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Fellow Horologists:

This issue, the first published in 1992, is devoted entirely to Henry E. Warren, his variety of early power station monitor clocks, reprints of some of the original instruction manuals, and a reprint of the paper read at the Boston Clock Club on February 6, 1937.

This material is offered as a supplement to the recent article by John Anderson which appeared in the NAWCC Bulletin. Mr. Anderson did a masterful job of researching the background of Henry Warren as well as the TELECHRON Company, and our material will hopefully add to the Bulletin article and fill in a few minor gaps.

A few words of explanation may be in order in response to occasional inquiries about the delay in depositing dues payments.... Our chapter enjoys a "no-fee" checking account without any minimum deposit requirement because of the business account maintained by one of the officers which generates sufficient revenue for the bank to warrant the courtesy position received. The only condition being a "minimum" activity condition which means a limited number of deposits and checks drawn. This resolves itself to deposits made on an approximate quarterly schedule, and a maximum of 10 to 12 checks issued per year. This may create a bit of annoyance to some members, but the overall benefit seems to justify the procedures employed. Additionally, we do not mail dues cards unless requested and a SASE is received with the payment. All this, in an attempt to hold the line on dues, which has remained at $10 in spite of cost increases in printing and postage. Your editorial staff is interested in your opinions, so if you disagree, let's hear from you.

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Thanks for your understanding and cooperation... enjoy this issue.

Good reading ahead...

Co-Editors: Harvey Schmidt
Dr. George Feinstien
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V

MODERN ELECTRIC CLOCKS

By

Henry E. Warren

A paper read at a meeting of the Clock Club held at the Old State House, Boston, on February 6, 1937

The work of any individual is quite likely to have a different appearance when examined from the perspective of centuries after his death. For example, when Columbus was voyaging across the trackless ocean, then only searching for a passage to India, the discovery of a new world was not in his picture at all. To-day we only think of Columbus as having discovered a new world. Likewise this Clock Club, in giving consideration as it does to the work of the early American Clock Makers, is perhaps more greatly interested in certain features of their product, such for example, as the artistic appearance and the slow evolution of the case and dial, than in the technical problems which in all probability occupied most of the original artizan's thoughts and activities. I doubt very much whether the Willards worried half as much about the shape and appearance of the cases which they made as they did about the movements that went into these cases, and yet to-day the cases are of paramount interest. My story will probably appear less exciting to you than that of the early clock makers. In fact my tale would probably appeal more strongly to a group of engineers who are especially interested in science and technique. It may well be that one or two centuries from now some other aspect of this work will be more interesting and perhaps seem more important.

Let me recall in the beginning that there are two distinct functions of clocks. One is to measure time as accurately as possible and the other is to tell time with the greatest possible convenience. The work which I have done has a great deal more to do with the second function than with the first, for I must plead at the start that I am innocent of having made any advance in the accuracy of measuring time. My work has been wholly concerned with providing devices which would tell the time with the very greatest convenience and with a high degree of accuracy wherever other modern conveniences of civilization are found. Centuries ago the very early clock makers recognized the desirability of telling the time over as wide an area as possible, and therefore, their timekeepers were provided with bells which rang out the hours. It was from the French name for bells that the word clock came. That method of telling time, although it represented a great advance, is wholly inadequate for modern civilization. We now need to know the minutes as well as the hours, and so striking clocks are no longer dominant. Our modern clocks must tell the minutes and even the seconds with precision, if we are to keep abreast with the procession.

Prior to 1916 when the work which I will describe to you began, the only timekeepers which were used on a very extensive scale consisted of separate clocks, each one of which was constructed to measure time independently. Mr. Brown's clock had no connection with Mr. Jones' clock and either one of them had only that degree of accuracy which was imparted by the design and construction of the movement, aided or hindered by skill or lack of skill in regulating by Mr. Brown or Mr. Jones. The result, as you know, was that the average clocks were frail reeds as regards accuracy of time measurement. It was necessary to set them at rather frequent intervals if the owners expected to keep engagements and make train connections. Moreover all of these separate clocks had one particularly annoying feature which was that they would stop running unless wound up at regular intervals of a day or a week.

For a hundred years, more or less, inventors yearning for mental excercise have concerned themselves with the problem of using electricity to drive clocks. Springs and weights, although reasonably satisfactory for that purpose, can supply only a very limited amount of energy, but electric batteries and generators are not limited in this respect. A multitude of ways were discovered whereby electric energy could be used to keep a clock train running. From time to time many forms of electrically driven clocks have appeared on the market, but they have only been sold in small quantities and each particular variety has folded up after a while and passed into oblivion. The reasons have been, first, that all these various electric clocks were more costly, usually more delicate, more likely to get out of order, and generally speaking, no better time-keepers than the common variety. They had the advantage that no winding was necessary, but this was offset by the fact that the batteries were somewhat uncertain in durability. For public buildings, however, battery-driven systems of clocks with time-telling units scattered throughout a given building, all of the units being energized and synchronized from a central master clock,, were coming into wide general use by the beginning of this century. Such clock systems eliminated the burdensome labor of winding numerous units and more important still they insured uniformity in the time-telling function of the various clocks. Moreover these clocks minimized the cost of measuring time accurately, because only a single unit was used for this function. The obvious weakness of these electric clock systems was the necessity for separate sets of wires to carry energy and synchronizing impulses from the master clock. Such a system was practically out of the question for wide-spread use in a community, although the Western Union Telegraph Company established limited systems of this kind in our great cities where people were willing to pay a substantial rental charge per month for time service. The Western Union systems were substantially the same in principle as the building installations. They utilized a single master clock at a central point with wire connections to various stores and offices throughout a city where the service was under contract.

Like most of the other electric clock inventors I had dreams of various methods whereby electricity from batteries could be used to drive clocks. As far back as 1908 I filed a patent application on a rather crude form of electrically driven clock which represented the result of several years of desultory experimenting during my spare time. This work until then and for several years later was simply a hobby which gave me the same kind of pleasure as collecting stamps or playing bridge does to other people. However, as is often the case, the habit grew stronger and developed into a compelling urge. Eventually I engaged assistance and organized a small independent company for the purpose of making further developments in electric clocks which were still of the battery type. This was done without severing my regular job of superintending the work of a manufacturing company. In 1916 the inadequacy of the battery clocks which I had been able to design and build impressed me so forcibly that I began exploring other possibilities in the art of telling time. The need of some simple mechanism which would have universal application made me think, as a few people had done in the preceding decades, of the possibility of utilizing the existing communication systems for the distribution of time.

The two great networks which were then available were the telephone system, then reaching a very large portion of the houses and offices of the well-to-do people, and the electric light and power lines which covered a still more extensive territory. Of these two systems of communication, the one which appealed to me more strongly was the electric light system, because this carried abundant power for the purpose of driving clocks and, far more important, it contained the germ of a system for measuring time. In 1916 more than 90% of all electric light, heat and power was distributed in the form of so called alternating current. The alternations of this current might conceivably be used to measure time intervals provided they could be properly controlled. The other 10% of electric power was distributed in the form of so called direct or constant current which flowed smoothly in one direction like the current from a battery, and there was nothing about this current itself which could be used to measure time. At least three or four other people in various parts of the world had thought of the possibility os using alternating current for time-telling purposes as was afterwards discovered by a thorough investigation. However, none of these individuals had taken any effective action towards turning the dream into reality and consequently there was not anywhere in the world twenty years ago a place where alternating current was used to operate clocks. Unfortunately we have not in this ancient room a regular supply of alternating current because the older cities were, in the beginning, provided with direct current systems by the original power companies. The cost of these systems, which required immense amounts of copper to be buried under the streets was so great that even after the use of alternating current became almost universal many of the older networks like the one in the center of Boston were still continued in use. Consequently, in this district where only direct current is available, modern electric clocks cannot be used.

For the purpose of this lecture, however, I have brought a small alternating current generator which is capable of developing a supply of alternating current suitable for demonstration and I can now show you how alternating current differs from direct current. You will notice that the rapidly revolving Neon lamp of the demonstration device appears, when supplied with direct current, as a smooth ring of light, which means that the brightness of the lamp remains practically constant as it revolves rapidly in the circle. When, however, the same revolving lamp is supplied with alternating current you will see that the circle of light becomes a chain resembling separate links of light. Each one of these links of light is caused by an electric wave or impulse in the wire through which the current flows. The fact that some of the links are on the outside and an equal number on the inside means that these impulses which flow in the wire are first in one direction and then in the other direction, which explains the designation "alternating". If you will take the trouble to count the separate links of light in the whole circle you will find that there are six in the outer row and six in the inner row or twelve altogether. When I tell you that the lamp is revolving ten times every second you will see that there are 120 of these separate alternations of electricity in the wire every second.

For convenience the alternating current is characterized by the number of pairs of these alternations, each pair being called a cycle so that this particular current as 60 cycles a second. Now in the demonstration device the number of these cycles every second is not exactly sixty but only approximately that value and that was the situation in 1916 when I dreamed of utilizing this alternating current for time-telling purposes. It seemed to me possible that the number of these cycles or pairs of alternations per second could be made equal to exactly 60 on the average, if I could only persuade the operators of the power stations to adopt a different method of regulating the speed of the generators, which alone determined the rate of alternations. Before this could be done it was necessary to provide some means whereby the time characteristics of these alternations could be used to drive the hands of a clock. You can readily understand I think that if each of these flashes of light which you see so clearly could be used to move a gear wheel having a very large number of teeth, by the space of a single tooth, this imaginary gear wheel might be connected to the hands of a clock so that this hand would creep along the same small distance on the dial for each alternation and thus behave exactly the same as any ordinary clock hand. You will recall that an escapement serves precisely the same function since it permits the hands of a clock to move a small distance for wach swing of the pendulum and if you can imagine these flashes of light serving in place of the oscillations of a pendulum with some kind of an escapement which would form a connecting link between the flashes of light and the hands of a clock you may visualize exactly what I had in mind.

When alternating current was first used to distribute light and heat in 1886 there were no satisfactory motors which could be used for power purposes. The great advantage of the alternating current over the direct current lay in the fact that, through what is called magnetic induction, current could be distributed at a high voltage and then transformed by means of motionless magnetic devices called transformers to low voltage which would be safe for household use. It was not possible to use these transformers with direct current and consequently such current could not be transmitted economically for great distances from the power station. However, the motors which had been successfully developed to convert direct current into power would not perform even reasonably well when supplied with alternating current. The problem of building a successful alternating current motor was not solved until Nikola Tesla and Elihu Thompson discovered how to produce a so-called rotating magnetic field in a stationary iron structure when supplied with alternating current. Then it became feasible to build alternating current motors which were rather crude at first, but have now been developed to a point where, for many purposes, they are equal to or better than direct current motors.

I have here a simple apparatus designed to demonstrate the production of a rotating magnetic field in a stationary structure and the effect of such a field in causing the rotation of a movable member. In order that you may appreciate the rotation of the field I have a commutating device which can supply current from a bettery into any one of four soft iron pole pieces arranged around the circumference of a circle. Any one of these four pole pieces is thus magnetized by current passing through a coil of wire similar to that which is used in an electric bell. The commutator can be turned by hand as slowly as desired and there is a small electric lamp located on each pole piece so that you can see which one is magnetized at any instant. Inside the circle of these pole pieces is a thin smooth hardened steel disc which, like all hardened steel, has the power of becoming permanently magnetized and when so magnetized it has the properties of a needle of a compass. That is to say one end of the magnetic axis tends to point toward the north pole. When the demonstration device was first put in service the hardened steel disc had not been magnetized so it did not have a magnetic axis tending to point in any definite direction. The instant, however, I turn on the current from the battery and thus set up a north magnetic pole in the position indicated by the little electric lamp and, by the way, the structure is so arranged that a south magnetic pole is always set up diametrically opposite, the magnetic force passing through the hardened disc immediately magnetizes the disc in the diametrical direction of this force. Now the disc has become a permanent magnet like a compass needle and this means that if the north pole is shifted by means of the commutator, either to the right or to the left of its present position, the disc will tend to follow, as you can see by the motion of the arrow which has been painted upon its surface. From this time on you will see that the white arrow follows the lighted lamp, however fast I turn the commutator, so that I now have a motor in which there is a rotating part capable of delivering power moving inside a perfectly stationary structure. The intangible thing which is rotating and dragging this steel disc around is the magnetic field which is following exactly the rotation of my hand. I am in fact sending alternating current impulses into the field.

Now a commercial alternating current motor is not quite as simple as this demonstration device. In the first place the alternations are so rapid that the eye could not possibly follow such a field, if it was set up in this particular structure, and in the second place there is no commutator in most alternating current motors. However, the fundamental thing, namely, the rotating field does exist in all alternating current motors. This rotating field may be very easily produced in magnetic structures by several methods, but the simplest of these methods is by the use of what are called shading coils mounted on magnetic poles. Most ordinary alternating current motors do not have rotating parts which follow the rotating magnetic field with the exactness of this demonstrating device. Usually the tendency is for the rotor to run almost but not quite as fast as the field. The difference between the field speed and the rotor speed is called slip and the amount of slip depends upon the load. In small commercial motors the rotor may slip as much as 10% behind the field. This means that if the field is revolving 3600 times per minute, the rotor would revolve when loaded less than 3300 times per minute; although when the rotor is carrying a very light load its speed would be nearly 3600 turns per minute. You will observe that in alternating current motors of this kind there is a very strong tendency for the speed of the motor to be dependent upon the number of alternations of the current and not upon its strength or voltage. In order to use the alternating current for accurate time-telling purpose I was compelled to devise a small reliable alternating current motor in which the rotor would follow the alternations of the current with extreme accuracy. There could be no slip between the rotor and the rotating field, otherwise my clocks would be unreliable. A motor having these characteristics was long ago designated as "synchronous" from two Greek words meaning "equal time".

In 1916 very few synchronous motors were used for power purposes and none of them were in any respect adaptable for driving common clocks. By utilizing the same principle which is illustrated in this demonstrating device, namely, a rotor of hardened steel which could by permanently magnetized and then made to revolve synchronously in a rotating field there was created a device admirably suited to drive even small clocks. As you can readily see, this device is one that may be made very small and inexpensive, while because of its simplicity and the very light weight of the moving parts durability may be readily secured. Motors of this type are not well adapted to develop power, nor are they efficient when compared with commercial motors, but the work of driving hands of a clock is so light that these little motors, of which I will hand you samples for inspection, are very suitable. The power output of the first motors which I made for driving clocks was in the neighborhood of one millionth of a horsepower, but minute as this seems it still represents very much more power than is delivered by an ordinary spring clock movement. This is illustrated by the weight lifting capacity of this demonstrating apparatus. You can see that a very strong spring clock movement is able to lift on a drum mounted on its second hand arbor, which turns one revolution per minute, a small weight amounting to 1/4 oz. Alongside is a Telechron clock motor which has a shaft revolving one revolution per minute and this motor will easily lift through a drum of the same diameter a weight of 35 oz. Moreover I would point out that the spring clock movement even when tightly wound has its rate very considerable affected by lifting the tiny weight, while the Telechron motor does not change its rate to the smallest degree with a load 140 times as great.

As soon as a satisfactory motor which could be used to drive the hands of a clock became available, in the early summer of 1916, the next problem which I faced was to bring about in some manner the accurate regulation of the alternating current impulses which were bring sent in all directions over the wires so that these impulses in connection with the newly designed motor might be used to supply power companies' customers with a dependable time-telling device. For the solution of this problem two things were necessary, first, an instrument that could conveniently be used by power station attendants for the purpose of regulating the frequency of the alternations, and, second, creation of a state of mind among the power company managers that would justify them in giving this extraordinary new service to the public. The second part of the problem was, on the whole, more difficult than the first. It took only a few months to design and build a thoroughly satisfactory master clock which could be used at power stations so as to indicate errors in the average frequency, which were hundreds of times smaller than could be measured with the instruments then in use.

Several years elapsed, however, before resistance on the part of some of the managers of the electric light companies was overcome to a point where they would give this new service. This was because some of them felt that the added responsibility might be serious and many of them believed that the new service would be of no financial advantage to their companies on account of the very small power consumption of the clock motors. However, most of the managers were public spirited and progressive and they could see a real opportunity which eventually became evident to all. At that time the meters for measuring electricity were scarcely sensitive enough to register the current consumed by a single clock on any customer's premises so that the company might get no returns, but better meters soon became available and in the course of a few years power companies found the revenue received from current used by these tiny motors was really an important matter. The value of current used by a single clock during a year will vary anywhere from $.50 to $1.50, depending upon the rate. If $.75 per year be taken as a fair average, youbwill see that a company having 100,000 of these clocks on its lines would receive a return of $75,000 a year from the current used. As a matter of fact this income is mostly extra profit, because the motors run 24 hours a day and the load is absolutely steady. For 100,000 clocks a generator with a capacity of 300 k.w. is adequate. Modern generators range from 25,000 to more than 100,000 k.w. capacity. Consequently this represents a very trifling portion of the output of one large generator. This means of course that the money invested in generating equipment , transmission lines, etc., to operate these 100,000 clocks is really small compared with $75,000 per year return. There is no other electrical device which yields as large a return on the investment to the power companies. Furthermore there are a good many power companies that have several times 100,000 clocks on their lines. It is estimated that the number of electric clocks now running in the United States is above ten million. As a result these clocks have become of considerable economic importance to power companies, which explains their eagerness in stimulating sales.

The growth in the sale of these modern electric clocks was very gradual after the first system became available in 1916. Only a few thousand were sold each year for the next three or four years. By 1921, however, the success of those in use and the publicity which followed stimulated sales to a point where manufacturers of other kinds of clocks began to take notice, but it was not until 1927, ten years after the system first became available, that forms of synchronous electric clocks other than the ones which I have described to you began to appear on the market. Then a group of rival manufacturers began to grow and within a few years there were over a hundred different concerns which were selling synchronous electric clocks intended for use on systems that had been established quite generally throughout the country. Nearly all of these new forms of clocks differed from the original type in that they possessed no starting power, that is to say, it was necessary to start them manually and whenever there was an interruption in the power supply they would stop and not run until they had again been started by hand. While they were running they kept just as good time as the original type of self-starting synchronous clocks, but most of them were defective in some respect or other so that within another period of a few years they began to disappear from the market. Most of them were noisy, nearly all were short lived, and the universal habit of stopping after every interruption proved to be a nusiance in many cases.

You will notice that the Telechron clocks of which there is a display in this room are provided with an indicating device so as to give a signal after an interruption. Such interruptions, of course, make an error in the time indicated by the clock equal to that of the interruption. Generally speaking interruptions are short so that the warning signal is sufficient for most purposes to take care of the usual interruptions in the current. When it becomes very necessary to eliminate the effect of interruptions, as in public building installations and some other places, Telechron clocks are built wither with sustaining mechanisms which keep the hands in motion during an intrruption or with resetting apparatus which automatically measures the length of an interruption and then after the current returns moves the hands forward to make correction.

On account of the relatively great power of this little synchronous motor as compared with spring clock movements many new uses have been found for this kind of time-keeping device. Prior to 1916 there were a number of recorders on the market which depended on spring clocks to drive charts or perform other services that had a time function, but the performance of these devices was limited by the relatively weak power of the spring clock movements. When Telechron motors became available for power which was a hundred times greater than that of the spring clock movements, the instrument makers began to redesign their mechanisms so as to be of greater service to their customers. Many kinds of new devices making use of these synchronous motors were also developed.

Consequently a large part of the output of Telechron motors each year is used in instruments and devices that cannot be considered as ordinary clocks. In fact hundreds of thousands of motors are used annually for such purposes. Another field of usefulness for these new time-keeping motors is apparent for the very large dials such as are used in tower clocks. Instead of requiring a very heavy weight, a long pendulum and an expensive movement a tower clock with a dial several feet in diameter can be perfectly operated by means of one of these tiny motors which I hold in my hand. The use of large clocks especially those having Neon illumination has spread into the advertising field and wherever you go now-a-days you will find frequent outdoor signs which are seeking the good-will of observers by showing the time of day on very large clock dials.

