Meccano Clock Nearly 10 ft. High

Bombay Government Official's Wonderful Model

EVERY one who is familiar with its principles, knows that Meccano is far from being merely a toy. Articles have appeared in the "*M.M.*" from time to time showing that the system is of great practical value to engineers, inventors, and scientists, and that it is regularly used by engineering firms for experimental purposes. It also forms an ideal hobby for men who delight in setting themselves tasks which, whilst exercising their intellects, afford pleasant contrasts to their ordinary business. This is borne out by the remarkable number of artists, lawyers, doctors, and men in similar professions who find their greatest relaxation in "creating" Meccano models.

Lieutenant-Colonel B. Higham, Chemical Analyser to the Government of Bombay, spent some eighteen months on the design of a Meccano clock. That his time was not wasted, apart from the value of the recreation that the building must have afforded, is proved by the illustrations that we are now able to reproduce. Many forms of clocks have been constructed at different times in Meccano, but we know of no other of quite such original and interesting design as that of Lt.-Col. Higham.

Overhead Pendulum

The general appearance and layout of the clock can be gathered from the full length view (Fig. 1). It stands 9 ft. 9 in. in height, but—and this is one of the most novel features—the clock proper ends just below the face, all below that being merely in the nature of a stand. The pendulum is at the top and the works of the clock are at the bottom, instead of the other way about. The reason for this will be understood later on when the working of the escapement has been described. A "seconds hand" is provided with a separate dial, which can be seen immediately beneath the dial proper in Fig. 1.

The clock is driven by ten Meccano Clockwork Motors, all coupled together and driving on to a common main shaft. This fact may deter many Meccano boys from building the model unless they wish to keep it built up permanently, for it is doubtful whether many uses would afterwards be found for so many Motors. However, those readers who prefer the gravity method of propulsion will still find many features of this clock of very great interest; indeed, the clock could be converted by substituting weights for the Clockwork Motors without a great deal of alteration to the remaining sections.

For convenience in transport the clock can easily be separated into three approximately equal parts, and as quickly reassembled, the position of the two dividing zones being plainly discernible in the illustration, viz., one where the narrow top part joins the wider middle portion and the other where the clock rests on the stand. The stand is mounted at the bottom on four short adjustable screw-feet by which it can be made perfectly level, and a plumb-line and bob are provided for this purpose.

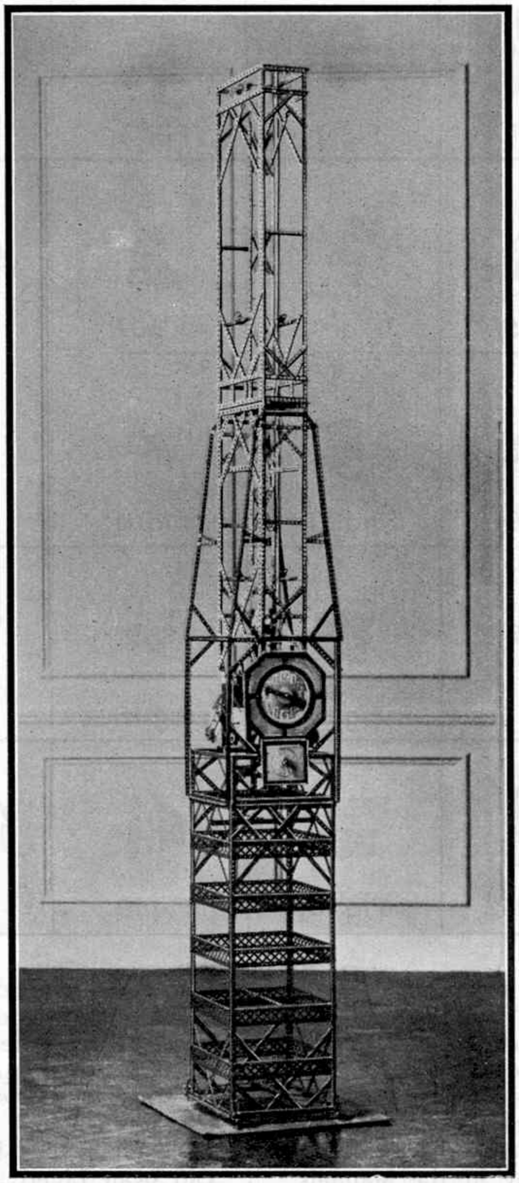

Fig. 1. General view of the Clock. The pendulum is mounted above the Clock mechanism.

