INSTRUCTIONS FOR THE ERECTION OF FREE PENDULUM, MASTER AND SLAVE CLOCKS

Introduction. These clocks are operated from a common battery and arranged so that the half-minute impulses of the Master firmly hold the Slave in absolute synchronisation with the Master. The half-minute impulses of the Slave release the impulse mechanism of the Master and so relieve it of all work.

In order that the energy required to be supplied to the Master Pendulum to keep it moving may be as small as possible, the air pressure in the case is reduced to about 2 c.m.

The Master Clock, or Free Pendulum, is accordingly mounted in a cylindrical copper case closed at the top by a glass jar and at the bottom by a plate glass disc.

The ends of the cylinder are terminated by flanging the copper tube to form wide flat surfaces which enable grease joints to be made with the glasses. Each gunmetal ring is provided with a pair of lugs, or feet, which enable the case to be firmly bolted on the wall of the clock chamber or room.

For the best results, the Free Pendulum should be bolted to solid rock. In practice, it is rigidly fixed to a foundation wall in a clock chamber in a cellar.

Although every care is taken to make the temperature compensation as perfect as possible, it is undoubtedly desirable, if the very highest order of timekeeping is required, that the temperature of the clock chamber should be kept constant by means of an electric heater controlled by a thermostat. It is also desirable to instal a fan to operate when the heater is cut-out, in order to prevent stratification of the air.

If the Master Clock is mounted in a small cell, it is only necessary to control the temperature of this cell. A chamber of the following dimensions is sufficient:-

4 ft. x 4 ft. x 8 ft. high

As the Slave Clock is controlled by the Master, there is no need to mount the former in the constant temperature cell: in fact, it is better to keep it outside, and it may be erected wherever its dial can be most conveniently seen.

The Erection of the Master Clock Case.

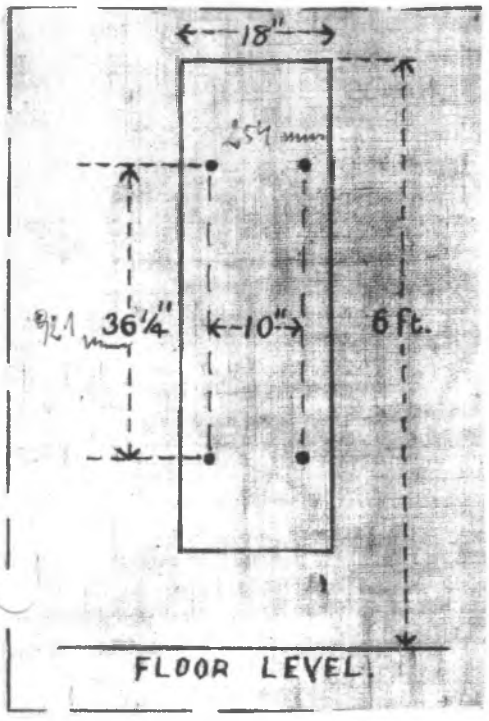
The clock case should be fixed on the wall of the clock room or chamber by four half-inch diameter steel bolts.

It is desirable to have a section of the wall 18 inches wide floated with cement from 12 inches up to 6 ft. above floor level, in order to ensure that it is quite flat and vertical.

The four half-inch steel bolts should be set into the wall and grouted up so as to project 2 inches from the face of the rendering, and they should be threaded half-inch Whitworth to within 1 inch of the wall.

The two bottom bolts should be set 10 inches apart centre to centre and 20 inches above floor level.

The two top bolts must be set vertically above the bottom bolts and at a distance of 36¼" from them, measuring from centre to centre.



The marginal sketch indicates the positions, also the cement rendering required.

The clock may be mounted at a greater height if desired, but this will put the movement more than 5 ft. above the floor.

When unpacking the cylindrical copper case, great care must be taken not to damage the surfaced ends.

