in a double receptacle, so that water surrounds the container holding the glue. When gluing a job together there are three things to keep in mind: heat, speed and cleanliness. The glue should run off the brush like thin oil in a continuous stream—no lumps or blobs. The thing to remember is that the glue has to penetrate the pores of the wood and thick glue cannot do this. A good glued joint should be stronger than the wood itself. Now for the gluing. Place one style in the vice and with a ½ in. flat brush, glue quickly the three main joints. Now take the rails one at a time and glue the end required and place into position. When all three are home, glue the tenons at the other ends, take the remaining style, glue quickly, and place on top of the rails and tap home with a block and mallet.

Checking diagonals

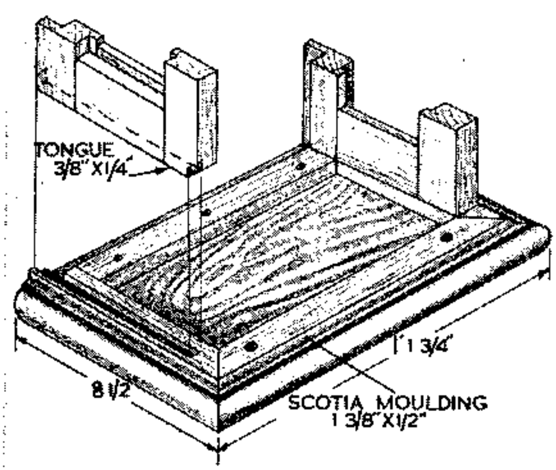
Remove the frame and put between the blocks already prepared and screw up the cramps evenly. With an accurate try-square check the angles of the rails, or with a long thin piece of wood having a point at one end, check the diagonal distances corner to corner. This latter method is often the only way to obtain accuracy in some work and is used a lot in workshops. Any glue which has come through on to the inner edges or rebates may be removed with a clean rag dipped in hot water from a saucepan left handy for the purpose. Beware of using hot water from an old glue kettle as stains can easily develop from a cast iron pot. Leave the framing between the cramps for at least 24 hours. The gluing of the rest, of course, is similar.

Take one of the frames and lay it flat on the bench. Find some odd pieces of strip wood and cut a piece in at each end of the frame, to fit snugly between the extended styles-horns. These strips should be lightly nailed to the bench to keep the frame firm. Incidentally the thickness should, of course, be less than that of the frame. Now with a sharp jackplane level off the surface, removing as little as possible to produce flatness. Finally with a smoothing plane run over again being careful not to leave plane marks across the grain. Finish off the surfaces with steel scraper and glasspaper. Take the frame and place between the strips. When



turning over the frames to clean off the other sides it will be found that the strips need altering in length owing to the rebated styles. The door can be tackled in the same way and we now have the major portion of the case done.

The next step is to prepare the side frames for the backboard, the plinth and the fixing of the top. Set a marking gauge to ½ in. for the depth of the rebate. Before gauging it is a good plan to check the straightness of the long edges of the frames. If there is some inaccuracy take a jackplane or preferably a trying plane and shoot a small amount off to true up. This is very important on the front edges as we not only have a strip to glue on at the base, but the door shuts against these edges as well. Gauge the back edges to the ½ in. set keeping the stock of the gauge against the inner face of the frame. Now set to ¾ in. and gauge the face



Above, Fig. 6: Details of the separated tongue and the groove joint

Left, Fig. 5

with stock on the back edge. Cramp or pin the frame to the bench and with the rebate plane set accordingly take out the rebate from end to end. Remove the frame from the bench and do the same to the back edge of the other one.

We are now ready to fit the strips at the lower front edges. These being ⅞ in. square will be a trifle proud of the thickness of the side frames owing to the cleaning off process. All to the good. Mark out and bore three clearance holes in each piece to take 1¼ in. steel flathead screws of No 8 gauge. Assuming that the strips fit well screw them into position with the bottom ends flush with the horns on the frames. This will allow a little to be sawn off and cleaned up at the top later. Unscrew the strips and quickly glue them and the front edges at the same time, bringing together again and re-tightening the screws.

Screws first

When screws and glue are to be used, always put the screws in first with a dry joint and glue up later. A moment's contemplation will see the wisdom of this method. The glue having set we can now flush off the front strips to be in line with the faces of the frames.

The top ends of the frames are now ready for attention. Saw off the horns protruding and take a shaving off the top edge with a smoothing plane working inwards to prevent breaking the corners. Now refer to Fig. 6. The left-hand, or rear side, shows the separated tongue and groove joint. To mark out for the tongue set a gauge to ⅜ in. and holding the stock against the outer surface make a line right across the top edge of the frame, and also its opposite partner. With the same setting gauge across from the front edge to form the shoulder or set back. Reset the gauge to a ¼ in. and mark along the inside surfaces for the depth of the tongue, or rebate which forms it. The rebate should be cut first, by sawing across the styles and rail when the frame is flat on the bench. Then the end grain remaining can be chopped out with a 1 in. chisel and mallet and the remainder removed with the steel shoulder or rebate plane. Finally saw off the shoulder at the front and clean up, making sure that all is square and true.

The top

You will see in Fig. 6 that the construction consists of a solid piece 1 ft 1½ in. × 8½ in. × ¾ in. Screwed and glued to this is the Scotia moulding at front and sides, and at the back a strip set back to form the rebate for the backboard. The moulding is mitred at the front, the side pieces having trenchings or stopped grooves worked in them to take the tongues we have formed at the top of the frames. The fixing screws can be conveniently placed at the bottom of these grooves and, therefore, will not require to be covered. The screws in the front pieces are sunk below the surface for ⅛ in. or so and plugged with oak, having the grain running the same way as the strip. I did not feel that the rear ones needed this treatment, as they are practically out of sight.

The setting out for the grooves should be done with a mortise gauge, the spurs first being set to the tongue formed, and then the stock adjusted to coincide with the inside face of the side frame. Mark up from one squared end the length of the tongue and gauge up to meet this point. Set a marking gauge to ¼ in. and gauge the squared end for depth. The trenching can now be cut. Chop out a mortise about 1 in. long at the stopped end and check this for depth. Now carefully saw along the grain following the inside of the gauge lines, remove the waste with a ¼ in. chisel and finish to depth with a router set to the gauge line at the end of the strip. Repeat on the other piece, being careful to make a "pair" of the two strips. We can now mark the moulding on the edges.

Finishing the moulding

Mark two fine gauge lines ⅜ in. in each way from the outer corner and bevel off to form a chamfer. Now with a round plane held at about 45 deg. to the horizontal, plane away the centre of the bevel to form the hollow required. Finally clean up the moulding with glasspaper and a block shaped to exactly fit the curve formed.

The next job is to mark out and cut the top piece to length. Leave enough to clean off the end grain with a smoothing plane to square up. When doing this place the piece end upwards in the vice and plane from the corners inwards being careful to stop the plane before the opposite corner. To make the "round" on the edge, plane a chamfer or bevel on the end grain and then, varying the angle, take off the corners gradually to form the required corner. A "hollow" plane of the right shape, of course, will produce the best result. Having shaped the ends, finish by moulding the front edge.

It is now necessary to position the strips for attachment. Mark two cut lines across the under surface of the top to coincide with the inner edges of the frame sides. The case is 12 in. wide and allowing for the thickness each side, the central distance will be 10¼ in. If much has been taken off the frames in cleaning up, the distance will be increased between them to allow for this. Gauge in from the back edge ¾ in. for the backboard and 1 in. from this line for the back strip. To position the front moulding mark in from the front edge 1¾ in. With these lines set out, it is an easy matter now to lay on the strips, mark the lengths for the mitres and cut to size. A bevel set to 45 deg. will suffice for marking out and can be used to check the cleaning up of the mitred surface with a sharp smoothing plane or block plane. I found it was a good plan to cut one piece, bore and countersink where necessary, screw into place and then fit the other pieces as I went along.

When they are all in position offer up the tongued ends and try the general fit. It will be noticed in Fig. 6 that a piece of wood is to be cut from the back of the side mouldings to accommodate the corner of the backboard and so complete the rebate all round.

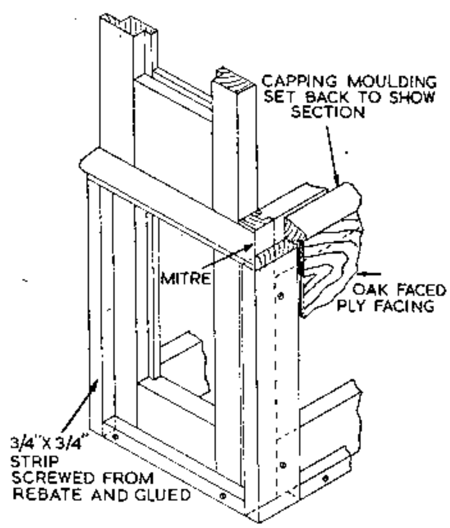


Fig. 7: Constructing the rails for the bottom of the clock case

The strips can now be removed from the top board, a thin application of glue applied to both surfaces and the strip rescrewed into position. Make sure that the mitred surfaces get their share of glue. (Make and fit glued plugs to front screws.) Clean off any surplus glue with a damp brush or rag. When the glue has set the mouldings can be cleaned off all round and finally glasspapered. The top can now be put aside with suitable weights to keep it flat, until needed later for final assembly.

★ *Continued on September 25*

A CASE *for the* ME *Jubilee clock*

Details for completing the cabinet are given in this concluding article by A. L. HEADECH

WE can now turn to the setting out of the four rails to hold the bottom of the case together. Reference to Fig. 7 will show the method of construction. It is a simple job to achieve.

The four pieces can be sawn to length, $10\frac{3}{8}$ in., and marked out for the tongues. The shoulder distances between each end should be exactly those set out on the top just described. In fact one of the rails can be laid across the moulded strips and the shoulder line cut straight from them. Set out the other three rails from the first one to ensure accuracy. Adjust the mortise gauge, which we left set to $\frac{3}{8}$ in. between the spurs, so that this distance comes exactly central to the rail's thickness. Mark the end grain and edges of the four rails. On the inside surface of the strip glued to the front edge of the frames, mark up 12 in. from the bottom edge, scribe a line and from this mark down the width of the rail —$2\frac{1}{4}$ in. From the bottom edge mark up the same distance. Square these lines to the back style, Fig. 7, and repeat the setting out for the opposite frame.

The front mortises may now be gauged but the rear ones will require the stock to be adjusted to allow for the space taken out by the rebate for the backboard. The tenons and mortises can then be cut and fitted in the usual way. Finally make sure that all rails fit square and that they are exactly the same size shoulder to shoulder. To give additional support I bored and countersunk the frames from the outside to take $1\frac{1}{2}$ in. No 10 flathead screws into the end grain of the four rails. The frames were cramped together dry and the eight screws put in.

Assembling the sections

The final assembly is now simple. Take out the screws at the base, having the glue ready to hand and quickly glue the eight joints and place together. Tighten up the cramps firmly and turn in the screws, giving a good half turn more to bring them right home. You can, of course, leave the cramps in position over night to give extra control till the glue has set. The top having been thoroughly cleaned up, scraped and glasspapered, can now be placed in position. Two pieces of hardwood 9 in. × $1\frac{1}{2}$ in. × 1 in. will serve to distribute the pressure at each end of the top. Four smaller blocks will be required to fit into the rebates on the top rails so that the G-cramps do not mark the work. Have all the cramps set ready and then quickly glue the tongues and grooves, bring together and cramp up firmly. Clean off any excess glue as before. If the joints have been carefully and accurately fitted the case should be perfectly square and parallel.