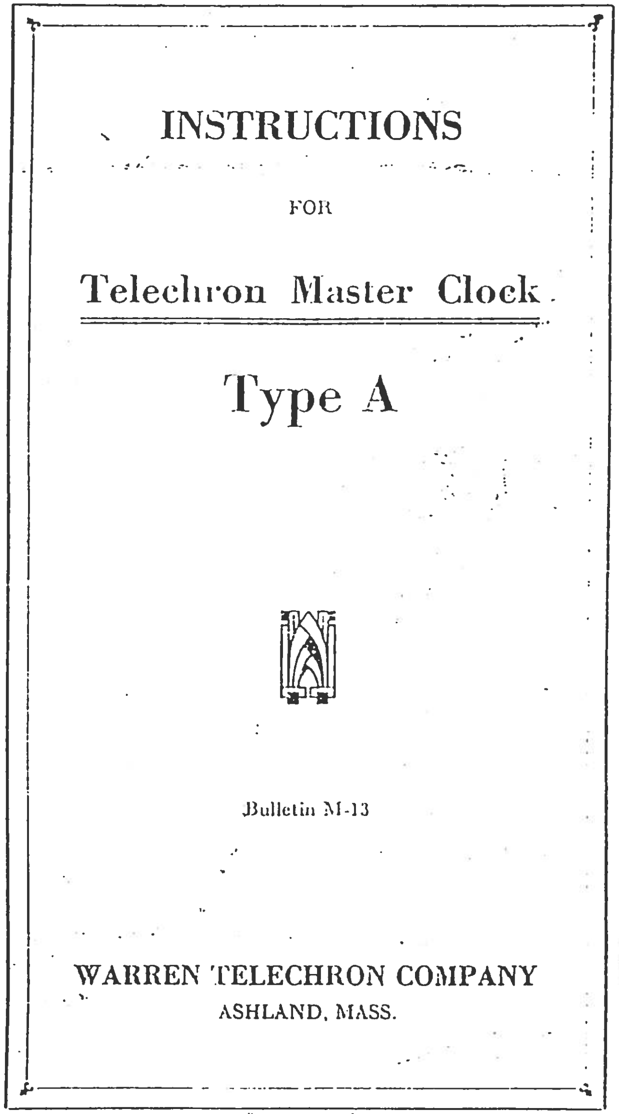
In the modern electric clocks, as I have already intimated, the function of measuring time is separate from the function of telling time. Two devices are necessary, first a single very reliable and accurate master clock located at some central point on a power system, and second an unlimited number of synchronous motor clocks located wherever convenient on the distribution system of the power company. The same generators, wires and transformers which carry light, heat and power to all the company's customers also carry without any extra charge accurate time impulses to these modern electric clocks. The only thing that is necessary for the electric clock to do is to translate the alternating current impulses into time indications. Therefore, they serve to tell the time which is accurately measured by another device. As a result of this arrangement the mechanical construction of the electric clock is of a very different nature from that of the ordinary spring and weight-driven clock. In the latter conservation of power is of the utmost importance. Only a slight amount of energy is available in a tightly wound spring or a lifted weight and this naturally must be used in the most miserly way if the delicate time-measuring escapement device is to perform accurately. Therefore, we find that in the ordinary clocks and watches the gear wheels are made very light, the teeth are made very perfect and the bearings are made as nearly frictionless as possible so as to reduce to the minimum the power needed to drive the escapement and all other moving parts.

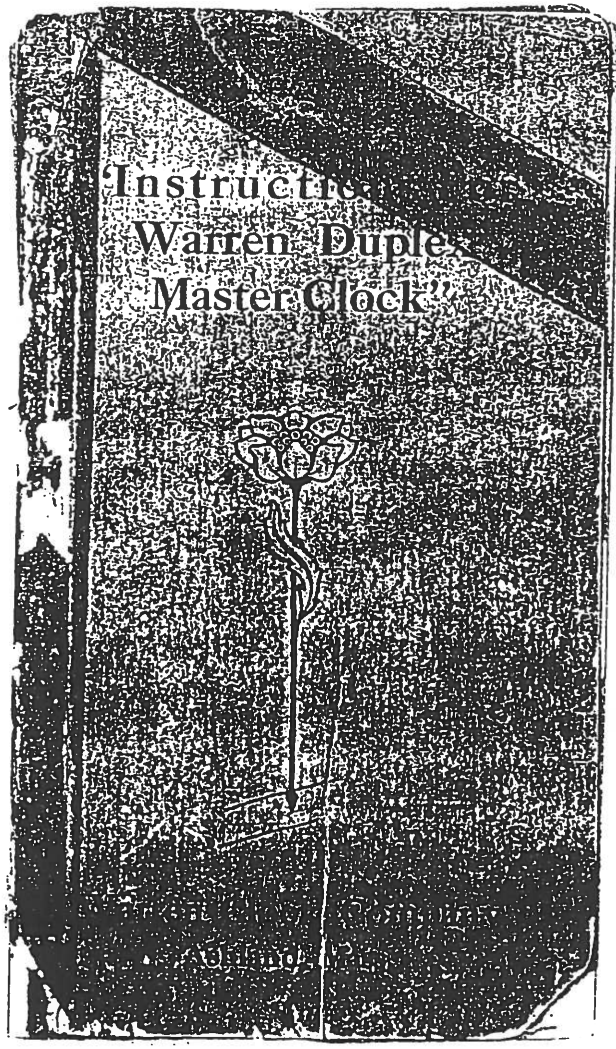
In the electric clock, however, it is not difficult to provide an abundance of power which can be used for the simple task of keeping the clock hands in motion. There is no escapement to bother about. Consequently the gear train which connects the spinning rotor with the clock hands may be of relatively coarse construction, with bearings that might be considered crude in the former type of clocks. The two important conditions which must be met are that the gear train from rotor tomhands is durable and capable of running for a long time without attention and that in operation the moving parts are very quiet. It is really immaterial whether the teeth of the slower moving members of the train are cut or stamped orwwhether the gear wheels are solid or spoked, the bearings coarse or delicate. The most difficult problem is to make sure that the faster moving members of the train are well lubricated and will remain so for a period of years and that there is not anywhere in the device a troublesome source of noise.

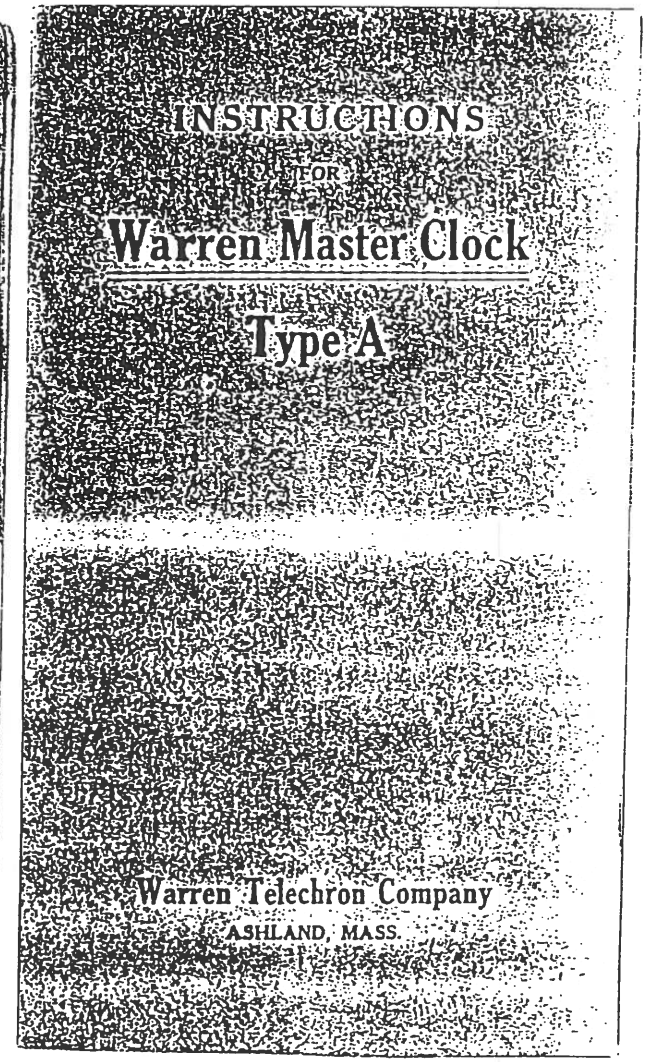
People have become accustomed to the ticking of ordinary clocks, but in twenty years they have not become accustomed to the much fainter buzzing or humming sound which is emitted by some of the electric clocks on the market. The modern electric clock is required for public acceptance to be practically silent. Such a result is not easy to obtain because wherever alternating current is used to set up a magnetic field, there is a tendency to generate a humming sound. Motion which cannot be seen by the eye is ample to make a very disagreeable sound. Consequently while the manufacturer of modern electric clocks escapes naturally some of the very difficult manufacturing problems which are connected with other kinds of clocks, he is obliged to solve this new problem of noise, if he is to make a success of his product.

Synchronous motor clocks may be readily substituted for practically all forms of ordinary clocks and their field of usefulness may be extended far beyond that of spring and weight-driven clocks. The electric movements are small and compact so that they may be mounted in any ordinary form of case. The dial may be readily illuminated by using a trifling amount of the energy which is available inside the case itself. They have already become the most popular form of alarm clock. They may be arranged to show the time of day by moving numerals in place of moving hands. They may be arranged to switch electric current on and off at predetermined times or to give signals according to a regular program. In fact there seems to be no limit to the field of usefulness of these new time-keepers.

Covers of the 3 instruction booklets







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WARREN POWER STATION MONITOR CLOCK

The following is from three instruction booklets for the Warren Master Clock:

1. "Instructions for Warren Duplex Master Clock", Warren Clock Company, Ashland, Mass. Printed in 1918, with an Appendix from 1919.

2. "Instructions for Warren Master Clock Type A", Warren Telechron Company, Ashland, Mass. Printed circa 1923.

3. "Instructions for Telechron Master Clock Type A", Bulletin M-13, Warren Telechron Company, Ashland, Mass. Printed in 1934.

The second instruction booklet is very similar to the first one. The paragraphs that are different have been inserted in the text of the first booklet with the number 1 along the left border for parts that are found only in the first [1] booklet and the number 2 along the left border for parts that are found only in the second [2] book.

1 **"INSTRUCTIONS FOR WARREN DUPLEX MASTER CLOCK"**

1 Patents Pending

2 **Instruction Book for Type "A" Master Clock**

Unpack the parts of the clock carefully and locate the case on a firm foundation, where it may easily be seen by switchboard operators.

By means of the three levelling screws underneath, adjust the clock so that it is plumb on all four sides, and then clamp the screws.

1 Attach the movement to the two horizontal bars near the
1 top of the case, by means of four screws. The large five
1 minute dial should be on the top facing toward the front of
1 the clock, which is the side having the large panel of glass.

1 Attach the wires leading from the motor to the terminals
1 of the double-pole switch underneath the cover of the clock
1 and to the other terminals of the same switch bring in wire
1 connections from a 110 volt instrument transformer attached
1 to feeder busbars or from some other part of the alternating
1 current system, which will be alive at all times. If there
1 is no single unfailing supply, a transfer switch should be

1 provided, so as to be sure that the synchronous motor of the
1 clock is always supplied with current. Only two watts are
1 required and consequently it may be connected to a circuit
1 supplying a switch board instrument without appreciably
1 affecting the instrument.

2 Slide the horizontal brass bars projecting from the
2 movement into the slots of the cast frames which are attached
2 to the inside of the case. The large five minute dial should
2 be on the top facing toward the front of the clock, which is
2 the side having the large panel of glass. Hook the pendulum
2 on from the back with the hook facing toward the front. Be
2 sure that the rod passes through the fork of the verge.

2 The small auxiliary five minute dial is to be clamped on
2 the front plate of the clock so as to be directly over the
2 large five minute dial. Attach the wires leading from each
2 of the two motors to one of the double pole switches
2 underneath the cover of the clock. Bring to these switches
2 connections from some reliable 110-volt alternating circuit.
2 It would be desirable to supply the two switches from
2 different circuits so as to reduce the danger of complete
2 interruption. Each motor requires about four volt-amperes.
2 Consequently connections may easily be made to instrument
2 transformer circuits. Obviously the wires supplying these
2 motors should be connected to the circuit to be regulated.

There will be found within the space under the top cover of the clock a slender steel rod, with three small nuts on one end. This rod is intended to connect from the spring strap switch at the top of the clock, passing through a hole in the wood to a brass bearing on the front of the clock plate on the right hand side, midway between the two dials. The nuts at the top should be adjusted when the rod is in position with a single one underneath and two on top of the strap switch. This should be held barely closed by the trigger attached to the brass bearing and when this trigger is released the switch should open.

1 The pendulum of the clock should be hooked on from the
1 back with the hook facing toward the front, and the rod should
1 pass through the fork of the verge.

Two cells of No. 6 Columbia dry battery should be connected to the three wires at the bottom of the case inside, in such a position as to be wholly out of the way of the pendulum. The carbon of one cell connects with the wire marked "Carbon," and the zinc of the other cell connects with the wire marked "Zinc," and the zinc of the first cell and the carbon of the second cell should be connected together with the wire marked "Carbon Zinc."

When the clock is ready to run, the main spring should be wound nearly, but not quite tight, by means of the arbor which projects from the back of the movement. The pendulum should then be started by pushing it gently with the finger, and if the clock has been properly levelled and not injured in shipment, the sound of the beats should be nearly even as determined by listening.

2 This adjustment for even beats may be made by the small
2 levelling and clamping screws which determine the position of
2 the horizontal bars supporting the clock movement.

The black hand on the five minute dial and the minute and hour hand on the lower dial should now run, and it would be well to let them continue to do so for an hour (a day [2]) or so before starting the motor, which can be done by throwing on the switch at the top of the clock.

Upon the circular platform, midway of the pendulum rod, there should be placed several small weights which will be found in an envelope marked "Regulating Weights." Some extra weights, marked "Reserve Weights," should be placed on a little stand provided for the purpose. Each weight is marked with a number and this number designates the number of seconds per day which that particular weight will make the clock GAIN if it is placed on the pendulum rod.

The clock, when tested at the factory, kept correct time when the weights in the envelope marked "Regulating Weights" were upon the pendulum rod. After shipment it may require more or fewer weights on the pendulum rod, but this can only be determined after it has run for several hours or a day.

Under the cover on top of the clock will be found two graduated dials. When the clock is started the indicators of these dials should be placed on zero. These dials are for the purpose of fine adjustments of the clock and it will not be necessary to make use of them until a coarse adjustment of the rate has been effected by means of the weights upon the pendulum rod.

Each day, soon after noon, when time signals are received from Washington, the error of the black second hand should be determined to the nearest second, and a record should be kept of the daily error. It will be useless to attempt to regulate this clock except by comparing it with accurate time signals. The clock is capable of running with an error of less than one second per day. Consequently any comparison which may be made with another clock is worse than useless if you are not sure that the other clock is within one second of the correct time.

The best way to get the correct time is by wireless. Signals are sent out each day from Washington, starting at 11:55, continuing for five minutes. There is an interruption of five seconds at the end of each minute, with the exception of the last, when the interruption is for ten seconds. (The wave length of these signals is rather long but an outfit costing less than $100.00 will receive them very well [1].) If the wireless signals from Washington are not available, the next best method is to get the time by means of telephone or telegraph from some astronomical observatory or from the Western Union Telegraph Company at noon.

If the Master Clock shows by its record that it is LOOSING, weights should be ADDED to the pendulum rod, of the same value as the number of seconds which the clock is loosing on the average, in twenty-four hours.

If the Master Clock is GAINING as shown by the daily record, weights should be subtracted from the pendulum rod, of the same value as the number of seconds per day which the clock is GAINING on the average. The accumulated error of the clock may be eliminated by stopping the pendulum carefully with the fingers, if the clock is ahead, or if the clock is slow by vibrating the pendulum through its normal arc, but at a more rapid rate than normal by means of the fingers. In this way the clock can be set right very easily without touching the second hand at any time.

The minute hand on the lower dial should read some multiple of five minutes when the second hand is on zero. This may be set with the finger. The gold second hand (on the large dial [2]) is driven by a self-starting synchronous motor in the rear of the movement, and this same motor keeps the clock constantly wound. This gold hand should be set by opening the motor switch on the top of the clock and closing it again just as the black hand passes beneath the gold hand. Do not touch either second hand with your fingers.

The switch board operator should be instructed to keep the black hand and the gold hand together by adjusting the frequency from time to time whenever these two hands show any tendency to diverge. Such adjustments may not be necessary oftener than three or four times an hour, depending, of course, upon load conditions.

This method of regulating the frequency will be found easier than the former one that necessitated watching the frequency meter which was constantly varying up and down. On a large system it will probably be found feasible to keep the black hand and the gold hand together at all times with an error of less than five seconds.

If at any time the current supply to the Master Clock is interrupted by accident, for example by severe lightning disturbances, the gold hand will of course stop, but the black hand will continue to move. When the current is restored to the clock, the two hands will no longer be together. The operator should not attempt under these conditions to raise or lower the frequency so as to bring the hands together, but instead he should open the motor circuit at the top of the clock, and allow the black hand to catch up with the gold hand on its next revolution, when the switch should be thrown in again.

The clock will run without rewinding for two or three days, if the motor is stopped, but if it is rewound every day, it will of course run indefinitely. Rewinding is unnecessary so long as the motor runs.

2 The small five-inch dial which is driven by an
2 independent motor at the top of the movement is provided for
2 emergency operation. If for any reason the main motor which
2 drives the gold hand should stop, it will still be possible
2 to maintain constant average frequency by comparing the black
2 hand of the large dial with the gold hand on the small
2 auxiliary dial. Both gold hands should be set to indicate
2 the same time, so that if either one fails to run the other
2 one will be available.

2 The auxiliary movement can be used to replace the main
2 motor at any time, if it should become desirable to make
2 repairs or replacement. Recommendation is made that an
2 additional master clock motor be held in reserve, and this can
2 be used at any time to replace either of the motors in the
2 master clock.

2 There is included with the master clock a secondary clock
2 or Telechron having a second hand. This should be placed on
2 the wall near the master clock and used as a check on the
2 master clock. In an emergency this Telechron can be used to
2 regulate the frequency by comparison with an accurate watch
2 or clock.

The setting and regulating of the clock should be placed in the care of one person only, and it is very desirable that he should be familiar with fine instruments and delicate manipulation.

After this attendant has become proficient in regulating and setting the clock by the method above described, he may then regulate it, if he prefers, by means of the dials, under the cover of the clock. The one in the rear of the case, which is connected in series with the automatic strap switch, is for the purpose of setting the clock. The indicator on this dial should be placed on the number of seconds which the clock is to gain or to lose in order to make it right, and then the strap switch should be pressed down. It will remain closed for about ten hours, provided this operation is performed shortly after noon-time, and during this period, the clock will gain or lose the number of seconds marked on the dial. The strap switch will then open automatically, and after that the clock will continue at the former rate. For the purpose of correcting the rate of the clock, the dial on the front of the case should be used. This remains in circuit all the time. If the clock runs two seconds per day slow, the pointer should be put on 2 on the fast side.

If the coarse regulation by means of the weights on the pendulum rod is properly managed, it will never be necessary to correct the clock by means of these upper dials, more than a second or two.

The two battery cells used for regulating the clock should be renewed every six months.

2 If for any reason the pendulum is stopped for more than
2 a few hours, be sure that the main driving motor is stopped
2 also so as to prevent over-winding of the spring.

If for any reason the clock does not operate properly or there is any feature about it which is not clearly understood, please communicate immediately with the

1 WARREN CLOCK COMPANY
1 Ashland, Mass.
1 Patents Pending

2 WARREN TELECHRON COMPANY
2 Ashland, Mass.

2 Patented Oct. 29, 1918
2 Mar. 14, 1922

1 APPENDIX
1

March1919.

1 Master clocks as now furnished are provided with an
1 auxiliary dial which is located by means of clamps above the
1 main 5" dial. This extra dial which embraces 5 minutes has
1 a single gold hand driven by independent motor which is a
1 duplicate of the regular motor that drives the master clock.
1 It is desirable although not necessary that this auxiliary
1 motor should be connected to a separate 110 volt transformer
1 for the sake of safety so that there will be less chance of
1 both motors being deprived of current simultaneously. In an
1 emergency, an operator can maintain frequency by comparing the
1 black hand on the large dial with the gold hand on the small
1 auxiliary dial. Both gold hands should be set to indicate the
1 same time so that if either one fails to run, the other one
1 will be available.

1 The auxiliary motor can be used to replace the main motor
1 at any time when it becomes desirable to renew the oil in the
1 former or to make repairs. Recommendation is made that an
1 additional master clock motor be held in reserve, which can
1 be used at any time to replace either of the two motors in the
1 master clock.

