The ME Jubilee ELECTRIC CLOCK

An entirely new design for a one-second pendulum impulse clock, specially suited to amateur construction

By Edgar T. Westbury

ALTHOUGH it is often considered that clockmaking is not within the legitimate scope of model engineering, it has always been very popular among ME readers.

There are very good reasons for this ; clocks are among the most interesting of mechanisms, provide scope for good craftsmanship both in hand and machine tool operation, and, when completed, can be appreciated by everyone for their beauty and utility.

Electric clocks, in particular, attract the amateur constructor, not only on account of their novelty, but also because they depend less on specialised horological skill for their success than the conventional type.

Many designs for electric clocks have been published in ME during its 60 years of existence-it may be recalled that the first constructional article on the now famous Synchronome system was published in this magazine-and material proof that full advantage of these designs has been taken by readers can be found not only at most model exhibitions but also in innumerable homes.

In presenting yet another design for an electric clock, my aim is not to supersede all previous designs or to claim any very special advantages over them, but to introduce some original features and interesting methods of construction, which, I trust, will appeal to an even wider circle of readers.

Although I have never submitted an electric clock design for publication before, I have always possessed a very keen interest in the subject and have made many experiments with an aim to improving or simplifying design. In particular, I have studied the problems of design from the aspect of the non-specialist constructor, who often encounters small but irritating obstacles to success in this branch of work.

Among several essays on construction, I may mention that many years ago I built a clock with only three wheels in it, and this idea has since been exploited in at least two clocks which have been exhibited at ME Exhibitions.

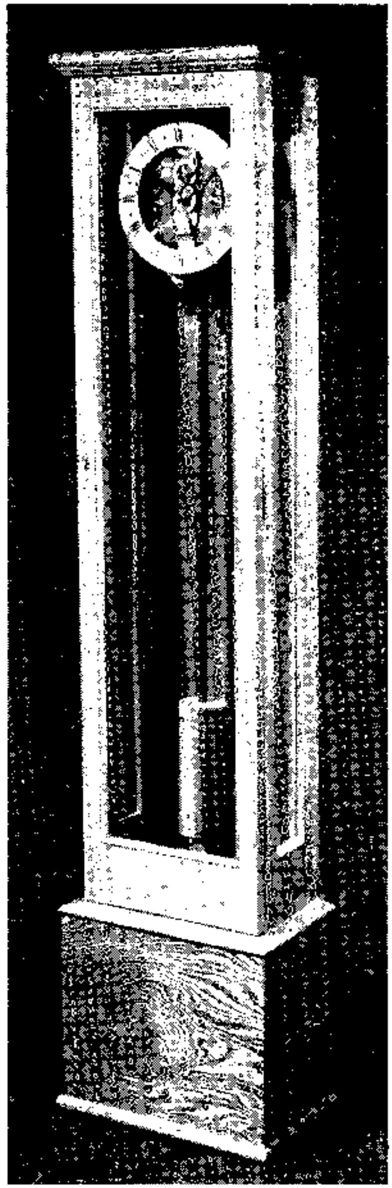
TYPES OF ELECTRIC CLOCKS

Before describing this particular clock, it may be helpful to review the various types of electric clocks that have been designed in the past, to explain what literally "makes them tick."

The term " impulse clock " is used to define any type of clock driven by electro-magnetic impulses applied to the pendulum. which. in effect. becomes a precision-governed motor; capable of driving the dial motion (or other time indicator) at a constant rate. In this way the mechanism may be said to be inverted in comparison with weight or spring-driven clocks, in which the pendulum is driven by motive power applied through the indicating gear train.

From the mechanical point of view, therefore, the electric clock offers some advantages as it avoids the heavv loading on the gearing. affords a very robust pendulum action, and enables interference with free pendulum action to be reduced in comparison with most kinds of escapements; the latter property, however, is not always exploited to its fullest advantage.

Some kinds of impulse clocks have a balance wheel instead of a pendulum, but the same general conditions apply. Except in cases where it is necessary for the clock to be readily portable, however, the pendulum is generally preferred, and only one or two types of balance-wheel electric clocks have achieved any degree of popularity, though they are interesting to construct. A notable example was the Eureka clock which was fully described in ME some years ago.



The completed clock, fitted in a handsome longcase with glass front and sides and a battery compartment fitted in the base

The type of electrically-driven clock in which a normal gear train and escapement is employed in conjunction with a short spring which is rewound at fairly frequent intervals by an electro-magnet,. might loosely be described as an impulse clock. But a more accurately descriptive term is " electrically wound," or " remontoire," to borrow from the French, who are experts in coining technical terms.

This system is common in motor-car clocks, and has also been used in electric supply meters; it offers attractive possibilities for the adaptation of existing clocks-from cheap alarms and grandfathers, to automatic electrical maintenance.

Prejudice against electricity

The modern a.c. Synchronous clocks are not in the true sense devices for measuring time, but only remote-controlled repeaters, following the motion of a master clock which is used to govern the frequency of the mains supply. Under normal circumstances, they give accurate and reliable timekeeping. But their total dependence on external factors may be a serious disadvantage as some of us have discovered to our cost in the bad old days of overloaded mains and power cuts.

For various reasons, traditional and otherwise, practical horologists of the orthodox school are not in love with electric clocks of any kind. No doubt many of them adopt as an article of faith the dogmatic pronouncement of Lord Grimthorpe, the designer of the Westminster clock, who in his book ***Clocks, Watches and Bells,*** stated : " These clocks never answered in any practical sense; nor would anything but the strongest evidence, independent of the inventor, convince me that any independent pendulum directly maintained by electricity can succeed in keeping good time for any considerable period."

In my opinion, however, this evidence is now forthcoming in the large number of electric clocks which have been, and still are, really accurate and reliable timekeepers.

A more rational reason for the dislike of electric clocks was once given to me by a working clock-maker, who said that he would not have a magnet of any kind anywhere near his work bench, where tools might become magnetised and delicate balances deranged. Generally, however, it may be said that human nature dislikes, and often fears, anything which is unusual and, even in the remotest sense, mysterious.

HISTORY OF ELECTRIC CLOCKS

The first inventor who applied electrical power to drive a clock, so far as is definitelv known. was Alexander Bain (1846) who used two solenoid coils in conjunction with a permanent magnet on the pendulum rod, to drive the latter in alternate directions by current controlled by a sliding contact switch. A further interesting feature of one of Bain's clocks was the use of an " earth battery," consisting of carbon and zinc electrodes sunk in moist earth, to provide the current for driving it.

Although his clocks undoubtedly worked, the contact mechanism gave a good deal of trouble. and they violated basic principles of good clock design by undue interference with the natural swing of the pendulum.

Sir Charles Wheatstone, the pioneer of the electric telegraph, with whom Bain was at first associated but later came into violent altercation, also applied the principles of electro-magnetism to drive clocks and the transmission of time impulses to remote-controlled dials. But here again incomplete understanding of basic requirements in clock design limited his success.

Similar limitations were apparent in the clocks designed by C. Shepherd (who exhibited a clock at the 1851 Crystal Palace Exhibition), Sir David Gill (1879), and Professor Froment.

Major problems

There were two outstanding obstacles to complete success of electric clocks, which were never successfully surmounted in these early attempts, namely ***a*** that of obtaining a reliable and efficient electric contact without interfering with the free swing of the pendulum, and b regulating the electro-motive force of the impulse to maintain a constant arc of pendulum swing. which is essential to really accurate isochronism-in other words, good timekeeping.

Inventors have tackled these problems in many ways, and with equally varied success; the inventions of M. Fery (1908), Frank Holden (1909) and M. Fabre-Bulle (the designer of the once-popular Bulle clock) deserve mention in this respect. And out of these experiments, two distinct but equally successful principles in utilising electro-magnetic force to drive a clock have emerged. These are: a the use of an impulse directly applied to the pendulum rod, uncontrolled in strength but governed in frequency, and b indirect action by an impulse of constant frequency which is used to lift a weight. the fall of which nrovides a constant imvulse to drive the pendulum.

Method a is employed in the Hipp type of clock, which is by far the most popular among amateur constructors while b is used in the synchronome system and also in several others which might be described as modifications and variants of it, extensively employed for multiple control of secondary clocks.

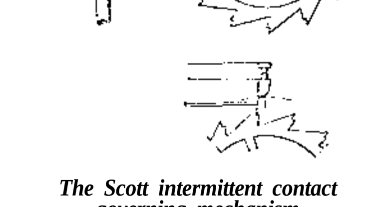
A close-up of the dial and motion work

The term " escapement " is generally used, for purposes of convenience, to describe the contact-making mechanism of impulse clocks, though its correctness in this application may be open to question. Thus in the Hipp clock the so-called " butterfly escapement " is referred to, while the synchronome system is said to employ a "gravity escapement."