The capping moulding, Fig. 8a, can be made or " stuck " in one long piece or in two pieces—one for the front and one to cut for the sides later. Set a gauge to $\frac{3}{8}$ in. and mark the underface, reset the gauge to a $\frac{1}{4}$ in. and mark the corresponding edge. Now set the rebate plane or fillister and take out the rebate. The next step is to plane the bevel at the top of the moulding. Put a gauge line on the front edge a $\frac{1}{4}$ in. down and mark a sloping line in pencil on the end grain from this gauge line to the back corner. Plane down to this line. It only remains now to round off the remaining front edge with a smoothing plane and finish with a shaped rubbing block and glasspaper and the moulding is ready for fitting. In the detail sketch, Fig. 8a, the moulding is screwed from behind and glued. Using a bevel or mitre box cut the moulding to fit around the case. A fine shaving should be taken off the mitres with a block plane to ensure a perfect fit. Mark out and bore three fixing holes on the front top rail and two holes in the frames, countersinking the inside by hand as the brace will not possibly work in such a confined space. One could, of course, set out and make these holes before the frames were glued together.

Fitting dry

Hold the front moulding in place with blocks and G-cramps and having used the bradawl, turn in the screws from behind. Then fit the side mouldings in a similar manner. By fitting these parts dry one can take time in fitting and adjusting where necessary. Remove mouldings, glue sparingly the meeting surfaces and mitres and quickly screw up. It now remains to fit the " grounds " or fillets which provide the base for the plywood surround. Fig. 8 shows the necessary construction and little need be said here. Make sure that all meeting surfaces are level and in the same plane as the rebated moulding. Here again fit the parts dry and screw up and then dismantle again for gluing.

We can now cut and fit the ply facing. It is a good plan to buy the panel all in one piece and then, if any part of the grain has a distinctive feature, it might be arranged for the centre of the front panel. The sides will then be cut and the grain will follow round. A careful look at the photograph of the finished case will show what I mean. Commence by shooting the top edge of the plywood and fit this into the rebate under the moulding. Measure the exact depth and plane the plywood to width.

Planing the mitre

Mark with the bevel and try-square a mitre at one end and saw off the waste with a panel or tenon saw. To plane the mitred end accurately I prepared an odd piece of thicker timber with a 45 deg. bevel on one edge, wide enough to support the whole end grain of the ply. Then with the two surfaces in line and the sawn mitre just proud I held them in the vice and planed carefully down to the supporting piece. Without this piece it will be difficult to prevent the corners being broken on the oak veneer.

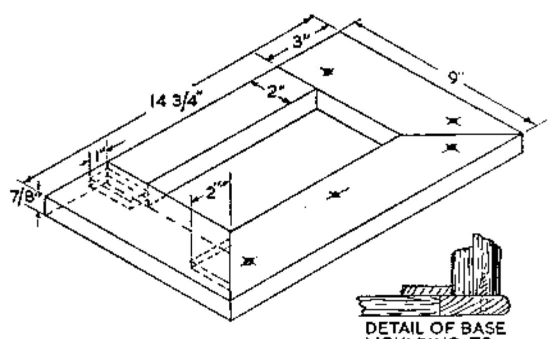
Having completed the mitres at each end of the front panel, pin the piece into position with $\frac{3}{8}$ in. veneer pins, tapped in about half way. The side panels can now be fitted to meet neatly at the corners. When all is ready remove the panels, quickly glue meeting surfaces and drive the pins home, being careful not to mark the face veneer. The heads should be punched $\frac{1}{16}$ in. below the surface with a fine nail punch ready for stopping later. The glue having set we can now clean off with block and glasspaper keeping with the grain all the time.

We are now ready for making the base moulding which sets off the plinth and gives a pleasing finish to the bottom of the clock base.

From the illustration, Fig. 8, it will be seen that the mitres are stub mortised and tenoned to give added strength, and the back rail also has short 1 in. tenons as well. I felt that a really firm base was called for here to prevent damage to the rest of the case when moving the clock from time to time. Someone once said that the test of good construction in furniture was how many removals it could stand! Some of the flimsy constructions of today leave much to be desired in this respect.

The whole of the setting out is straightforward and should be carried out at once. The ends should be cut to length and mitred and then gauged for the mortises. The front rail can have the mitres marked out but not cut. Saw the tenons in the usual manner and cut along the mitred shoulders. Mark out the length of the stub tenon in pencil and cut off the waste. The mitred surface should be carefully eased with a rebate or shoulder plane and tested with the set bevel or better still a mitresquare. Mortise the end rails taking care to keep the chisel vertical and also to check the depth of the mortises. Clean off the mitred ends which could have been left a little proud from the tenon saw. Fit the frame together and check for accuracy—squareness and winding. The round moulding can now be marked on the front edges using smoothing plane and "hollow" to finish off. Make up a rubbing block and glasspaper to remove flats or plane marks. Set up the sash cramps and glue the front quickly together. Softwood shaped blocks should be inserted between the shoes nearest the moulded edge. Shaping can, of course, be left till last if preferred.

Clean both sides, checking for winding and flatness. This is very important here as a good butt fit is essential between the clock case bottom and the base moulding. Arrange for fixing screws—1½ in. No 10—placing the holes as in Fig. 8. It is a good plan to stand the case on the moulding and mark around lightly with a pencil inside and out to show the areas for screwing. I always rub the screws over a damp piece of soap before turning in, to help against friction. When using brass screws this is essential, as without some lubricant they will usually break off. A broken screw down inside the wood is nearly impossible to remove. A good dodge is to use a steel screw of the same size first and then replace with the correct brass or plated one. The base moulding should be glued before final screwing up to the case.



Left, Fig. 8: Base of the clock

Right, Fig. 8a: Capping moulding

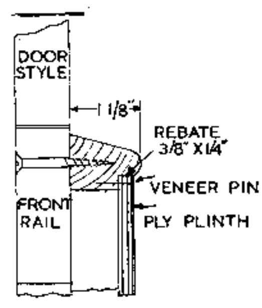
Completing the backboard

All that is required for the backboard is to shoot the edges with a jack or trying plane until the board drops snugly into the rebates provided. A good fit all round will ensure perfect rigidity to the case. Screws should be arranged around the edge and across the centre of the lower middle rail. They require countersinking just beyond flush. I used steel, 1¼ in. No 8 screws. Brass screws to prevent rust may be used. The backboard is only screwed and is made removable for fitting the movement, and subsequent cleaning or adjustment. A glance at Fig. 9 will show there is a strip screwed on the side frames between the front and back rails. This supports the plywood shelf over the battery compartment. Fig. 11 shows the dimensions of the loose shelf and a strip fixed along the front edge to keep the shelf in position. The front edge also provides a door-stop at the bottom. The base shelf should be cleaned up with a smoothing plane on the edges and glasspapered to be a loose, but neat fit when in position.

The glass beads

The beads used were made from the solid and sawn off as they were "stuck." Readers who wish to buy this moulding could, no doubt, find an oak moulding similar at moulding stockists, but it may not be tapered as Fig. 10. I feel that the one shown is more tasteful and elegant than a parallel bead which is used in building construction. If one can acquire a ¼ in. bead plane then the experience and pleasure of making one's own moulding is worth while. The method is as follows: plane the edges of the piece from which the beads are to be cut, and fix the board to the bench top face upwards. Take a few shavings off the corner to form a small chamfer. Then, holding the bead plane vertical, traverse the wood backwards and forwards as for rebating until the plane stops cutting or a full "round" is visible on the chamfered corner. Remove the board from the bench, reverse and repeat the operation on the opposite edge.

Saw off the bead, cutting carefully along the board about $\frac{1}{16}$ in. from the square or quirk. Fix the bead to the bench, sawn surface uppermost, and plane down to the bevelled section shown in Fig. 10. A gauge line ¼ in. up will help on the square edge and the bevel should just finish at the bottom of the quirk. Normally, of course, the quirk is left on this type of bead to form a break between the "round" and the work. If preferred, a parallel bead and quirk can be fitted and the bead left flush with the outside of the frames. After the two beads are prepared, replane the edges of the board and repeat the operation. This should be done until sufficient moulding has been made to allow for side frames and door. The width of the bead depends on the thickness of glass used. I used 21 oz. window



glass free from blemishes. The beads should be carefully glasspapered with a rubbing block of correct shape and put aside for awhile.

Fitting and hanging the door

Take the door frame and placing it flat on the bench, mark a line across the "horns" in line with the top and bottom edges, and saw the waste off. Place the style on the top rail end in the vice and support the bottom rail end with a block projecting over the bench into the rebate.

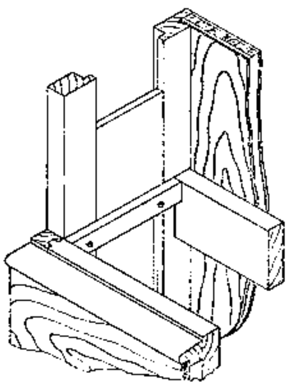
With jack or trying plane shoot the edge straight in as few shavings as possible. Then check the width with the clock case and take off the remainder to size with the other style in the vice. If the door has come out wider than a shaving or two, the amount will have to be shared by each style to keep uniformity. Having planed the door to width, clean off the top and bottom edges, working inwards to prevent breaking the corners. When the door is tight against the top of the case, there should be a good $\frac{1}{16}$ in. gap at the bottom.

Fixing the hinges

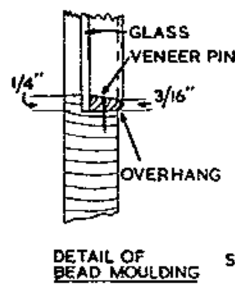
Get three 2 in. brass butt hinges of best quality and $\frac{1}{2}$ in. brass flat-

gauge to the thickness of the flange and gauge along the edge of the style opposite the previous lines. Place the door flat on the bench, which has been brushed clean of shavings or grit, and with a $\frac{3}{4}$ in. chisel and mallet cut across the grain from the centre to the ends of each recess. Then place the chisel with the grain $\frac{1}{8}$ in. from the gauge line and tap gently with the mallet, and finally in the gauge line. Carefully pare inwards and remove the waste down to the depth line. Try the hinge in place and it should be a tight fit and quite flush. Repeat this on the other two recesses. Using a bradawl first, and then a little soap on the screws, turn them in flush and true. Make sure that the screwdriver is the right size for the job and the blade correctly shaped—parallel end, not bevelled off

Because of the way the door is fitted into the case, a link plate lock is needed. Buy the smallest you can get. The one I used had to be specially ordered and cost ten shillings with postage. Be careful in the fitting of this, as there is little room for adjustment—it has to be right first time! First set out the height of the lock or keyhole. I set mine just above half-way up. If you put it in the middle it will look low afterwards. Carefully bore or drill the two holes for the keyhole the larger one at the top and the little one at the bottom. Correct the two holes with a fine coping saw or $\frac{1}{16}$ in. chisel. Put the key through the hole and place the lock on to it and hold against the style. Mark around the box holding the mechanism and chop out a mortise to take this first.



Left, Fig. 9: Detail of strips for shelf



Centre, Fig. 10: The bead moulding

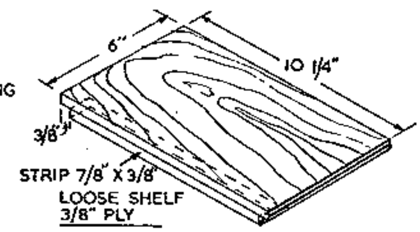


Fig. 11: Loose shelf of $\frac{3}{8}$ in. ply

head screws to fit. Be careful here to test the heads in the hinges yourself to make sure the surface of the head is not the slightest bit above the flange. Some hinges these days are sold in packets complete with screws. Avoid these at all costs on work of this nature. The screws are not brass—only plated, and, worst of all, are too long for the countersinks in the hinges. If this type of fitting were used, the door would not close properly unless an ugly gap to accommodate the screw heads was made. To be on the safe side, see that the screws are slightly below the hinge surface.