1 There is included with the master clock a secondary clock
1 with a second hand which should be placed on the wall near the
1 master clock and used as a check on the master clock. In an
1 emergency, this clock can be used to regulate frequency by
1 comparing with an accurate watch or clock.

1 WARREN CLOCK COMPANY
1 Ashland, Mass.

INSTRUCTIONS

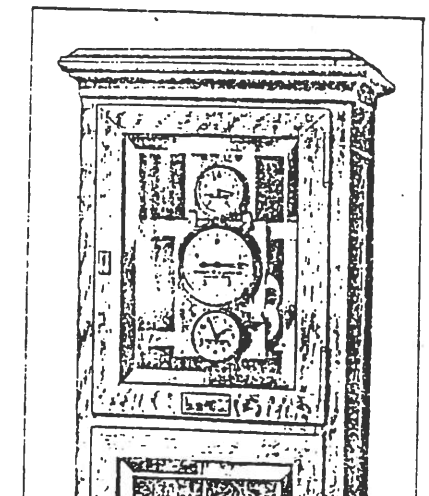
for

Telechron Master Clock

Type A

Bulletin M-13

WARREN TELECHRON COMPANY
ASHLAND, MASS.



Type "A" Telechron Master Clock

Installation and Operation of Type "A" Master Clock

It is recommended that only a man familiar with clock or meter movements be allowed to install, start and regulate this Master Clock.

Use care in unpacking the clock so as not to break the glass or to damage the case. Do not allow any packing material to get inside the case.

The following articles are packed as indicated and care should be taken so that all are properly unpacked and accounted for.

Inside of case

Pendulum

In top of case

Setting Rod	Reserve weights
Keys to case	Regulating weights

Instruction book

In separate packages

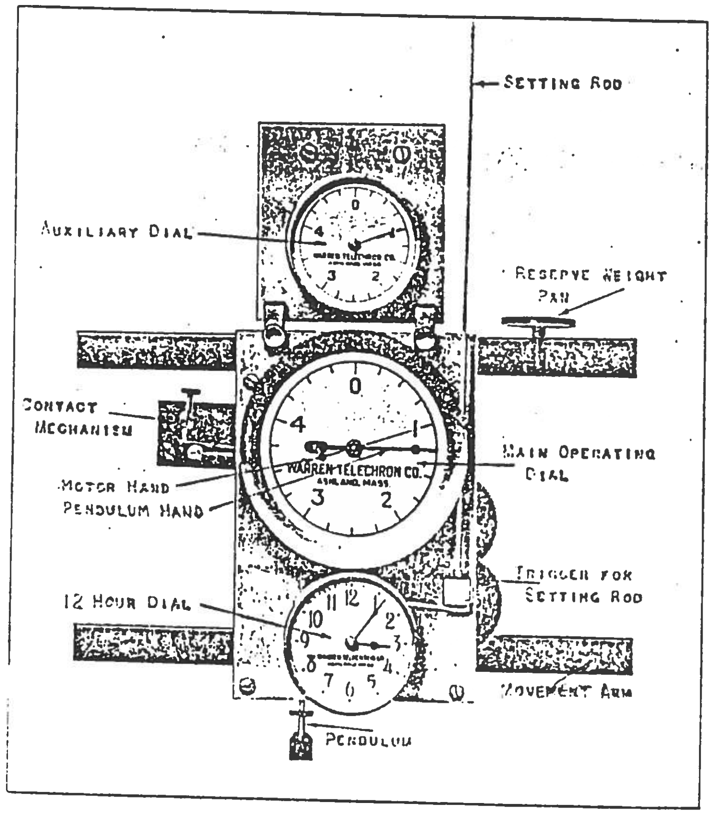
Main movement with reserve weight pan
Auxiliary movement
Dry cells (2)
One Telechron clock for wall mounting

Location

Place the Master Clock in a location which is firm and free from vibration, and, in addition, where it may be readily observed by the switchboard operators or load dispatchers. It is recommended that the clock be mounted on a separate base, above the level of the floor, in order to lessen the vibration and to prevent undue handling. This base may consist of a heavy concrete or stone block which rests upon a felt or cork pad about one inch in thickness. By means of the three adjustable legs underneath, and the use of a plumb bob, the case should be leveled so that it is plumb in two directions, after which the legs should be locked in position with locking rings.

Installation of movement and pendulum

Place the horizontal brass bars, projecting from the main movement, in the groves of the cast frames which are attached to the inside of the case. The large five-minute dial should be on the top, facing the glass front of the clock. Be sure that the bars are resting on the leveling screws in the top lugs of the frame and not on the clamping screws in the bottom lugs. Level the movement, with a spirit level on the arms, by adjusting the small leveling screws and lightly clamp it in place with the clamping screws. Hook the pendulum on from the back, with the hook facing the front. Be sure that the pendulum rod passes through the fork of the verge rod. The distance between the bottom of the pendulum bob and the block should be 1/32-inch. If this distance is not correct, adjust the leveling screws until the pendulum is in its proper position and relevel the movement. The small auxiliary five-minute dial should be clamped on the top of the front plate of the clock so as to be directly over the large five-minute dial.



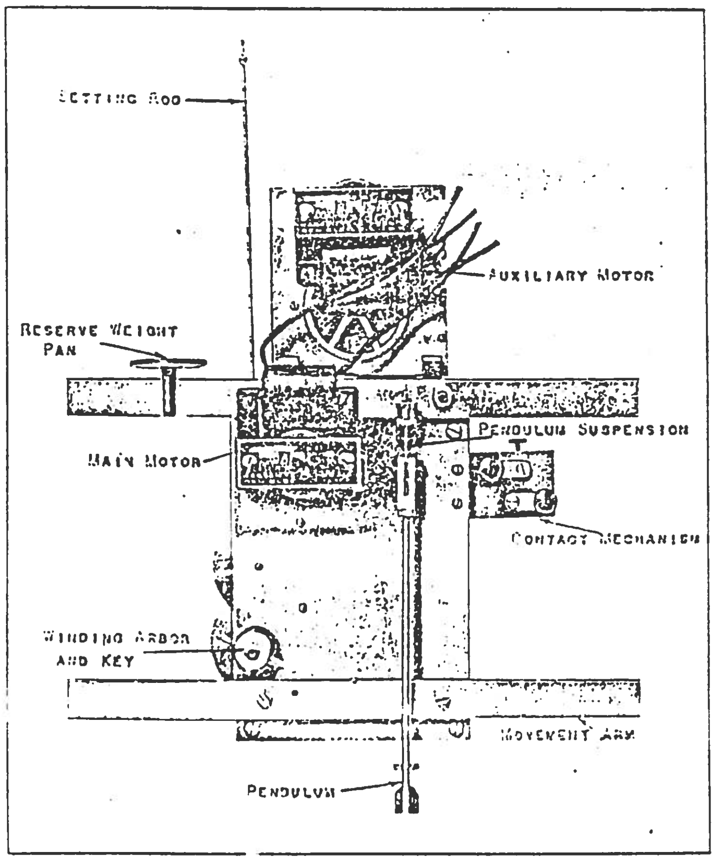
Front view of Operating Dials

Motor connections

Connect the wires, leading from the two motors, to the double pole single throw switches underneath the cover of the clock, keeping the switches open. Connect the line sides of these switches to a reliable source of regulated alternating current of the characteristics shown on the nameplate. It is recommended that each switch be supplied from a different primary circuit, if possible, so as to reduce the danger of a complete interruption. Each motor requires but four volt-amperes which will allow it to be connected to an instrument transformer circuit.

Adjustment of setting rod

Within the space under the top cover of the case, there will be found a slender steel rod with three small nuts on one end. This rod runs from the spring strap switch in the top of the case to the small brass block on the right hand side of the dial plate. The upper two nuts should be removed and the threaded end of the rod should be passed up through the holes in the case and the strap switch. The large end of the rod should be placed in the hole in the brass block. Holding the rod with the left hand, so that the trigger prevents any further upward motion, replace the small hexagonal nut so that there is a nut on each side of the spring strap switch. Adjust both nuts so that the spring contact points make a good firm contact. Release the trigger and make sure that the contact points have opened. When the position of the spring strap has been adjusted, so that the contacts are open or closed respectively when the trigger is released or caught, replace the round lock nut on the rod and leave the switch in its open position.



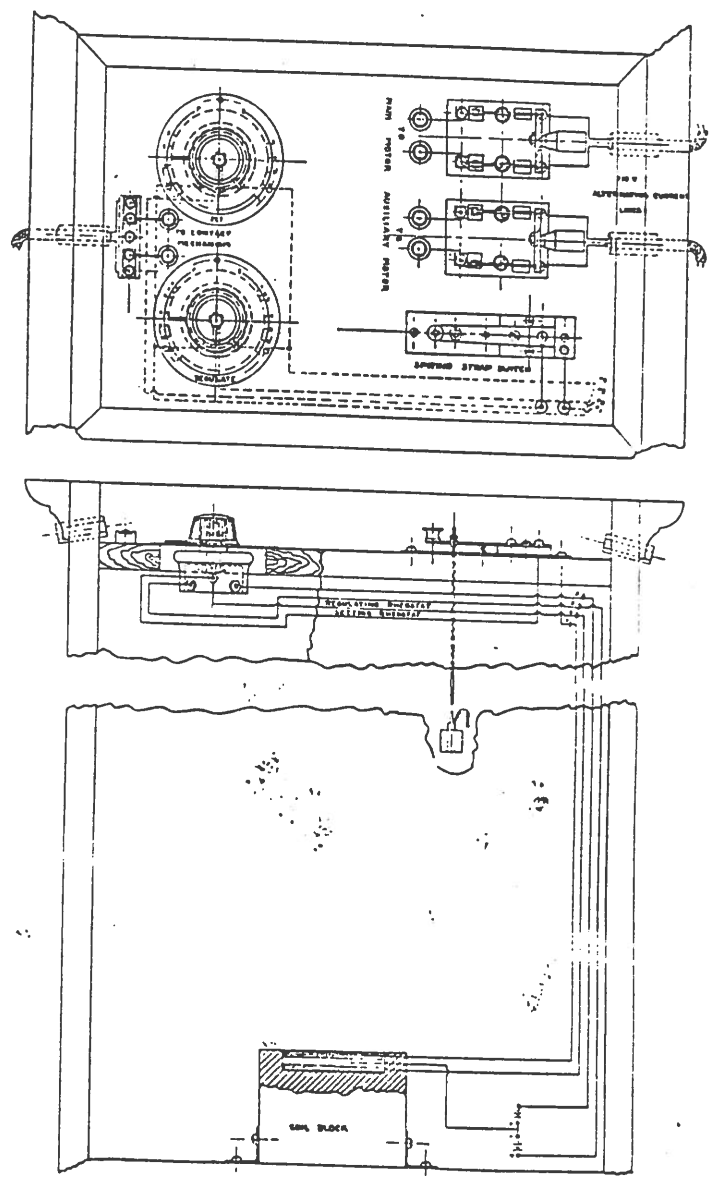
Back view of Movement

Dry cells

The two No. 6 dry cells should be placed in the bottom of the case against the right side wall in such a position that they will not interfere with the pendulum. The carbon (positive) of one cell connects with the wire marked "Carbon" and the zinc (negative) of the other cell connects with the wire marked "Zinc." The zinc of the first cell and carbon of the second cell should be connected together with the wire marked "Carbon-Zinc." These cells should be renewed every six months.

Regulating weights

Two small envelopes (marked "Regulating Weights" and "Reserve Weights") will be found in the top of the case. The regulating weights should be placed on the small circular pan secured to the pendulum rod. The reserve weights should be placed on the circular stand that can be easily attached to one of the movement arms. Each weight is marked with a numeral which designates the number of seconds per day which that particular weight will cause the clock to change its rate.



Electrical Wiring of Telechron Type "A" Master Clock

Starting the Master Clock

When the clock is ready for operation, the two switches in the top of the case should be closed, thereby energizing the motors. The pendulum may now be started by moving it with the fingers. If the clock has not been injured in shipment and has been properly leveled and set up, the swings of the pendulum will give a balanced and even beat. The evenness of the beat can be readily ascertained by carefully listening to its sound which should be the same on each side of the swing.

Adjustment for even beats

The final adjustment for even beats can be made by the small leveling screws which support the horizontal bars projecting from the clock movement. When an even beat has been obtained, carefully tighten the lock nuts so that the leveling screws will not work loose.

Timing

The Master Clock, when tested at the factory, kept correct time when the weights in the envelope marked "Regulating Weights" were upon the pendulum pan. As mounted in its new location, the clock may require a different number of weights to give correct time but this can only be determined after it has run for several days.

The error in time of the black seconds hand should be determined each day by comparing its time with the radio time signals broadcast by the U. S. Naval Observatory at Washington, D. C. or from some other reputable astronomical observatory. This error should be determined to the nearest second and a record kept of it, together with the corrections which were made. It will be useless to attempt to regulate the Master Clock except by comparing it with accurate time signals. If properly regulated, the clock is capable of running with an error of less than one second per day.

If the Master Clock shows by its record that it is LOSING, weights should be ADDED to the pendulum pan of the same value as the average number of seconds which the clock is losing in twenty-four hours.

If the Master Clock is GAINING, as shown by the daily record, weights should be REMOVED from the pendulum pan of the same value as the average number of seconds per day which the clock is gaining in twenty-four hours.

The best method of changing the weights is by handling them with a pair of tweezers, moving the latter back and forth in time with the pendulum. In this manner, the period of swing of the pendulum will not be disturbed.

The accumulated error of the clock may be eliminated by carefully stopping the pendulum with the fingers, if the clock is fast, or, if the clock is slow, by vibrating the pendulum through its normal arc but at a more rapid rate than usual. In this manner, the clock may be easily set without touching the seconds hand at any time. The minute hand on the lower dial should read some multiple of five minutes when the black seconds hand is at zero. The former hand may be set manually.

The Master Clock can be very accurately regulated by means of weights being added to or subtracted from those in the pendulum pan. However, there are, in the top of the case, two additional methods of regulating the pendulum movement. This regulation is accomplished by the adjustment of the two small dial rheostats which control the intensity of the magnetic field set up by the coil block in the bottom of the case.

The setting dial, in the rear, is connected in series with the spring strap switch and is installed for the purpose of setting the clock. This rheostat should be set for the number of seconds which the clock must gain or lose in order to get back to correct time and the strap switch should be pushed down so that its contacts are closed. If the strap switch has been properly adjusted, the trigger on the front of the movement will catch the setting rod and hold it in position. The switch will remain closed for about ten hours, provided that this operation is completed shortly after noon-time, and, during this period, the clock should gain or lose the number of seconds for which the dial is set. At the end of the setting period, the strap switch will open automatically, break the setting circuit, and the pendulum movement will continue at its former rate.

For the purpose of correcting the rate of the pendulum movement, the regulating dial in the front of the top should be used. This correction remains in effect at all times and acts in the same manner as the weights on the pendulum pan. If the pendulum movement has a rate of two seconds slow per day, the rheostat should be set to 2 on the fast side.

Radio time signals

Radio time signals are broadcast at noon and at 10:00 P.M., Eastern Standard Time, each day by the U. S. Naval Observatory at Washington, D. C. These signals, in the form of quarter second impulses, commence at five minutes before the hour and are sent in the following sequence, expressed in minutes and seconds. The one second dash at the end of the 10 seconds interval in the 59th minute is the signal for the hour.

55:00--55:28	55:30--55:50	55:52--55:55
56:00--56:28	56:30--56:51	56:53--56:55
57:00--57:28	57:30--57:52	57:54--57:55
58:00--58:28	58:30--58:53	58:55
59:00--59:28	59:30--59:50	60:00 (1 sec.)

If the naval radio time signals are not available, they may be obtained by telephone or telegraph from a reputable astronomical observatory or from either of the national telegraph companies at NOON, Eastern Standard Time.

Setting hands

The gold seconds hand on the large dial is driven by a Telechron self-starting synchronous motor in the rear of the movement, and this same motor keeps the spring movement constantly wound. The gold hands on the two upper dials can be set by controlling the motor switches in the top of the clock. This can be easily done by closing the motor switch at the instant that the black hand passes beneath the gold hand. DO NOT SET EITHER THE BLACK OR THE GOLD SECONDS HANDS MANUALLY.

Auxiliary dial

The hand of the small auxiliary dial, at the top of the movement, is driven by an independent Telechron motor and is provided for emergency operation. If, for any reason, the motor which drives the gold seconds hand on the large dial should stop, it will still be possible to maintain constant average frequency by comparing the black seconds hand of the large dial with the gold seconds hand of the small auxiliary dial. Both gold hands should always be set to indicate the same time so that if either one fails to operate, the other one will still be available.

This auxiliary dial can be used to regulate the frequency at any time if it is necessary to repair or replace the motor in the in the main movement. It is recommended that an additional Telechron Motor be held in reserve so that it can be used to replace either of the motors in the Master Clock.

Pendulum spring

The spring for the pendulum movement was wound before the Master Clock was shipped from the factory, and, unless it runs for more than a day while the motor is stationary, it will not require any additional winding. If the spring should run down, which it will do if the main motor is stopped and the clock continues to run for several days, it will be necessary to rewind it by means of the key on the winding arbor in the back of the movement. The spring should not be tightly wound. If it were, the motor might tend to over wind it. An easy way to avoid this danger is to allow the pendulum movement to run for at least twelve hours, after the spring has been wound fairly tight, before STARTING the main motor. In the meantime, the hand of the auxiliary dial may be used to obtain the correct frequency.

CAUTION: Do not permit the main motor of the Master Clock to run for any considerable length of time if the pendulum is standing still. Such a condition may cause the motor to overwind and thus break the clock spring.

Wall Clock

A Telechron wall clock with a sweep second hand is included with the Type A Master Clock and should be mounted near the latter where it can be readily observed by the switchboard operators. This Telechron clock will allow a check to be made on the system at all times, and, in an emergency while the Master clock is out of service, will also permit accurate frequency regulation by comparing its sweep second hand with that of an accurate watch or clock. It will not be necessary to connect this Telechron clock directly to the Master Clock for it can be plugged into any regulated alternating current circuit of the proper voltage and frequency.

Operation of Master Clock

When the Master Clock has been accurately regulated by a number of successive timing tests, it is ready to be used in controlling the frequency. The switchboard operators should be instructed to keep the black and gold second hands together by adjusting the frequency from time to time whenever these two hands show any tendency to diverge. It should not be necessary to make any adjustments more often than three or four times an hour depending of course, upon load conditions, sensitivity of governors, etc. On a large system it will be the best practice to keep the two hands together at all times with a maximum error of not more than two or three seconds at any time.

Power interruptions

If the power supply to the Master Clock is interrupted for any reason, the gold hand will, of course, stop but the black hand will continue to operate. When the power is restored to the clock, the black and gold hands will no longer be together. The operator should not attempt, under these conditions, to change the normal frequency so as to bring the hands together but instead he should open the motor switches in the top of the clock and allow the black hand, on its next revolution, to catch up with the gold hand at which time the switches should be closed. Under no conditions should a divergence between the hands be overcome by manual resetting.

Recording Master Clock connections

On the left hand side of the top of the case is a small porcelain cleat which should be connected to the small contact mechanism on the left side of the main movement. These connections are to be used when a Telechron Recording Master Clock is installed in connection with the Type A Master Clock. The contact mechanism should be connected to the Recording Master Clock as shown in blueprints attached to the latter. It is sometimes advantageous to connect a low powered bell to this circuit so that the clock time may be checked over the telephone.

Overhaul

The Master Clock should be cleaned and overhauled every two years. At the same time, it is recommended that the two motor units be replaced. No difficulty will be encountered in changing the units and the only care necessary is to locate the new motor casings in the field in the same position as the old. When desirable, a similar master clock can be shipped as a temporary replacement while the original master clock is returned to the factory for overhaul and repair. Such an overhaul results in practically a new movement at a very reasonable charge.

Any communications concerning the operation, construction, etc., of Telechron Master Clocks should be addressed to the Commercial Engineering Department.

WARREN TELECHRON COMPANY
Ashland, Mass., U. S. A.

Patents: October 29, 1918; March 14, 1922; July 22, 1924

8-17-34 5ØØ

The material contained in the 3 versions of the Type A Monitor Clock instruction manuals has been coordinated by the journal Co-Editor, Dr. George Feinstien.