The following is Lieut.-Col. Higham's description of the clock. This description will be continued in a second instalment next month, when the main driving train, the escapement mechanism and the adjusting devices will be dealt with:—

Mechanical Details

The pendulum is about 5 feet 6 inches long and is not a simple rod, as it is in most clocks, but a rigid lattice girder constructed of two parallel lengths of Perforated Strip, placed $2\frac{1}{2}$ inches apart and connected together at intervals by Double Angle Strips and Threaded Rods and nuts, and stiffened by a series of five X-shaped struts, all of which can be made out in the illustration. It swings from front to back instead of from side to side and makes twenty-five double swings in every minute. It is suspended from the top of the frame and to reduce friction, which would otherwise be very considerable at this point, its axle rests at each end in the interval between two Flanged Wheels, which rock slightly to and fro as the axle rolls backward and forward on them.

For transport the pendulum is separated into two parts corresponding with the upper and middle sections of the clock. Clips are provided to hold each of the two portions firmly in the frame when separated and a special mechanism has been devised to insure that when reassembled the length of the pendulum shall be precisely the same as before. In the ordinary way Meccano construction does not admit of adjustments of length of less than half an inch. By means of Slotted Strips (parts Nos. 55 and 55a), however, finer adjustments are possible and at one point in the pendulum a slotted union has been provided so that the level of the lower end of the pendulum can be adjusted to a nicety.

This end, which is shown in Fig. 2, is equipped with three heavy brass paper-weights, placed one above the other. The outlines of all three of the weights can just be made out in Fig. 2, and of two of them in Fig. 4 (to appear next month). These are the only parts of the whole clock which are not standard Meccano accessories. They are suspended in a cage which can be raised or lowered by turning the Threaded Rod 1. This end of the pendulum also contains some of the integral parts of the escapement mechanism, but these will be described later on, when the effect of raising and lowering the cage of weights will also be considered.

The motive power of the clock is provided by ten Meccano Clockwork Motors, four at the back and three on each side. When fully wound the clock goes for between twenty-eight and thirty hours and after going for twenty-four hours as in ordinary running, each of the ten keys has to be given about nine half turns to wind the clock up fully again. When a Meccano Clockwork Motor is completely run down it requires about eighteen half turns of the key to wind it up fully. After twenty-four hours of running, then, the Motors in this clock are still only about half run down and this is a suitable arrangement because, while the Motors maintain their power at a fairly constant level during the first half of their course, thereafter they depreciate fairly rapidly.

The Motors on the "9 o'clock" side of the clock drive ahead and those on the "3 o'clock" side in the reverse, and the reversing levers of all the Motors are secured in the requisite position by Strips and bolts to prevent accidental movement. The advantage of using the terms "9 o'clock" and "3 o'clock" instead of "right" and "left" for the opposite sides of a clock will be readily granted.

During the construction of the clock it was useful to be able to apply the brake to any particular Motor at will. This necessitated a slightly different method of linking the Motors on the two sides. Fig. 2 shows the arrangement adopted for three Motors driving in the reverse direction. The Motors are connected together by Chains and Sprockets, the back Motors in pairs and the side Motors in sets of three, and finally each set of Motors drives through a 2″ Sprocket and a $\frac{3}{4}''$ Sprocket on to the main shaft. The gearing from this shaft to the escapement and hands will be described next month.