It must be mounted so that the ring with the three projecting terminals is at the top. Proceed to fit up the case fittings as follows:-

Unpack the valve, remove the nut, steel washer and thick copper washer from the thread on the valve, leaving the thin copper washer on. See that the valve thread and seating, also the washers, are clean and free from dust. Put some of the special grease round the thread of the valve and the thin copper washer and insert thread into the hole provided for it on the left hand side of the bottom ring of the Free Pendulum case; having greased the remaining copper washer, place it in position on the projecting thread inside the case. Now place on the steel washer and nut and tighten up with the nozzle pointing downwards.

Unpack the glass base plate and bell jar, also the triangular frame and fixing screws necessary to hold it in place.

It will be found convenient to make the joint between the glass disc and the bottom of the case before fixing the case to the wall; for this purpose, the case should be inverted (a soft pad being placed on the ground to protect the surfaced end) and the bottom surfaced end carefully cleaned and rubbed over with a uniform layer of the special jointing grease, a tin of which is supplied.

The plate glass disc, after being cleaned, should then be carefully placed in position and gently squeezed, with a slight rotary motion, into contact with the copper flange, seeing that glass is correctly centred, and the joint free of air bubbles.

A fillet of grease should finally be formed round the glass disc where it joins the copper flange by rubbing the junction round with the special grease with the aid of the finger.

If the triangle casting is fitted with a mirror, bowline, etc., these should now be assembled as shown on Drawing 24124. When a microscope is supplied, this is already in position on the triangle as shown on Drawing 18138.

Place the triangle in position over the glass, fix it in position with the three fixing screws, after which the three padded screws in the corners of the triangle may be gently turned until they press firmly upon the glass and prevent any possibility of it moving.

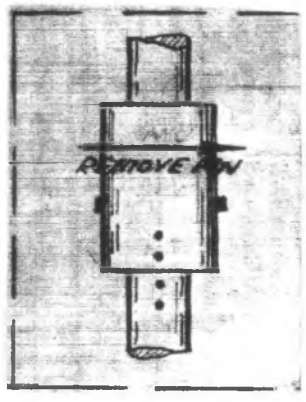
The cylinder is now ready to be bolted to the wall. This should be done as follows:-

Remove the nuts from the bolts built into the wall, lift the cylinder into position, sliding the feet of the two end castings over the bolts. Place a flat washer on each of the two top bolts and spring washers on the two bottom bolts. Replace the nuts and tighten up the two top ones. If the wall is not absolutely flat, there will be a space between one of the bottom lugs and the wall.

Erection of Master Movement and Pendulum.

The erection of the movement and pendulum can now be proceeded with.

The first thing required is the pendulum. The pendulum rod has a hook formed at its top end and when mounted up this hook will face the front, a little lower down is a cross pin called the safety pin, used in conjunction with the safety plate on the head-casting (see Drawing No.14124). Near the bottom will be seen the brass compensating collar; remove the steel pin holding the compensator and slide it off the rod.



Insert the end of the pendulum rod through the small hole in the top of the bob.

After making sure that the seating, at the point where the large hole joins it which will rest on the top of the compensator, is quite clean, slide on the compensator and replace the steel pin, seeing that the compensator is not reversed; the double dot (:) on it and the rod indicate the correct way.

Then put the beat plate on at the bottom of the rod making sure that it is parallel to the plane of swing.

Then slide the ring magnet on to the rod and temporarily fix it by tightening it's screw at about two inches from the bottom of the pendulum rod.

Next put the beat plate on to the bottom of the rod as far as it will go. The beat plate should then be pinned to the rod by first lining up the dot on the collar of the beat plate holder with a corresponding dot on the front of the rod, and then inserting the pin, from the right, through the hole provided for it.

Adjusting screws A.A., Drawing No.10720, are fitted to the beat plate holder to enable the scale to be swivelled round, one way or the other, should the scale not be travelling straight when the pendulum is suspended and in motion. This adjustment cannot be made until the pendulum is fitted in position, set in motion and observed through the microscope.

It will be necessary for the plate glass circle to be removed whilst this operation is being tested and dealt with.