On the inside surface of the hanging style mark a distance of 3 in. down from the top edge and make a cut-line the width of the flange. Place the hinge against this line and mark the length lower down. The bottom hinge can be 5 in. up and the width again, and the third, centrally placed between them. Set a gauge to the distance between the edge of the flange and the centre of the pivot pin. Gauge carefully between the marked lines only. If you have another gauge keep the one just used set to size for the case. Set the second

both ways. The screws should appear unmarked when in place With the case lying on its back, place the door in position with the top rail tight against the underside of the top. With a small chisel mark the corner of the frame style, top and bottom of each hinge. Remove the door and with a knife cut the lines inwards as before and gauge with the same settings.

To chop out the recesses, fit an odd piece of wood in the rebate to take the shock of the mallet blow and transfer it to the bench. Without this intermediate block serious damage will be done to the side frames. Carefully chop out the spaces and then, using only one screw in each hinge—in the middle hole—try the door for shutting. With any luck it should open and close first time. It may have a little too much gap between the hanging style and the frame. If this is the case, remove the door again and pare a little off each recess, preferably to a new gauge line—not guesswork! Try the door again. Remember that a door will always drop of its own weight so keep the top joint to a minimum first. If you are satisfied with the fit everywhere turn in the remaining screws.

We are now ready to fit the lock.

Having got it accurately into place, finally mark around the cover plate and let that into the style. The lock should be just flush at the back of the door style and a good fit. Put the socket plate into the lock and turn the key. Close the door and give the style a tap with a hammer and block. Then open the door and remove the plate. On the back of this are two small projections which have registered their position on the case frame. Put the plate on to the frame style, into these holes made by the projections, and mark around the plate. Chop out enough wood to let the plate lie flush at first.

Put in the screws and close the door and lock it. If there is a rattle, it means that the plate must be let in further. Make the adjustment and try again. It should be possible to just turn the key easily but no movement be felt afterwards in the door. This trouble is necessary, as a good fit will keep out dust from the movement. In fact I did think of incorporating a dust proof joint around the door, but this would have made the case much more difficult for the amateur to construct. Experienced readers can do this if they consider it necessary. Others could line the

● *Continued on page* **410**

mittee, of which I happen to be a member, recently considered a special gun designed to produce a very high muzzle velocity, in connection with an experiment. It had no military application.

The velocity attained was rather more than 5,000 f.p.s. and the gun had a smooth bore. The projectile was propelled by very heavy charges and was fitted with a sabot which separated from the shot at the muzzle. Hitler developed a somewhat similar device on a much larger scale in order to bombard London. It was not a success and was discarded. The projectile had insufficient stability. It had progressive charges but no sabot.

Mr Pinnock is not justified in assuming that the average velocity in a barrel is the mean of zero and the muzzle velocity. This would only be true if the chamber pressure were constant giving uniform acceleration. In practice the facts are very different. For example, the projectile engages the rifling at about ½ ton per sq. in.; the pressure then rises to around 20 tons per sq. in. and then drops off towards the muzzle when it might be, say, 2 tons per sq. in.

I think that the really interesting point raised by Mr Pinnock is the fact that the prototype has 12 times as long to burn its charge as the model. Of course it has; I said so previously. And if it is true, it is the complete answer because the speed of a chemical reaction is not proportional to the quantities involved In the time taken for a projectile to pass up the barrel of a 4 in. gun, it might be possible to burn several tons of propellant. But in 1/12 of this time it might not be possible to burn any completely. If this is so, then increasing the charge would yield no benefit.

Consider the question of range. A 4 in. naval gun might have an effective range of 9,600 yards, let us say. The scale range for a 1/12 scale model would then be 800 yd. Of course, this would have no practical application but, if it had, the muzzle velocity needed to produce a scale trajectory would be much less than 1,000 f.p.s. An ordinary 0.22 in. bullet of m.v. 1,100 f.p.s. will carry well over 1,000 yards and is stated to be dangerous within one mile.

Bromley, Kent. N. LAW.

CAR BOILERS

SIR,—I feel I must answer certain points made by Mr P. J. Atkins [Postbag, August 28] who claims to have fitted a reconditioned i.c. engine to his car for the equivalent of one year's boiler insurance on a steam car. Presumably this implies insurance against explosion.

I have repeatedly had my steam car licensed and insured without boiler insurance. If he can replace his i.c. engine for that cost he is doing very well.

A flash boiler *cannot* explode; there is colossal misunderstanding on this point. The worst that can happen is a burst tube, which can occur without stopping the engine.

About 20 years ago I burst a union on a steam pipe at about 1,000 p.s.i. There was a crack, like a cycle tyre bursting, and a fuzz of steam for about half a minute. The children in the car at the time just laughed.

Huddersfield. ERIC AINLEY.

CASE for the ME Jubilee clock . . .

Continued from page 387

edges of the case with a thin felt to exclude dust.

Finishing off

We now come to the final stages, the polishing, the fitting of the glass and the beads. I propose to be brief over the polishing, as books are written on this subject and with modern processes as well, readers may vary considerably in their requirements, according to environment and opportunity.

French polishing can be a long and tedious job to the amateur and in view of this I tried out a new commercial product which has found success in schools and homes through its ease of handling.

First, preparation of the wood. Glasspaper with the grain down to a good finish, assuming, of course, that plane marks have been erased with a cabinet scraper first. Then go over the whole case with a rag dipped in hot water but not too wet. When dry, this will have raised the grain somewhat and it can again be smoothed down with glasspaper. I next rubbed into the wood a film of raw linseed oil to bring out the grain. It was a glory to behold. A warmth came into the timber which was never there before. The beads, by the way, should be cut in to size —mitring the corners—and treated along with the rest of the work. They will be fixed a bit later on. Leave the oil a few days to sink in and dry off. One does not want much on the rag when oiling the grain or it may give trouble in subsequent stages.

The next process was to fill the grain with a wood filler. The actual polishing was done with Furniglas white polish. The five shilling packet just about completed the job. A rubber was made up from cotton-wool and old linen and the polish poured into the cotton-wool in the usual way and squeezed through the linen covering and worked into the grain with a circular motion at first. Keep a screw-topped bottle or air-tight tin handy to place the rubber in when not in use. After each application of the polish rub down with the fine glasspaper supplied in the kit. Finally, finish off the movements with the grain and a fine surface will result. The finish achieved is a nice soft gloss which avoids that glassy appearance seen on cellulosed furniture today.

The fitting of the glass is a simple matter provided it is cut to the right size. Have it cut a good 1/32 in. short on lengths and widths so that it will drop in easily. A piece of glass that is a little too large is very difficult to fix. It is not always possible to ease the rebate and the glass is more difficult still to reduce. The glass should be carefully cleaned and then placed in the rebates. I marked the beads on fitting so they would fit exactly in the appropriate place later. Replace top and bottom beads first and then spring in the long ones. Fix the beads with ½ in. veneer pins carefully tapped in with a light hammer and finally punched below the surface. Go over with a little of the filler and stop up all the holes made by the pins. One does not want to use too many—two at the top and bottom and four or five down the styles. A few rubs of polish put along the beads afterwards will complete the polishing. The beads, of course, will have already had their share of polish and filler before fixing into place.

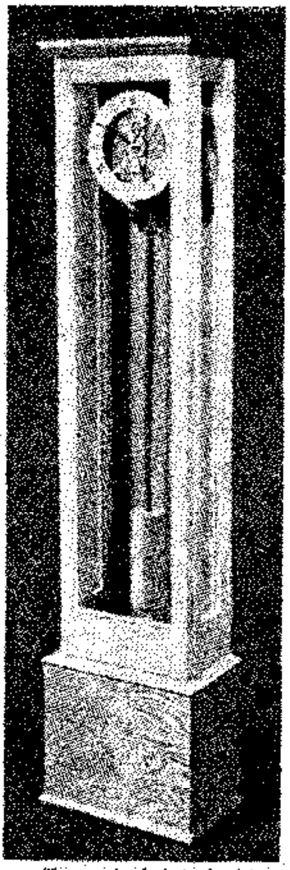
Finally a piece of plywood ⅜ in. thick was cut in to fit at the bottom of the battery compartment and glued on the under surfaces. The fitting of the movement to the backboard was done by Mr Westbury.

Those readers who find the rebating beyond their capabilities could simplify construction by using square edged material and adding beads on each side of the glass. This would mean that all shoulders would be square and not set back as illustrated.

Footnote—In listing the tools required for making the Jubilee Clock case, in our issue of August 28, we referred to "C-cramps" and "turner's chisels." This should, of course, have read "G-cramps" and "firmer chisels."

J. H. WILDING has carried out some alterations to the experimental design without disturbing the main layout

Improving the Jubilee clock



Experimental clock designed by Edgar T. Westbury for the Diamond Jubilee of MODEL ENGINEER ***and introduced in the Diamond Jubilee Number** (1 May 1958)*

IN the serial on the Model Engineer Jubilee Clock, Edgar T. Westbury made it clear that the design was experimental and was presented as an alternative to the well-tried and popular Hipp and Synchronome movements.

Although my Jubilee clock has been working for two years, I felt that there was room for improvement in the method of imparting the impulse to the pendulum. I have been to some trouble to arrange the modifications so that they can be easily fitted to existing Jubilee clocks. The main components, the count wheel and magnet assemblies, are hardly altered at all constructionally.

For the benefit of new readers and of those who would like to be reminded of the working principles of the clock, I shall describe the original layout and explain some of the difficulties in its operation. Those with back numbers should turn back to 1958: May 1 and 15, June 5 and 19, July 3, 17 and 31, and August 14.

Fig. 1 gives in diagrammatic form the original and modified layouts side by side. Fig. 2 shows the original magnet assembly, and Fig 3 the same thing after modification.

Now look at the left side of Fig. 1. Freely pivoted on the pendulum rod, which is of "seconds length," is the gathering arm E which has at its extremity the gathering pallet ***D.*** This gathers one tooth of the count wheel C at each complete double swing. The wheel has 15 teeth and is, therefore, rotated once in half a minute. With a cam or lever of some sort fitted to the arbor of the wheel, a pair of contacts may be closed at half-minute intervals to operate a series of impulse dials if you so desire. The original design specifies a movement worked mechanically by the pendulum; here the number of teeth on the count wheel is immaterial within reason, provided that the diameter of the wheel is such that the distance between two adjacent teeth is about 3/8 in.

You will notice that the tips of the teeth are notched. As the swing of the pendulum decreases, owing to various sources of friction, a time will come when the gathering pallet fails to gather the tooth of the count wheel completely and lodges in the notched part. This will give the gathering arm an extra high action on this swing, causing the momentary closing of two contacts just above. These complete a circuit which includes a battery and the magnets ***M,*** which become energised and attract the armature A -a piece of soft iron or steel.

Operation cycle

The armature is firmly attached to the impulse lever L pivoted at ***P,*** and so the roller ***R*** is pressed firmly against the left-hand side of the pendulum rod, driving it to the right. The arc of swmg is now restored: and the teeth of the count wheel will be fully gathered again. The pendulum continues to free-wheel until the swing again drops to the point when the gathering pallet fails to gather the complete tooth, and the whole process is repeated.