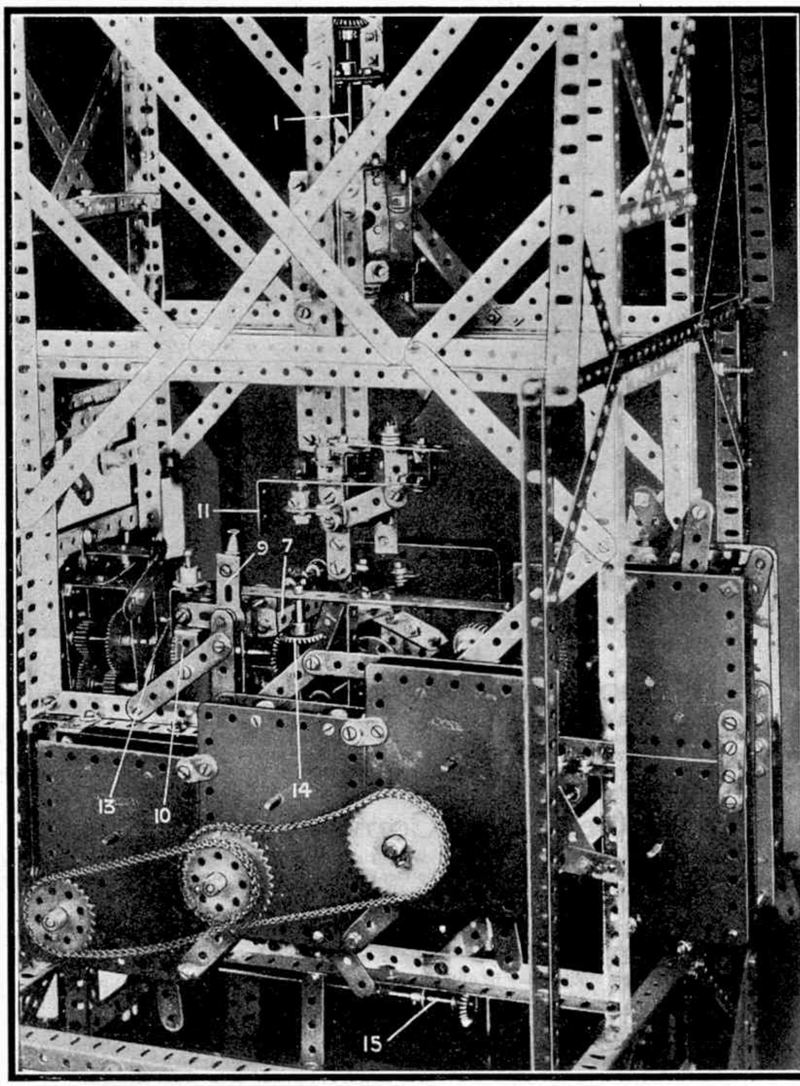

Fig. 2. The mechanism from the "3 o'clock side," showing some of the driving Motors and the lower end of the pendulum.

Gearing Between the Hands

The minute hand of the clock is a 2″ Strip bolted to the end of a Crank. The 12 to 1 reduction between the minute and hour hands is effected by means of four gears, namely, three 2 to 1 gears ($\frac{3}{4}''$ Pinions and 50-teeth Gears) and one 3 to 2 (1″ Gear and 57-teeth Gear). The final wheel of the series is the 57-teeth Gear, which revolves loosely on the axle of the minute hand, and the hour hand is a 2″ Strip bolted to one of its holes, so that, as in an ordinary clock, the two hands revolve on a common axle. The train of gears connecting the hands is shown on the left in Fig. 2.

Out of sight behind the face there is a counterpoise (13 in Fig. 2) for the minute hand. As shown in Fig. 2 it has just passed the horizontal on its way down, and thus corresponds to the position of the minute hand as seen in Fig. 1, viz., just past the quarter on its way up.

The setting of the hands to the correct time is effected by means of a train of three Bevel Gears (14, Fig. 2) connected to the spindle of the minute hand, two facing each other and the third, with its axis in a horizontal plane, between the other two. The horizontal Bevel can be moved in or out of gear with the other two by means of a system of levers controlled by a key conveniently placed on the front of the clock under the face.