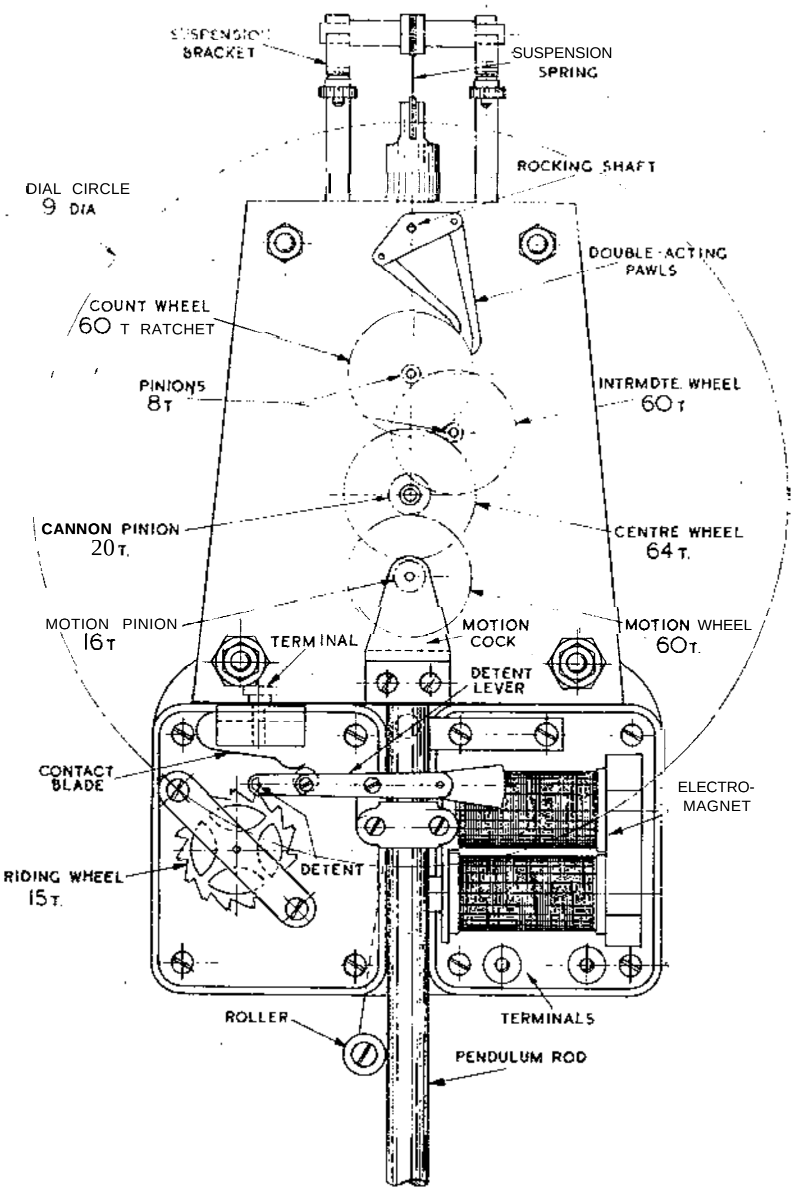
I do not propose to describe these devices in detail as they have often been dealt with in ME articles, and anyone who wishes to pursue the subject can obtain books on electric timekeeping to which I shall refer later

Some comments on the essential differences between the two systems may, however, be helpful to constructors as they explain some of the reasons for the adoption of essential features of the present design.

The electro-magnet of the Hipp clock is so arranged as to give a brief impulse or " kick " to the pendulum at intervals, which are timed by an



The Scott intermittent contact governing mechanism



ingenious trigger mechanism in the contact-making device.

Under normal working conditions while the pendulum is swinging over a determined arc-no contact is made as the trigger swings completely over the contact block; but as the momentum of the pendulum declines, it eventually reaches a point where the trigger fails to clear the block so that on the return swing it drops into a notch in the latter and depresses the contact spring, closing the contacts momentarily and thus energising the electro-magnet to produce an impulse which restores the arc of swing.

IMPULSE FREQUENCY

The frequency of the impulse may vary from a few seconds to well over a minute, depending on the efficiency of the magnet, the voltage or working condition of the supply battery-all of which in practice are variable factors-but the ultimate result is to keep the mean arc of swing substantially constant whatever the variation of power.

The Synchronome system, on the other hand, does not apply the electro-magnetic impulse to the pendulum direct, but employs it to the lifting of a weight which is then dropped at regular intervals (i.e. half a minute) on an impulse pallet attached to the pendulum rod, thus imparting a constant driving force, which also has the same effect of maintaining a constant mean arc of swing.

Both systems, therefore, are immune from the interference caused in other types of clocks, where electromagnetic force of varying magnitude is applied to the pendulum at regular intervals (sometimes at each complete or half cycle) thereby affecting the arc of swing.

Both the Hipp and Synchronome systems employ a gathering pallet and ratchet wheel in the count mechanism, but whereas the former operates the dial motion mechanically, the latter usually transmits power to one or more dials electrically, through the contacts which control the weight-lifting magnet.

Both systems are simple and robust, electrically and mechanically, but of the two the Hipp is rather better suited for use as a domestic clock, being quieter in action and readily adaptable to the conversion of an ordinary weight or spring-driven clock.

The Synchronome is, as it was originally intended, essentially a time transmitter, suited to the remote control of secondary dials. Although it can be used as a single self-contained unit its use for domestic installation is not popular; the noise of the falling weight at half-minute intervals is often found objectionable, and attempts to quieten it have not been completely successful.

NEW FEATURES OF DESIGN

In the present clock I have incorporated some of the features-I hope the best ones-of both the Hipp and the Synchronome clocks. Though intended primarily as a domestic clock, it can be used to control secondary dials if desired.

The governed frequency of impulse is adopted, but the method of applying it is modified, with the objects of still further reducing noise (some people object to the " wipe-scrape " of the Hipp escapement, especially if it occasionally catches a crab !) and also of avoiding point-to-point contacts.

The latter are often troublesome because if they are closed with sufficient pressure to be fully effective, they impose load which interferes with the free swing of the pendulum; while if made very light in action they may be unreliable, especially if pitted or tarnished.

A further feature which should be attractive to the constructor, is that the clock is made up of a number of self-contained and detachable units for carrying out the various functions, each of which can be removed for overhaul or adjustment. This increases the number of individual parts and would probably not be at all favourably regarded in a commercially-produced product, where the prevailing tendency is to reduce parts to a minimum-though some of them may have to be of complicated form to do so.

However, this unit construction method actually enables the individual parts to be simplified, and the finished result looks more complicated than it is, which may be an advantage from some points of view !

The units consist of a the pendulum and suspension unit, incorporating a metal " chassis " on which the other units are mounted,, with a bracket at the top from which the pendulum is suspended; b the electro-magnet unit; c the contact control unit; and d the clock train and dial unit. In all these there are optional features of design, to which I shall refer in due course.

WORKING PRINCIPLE

The main item of novelty in the mechanism is the method of controlling the frequency of the electrical impulse, which, in common with that of the Hipp clock, is only applied when the pendulum swing falls below a predetermined arc. But unlike the Hipp, it is practically silent in action, and employs a very lightly loaded wipe contact which is largely self-cleaning and imposes very little impediment to the free swing of the pendulum.

So far as the basic principle of this device is concerned, I cannot claim complete originality as it was first employed several years ago by Herbert Scott, of Bradford.

It entails the use of a ratchet wheel C of special form, one tooth of which is gathered at each swing of the pendulum ***A*** by a paw1 or detent carried by the rod. A contact-making device ***D*** is mounted above the wheel, and in fairly close proximity to it.

Under normal conditions of pendulum swing, the paw1 is carried well clear of the ratchet tooth so that it falls to the root and does not operate the contact; but if the arc of swing is reduced below a predetermined minimum, the paw1 fails to clear the tooth completely and drops into the step near the tip so that it rides at a higher level on the return swing, closing the contacts and energising the electro-magnet, thus giving an impulse to the pendulum.

In my modification of this device the ratchet wheel, which I have termed the riding wheel, to distinguish it from the count wheel employed in the clock train, does not necessarily play any part in the timekeeping function, its purpose being simply to control the contact.

It may thus be made with any number of teeth, unless it is intended to control secondary dials. But to cope with this eventuality I have designed it with 15 teeth so that it rotates once every half-minute so that it can be equipped with a subsidiary contact to energise dials on the Synchronome system if desired.

APPLICATION OF IMPULSE

The electro-magnet is arranged so as to impulse the pendulum rod in the direction of its travel (near the centre of its swing) when it is moving at maximum speed. Many impulse magnet mechanisms are inefficient in that they apply the power at the wrong instant or in the wrong direction. Hipp clocks and others often have the magnet mounted vertically under the pendulum rod, to the end of which an armature is attached, so that it swings as close to the poles of the magnet as possible.

This generally works quite well, but it does not always apply the power to the best advantage, and, moreover, it increases the vertical loading on the suspension spring, often causing a sudden jolt when contact is made. Its worst fault, however, is that if contact is not broken at exactly the right instant-as often happens if adjustment is not quite correct-it may waste power or even tend to put a brake on the pendulum movement.