This method of maintaining the swing of a pendulum is similar to the Hipp principle and will be well known to many readers. Fluctuations in the battery voltage are compensated by the pendulum itself in demanding either fewer impulses or more. But in my experience this does not work too well, and I have found that the essential point for a reasonable

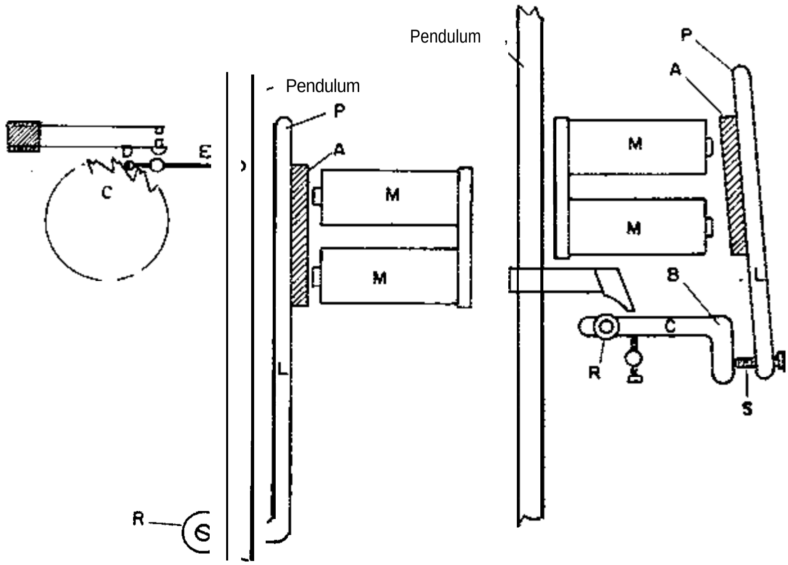


Fig. 1

degree of accuracy is to have large-capacity batteries, such as those for bells, which can be counted on to maintain a fairly constant voltage for 18 months or so. In this way a constant arc of swing is more likely to be attained.

The ideal would be to use the mains supply through a transformer and rectifier, providing that the clock is to be used only for domestic purposes. For myself, this is out of the question as my Jubilee operates as a master clock and will soon control a tower clock with three dials and striking mechanism. I always regard public clocks, which depend directly on the mains supply for their time-keeping or for the propulsion of their hands, as the lowest form of horological engineering. It would be quite permissible to use wet batteries on trickle charge but, generally speaking, the large bell batteries of 1-1/2 v. connected in series as required are the most suitable for amateurs.

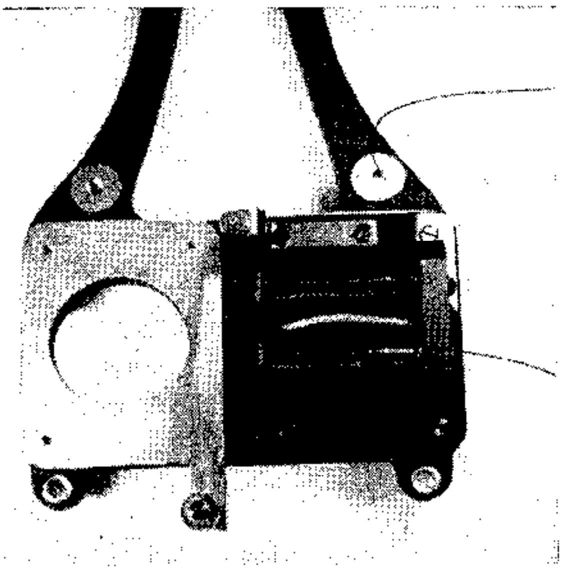
My difficulty was the shuddering of the pendulum rod ***every*** time an impulse was given. On the specified voltage of 4-1/2 it was very bad, and on 3 v. it was still bad. I finally used the clock on 1-1/2 v. and even then it was still noticeable, though the power transmitted by the magnet was not enough to maintain the swing of the pendulum for a reasonable number of vibrations between impulses. Consequently the batteries did not last as long as they should have done.

Cause of shudder

An examination of the action in detail will reveal the cause of the shuddering. The contacts are closed just as the pendulum starts its Journey to the right. At this moment the armature is some way from the magnet, and the attraction is only slight. As the pendulum moves to the right, the attraction increases until the armature touches the poles when the force is at its maximum, and the impulse then ceases abruptly.

Whether the impulse is finished by the breaking of the contacts, or for the other reason, makes no difference. The impulse is ending when the magnet is at full power. Although the pendulum is in the vertical position, and therefore travelling at its fastest, the difference in acceleration (which operates on a cube law) between the pendulum and the magnet is too great; the excess energy is absorbed by the flexing of the pendulum rod. As soon as the impulse is cut off, the rod springs back in the form of a shudder.

The obvious solution might be to make the rod much stronger, and perhaps rectangular in profile, to resist the bending tendency. I tried this, and there was some improvement; but I felt that I was only hiding the fault instead of curing it. There was,



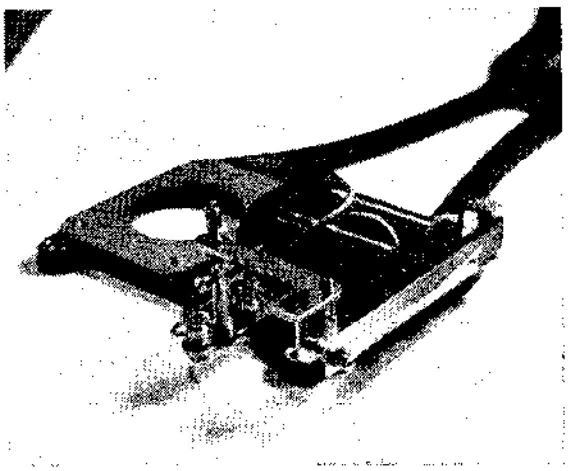


Fig. 2 (left) and Fig. 3: Right-hand clock panel before and after changes

too, another thing which I wanted to change. I did not like the way in which the pendulum was required to pick up the impulse roller at each swing. carry it to the extreme left. and brige it back to the centre position: This was, I felt, an unnecessary source of friction.

My final solution to the problem is shown on the right-hand side of Fig. 1 Straightaway it-can be seen that-the pendulum no longer has to pick anything up at each swing. But the main improvement is in the increase of the amount of leverage between the armature A and the roller R, which now operates on a curved pallet. Because of this increase in the leverage, the armature movement is greatly reduced. Measured between the lower pole and the armature at that point, the total tnovement is little more than l/32 in.

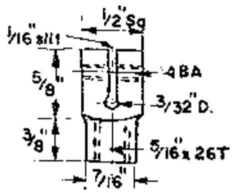


FIG. 4

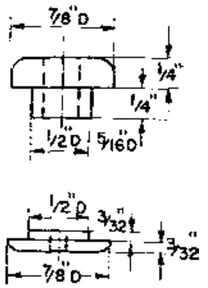


FIG 5

Top, Fig. 4: Pendulum top chop, 1/2 in. sq. brass. Above, Fig. 5: Pendulum bushes

Because of this short movement, the force is more nearly constant; there is not a wide variation in power as there is when the armature starts at a considerable distance from the magnet poles. Besides, the efficiency is greatly increased as the armature is so close to the poles.

It only remains to transmit this power, in a suitable way, to the pendulum. In *Electrical Timekeeping,* Hope-Jones explains quite clearly that the impulse should begin gently, build up to a maximum as the rod passes the vertical, and gradually tail away. The roller is arranged to travel a curved path which is calculated to produce exactly the effect demanded. The mathematics of the curve are shown in Mr Hope-Jones's book in graph form; some readers will recognise the curve as the one in the Synchronome movement. But the curve is calculated for a gravity impulse which would be constant. As ours is not constant, the curve should be different-in what way, and to what extent, is beyond me. I do not think that there is much need to worry about it; I have had excellent results with the curve shown.

Trials with the pallet

What I have written seems obvious; yet I spent a long time trying to get results by using a straight-sided pallet which I made adjustable so that it could swing through a wide range of angles. I was certain that somewhere I would find the optimum position. I could see that if the slope were nearly vertical the impulse would be strong, and if nearly flat it would be weak, and I spent ages juggling with the angle of the pallet, the adjusting screw S, and the voltage of the battery; but I could not get more than about 20 swings between impulses, and the shuddering was still present.

At last I removed the pallet. Placing a scrap end of 3/4 in. dia. brass on top of it, I scribed the 3/8 in. radius and filed the curve roughly to shape. I replaced the pallet on the pendulum without expecting much to happen. But the result was highly encouraging despite the roughness of the curve.

At this stage the whole assembly was very rough and experimental. There was no roller; I had only the fixed head of a 4 BA bolt with a drop of oil to help it slide! But even with this, I had an improvement of 300 per cent.

Thus encouraged, I began on the contact side and tried to time it so that the contacts closed and opened at an equal distance on either side of the centre position of the pendulum; I felt that this would be the best timing to suit the curve on the pallet. By adjusting the screw S, I was able to control the power applied to the pendulum. I soon had the pendulum swinging for 90 seconds between impulses with no visible vibration of the pendulum rod. I thought that this was satisfactory; in fact, I have now reduced the 90 seconds purposely to 60-with 3 v., from two bell batteries in series.

All that I had to do was to tidy up the constructional side. As I have said, the main components are hardly altered. The magnet,. armature, impulse lever and supportmg cock are all used as they are, but are turned round to face in the opposite direction. Some new parts are mounted on a sub-plate which is fixed by the existing screws to the back casting.

The left-hand side of the clock need not be touched, but I have tried one or two variations of the contacts; they are, I think, an improvement, and I shall describe them.

Some of the photographs do not tie up with each other. This is because there are two clocks. I made the second one to experiment with, and then converted the first.

There should be no difficulty in making the new parts. While I was designing these modifications, I changed the pendulum rod to one of steel. The original was of wood, 1/2 in. in diameter. I have nothing against wood from the operating point of view, but I had never liked the appearance of the original rod; it seemed to me to look amateurish, but, of course, that is only my own view.

For those who would like to alter the rod I have included some drawings (Figs 4 and 5). I have used a mild steel rod, and I doubt whether there is much to be gained in this type of clock by fitting an Invar. My own clock is kept in an office which is warmed by an electric heater controlled by a thermostat and so the temperature variation throughout the year is not very great.

Improved suspension

The same suspension spring is used, but a new top chop (Fig. 4) is needed. It can be of 1/2 in. square brass. The 1/16 in. slit can be made with a slitting saw between centres in the lathe. Do this before you part the chop from the original length. It will then be easier to grip it in the toolpost and to align it at right angles to the lathe bed.

I used the same pendulum bob, but two brass bushes (Fig. 5) are required to reduce the size of the hole. Do not ream the 5/16 in. hole in the top bush, as the pendulum rod is sure to be slightly undersize when a close fit is essential. I would advise you to carry out any polishing or cleaning of the rod first.

There are a number of components which should all be good sliding fits on the rod. I drilled them out gradually to a letter N size and finished them off with a 7.9 mm one thou under 5/16 in. I bought this drill especially.

Try the fit. You can do any enlarging by lapping on a piece of brass rod 5/16 in. dia. in the lathe chuck. Slit the end with the hacksaw for about in. and hold the component in the fingers. I used a fine water paste lapping compound made by the Carborundum Company. I found that it needed only about ten or fifteen seconds to remove enough metal-but this will depend, of course, on the diameter of the rod.

The bottom bush is drilled 4 BA clearance size. A short length of threaded rod this size is screwed into the bottom of the rod; this is much easier than threading the rod itself.

Work on the right-hand pane1 can now begin. I found that my original marking out of the Paxolin pane1 had been sufficiently accurate for me to turn the whole panel through 180 deg. leaving the magnet in its original fixing holes. I had to drill only one 4 BA tapping size hole for the back plate and cock supporting the armature pivots, as these parts must now be brought from the bottom of the panel to the top. The armature and impulse lever are both used again. The impulse lever requires a 4 BA tapped hole 3/16 in. from the bottom of the lever this is to take the adjusting screw with its locknut.

* To *be continued on March 8*

Steam age ending in Bendigo

J. N. MASKELYNE'S *Locomotives I Have Known* which has delighted me here in Bendigo, is really an epitome of British locomotive practice in its most flourishing period. Together with J.N.M.'s posthumously published additions, it will be of incalculable value in the years to come. With matchless draughtsmanship and in vivid, living prose J.N.M. captured the very ethos of his subject.