Of the vertical pair one is connected with the drive and the other with the hands, and therefore by depressing the key the hands are freed. *(To be continued).*

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Below we conclude the description of a remarkable working clock constructed from Meccano parts by Lt.-Col. B. Higham, I.M.S. The first part of the article, which appeared last month, was illustrated by a general view of the clock (Fig. 1) and a view of the mechanism from the "three o'clock side" (Fig. 2).

THE mainshaft is shown at 2 in Fig. 3. Bolted to its free end and seen in the foreground is the driving Sprocket of the three side Motors, and a little farther back is the Sprocket that receives the drive from the nearer of the two back pairs of Motors. The axle revolves clockwise, as viewed from this aspect, and its rotation is transmitted directly to the minute-hand of the clock through a Worm-and-Pinion gear 3. The axle 4 of the minute-hand can also be seen in this figure running along horizontally with the Pinion bolted to its left-hand end. With a Worm and ½" Pinion the Worm has to revolve 20 times* to effect one revolution of the Pinion. Since the Pinion is on the axle of the minute-hand, it must revolve once in every hour, and the main axle must therefore be made to rotate exactly 20 times* per hour for the clock to keep correct time. This speed is maintained by the pendulum through the agency of the escapement wheel, which is connected with the main axle through a train of three gears.

Fig. 4 is taken from the same side of the clock as Fig. 3, but the three side Motors have been removed to show the working of the parts behind them. The main axle 2 can be seen with the Sprocket of the missing Motors bolted to its free end.

Of the train of gears connecting the main axle to the escapement wheel, the first consists of a 57-teeth Gear engaging with a 38-teeth Gear, and the first subsidiary axle therefore rotates 30 times per hour. The next gear consists of a 50-teeth Gear Wheel 5 engaging with a 20-teeth Pinion, and the axle of this consequently rotates 75 times per hour. The last gear consists again of a 50-teeth Gear Wheel and a 20-teeth Pinion, so that the latter's axle, to which the escapement wheel is bolted, rotates 187½ times per hour. Only two of the four axles in the transmission, namely, the first and the last, go right across the clock from one side to the other. The other two go only half-way across, and are supported there by a piece of the framework not visible in the illustration. In this way a space is left in which the escapement wheel may revolve.

The difficulty of getting Gear Wheels and Pinions of these sizes to mesh with each other has been surmounted by journalling each axle in one of the end holes of a 1½" Strip that, in turn, is bolted through its centre hole. The proper setting of these Strips, so that the Gears shall engage nicely and without undue friction, is ascertained before tightening up their attaching bolts. This construction is shown in Fig. 4, where the 1½" Strips appear in a darker shade than the main frame member to which they are bolted.

The escapement wheel 6 is not circular but is a regular octagon, each side of which is one inch long. Each side is actually made of a 2" Strip, however, so the periphery of the octagon has eight projections, and in operation it acts as a cog-wheel with eight teeth. Each tooth has a ½"×½" Angle Bracket bolted to it and this gives the whole unit a resemblance to the paddle wheel of an old-fashioned steamboat. Three of its teeth can be seen above the main side member of the frame and two below, the other two teeth being hidden from view. It is driven through the train of gears in an anti-clockwise direction when observed as in Fig. 4. In the actual position of the mechanism depicted in the illustration, however, its rotation is prevented by a catch 7, which can be seen on the right-hand side of the wheel engaging with the outer edge of the tooth that is placed horizontally.

The mechanism of the escapement may now be described. The catch 7 is connected with the axle 8 (Fig. 3), and to the other end of this axle is attached a kind of trigger 9 composed of the vertical arm of a Boss Bell Crank. The trigger is surmounted by a Buffer that has one edge filed away, as may be seen in Fig. 2 (in last month's "*M.M.*"). A glance at the horizontal arm of the Crank in this view will show that the trigger is free to move to a limited extent in a clockwise direction, but is altogether prevented from rotating in the opposite direction by the Angle Bracket 10, upon which it is shown resting.