--- MART ---

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REVERE Electric Clock Service Manual, $3.50 each PPD. Also two 12 page Booklets from Self-Winding Clock Co., Schedule of parts, Style F and Style A & C Movements, $2.45 each PPD. Tom Welch, Box 23753, Eugene, OR 97404

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The
JOURNAL
OF THE
ELECTRICAL HOROLOGY SOCIETY
Chapter No 78
NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.
VOLUME XVIII, #2, JULY 1992

Fellow Horologists:

Have you heard the story about the man who fell off the Empire State Building? As he passed the 84th floor on his way down, he was heard to say, "So far, so good."

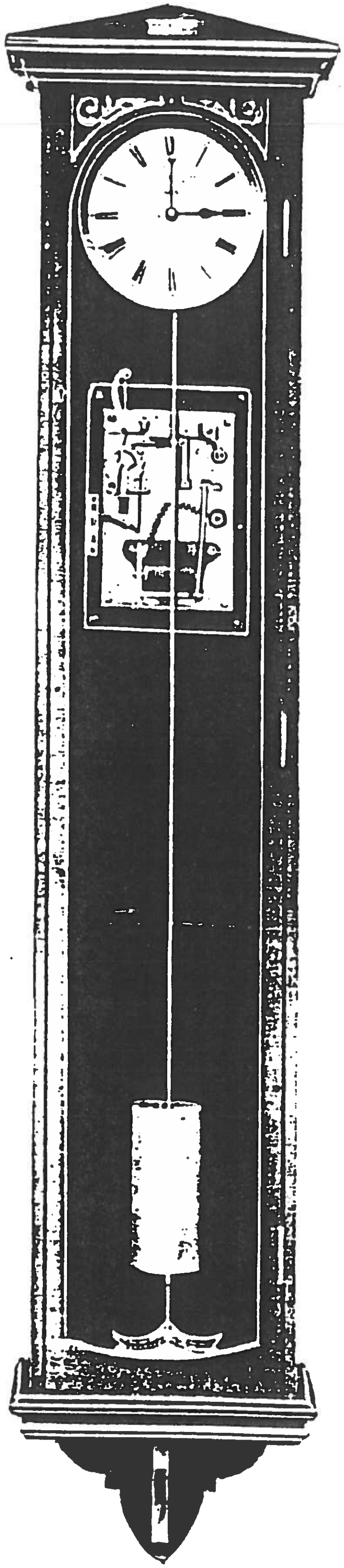
The Electrical Horology Society, Chapter 78, is in the same position... We are the fortunate recipients of a Presidential Citation awarded at the recent National Convention of the NAWCC in Chicago. So we can now say, "So far, so good" but let's keep an eye on the future, and not slack off and rest on our laurels. The award was presented because our Journal has become a standard for reference, used by our Library, and frequently quoted in response to inquiries by the membership. We need the continued cooperation of our members, with an ongoing supply of material for publication. Reprints of older and obscure information as well as new, original articles. We can all stand proud, and look to even greater accomplishments in the future.

In addition, our Secretary/Treasurer, Harvey Schmidt, was honored with a Certificate of Appreciation, recognizing his efforts in our behalf. Well done, Harvey!

Back to the National Convention... the exhibit theme was ELECTRICAL HOROLOGY, and thanks to Elmer Crum, exhibit chairman, the display was unbelievable, containing hundreds of electrics of every description, both rare and popular, many never before exhibited anywhere. Elmer worked tirelessly in soliciting items for display, in building and assembling the free-standing display supports, in labeling and placing the various items in appropriate groupings, and, in general, managing to get the show on the road in such professional manner as to rival any museum's electrical clock disply. HATS OFF!

William Keller compiled and edited the souvenier book, originally intended as a small booklet, as a catalog of the clocks on display in the exhibit. This turned into a 100+ page book of photos and historical background covering the exhibit content that will be a reference standard for years to come. The title, 150 YEARS OF ELECTRIC HOROLOGY covers it all, with an emphasis on American electric clocks. Various electrical collectors were enlisted to research a specific maker and provide material for the publication, with the editing and re-writing handled by Bill. (Where necessary) Additionally, professional photos of many of the display items enhanced the descriptions and historical information. Another well-deserved HATS OFF, Bill Keller!

(continued to page 26)



THE "SYNCHRONOME" MASTER=PIECE.

An electrically driven pendulum which will operate any number of electrical impulse clocks.

The pendulum is combined with a simple switch in such a manner that both the **time-keeping** and **switching** functions are performed automatically and in an ideally perfect manner.

Each dial has only a "one-wheel" movement behind it, yet this simple mechanism secures uniform and accurate time-keeping without winding up or any other attention.

THE SYNCHRONOME CO.,

(F. HOPE-JONES, M.I.E.E., ETC.)

Contractors to:

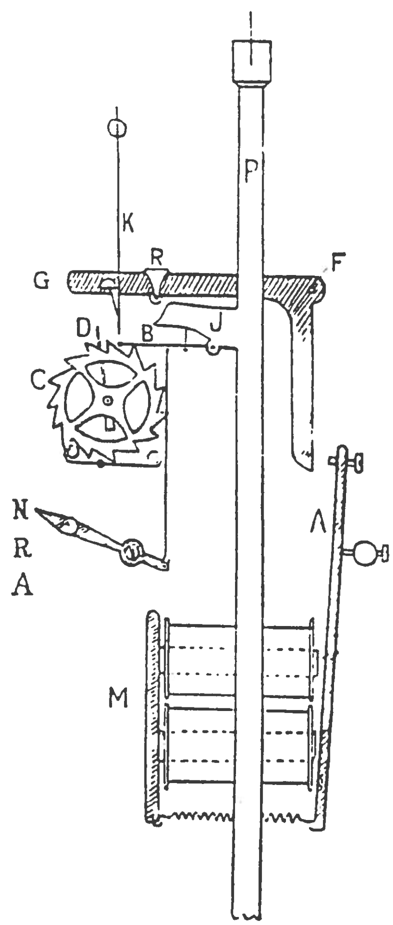
The Admiralty.
The Agents General of the Colonies.
The Great Railway Companies.
The National Telephone Co., Ltd.
The London County Council.
The Metropolitan Asylums Board, Etc.

32 & 34, Clerkenwell Road,
LONDON, E.C.

Telephone No. 4643 Holborn.

THE switch consists of two moving parts: (1) the right-angled lever G centred at F and normally supported on spring catch K. Once every half-minute the lever is let down (in the act of giving an impulse to the pendulum P) upon (2) the armature A. Current from any available source then passes through the series circuit of dials and the magnet M, which attracts the armature A and throws up the lever G on to its catch again.

The pendulum releases the switch by means of the fifteen-toothed wheel C which carries a vane D engaging with the catch K at each revolution. The hook B pivoted upon the pendulum P turns this wheel once every thirty seconds. At the moment of its release the little roller R on the gravity arm G is just above the curved end of the pallet J, down which it runs, giving an impulse to the pendulum **at the moment when it passes through its zero or central position.** Thus the pendulum is free at all times except in the middle of its swing: not only is the escapement detached, but it operates at zero, thus realizing the ideal which horologists have been aiming at for centuries.

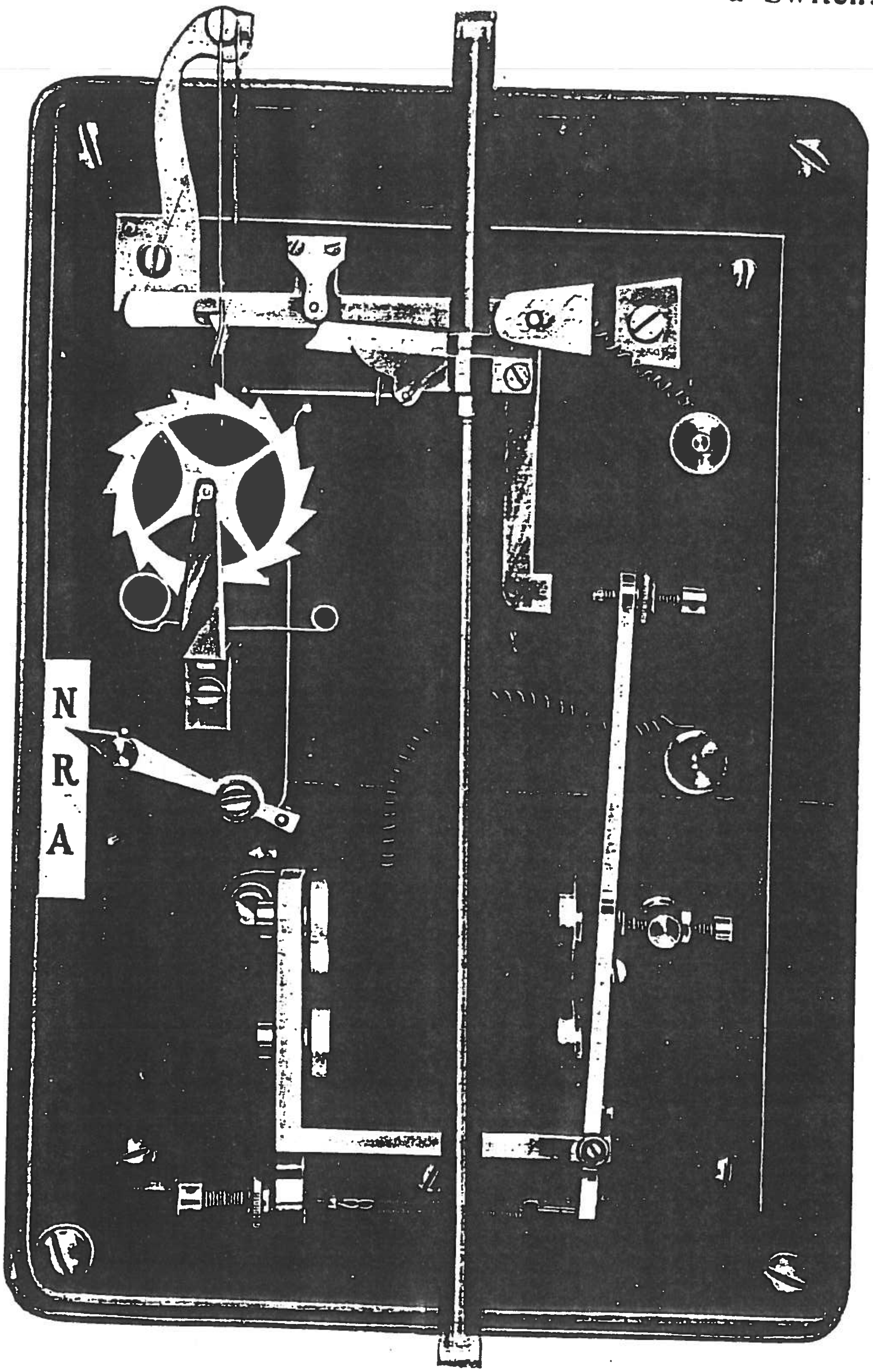


The shape of the impulse surface of the pallet J is mathematically produced to yield an impulse, beginning with extreme gentleness, increasing to a maximum at zero, and diminishing in identical ratio.

The switch cannot stop in closed circuit.

The dials can be readily set to time by merely removing the lever from Normal to Retard or Accelerate.

The Ideal Combination of a Pendulum and a Switch.



PATENTED.

Perfectly Simple and Simply Perfect.

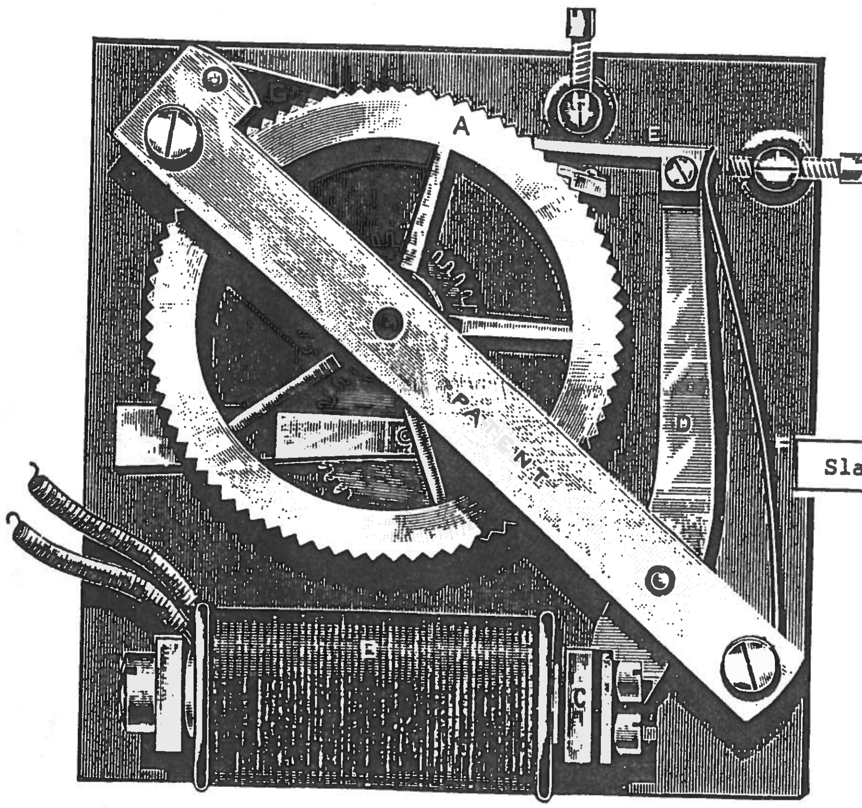
BATTERY WARNING.—When pallet **J** pushes roller **R** attention is required. Each contact will then be a whole second in duration, and this is clearly noticeable also on every dial.

Note the square plate used in the early models...(editor's note)

This electrical contact, occurring at each half-minute precisely, is the only contact in the system, and it is a very perfect one: **the whole of the energy required to keep the pendulum swinging being transmitted through its surfaces.**

It is so designed that at each operation **it transmits to all the dials sufficient current to propel them.** By an entirely novel application of the phenomenon of self-induction, it becomes impossible for the switch to operate without doing so.

Thanks to these two essential principles, which were first enunciated by Mr. Hope-Jones in a lecture before the Institution of Electrical Engineers in 1899, clock dials, with ideally simple mechanism, can be electrically propelled in perfect synchronism.



Slave unit (editor's note)

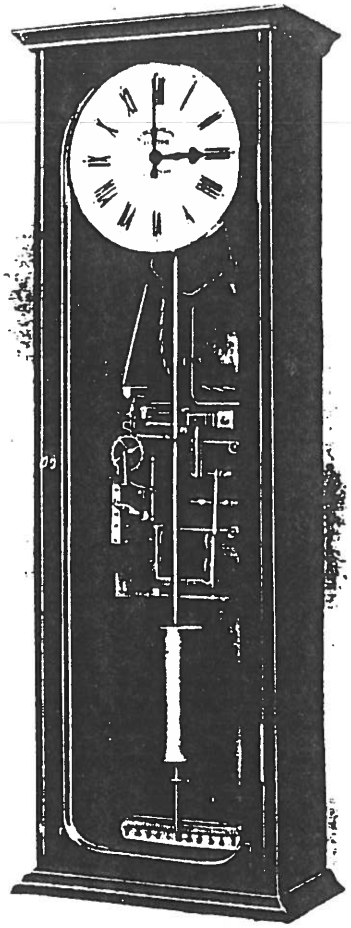
Step-by-Step Dial.

Published in this form ten years ago —Beware of Imitations.

A is a wheel having 120 rectangular teeth, and is rigidly connected with the minute hand. **B** is an electro-magnet with armature **C** and lever **D** carrying a pawl **E** at its end. **F** is a spring, **G** a backstop click, and **H I** are fixed stops.

The impulses from the controlling clock pass through the electro-magnet each half minute, causing it to attract the armature and allow the driving click to pick up another tooth. The spring then carries it forward, the wheel remaining rigidly locked.

The dials are almost noiseless in action, and a perpectly silent movement can be put in whenever required.

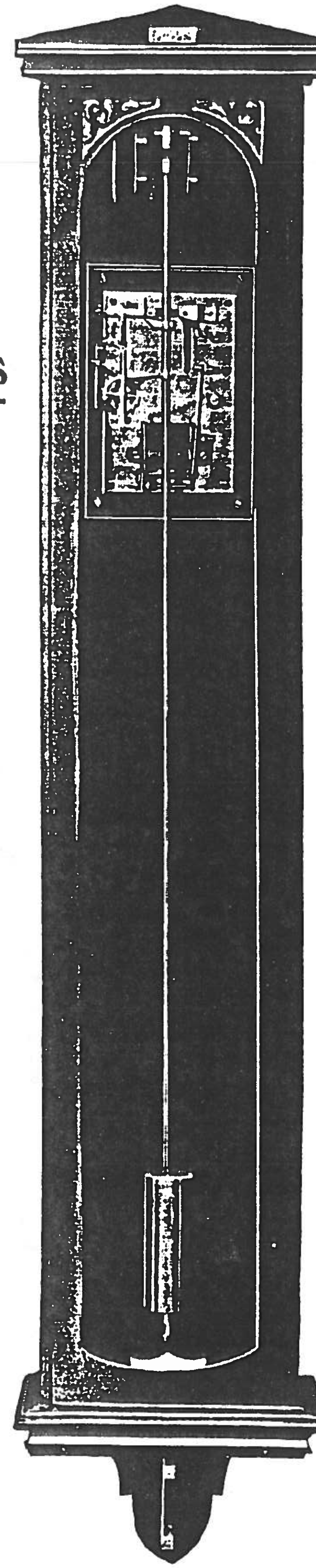


PRICE LIST.

Controlling Pendulums

With Steel Rods and Lead Bobs.

In Polished Oak or Walnut Cases, With Glass Fronts.



	£	s.	d.
CONTROLLING PENDULUMS:			
Of ¾ seconds beat (22·01 long, 80 beat) ..	6	0	0
Of seconds beat (39·14 long, 60 beat) ..	9	10	0
Or the same, but with rod of "Invar" (Nickel Steel)	12	12	0
Extra for extension at base of case to enable it to stand on the floor	1	0	0
Supplied also without case; suitable for fixing in the body of a Grandfather Clock; with steel and lead pendulum ..	7	5	0
With "Invar" pendulum	10	7	0
Extra for silvered engraved dial to either of the above as illustrated	1	7	6
PRECISION REGULATOR FOR OBSERVATORIES, with highest grade "Invar" Pendulum	40	0	0

If desired the switching and self-winding action in this instrument can take place every two seconds instead of every thirty seconds.

The word "SYNCHRONOME" is registered as a Trade Mark, and the system known by that name is protected by numerous Patents in most countries of the world. The detached gravity escapement in the controlling pendulums above described is the recent invention of Sir H. H. S. Cunynghame, K.C.B., and F. Hope-Jones, M.I.E.E.

PRICE LIST—*continued.*

PLAIN DIALS.

Complete with Movement and Hands.