How redolent of the British character and genius one of the designs illustrated: nothing grotesque nothing bizarre, no dramatic and startling changes-everything " broadening down from precedent to precedent." The master magicians, even in what a harsh critic might term their " aberrations," never lost their dignity and produced anything aesthetically unworthy-witness Webb's Compounds and Drummond's Double Singles.

It is a melancholy reflection that our late friend has only embalmed his subjects; for the steam locomotive is, to all intents and purposes, dead. By 1970, on our Australian system-and this is typical of all the States of the Australian Commonwealth-Rudof Diesel will have finally triumphed over George Stephenson.

For the first time in my life-apart from a visit to New Zealand-l am venturing outside Australian waters. I am leaving for Singapore on a family visit early this year-overland to Fremantle and thence by ship. The land journey is now made in air-conditioned, diesel-hauled luxury, a contrast to my first trip to West Australia in 1922. Then, as one moved forward through the State of South Australia, the years seemed to roll back to the Victorian era. The motive power from Serviceton (the border station between the VR and SA systems) belonged to 1891-two 4-4-0 inside cylindered S class engines with 6 ft 6 in. driving wheels-the largest ever used in Australia, beautifully turned out in glossy black livery, with a profusion of polished brass and copper, and neat red livery. They gave place at Murray Bridge to two 1901 4-6-0s of the RX class for the 60-mile journey through the hilly terrain that constitutes the Eastern approach to the capita1 city of Adelaide.

From there, on the Northward section, we had another S, banked (you would probably say "piloted ") by an 1886 Q class, a 4-4-0, very similar to the S, but with 5 ft drivers, and, believe it or not, Salter spring balance safety valves on the dome. The whole was strongly reminiscent of Samuel Johnson's lovely creations.

At Terowie there was a change of gauge from 5 ft 3 in. to 3 ft 6 in. to Port Augusta. Two 4-4-0 Z class engines of 1890 headed the tram. The Zs were very like small cousins of the Ss with outside cylinders. At Quom the Zs gave place to a 2-6-0 Y-the maid of all work of the SAR narrow-gauge system of that time-for the journey to the Commonwealth Railway terminal at Port Augusta where one transferred to the 4 ft 8-1/2 in. gauge for the 1,500-mile run to Kalgoorlie.

The section was operated by 4-6-0s -replicas, generally, of the New South Wales Railways 32 or P class. At Kalgoorlie the West Australian State system-3 ft 6 in. gauge-begins.

At the time of my visit, the trains were headed by 4-6-2 engmes of the E class-mostly from the Vulcan Foundry or the North British Locomotive Company. It took me quite a while to get used to the eerie silence that seemed to pervade them. They were equipped, of course, with the vacuum brake, and I missed the familiar ***tish-tish*** of the Westinghouse brake pump.

Most of the engines to which I have referred were illustrated fifty years ago in a special issue of the ***Railway Gazette*** devoted to Australasian Railways. I wonder if the ***Railway Gazette*** is still in print, or obtainable in Tothill Street ?

I find that the r.p.m. of the wheels of memory has been increasing lately and so I must shut off steam now. Greetings to all at Noel Street-to those who, with lens and pen, are building a memorial to the object of our common affection-and also to those dedicated men who (even though only in miniature) are performing the miracle of resurrection-the modellers. G. DOENAU.

[The " Railway Gazette " is still pubhshed from Tothill Street. -EDITOR.]

PM PLANS SERVICE

THE Catalogue of Working Drawings published by Percival Marshall Ltd, price 6d., or 10d. by post, contains designs for many interesting projects. But not all the subjects are models or pieces of workshop equipment , some of them are useful accessories.

For example, drawing No LO 17 is of a locomotive feed water pump. It was designed by J. Austin-Walton (of Twin Sisters fame) and is a double-acting type for 1 in. scale engines. Price is 3s. 6d.

Martin Evans has produced two recent drawings for steam brakes. No LO 25 gives details for a hand and steam brake for 3-1/2 in. gauge tank locomotives and No LO 29 shows constructional data for a 5 in. gauge steam brake. Both drawings are priced 3s. 6d.

Our Queries Service is often asked to recommend a simple marine steam power unit for the less-experienced. One which a person of moderate skill can tackle is M 6, a small double-acting slide valve engine of 5/8 in. bore and 5/8 in. stroke. A suitable steam plant for the beginner is M 18, an oscillating engine of 7/16 in. bore and 3/4 in. stroke. It is an Edgar T. Westbury design. M 6 is 2s. M 18, 3s. 6d. ❑

WHERE WAS THE FAULT?

“ One was behaving perfectly and the other was not. Again and again I checked the timing of the contacts ... ” J. H. WILDING in this second instalment tells of a mystery which he solved

Continued from February 2 page 237

THE new parts are mounted on a sub-plate (Fig. 6) cut from 3/32 in. brass plate in accordance with the drawing. It is secured by two 4 BA screws which hold the bottom of the Paxolin panel to the back plate. Although the holes should be 2 in. apart, I should check this, and make any necessary adiustment on the plate. before drilling.

The two 7/32 in. holes are to mount the terminal screws insulated by the fibre washers shown in Fig. 7; the terminal nuts are seen in Fig. 8.

Making the impulse arm pivot post from 1/4 in. mild steel is straightforward turning. The 1/8 in. dia. part must be brought to a good finish with emery sticks. You should first make the collet which will run on it. Finish the collet with a 1/8 in. reamer; then you can finish the pivot to a close fit.

The No 60 hole can be easily drilled in a simple jig (Fig. 10)-a short length of 5/16 in. square mild steel stock gripped in the four-jaw chuck with about an inch or so projecting. Coat with marking fluid, and with a pointed tool mark the adjacent sides by rotating the chuck by hand. Do this at about 1/4 in. intervals. The marks on one face are drilled to suitable sizes such as 1/16 in., 1/8 in., and 3/32 in., and the other face is drilled with the No 60 which will, of course, break into the larger holes.

It is only necessary to place in the jig the component to be cross drilled, and there can be no doubt that the hole will be drilled through the diameter. The retaining pin can be a l/32 in. split pin or a tapered pin filed up in the lathe.

The stop for the impulse arm is made from 1/4 in. dia. brass. It is slit in the lathe after you have drilled and tapped the 5 BA cross hole. The slit is either closed up in the vice or is opened out slightly with a screwdriver, so that the adjusting screw is gripped tightly enough to prevent it from turning on its own. Drill the screw in the lathe for a short distance to accommodate a fibre button, which is fixed by a dab of glue after the screw is in position. The button is to quiet the action of the impulse arm as it drops after giving the impulse. It could just as well be a piece of leather glued on to a brass button; but it must be reasonably firm, as the height adjustment of the impulse arm is carried out through this screw.

The impulse arm (Fig. 12) is cut from a strip of 3/32 in. brass 1 in. wide. After marking out, machine the slot by gripping the strip in the machine vice on the vertical slide.

I use home-made D cutters produced from silver steel. They have the advantage that they are easy to sharpen free-hand and need not be mounted so truly as the multi-toothed commercial cutters.

There is a separate drawing of the collet, which is riveted in place. Fitted to the arm is an angle bracket made from 1 in. x 1 in. x 1/16 in. brass angle and fixed by two 6 BA bolts.

A 5 BA clearance hole is provided at one end of the long leg of the piece to take a case-hardened button -simply a 5 BA bolt with the screwdriver slot machined away and the face domed and polished. This part is acted on by the 4 BA screw at the end of the original impulse lever. Its proper position is ascertained by assembling the components and checking from the job.

The impulse roller and its pivot are both machined from 1/4in. mild steel. You should case-harden the roller. The No 60 hole is drilled with the help of the same jig as before, except that the 3/32 in. hole is used instead of the 1/8 in. The finish of the 3/32 in. pivot should be of a high standard.

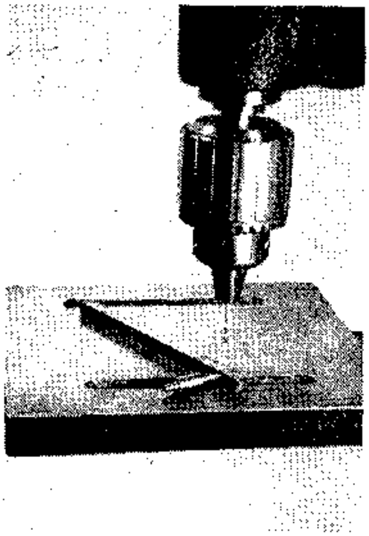
Fig. 13 shows the dimensions of the impulse clamp block for the pendulum rod and the impulse pallet. After coating with marking fluid the end part of a length of 1/2 in. square brass, mark out the dimensions as shown. Make the 5/16 in. hole with the 7.9 mm., and drill and tap for the 2 BA hole. Take a clearing-size drill halfway through, and mount the piece of material in the toolpost ready for a 1/16 in. slitting saw.

Remove the surplus metal with a hacksaw to form the oblique step. The block still attached to the parent metal is then clamped to the face of the vertical slide and set by a protractor for the machining of the 60 deg. angle with an end mill. At the same time the 3/16 in. dimension is machined.

The block can now be parted from the stock with a hacksaw. Machine the curved ends by gripping a scrap piece of 1 in. dia. round brass in the three-jaw chuck, facing the end and drilling and tapping 2 BA. The block is fastened to this by a 2 BA screw, and light cuts are taken. A fine feed is used and efforts are made to get a good finish.

Leave the two 6 BA holes until the pallet is completed. This part is made from 1/8 in. brass (Fig. 14).

Select a length of brass strip 1 in. wide and 1/8 in. thick. After making sure that there are no blemishes or burrs which may upset the accuracy of the protractor, coat the end 3 in. with marking fluid. At about 1-1/2 in. from the end of the strip and 7/16 in. from one side mark centre 0. With the dividers, scribe two circles of



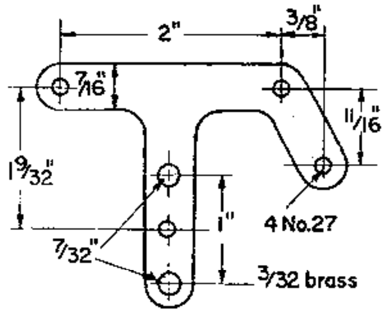


FIG.6 Sub plates for magnet assy.

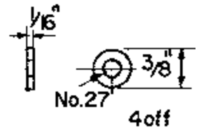
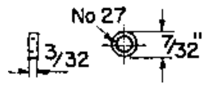


FIG.7. Insulating washer



2off fibre

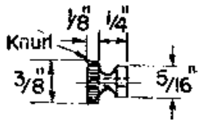


FIG.8 Terminal nut 48A

2 off brass

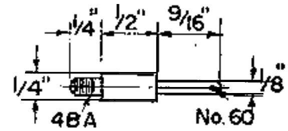


FIG.9 Impulse arm

pivot post. MS

Fig. 10: *Simple method of cross-drilling small parts*

3/16 in. and 1/8 in. radius. Using the protractor, draw the line BC through centre 0 and at 30 deg. to the side *AB*.

Then, with the protractor set at 60 deg., draw tangents *FG* and *HJ*. These lines will, of course, form right angles with the line *BC*. Make *EK* parallel to *AB*. Draw the angle LDJ, 10 deg. The portion of curve required is that from *E* to D.

Mount the whole piece on the faceplate and centre it so that the point 0 runs truly. The 3/4 in. dia. circle is now bored out (Fig. 15). Finally, the acting face of the pallet is shaped to form a convex surface. This 1 did with a form tool.