In some cases a solenoid is used to attract the armature and this is more efficient, also less critical in adjustment; a typical example is the Bulle clock.

The electro-magnet in the clock illustrated has a pivoted armature, swinging vertically, immediately behind the pendulum rod and on the centre line. At the lower end this is fitted with a roller which rests against the rod, and, when the magnet is energised to attract the armature, pushes it gently but firmly to accelerate the swing.

The armature movement ***is,*** however, limited when it contacts the magnet poles at the centre of the swing so that it does not prolong the effect of the impulse while the speed of the pendulum is decreasing. If contact is delayed beyond this point no retarding effect is produced, though electrical energy would be wasted.

The actual clock train could be driven from the riding wheel by suitable gearing, but it has been considered more appropriate to use an entirely separate unit, which is operated from the pendulum by means of a crutch, comparable to that employed in a weight- or spring-driven clock, but acting in the reverse sense. Instead of the form of ratchet and paw1 commonly used in electric impulse clocks, in which one tooth is gathered in one direction of pendulum swing only, the rocking lever operates two pawls in alternate directions of swing.

One reason for the adoption of this form of motion is to enable a seconds hand and dial to be fitted if desired; with the usual single-acting ratchet in conjunction with a seconds pendulum, the hand would move two seconds distance at each complete double swing, and thus would not count odd seconds.

In the form shown here the clock is designed as a timepiece only, but the possibility of adding striking and chiming gear has been taken into consideration, and it is hoped to develop this at a later date. The clock motion plates have, therefore, been made large enough to allow plenty cf room for fitting this extra mechanism if desired.

It is possible to fit the complete assembly in either a hanging or standing case, but the latter is considered most suitable for domestic purposes, and as pictured the case is of tasteful design, quite in harmony with up-to-date ideas in house furnishing, without being too blatantly contemporary."

A full description of its construction will be given, following that of the clock mechanism.

The experimental work in the development of the clock may be described as a team effort, and I am happy to acknowledge the valuable assistance rendered by Mr C. B. Reeve, in wheel cutting and producing a very handsome engraved dial, Mr J. Cooper, in experiments with the electro-magnet, and Mr A. L. Headech in making the case to my rough specification.

One of the difficulties often experienced by readers who wish to embark on horological work is that of obtaining the necessary special materials, either finished or semi-finished, which are involved in this form of construction. Many enquiries for advice in this matter were received following the articles on the ME Musical Clock, and considerable attention has, therefore, been devoted to ensuring that the essential supplies for construction are available in the present case.

These will include such items as wheel blanks or flnished gear wheels, pinion wire, pendulum suspension springs, engraved or fretted dials and hands, etc., which readers often find difficulty in making for themselves. At present arrangements for supplies are not finally completed but an announcement will be made as soon as they are ready.

● ***To be continued***

The ME Jubilee ELECTRIC CLOCK

Even those who are not intending to build this timepiece will be interested in the construction of the pendulum, a feature which is vital to accurate timekeeping. By Edgar T. Westbury

Continued from **I** *May 1958,* **pages** *569 to 572*

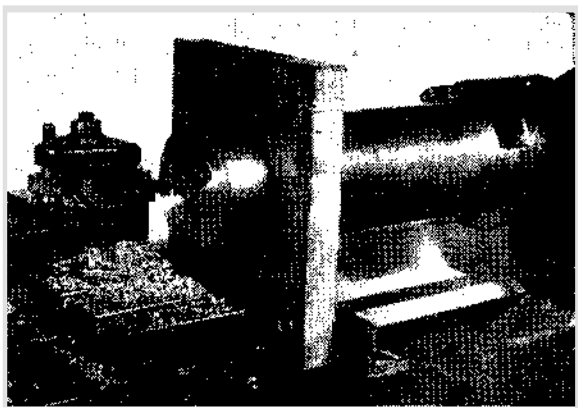
IN the experimental development of this clock, several alternative methods in the construction of the various details have been tried out, and the features of design which will be described are those which have been decided upon as most satisfactory from the all-round aspects of constructional simplicity, or the facilitating of machining, fitting and adjustment. There are, however, several instances where optional methods or details could be incorporated or minor improvements introduced.

"Capable of improvement" is generally regarded as a euphemistic implication that things are not as good as they ought to be, but in its literal sense it surely applies to everything in this imperfect world. Whether I suggest possible modifications or not, many constructors will undoubtedly exercise their prerogative to depart from the blue print; which is as it should be, for this is one of the essential differences between model engineering and mass production. In calling attention to optional features, I can advise readers as to what alternatives are permissible or desirable, and thereby help them to avoid fallacies or pitfalls in any experiments they may venture to make.

NEED OF CHASSIS

The object of mounting all parts of the clock mechanism on a rigid metal backplate, or chassis," to use a popular modem term, is to ensure stability in the relative location of the various parts. Many electric clocks are assembled by simply attaching the parts to a wooden backboard. Subject to normal precautions, this is generally satisfactory; but even under the best conditions, timber is sometimes liable to warp or distort under stress, and examples of failure to maintain exact adjustments have occurred from this cause. Most established designs of electric clocks, including the Synchronome, incorporate some form of metal chassis.

Our chassis frame consists of a light alloy casting, which has a three-point attachment to the backboard of the clock case, so that it is not distorted in the event of any possible warping of the latter. It has three flat facings, one of which carries the pendulum suspension bracket, while the other two serve as mountings for the electro-magnet and contact control units respectively.



Facing the end of the pendulum bob with the aid of an improvised wooden steady

No machining of the chassis casting is essentially required, though it may have a skim taken over the rear bosses and front faces if suitable machining facilities, such as a planing machine or a large-capacity lathe, are available. It is, however, quite in order to true these to a reasonable degree of flatness by filing; a non-clogging type of file such as the Dreadnought, Surform or Tresa file will be found most efficient for this purpose. Exact adherence to the thickness shown in the drawings is not highly important.

Three holes are drilled for fhe fixing screws. Other holes, including the tapped holes in the bosses just above the lower facings, and those for the attachment of the units to the lower facings, may be left till later, as they can be accurately related to holes in the mating parts by jigging or spotting; in fact, it has not been considered necessary with the latter to indicate the holes on the detail drawing. Apart from cleaning up any rough edges or surfaces on the casting, no further work on this casting is called for.

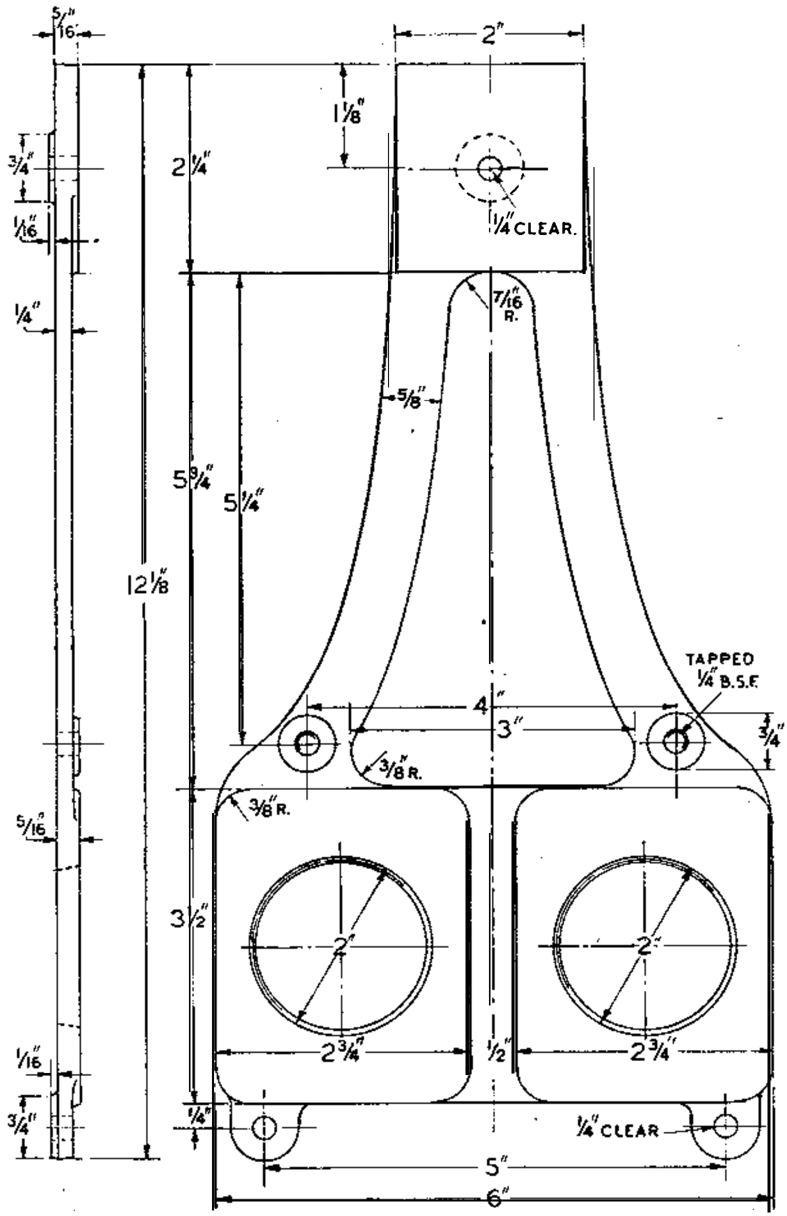
BRACKET FROM CASTING

Our pendulum suspension bracket is also made from a light alloy casting, though it could be fabricated if desired. At one stage in development, a built-up brass bracket was actually used, but the work involved in making it, and also the cost of material, was considerably greater than with a casting.