Having fitted the beat scale, lower the magnet on to it until it is resting on it and fasten the ring magnet by means of the screw in the collar; this screw should be facing the front.

NOTE. Great care must be taken not to touch or rub the stainless steel scale as the diamond engraving is very finely cut and may easily be damaged and affect its reflecting properties adversely.

The pendulum may now be lifted and carefully placed in the cylindrical case, the beat plate resting on the plate glass bottom.

Erection of Head Casting and other Fittings at top of case.

The three specially bent connecting wires should be connected to the inner ends of the three terminals passing through the top ring casting of the case.

Slacken the hexagonal nuts and hook the appropriately labelled ends of the wires into the corresponding terminals, behind the washers and re-tighten the nuts, taking care that the rising portions of the wires are vertical.

Now screw the small L shaped brass bracket to the right hand side of the top ring where a hole is provided, with the countersunk headed screw, the upwards pointing arm being towards the pendulum. Fit the spark condenser at the back of the top ring.

Unpack the four-legged casting, clean it and place it in position on the top ring of the case, so that the two legs which carry the projections are on the right hand side. The Print No. 14124 will be helpful.

It will be found that the pendulum rod is just too long to enable the top of it to be inserted in the elongated hole in the safety plate attached to the underside of the body of the head casting; therefore lift the casting carefully to a sufficient height to enable this to be done and then lower it again into position, rotating the pendulum so as to get the safety pin through the slot in the safety plate.

The head casting may now be screwed down with the aid of the four cheese headed brass screws to the top ring of the case, the four holes in the finished surface for the reception of these screws will have already been noticed.

Finally adjust the milled screw holding the left hand end of the safety plate until this plate is level, place the fingers underneath the weight tray and lift the pendulum until the safety pin is just clear of the safety plate, rotate the pendulum rod through about 90° so as to bring the safety pin squarely across the elongated hole in the plate and then lower gently until the safety pin rests on the safety plate and the latter takes the whole weight of the pendulum.

Pendulum Suspension.

The next thing to be done is to carefully unpack the pendulum suspension from its small box. The greatest care must be taken in unpacking this piece of apparatus to ensure that the special spring is not damaged in any way.

The cross pin attached to the lower end of the suspension is provided to take hooks at the top of the pendulum rod and before placing the suspension in position, care should be taken to see that the hooks on the pendulum are facing the front and the rod is central in the round hole.

When the position of the pendulum has been satisfactorily adjusted, the suspension may be carefully lowered into position between the six adjusting screws, which must be withdrawn sufficiently to allow the cylindrical portions to set down on the top of the steel blocks.

The cross pin should pass in front of the hooks on the pendulum and if these hooks are not high enough to enable the cross pin afterwards to pass under it into its proper position, the milled screw supporting the left hand side of the safety plate should be turned and the plate and pendulum raised until the suspension cross pin will pass under the hooks.

When this has been done, the safety plate may be gently lowered until the suspension cross pin takes the whole weight of the pendulum and it swings freely.

It is again necessary to emphasise that every care must be taken to prevent tortional vibration of the pendulum and the buckling of the spring.

The safety plate should not be lowered clear of the safety pin more than is sufficient to ensure that there is no possible danger of their touching one another.

Assembling and Erection of Movement.

The movement itself may now be carefully unpacked from the box containing it. In order to ensure that it should not be damaged in any way during transit, the heavy re-setting lever, marked X on the accompanying Drawing No. 181229 of the movement, has been removed and also the light impulse lever marked Y.

Before replacing these levers in the movement, it should be tried in position on the right hand side of the head casting, so as to make sure that it can be readily inserted and removed subsequently, also that the connecting wires come in their right position etc.

This having been done, the insertion of the heavy re-setting lever may be proceeded with. For this purpose, remove the screws indicated by the letters A.B.C. and D. on Drawing No. 181229 and lift off the inverted 'T' shaped front plate of the movement. See that the pivots of the heavy lever are quite clean and carefully insert the proper pivot into the jewelled hole in the back plate of the movement and, whilst holding the lever in its proper position carefully place the jewelled hole in the front 'T' shaped plate of the movement over the other pivot of the heavy lever and replace the fixing screws A.B. and C. The utmost care must be taken in this operation that the jewels in the holes are not in any way damaged or strained by the pivots.