The object is to ensure that the roller acts as near the centre of the pallet as possible even if the two components are slightly misaligned. After the pallet has been cut free and the lines *KE* and *DL* have been carefully filed, it can be either temporarily soldered, or fastened on the clamp block with a small toolmaker's clamp, for the drilling and tapping of the fixing holes.

As I have mentioned, the left-hand side of the clock need not be altered. But I carried out some useful experiments with another type of gathering arm and two different contact arrangements.

1 set up both clocks after having modified them as described, and arranged for them to be close together on the workshop wall so that I could easily compare their performances. On one clock I fitted the gathering lever as specified in the original design. On the other clock I fitted the gathering lever shown in Fig. 17. This is a much lighter component. The clock with the original arm would go for about 45 seconds between impulses and the one with the lighter arm went for 90 seconds.

The main point about the gathering arm and the back stop pawl is that they should be as light as possible as they are both lifted at each swing of the pendulum and any extra weight in either has to be paid for many times over when the pendulum receives an impulse.

I advise you to lighten the back stop. Grip the pawl by the little collet which is riveted at its centre, and with a sharp pointed tool reduce the thickness to 1/32 in. in the lathe. I also discarded the silver steel roller and substituted one of fibre which is much lighter and seems quite tough enough. Counterbalancing is carried

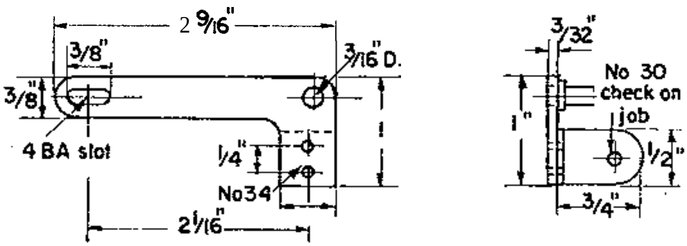
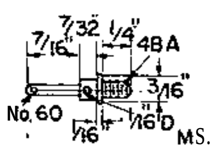
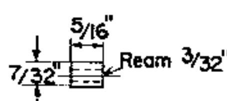


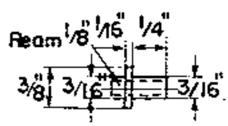
FIG.12 Impulse arm 3/32" brass



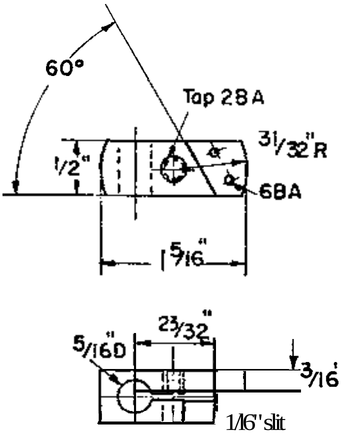
Impulse roller pivot

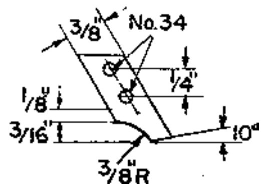


Roller MS CS



for impulse arm





Bmss

FIG.13 Pendulum clamp block and impulse pallet

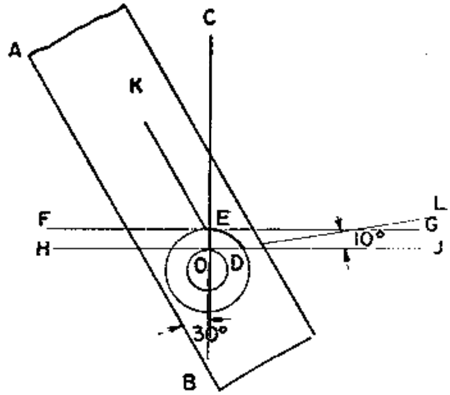


FIG.14 Marking out diaqram for impulse pallet. I "x1/8" brass strip

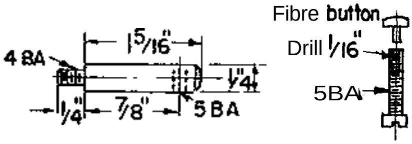


FIG.11 Impulse arm stop brass

out by dropping a blob of solder on the back of the tail end of the pawl and filing it away until the correct balance is achieved.

While I was experimenting with the two different types of gathering paw1 I made another discovery. One clock did not at first go very well. I was getting a small amount of vibration at each impulse of the pendulum, the very trouble which I had set out to cure. It was almost uncanny. Here were two clocks, identical as far as their impulsing was concerned, and not 12 in. apart on a wall. One was behaving perfectly and the other was not. Moreover, the one which was shuddering slightly was also making a slight rattle at the moment of impulse as if there was something loose on the pendulum rod.

Again and again I checked the timing of the contacts, looking from the good clock to the bad one and copying the adjustments closely. I checked the measurements of the curved pallet, trying to find a discrepancy between the two movements. Eventually 1 discovered the fault.

The only part of one clock which was different from the other was the suspension spring. On the good clock I had copied the pendulum suspension from the synchronome movement, which has only 3/16 in. of spring exposed between the chops. On the other clock 1 was still using the original spring which had 1/2 in. of spring exposed. On examining the top of the pendulum rod with a magnifying glass at the moment of impulse I was able to detect a distinct sideways movement. After I had shortened the spring, the trouble was completely cured. The rattle was being caused by the vibrating rod in the top bush of the pendulum bob. this was not as tight as it should have been, although the play was only just perceptible.

** To be continued on March 22*

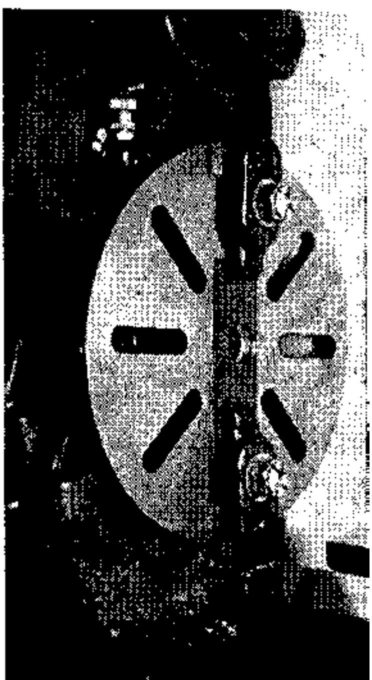
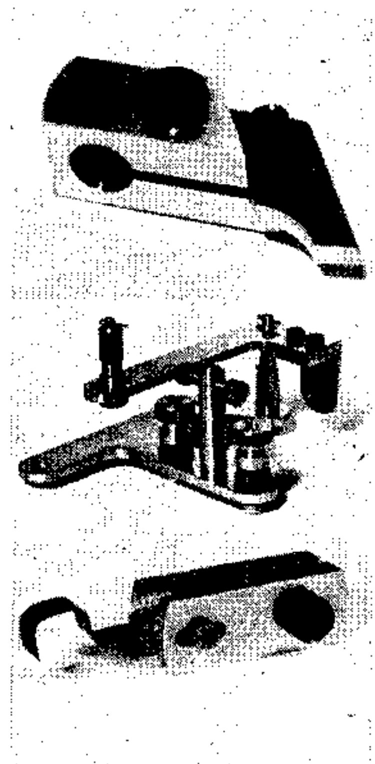


***Fig.** 15: Set-up for the machining of the curve on the impulse pallet*



Top, Fig. 16: Finished clamp block and impulse pallet. Centre, Fig. 16a: Here is the completed sub-plate assembly for fixing to the right-hand clock panel. Above, Fig.** 17: **This type of gathering pawl and clamp block is suggested

FIX IT FIRMLY

J. H. WILDING in his last instalment quotes an authority on the importance of a factor which affected the pendulum arc of Big Ben

To construct the gathering pallet is a straightforward task. The paw1 is made from a used Eclipse Junior hack-saw blade. with the teeth ground away to reduce the width of the blade to about 7/32 in. You can do the bending with pliers. in the flame of a Bunsen burner.

I keep an old pair of pliers especially for this kind of work and I do not hesitate to grind away a sharp corner to form rounded bends. The pliers should be warmed or the chilling effect on the blade may cause it to crack. While the exact shape is not critical, the measurement of 1-l/32 in. is important as there is not a great deal of adjustment in the clamp block.

The blade is clamped by a 10 BA screw in a small block, the slit in which can be made by a saw in the lathe while the component is still part of a length of 1/4 in. square brass rod. You can drill the hole in the blade easily after annealing. Quench the tip after it has been brought to red heat. It must also be stoned with a really hard slip stone to give a smooth polished edge. The clamp block is similar to the other.

You can machine the 1/4in. slot in the lathe by various methods. The 5/16 in. hole is formed in exactly the same way as the hole for the other block. I made the 1/8 in. slot by end-milling first one side and then the other with a home-made cutter from silver steel.

To machine the curved ends to the block, take a scrap piece of round brass about 1 in. in diameter and 1 in. long, grip it in the chuck for facing the end, and turn a number of grooves on the end with a pointed tool. The piece is then removed, placed on a fire brick, and warmed with a gas flame until shellac will melt on it. Shellac can be had from horological suppliers. It comes in the form of sticks similar to sealing wax.

The clamp block is also warmed. and when both parts are at the quite low temperature where shellac will melt, the piece of 1 in. round is replaced in the chuck and the clamp block is placed against it. Before this, a centre dot should have been made in the centre of the reverse face of the clamp block. This is located on the tailstock centre, which is then screwed in to press the two parts together. Thev should be held together for about a minute.

Then machining can proceed. Only light cuts should be taken, owing to the intermittent nature of the work. Note that the centre is made in the back face of the clamp block, as if it were made in the front face it would be found difficult to erase unless a lot of metal were removed. It is surprising how deep a centre dot goes in.

The pivot pm with its screwed collar is straightforward turning. To prevent the paw1 from falling down, a hole is drilled in the back face for a piece of 1/16 in. brass wire which is pressed in. The hole should be drilled slightly lower than is required. Then the wire is bent upwards to bring the paw1 to the horizontal position. Height adjustment is made by sliding the block up and down the rod after slackening the 2 BA screw.

You will see the contacts in Figs 20 and 21. Those in Fig. 20 are taken from a telephone relay and have proved highly satisfactory. Similar relavs can be obtained from Whistons: they contain four pairs of contacts which are separated by undoing three screws. I do not know what metal is used for the points; it seems to be of very good quality, and I have had a pair in use for three years in one of my clocks without any trouble.

An alternative arrangement shown in Fig. 21 has the advantage of being slightly lighter in action, as only one spring has to be flexed. But it is much more complicated to make and set up, and so I am not giving drawings. I made it because at one stage in my experiments I thought that the period of impulse was not long enough, and I had intended to arrange for the contact to be locked in the closed position and then released by the upward movement of the impulse arm. But none of this proved necessary, and I would advise the simpler arrangement.

As can be seen, the bank of contacts and the insulating packing is fixed to a brass plate which is machined to provide a spigot gripped by a clamp which also grips the top left-hand pillar of the count wheel assembly. It will be necessary to make a new pillar here if the original one has already been made, as a parallel surface is needed. Make it 5/16n. in diameter.

The spigot on the flat plate, Fig. 19, is machined by gripping a short length of brass strip 1 in. x 1/8 in. in the four-jaw chuck. Holes are drilled to suit the contacts. The clamp can be made from strip brass 7/16 in. x 1/4 in. Drill and ream the holes, and slit with a saw in the lathe. A 4 BA Allen cap screw should be used here as there will not be room in the case for a screwdriver.

It will be noticed that in Fig. 20 a second pair of contacts is provided. These are for use if the Jubilee is needed as a master clock. A Perspex disc is machined 1 in. in diameter and fitted with a brass collet which has a 10 BA grubscrew to lock the whole to count wheel arbor. The disc is provided with a D-shaped piece, screwed into the disc. This closes the contacts each 30 seconds. Another screw fitted at 180 deg. to the D shaped one, and in the reverse face of the disc, acts as a counterbalance.