Although the essential work on this casting can, as in the previous instance, be done satisfactorily by filing, it is quite a simple matter to machine the rear bolting face, and also the top surface of the arms, by clamping it to an angle-plate mounted on the lathe faceplate. The V-notch was milled, in my case, by mounting the casting on the vertical slide, with the top edge parallel to the vertical edge of the slide, the base of which was swung round at 45 deg. to the lathe axis. It was then possible to machine the notch with an ordinary side and face cutter, but this arrangement would not have been necessary had a 90 deg. angle cutter been available.

A 1/4in. clearance hole is drilled in the centre of the bolting face, and thus coincides with the position of the top fixing hole in the chassis when assembled, but to ensure permanent location, two 4BA screws are fitted to hold the bracket in place; the exact position of these is not important.

The detail drawing of the suspension bracket also includes the clamps employed to secure the crosshead or



CHASSIS 1 OFF L.A.

suspension bar after the bar has been allowed to find its own position in the V-notch. These clamps are simply bars of 1/8 in. x 3/8 in. brass, each fitted with a single 5 BA stud, which passes through a vertical hole in the arm of the bracket and is pulled down by a knurled nut. To keep the bar horizontal a short distance stud is screwed or riveted into its rear end, having a round or pointed tip to seat in an indentation drilled in the top face of the arm. To avoid any liability to jam, the stud hole should have ample clearance and at the lower end it should be slightly countersunk, the face of the knurled nut being bevelled to correspond, as shown.

With this arrangement the entire pendulum assembly may be removed or replaced in a few seconds, by slackening off the two nuts and swinging the clamps round to release the suspension bar.

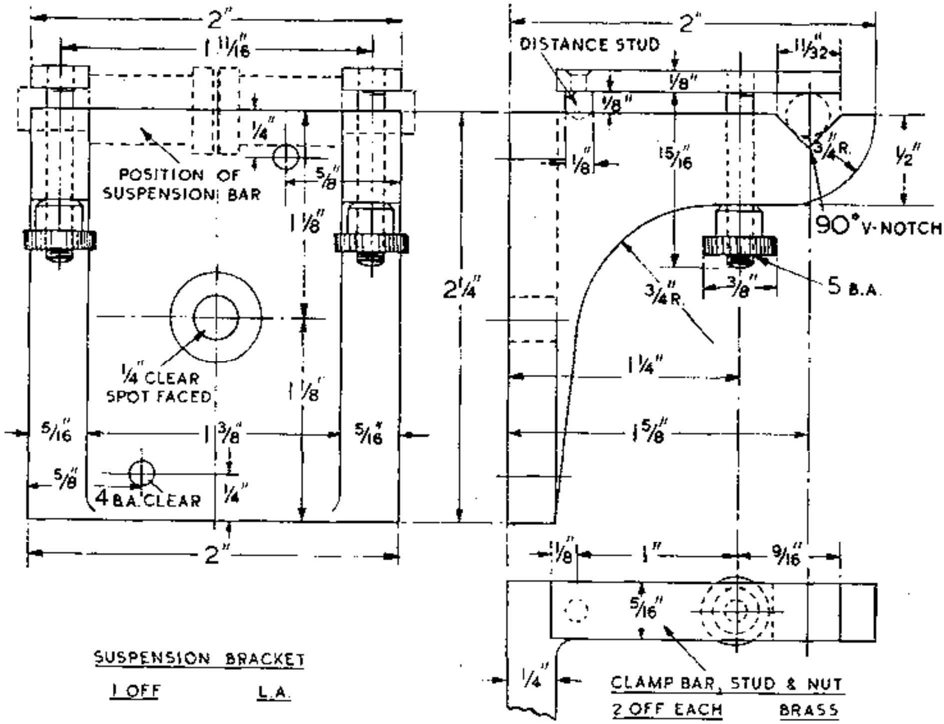
PENDULUM

It is well known that one of the most important factors in accurate timekeeping is the maintenance of an exactly constant distance between the suspension point of the pendulum and its effective centre of gravity. Although both the pendulum bob and its rod are often made of common metals, the thermal expansion of these metals will introduce timekeeping errors if there is any variation of temperature. To compensate for these, many ingenious devices have been employed, including the bimetal or " gridiron " pendulum, but the' commonest method in modem practice is to make the pendulum rod of an alloy which has practically a negligible coefficient of expansion, known as Invar. This material is relatively expensive, but is worth getting when extreme exactness in time recording is necessary; often, however, it does not produce the desired effect because other errors in the design or execution of the complete clock may completely nullify any advantage which it confers in temperature compensation.

Unless high precision is a definite end in itself, it is rather doubtful, in these days of regular time signals, whether extreme accuracy is necessary or even greatly advantageous in a domestic clock. I know that expert horologists will hold up their hands in horror at such a suggestion, but the average householder is usually satisfied with a clock which keeps time within a few seconds a week, sufficient to avoid the risk of losing trains or other important appointments. The good old grandfather clock, with its plain iron wire pendulum rod, will fulfil this condition if carefully adjusted, and so will hundreds of modem mass-produced and not very expensive clocks. By all means pursue the ultimate in precision timekeeping if you wish (you will, I think, find it a full-time hobby !) but do not imagine that it is just a matter of using a compensated pendulum, as there is much more to it than that.

The pendulum rod in this clock is made of wood, which has been exploited extensively for this purpose, as it is subject to very little thermal expansion in the plane of its grain fibres. With a very heavy pendulum however, such as is necessary or at least desirable in an electric impulse clock, it is necessary to exercise some care in the attachment of the rod to its suspension and also to the fittings which support the bob, as these are subjected to considerable strain.

The wood used is a length of 1/2 in. dia. hardwood dowel rod, the most suitable varieties of wood being those with long fibres such as ash, oak or birch; birch, I believe, being the most



readily available, as it is extensively used in the furniture trade-mostly as a substitute for rectangular tenons for jointing. The particular specimen was slightly oversize, even after it had been glasspapered down to a good finish in the lathe, but this is not of the utmost importance so long as other parts are made to fit.

After cutting to overall length, the two ends were reduced to 3/8 in. dia. for a length of 1-3/4 in., holding the rod in a split bush in the self-centring chuck. If the lathe does not have a hollow mandrel, or if its bore is too small, this may not be a very easy operation to carry out, but it is generally possible to rig some kind of outboard bearing or steady, and also a hand-tool rest, for dealing with it. The thread only needs to be a rudimentary one, and is best produced by the old-fashioned kind of split dies, which tend to compress the wood rather than cut it; the solid circular dies push the chips in front of them, and may strip the threads by end pressure. Alternative methods are screwcutting or hand chasing. Note that the thread does not extend full length of the reduced end portions, a plain part being left to ensure proper centring in the socket or ferrule. The rod should be given two or three coatings of thin shellac varnish or french polish to seal the pores, the threaded parts being liberally treated or a thicker consistency of varnish used.

The ferrules at each end are made from brass ‘rod, which need not be machined outside if they can be accurately chucked. Both are drilled and tapped to a depth sufficient to clear the threaded ends of the rod, the mouth of the hole being opened out to the crest diameter of the thread for a depth of about 3/8 in. The top ferrule is flattened on two sides, and slit down the centre to a width of 1/16 in. and a depth of well over 1/2 in., with a 3/32 in. hole across the bottom of the sawcut to improve flexibility, and also, by breaking into the axial bore, to form an air vent when the rod is screwed in; note that a similar cross hole is drilled in the lower ferrule, though it need not go right through to the other side.

The lower extension of this ferrule is turned down and screwed 1/4in. tine thread (exact pitch is optional, but fine thread is desirable for nicety of adjustment) and pointed at the end, the idea being to enable the pendulum to be used as a plumb-bob when setting up the clock, or to indicate the arc of swing.

To attach the ferrules, shellac varnish may be used as a cement, the insides being well coated and allowed to dry, after which they are warmed up to soften the varnish, and screwed well home to the shoulder. This gives very satisfactory results if the threads are a good fit, but if they are slack it may be found safer to use resin or similar heat cement; alternatively Bostik or other plastic adhesive may be used, but not glue, or any cement which becomes brittle when dry.