The screw D may now be replaced through the centre of the continuity hairspring and the electrical connection from terminal B to the contact screws at the end of the contact arm of the heavy lever completed.

It will be noticed that there are two cylindrical weights in the box with the impulse lever, the heavier one is for use in normal air pressure and the smaller weight for the reduced air pressure. Fit the heavier weight on the impulse lever exactly midway between the impulse corner of the jewel and the pivot.

When this has been done the insertion of the impulse lever may be dealt with on similar lines. Remove the cock piece by taking out the screw E, place the impulse lever into position with its lower pivot in its pivot hole, then replace the cock piece and screw, being careful to gently guide the top pivot into its bearing hole, great care must be taken not to damage the pivots or the jewels.

The movement may now be placed in its proper position on the head casting and the connecting wires fixed to terminals on the movement. The flex from the movement to be connected to the spark condenser.

Fitting of Impulse Wheel Carriage.

The next stage in the erection of the Master clock may now be completed by unpacking the impulse wheel carriage. This carriage carries the small impulse wheel at its lower end and only requires to be hung in position on the pendulum. The two pointed steel screws go into the two holes already mentioned in the brass block fixed to the pendulum just below the safety plate.

When hung in position, the impulse wheel should only just clear the underside of the 'D' shaped impulse jewel and unless the adjustments of the various parts have altered in transit, this should be found to be the case when the pendulum suspension has been placed with the aid of the six adjusting screws so that the pendulum hangs in the centre of the case.

The plane of the impulse wheel when the pendulum is swinging to and fro should pass through the centre of the 'D' shaped portion of the impulse jewel.

The position of this jewel relative to the position of the impulse wheel when the pendulum is at rest is defined on the accompanying enlarged print No.2423D of the impulse wheel and lever. From this print it will be seen that the left-hand edge of the impulse jewel should be exactly $1\frac{3}{4}$ millimetres on the right-hand side of a vertical line passing through the pivot of the impulse wheel.

The necessary adjustment to effect this may be made in two ways: one by shifting the pendulum bodily to the right or left by means of the two adjusting screws at the top of the head casting, or by adjusting the milled screw at the bottom right-hand corner of the movement plate, which rests against the small bracket attached to the top of the case.

Measurement of Arc.

It only remains to adjust the bowline at the outside of the bottom of the case to enable the arc of vibration to be measured from time to time.

The bowline should be carefully adjusted to coincide with the zero of the beat plate scale, but this, of course, must be done after the pendulum has been finally adjusted for position.

The normal total arc of vibration should be 110 minutes approx. The minimum arc on which the clock will work is 60 minutes, which is represented by a movement of the beat plate of 20 mm: or from 1cm. to 1cm. on the beat plate scale which is divided into millimetres.

If a microscope is provided with your Free Pendulum, the reference to the working arc above mentioned does not apply, and a memorandum will be found attached, illustrating the scale on the special beat plate and the method of reading it.

The Free Pendulum may now be left for the moment, with the bell jar placed in position to protect the movement from dust or damage.

Erection of Slave Clock & Wiring of Circuit.

The slave clock should be unpacked and erected and the electrical wiring and battery arranged.

As already explained, the position of the slave clock does not require the same care in selection as that of the Master, but a good wall and sound fixing are essential.

The accompanying print shows the electrical wiring required and as the terminals of both the slave and Master are lettered S.B.F. respectively, there should be no difficulty in correctly starting them up.

As the Master movement has not yet been set going, connect together temporarily the two terminals on the Master's case marked S and B so that the slave may be started going, without the Free Pendulum.

INSTRUCTIONS FOR THE ERECTION OF THE SLAVE CLOCK.

