barrels, etc., and when worked up by me made a really beautiful movement, much admired by both professional and amateurs. Mr. Oppermann cut the teeth, and I used for the pinions those excellent German pinions which had just then been put on the market. After 40 years wear it is still in excellent condition.

These old workmen did not cut the teeth; the wheels were simply slotted with a small circular saw and the tooth rounded up with a special file still in use if, as sometimes happens, new teeth have to be inserted; pinions were made from pinion wire or from those rough pinions with the pinion heads simply slotted and requiring working on with spacing file and rounding up file; I have, and still use, some of these obtained from an old country clockmaker. Depth tools were not used, but depths found by compass (see HOROLOGICAL JOURNAL for May, 1884), "it being a very rare occurrence for a mistake to happen."

The local cabinetmaker would make a good plain case, and I should think there would be no great difficulty in getting the dial painted in the neighbourhood; I know a very good paperhanger and painter not 100 miles from here who could do it, and do it well too, if required.

So it seems to me that if a man had the tools and small lathe and divided head required for repairs, he could also make a clock whenever requested to do so by those requiring such a thing, and, of course, it was possible to get in touch with London or other large towns if necessary for something special. The letters of Thomas Mudge show that though living at Plymouth, he still was in touch with his late partner, Mr. Dutton, and so was enabled to proceed with his work on marine timekeepers, blue and green. Things took longer then, that's all.

F. M. MANN.

Blackgang, Isle of Wight.

P.S.—*Perhaps I ought to say that the similarity observed in these old clocks is due to the castings being supplied from one or two foundries only.*

International Jewellers' Congress.

With reference to the International Jewellers' Congress which will take place in London on May 20th, 21st, and 22nd, it is announced that the evening reception which the Prime Warden and Wardens of the Worshipful Company of Goldsmiths are kindly giving on May 21 will be definitely at 9 p.m. As it is essential that the number attending be known at least three weeks beforehand, members of the trade who wish to be present are asked to forward their names immediately to:—

The Organising Secretary,
The National Committee of the Jewellery and Allied Trades for Great Britain,
97, Cannon Street, E.C. 4.

MY EXPERIENCES WITH ELECTRIC CLOCKS AND SYNCHRONISERS

A LECTURE DELIVERED AT THE BRITISH HOROLOGICAL INSTITUTE ON FEBRUARY 12, 1930, BY MR. ALFRED E. BALL, F.B.H.I.

My experiences with electric clocks commenced while I was apprenticed to watch and clockmaking, when I made my first electric impulse clock. As my apprenticeship was completed in 1888, it may be safely assumed that it was made about 44 years ago.

It is a small affair with 6-inch dial, so I have brought it with me to show you. It has been kept going practically continuously, operated in turn by several types of master clocks, so the amount of wear will be of interest. I also made an almost similar but larger impulse clock in 1888, which has also been in practically continuous service.

These clocks were first operated from experimental contacts of various designs fitted to mechanical clocks, and from these early experiences I acquired a wealth of knowledge of the requirements of electrical contacts for this purpose, and which has served me in after years.

The earliest documentary evidence of my interest in the subject was in 1898, when my name appeared in conjunction with that of my friend, Mr. Harry Whidbourne, in patent No. 15509 of July 15th of that year. This patent was for a master clock, and revealed means for closing a circuit precisely and definitely at every half-minute, and of making a reliable contact without disturbing or taking power directly from the wheel train.

According to our patent, a pair of springs were closed at every 30th second by a seconds pendulum, when a lever oscillating therewith finds a pin in the scape wheel in its path. The spring driving the clock train was rewound every half-minute by the current flowing through the impulse circuit, but the duration of the contact was then, however, one full second.

Subsequently we devised means for breaking the circuit the instant that the rewinding operation was complete. A patent for this improvement was applied for on April 25th, 1903, and numbered 9359.

The clock as then made was in many respects an advance on the existing practice. It made contact precisely at every 30th second, it had one contact only, the duration of the contact was controlled by the self-induction of the circuit, and it would not stop on contact.

With a master clock possessing these advantages we felt justified in endeavouring to interest some firm in same with a view of exploiting it. This was in 1903, it must be remembered. One electrical firm stated that electric clocks never were and never could be a success. Another stated that the master clock we submitted operated satisfactorily, but the duration of its contact was too short—evidently not appreciating that the design of the clock was such that duration was controlled by the self-induction of the circuit.

Yet another large electrical firm turned down our invention with the statement that in their opinion no money could be made out of electric clocks.

Manufacturers of to-day would probably say that there is some truth in the statement of 27 years ago.

Towards the end of 1903 I was attracted by the possibilities of maintaining a pendulum in vibration by means of gravity impulses given direct to it at half-minute intervals, somewhat after the manner of the spring impulse revealed in patent No. 8830 (1893), which I had come across in a periodical of that time. Grave doubts arose, however, regarding the timekeeping properties of a clock whose pendulum was impulsed so infrequently. The pendulums of best timekeepers at that period were impulsed every second, and it appeared to be a daring thing to impulse it at half-minute intervals. It is interesting to note, however, that an engineer and co-patentee—Mr. W. S. Hubbard—has since proved that academic timekeeping can be obtained from a pendulum impulsed only at such infrequent intervals as seven minutes.

Early in 1904 I completed a master clock in which a gravity lever impulsed the pendulum at half-minute intervals by means of an arm of same depending from it and operating on the pendulum at one side. This arrangement had the advantage of simplicity, but the impulse was given with an objectional shock to the pendulum.

Cushioning with a spring did not prove satisfactory. My experience as a clockmaker suggested to my mind the application of the impulse, as in the Graham escapement, substituting a roller for the (acting) tooth of the scape wheel and providing the pendulum with a pallet shaped as the exit or down pallet of the Graham anchor. In carrying out the idea, impulses only at half-minute intervals were obtained by supporting the gravity lever carrying the roller on to a catch, so that normally the dead face of the impulse pallet swinging with the pendulum just cleared the roller, the latter, on being released, running down the inclined face of the pallet, thus giving the impulse.

This arrangement proved eminently satisfactory, and on being suitably tried out became the subject of a patent jointly in the names of Mr. Hardy Parsons (of Gent & Co., Ltd.) and myself, its date being November 14th, 1904, and its number 24620.

This 1904 patent became a landmark in the history of modern electric clocks, inasmuch as it was the first to contain the essentials of the modern electric master clock and gave the lead in master clock construction. It has since been adopted by several manufacturers.

FIGURE 1 illustrates the movement of the master clock which I commenced late in 1903 and completed early in 1904. It will be seen that the gravity lever is pivoted at a position coincident with the bending point of the suspension spring and has a depending arm disposed at the side of the pendulum. The position chosen for the pivot results in the minimum amount of friction at the point of contact with the pendulum rod. I have this movement here on view. The scape wheel is propelled in steps and the half-minute release of the gravity lever is effected by two pins in the scape wheel, and the gravity lever is replaced electro-magnetically.

In the event of the current flowing being insufficient to lift the gravity lever, the pendulum in its return swing finds the depending arm in its path and assists the magnet. This results in the replacement being delayed, and produces a longer duration of contact which may be utilised to operate any form of weak battery warning device such as a bell.

FIGURE 2 shows Parsons and Ball's patent master clock of 1904, first known as Gents' B.P., but long since known by the trade name of "PUL-SYN-ETIC." This master clock made history, inasmuch that it was the first to employ the roller and inclined plane method of impulsing the pendulum from gravity at

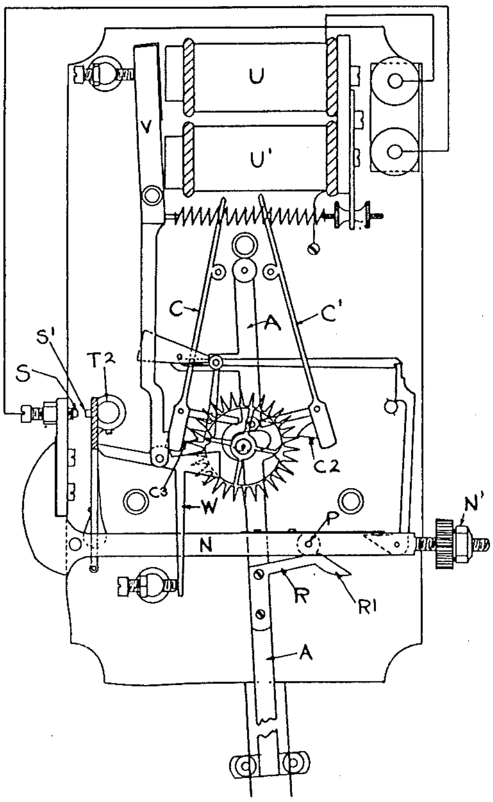


FIG. 2. *Gents' Original Master Clock, 1904. The first to employ Roller and inclined Plane direct to Pendulum together with Gravity Lever replacement through Contact Surfaces. Described in "Horological Journal" in 1906, February issue, pages 84-85.*

half-minute intervals and the first to combine the roller and inclined plane impulse with the replacement of the gravity lever through the surfaces of the contacts. Inherent with this form of master clock comes the advantage that timely battery warning is automatically given, and if disregarded the master clock does not stop on contact. Even more important is the inherent advantage that the duration of contact is automatically controlled by the self-induction of the circuit, thus assuring all impulse clocks in circuit operate at every impulse. The impulse clocks are always set to operate at a lower current value than the master clock, with the result that no matter how quickly or slowly the gravity lever is lifted the current value must rise to the value required to operate the impulse clocks before the circuit is broken by the master clock contacts.