● *To be continued*

The ME Jubilee ELECTRIC CLOCK

Continued from 15 May 1958, pages 619 to 621

The construction of the pendulum, its suspension, and the assembly of the detent lever are reached in this article

By Edgar T. Westbury

A MIID steel pendulum bob was used in the actual clock, the dimensions being 8 in. long x 3 in. dia., and the weight approximately 15-1/2 lb. Any other convenient-sized piece of metal may be used; some constructors may prefer to cast a lead bob inside a piece of brass tube, which certainly enhances appearance, though it confers no practical virtue, and both brass and lead are more expensive metals in relation to weight. If nothing else is available, a simple wood pattern may be made and an iron casting obtained.

It is not essential to machine the outside of the bob except on the score of appearance, but the hole should be as truly as possible in the centre, and the lower end face, at least, should be square with its axis to provide a true seating for the rating nut. The centre may be marked out on the two ends of the bob by the use of any of the well-known centring devices, or by surface gauge and V-blocks, then drilled with a centre drill, after which it is possible to, drill the bob from either end, by holding it against the back centre and running fhe drill in the lathe chuck.

It is, however, much more comfortable and also more accurate, to chuck the bob and drill it from the tailstock in the approved manner. Unless a very large lathe is available, the overhang of the heavy bob will necessitate fitting a steady on the outer end, but the standard three-point steady for 3-1/2 in. lathes will not take so large a diameter as 3 in.

This difficulty was, however, surmounted in my case by making an improvised wooden bush steady, by bolting a piece of hardwood to a foot made of angle iron, clamping the latter to the lathe bed, and boring *a* hole to fit the bob by means of *a* cutter bar held in the chuck. It was then a simple matter to face and centre the bob, and drill it from each end, as shown in the photograph; this also enables the hole to be reamed or otherwise opened out, if it should be necessary, to fit the rod. It should slide easily on the latter, but not with excessive clearance, as a sloppy fit may cause it to rock from side to side,. and interfere with the proper working of the clock.

Pendulum suspension

The method of suspending the pendulum on a flexible spring follows the principles which have been universally employed' in. clocks for hundreds of years, and are very difficult to improve upon. Various other devices have been tried, including ball bearings, cone pivots, and knife edges, but so far from offering any advantages, they have generally been found less durable and efficient.

One merit of the suspension spring which is not always realised is that it provides some slight correction for the " circular error " which occurs in a pendulum swinging in a true arc.

A well-tempered flexible steel spring produces very little friction, because practically all the work done in deforming it is given back on the return swing by its natural elasticity. It is, however, very important that good quality spring steel should be used, as fatigue must be considered, and low-grade material will become brittle in a relatively short time. Shim steel is sometimes recommended, but this material usually has a low carbon content? and such elasticity as it possesses is mainly due to cold rolling; I should hesitate to guarantee it for this purpose. Fortunately, the correct grade of spring steel, specially made for clock springs, is not difficult to obtain, or very expensive.

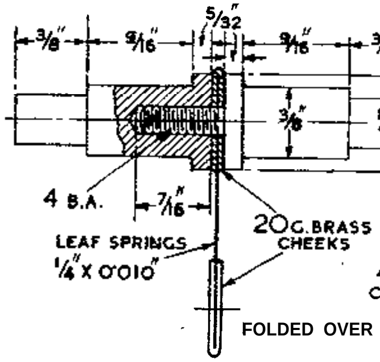
The two leaf springs used in the suspension of this clock are sandwiched between brass cheeks, or " chops " as they are called in the trade, and secured by small rivets at each end. Tempered spring steel is difficult to drill, and it will be found easier to punch the holes with a ***square-ended*** blanking punch, though locating them properly is not so easy. Centre-punching is not recommended, as it is liable to distort the spring.

The method I have used is rather unorthodox, but produces satisfactory results; I make the cheeks by folding over strips of sheet brass as shown, and drilling the rivet holes in them first. Before closing them right down, the leaf springs are inserted, and also a slip of foil between them, the same thickness as the springs, to take up space. The assembly is then clamped tightly in the vice, so that the springs are held in place, but can be adjusted if necessary, after which the punch is located by the holes in the cheeks, and driven through with a smart blow.

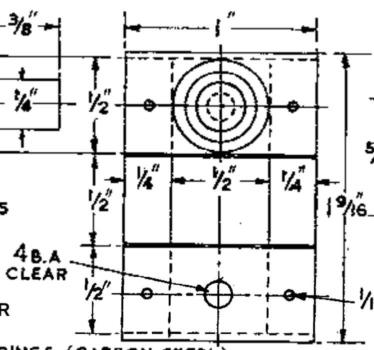
If drilling is preferred, a glass-hard spearpoint drill, or a dental burr, will generally penetrate the tempered steel if lubricated with turps and run at low speed. The rivets should fit the holes closely and should not project too far, so that they can be closed up with a few light blows; brutal bashing is more likely to distort them and put the assembly out of truth. After one cheek has been riveted, the location of the springs in the other cheek should be checked, so that the assembly is square and the springs parallel to each other. These precautions are highly essential, as an untrue suspension spring causes the pendulum to roll, and sound assembly is necessary to carry the very heavy weight of the bob.

The suspension bar is made in two parts, which screw together and clamp the top cheek of the suspension assembly, the lower cheek being inserted in the slotted end of the rod, which it should fit closely, and clamped by a 4 BA steel screw. When the bar is placed in the V-notches of the suspension bracket, it will take up its proper alignment, and can finally be secured by the clamp bars.

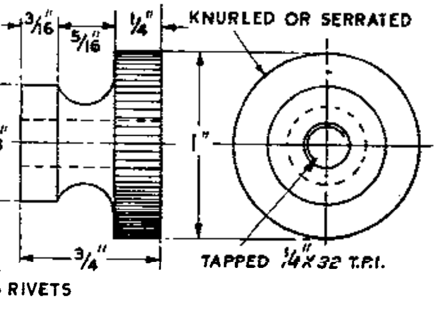
Little need be said about the pendulum rating nut, which is quite a straightforward job, and can be turned, drilled and tapped at one operation. Care should be taken to produce a good thread in view of the load it carries; the tine thread employed here, and on the end of the



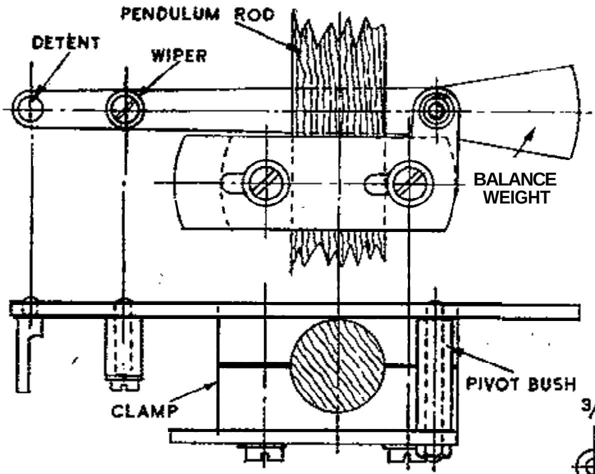
SUSPENSION BAR BRASS) & I OFF



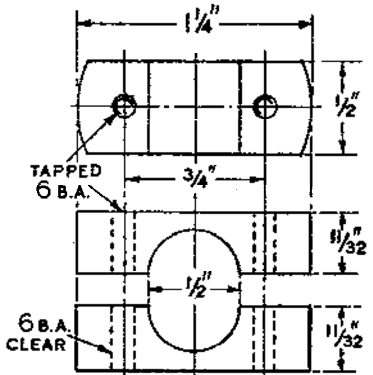
SPRINGS (CARBON STEEL) 2-OFF



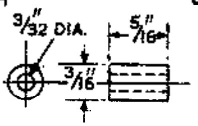
RATING NUT I OFF BRASS



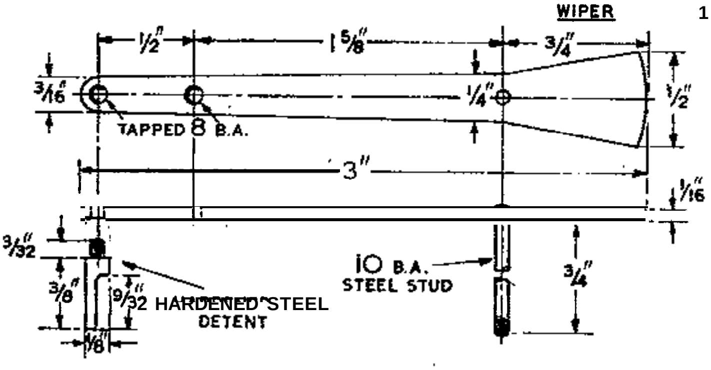
DETENT LEVER ASSEMBLY



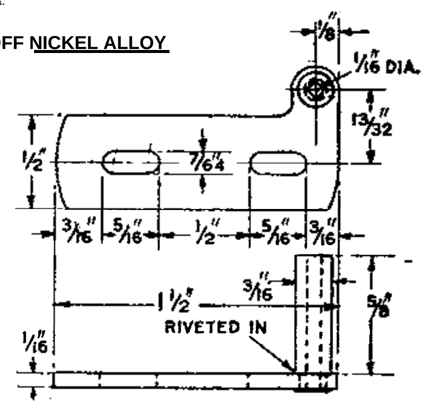
SPLIT CLAMP I OFF BRASS



WIPER 1 OFF NICKEL ALLOY



LEVER I OFF BRASS



PIVOT PLATE I OFF BRASS

rod, is conducive to precise adjustment, but may be varied if desired. Some constructors may prefer to serrate the edge of the nut, with equal-spaced notches to indicate some defmite increment of axial movement.