		£	s.	d.
Wood.	7" diameter, silvered and engraved in solid turned American whitewood case, stained and polished to any colour	1	17	6
	8" diameter, hand painted black on white in wood case, as above	1	17	6
	12" diameter, as above	2	5	0
	18" diameter, as above	3	18	6
Metal.	12" diameter, dial and case, in one piece of stout iron, enamelled at high temperature, and highly finished to imitate hardwood. Dust and weather proof	2	0	0
	18" diameter, as above	3	10	0
	24" diameter, as above	4	17	6
	35" diameter, hand painted black on white in rolled metal case, japanned black with gilt bands ...	11	18	0
	48" diameter, as above	19	10	0

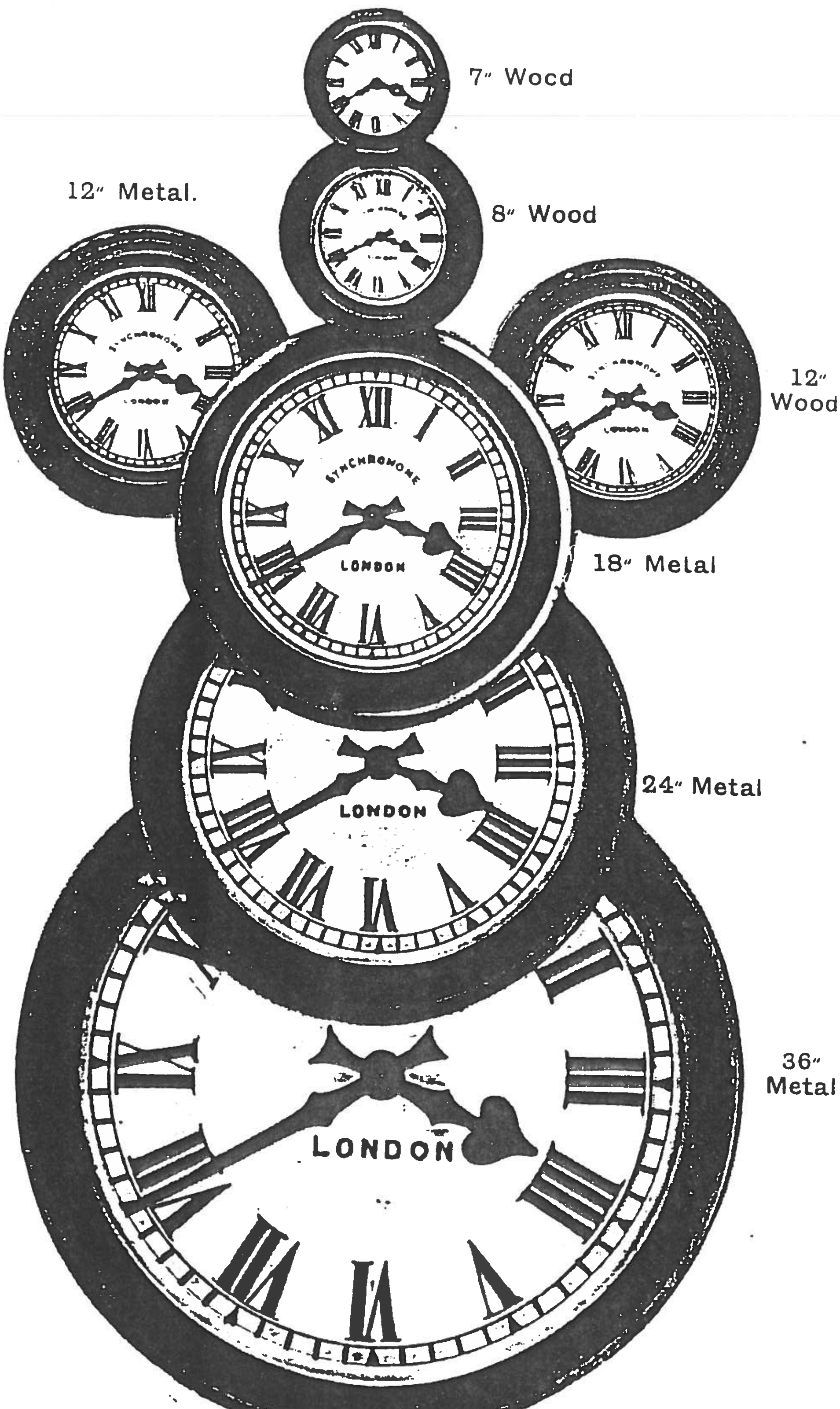
OPAL DIALS FOR ILLUMINATION are provided with circular movements attached to their centres by means of screw collar and rubber washers. These movements are so small that no shadow is thrown by them.

Prices of opal dials complete with movements and hands erected *in glazed openings provided by customer:*

		£	s.	d.
18"	diameter	4	2	6
24"	,,	5	8	6
30"	,,	8	18	6
36"	,,	12	16	0
4' 0"	,,	19	0	0
5' 0"	,,	24	0	0
6' 0"	,,	27	10	0

TURRET CLOCKS. Electro-magnetic release for applying to the escapement of an ordinary turret clock in place of its pendulum 5 17 6

The clock will require to be wound up as usual, but will then keep uniform time with all other dials on the circuit.



These dials having no "clock-works" inside, lie flat against the wall. They are hung on single nails like pictures. They cannot be tampered with, for it being unnecessary to get at the hands the glasses are permanently fixed.

EMPLOYEES' TIME RECORDERS of all patterns are electrically propelled by substituting our dial movement for the heavily driven clock usually supplied in these machines.

These have been installed in such works as:

Western Electric Co., Ltd., North Woolwich - - -	(26)
John Broadwood & Sons, Ltd., Old Ford, E. - - -	(4)
Debenham & Freebody, Wigmore Street, W. - - -	(8)
Whitaker Bros. & Co., Ltd., Dyers, Leeds - - -	(8)
Stapley & Smith, Hackney, N.E. - - - - - -	(6)
Henry Livesey & Son, Blackburn - - - - - -	(9)
Newcastle Corporation Electric Tramways - - - - -	(15)
Lloyds, Ltd., and Daily Chronicle - - - - - -	
J. Parkinson & Son, Shipley, Yorks. - - - - -	
Selfridge & Co., Ltd., Oxford Street, W. - - - - -	
Etc., Etc.	

Price of large movement, including fitting in place of ordinary clock-works - - - - -	£3 10 0
Or Electro-Magnetic release applied to the existing clock movement in place of its pendulum - -	£2 10 0

BELL CONTROLLER.

For ringing a circuit of ordinary electric bells automatically at pre arranged times. This instrument may be placed in any time-circuit wherever desired as an ordinary dial. In its simplest form it consists of a one-wheel dial movement provided with a disc of vulcanite carrying copper segments in its periphery, to make contact with a spring at **one or more half-minutes in every hour.** A wheel revolving once in twenty-four hours is fitted above it, and by means of pins set in its periphery, it selects the required hours in which the bells are to ring.

It is obvious that whatever half-minute calls are made in any one hour, will be repeated in any other hour at which a pin is placed on the wheel. If different half-minute calls are required in different hours. one or more extra discs are provided controlled by longer pins set in the slowly revolving wheel.

PRICES:

With simple programme - - - - - -	£7 17 0
With double programme - - - - - -	9 15 0

CONTROLLING CLOCKS operated on this principle can be supplied in **any other form**, and the self-winding action is as readily applicable to a balance wheel as to a pendulum.

For passenger Steamers, particularly for **large Ocean Liners**, the system is peculiarly well adapted. For this purpose the switch is applied to a Marine Chronometer, which thus becomes a self-wound controlling clock capable of operating dials wherever required throughout the ship.

The daily alterations necessitated by change of longitude at sea is effected in all the dials simultaneously by merely altering the "Pilot" dial usually placed in the Chart Room.

CREDENTIALS

FIRST IN 1895

The Synchronome Company Ltd., was established in 1895 by—

F. HOPE-JONES, M.I.E.E., F.R.A.S., F.B.H.I., etc., Liveryman of the Worshipful Company of Clockmakers, Past Chairman of Radio Society of Gt. Britain 1914/24, Past Chairman of British Horological Institute, 1924/5; who invented the first reliable system of electric clocks and enunciated the SYNCHRONOME PRINCIPLES in the following Lectures, Patents, etc.

ORIGINALITY AND SCIENTIFIC MERIT

1895. Patent No. 1587, by F. Hope-Jones & G. B. Bowell.
1895. Lecture, British Horological Institute, by F. Hope-Jones.
1897. Patent No. 7868, by F. Hope-Jones & G. B. Bowell.
1899. Paper, Inst. of Electrical Engineers, by F. Hope-Jones.
1901. Article in Fielden's Magazine, by F. Hope-Jones.
1905. " Electrician " Primer, by F. Hope-Jones.
1905. Patent No. 6066, by F. Hope-Jones.
1906. Paper, Brit. Horological Journal, by F. Hope-Jones.
1907. Patent No. 1945, by F. Hope-Jones & Sir H. H. S. Cunynghame.
1910. Paper, Inst. of Electrical Engineers,* by F. Hope-Jones.
1910. Lecture, British Astronomical Association, by F. Hope-Jones.
1911. Lecture, Royal Astronomical Society, by F. Hope-Jones.
1911. Patent No. 12328, by W. H. Shortt, M.Inst.C.E.
1914. " Electrician " Primer, new edition, by F. Hope-Jones.
1915. Patent No. 9527, by W. H. Shortt, M.Inst.C.E.
1919. Patent No. 138708, by F. Hope-Jones.
1921. Patent No. 187814, by W. H. Shortt, M.Inst.C.E.
1923. Lecture, British Horological Institute, by F. Hope-Jones.
1924. Lecture, Royal Society of Arts,† by F. Hope-Jones.
1925. Patent No. 239017, by F. Hope-Jones.
1929. Patent No. 323001, by F. Hope-Jones.
1929. Lecture, British Horological Institute.
1930. Lecture, British Horological Institute.
1931. " ELECTRIC CLOCKS," by F. Hope-Jones, the standard work on the subject.

* Awarded extra premium. † Awarded silver medal.

THE ORIGIN OF AN INDUSTRY

The above inventions not only *founded a system* but have *established an industry* since all systems of British origin have adopted or adapted them.

Synchronome installations outnumber those of all other systems put together. The following are a few of many thousands :—

SOME NOTABLE INSTALLATIONS

Imperial Chemical Industries Ltd., Millbank, S.W. ... ... (The largest installation in the world operated from one Master Clock.)	680 Dials
Nestle & Anglo-Swiss Condensed Milk Co. Ltd.	120 ,,
J. Lyons & Co. Ltd., Cadby Hall, W. & Greenford	147 ,,
John Player & Sons, Nottingham	150 ,,
Lever Bros. Ltd., Port Sunlight	172 ,,
Unilever House, Blackfriars	170 ,,
Iliffe Press, Ltd., Stamford Street, S.E.	280 ,,
Asiatic Petroleum Co. Ltd.	220 ,,
Anglo-Persian Oil Co., Finsbury and Skewen	418 ,,
Vickers, Ltd., London, Sheffield, Barrow, etc.	436 ,,
Guest, Keen & Nettlefolds, Ltd., Smethwick	118 ,,
Crittall Manufacturing Co. Ltd.	106 ,,
Austin Motor Co. Ltd., Northfield, Birmingham	202 ,,
Morris Motors, Ltd., Cowley (51 Employees' Time Recorders)	68 ,,
London Hospital & Medical College	231 ,,

Middlesex Hospital, 100 Dials, and innumerable Universities, Colleges, Schools, Town Halls, Municipal Offices, Hospitals, Banks, Insurance Buildings, Hotels, etc.

BROADCASTING HOUSE, and *all* the Transmitting Stations of the B.B.C. for whom Mr. Hope-Jones originated the six dot seconds time signals.

SOME NOTEWORTH ACHIEVEMEN

The Cable Stations of the Eastern & Western Telegraph Companies all round the world are also equipped with *Synchronome* Master Clocks which transmit seconds as well as half-minute impulses.

All the larger London Stores are equipped with *Synchronome* uniform and accurate time, notably HARRODS, the ARMY & NAVY STORES, SELFRIDGES, and LIBERTY'S, where St. George chases the Dragon every 15 minutes, and slays him every hour.

Many great Railway Stations, such as Euston and Waterloo.

THE SYNCHRONOME SYSTEM HAS REVOLUTIONSED THE CONSTRUCTION OF TURRET CLOCKS BY DISPENSING WITH THEIR WORKS.

THE WORLD RECORD

The famous "FREE PENDULUM," designed by Mr. W. H. Shortt, M.Inst.C.E. in association with the Synchronome Company, has measured the time of the world at Greenwich since 1925, having regained for England the record for accuracy here and in foreign Observatories.

THE NEW MAINS CLOCI

Thirty-eight years ago, in 1895, Mr. Hope-Jones forecasted the synchronous motor clock as the ultimate means of time distribution. The "**SYNCHRONOMAINS**" clock is **the best of this type.**

The timing of the frequency in the Electricity Generating Stations is a great National duty, and is being largely accomplished by the new Synchronome "Free Pendulum type" Master Clock, aided by the six dot seconds.

TESTIMONY

"I must assert, and I think with authority, that by no man, living or dead, have Electric Clocks been brought to such perfection as they have been by Mr. Hope-Jones."

H. R. KEMPE, M.I.E.E., former Chief Electrician to the Post Office.

"I have no hesitation in saying that your System as installed at Nottingham is as near perfection as anything ever will be in this world, and I shall be very pleased to give this recommendation, privately, to any one."

JOSIAH SAYERS, M.I.E.E., Chief Telegraph Superintendent, L.M. & S. Co.

". . . The clock system is a joy, and the envy of everyone who sees it. My Architect is going to mention it in an article on the restoration of this house which I believe he proposes to publish."

Lt.-Col. J. V. RAMSDEN, C.M.G., D.S.O., Shrewsbury.

"I really can hardly express the emotion aroused by thinking of the quality of the performance of your clocks, and I feel privileged in writing to the man who has added what you have to human achievement. I hope you will not think me too effervescent—I am not ordinarily so; but I feel that effervescence in this case is unavoidable; the alternative would smack of wooden-headedness."

JOHN J. BOWMAN, Principal, Bowman Technical College, Pennsylvania, U.S.A.

CREDEN

CATALOGUE E.I. 35.

SYNCHRONOME ELECTRICAL IMPULSE CLOCKS

The Synchronome Co., Ltd.

SALES AND CONTRACTS DEPARTMENT
(to which all enquiries should be addressed)

19, CAXTON HOUSE,
WESTMINSTER,
LONDON,
S.W. 1.

TELEPHONE WHItehall 4157.

HEAD OFFICE AND WORKS:—

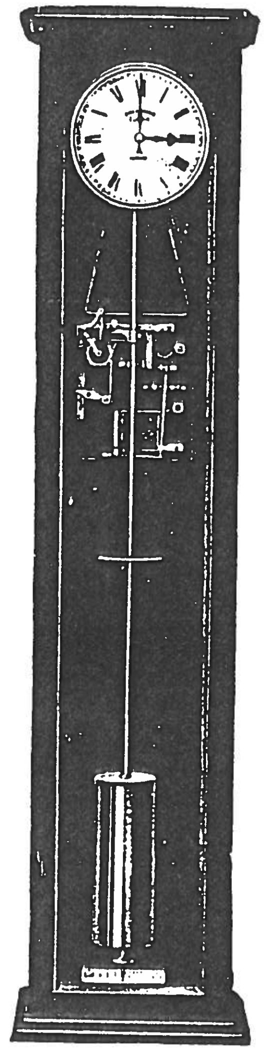
32, 34, CLERKENWELL ROAD,
LONDON, E.C. 1.

Managing Director:
F. HOPE-JONES.
M.I.E.E., F.R.A.S.

TELEPHONES: CLErkenwell 1517, 1518 & 5129.

THE CONTROLLING PENDULUM or MASTER CLOCK

(Standard Type)



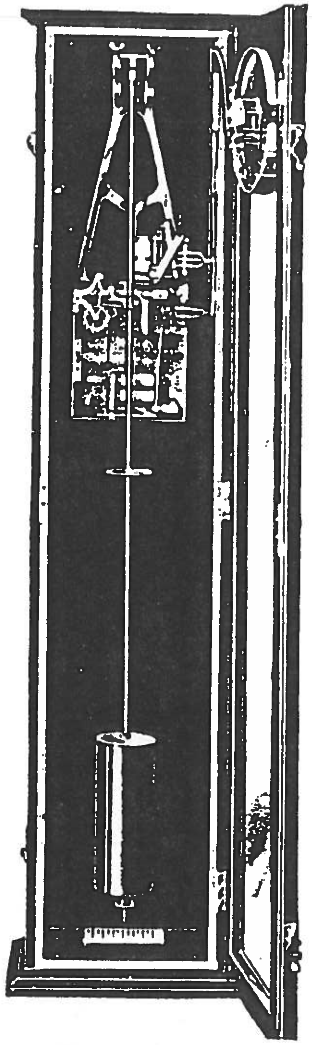
is a combination of a pendulum and a switch and will operate any number of subsidiary clocks of any size including Turret Clocks, thus ensuring uniform time throughout the premises without winding or other attention.

The pendulum has a rod of INVAR, a nickel steel alloy having a negligible temperature coefficient.

It has a free detached gravity escapement with impulse at zero, the time counting and releasing of the gravity lever being performed by a jewelled mechanical action.

Overall dimensions of case—51 inches long, 12½ inches wide, 6½ inches deep.

Master Clock, Standard Type, complete with 7" silvered engraved dial	£17 10s. 0d.
Master Clock without dial	£14 0s. 0d.
Movement only, for fitting into customer's own case	£12 7s. 6d.
Superior type Master Clock with steel cylindrical bob and weight-tray for more precise regulation	£22 0s. 0d.



THE CONTROLLING PENDULUM or MASTER CLOCK

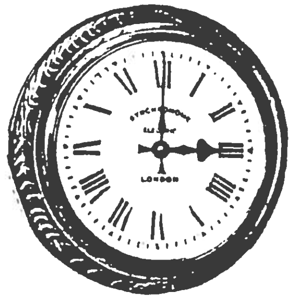
(with seconds contact)

This instrument shown with its door open is similar to that on page 8, but is provided with means for transmitting impulses at intervals of one second in addition to impulses every thirty seconds.

The seconds contact is produced by a subsidiary Synchronome Switch released by a jewelled steel toggle on the pendulum. Its duration is determined by the self-induction of the circuit, and a powerful switching action is obtained without any interference with the high standard of timekeeping of the pendulum.

Useful for many scientific and industrial purposes where seconds impulses are required. Its time-spacing is accurate to one-thousandth part of a second.

Standard type, as described on page 8, but with seconds transmitting contact and inset seconds hand on dial	**£27 2s. 6d.**
Superior type, as above, but with cylindrical steel bob and weight-tray for more precise regulation of the pendulum	**£31 12s. 6d.**



SURFACE MOUNTING DIALS

TYPES "A" AND "B"

The "A" type is fitted with matt-white or cream dial, bronzed spun bezel and sheet glass, mounted in whitewood frame, stained and polished to any desired shade.

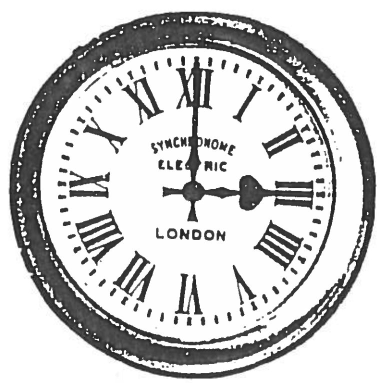
The "B" type is fitted with hand-engraved and silvered brass dial, cast bezel and bevelled plate glass, mounted in mahogany, walnut or oak frame which can be polished to any desired shade.

Dial size. Inches.	Overall size. Inches.	Projection. Inches. "A"	"B"	Price for "A" type. £ s. d.	Extra for hardwood frame. £ s. d.	Price for "B" type. £ s. d.	Extra for Convex dial and Glass. £ s. d.
6	8.5	2.4	2.5	2 13 0		3 10 6	7 6
7	9.4	2.4	2.5	2 15 0		3 15 0	7 6
8	10.6	2.4	2.5	2 17 0		4 0 0	10 0
9	11.6	2.4	2.5	2 19 0	5 0	4 12 6	10 0
10	13.0	2.4	2.5	3 1 0		4 18 6	10 0
12	15.2	2.4	2.5	3 3 0		5 10 0	1 0 0
14	17.3	2.6	2.6	4 0 0	6 6	7 2 6	1 0 0
16	20.0	2.7	2.8	4 19 6	7 6	8 12 6	1 0 0
18	22.2	2.8	3.0	5 18 6	10 0	9 12 6	1 10 0
20	24.5	3.0	3.2	7 15 6	15 6	13 5 0	—
24	28.5	3.2	3.5	9 4 6	1 5 0	15 10 6	...

TYPE "C" (Workshop Pattern)

The frame and dial consist of a single sheet steel stamping, high temperatured vitreous enamelled, the hands protected by glass.

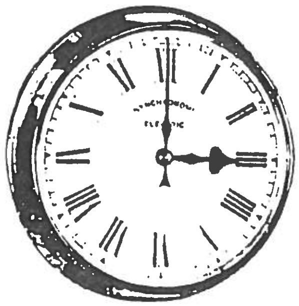
Specially designed for use in workshops, etc.



Dial size. Inches.	Overall size. Inches.	Projection. Inches.	Price. £ s. d.
12	16.8	2.5	3 0 0
18	23.0	3.3	4 5 0
24	29.5	2.8	6 5 0

NOTE.—When this dial is supplied for use exposed to the weather, the movement is enclosed in a cast metal box, drilled for conduit entry or cable gland.

SURFACE MOUNTING DIALS



TYPE "D"

Bronzed metal frame, matt-white or cream dial, Roman or Arabic numerals.