It may be here mentioned that one inventor only can be traced who employed a gravity impulse to the pendulum by means of a roller, incidentally combined with a poor form of contact, but the invention was not described in the English language. A description of it was printed in German (at Leipzig) in 1902, but was not available in this country until 1906.

It must also be stated that the first inventors to point out the advantages of that type of contact which passed all the energy necessary to operate the clock were Messrs. F. Hope Jones and G. B. Bowell, and these advantages were described in their early literature.

FIGURE 3 shows an oscillograph record of a "PUL-SYN-ETIC" master clock. The depression seen indicates where the impulse clocks operated, because their moving armatures sent a back E.M.F. through the circuit, and the current has to again rise before it reaches the value at which the gravity lever is lifted and the contacts separated. The impulse clocks are set to operate at 0.12 amp. and the master clock at 0.17 amp. With a normal battery the action of making and completing a contact as shown in the diagram all takes place in a fraction of a second, and the total time shown in the diagram is 1/20th of a second.

FIGURE 4 shows diagrammatically another form of the master clock made under Parsons & Ball's patent of 1904. The form just previously shown in Fig. 2 was provided with the scape or count wheel disposed in the centre of the movement, where it would operate a central seconds hand. This was found to be a disadvantage from a manufacturing point of view. Also after marketing electric clock systems for a year or two, it was soon found that electric clocks appealed to electrical engineers rather than to clockmakers, and the central seconds hand, so dear to the hearts of clockmakers, did not appeal to the electrical engineering profession. The construction was, therefore, simplified and the scape wheel planted on one side, and this enabled the pendulum to be in front of the gravity lever and, therefore, ready placed in position. The modified construction resulted in the movement being more robust and better for being handled by people who have not had a clockmaker's training.

The operation is as follows :—

The pendulum H in vibrating carries with it the driving pawl D, which propels the wheel E tooth by tooth. On the driving pawl engaging the tooth E1 (cut deeper

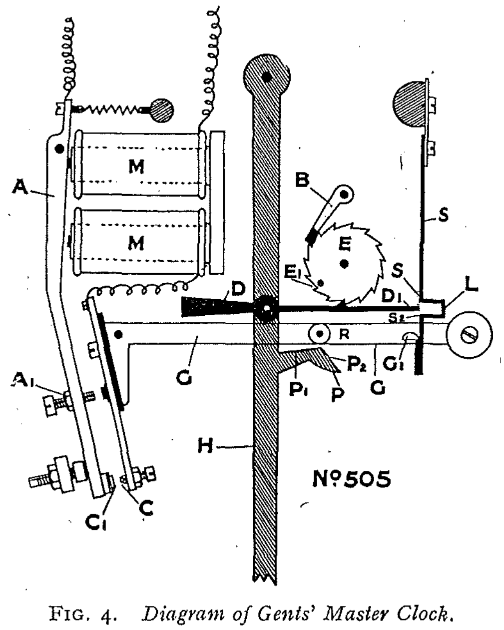


FIG. 4. *Diagram of Gents' Master Clock.*

than the rest), its end D1 no longer passes clear through the stirrup, but rises and charges into it at point S, pushing it to the right clear of catch G1. The gravity lever G is then released and its roller R drops on to the dead face of the impulse pallet P, and then on running down the inclined face P2 gives the required impulse to the pendulum. This impulse is terminated on the contact C meeting C1. The current then flows through the circuit, the electro-magnet MM is energised, the armature A attracted and the gravity lever G is replaced on to its catch G1, the energy being transmitted through the surfaces of the contacts, thus ensuring the necessary pressure and rubbing action to ensure a reliable contact.

While the gravity lever is being replaced, all impulse clocks in the circuit are operated by the flowing current. The movement of the armature is finally arrested by the contact breaking screw A, but the Contact C continues to move with the gravity lever, thus breaking the circuit and allowing the armature A to return to its normal position as shown. While I have used rather many words to describe its working, the action is quickly grasped on seeing it in operation.

FIGURE 5.—This illustration shows the movement as made in quantities. The parts are all fixed to a rigid cast-iron base with that portion supporting the pendulum made separate from that supporting the mechanism, so that the former may be bolted to the wall and the movement removed without disturbing the rigid fixing. A further advantage is that the construction conduces to quiet working.

The driving pawl and impulse pallet are attached to a light aluminium crutch and all adjustments, therefore, fixed so that the erector has nothing to do but hang on the pendulum.

In the design we have aimed at a construction which will give continuous service in the hands of people who are not necessarily skilled mechanics.

I have thought it an advantage to educate the custodian of the clock system to understand the working of the master clock. This is, however, not altogether necessary, as proved by the fact that one of our "PUL-SYN-ETIC" clock systems is being maintained by a man who believes the pendulum is kept in vibration by the aluminiun crutch being attracted by the electro-magnet, and will not be convinced of anything else. "You cannot tell me," he says—" I have watched it too often, and you can see it working !"

This is by no means an isolated case. We have systems satisfactorily maintained by caretakers with no technical knowledge. These men simply do what they are told, and all is well with the system. One such caretaker I recently met did not know an accumulator from a Leclanche cell, and another could neither read nor write and was very deaf. The worst clock custodian is the man who thinks he knows more than the makers. A few such have even endeavoured to adjust the master clock so that the pendulum with its inclined plane on its return swing after the impulse replaces the gravity lever on to its catch without the help of the electro-magnet ! Perpetual motion, I suppose, was the objective !

(*To be continued.*)

*** Figs. 1, 3 and 5 will appear in our next issue.

MY EXPERIENCES WITH ELECTRIC CLOCKS AND SYNCHRONISERS

A LECTURE DELIVERED AT THE BRITISH HOROLOGICAL INSTITUTE ON FEBRUARY 12, 1930, BY MR. ALFRED E. BALL, F.B.H.I.

(*Continued from page 178.*)

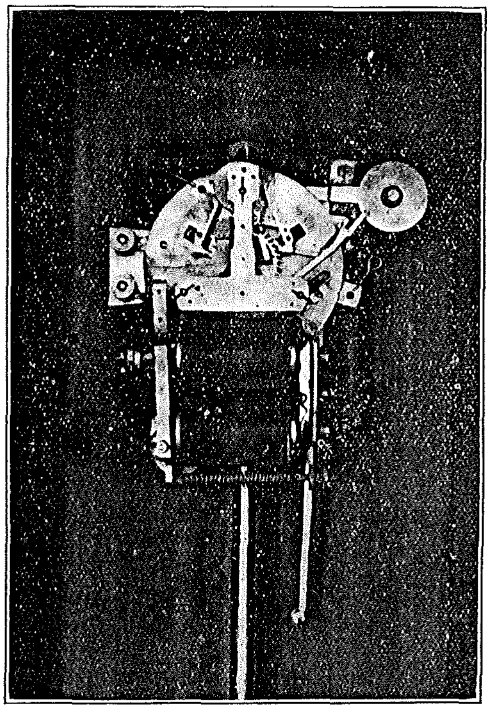


FIG. 1. *Early Master Clock by the Lecturer with ½ minute gravity impulse to pendulum and replacement through contact surfaces. 1903-1904.*

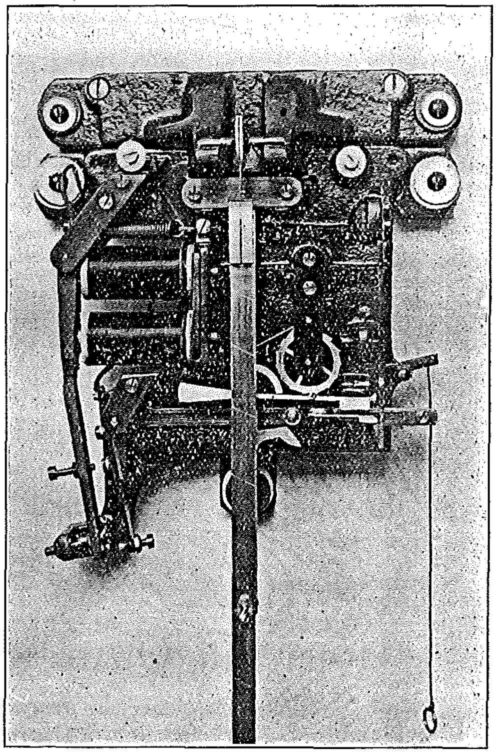


FIG. 5. *Standard Pul-syn-etic Master Clock Movement with separate solid support for pendulum.*