In describing the detent lever assembly and other details of the contact-makine mechanism. it is necessary to point out that some modifications have been introduced since the general arrangement drawing shown on page 571 of the Jubilee issue was made. The latter should, therefore, be taken as explaining the general principle and order of assembly only, in which respects it is quite correct, but details have been altered.

Lever assembly

The lever assembly is carried on a split clamp mounted on the pendulum rod, and is thus adjustable for height and alignment. Brass is specified for the clamp, but it may with advantage be made of lighter material. such as aluminium alloy or laminated bakelite. It may be machined in one piece and split afterwards, or two pieces may be used, by drilling and tapping the screw holes and fixing them together with a slip of packing between for the boring operation; in either case the hole should be bored to fit easily on the rod, so as not to jam on the " horns," when the halves are fitted to the rod. The top and bottom faces of the clamp are trued up, and it is advisable to stamp or otherwise mark them for relative location.

To round off the ends of the clamp, it can be secured by its own fixing screws to a plate or block which can be held on the faceplate or in the four-jaw chuck. An alternative method is to drill and tap a hole in the centre of the rear face so that it can be screwed on to a stud and held in the three-jaw chuck. The shape of the ends, of course, has no vital significance, and they may be filed or machined to any desired contour, so long as they are neatly finished.

The pivot plate has been made adjustable in the horizontal plane, and placed at the front of the clamp for ready accessibility. It is made from 1/16 in. sheet brass, with the pivot bush spigoted and lightly riveted in. For fixings of this nature, including wheel collets, it is desirable to make the spigot a light press fit, and of a length to project about l/32 in. bevond the plate, which in this case is 3/32 in.

The centre hole of the bush should be left slightly undersize for finishing afterwards-for a 1/16 in. pivot, a No 5 drill may be used; and the spigot end should be bevelled inwards to a shallow angle, so that it can be riveted over without burring up the hole. Support the other end of the bush on a soft metal or fibre pad for riveting, to avoid damaging the machined face. and take care to keev it quite square with the plate. If desired, the fixing screws of the clamp may be modified so that the plate can be adjusted without loosening the clamp on the pendulum rod.

For the detent lever 1/16 in. sheet brass is used, cut to the outline shown and drilled and tapped in three places. The 10 BA hole for the pivot should be tapped only partially through with a taper tan. so that the pivot will screw in-tightly: As a matter of fact, 1/16 in. rod will not allow of producing a full 10 BA thread-it is nearer 11 BA, which may be beyond the scope of the equipment in many workshops. I was able to obtain silver steel rod approximately 0.067 in. dia., which is just right for screwing 10 BA, and the pivot. bush was, therefore, opened out to suit.

Another minor alteration of detail in this assembly is seen in the design of the contact wiper, which was originally made in the form of a disc mounted eccentrically for the purpose of adjustment. It has now been found moreconvenient to provide the adjustment on the contact blade, which enables the wiper to be made simpler and lighter, namely in the form of a small bush, which is secured to the lever by an 8 BA screw and washer. The best material for this is silver. but nickel alloy or " German silver " appears to give quite good results.

Hardening the detent

The actual detent which engages with the riding wheel is made from 1/8 in. silver steel, turned down at the end to 0.086 in. and screwed 8 BA. After locating its position when it is screwed tightly into the lever, the outer end should be marked across the diameter, square with the lever, and filed half away as shown in the plan view. This part of the detent should be hardened and polished, but the screwed end should be "let down" to deep blue, by holding the cutaway part in the jaws of a hand vice or pliers and heating the end in a bunsen or spirit flame. The working surfaces, both flat and rounded, should finally be polished.

It may be observed that while many liberties can be taken with the design of this assembly, the lever should be kept very light so that it does not produce unnecessary friction when in contact with the riding wheel. The object of the balanceweight at the right-hand end is to take some weight off the detent, and it may be found worth while to experiment by adjusting the size of this or adding metal to it, but a point will inevitably be reached where the effective weight of the detent is not sufficient to ensure reliable engagement.

In order to fit the pivot to its bush in such a way that it works quite smoothly and freely, but without slackness, I recommend making a reamer or D-bit from the same piece of silver steel rod as that used for the pivot itself. This is made semicircular in the usual way, but instead of the flat being parallel to the external surface, it is made with a long taper, starting well below the half-diameter and running right out to full diameter.

Finishing the pivot hole

After honing the flat face,. it is hardened right out in thin oil. It should not be expected to take out more than about 0.001 in., but its chief merit is that in the final stages it burnishes the bore of the hole and leaves a high, accurate finish; if the pivot is found to be slightly on the tight side when fitted, a little lapping on a spare bit of rod, using plate powder or oilstone sludge, will enable it to work freelv. This simple tool is applicable to the finishing of all pivot holes; and can be made in a few minutes in any size required.

The outer end of the pivot stud must be provided with some form of retaining device, and although it is not orthodox horological practice, the easiest thing is to screw it and fit a nut. This should screw on just far enough to allow the pivot to work with slight but not excessive end play. A mere suspicion of ***recommended*** clock oil such as Chronax or Ragosine, made by Rocol Ltd, Swillington, near Leeds, should be applied to the pivot on final assembly.

● *To be continued*

Plug Cleaners

THE Birmingham Manufacturers and Traders company, of Masterpiece Works, Aston, Birmingham, ask us to point out that sparking plug cleaners which were described in the article " Blast Those Plugs " (24 April 1958) are similar to those manufactured by them, still in production, and on sale at motor accessory dealers.

The author of the article concerned has assured us that he wrote the description in good faith and with no intention of encroaching on the rights of the manufacturers. We are glad to publish this assurance and at the same time draw the attention of readers to the plug cleaners which are manufactured by Birmingham Manufacturers and Traders Ltd.

They are operated from motorists' foot pumps and in a few seconds thoroughly clean sparking plugs. The retail price is 16s. 6d.

ME Jubilee electric clock

Making the contact unit

EDGAR T. WESTBURY deals in this article with one of the most vital parts of the mechanism

Continued from 5 June 1958, pages 718 to 720

As mentioned in the previous article, several detail modifications have been made in the clock mechanism since the general arrangement drawings were made, the object being to simplify construction and facilitate adjustment. In the case of the contact unit now to be described, these include increasing the diameter of the riding wheel, and altering the fittings which control the timing and period of contact.

The entire unit is mounted on a panel,. which is specified as being of Paxolm, a proprietary form of laminated phenol resin bonded plastic; other very similar materials are Tufnol and Delaron. No doubt there are many other kinds of plastics which would serve the same purpose, and it is also possible to substitute wood or metal, but whatever material is used, it is most important that it should be stable, and not liable to warp or distort m any way.

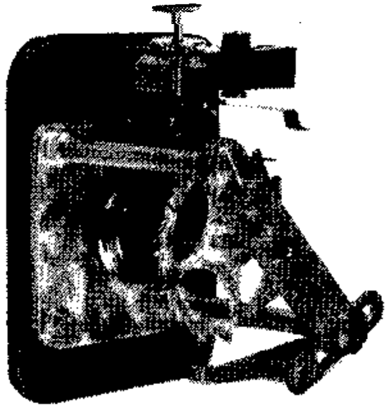
While cutting out the panel, it may be noted that the external dimensions are the same as that of the panel which carries the electro-magnet, and advantage may be taken of this fact to cut them out, or at least finish the edges, at one operation, by first marking out and drilling the four corner fixing holes, and bolting the two pieces together. The rounded ends conform to the shape of the seatings on the chassis, and chamfering of the edges is specified, partly because it is difficult to ensure perfectly clean corners when filing or machining plastic materials of this kind. In my case, I produced a hollow chamfer or flute all round the edges by a simple milling process, using a round nose cutter in the lathe chuck, and a flat saw table on the cross slide with a 1/8 in. strip attached to act as a fence, limiting the width of the chamfer. The work was applied by hand, feeding from the back of the lathe (if the cutter is run in the normal direction) and the process is the same as employed in woodworking, using a spindle moulder. Obviously it would be just as easy to produce a more elaborate moulding, by the use of an appropriate cutter.

The contact block is made from similar material to the panel, the sides and edges being finished square and true, and the cross groove produced preferably by milling. It is attached to the panel by two 4 BA countersunk screws from the back, and care must be taken to set them flush or slightly below the panel surface, so that they do not interfere with its proper seating on the chassis. This applies also to the other two screws, which hold the plate from the back.