Attached to the lower end of the pendulum on this side there is a lever 11 (Fig. 2), the free end of which is bent downward at a right-angle, the other end being attached to the pendulum by a Hinge. The height of this lever is so arranged that when the pendulum swings towards the left the bottom edge of the lever just rides over the rounded top of the Buffer on the trigger, but when the pendulum swings back again the lever engages with the flat cut side of the Buffer and draws the trigger over with it towards the right. As the trigger rotates about its pivot the elevation of the buffer decreases, of course, and this downward movement soon frees it from the lever. When released the trigger falls back on its stop, the pendulum continuing on its course unfettered.

The movement of the trigger has involved corresponding movements in the catch on the escapement wheel, both of them being secured to the same axle. The first movement of the catch has liberated the escapement wheel

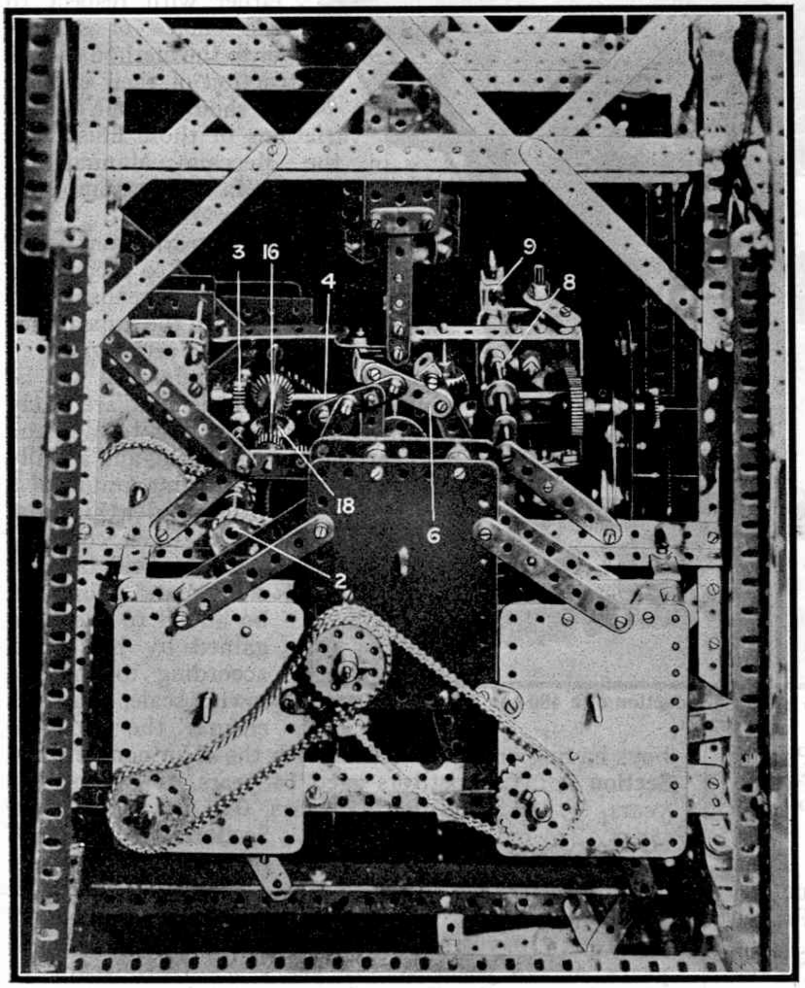

Fig. 3. The mechanism from the "9 o'clock side," showing the driving spindles of the three side Motors linked together by Sprocket gear.

*Since Lt.-Col. Higham built the model the design of the Meccano ½" Pinion has been altered and it now comprises only 19 teeth. Therefore, if the old style Pinions are not available when building the clock, it will be necessary to alter the gearing, or alternatively to adjust the pendulum so that it will beat more rapidly. In any case it will no longer be possible to take the drive for the seconds hand from the first subsidiary axle of the escapement gear train.

which, the moment it is released, starts off in an anti-clockwise direction (as seen in Fig. 4) and in its course strikes against the short tongue 12 that is seen in this view projecting downward from the bottom of the pendulum.