Used impulse movements can be obtained from the Synchronome Clock Company for, I believe, 17s. 6d. each, plus postage. At this price they are hardly worth making. I have had several, and there seems to be nothing wrong with them.

Spark quenching should be provided in the circuit. And I have fitted a two-micro-farad condenser and a 68-ohm resistance in series across the contact points. On the actual clock magnet I have fitted a 75-ohm resistance across the magnet windings.

This completes the construction, except for the finishing of the parts. As there is so little work in this type of clock, it is important to give the parts a good finish. Emery sticks from the horological material dealer are graded 1, 0, 00, and 000, and may be used for work which can be rotated in the lathe. Flat pieces can be treated first with the finest grade of wet and dry, and finished off with a

0000 grade. The paper is laid on a flat surface, such as the drilling machine table, and the parts are rubbed on it. I do not use metal polish as it seems to produce a yellow colour which is not so bright as the finish from the fine grades of emery paper. I use Canning's Frigilene lacquer, applied by brush. Using the grades of emery stick in order, I polish the screw heads in the lathe.

On one clock I blued all the screws which were on brass by drilling various sizes of hole in a brass plate. After the screws have been highly polished, I put them one at a time in the plate and heat them from underneath with a gas flame, tipping them into oil when a rich royal blue is reached. The brass plate dissipates the heat and slows down the colour changes, giving me more time to observe them.

All that is left now is the setting up and adjusting of the clock.

I feel that the best case is one which is hung on the wall. It can be secured rigidly top and bottom. I cannot overstress the importance of rigidity in this kind of occasional impulse clock with a heavy pendulum bob. One of my Jubilee clocks was mounted in a rather crude and haphazard manner on the wall of my workshop during the testing period; and as soon as it was correctly mounted in a proper case on the wall, and rigidly fixed, the arc of swing immediately increased and the action altogether improved.

Lord Grimthorpe in *Clocks, Watches and Bells* (seventh edition, page 93) tells us how a rigid pendulum fixing affected the arc of Big Ben's pendulum. Of rigid fixing, he says: " I cannot give a better proof of how much the arc depends on that, than

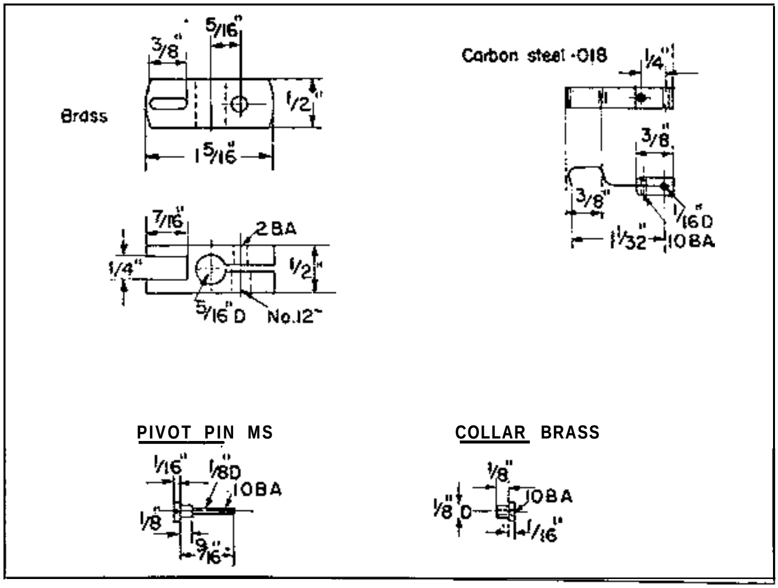
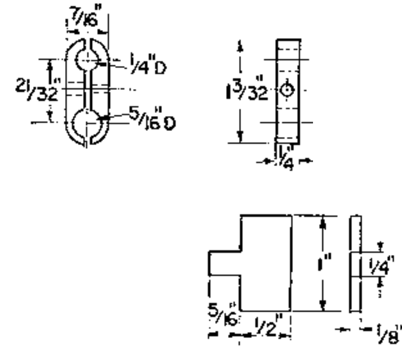
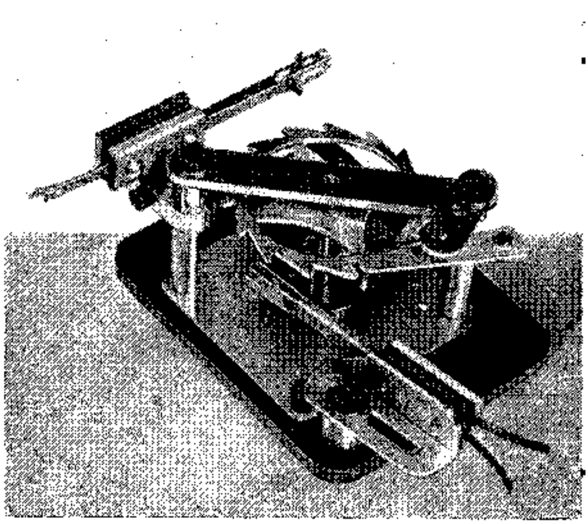
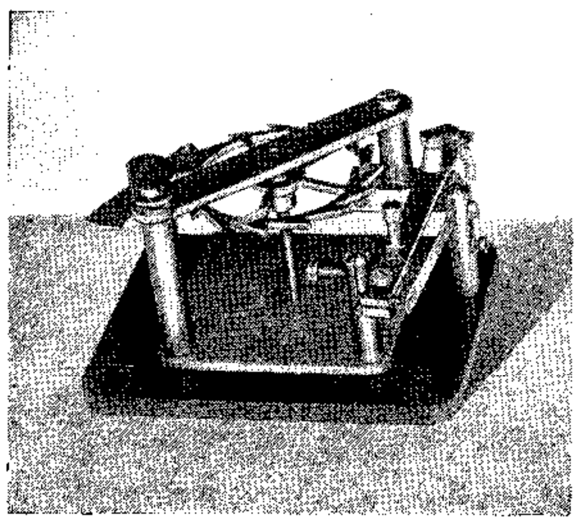


Fig. 18: *Clamp block and gathering pawl.* *Fig.* 19 *(right) illustrates the contact platform and clamp brass*



Below: Fig. 20 (left) and Fig. 21





the effect of hanging the Westminster pendulum on its proper cock,. which is a large cast-iron bracket bwlt into the wall; the arc increased full 45' over what it had been in the factory, where it was hung on what seemed a perfectly firm support, a strong timber frame built from the ground. Even smaller pendulums generally increase their arc from about 2 deg. in the factory to 2 deg. 30' as soon as they are properly fixed to a good wall on stone corbels or iron beams. This shows the extreme badness of the common way of fixing large clocks on a stool or timber frame set upon a wooden floor in a tower, and common clocks by a single nail through a thin back of the case." He then refers the reader to an earlier paragraph, where he states: " A perfectly firm suspension is essential to good performance of any clock, and the heavier the pendulum the firmer its support must be."

The case designed for the Jubilee clock is meant to stand on the floor; but if it can be secured to a wall as well, so much the better. A vertical centreline should be drawn inside the case on the backboard and the back plate casting should be bolted so that it is equally disposed either side of this line. If the case is of the hanging sort it should be hung on a vertical wall. This may seem a stupid remark, but those who, like myself, enjoy the doubtful privilege of living in " Ye Olde Worlde," will appreciate how difficult it often is to find a wall that is upright and flat. It is better to have the case flush against the wall and to pack out the movement back plate-which is what I have had to do. There is something to be said for leaving the top edges of the pendulum support bracket flat, and not veeing them out, so that the pendulum can be moved forward and backwards if it is not possible to hang the case vertically. Play in the trunnion is also convenient; then the pendulum can be moved laterally if this is required.

Adjusting the motion work

When the clock has been mounted in the best manner possible, adjust the back stop of the count wheel so that any tooth of the wheel lies on the line between the top of the suspension spring and the wheel centre. This can be done either by stretching a thin wire between the two points or by laying on a 12 in. rule edgeways. When you have locked the back stop, check that it can release the wheel when this is turned, as it is possible for its tail to hit the support pillar and the tip of the tooth to be damaged.

With this setting, arrange for the gathering paw1 just to clear the top of the tooth previously gathered: when the pendulum is hanging vertically the pallet should lie about mid-way between the tooth just gathered and the one about to be gathered. Check that the edge of the paw1 is truly at right angles to the wheel, or there will be a hit-and-miss action when the paw1 is deciding whether to stop in the notch or fall clear.

The contacts can now be adjusted; if they are from the PO relay there will be a fibre projection on the bottom one. It should be set so that the shoulder on the gathering paw1 just clears it; then move the contact sideways so that, as the paw1 rides up the sloping tooth, it hugs the contact projection as closely as possible. Watch the action carefully for all fifteen teeth, in case there is any inaccuracy in any one of them.

You can then turn your attention to the magnet side. Fix the impulse arm by the adjusting screw so that it is horizontal, and then lower the impulse pallet so that the lower edge just clears the impulse roller. Now, make the electrical connections holding the pendulum by hand, cause it to go through the impulse cycle. Watch the impulse roller keenly, and adjust its position so that when the magnet is energised the centre of the roller is directly under the lowest part of the curve on the impulse pallet.

Check that the adjusting screw on the impulse lever is so positioned that the roller can make the full journey all the way to the top of the curve without the magnet armature's touching the magnet poles. It will be noticed that if this screw is taken out too far the armature will reach the poles before the roller has completed its journey.

Continue moving the pendulum to the right and note the point at which the contacts break. The roller should be at the top of the curve; if it is not there, adjustments must be made, as the success of the impulse depends on the roller's completing its full amount of travel.

First. check the contacts. There must be no lost motion. The initial gap between the points must be the minimum, and the paw1 must clear the projection on the lower contact blade by only a few thou of an inch. Make sure that the roller is not too far to the right. There must be no travel along the flat part of the pallet.

Check that you have not made the curve too long. The 3/16 in. measurement shown on Fig. 13 must not be exceeded.

Provided that all this is done, the impulse should be pretty well free from shudder. The adjusting screw on the impulse lever should now be screwed in half a turn at a time until the impulse is completely free from vibration. Ninety seconds between impulses should be achieved with the clock running free, or as a master clock. I cannot say what result would be achieved with the pendulum driving the wheelwork, as my clocks are both used with impulse movements. I should think that the 90-second period would be reduced to about 60.

Adjustment of case

If the clock is mounted in a Grandfather case, adjustable feet should be provided, two at the back and one centrally in the front, to give a three-point mounting. An adiustable point should be urovided under the pendulum rod so-that the pendulum can be used as a plumb line for the clock to be correctly set should it be accidentally moved or bumped. But this kind of clock will not stand much rough treatment; the heavy bob will cause serious damage if it is caused to swing out of its proper arc. And the clock will most certainly stop if the case is tilted by even a small amount; 1 think this is the main reason why electric pendulum clocks have never been much of a success as domestic timekeepers. The anchor escapement thinks nothing of being lifted off the mantle piece for dusting, and I have seen Grandfathers lifted from one room to another without even the unshipping of the pendulum rod.