Dial size. Inches.	Overall size. Inches.	Projection. Inches.	Price. £ s. d.
6	7.0	2.2	2 5 6
8	9.0	2.2	2 7 6
10	11.5	2.2	2 9 6
12	14.0	2.2	2 12 0
18	21.0	2.2	4 5 0

TYPE "E"

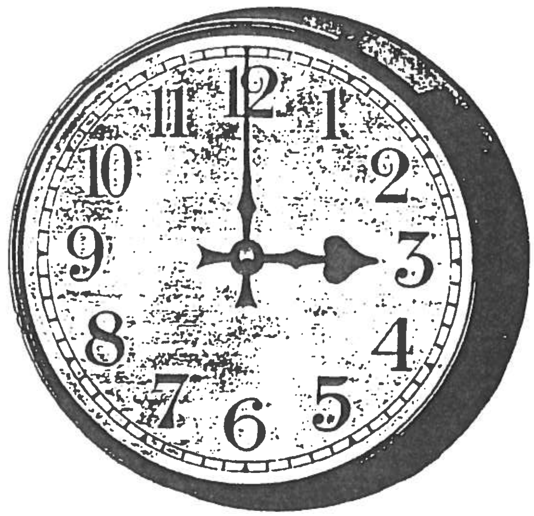
BAKELITE FRAME

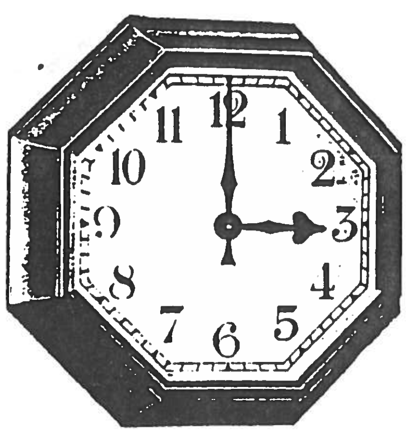
Finishes : Oak, Mahogany, Black, Walnut.

Matt-white or cream dial with Roman or Arabic figures.

12 in. dial, 13¾ in. overall, 2½ in. projection.

Price £2 12s. 0d.





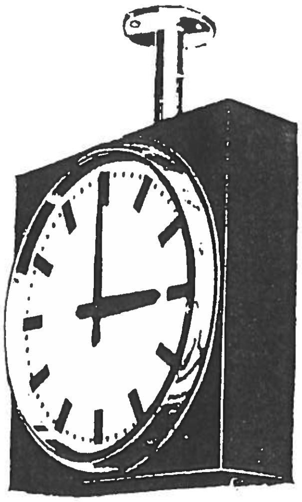
TYPE "F"

BAKELITE FRAME

Finishes : Mahogany, Black, Walnut. Matt-white or cream dial, Arabic figures only.

8 in. dial, 11 in. overall, 2½ in. projection.

Price .. .. £2 8s. 6d.



TYPE "LM"

Matt-white dial with black ciphers, chromium-plated cast bezel with bevelled plate glass, mounted in square ebonised case, for either surface or insertion mounting, with projection of 2¼ in. and 1¼ in. respectively.

Dial size. Inches.	Overall Size. Inches.	Price. £ s. d.
8	9	3 17 6
10	11¼	4 17 6
12	13¾	5 5 0

DOUBLE-FACED CLOCKS

(As illustrated)

TYPE "DLM"

Exactly to the specification given above, complete with 18 in. chromium-plated suspension fittings.

Dial size. Inches.	Overall size. Inches.	Depth. Inches.	Price. £ s. d.
8	9	6	9 0 0
10	11¼	6	11 0 0
12	13¾	6	12 10 0

TYPE "BBC"

Matt-white dial with black cipher marks, chromium-plated bezel with bevelled plate glass, for either insertion or surface mounting, the latter having oak, mahogany or walnut frame.

Dial size. Inches.	Overall size. Inches. Surface.	Overall size. Inches. Insertion.	Projection. Inches. Surface.	Projection. Inches. Insertion.	Price. £ s. d.
8	10.6	8.5	2.5	0.83	3 12 6
10	13.0	11.0	2.5	0.87	4 5 0
12	15.2	12.7	2.5	0.9	4 15 0
18	22.2	19.4	2.8	1.1	8 5 0

TYPE "DM"

Bronzed metal frame for surface mounting with matt-white or cream dial with black cipher marks.

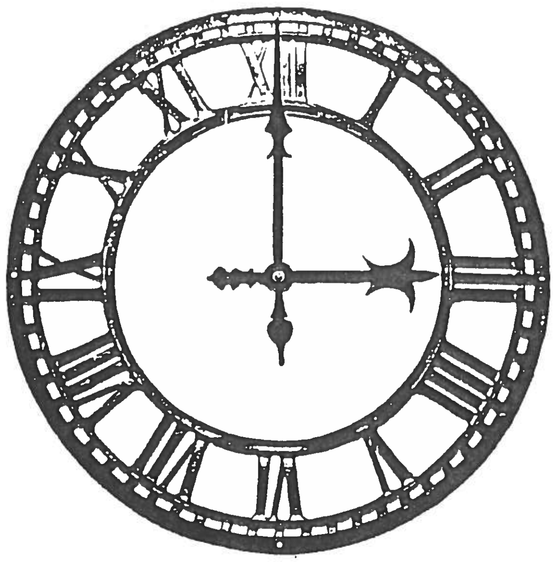
Dial size. Inches.	Overall size. Inches.	Projection. Inches.	Price. £ s. d.
6	7.5	2.2	2 15 6
8	9.0	2.2	2 17 6
10	11.5	2.2	2 19 6
12	14.0	2.2	3 2 6

Can also be supplied with frame chromium-plated or cellulose-enamelled to approved colour at additional cost.

SKELETON DIALS FOR INTERIOR USE

SUITABLE FOR ENTRANCE HALLS OF PUBLIC BUILDINGS, BANKING HALLS, Etc.

The dials are fixed directly to the wall surface or panelling, which should be coloured to form the greatest possible contrast with the dial itself. The movements, which are enclosed in dust-proof metal boxes, are mounted on metal plates fixed separately to the wall or panelling. A recess 6 in. diameter by 2 in. deep is required to accommodate the movement, and this recess is covered by the metal plate above referred to.



TYPE "TS"

Consisting of a casting of brass or bronze with raised Roman chapters superimposed upon three concentric rings, minute marks being arranged between the two outer circles.

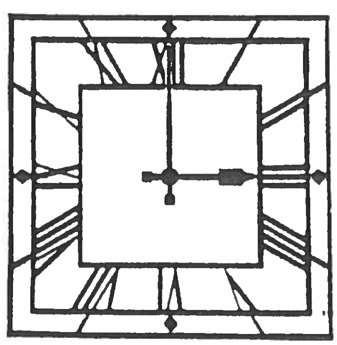
Brass (finished bronze if desired).

	£	s.	d.
18 in. diameter	7	10	0
24 in. ..	9	5	0
27 in. ..	12	0	0
30 in. ..	16	10	0

Real bronze metal.

	£	s.	d.
18 in. diameter	8	5	0
24 in. ..	9	17	6
27 in. ..	13	0	0
30 in. ..	18	0	0

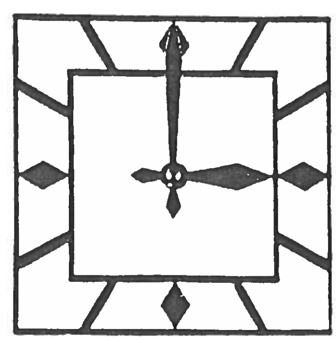
As an alternative to bronze, any of the dials on this page can be supplied finished gilt, chromium plate or any colour at additional cost. Prices on application.



TYPE "RS"

Fretted from a single sheet of bronze, the movement being mounted on separate plate as detailed above.

12 in. square	£5 5s. 0d.
18 in.	£8 5s. 0d.
24 in.	£9 17s. 6d.
30 in.	£18 0s. 0d.



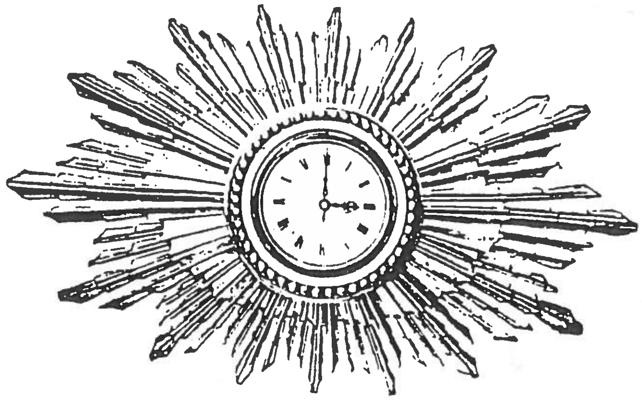
TYPE "MS"

Fretted from a single sheet of bronze, the movement being mounted on separate plate as detailed above.

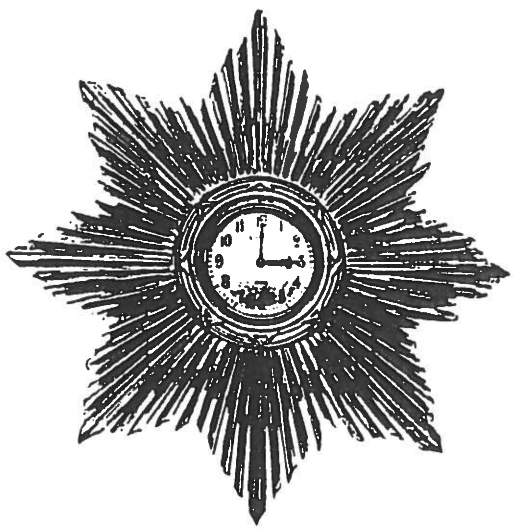
12 in. square	£5 0s. 0d.
18 in.	£7 15s. 0d.
24 in.	£8 17s. 6d.
30 in.	£16 10s. 0d.

If desired, Types "RS" and "MS" can be supplied suitable for use in the open exposed to the weather and fitted with heavy duty type movements sufficiently powerful to drive the hands through any weather. Prices on application.

PERIOD CLOCKS



We are fortunate in our inheritance of the beautiful designs which have come down to us from the hands of such masters as Tompion, Joseph Knibb, Daniel Quare and the incomparable artists of the gorgeous courts of the French Renaissance.



Undoubtedly one of the most pleasing of these designs is that known as the Sunray Clock.

Almost every one of the insertion type dials listed in these pages is appropriate for mounting upon a Sunray frame, but since conditions vary so widely it is left to the individual taste of the customer to choose a suitable type.

OVAL PATTERN

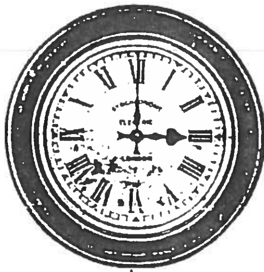
Fitted with "G/I" type dial as described on page 15

	£	s.	d.
20 in. × 15 in. overall, dial 5 in. diameter	12	10	0
24 in. × 18 in. ,, dial 6 in.	14	5	0
32 in. × 24 in. ,, dial 10 in.	18	12	6

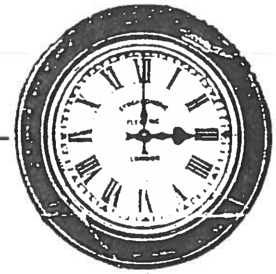
CIRCULAR PATTERN

Fitted with hand-engraved and silvered convex dial and glass.

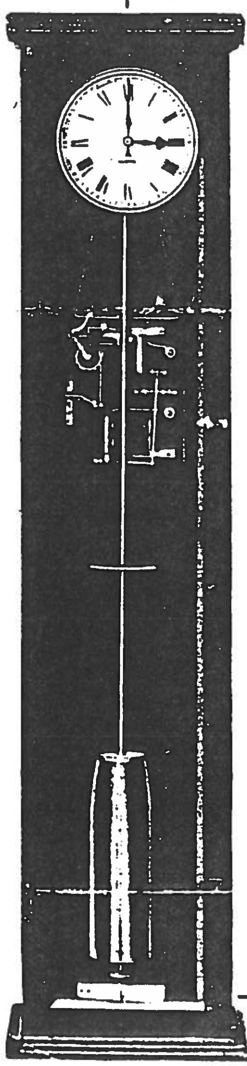
20 in. diameter, dial 6 in. diameter	12	10	0
24 in. ,, dial 8 in. ,, ...	14	10	0
28 in. ,, dial 10 in. ,, ...	17	15	0



TO BE KEPT FOR REFERENCE.

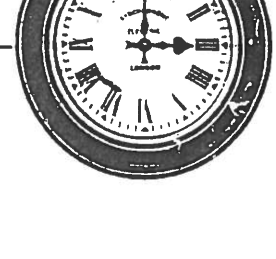


INSTRUCTIONS *for* ERECTION and MANAGEMENT OF Synchronome ELECTRIC Time-Circuits



In Great Britain our prices generally include a visit of inspection to make sure that all the clocks are properly erected and in good order and adjustment. We then accept full responsibility for their safe-going and time-keeping, but we ask that they be put in the hands of a competent assistant provided with a copy of these instructions.

THE SYNCHRONOME CO., Ltd.,
ABBEY ELECTRIC CLOCK WORKS,
WOODSIDE PLACE,
ALPERTON, MIDDLX.



Telephones: WEM. 3643-4-5.

ERECTION

WIRING.—A single line to connect each dial to its nearest neighbour in simple series circuit, as shown in diagram on previous page. Electric light wire of 3/.036 (3/20) gauge is recommended on account of its mechanical strength.

BATTERY. Any form of good primary cell, one being required for every two 12 in. dials in circuit, or two for every three according to quality installed.

Electric Light Supply (D.C.) through a carbon filament lamp as a resistance, or Storage Cells may also be used. The consumption of current is negligible. Join up cells or lamp in series with clocks.

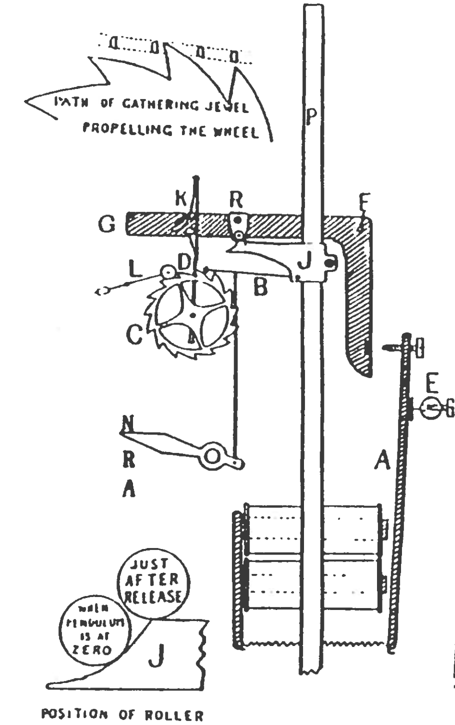
MASTER CLOCK.—Unpack carefully and hang **the pendulum case** on a substantial wall with its top no higher than 6 ft. 6 ins. from the floor.

It is important to hang the case vertically both with regard to in and out and side to side planes, and it should be fixed firmly by means of screws through the back, one on each side of the pendulum suspension and one behind the bob, into Rawlplugs or ordinary wood plugs in the wall. The brass plate at the top of the case is to assist you to hang it temporarily whilst " marking off " for the plugs and screws.

Take the nut and washer off the lower end of the pendulum rod, put the bob on and replace washer and nut, screwing the latter up to such a position that the filed notch in front of the rod is just in sight above the pendulum bob. This will give approximate regulation. Now slip the click B into position. It will be found in a small envelope with the beat plate and the key of the case, tied to the pendulum rod.

The pendulum being now complete, proceed to hang it in position in the following manner. Observe the position of the trunnion and suspension spring on the top of the cast iron bracket, slacken the wing nuts and swing the clamps to one side, thus releasing it. Take out the small metal screw in the split brass head of the pendulum rod and place the lower end of the suspension spring carefully in the slit and fix it by replacing the screw. The complete pendulum may now be hung, the pallet J and click B being on the left and the small set screw on the trunnion being in front ; but before fixing it with the clamps and wing nuts it is necessary to see that the pendulum is in exactly the right position both with respect to in and out and side to side planes.

- A Armature.
- B Gathering click.
- C Wheel.
- D Vane.
- E Stop screw.
- F Pivot.
- G Gravity arm.
- J Impulse Bracket.
- K Catch.
- L Backstop.
- P Pendulum.



To ascertain this, release the catch K allowing the lever G to fall. The steel roller R should then rest on the steepest part of the curve of the impulse pallet J. If not, the pendulum must be moved right or left along the trunnion and fixed by the set screw provided. The trunnion must be parallel with the back of the case and in such a position that the gathering jewel B lies squarely with its middle on the wheel C midway between the points of two teeth. This position can be adjusted by moving the trunnion inwards or outwards on the cast iron bracket, and when correct it should be clamped by the wing nuts.

The gathering jewel B should engage the wheel C with **just sufficient depth** to move one tooth at a time and no more. The steel wire which carries the jewel must not touch the N.R.A. wire when the indicator is at N (normal), and the upper surface of the pallet J should just not touch the roller R. Catch K being released the pendulum should be unable to reset lever G upon it when the current is off. The beat plate may now be placed in position and fixed if desired.

... when the pendulum is at or about zero and travelling (at its greatest speed) through a very small part of its excursion, that it is engaged in (1) turning the wheel (2) releasing the gravity arm, and (3) receiving its impulse. Its entire freedom at all other times (particularly at the beginning and end of each swing when it is moving at its slowest) is the feature of overwhelming importance, and it is in this respect that it realises the ideal which horologists have been striving after for centuries.

THE DIALS may be hung like pictures on single screws or nails. The ends of the line wires must be carefully led into the back of the dial cases and securely gripped in the spring clip terminals.

THE BATTERY can be proved sufficient in the following manner. **Having joined up the instruments in series circuit with all the cells and started the installation, reduce the battery one cell at a time until the magnet is incapable of resetting the gravity lever G without the assistance of the pendulum pushing roller R in its return excursion to the left. This is known as battery warning.** Note the number of cells in circuit when this occurs and replace say 10% or 15% of that number.

MANAGEMENT

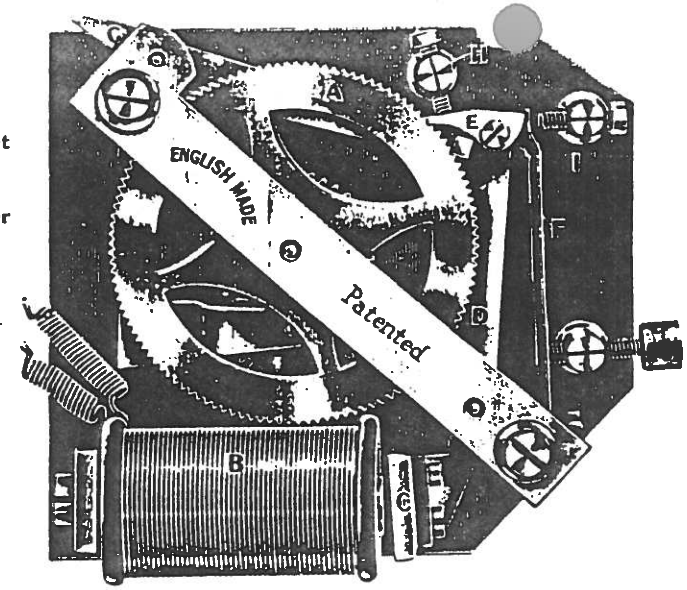
If a breakdown occurs you are earnestly requested to communicate at once with us, as the installation is guaranteed.

If the pendulum has stopped and it is desired to ascertain the cause, note whether **lever G is** supported **on** catch K or is **down,** resting against the pendulum. If the latter, start it swinging again gently with a sufficient arc to enable the contact surfaces to meet. If no current passes, then there is a disconnection at one of the terminals or a break in the line. On the other hand, if the magnet attempts to throw up the weighted lever but is unsuccessful, then either the current is insufficient, the automatic warning of impending failure having been neglected, or there is something preventing the spring catch K from holding the lever G.

If when the pendulum is stopped, lever G is found to be **resting on catch K** and the pendulum only requires to be restarted, the battery and wiring being all right, then the stoppage has been due to something impeding the motion of the pendulum, such as undue friction in the movement of the wheel or its releasing of the catch.