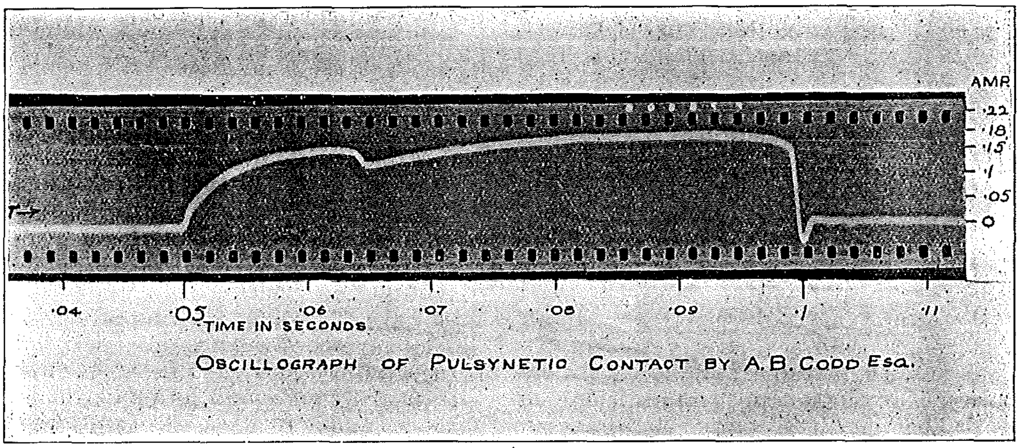


FIG. 3. *Oscillograph produced by contact of standard Pul-syn-etic Master Clock.*

One of the worst examples was the man (a clockmaker, I mention with sorrow) who "knew all about it." "I'm a clockmaker, you know," he said. He would not read any instructions—he was above it—and he told his client that so long as the warning bell rang, all was well. He had *not* read the inscription on the door of the instrument—he was above it! I could multiply such experiences, but time forbids.

The contribution to the science of electric clock-making by Von Geist, of Würzburg, is shown at Fig. 6. Details of this device were first published in this country in 1906,

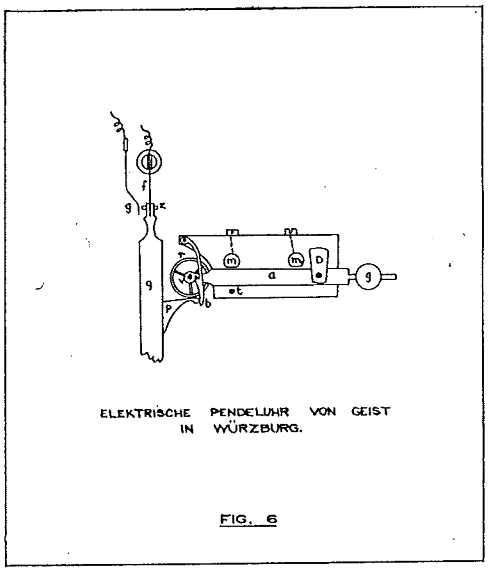


Fig. 6.

and a short account of same was given in the September, 1906, issue of the British Horoligical Journal.

In this figure the pendulum q, while swinging to the right, pushes the catch b clear of the pin shown above, and releases the gravity lever (which consists of the armature a), and on the return swing of the pendulum, the wheel or roller r—attached pivotally at v to the armature—runs down the incline formed by the rounded end of the pallet p, meanwhile giving the pendulum an impulse to the left. On the completion of the impulse, the pin z contacts with the spring g, the magnet mm.l. is energised and the armature is restored to its potential position, only, however, to be again released on the return swing of the pendulum, when the above-described actions are repeated.

It is, of course, now understood that the type of contact shown has been exploited and found wanting, and that it is bad practice to employ an armature as a gravity lever because of the varying effect of residual magnetism.

Figure 7 * shows a "pul-syn-etic" time transmitter of special construction known as the Simpson pattern. In this pattern (Parsons & Ball's Patent No. 160204), instead of the energy required to release the gravity lever being taken from the pendulum, it is provided electromagnetically, and is stored at the previous ½ minute impulse. This arrangement has the advantage of freeing the pendulum of this work, and consequently removing an escapement error. Also, in this pattern, frictional errors are reduced by jewelling the impulse roller count or scape wheel and pallets. The moving parts are made specially light, and these improvements result in a steady rate.

Figure 8 shows the well-known "pul-syn-etic warning bell which in conjunction

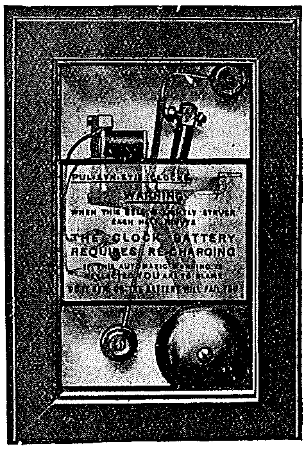


Fig. 8. *Warning Bell.*

with any "pul-syn-etic" time transmitter gives timely warning of an impending failure of the battery or indicates an insufficiency of current.

The combined action is best described with reference to Figure 4 (illustrated in the May issue of the Journal) as follows :—

When—due to a weakened current—the armature A is unable to lift the gravity lever G, the pallet P.2 of the pendulum on returning to the right and finding the roller R in its path renders mechanical assistance by

* Fig. 7 will appear in our next issue.

raising the roller and enabling the armature to complete its work. Meanwhile a contact of a full second's duration is made instead of the normal duration of approx. 1/20th second and the longer duration enables the inertia of the balanced hammer of the warning bell to be overcome and its gong is struck.

The contact of a full second's duration can also be recognised at each impulse clock in the circuit by a really observant person, but a warning bell provides a definite warning, and is a necessity with non-technical custodians.

Impulse Movements.—Figure 9 shows diagrammatically at A the movement of the impulse clock I made 44 years ago. It also shows that the position then chosen for the driving pawl to engage the wheel is practically that chosen to-day, the only difference being while in the old clock, the return of the armature pulled the ratchet wheel, with present practice we push the wheel as at B.

Fragmental drawing C shows a bad position.

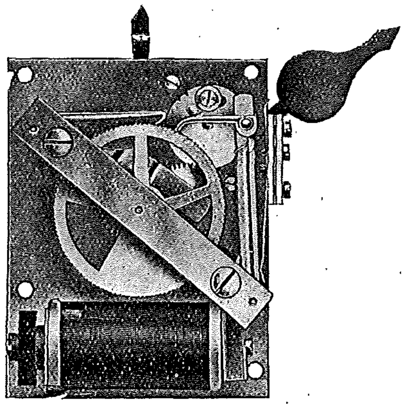


Fig. 11.

Figure 11 is a photographic illustration of the modern "PUL-SYN-ETIC" impulse movement as manufactured by my firm in quantities.

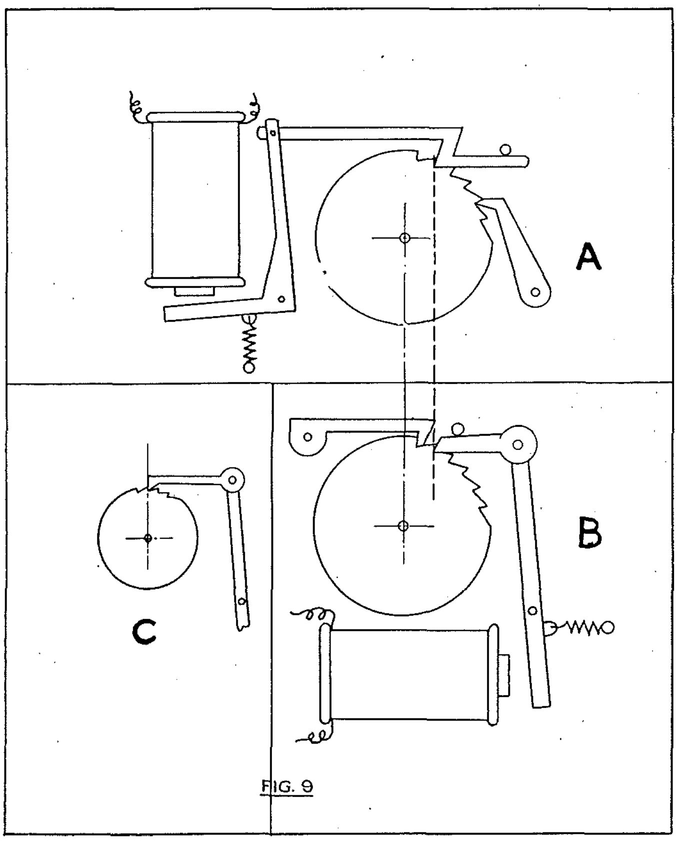


Fig. 9.

(To be continued.)

MY EXPERIENCES WITH ELECTRIC CLOCKS AND SYNCHRONISERS

A LECTURE DELIVERED AT THE BRITISH HOROLOGICAL INSTITUTE ON FEBRUARY 12, 1930, BY MR. ALFRED E. BALL, F.B.H.I.

(*Continued from page* 196.)

FIGURE 12 shows a type of movement which is absolutely inaudible in operation. The only drawback is its high cost of manufacture, which prevents its more general use for positions where inaudibility is desirable.