This impact of the escapement wheel upon the tongue gives the pendulum an impulse in the direction of its movement at the time (to the left). Directly it has given its impulse to the pendulum, any further movement of the escapement wheel is prevented by the engagement of its next on-coming tooth with the catch which, together with the trigger mechanism, has meanwhile fallen back into its original situation. Therefore the escapement wheel, after its one jump forward, remains at rest again until the pendulum, in its swinging, once more engages with the trigger.

The same series of events is then repeated for as long as there remains sufficient power in the clockwork, the escapement wheel being permitted to rotate through one-eighth of its circumference at each complete swing of the pendulum which, in turn, is kept in motion by the impulses that it receives. There are thus eight swings of the pendulum for each revolution of the escapement wheel.

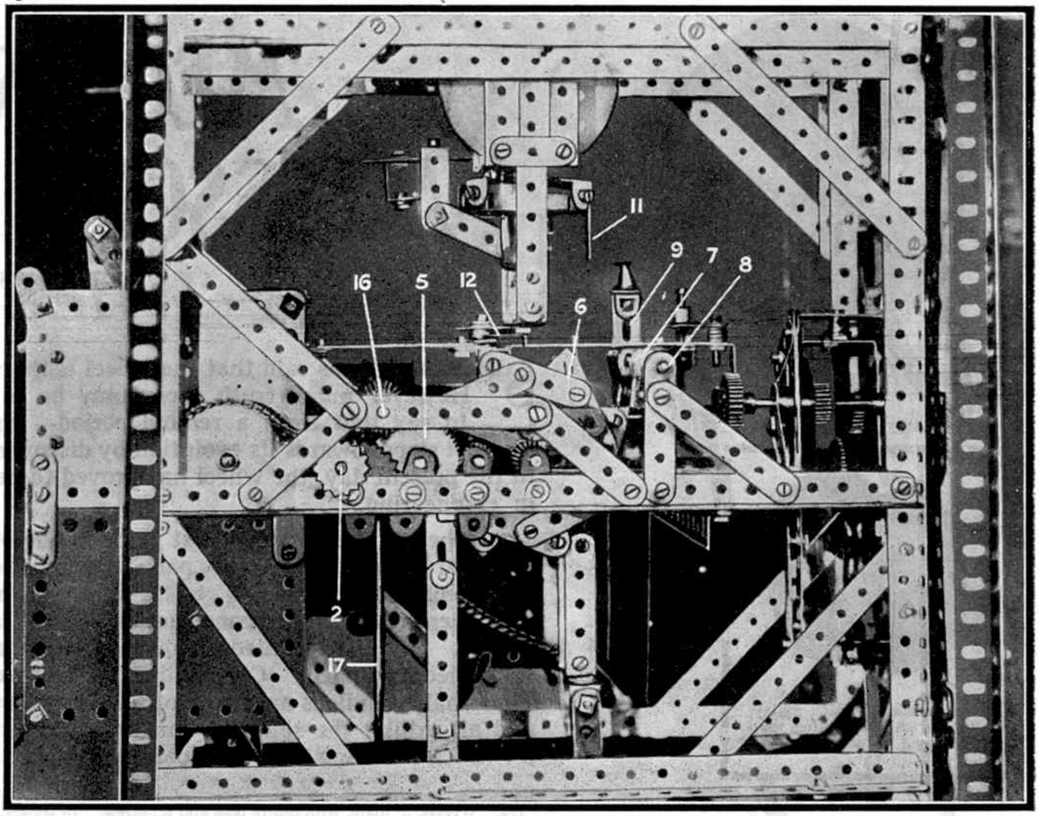

Fig. 4. View of the " 9 o'clock side " of the mechanism with the three side Motors removed.