Unpack the clock and its parts contained in the small boxes, the case keys will be found in one of the boxes, open the case and remove the tissue paper, unpack the pendulum rod and bob.

It is necessary to fix the clock on a substantial wall free from vibration if the best results in timekeeping are to be obtained.

The clock should be erected so that the top of the case is about 6 ft. above the floor level, this will bring the clock movement to a convenient height for fitting up now and attention in the future.

A hanging plate will be noticed on the back of the clock case. Plug the wall and fix screw in plug so that the clock may be hung by its hanging plate on the wall at the recommended height.

A set of wood screws will be found in one of the small boxes, one screw $1\frac{1}{2}$" long to hang the clock on and four $2\frac{1}{2}$" screws for fixing the clock firmly to the wall.

As the clock is hanging on its one screw, open the door and hang a plumb line from the top of the case and down the left hand side of the clock, bring the clock to an upright position and mark off wall through the 4 - $\frac{1}{4}$" diameter holes in the back board of the case. Remove the clock and plug the wall in the four marked off positions.

Replace clock and screw back through the 4 holes firmly to the wall using the $2\frac{1}{2}$" screws for this purpose.

Ascertain with the plumb line that the clock is not leaning out or inwards i.e. that the face of the wall is upright. If the clock is not upright in this respect, the fixing screws should be slackened off and hard wood packing of the right thickness placed behind the top or bottom batten to make it so, and the screws tightened up again.

Having got the clock firmly fixed to the wall, remove the wire ties from the seconds switch lever and the half minute gravity lever.

Proceed now to complete the assembly of the pendulum. Drawing No.20638 should be referred to.

Fit the top chops in which is fitted the suspension spring and cross bar or trunnion, remove screw from the suspension spring chop at the top end of the pendulum rod and insert spring into the slot until the holes in the spring and chop line up taking care to see that the clamping screws in both chops will be the same way round. Replace screw in the pendulum chop and tighten up until the spring is gripped firmly but not dead tight.

The bob should now be fitted having the rounded brass collar at the top and the flat shouldered collar let in at the bottom. Screw the rating nut on until the top of the rounded collar at the top of the bob is level with the line marked on the pendulum rod.

If the clock has a magnetic corrector fit the ring magnet on the plain part of the rod below the rating thread having the grub screw at the front, fit the beat ring at the bottom of the rod so that the black beat line is at the front - Drawing No. 20638 shows this.

Fit the jewelled click B into the special slotted screw at the back of the pallet so that the arm of the click comes to rest at the bottom of the circular slot.

Hang the pendulum in position and check for the right to left position whilst the pendulum is hanging stationary. Sketch 5 on Drawing No. 20638 shows the correct position with the gravity lever off its catch and the roller R resting on the pallet J.

If the clock is mounted upright the pendulum should be correct for position. If a slight adjustment is required use the trunnion traverse screws. (See Drawing No.9542).

When the pendulum is settled for position check the adjustments of the toggle, pallet and synchronising spring and re-adjust if necessary.

First adjust the seconds switch toggle for correct height on the rod which should be so that the rocking toggle piece just lifts the steel catch lever supporting the heavy switch lever just sufficient to release it, plus $\frac{1}{4}$ millimetre to spare as the pendulum is swinging from left to right and vice-versa.

Now adjust pallet J for position relative to roller 12 on gravity lever G. The top corner of the impulse curve of the pallet should swing under roller R with 1/100 inch clearance when gravity lever G is supported on its catch K. The pallet should also be adjusted so that its length is parallel to the plane of swing or to the back of the clock

The jewelled click B should now be in the correct position for gathering one tooth only of the fifteen toothed wheel for each complete swing of the pendulum however large the arc. The clock was sent out with this adjustment correct but should it need further adjustment the click wire may be slightly bent.

Next come the synchroniser fittings. Adjust the wire support ring so that the spring support wire is $\frac{1}{2}$" below the lip of the synchroniser blade and adjust the synchroniser block holding the spring so that the top hook end of the spring is free to pass under the tip of the synchroniser blade with 1/100 inch to spare, see also that the spring is resting against its support wire and that the block and support wire are in a parallel plane to the swing of the pendulum. The position of the synchroniser fittings are shown on Drawing No. 191229.