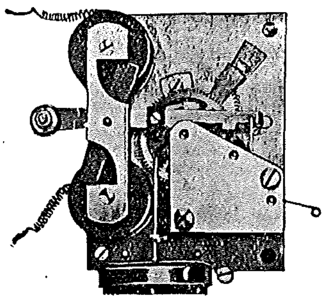


FIG. 12. *Inaudible movement.*

Inaudibility is obtained by the elimination of armature stops, and all side shakes in pivot holes by keeping all tensions in one direction and by slowing the return of the armature and driving pawl by a bellows, the operation of which is similar to a dash pot with the difference that it has no tendency to stick as has the dash pot. The leather for the bellows has to be carefully selected, but the right kind is very durable. One early example has been in continuous operation for the past 16 years with no signs of cracking or stiffening.

The movement shown in FIGURE 13 is known as the silent triangle movement. It takes its name from the triangular space enclosed by the stop rods between which the driving pawl works. To obtain silent working in this pattern, the driving parts are made light and " mass " is eliminated, so as to avoid concussion which would produce noise. Stops are provided, but these consist of light rods of phosphor bronze and are touched only by a light pawl.

This movement is surprisingly noiseless in operation and therefore, suitable for bedrooms, quiet libraries or sitting-rooms, etc. The slight sound made at the impulse has to be carefully listened for to be heard at all. This is not costly to manufacture. I have brought samples of these impulse movements.

It will be appreciated that there is no point in using these light running movements for workshops or noisy positions where the standard and cheaper type should be employed and which incidentally is reasonably quiet in operation.

" W " TYPE IMPULSE MOVEMENTS.—These comprise a larger and much heavier range of movements for driving the heavier hands of turret clocks up to about 12 feet diameter.

A more satisfactory mechanism for large clocks, particularly when the hands are exposed to the elements, is the " waiting-train " movement. After being actively engaged in the electric clock business for a few years, I appreciated that the impulse movement had its limitations in so far as large clocks with hands exposed to the elements were concerned.

One day during a long railway journey, while pondering on the matter, I evolved the general principle of the mechanism now known as the " waiting-train " for driving large clocks. I communicated the principle to my co-patentee, Mr. Hardy Parsons, and between us we produced the mechanism which is known practically the world over.

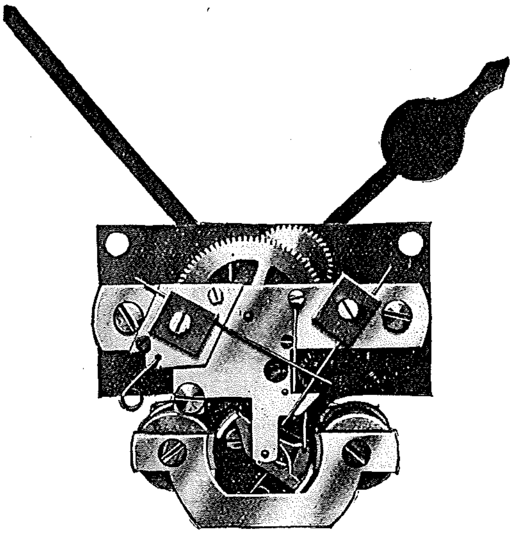


FIG. 13. *Silent Triangle movement.*

We patented it in 1907 and when in 1913 the engineers of the Royal Liver Friendly Society were locking for a type of electric mechanism suitable for driving the hands of the large clock with 4-25 feet dials, which they desired to instal in the towers of their new chief offices, we were in a position to offer them our already well tried out " waiting-train " movement, and it was my pleasure to demonstrate its operation to the engineers.

In designing the " waiting-train " movement we at once recognised that the method employed by Hipp for small clocks would be ideal for our purpose if driven through worm gear so as to be self-locking, but the problem to be overcome was to devise a method of combining such an arrangement with the periodic half-minute impulse of our clock circuit. This was eventually accomplished by means of a masking-pawl which operates in an exceedingly simple manner. It is lifted 3 seconds in advance of every half minute by a pin in the scape wheel and in turn the masking-pawl lifts the driving pawl out of action when the pendulum oscillates idly (for about 3 seconds) until the next half-minute impulse, when the masking-pawl is dropped and the driving pawl drives the hands through the scape wheel and worm gearing as before.

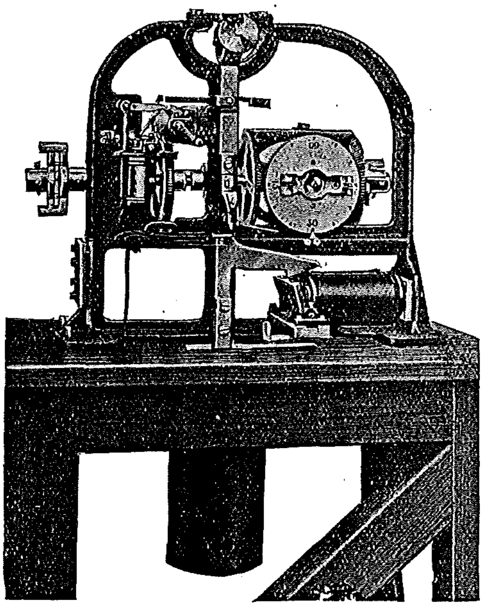


FIG. 14. *Waiting Train Movement.*

The pendulum is termed the motor pendulum and, as will be seen, its function is not to keep the time of the movement, but to drive the hands, time being kept by the half-minute control operated by the master clock.

The motor pendulum is energised by an electro-magnet as often as its oscillation falls below a certain amplitude by means of a " toggle " contact. Under normal working conditions re-energisation takes place about every three-quarter minute, but on heavy work being thrown on the movement due to resistance set up by wind pressure or the weight of snow on the hands, the motor pendulum becomes energised more often, each vibration if necessary, when it develops 30 times or more its normal power, when it is impossible to stop the movement by hand, even when exerting one's full power on the worm wheel.

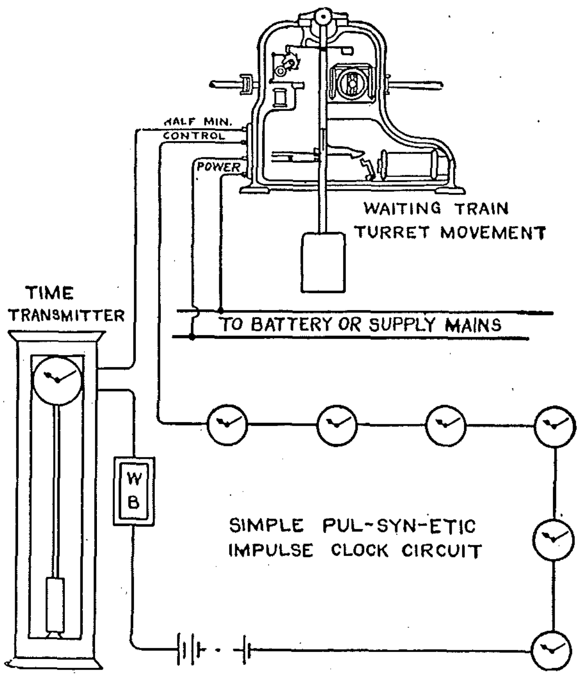


FIG. 15. *Waiting Train Connection.*

The movement on view—illustrated at FIGURE 14—is the C.40B size and is capable of driving the hands of 4-9 foot dials. It will lift a weight of 15 lbs. hung at a distance of one foot from the arbor of the centre wheel which represents power considerably above requirements. Incidentally on test before bringing it here it lifted 25 lbs.

The operation of turret clocks by " waiting-train " movement provides the ideal conditions required by clockmakers. It gives practically unlimited power for driving the

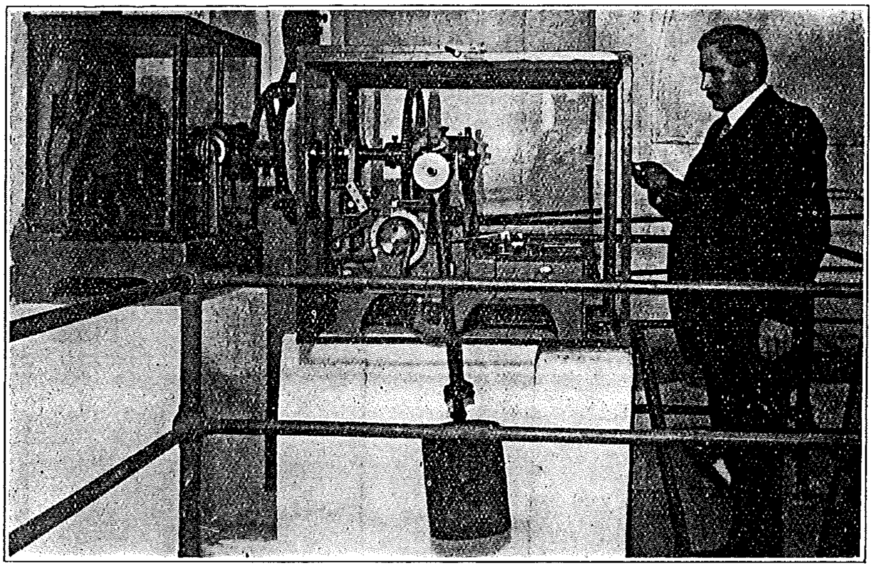


FIG. 16. *One of the 4 Waiting Train Movements of the Royal Liver Clock. The Lecturer (one of the inventors) checking.*