When describing the train of gears it was explained that for the minute-hand to revolve once per hour the escapement wheel should revolve 187½ times in that time. The pendulum therefore must swing 8 × 187½, or 1,500 times per hour, or 25 times every minute, and its length had to be adjusted accordingly. If the pendulum had been of the ordinary type with the details of the escapement at the top, it would have been an easy matter to obtain the right length by timing its swings and either lengthening or shortening it as required. In this pendulum, however, the lowest point is the tongue 12, and that cannot be either raised or lowered, because if it were lowered it would foul the escapement wheel and if raised it would not receive properly its periodic impulses. Hence this pendulum can only be lengthened or shortened from its top end, and to do this the superstructure of the clock has to be opened up and remade each time. This method of construction was adopted deliberately and in spite of this defect, which is comparatively a minor one since it was only felt during the actual process of construction.

In some of the earlier designs the tongue was in fact put higher up and the pendulum extended below it, but it was soon realised that the higher the tongue was the wider the pendulum had to swing for the escapement wheel to clear it. Wider swings need more power, and apart from this the periodic time of a pendulum is, strictly speaking, only constant for relatively short swings. In all the later models, therefore, the tongue was put at the lowest point and the excursions of the pendulum were thus kept as short as possible. After considerable experiment the correct length was found for the pendulum—correct, that is, in the sense that when fitted it caused the clock to run " slow," and when it was diminished by one hole the clock gained. Beyond this point the precise adjustment was made by means of the cage of brass paper-weights to which reference has already been made. Raising or lowering the cage is equivalent to shortening or lengthening the pendulum, and as this movement is controlled by the turning of a screw, it is an easy matter to get the right adjustment and to modify it at any time.

Before proceeding to this last operation, the position of the tongue relative to the escapement wheel was adjusted to a nicety by means of the slotted joint in the shaft of the pendulum already mentioned. Other facilities for accurate adjustment are provided at two points in the escapement, namely (1) in the catch that holds the escapement wheel, and (2) in the lever that works the trigger. Each of these is important and must be made exactly right. If the former does not hold the escapement wheel properly at every tooth but occasionally allows two teeth to slip by, or if the lever does not pull the trigger and release the catch at every single swing of the pendulum, the clock will go 2⅗ seconds fast or slow, as the case may be, at each such occurrence. If this happens only once in a hundred swings an error of a quarter of an hour per day will result!

In addition to this up-and-down adjustment the lever requires also adjustment sideways, for upon its position in that direction depends the timing of the impulses. If these are given to the pendulum either too early or too late in its swing, their full effect will not be operative and the clock will not go for its full course at each winding.

Now that the mechanism of the escapement has been explained it will be understood why a rigid construction was required in the pendulum. The impulses are given at its middle point, but the trigger mechanism is to one side. If the pendulum were not rigid the twisting produced by repeated pulls on the trigger would impart a wriggling motion to the pendulum that would be very unsightly and also would interfere with its efficiency.

The second-hand is a Coupling with a 2" Rod passed through it so as to leave unequal ends. The shorter end has a collar bolted to it so that the hand as a whole is balanced accurately. This hand revolves on a dial of its own, placed beneath the ordinary face of the clock. Its axle 15 can be seen in Fig. 2 lying parallel to and just below the bottom mainframe member. A Bevel Gear attached to the end of the axle is driven through a vertical shaft 17 (Fig. 4) from an axle 16 on the top of the machine. This latter axle has a 25-teeth Pinion that engages with the 50-teeth Gear Wheel 5 of the train of gears between the main axle and the escapement and drives the shaft 17 through the Bevels 18 (Fig. 3). The axle of Gear 5, it will be remembered, revolves 30 times per hour, and the axle of the second-hand therefore revolves 60 times per hour, or once every minute, which is of course its proper speed. At each swing of the pendulum the seconds hand advances 2⅖ seconds in one bound.

On completion the clock was exhibited by Favre-Leuba & Co. Limited, the well-known Bombay watch and clock manufacturers, and was kept under their constant observation for six weeks. During that period it was found to make an average variation of only 1 to 1½ minutes per day.

The clock has since been in almost constant operation for six months and has kept reasonably accurate time throughout, which shows that it is of satisfactory design. Nevertheless, changes have suggested themselves, the most important of these being the substitution of weights in place of the Clockwork Motors and a modification to the pendulum in order that a " one second beat " may be obtained. No doubt these alterations will lead to greater accuracy.