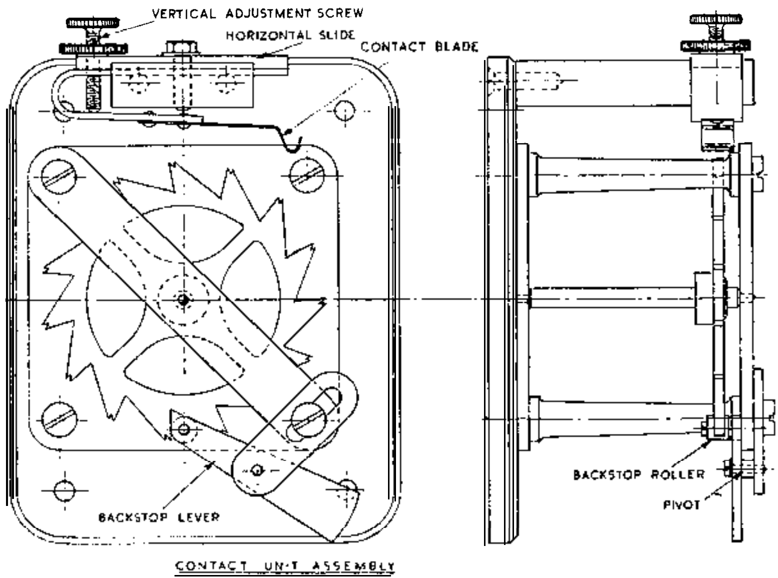
Wheel mounting frame

The riding wheel is mounted in a little motion frame of its own, consisting of a square plate, two turned pillars, and a front bar. Both the plate and the bar are cut from 3/32 in. sheet brass, and must, of course, be quite flat and true. As the centre distance between the two pillars is taken on a diagonal, there may a slight discrepancy between the ***stated*** dimensions on the plate and those on the bar, but it is quite obvious that these must be made to coincide, and this can easily be ensured by using the part first drilled as a jig for the other.

This applies equally to the centre hole for the pivot, which should he drilled undersize and finished by reaming, as described for the detent lever bush; the same tool should be suitable, as the pivot can be made to fit. Note that pivot holes should



Complete contact unit mounted on. its panel (backstop disengaged)



CONTACT UNIT ASSEMBLY

always be countersunk on the outside, to form an oil sink ; a very slight breaking of the corner is also desirable on the other side, to eliminate the burr, or the possibility of riding on the fillet of the pivot. These operations can best be carried out by means of a flat drill, ground to 90 deg., with not too fierce a cutting angle, and twirled between the finger and thumb. Finally mark the two parts, to show which way up and which way round.

The pillars are a plain turning job, which may be carried out between centres, after first deep centring and drilling (but not tapping) the holes in the ends. It is, of course, important to ensure that the length of the pillars, between shoulders, should be the same within a few thou, and that the spigoted ends should fit closely in the 7/32 in. holes in the plate and bar.

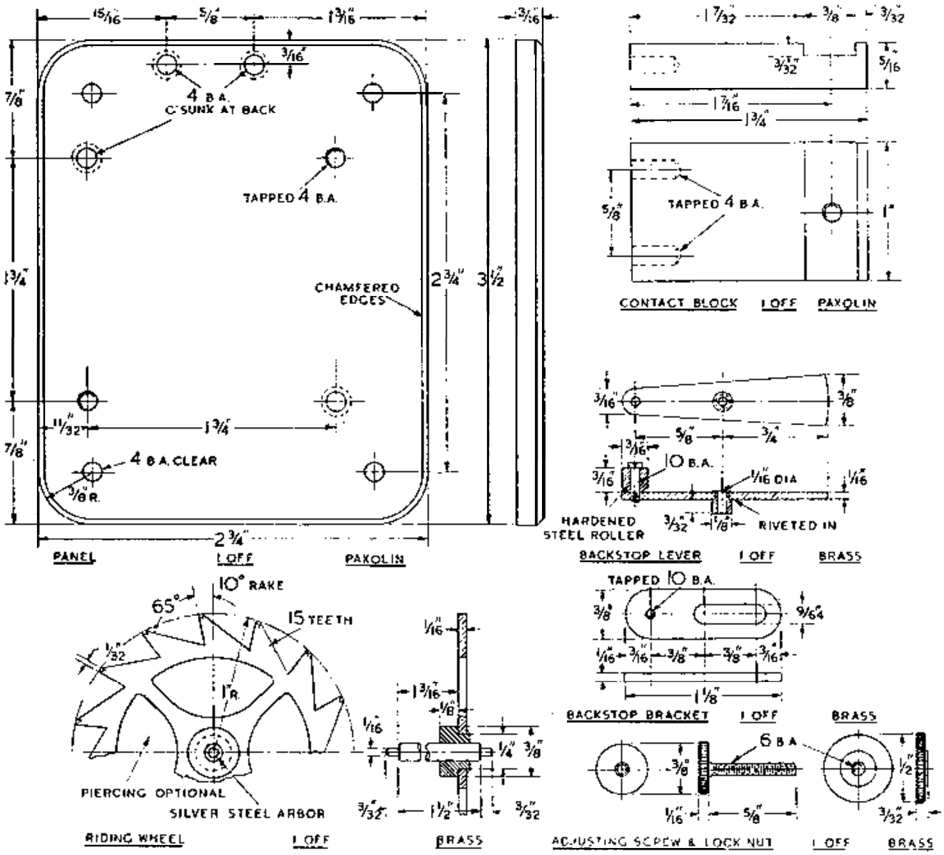
Riding wheel

The production of this wheel may possibly worry some constructors, owing to its specialised design, and the improbability of being able to obtain one ready-made. It is, however, by no means a difficult job, and the cutting of the teeth can be carried out without very elaborate equipment. Some readers are no doubt quite equal to the task of dividing out and filing the teeth by hand, as the contours are simple, and the standard of accuracy much less exacting than those of a gearwheel. But for those less highly skilled with hand tools, milling with the aid of a simple indexing gear is recommended.

A pierced wheel blank, if obtainable, may be used with advantage, but otherwise it may be cut from 1/16 in. hard brass sheet, drilled and reamed fin. dia., and mounted for external turning on a shouldered and nutted mandrel, which serves also to hold it while cutting the teeth. Here, it may be observed that it is well worth while to make two or three wheels at once, there is not only the possibility that one might be scrapped in the course of further operations, but a pack of wheel blanks will be much more rigid to withstand side pressure during the cutting of the teeth. If a single wheel is to be cut, it will be desirable to provide check washers of at least 1-1/2in. dia. to support the blank, I omitted these in my first attempts, and nearly came to grief as a result.

Cutting main teeth of experimental ratchet wheels with a home-made cutter

The cutter employed in my case was a home-made one, turned from 5/8 in. dia. silver steel, with an integral 1/4 in. shank to hold it in the chuck of my milling spindle. At the business end, it was turned to a reverse cone with an included angle of 50 deg., and the end face was well



undercut to give clearance. Three axial grooves were then milled to form teeth, with deliberately inaccurate spacing; these were, backed off, the cutter hardened and tempered, and finally honed.

Cutters of this type can be made in a matter of minutes, and cut brass very efficiently if kept sharp (as they easily can be) and run at high speed. Alternatively, a flycutter, or a multi-tooth angle cutter of suitable shape, can be used. Incidentally, I had to make several cutters in the course of experimental work with teeth of varying depth and rake, some of them had up to five teeth, but did not appear to work any better, and were more difficult to hone by hand.

For the cutting operation, the mandrel with the pack of blanks in position was held in the chuck, in fact, at the same setting as for turning, thereby avoiding possible inaccuracy. The milling spindle was mounted horizontally on the vertical slide, at right angles to the lathe axis, and driven by a plastic belt at a speed of about 3,500 r.p.m. Indexing was carried out by means of a 60 t change wheel mounted directly on the lathe mandrel by means of an expanding bolt, and locked by a strongly spring-loaded plunger (no trains of wheels or bits of clock spring for me, thanks !)