Finally see that the weight tray is about $\frac{3}{8}$" below the synchroniser block.

Magnetic Corrector. (See memorandum attached)

The battery may now be wired up to the clocks as shown on Drawing No. 11252, but as stated before, terminals S and B on the Free Pendulum should be temporarily connected together so that the slave may be started going. 6 volts is sufficient for all purposes.

Start the pendulum on a small arc, just large enough to ensure the 15 toothed wheel being rotated and the electrical beating of the seconds switch operating.

After about 1 hour the arc should have increased to 4 plus 4 centimetres on the beat scale.

On the right hand side of the case will be seen a panel with two adjustable resistances, one for the F.P. and the other for the slave. Providing the wiring resistance is negligible the F.P. resistance should be set at 7 ohms when the Atmosphere test is in progress i.e. when the heavy weight is being used on the F.P. gravity lever, and at 9 ohms when the F.P. is working at the reduced pressure of 20 millimetres of air i.e., when the light weight is being used. The slave resistance should be set at 7 ohms. In the latter case of the Free Pendulum and in the case of the slave clock these adjustments allow for the current flow to be 1/3 amp which is correct working value.

When the heavy weight is being used on the Free Pendulum gravity lever more current is required to operate the switch, adjusting the resistance to 7 ohms ensures this.

On the left hand side of the case are a similar pair of resistances mounted on a calibrated panel which, as will be seen by Drawing No. 11252, are for use in the seconds circuits. The top resistance is in series with the seconds switch and regulator dial coil and should be adjusted to 15 ohms to ensure a working current of 75 milliamps. The lower resistance provides a further seconds beat electrical circuit if required and the dotted line wiring on Drawing No. 11252 shows how this may be used. It is advisable not to pass more than .25 amp through this circuit which may be used for operating relays or chronograph pen or additional dials of seconds beat.

The Seconds Beat Regulator Dial.

The propelling of the dial wheel work is by means of a reciprocating brass lever having an armature plate at its top end which is attracted at each impulse by the magnet, and at the bottom end

As the armature is attracted the click steps back and down one tooth of the wheel and the spring resting on the heel of the click drives the armature brass lever forward on cessation of the impulse. Whilst this operation is taking place the wheel is held steady by a backstop i.e., a brass lever terminating in a steel square which fits into the teeth of the wheel.

To set this dial to time the minute hand must be turned in a forward direction by means of the set button on the back end of its arbor, the hour hand will follow the minute hand.

The seconds hand may be set by pressing on the left hand end of the back stop lever i.e., that part which overhangs its pivot, the wheel is then free to be revolved forwards to the correct second. If the seconds hand is some seconds slow the armature may be tapped on in between impulses.

The F.P. and Slave Dials.

The action of these movements is similar to the seconds beat dial excepting that they only move half-minute at each impulse.

To Set to Time.

Depress left hand end of backstop lever which will free the wheel work of the click and backstop and turn large wheel until the correct time is indicated. If a little slow these movements can also be tapped on in between impulses.

The above Slave Clock's normal rate when uncontrolled must be a losing one of six seconds per day, relative to the time to be measured (Sidereal or Mean as the case may be) and the rating of the Slave should be attended to before bringing it under the control of the Free Pendulum.

Starting up and Rating of Master Clock.

Two sets of regulating weights will be found among the accessories and the position of the weight tray and the weight of the pendulum bob have been so arranged that the placing of a one gramme weight on the tray will accelerate the pendulum by one second per day. The tray should be 5.5/16" below the safety pin, which will be found to be about $\frac{1}{4}$" below the surface on which the bell jar rests.

The compensator supporting the bob has been pinned to the pendulum in such a position that the clock will lose a few seconds per day on [illegible] time at [illegible] in vacuum, so that if a 10 gramme weight is placed on the weight tray, the rate should be found to approximate closely to [illegible] time, during the preliminary rating at ordinary atmospheric pressure.