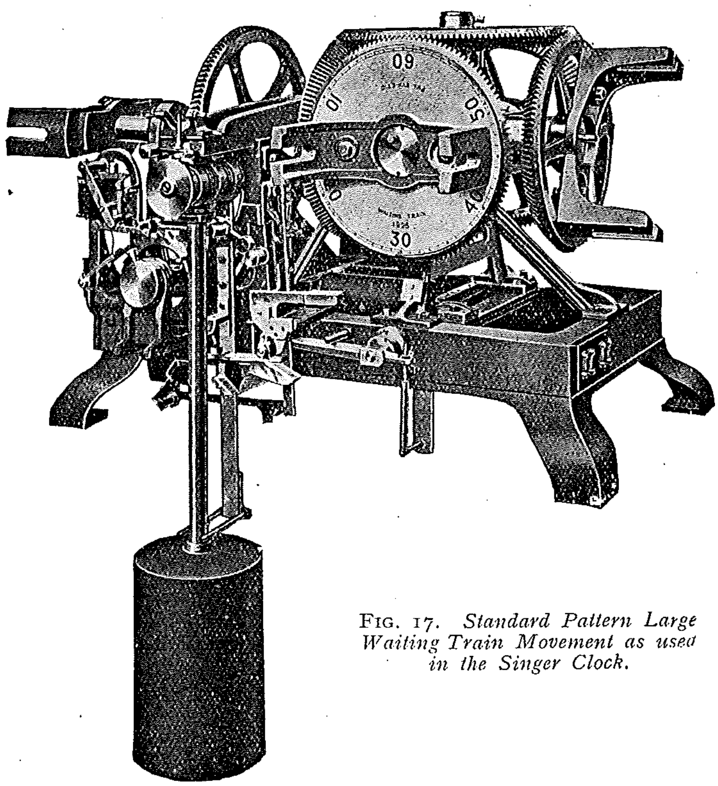


FIG. 17. *Standard Pattern Large Waiting Train Movement as used in the Singer Clock.*

exposed hands against atmospheric conditions on the one hand, and on the other hand provides the complete disassociation of the time-keeping mechanism from the hand-driving mechanism, thus leaving the time-keeping mechanism entirely free to perform its own particular function.

Perhaps what is more important, it permits the time-keeping mechanism (the master clock) to be fixed in the base of the tower where vibration is least. A position high up the tower is obviously not a good one for a time-keeping pendulum.

FIGURE 15 shows diagrammatically the and connecting rods would be quite impracticable for this distance so, therefore, as the East dial had to be driven from a separate movement, it was decided to employ four separate movements all alike. The question of uniform timekeeping presented no difficulty, all four being controlled from the same time transmitter or master clock, which is incidentally fixed in the Grand Marble Vestibule.

(A number of slides were here shown, illustrating the building of this large clock at Faraday Works, Leicester, and its erection at Liverpool.)

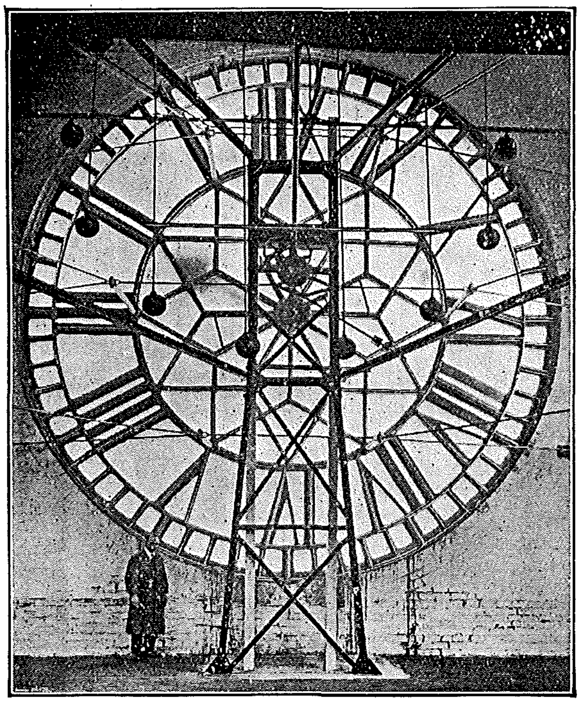


FIG. 18. *26 ft. dial.*

electrial connections of a "waiting-train" movement.

These "waiting-train" movements are made in a number of sizes for clocks having dials 3 feet in diameter and upwards.

FIGURE 16 shows one of the four "waiting-train" movements of the Royal Liver Clock at Liverpool. You will naturally ask, "Why four movements?" It must be explained that while three of the 25-feet dials are in the West tower, the fourth dial is in the East tower, at the other end of the building overlooking the city, and some 300 feet away.

The employment of the usual crown work

FIGURE 17 shows the movement of the large clock at the Singer Manufacturing Co.'s works at Clydebank, Glasgow. This movement is fitted with ball-bearings throughout, and is operated from a 42-volt accumulator. As the four dials are in the same tower, the four pairs of hands are driven from the movement through the large crown-work seen at the right of the movement.

To give some idea of the power of this movement :—

It will on actual test lift a weight of 200 lbs. at one foot from the centre of the minute hand spindle, which is well above the power needed to drive the hands against the wind resistance given during the strongest storm.

The four dials are each 26 feet in diameter, some 3½ feet larger than the four dials of the renowned "Big Ben" at Westminster.

FIGURE 18 gives an interior view of one of the dials, together with the iron structure supporting the motion work and lamps. Incidentally our foreman erector seen standing below gives a correct impression of the large size of the dials.

The "Singer" clock was originally a weight-driven mechanical clock, and on conversion to the electrical "waiting-train" the original dials and hands were again employed.

The advantages of the "waiting-train" movement is rapidly being recognised, and several railway companies in this country and abroad have adopted it for both new and old clocks. In the case of the latter, it is frequently only necessary to fit the "waiting-train" movement in place of the weight-driven movement, the complete motionwork, hands and dials being usable without alteration.

(*To be continued.*)

THE PROBLEM OF WATCH LUBRICATION AND ITS SOLUTION

A LECTURE DELIVERED AT THE BRITISH HOROLOGICAL INSTITUTE ON APRIL 9TH, 1930, BY MONSIEUR PAUL DITISHEIM.

(*Continued from page* 182.)

VISCOSITY.

In the case of perfect lubrication, the friction surfaces are always entirely separated from one another by a continuous layer of certain thickness, of a viscous lubricant adhering to the surfaces. The friction takes place within the mass of the lubricant itself, and in the midst of the fluid layer, at a distance from the surfaces which when reduced to the molecular scale is relatively great, and thus *the influence of the solid surfaces disappears altogether*. The resistance to motion, which may be very small, depends solely upon the internal friction or *viscosity* of the lubricant.

The fluid layer which is interposed between the friction surfaces, and upon which the movable piece may be said to *float*, should be maintained under a suitable pressure, either by auxiliary means or by the motion of the movable pieces themselves, which tend, when in motion, to force the lubricant between them, after the manner of a wedge.

SPREADING OF THE OIL.

Dr. Paul Woog showed the nature of the inequality between the fatty oils and the mineral oils, which is due to a difference in the activity of their molecules. Molecular physics furnished him with an

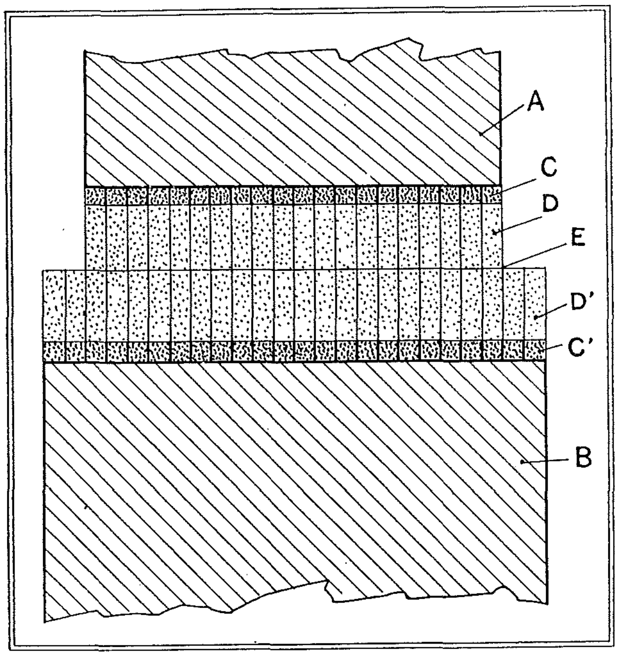


FIG. 3. *Diagram showing the active molecules of the "epilame" film which produces unctuous friction between the surfaces.*

MY EXPERIENCES WITH ELECTRIC CLOCKS AND SYNCHRONISERS

A LECTURE DELIVERED AT THE BRITISH HOROLOGICAL INSTITUTE ON FEBRUARY 12, 1930, BY MR. ALFRED E. BALL, F.B.H.I.