In the event of any one Dial stopping or dropping behind time, take it out of circuit, twist the wires together quickly between successive impulses, noting the precise instant of their occurrence by means of the seconds hand of your watch. Then send a post-card to us for another dial.

A Main wheel
B Electro-magnet
C Armature
D Armature lever
E Driving click
F Driving spring
G Backstop lever
H Momentum stop
I Stroke limit stop

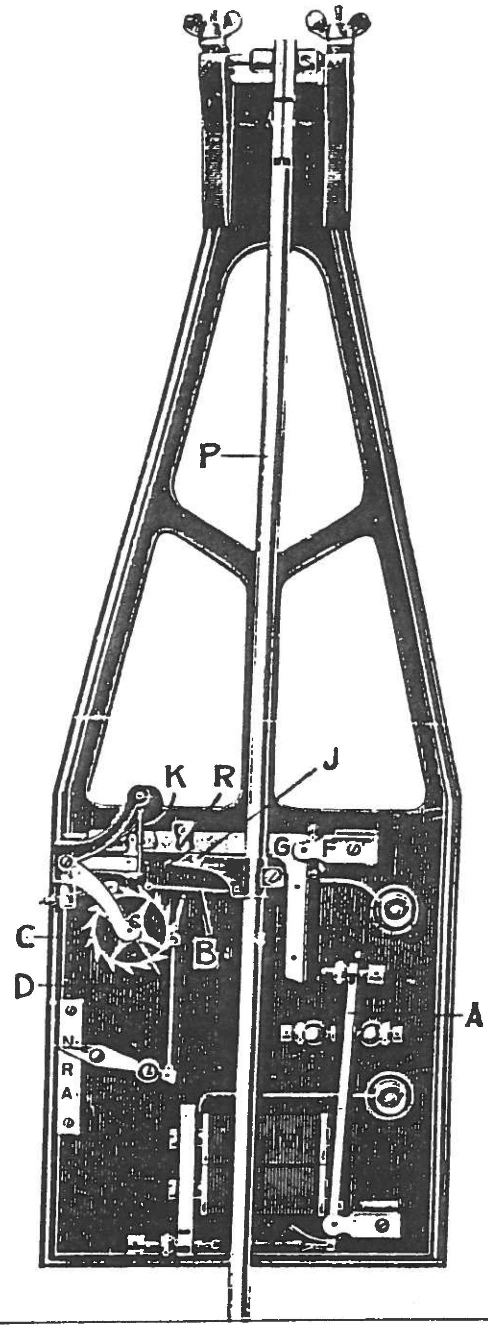


In the meantime, if it is desired to ascertain and correct the fault, open the back and lift the backstop lever G, which will hold the driving click E out of engagement with the wheel A, and spin the wheel A to find undue friction. If the wheel and hands revolve quite freely, there is only one thing more to look at, viz.: the flat steel spring F, which must be just strong enough to propel the hands, but not too strong for the electro-magnet B to pull it over. It may be easily adjusted by the capstan screw.

In the event of its being necessary to attend to any individual dial to turn the hands to time, **never touch the hands themselves,** but open the back and touch the armature with the finger, or lift the backstop lever and spin the wheel.

Notice to those who erect their own installations.

All adjustments are carefully made in these works before the instruments are sent out, and are securely locked. In order to prove that these adjustments have not been altered and to satisfy yourself and us that the Controlling Pendulum has been properly erected you are asked to fill in the following form by answering the questions. If this is done the Synchronome Co., Ltd., will accept it as a substitute for erection by their own staff, and will be responsible for the safe-going and time-keeping of the installation.



Later model emplying larger casting with trunion pendulum support built in at the top. (editor's note)

CONTROLLING PENDULUM ERECTOR'S CERTIFICATE.

Movement No.................erected by...
(See bottom of N.R.A. plate)

at.......... .... Date.

address ....

What is the space between the poles of the magnet and armature? It should be one-hundredth of an inch. Insert a piece of thin notepaper and see that you cannot grip it. ....

What is stroke of the armature and gravity lever? **It should be ¾ travel in company with ¼ kick.** ....

What is the minimum arc of the pendulum on which the jewel will gather? It should be 1° + 1' or 20 m.m. + 20 m.m. ....

What is position of impulse roller when pendulum is at zero? Sketch the curve and the roller. ....

What is the minimum contacting arc? *i.e.*, minimum arc at which contact can be made and gravity lever reset. ....

What switch air gap results? *i.e.*, space between contacts when lever is on catch and armature is pushed against the poles of magnet. ....

Is the gathering click no deeper in engagement than sufficient to allow backstop roller to drop into next tooth? ....

Is N.R.A. adjusted? The lifting wire should be altogether clear of B when indicator is at N; should raise B clear of the wheel at R; and should raise the jewel to engage the accelerating arm of catch when the indicator is at A. ....

How many cells were taken off before battery warning? ....

How many cells were taken off further before dying kick? (battery too weak to replace lever). ....

Hoy many cells were left operating the circuit? ....

In which room is battery situated? ....

Is pendulum case rigidly fixed to a substantial wall? ....

How many screws, and is wall plugged? ....

Who did the wiring? ....

Who keeps series order list, and/or wiring plan? ....

Fill in spare form and return to -

THE SYNCHRONOME CO., LTD.,

REGULATION

REGULATION.—Take hold of the pendulum rod firmly, just above the bob, in order to prevent its twisting and damaging the suspension spring or click B, and if the clock is slow, turn the rating nut so that the front edge moves from left to right, and the bob is raised : if fast, turn it in the opposite direction. **One complete revolution of the rating nut will make a difference of half-a-minute in 24 hours,** the figures 10, 20 and 30 on the rating nut representing **seconds** in 24 hours.

For accurate regulation, prove a small but definite losing rate by two or three observations, then turn the nut upwards accordingly, taking great care not to overshoot.

If an adjustable platform is provided at the middle of the pendulum rod, the addition of 0.6 gram weight will cause the clock to gain 1 second in 24 hours.

DIAL SETTING FROM MASTER CLOCK.

To set all the dials forward if slow :—

A Few Seconds.—After the release occurs, move the wheel forward, each tooth passed representing two seconds.

A Few Half-Minutes.—When the pendulum swings to the **left** release the catch K with your finger. **On no account must lever G be released unless the pallet J is underneath it to prevent its falling on to the armature contact, which might cause trouble.**

Longer Periods.—Depress the lever to A (accelerate). The switch will then work every two seconds instead of every half-minute. By this means the Summer Time advance of one hour will be accomplished in 4 minutes and 16 seconds.

To set all the dials back if fast :—

A Few Seconds.—Before the release takes place depress the tail of the backstop glass roller L and turn the wheel backwards, each tooth representing two seconds.

A Few Half-Minutes.—Hold a piece of paper between the contact surfaces before the gravity lever is released, and then reset it by hand.

Longer Periods.—Move the setting lever from N (normal) to R (retard) for as long as may be necessary. After one hour's stoppage to revert to G.M.T. in the Autumn, it will be necessary to start the pendulum again.

The Church Army Press, Cowley, Oxford. S

--- MART ---

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WANTED: HOROLOGICAL LITERATURE, Repair info, Catalogs, etc. for the Journal
PORTESCAP Secticon Clock or Movement. (718) 969-0847
Harvey Schmidt, Editor, 75-80 179th St., Flushing, NY 11366

ACROTYNE made by Seth Thomas, buy or borrow, details in EHS Journal of April 1985.
MONARCH Master Clock made in Chicago. Any information. (313) 881-2906
Bill Ellison, 1635 Ford Ct., Grosse Pointe Woods, MI 48236

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SYNCHRONOME, or any Hope-Jones equipment or literature.
John Cammarata, 45 Murray Hill Terrace, Marlboro, NJ 07746

Junker EARLY BATTERY CLOCKS, Movements, Parts, etc, send details.
Martin C. Feldman, 6 Stewart Pl., Spring Valley, NY 10977

SOHM ELECTRIC CO., Chicago, need Patents, Patent #'s, Ads, any Information. David Lee, RD #1, Box 187, Delanson, NY 12053

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High Quality Electromechanicals, European or American, Wall or Mantle. Steve Lefkowitz, 13 Puritan Park, Swampscott, MA 01907
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Pendulum support casting, suspension spring, pedulum rod, and bob for a 1 second GENTS
Richard B. Pridham, 10402 Bellman Ave., Downey, CA 90241

Plans, drawings to build a SETH THOMAS No. 2 Case
K. C. Denney, 3819 E. 55th Street, Tulsa, OK 74135

AMERICAN CLOCK CO., Chicago USA, movement or parts for a model 5B 80 beat wall clock. (215) 287-8934
Wayne MacAvoy, 3400 Pruss Hill Road, Pottstown PA, 19464

GENTS pendulum: cylindrical bob, flat invar rod. Will buy complete clock, if necessary, to get pendulum.
Cylindrical bob with round rod. (713) 554-7387
BRILLE pendulum: spherical bob with horiz. iron bar underneath.
Kenn L. Koerber, 105 Royal Drive, League City TX, 77573-1951

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From the editors...
(continued from page 1)

This issue of the journal is devoted to the SYNCHRONOME clock, which has a great deal of significance in the development of ACCURATE electric clocks. The concept of the occasional impulsing of the pendulum, combined with the "Synchronome Switch" led to the later development of the Schortt free-pendulum observatory clocks which became the standard of timekeeping for many years. We will feature the Schortt clocks in a future journal issue. The material contained herein was compiled by co-editor, Dr. George Feinstein, and consists of catalog reprints, in part, from publications that were available over many years. Note the prices as they increased to virtually twice the original... was inflation as prevalent then too? Dr. Feinstein, by the way is scheduled to be one of the speakers at the National Seminar in Cleveland in October. More on that at a later date.

To those members with a PAST DUE dues notice attached, this is your LAST JOURNAL ISSUE... take heed.

Good reading ahead...

Martin Swetsky, FNAWCC, President
Dr. George Feinstein)
Harvey Schmidt) Co-Editors

The
JOURNAL
OF THE
ELECTRICAL HOROLOGY SOCIETY
Chapter No 78
NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

VOLUME XVIII, #3 SEPTEMBER 1992

Fellow Horologists:

This issue of the EHS Journal celebrates our 20th ANNIVERSARY! Chapter 78 was issued its charter in August 1972, and has been publishing continually since then! Our journal has become the standard for Electrical Horology reference with the contents frequently quoted. A WELL-DONE for all of the contributors, past, present, and future.

In the Journal issue #2 of July 1992, we spoke glowingly of the efforts of ELMER CRUM and BILL KELLER as regards the National Convention Exhibit and Souvenier Book, and through their kind cooperation, we have been able to purchase a quantity of the book, "150 YEARS OF ELECTRICAL HOROLOGY" at a special subsidized price.

Copies of the book are being sent to the membership of Chapter 78 in place of the more conventional journal #3, to help celebrate our anniversary, and because it is such an important reference volume for future use. Since our budget and treasury balance can't handle an expense of this magnitude, we are requesting a $6 donation from each recipient to assist in covering PART of the purchase cost and postage. This is, of course, entirely voluntary, but in the light of the value of the book itself, we feel that the request is justified and merits the enthusiastic cooperation of each of us.

Additional copies may be purchased from Chapter 125 at $14.95 plus postage by addressing your orders to ELMER CRUM, president, at: 8510 Harms Road, Skokie, IL 60077. The NAWCC Headquarters in Columbia also offers copies at $16, with order forms appearing in the issues of the MART.

Most of the clocks that were on display at the National Convention have been transported to our museum in Columbia as part of a semi-permanent display on Electrical Horology, to remain on exhibit until the end of the year. If you haven't seen this collection of clocks, you still have the opportunity to view them at headquarters, but don't miss it... it will be an event long remembered...

continued to page 2.

V

continued from page 1.

Any reference to the anniversary, and origins, of Chapter 78 would be remiss if we didn't include a special thanks to MARTY FELDMAN, the chapter's first president and editor. Marty is well and busy, and sends his regards to all of his old friends. For those members who would like to get in touch with Marty, his ad appears on our MART page.

Enjoy your copy of 150 YEARS OF ELECTRICAL HOROLOGY, and please consider our $6 donation request, to be sent to our Secretary/ Treasurer, HARVEY SCHMIDT at 75-80 179th Street, Flushing, NY 10977.

VERY GOOD reading ahead...

Martin Swetsky, FNAWCC, President
Harvey Schmidt)
Dr. Gerorge Feinstein) Co-Editors

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NAME ____

ADDRESS ____

CITY & STATE ______________________________________

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COMMENTS (OPTIONAL)

A SPECIAL NOTE TO THOSE MEMBERS OF CHAPTER 78 THAT ATTENDED THE CHICAGO NATIONAL NAWCC CONVENTION IN JULY..

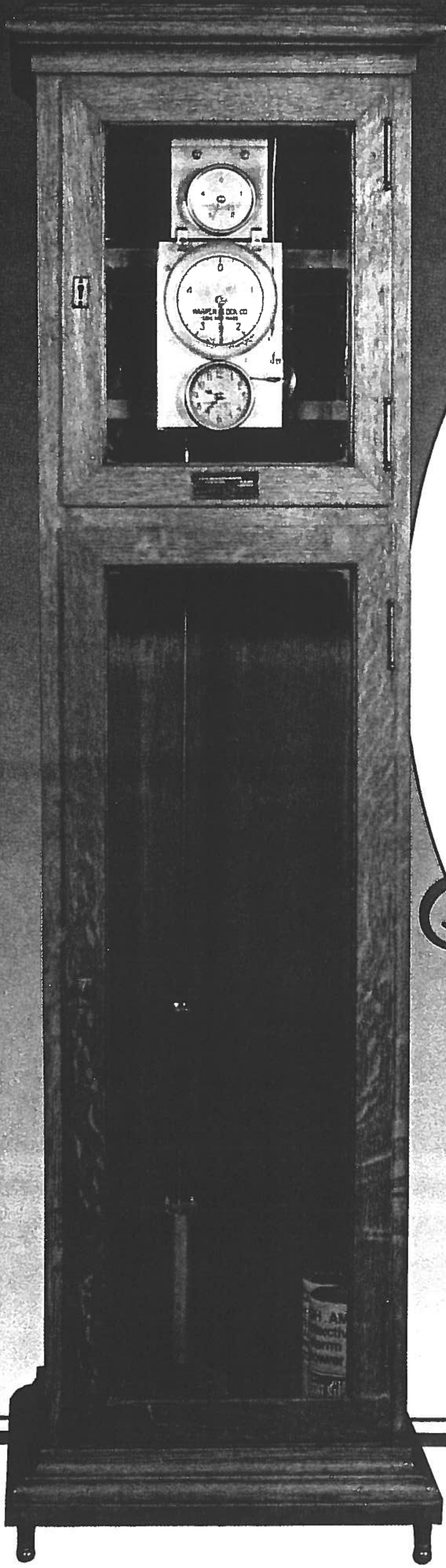
AS INDICATED IN THE EDITORIAL, WE FELT THAT THE SOUVENIER BOOK WAS SUFFICIENTLY IMPORTANT AS A REFERENCE FOR ELECTRICAL HOROLOGY ENTHUSIASTS, THAT ARRANGEMENTS WERE MADE TO PURCHASE A LIMITED QUANTITY AT A SUBSIDIZED PRICE, COURTESY OF CHAPTER 125, BUT THE NUMBER OF COPIES RECEIVED IS LESS THAN OUR TOTAL MEMBERSHIP.

IN THE LIGHT OF THE FOREGOING, WE ARE TAKING THE LIBERTY OF ASSUMING YOUR AGREEMENT IN THE ELIMINATION OF ANOTHER COPY TO BE SENT TO YOU, SINCE YOU RECEIVED ONE AT THE EXHIBIT IN JULY. IF WE HAVE INADVERTENTLY OMITTED YOUR COPY, PLEASE ADVISE AND WE'LL GET ONE RIGHT OUT.

IT IS OBVIOUS THAT A $10 ANNUAL DUES CANNOT COVER THE COST OF PRINTING AND MAILING THE NORMAL JOURNAL ISSUES, AND THE BOOK VALUED AT $15, EVEN WHEN SUBSIDIZED, AND WE THANK YOU FOR YOUR COOPERATION AND UNDERSTANDING.

THE EDITORIAL TEAM,

MARTY, HARVEY, & GEORGE



150 Years of Electric Horology

1992 NAWCC
Chicago National
Convention Exhibit

The JOURNAL OF THE ELECTRICAL HOROLOGY SOCIETY Chapter No 78

NATIONAL ASSOCIATION of WATCH and CLOCK COLLECTORS, Inc.

VOLUME XVIII, #4, DECEMBER 1992

Fellow Horologists:

The July 1992 issue #2 of the journal featured the SYNCHRONOME clocks which were the forerunners of the SHORTT free-pendulum observatory timekeepers. This issue concludes the series with a reprint of a lecture delivered to the British Horological Institute on April 19, 1923 by Frank Hope-Jones. Mr Hope-Jones discussed the evolution of the Shortt free-pendulum based upon the Synchronome design and credits RIEFLER, FROMENT, FERY, HARE, GRIMTHORPE, RUDD, BARTRUM, & REV. O'LEARY, among others for their small contributions, albeit reluctantly, and certainly, out of character for his opinions of other clockmakers. He concluded his dissertation with an explanation of the operation of the SHORTT clock, and its undeniable advantages.

In an additional publication, further information on the Shortt system is presented along with details of some less known types of Shortt clocks, which completes our presentation on the subject of Shortt & Synchronome. A listing of the locations and dates of installation, complete with serial numbers and comments regarding Mean Time or Sidereal Time options, was added, courtesy of Dr. Iain Cleator and Dr. George Feinstein and R. John Griffiths.

Since this is the final journal issue of 1992, it becomes necessary once again, to remind our membership of the fact that **DUES ARE DUE!** In addition, we wish to remind those members that failed to make a contribution to cover the cost of the book, 150 YEARS OF ELECTRICAL HOROLOGY, that it would not be inappropriate to add a couple of bucks to the dues payment! We have not had to increase dues from the initial $10 figure that was established almost 20 years ago, and with your cooperation, will attempt to continue to hold the line, but **help**, please. Note the back page of this issue where the dues renewal notice appears, and check the box for your voluntary contibution. If a reminder note is attached, you owe....

It would appear that many of the ads in our MART section are out of date and no longer indicate current WANTS or NEEDS, or ITEMS FOR SALE. In this regard, it was decided that an annual clean-up of this section would be in order, and the next journal issue, #1 of 1993, will have all of the present ads deleted, **unless** we are advised that the advertiser wishes the insert to remain. Please respond ASAP to HARVEY SCHMIDT.

The officers and editorial committee wish to extend their fondest wishes to all for a Joyous and Healthy Holiday Season, and a most prosperous New Year. Enjoy this issue...

Martin Swetsky, FNAWCC, President
Harvey Schmidt }
Dr. George Feinstein } Co-Editors

v 2

:: The ::

FREE PENDULUM

A Lecture Delivered before the

BRITISH HOROLOGICAL INSTITUTE,

on April 19th, 1923, by

F. HOPE-JONES, M.I.E.E.,

Vice-Chairman of the Institute,

Chairman of the Radio Society of Great Britain.

THE SYNCHRONOME COMPANY, LIMITED

32-34, CLERKENWELL ROAD, LONDON, E.C.1.

THE FREE PENDULUM.

A Lecture delivered at the British Horological Institute, on April 19th, 1923, by Mr. F. Hope-Jones, M.I.E.E. (Vice-Chairman of the B.H.I.)

THE British Horological Institute has a great name and great traditions, and it is for us to see that they are worthily maintained. The possession of such a title imposes a heavy responsibility on those who are charged with the conduct of its affairs, for if they fail to maintain it as a living centre of the profession and the science, then who else will, when they monopolise the title?

An Institution such as ours, whose foundation stones were well and truly laid, should carry on its activities in peace or war, in prosperity or hard times; indeed, its services are the more needed when trade is bad.

When it was founded in 1858, Clerkenwell was still the clock workshop of the world. I do not propose to discuss here the reasons why we failed to adopt engineering principles and factory production with interchangeability of parts, and allowed other countries to take a large share of our trade, nor the economic conditions which contributed to that unhappy result, but I wish to emphasise that the misfortune could be no excuse for restriction of the Institution's activities; on the other hand, it should be a spur to greater endeavours. We should not merely reflect prosperity, but should hold aloft the standard bequeathed to us, to raise the status of our profession and the quality, if not the quantity, of our manufactures.