The time has come to start up both the Free Pendulum and Slave, but before doing this replace the appropriate wires on the S and B terminals on the Free Pendulum case which were connected together during the trial run and rating of the Slave clock, also stop the slave pendulum.

Now start up the Free Pendulum taking care that it swings in a true plane and not with a circular motion, work it up gently until

the arc is about 18 mm. plus 18 mm. on the ivory beat plate or 100 minutes on the diamond engraved beat plate. Replace the bell jar whilst attention is now given to the Slave clock. Start the slave pendulum in motion to a little under its normal arc. It will be found that when its switch action occurs, the release magnet on the Master will operate, i.e., every half-minute.

The operation of the releasing magnet will allow the impulse lever to drop, and when this lever reaches the limit of its movement, it will release the catch holding the re-setting lever which, in its turn, will gently re-set the impulse lever upon its catch and finally close the Master remontoire circuit by means of the screw mounted on the contact arm. This energises the re-setting magnet and causes its armature to throw the re-setting lever back on its catch once more.

The closing of the Master remontoire circuit causes an impulse to return to the synchroniser on the Slave clock.

The action of the synchroniser should occur just as the slave pendulum is passing through zero on its excursion from right to left but owing to both pendulums most likely not being in a relative phase on starting up, the phase of the Slave pendulum should be gently retarded or quickened, whichever is nearer to synchronisation, by hand until a synchroniser HIT occurs i.e., when the spring on the pendulum is caught and bent back by the synchroniser blade.

The synchroniser action can be tried more frequently than its normal half-minute spaces by waiting until the Slave pendulum is over to the extreme left when catch K can be pushed aside by the finger thus releasing the gravity lever. Each time this is done the cycle of operations will be repeated.

Having got the Slave clock into a position where it is being synchronised it now remains to leave the clocks to work normally and watch the action of the synchroniser.

Owing to the slowing rate of the Slave of approximately six (6) seconds per day relative to the Master, the interval between the release of the impulse lever and the operation of its remontoire will gradually decrease, until the time arrives when the synchronising spring on the Slave just fails to get under the end of the synchronising magnet armature before this armature moves, that is to say, the armature will come down before the spring reaches it, with the result that the spring will engage with the end of the armature and be deflected as the pendulum continues its swing to the left.

This engagement and flexing of the spring naturally results in a shortening of the time of the particular swing of the slave pendulum by an amount dependent on the strength of the spring. The spring has been adjusted so that each time it is flexed that particular period of the slave is decreased by 1/240th of a second. As 6 seconds per day equal 1/480th of a second per half-minute, it follows that the slave will only drop back this amount between successive contacts and that it will not have dropped back sufficient for engagement to take place at the next contact and a miss will occur. At the end of another half-minute, however, it will drop back where it was before, and an engagement should take place. Thus engagements and misses should follow one another alternatively for an indefinite period, if the rate of the clocks does not change.

If the engagements and misses do not occur alternatively, or approximately so, the rating of the slave should be altered by adding or removing weights from its weight tray in order to bring this about. If more misses occur than engagements, the slave is obviously going too fast and weights should be removed from the tray. On the other hand, if the engagements preponderate, the clock is going too slow and weights should be added to the tray.

As soon as the synchronising of the slave is in satisfactory operation, the rate of the Master Clock can be determined. When the rate is definitely known to 1/10th of a second per day, arrangements for sealing the case and pumping out the air may be made. Before doing so, it is necessary to remove 12.25 grammes from the weight tray of the Master Clock, in addition it will be necessary to lighten the impulse lever by removing the weight and substituting it with a smaller weight. In ordinary air pressure the current rate is somewhat more than normal, owing to the use of the heavy cylindrical weight which, when being replaced by the lighter weight will bring the current to normal. Therefore it will be necessary to re-adjust the Free Pendulum resistance in order to obtain the standard current rate of .33 amp.