(*Continued from page* 211.)

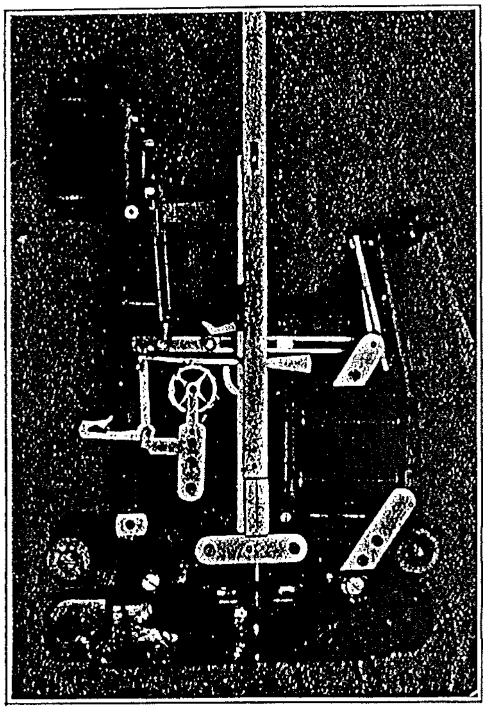


FIG. 7. *Special Pul-syn-etic Master Clock, Simpson pattern with free release.*
For description see page 195 June issue.

SYNCHRONISATION BY REFLEX CONTROL.

"Reflex" control provides a means for synchronising clocks (mechanical or electrical), which incidentally have been given a losing rate, the control being effected through their pendulums. The control periodically "flexes" a spring attached to the pendulum of the clock, and the "Reflex" action of this spring quickens one beat of the pendulum as often as it is found to be slow in that beat, thus keeping it up to time.

It was invented chiefly by my friend, Mr. S. Hubbard, an engineer by profession. He was looking for a satisfactory means for synchronising a slave clock from a free pendulum.

The subject of academic time-keeping was Mr. Hubbard's hobby. He had read the attempts of Bartrum and others and of their lack of success, but notwithstanding believed the free pendulum would solve the problem of perfect time-keeping. He completed his clocks, but subsequent changes of domicile and foreign travel after retirement prevented him from fully exploiting his free pendulum and slave clock.

In 1919 he invited me to inspect them in operation, and to see his "Reflex" synchroniser in action, and suggested that his

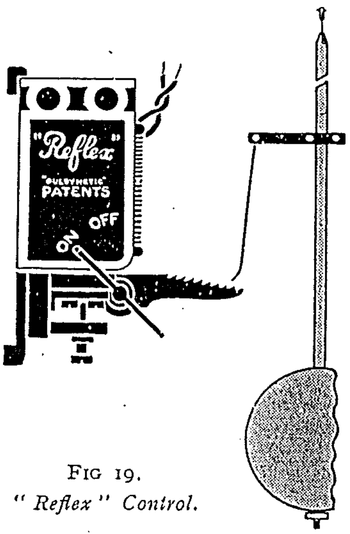


FIG 19.
"Reflex" Control.

invention could be applied to clocks generally.

My firm, Gent & Co., at once saw the possibility of applying it to workmen's time recorders and existing turret clocks, and after putting it in suitable form, the invention was, in June, 1920, patented in the names of W. S. Hubbard, I. H. Parsons and A. E. Ball, and patents of addition followed.

While the control of a losing rate was found to be quite satisfactory for workmen's recorders and a loss an advantage rather than otherwise in the event of the control being temporarily disconnected, yet for public turret clocks a loss could not be tolerated. I felt, therefore, the need of a control for turret clocks, which in the event of the control being temporarily disconnected, would leave the clock to perform its best uncontrolled time-keeping. With this requirement before me, I produced the " Duflex " control, which controls any tendency to gain, in addition to any tendency to lose.

I will first describe " Reflex " control by the aid of Fig. 19, which shows the control applied to a card recorder of a popular type. It must be first understood that the pendu-

" DUFLEX " CONTROL.—This form of control provides a means for synchronising pendulums which may have a tendency to gain or to lose.

The pendulum is regulated to keep its best time, and so long as it has no error, no controlling action takes place. On, however, the pendulum developing a tendency to lose, it is hastened, or, on developing a tendency to gain, it is retarded.

This form of control is best suited to turret clocks, and Fig. 21 is a photograph of Gents' Patent " Duflex " control, fitted to one of the public turret clocks in Chesterfield.

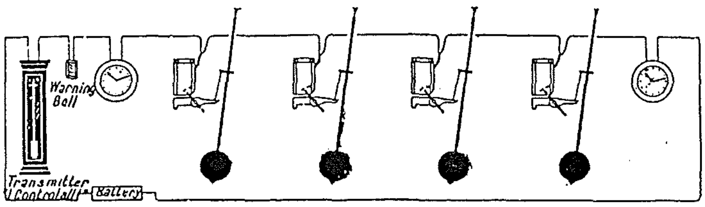


FIG. 20

lum of the recorder to be controlled must normally beat an even number of beats per half-minute or minute. The recorder in the photograph beats 84 per minute, and therefore at every half-minute it will be performing its 42nd swing, and being slow, it will yet be swinging to the left when the rack is being lifted by the half-minute impulse (of the " Pul-syn-etic " circuit) passing through the electro-magnet seen on the left. The free end of the vibrator spring will engage one of the teeth of the rack sustaining the latter by its pressure to the left. The spring is deflected, which action terminates that particular beat sooner, and, moreover, the spring in giving back the energy stored in it, sends the pendulum to the right more quickly, thus removing its loss. The " Reflex " action may even cause the pendulum to be fast at the next half-minute impulse, in which case no " Reflex " action will take place until the pendulum is found to be slow. The " Reflex " action will control a losing rate up to 8 minutes per day—with a loss of 3 or 4 minutes per day a " Reflex " action will be found to take place practically every half-minute. The " Reflex " idea has been employed by Mr. W. H. Shortt with great success for controlling a slave clock from his highly successful free pendulum.

Fig. 20 shows the effect of a number of recorder pendulums all kept in beat by " Reflex " control.

Its action will best be described by reference to Fig. 22.

When the control and pendulum is found —by the half-minute impulse of the time

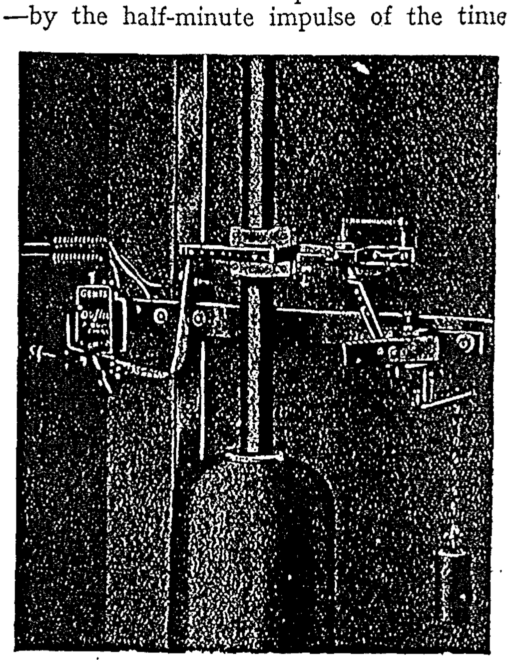
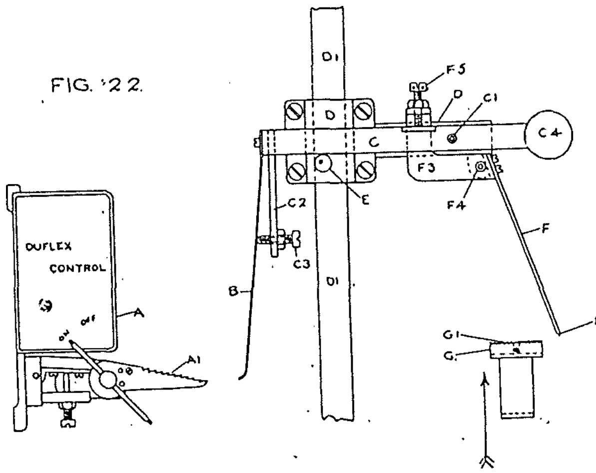


FIG. 21 *" Duflex " Control fitted to existing Turret Clock Pendulum.*

circuit—to be slow, the vibrator spring B will be moving to the left and over the rack A1, which will be lifting and consequently one of the teeth of the latter will engage the point of the vibrator spring, which will then be deflected. This action will terminate this particular swing of the pendulum