Readers who have already made the clock will, I hope, try out the conversion for themselves. I am going to make a pendulum movement for one of my timekeepers as it is stupid to have two master clocks in one house. I thought that I would try using a worm to get the reduction instead of the conventional train of wheels, as I have a small electric clock with a worm and it has proved highly satisfactory. *

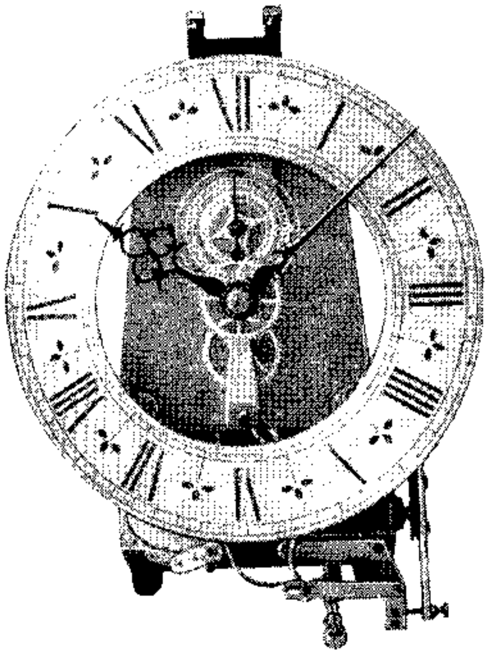
* *This three-part serial began on February 22 (page 234). The* **other** *instalment was published on March 8* (291).

Edgar T. Westbury introduced the ME Jubilee Clock, "an entirely new design for a one-second pendulum impulse clock, specially suited to amateur construction," in the Diamond Jubilee Number of 1 *May* 1958.

SUPPLIES FOR THE JUBILEE CLOCK

Castings (12s. 6d. a set) and gears and pinions (15s.) for the Jubilee electric clock, may be had from Percival Marshall Ltd, 19-20 Noel Street, London Wl. Prices include postage.

TIME AFTER TIME



The complete clock movement. Second dial cut from clear Perspex

Further modifications to the ME Jubilee clock

by H. H. Knie

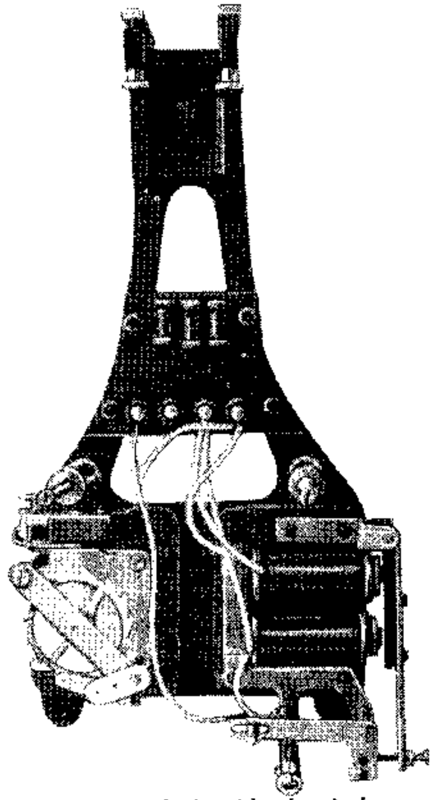
IT was not until Mr J. H. Wilding's articles appeared in MODEL ENGINEER (February 22, 1962) with his improvements to the ME Jubilee Clock that I became sufficiently interested in making one.

Constructing the movement was a most pleasant experience, particularly with the superb wheels and castings supplied by the ME offices at the give-away price of 27s. 6d. For the beginner in clockmaking this type is a "pushover" compared with the mechanical variety, and it serves as a good testing ground for more involved pieces.

The depthing is perfect, and this eliminates one of the greatest difficulties when pitching a train without the assistance of a depth tool—an essential appliance but normally hard to come by. At the price the wheels are offered it is not worth the trouble cutting one's own.

However, in the course of construction some faults soon became evident, which I will describe for the help of others. If you are cutting your own wheels, make the countwheel of 30 teeth—not 60 as specified. In any escape wheel or countwheel, the teeth of which are acted upon for each swing of the pendulum, whether for impulsing or gathering, each tooth is engaged twice in each revolution, hence the paradox to the uninitiated.

A 60-tooth wheel may be used provided that *two* teeth are gathered on each pendulum swing. This point was also noted in the instructions.



Baseplate of clock with electrical gear, and fitted with Mr Wilding's impulse mechanism.

The movement needs to be mounted higher on the baseplate to bring the pendulum crutch pivot into the same bending plane of the suspension spring. Otherwise objectionable friction is introduced at the point of contact, which is horologically bad in any case. In all horological work friction should never be ignored no matter how trivial it may seem.

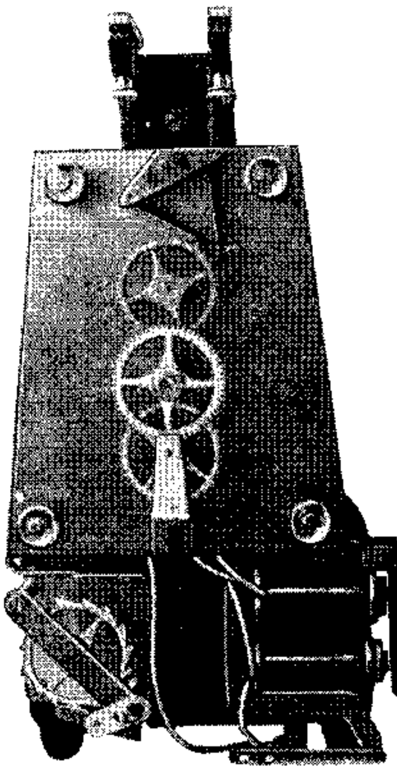
The magnets proved most efficient with the winding data supplied, but contact difficulty soon became apparent, and as I considered that the gathering pallet was too heavy, I adapted the lighter pawl as specified by Mr Wilding. However, I ran into contact trouble again. The contacts were blameless, the bugbear being the time lag introduced in their closing.

After experimenting I came up with a hybrid—part Westbury and part Wilding. Running free it was possible to get 190 swings from each impulse with 4-5 volts. This was purposely reduced. I do feel, though, that a more positive approach to this problem is to eliminate the riding wheel altogether and utilise the original Hipp trailer. There appears to be too much lost motion and needless friction with the riding wheel contact control, however efficient it may seem.

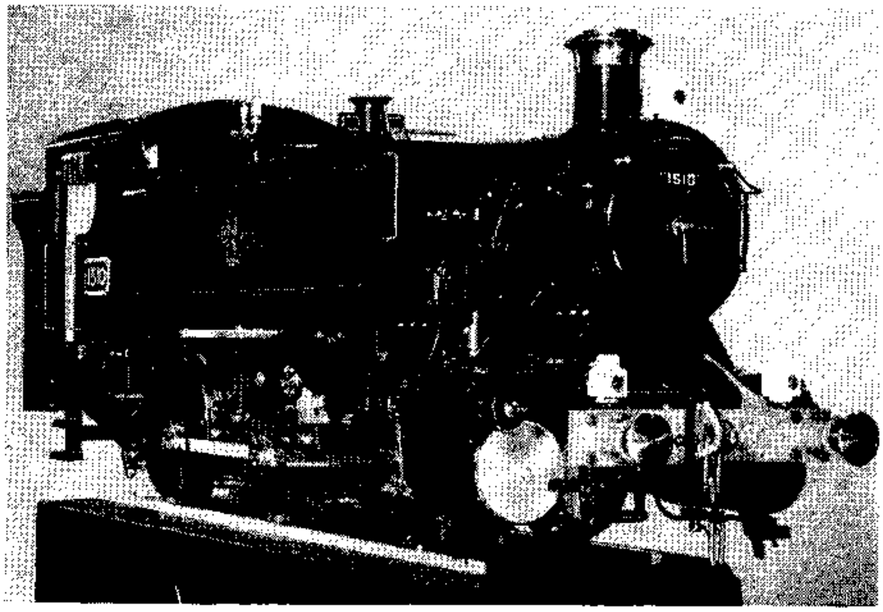
The form of lever devised by Mr Wilding, while a great improvement, does call for more contact control as its precise timing and duration is essential.

As it was not proposed to use the clock for control of secondaries, the original design was adhered to, i.e., taking time mechanically from the pendulum. If anyone wants to operate a series of dials I suggest that half-minutes be taken from the riding wheel by tripping a miniature Synchronome switch, such as described in *Electrical Clocks and How to Make Them.* As the late F. Hope-Jones laid

Continued on page 498

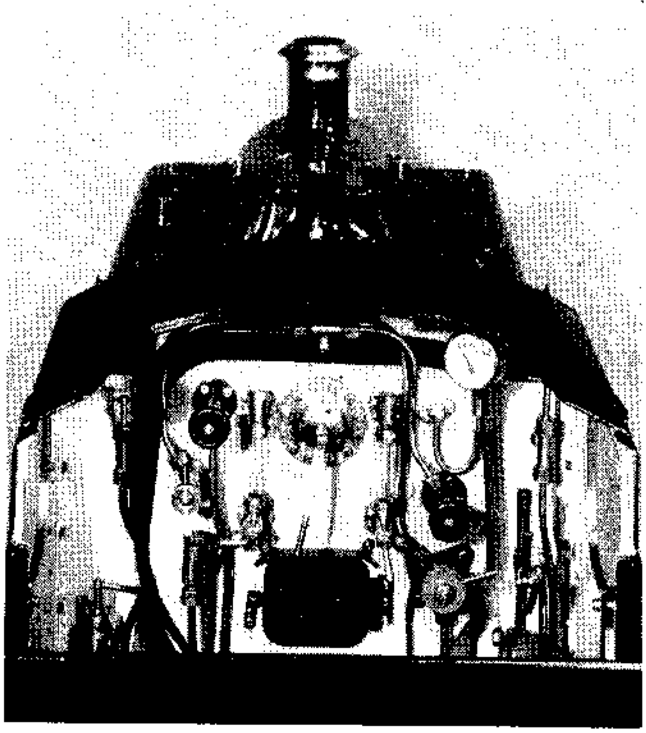


Front view, with dial removed



FINE DETAIL WESTERN REGION TANK IN 5 in. GAUGE

by A. C. Whitcher



My recently-completed 5 in. gauge model of a Western Region 1500 class locomotive was built to LBSC specification, but several departures from the drawing dimensions were found necessary. The valve gear was the greatest offender, entailing much extra work before the correct travel was obtained.

I believe the last of the class was number 1509, and as the model is not a replica of any particular engine, and is fitted with a steam pump, she carries the number 1510.

The engine steams and pulls well, and on its latest outing I had no trouble in hauling a load of nineteen passengers, which included seven adults, on three heavy-flat cars.

Water consumption was heavy and she ran decidedly wet, so some attention is indicated in the superheater. Most of the heat must be passing along the lower tubes. I am still not too happy about the valve events.

This engine is my second attempt (the first was *Rainhill*), and I have added a few refinements not included in the drawing specification, such as steam-operated cylinder drains made up of four cylinders which are self-draining so that there is no condensation in the system. (I had to try this, because the old Maestro said condensation would be an ever-present problem). The locomotive has floating piston valves that can be set and locked simply by removing the front end cover. There is mechanical lubrication for the steam pump. This oil pump has a 0.050 in. dia. bore and is housed in a container ½ in. sq. x ⅝ in. deep. It is directly coupled to the piston rod, but operates at a ratio of 1 to 26. ▣

TIME AFTER TIME . . .

Continued from page 481

down the basic principles in his book, *Electrical Timekeeping*, it seems pointless experimenting with something violating his principles, particularly with contacts.

The dial and hands were given the antique treatment, which came out quite easy. The hands are based on samples given in *Clock-making Past and Present* (Gordon) being cut from cold-rolled steel with a metal fretsaw and finished with needle files.

The dial was engraved on the lathe, the thick strokes being sawn out and finished with needle files, and finally filled with black wax. The chapter ring was then french silvered and given a coat of clear lacquer. ▣

CORRECTION

On page 402 of Mr W. F. Hughes's article "Steam Rolling Since 1865," the two captions were unfortunately transposed. The paper referred to at the bottom of the same page was presented to the Institution of Mechanical Engineers by Aveling and Batho in 1870.