These alterations should not be made while the movement is in place. It should be removed from the case for this purpose. When the lever has been lightened the movement can be replaced.

Next, the mercury and oil gauge should be unpacked and set up on the top ring of the case on the left hand side. The fixing screws will be found with the gauge. Take care to see that the mercury is to the top of the tube side of the gauge with the scale reading. Now remove the oil gauge bulb with its opal scale and put into its container pump oil to the depth of about 10 millimetres, then replace the bulb so that the end of its tube is immersed almost the complete depth of the oil. The object of the oil gauge is to give a pressure reading of about ten times greater than the mercury gauge.

It must be remembered that the impulses are now insufficient to maintain the arc of the pendulum under ordinary air pressure. It is therefore necessary to gently increase the arc by hand at least 50% above its normal amount and to proceed with the sealing and exhaustion of the case immediately, otherwise it may be found that by the time the case has been exhausted, the arc of the pendulum has got below the minimum value at which the mechanism will operate.

Now clean the bell jar, and carefully grease the ground edge with the special grease. Clean the surface of the top ring of the case, place the bell jar in position and gently squeeze it into close contact with the copper with a slightly rotary motion.

The pump should now be prepared. Cut the rubber tube into two convenient lengths, attach one piece to the valve inlet of the Free Pendulum case, and its other end to one side of the glass drying tube. Fit the other piece of rubber tube to the remaining end of the drying tube and its other end to the pump. Now put about one third of the bottle of drying salts, supplied for the purpose, into the drying tube. The clock case is now ready to be pumped out.

Open the valve by withdrawing the screw plunger about two turns and start pumping. Pumping should be continued until the mercury gauge shows 1.8 c.m. from a vacuum. Now let sufficient air into the case to send the oil up the tube and until the mercury reaches 2 centimetres.

When this value has been reached, close the valve by screwing the plunger home and note the position of the mercury and oil. After allowing the case to remain undisturbed for an hour or so, again carefully note the position of the mercury and oil, repeat two or three times at intervals of twelve hours. The oil will probably move a little for the first two or three observations owing to the settling down of the temperature, in fact, the oil will continue to fluctuate if the clock is not kept in a constant temperature.

If the oil and mercury has remained steady, the test may be considered satisfactory. On the other hand, should a movement be disclosed a leak is indicated and all joints and connections must be carefully examined. The order of probable leakage is as follows:-

1. Joint between bell jar and copper flange.
2. Joint between glass disc and bottom flange.
3. Joint between valve and socket and bottom casting.
4. Joints between terminals and top casting.

The whole case was carefully tested as above before despatch and proved to be able to hold 74 cm. of vacuum indefinitely.

If it should happen that while pumping out the air, the arc of the pendulum has got below the minimum value at which the mechanism will operate, shut the valve up and remove the rubber tube. Now place a finger over the valve inlet and unscrew the valve plunger about two turns, watch the pendulum and as it commences to swing away from the valve, let a spurt of air in for a duration of about half a second. Repeat this until the pendulum has regained a reasonable arc. These air impulses will rapidly restore the pendulum to the required arc. The valve may now be closed, the rubber tube replaced and pumping re-commenced when the valve is opened again.

Assuming that the case has been satisfactorily sealed, the pressure should be reduced until the mercury gauge reads 2 cm. or thereabouts, and the rate of the clock under this pressure can then be accurately determined.

As the effect of the reduction of the air pressure is not known to within 1/10th of a second per day, it is probable that the rate of the clock when exhausted may be so far from time it cannot be corrected by increasing or further reducing the air pressure. Under these circumstances, there will be no alternative but to open the case and adjust the regulating weights on the weight tray accordingly, in the proportion of 1 gramme to one second per day. This alteration should not, of course, be made until the rate of the clock is known to the nearest 1/100th of a second.

The amount of the arc is a valuable indication of the satisfactory going of the clock and once this arc has settled down it should remain absolutely constant, so long as the density of the air within the case is unchanged.