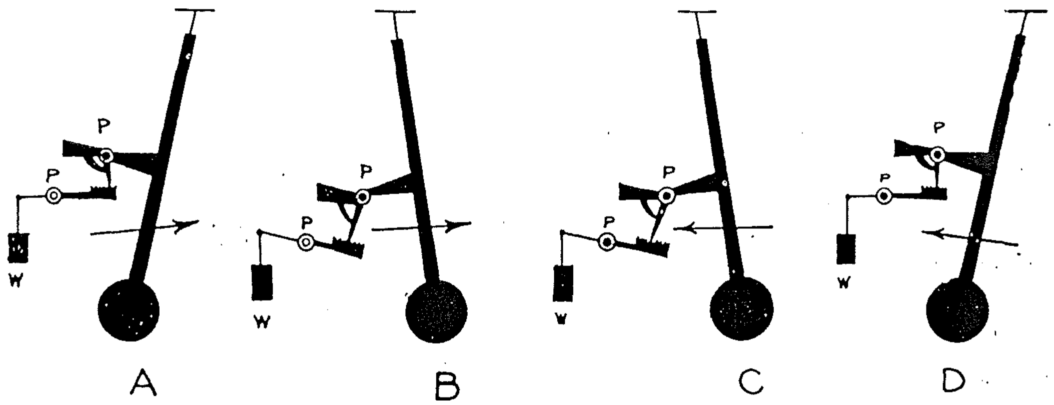
PAT. Nº 192,879

FIG. 22.



sooner, and by its "Reflex" action will hasten its return swing, thus taking out of the pendulum some or all its loss. This action will be repeated so long as necessary.

If the control is found by the half-minute impulse to be correct, the vibrator rack B



P. PIVOTS. W. WEIGHTS

FIG. 23.

will be at the end of the pendulum's arc, and for an instant will be without motion, consequently the momentarily lifted rack will simply touch it and again fall, and this action will be repeated as long as the pendulum is found to be correct.

If, however, the pendulum is fast it will be travelling to the right and an entirely different cycle of movements will take place. It will be observed that the vibrator spring B, the adjustment support C2, and the adjusting screw C3 are all mounted on the bar C which is pivotally connected to the pendulum at C1. The vibrator spring B will now be moving to the right, and on the rack A1 being lifted, the bar C will be tilted upwards, causing the pressure blade F to turn on its pivot F4. Its point F1 will then engage the teeth G1 of the rack G. This rack is then depressed against a spring (or weight), giving the pendulum work to do before it reaches zero, and consequently slowing it. This action is shown diagrammatically at A, Fig. 23.

The pendulum continues its swing to the right, and on passing zero, the rising rack G gives back to the pendulum the energy received from it, and provides an impulse after zero, which action is shown at B (Fig. 23) and also has the effect of slowing it. During the return swing of the pendulum, these two actions are repeated, C showing the action before zero and D the action after zero, the pressure blade F then returning to the position shown in Fig. 22. These four slowing actions take place every half-minute so long as the pendulum is fast.

Clockmakers will recognise that in designing this arrangement I have employed knowledge taught in the trade to the effect that "work or friction before zero tends to slow a pendulum, while impulse after zero also tends to slow a pendulum."

Normally these actions take place at infrequent intervals. To illustrate the powerful effect of this slowing action, we have found by actual trial that a turret clock, gaining as much as 8 minutes per day, can be kept under perfect control, and this statement also applies to a losing rate.

(To be continued.)

The First Lever Watch with Free Balance.

It will interest our readers to learn that a copy of the reprint of the technical and historical essay by H. Otto, F.B.H.I., on the "First Lever Watch with Free Balance," which appeared serially in this Journal, has been, by Royal request, forwarded to the King.

The beautiful binding, in green leather with elegant gilt tooling, was entirely executed by Mr. P. McLeich, the master of the department in the L.C.C. School of Arts and Crafts.

Mr. Otto has received the thanks of His Majesty, and he has been informed that the monograph will have a place in the Royal Library at Windsor Castle.

Practical Column.

By J. W. PLAYER, F.B.H.I.

"These little incidents will occur even in the best regulated workshops."

This column is published with the idea of giving practical assistance to watch repairers and others who seek a solution of any difficulty they have to contend with, whilst at the same time the answers to questions will be found of great interest and help to other readers. All questions should be addressed to The Editor, Practical Column, Horological Journal, 35, Northampton Square, London, E.C. 1, by the 7th of the month for reply in the following month's Journal.

V. H., of Victoria, Australia, writes:—Will you please publish the data regarding correct heights of pendulum bobs (lead, also cast iron) for one seconds, also half-seconds pendulums, in your practical column for use with Nos. 1, 2 and 3 grades of Invar.

Answer.—Data for the calculation of the height for pendulum bobs acting in conjunction with Invar rods vary somewhat owing to the fact that the coefficient of expansion of Invar rods is not always the same, even though the proportions of the constituent metals are apparently identical in successive series, consequently each batch has to be tested to ascertain its particular thermal coefficient of expansion.

I am informed by a well-known firm of steel manufacturers who specialise in Invar steels that they do not grade their product, each batch being sold as produced, and that a uniform price is charged whether the coefficient turns out to be very fine or not. They state, however, that the average coefficient of their production is 0.0000010 per degree cent. and under.

They say also that some French firms do grade their productions, but owing to its cost the price of their first grade is very high. The three French grades are as follows:—

Extra superior grade	0.0000008	per deg. C.
Superior	0.0000015	,, ,,
Ordinary	0.0000025	,, ,,

According to Britten's *Handbook, Dictionary and Guide* (13th edition), Invar is marketed in 3 grades, but where produced is not stated, the figures given are as under:—

No. I	0.0000010	per deg. C.
No. II	0.0000016	,, ,,
No. III	0.0000025	,, ,,

As my correspondent specially mentions numbers, I will use these latter figures on the

MY EXPERIENCES WITH ELECTRIC CLOCKS AND SYNCHRONISERS

A LECTURE DELIVERED AT THE BRITISH HOROLOGICAL INSTITUTE ON FEBRUARY 12, 1930, BY MR. ALFRED E. BALL, F.B.H.I.

(*Continued from page* 8.)

NOTE.—Fig. 7 (p. 5, Sept. issue). *Through an oversight this block is shown in an* inverted position.

* * * *

SYNCHRONISATION BY SUB-CONTROL —"WAITING" OR "HOLDING-UP" TYPE.

The "Waiting" or "Holding-up" type is a simple form of synchronisation which enables a number of distant groups of Electric Impulse Clocks to be so controlled daily—through their respective Master Clocks—that uniform time is kept by all; and yet, in the event of the controlling wires—usually overhead—which connect the distant Master Clocks and their groups to the Prime Master, being carried away by storm, timekeeping is maintained.

Further, on the controlling wires being reinstated exact synchronisation is resumed.

Fig. 24 shows diagrammatically the general layout of this synchronising scheme, and *incidentally shows a Prime transmitter* (Master Clock) controlling a number of distant sub-transmitters. The Prime transmitter is regulated to time, but the sub-transmitters are regulated to gain three or four seconds per day.