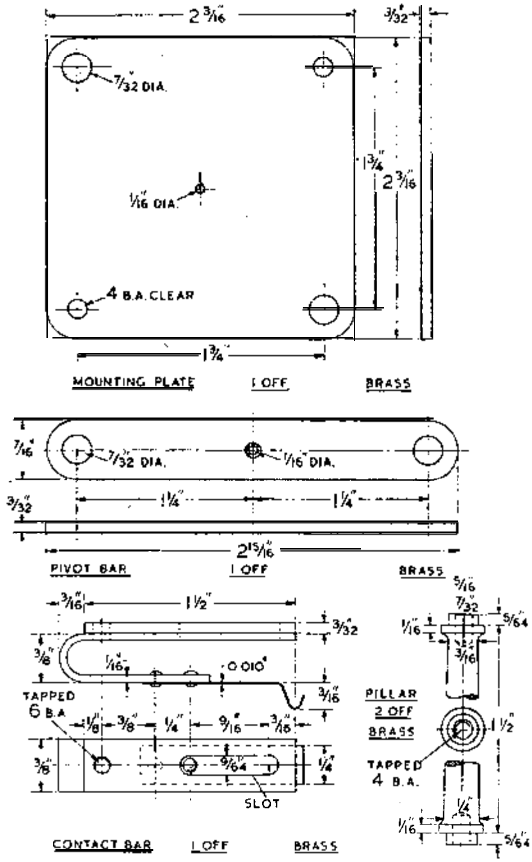
Alternative methods

For those who do not find it convenient to fit up a rotating spindle type of milling attachment, the alternative arrangement of running the cutter in the lathe chuck, and mounting an indexing attachment on the vertical slide, is equally practicable. Full details of these and other milling operations, can be found, in the ME handbook ***Milling in the Lathe.***

In setting up the gear for this operation, it is important that the cross position of the cutter relative to the blank should be properly located, so as to produce the specified rake of the teeth. To do this, the cutter should first be adjusted, by putting a point centre in the mandrel socket and lowering the spindle to its level by the vertical feed, then moving the cross slide till the front edge of the cutter is exactly in line with the centre point.

If the wheel was cut with the cutter at this cross setting, the teeth would be exactly radial, or in other words, would have zero rake, it is, therefore, necessary to make a further adjustment of the cross slide, beyond the centre position, to produce the required positive rake. As the radius of the blank is 1 in. and 10 deg. is equivalent to approximately 2.100 in. in 1 ft it follows that the amount of extra movement required is 0.175 in.

Cutting the steps of the teeth Second operation



The main portion of the tooth may be cut at one pass, and the cutter described is quite equal to the job, but it will usually be found more convenient to take more than one cut all round at a time, or at least a roughing cut and a finishing cut. No exact depth of tooth is specified, as it is not critical, but a trial cut on one or two teeth, will give a good indication of final depth, which should be such as to leave a l/32 in. land at the tips. When once set to depth, the vertical slide should be locked by tightening the gib strips, likewise the cross slide to avoid risk of indexing errors.

Mounting on the collet

After finishing the main teeth, the cutter should be re-set by moving the cross slide a further l/32 in. and the nick, or step, cut in the tips of the teeth. It will probably be found that burrs will be produced, and possibly some roughness of the milled surfaces, but these can easily be removed by the judicious use of a dead smooth pivot file.

The wheel is mounted on a hub or collet, which should be turned, drilled and reamed at one setting to ensure concentric truth, the end of the spigot being bevelled inwardly so that it can be riveted over without burring up the hole. A spindle or arbor is made from 1/8 in. silver steel by chucking it truly and turning down at each end to form the pivots, the accuracy and finish of which should be as high as possible to ensure frictionless running. I hope to be able to give some information on pivot polishing when dealing with the motion work of the clock, but the subject has already been dealt with by much more competent clock-makers than myself.

When in position in the motion frame, the arbor should have a slight amount of end play, and the collet should be a light press fit on it, as this is much the simplest and most satisfactory method of securing it in position, and if necessary, adjusting it endwise to coincide with the plane of the pendulum swing. As already explained, room is allowed on the arbor for the fitting of extra contact gear to energise secondary clocks if desired, but this matter need not be discussed further at present.

It is necessary with any form of ratchet operated feed device to provide some means of preventing the wheel

● *Continued on page 804*

CASEY JONES POEM

SIR,-As a boy in 1913 I used to watch the trains on the LBSCR line and I well remember two Pacific tank engines named ***Abergavenny*** and ***Charles C. Macrae.*** In all his Lobby Chats, I cannot recollect LBSC mentioning these engines. What is their history ?

LBSC sometimes gives us a hint of an apparently well known railway poem all about a driver named Casey Jones, and how he used to drive his engines till they groaned. Neither I, nor any of my fellow club members have come across the full poem. Could he dig it out and give it to us ?

Grpingtdn, Kent. HAYDN. D. SMITH.

GARDEN TRACTOR

Sir,-Would any readers be interested in model common-or-garden engineering ? Here is a photograph of a garden tractor just slapped together from what was lying around. The engine was borrowed from another task. Even then, bolts,. chain, and shaft ran to $50. Everythmg costs too much these days. The engine is 2-1/2in. x 2-3/4in. (3-5 h.p. American Wisconsin), and it needs another 5 h.p. of muscle to hang on to it. Nothing stops the engine even if a plough catches. Cleats or spuds just dig down and the whole business will be through to China in no time.

As a lad in Hertfordshire in the early years of the century I was able to see the steam ploughs in operation. I always thought the fella on the plough was due for decoration (above and beyond the call of duty).

I considered some winch arrangement to tear up my cabbage patch (75 ft x 200 ft) but I should need steam to do it'right. I like to see the pictures of those large ploughing engines. Incidentally, it was understood that the crew made big money in those days; £ 15 a week being mentioned at times. Probably owner operators.

Vancouver, 14 BC. R. C. FAJRALL.

METALLURGICAL BOOKS

Sir,-In modification and amplification of the reply to S.L.H.'s inquiry concerning early springs, may I suggest that reference is made to the following books: ***Metallurgy, Iron and Steel,*** by Dr John D. Percy. Published 1864 by John Murray of Albemarle Street, London. ***Metallurgy of Iron,*** by H. Banerman, F.G.S. Published 1868, 1871 and 1874 by Lockwood and Co., London. ***Iron in All Ages,*** by James M. Swank. Published 1884 (1st ed.) and 1892 by American Iron and Steel Association, Philadelphia. ***Manufacture of Iron,*** by Frederick Oerman. Published 1854 (3rd ed.), published at Philadelphia and by Trubner and Co., 12 Paternoster Row, London. ***Metallurgy of Iron,*** by Thomas Turner. Published 1895-1918 (5th ed.), by Charles Griffin and Co., London.

All these contain excellent, and accurate, information on the materials S.L.H. is interested in, but unfortunately without going into great detail, the answers given in the lower half of column three page 469 April 10, 1958 issue are, in many phases, inaccurate and misleading. All the references cited in turn furnish other references, and the interesting story of the hows and whys of early iron and steel manufacture may be readily tracked down.

Incidentally, as Hexham appears to be reasonably close to Newcastle upon Tyne, perhaps S.L.H. could contact the metallurgical people at the University of Durham and obtain more guidance in his sleuthing !

Birmingham, Michigan. R. V. HUTCHINSON.

The garden tractor which Mr Fairdl built from a collection of oddments

SUNDIALS

SIR,-I am very interested in sundials, especially the more elaborate types, and when in Britain recently thoroughly enjoyed looking through the collection in the Science Museum.

I also saw a very tine one in the Bodnant Gardens (a National Trust property near Llanrwst in Wales) but this was unfortunately incomplete. 1 wonder if anyone could give me details of this, or any other accurate type of dial so that I might be able to satisfy my ambition to make one of these interesting and ornamental timekeepers. Perhaps you could refer me to a good book on the subject.

I look forward very much to the arrival of my copies of ME, which usually come three or four together ! Being at present away from my homeland (Australia) and my workshop, I can only look forward with pleasurable -anticipation to the day when I can remove all the rust-protective coatings from my lathe and tools and get to work again.

Christchurch, New Zealand. K. G. ANDERSON.

ME Jubilee electric clock

Continued from page 784

from (running back on the reverse stroke of the pawl, or detent. In this particular case the backstop, as it is called, presented a special problem, as an ordinary click, or spring detent, would not necessarily stop the wheel invariably in the right place, due to the presence of the step, into which the detent might engage mstead of the root of the tooth. In early experiments, a form of silent or friction ratchet was tried out, in which a grooved wheel on the arbor was engaged by an eccentrically pivoted disc if the wheel tried to run back. This was certainly silent. and provided a remarkably powerful one way grip, but still the indexing was not positive enough for the purpose, and other methods had to be found.

The backstop gear finally employed may possibly look like an afterthought, but its position on the bottom end of the pivot bar is ideal for accessibility and adjustment, so I have not attempted to alter it very much from its experimental form. It will be seen that instead of a detent, this employs a roller, which cannot engage in the step, but must necessarily go fully into the root angle of the tooth.

The lever is made with a counterpoise at its tail end, so that it engages by gravity and it may be found necessary to adjust the weight to ensure that it acts quite positively but without imposing more friction on the wheel than is absolutely necessary. I did this by -fitting an 8 BA screw in the tail and adding one or more washers, but a neater method would be to solder a little extra metal on the back, should it be required.

The construction of the lever and its bracket calls for little explanation, as both parts are quite straightforward. Both the pivots should be turned from silver steel and highly finished, the ends being threaded only just far enough to enable them to screw stiffly into the plates; lock nuts could be fitted, but should not really be necessary. The roller should spin freely on its pivot, and after fitting should be hardened and polished. By means of the slotted bracket, it is easy to adjust the position of the backstop to arrest the wheel dead, with no run back whatever. A washer may be desirable under the screw which holds the bracket, but I have used special large headed screws which serve the purpose quite satisfactorily.

● *To be continued*