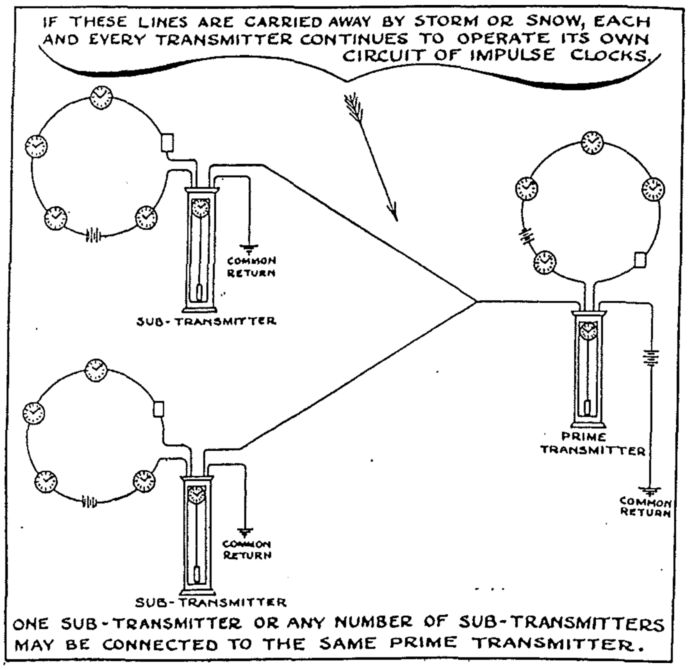


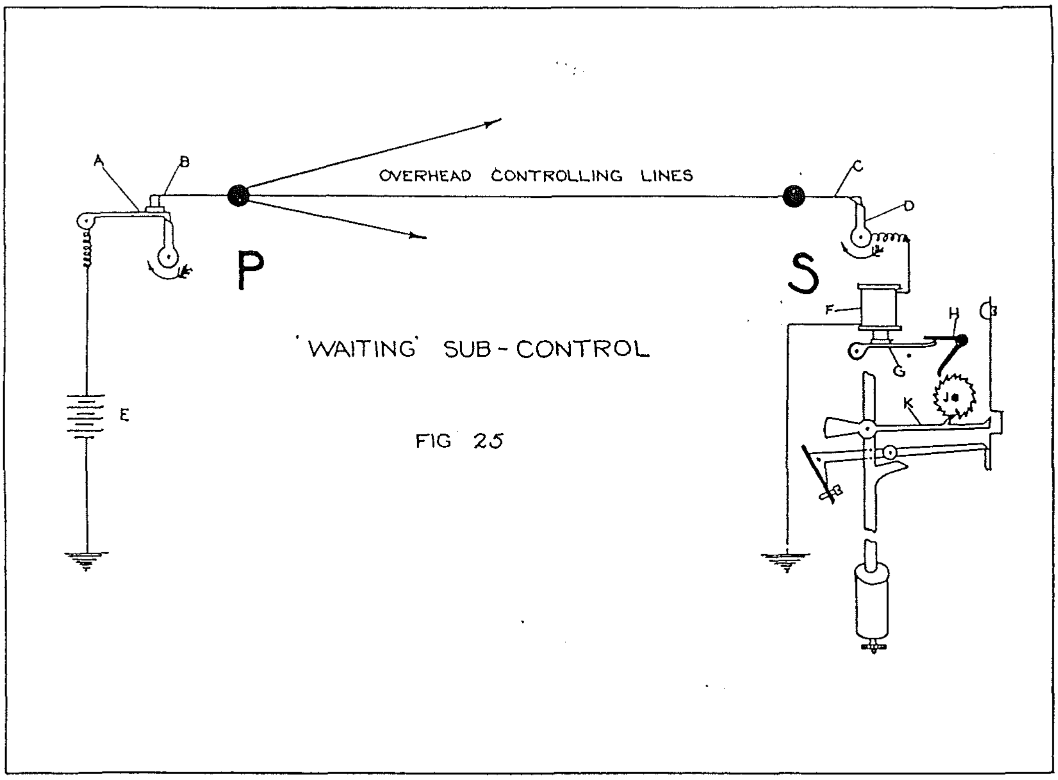
FIG. 24.

Fig. 25 will enable the functioning of this type of synchroniser to be understood. P shows diagrammatically the synchronising arrangement of the Prime transmitter, and S the arrangement at any sub-transmitter.

Daily, usually at 10 a.m., the Prime transmitter closes its contacts A and B a minute or two before, and the sub-controlled transmitters close their contacts C and D on arriving at 10 a.m., but a few seconds fast, as above mentioned. As each sub-transmitter closes its contacts, current flows from the battery E through contacts A and B, through the overhead line to contacts C and D, through the electro-magnet F, through the earth connections back to the battery E. The armature G is then lifted, and in turn lifts the back-stop click H out of engagement with the scape wheel J, with the result that the scape wheel, instead of progressing tooth by tooth with the vibrations of the pendulum, oscillates forward and backward idly. On, however, the Prime transmitter breaking the circuit at its contacts A and B precisely at 10 a.m., the armature G falls, and the scape wheel J progresses normally and with the amount of its gain removed. Any number of sub-transmitters may be connected in parallel.

SYNCHRONISATION BY HEART-SHAPED CAM.

A number of "Pul-syn-etic" time transmitters are controlled daily over the post-



office wires by the device shown diagrammatically in Fig. 26. This employs forcible correction by turning the scape wheel forward if slow, and backward if fast at the time of signal.

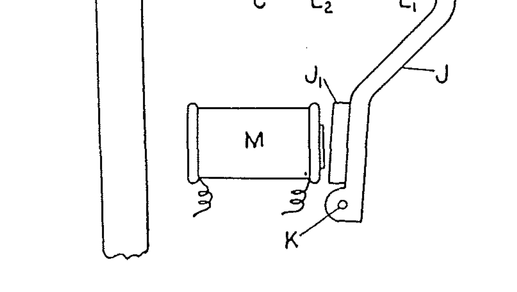


FIG. 26

Fig. 27 shows the heart-shaped cam fitted to the time transmitter of the Royal Liver Clock, an eliminator is provided to cut out false signals from immediately after the 10 a.m. signal from Greenwich has been sent until half-minute to 10 a.m. the following morning.

The need of an eliminator is shown by the fact that the pendulum has been swinging continuously for the past 18 years, with the exception that in the early days before the eliminator was fixed it was stopped on two occasions by false signals. One false signal was of no mean order when the 500-volt tramways cable under the street flashed across to the Greenwich signal line adjacent to it, burning out also a number of telephone and telegraph cables.

SYNCHRONISATION BY WIRELESS.

The lecturer's apparatus—as already described in the Journal—for automatically receiving the Daventry six-dot wireless time signal, and which utilises the sixth dot alone for synchronisation, was shown and demonstrated. It is illustrated here at Fig. 28. It was operated from a six-volt accumulator, and a push was connected across the terminals, which nornally are connected to

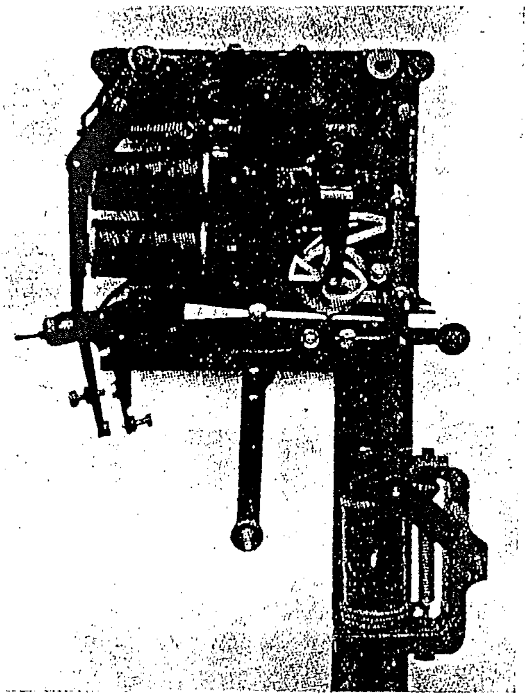


FIG. 27.

the contacts made by the clock at half-minute before 10.30 a.m. A momentary pressure of this push releases a time element, which after running for approximately 20 seconds closes a contact, lighting a lamp representing the valves of the receiving set. A Morse key was connected across the terminals, which normally are connected to the sensitive relay operated normally by the incoming six wireless dots.

It was seen on the key being pressed, the sixth contact alone caused a bell to ring (representing synchronisation), and at the same time the valves were extinguished, thus preventing subsequent interference by false signals.

Considerable interest was shown in this unique piece of apparatus.

Photographic slides were then shown illustrating the following :—

MR. W. S. HUBBARD'S FREE PENDULUM operating in conjunction with his Reflex control (two slides).

GENT & CO'S. FREE PENDULUM and Reflex slave.

IDLE MACHINE RECORDER operated from the "Pul-syn-etic" system, showing idle time of machines in spinning mills and factories.

FIREMEN'S TURN-OUT INDICATOR for fire station use, showing the time of the fire call and the number of seconds which elapse before the first and subsequent machines leave the station.

SPECIAL TIME TRANSMITTER, OBSERVATORY CONTROLLED, with apparatus for sending out six-dot wireless signals.

SPECIAL APPARATUS FOR AUTOMATICALLY RECORDING wireless time signals and giving a comparison with clock time to 1/100th second.

A TRICKLE CHARGING UNIT, enabling circuits of Impulse Clocks to be operated from alternating current supply.

A number of "Pul-synetic" exhibits were on view, and were the source of considerable interest.

At the close of the lecture a vote of thanks was proposed by the chairman, Mr. J. C. Burn, which was carried with acclamation.

Tenders for Egypt. The Physical Department of the Egyptian Ministry of Public Works is calling for tenders for the supply of the following scientific instruments and clocks :—Micrometer reodolites, levels, pantometers, plane table outfits, drawing and measuring instruments and apparatus, wall clocks, tell-tale clocks and stop watches. Firms desirous of offering goods of British manufacture can obtain further particulars upon application to the Department of Overseas Trade, 35, Old Queen Street, London, S.W. 1. Ref. B.X. 6787 should be quoted.

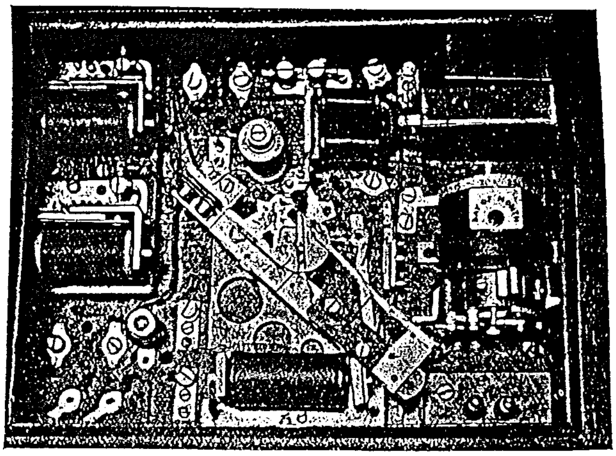


FIG. 28.