And there is another duty of an Institution such as ours of equal or even greater importance than that of what I may call oiling the wheels of the commercial machine. It is primarily a scientific society, and it is for us to foster invention and encourage research. Finances do not at present enable us to offer monetary rewards—we cannot endow scholarships, but we can direct education, and we command a distinguished platform, with an audience comprising everybody who is anybody in horological science. It is our birthright that every invention of importance should make its bow from this platform or first see the light in the pages of our Journal. That attitude is due to our founders; they created it, and it is due to their memory that it be maintained.

Since I gave my first lecture before this Institute in 1895, I have seen it suffer from the loss of that ripe scholar and historian of horology, Mr. F. J. Britten, its greatest Secretary. He left a gap that was not easy to fill, but I have witnessed many special efforts by the Council since then, such as the lead they took in the education of disabled soldiers under our President, Mr. W. J. L. Smith. I have seen the circulation of the Journal more than doubled, with the assistance of Mr. Frank Tournay; and 200 new members enrolled under our present Chairman, Mr. Cyril Johnston; but much remains to be done before it can truthfully be said that our profession supports the Institute and are dependent upon it.

I have proposed the resumption of regular monthly meetings, with papers or lectures and discussions thereon, as a means to that end. I hold the opinion that the membership is inclined to become apathetic when nothing appears to be going on.

It may be suggested that horological science, being many centuries old, the fountain of invention is drying up, and that material could not be found for monthly lectures. Don't you believe it; England is not as degenerate as her enemies think. Is there nothing more to do? How long is the scandal of our varying public clocks to remain? And where are our Municipal Time Services? Are we going to take it lying down that since the advent of wireless telegraphy, precision time measurement has fallen far behind the precision with which distant clocks can be compared? So long as it is necessary for us to interfere with a pendulum in its duty of measuring time, so long will the British Horological Institute require to meet and discuss every suggestion for its amelioration.

And this leads me, after too long a preamble, to the subject of my lecture, "The Free Pendulum."

In my lecture before this Institution in 1895, I emphasised what should have been a commonplace, but curiously enough was rarely mentioned, viz., that *any* interference with the freedom of the pendulum to perform its swing in its own good time was an enemy. The vibration of a pendulum cannot be indefinitely maintained, even in a vacuum, without some replacement of energy losses. Imparting that energy to it must itself be a cause of some disturbance, and this will always have to be accepted and minimised.

But in those days the profession could not conceive of the possibility of relieving the pendulum of the duty of unlocking motive power. The very word "escapement" implies the releasing of stored energy in small instalments, and who dared suggest that that function could be accomplished by anything but the pendulum itself, which alone knows the exact point of time or phase of its motion at which it ought to get it? No; the free pendulum has not hitherto been in the region of practical politics. The official attitude of the clock-making profession in this country accepts the weight-driven regulator clock with the Graham dead-beat escapement as being the last word in precision time-keeping. This was strikingly illustrated by an answer to a correspondent in our Journal only eighteen months ago. He asked for the best specification of a seconds pendulum clock capable of keeping the closest rate, and whether it should be electric. He was given the following: "Barrel, 2in. diameter; great wheel, 168; centre wheel, 120; third wheel, 98; scape wheel, 30. Pinions of 14, all hardened and tempered. Escapement, Graham dead-beat, embracing eight teeth. Pallets, jewelled sapphire. Mercurial pendulum. Suspension spring, short, broad and thin. Maintaining power must be fitted. Line to be of silk, and, if possible, carried over loose pulley to hang down side of case. Jewel holes should, for preference, be supplied to scape wheel and pallet holes. We do not advocate an electric clock for this purpose." Faultless advice, which would be endorsed by all the best clockmakers in the profession up to the beginning of this century, but not quite up-to-date, in so far as it ignores Riefler; perhaps on the ground that his construction would be beyond the powers of the ordinary clockmaker. And a little behind the times with regard to the weight-driven train, proved to be unnecessary not so much by the Synchronome invention of 1895 as by Riefler's adoption of it when the German patent ran out.

Dr. Seigmund Riefler produced his clock in 1890, since when nearly 500 of them have been supplied to observatories and scientific institutions all over the world. Briefly described, the top chops and trunnion are rocked on knife-edges coincident with the axis of suspension. By this means the impulse, derived from an escape wheel, is transmitted to the pendulum through the suspension spring. For a short distance beyond zero the spring is straight, the pendulum and trunnion swinging together on the knife-edges, then the scape wheel delivers its impulse to the pallet and rocks the trunnion back a little, locking it there, and thus imparting its impulse through the spring. (Described with lantern illustrations.)

Of course, it is not a free pendulum, though at first sight it appears to be, but the evils of interference are greatly reduced by avoiding all mechanical contact with the pendulum below the point of suspension. Its performances have been very good, and however unpalatable the truth may be, it has given Germany a clear lead in precision time measurement in the world's observatories during the last thirty years.

A more simple method of applying the same idea was devised by Professor Strasser (of Glasschutte), in which the pendulum suspension is fixed as usual, and the impulse is imparted through additional suspension springs on each side of the pair which carry the weight. (A large scale drawing of this escapement was exhibited, kindly lent by Mr. Eric Haswell.)

Prof. R. A. Sampson, F.R.S., the Royal Astronomer of Scotland, has analysed the action of his Riefler very thoroughly in his recent contribution to the Royal Society of Edinburgh. He also sums up the present position effectively in the following words: "The ideal clock is a free pendulum; but this is impracticable, because the motion would die out; besides, there would be no means of marking its seconds. To maintain the motion and send out signals, without introducing some noxious feature, is a task of great difficulty. It may be taken at once that the drum with cord and pulleys to carry a weight should be dispensed with, and the counting train and dial, if retained, should be made a mere accessory, quite free of the maintenance. Two things are, however, essential in one form or another. The pendulum must unlock the maintenance, losing in doing so a certain amount of energy which may be variable. And, second, the maintenance for a certain portion of the arc must interfere with the free swing of the pendulum."

Thus we have been unable to get away from the escapement, and have apparently arrived at an impasse. We have reduced its vices to a minimum, and have reached the limit of accuracy attainable along these lines.

This invites the reflection that there has been no invention of outstanding importance in horology for a long time with the exception of Riefler, whose home is Munich. The fruitful age was, as Mr. Litchfield has recently pointed out, from the middle of the 17th to the end of the 18th century, and the parents, birthplace and nursery of almost all the inventions of that period were English. Our orbit has been bounded by escapements ever since. Everyone, from the mathematician to the mechanic, has had his teeth in the problem, and there is not a scrap of meat left on the bones we have been gnawing for so long—no food for further theorising or experimentation. I am going to postulate that, for the purpose of the highest accuracy of time measurement, *escapements are dead*, and that we are at the dawn of a new era, in which the precision clock will consist of a pendulum which shall receive its impulse at zero and shall not be called upon to *do* anything whatever. Call it a free pendulum if you like; the degree of its freedom will be measured by the nicety with which the impulse is imparted to it and the extent to which it is concentrated at zero. To my mind, a pendulum sacrifices all claim to be considered free if it is called upon to perform any function whatever beyond time measurement.

The last British invention of importance was the Grimthorpe detached gravity escapement, but its value is confined to turret clocks, for which it was designed, and every effort to produce it on a small scale as a precision clock has failed in its object, for reasons which I shall shortly suggest.

This escapement, however, has inspired several attempts to achieve a free pendulum—free in the sense that it shall be relieved of the duty of unlocking the maintenance.

The lecturer then described, by means of lantern illustrations, a number of clocks in which the pendulum was driven by a gravity arm electrically replaced, such as that of Froment of 1855, Prof. Chas. Fery, and one of his own, exhibited at his former lecture in 1895 and described in the Journal of the Institute at the time. He also explained the action of Mr. A. T. Hare's free pendulum and exhibited a working model of the constantly rotating motor clock of Mr. A. Steuart, described in the April, 1923, number of the Journal.

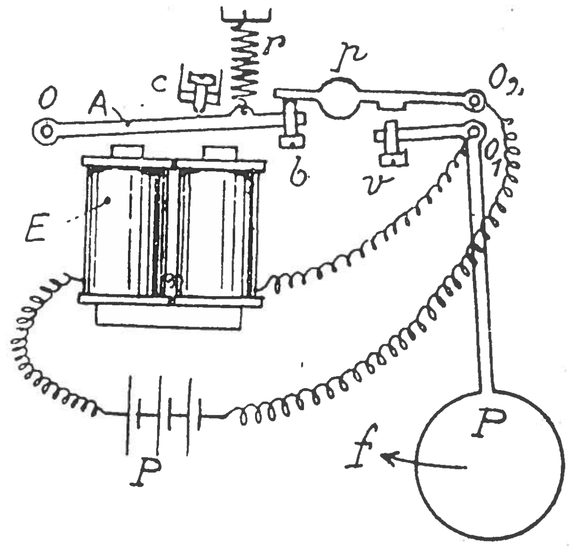


FIG. 1.

Fig. 1 is a diagram of Froment's clock of 1855. The gravity arm *p* is normally held up by armature A and spring *r*. When the pendulum arm *v* makes contact with *p* in lifting it, the electro-magnet E draws the armature A out of the way and the gravity arm *p* delivers its impulse.

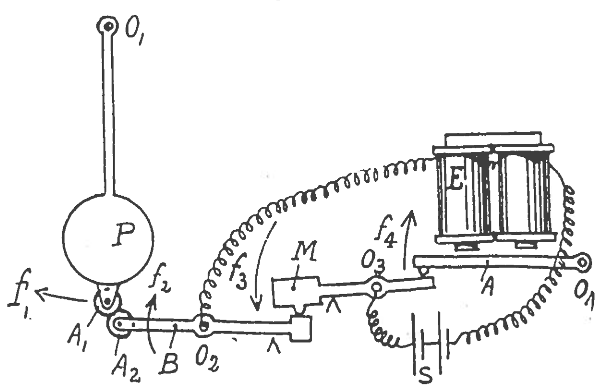


FIG. 2.

Fig. 2 is Professor Charles Fery's modification of the above, in which the impulse is delivered upwards and near the zero position. The armature A is heavy, and normally holds up the driving weight M, the action being as before.

Fig. 3 is Mr. A. T. Hare's clock. The pendulum E carries two ball-topped posts

H by means of the arms F which receive impulse in turn from the two washer-like weights B. These weights lie freely on the ends of the rocking frame which enable them to fall further than the pendulum has to lift them.

Now let us examine what are the fundamental features underlying these, and common to all. First, the impulse is exactly that of the Grimthorpe gravity escapement, the gravity arm or weight falls further than the pendulum has had to lift it, and the impulse is the difference between the two, but the pendulum has no unlocking to perform, or rather is not called upon to give up any energy for that purpose. In that

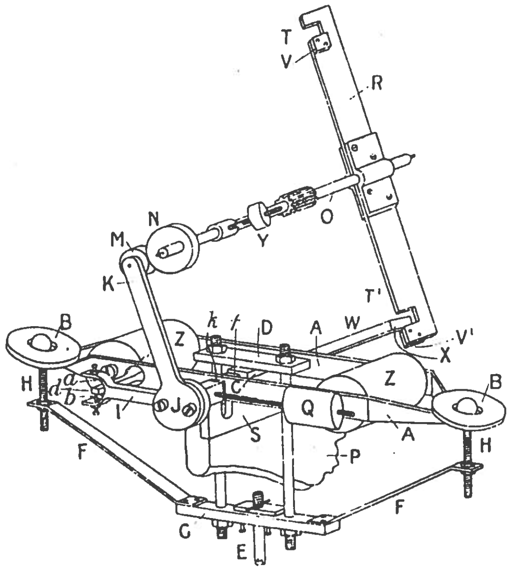


FIG. 3.

respect, and in that respect only, are they better than the gravity escapement, and it is not enough to lift them into the highest plane of precision time measurement.

In most of them the pendulum is engaged with its driving weight, either in lifting it or receiving its impulse, for a total of about half a second at each end of the double vibration; that is to say, for about one second out of every two. That does not spell a free pendulum. It is subject to interference for approximately one-half of the time which it measures, and the disturbance occurs in that part of its path where its effect is most harmful.

If you want to alter the time of a pendulum, to synchronise it for instance, the end of its swing is the ideal place to handle it, but it is hopeless to give it its impulse there. It is in the middle of its path only that interferences can be permitted.

The lecturer here demonstrated the matter with the assistance of the circle of reference and Hook's law *ut vis sic tensio*.

So all attempts to improve the gravity escapement by employing some outside agency to replace the lever are doomed to disappointment. I have heard of no real success on these lines, nor of any serious attempt to exploit any of them.

But with regard to some of them, I particularly regret that they do not appear to be destined to break rate records. Mr. Cottingham's version of Froment or Gill or whatever we like to call it, was distinguished by a simplicity and ingenuity of design which gave exceptional facilities for the accurate measurement of the forces concerned, and assisted Professor Sampson materially in his recent mathematical investigation of the whole subject. And Mr. Hare's clock, with which he delighted an audience at the Royal Institution of Great Britain in 1919, is a gem. It is a fascinating sight to see the little washers lifted in turn in readiness for the pendulum to receive their weight, the pendulum itself knowing nothing as to how this service is rendered. With regard to Mr. Steuart's clock, though it will probably not break a record for accuracy of timekeeping, I feel sure it is destined to be very useful as a means of controlling the speed of continuously running motors. Many most useful applications occur to one, such as turret clocks and telescope driving.

At last I have reached the end of my criticism. I have found fault with all these inventions in order to lead you to a clear understanding of the principles which I believe to be absolutely necessary to any real advance in the science of accurate time measurement.

The impulse must be given to the pendulum at or near to its zero position.

It must only be given occasionally.

There must be absolutely no other interference with the pendulum whatever.

I think it will come as a surprise to you to know that that which has hitherto been considered impossible, or would have been so considered if asked for by the intellectuals, has recently been accomplished by five different men, each one in total ignorance of what the others were doing.

The first was Mr. R. J. Rudd, of Croydon. He was the man who produced a synchronising device in 1898 without perpetrating the usual blunder of confusing *rate* with *indicated error*—a most enviable distinction, I can assure you. Here it is (described with illustration and model, made from British Patent No. 19,337 '98).

He then conceived the idea of impelling a free pendulum by a chronometer escapement unlocked at rare intervals by a separate clock synchronised by the termination of the impulse. I saw his clock in 1908, and ever since then I have been urging him to publish his work, and warning him that I would defeat his modesty by telling the world what he had done. It is true that he sent a short description of it to the Journal in 1899, but it was hidden under the title of "Controlling Pendulum for Inferior Clocks." Much to my regret, owing mainly to ill-health, Mr. Rudd has done nothing to develop it or to test its possibilities.

If only he had got in touch with the late Sir David Gill, the story of the Sidereal Clock which that astronomer designed for the Cape Observatory might have been very different. It is told in his Official Reports, the first being dated February 1st, 1904:—

"The clock consists of two separate instruments (*a*) a pendulum (swinging in a nearly airtight enclosure maintained at uniform temperature and pressure) and (*b*) the 'slave clock' with a wheel train and dead-beat escapement, the pendulum of which has a period of vibration slightly shorter than one second. This pendulum is held up by a trigger for about a tenth of a second at each alternate beat, and this trigger is discharged by the short-circuiting of its electro-magnet through the gravity arm of pendulum *a* at the instant when this arm is arrested by touching the platinum anvil that limits its fall."

Here the same idea is well expressed, but is based upon a checked gaining rate instead of synchronisation and the term "slave clock" first used. Sir David Gill retired in 1906, and in a few subsequent Annual Reports there are laconic references to contact troubles, culminating in the announcement, in 1911, that a new Riefler clock had been installed. No precise description of this clock can be found, and I am indebted to Mr. E. T. Cottingham and Mr. H. T. Hollis for the above information. By inference we are bound to assume that the clock never came into regular use.

The next man to do it was Mr. C. O. Bartrum, of Hampstead, in 1913. The fall of the gravity lever, after it has left the pendulum, is used to synchronise the slave clock, but in this case there is a distinct step forward in the use of the Synchronome remontoire for this purpose, electrically released by the slave, and which, in the act of its resetting, in turn synchronises the slave (described with lantern illustrations). Mr. Bartrum clearly distinguishes between error and rate, and has an ingenious method to avoid rocking, or back lash as he calls it; but I doubt whether his synchroniser is well adapted to keep two pendulums swinging in exact, or almost exact, phase, which is the essence of the problem. I have not heard of any attempt to develop this or to test its performance.

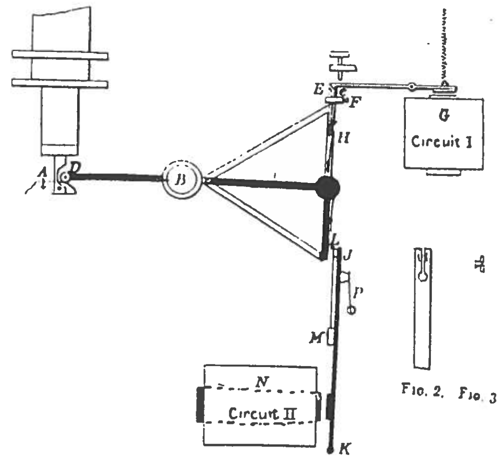


FIG. 4.

Fig. 4 shows the lower end of the controlling pendulum with gravity arm B released by electro-magnet G and replaced by electro-magnet N. Fig. 5 shows the synchronising device, it being understood that the electrical impulse resulting from the Synchronome replacement of the gravity arm B in Fig. 4 every minute is shunted to magnet 9 or 10, in accordance with whether the clock is fast or slow. The armatures 11 and 12 of these magnets propel the wheel 15 backwards or forwards. This wheel is a capstan which, by means of the cord 17-18, increases or diminishes the tension of a spiral spring attached to a subsidiary pendulum, to which the pendulum of the slave clock is linked.

We now come to the clock of the Rev. Father O'Leary, of Dublin. He is an astronomer and a priest of the Jesuit Order, a community whose learning is profound and is often distinguished in science. His slave clock consists of a humble American type with balance wheel. He does not attempt to drop his gravity arm in exact phase, but lets it fall on the dead surface of the pallet.

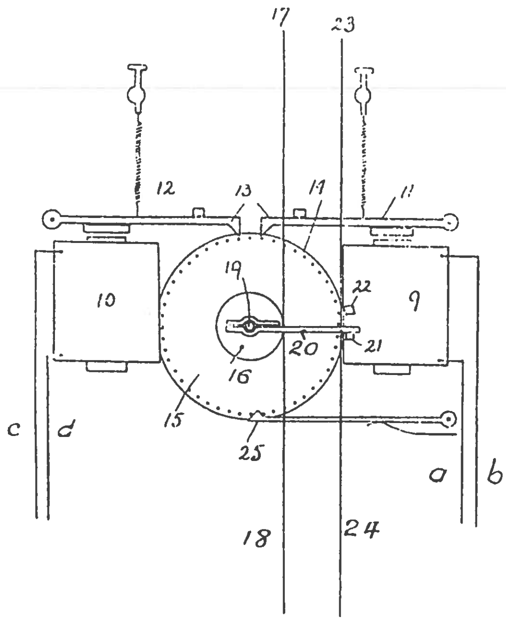


FIG. 5.

The first thing it does on beginning to fall is to stop the clock by clutching the balance wheel, then having done its work on the pendulum, it falls further and releases a cam, which rapidly raises the gravity arm again on to its catch, and at the same moment starts the clock going again. Fig. 6 is a diagram of it. The free pendulum B is shown in three positions and also in association with the Slave clock *t*. The gravity arm C is pivotted at D. I don't think the reverend Father will mind my reading you some extracts from an interesting letter he wrote me a few months ago :—

"It is strange that I was driven into this sort of work *malgré moi*, and now it has become so intensely interesting that I cannot leave it aside. During the war I wanted a clock of precision for my observatory, and could not get one. I was forced to the conclusion that I should have to design and make one myself. It seemed rather a large order, because beyond the fact that I had some 14 clocks of various sorts to look after in my observatory instruments, I knew nothing of clockmaking. However, I had come across problems before that seemed hopeless, and had won through; so I set to work. It has been very enjoyable, and has resulted in extraordinarily accurate timing. Clearly, mere clock error has no effect. I have made the crudest movements out of old alarm clock parts, jumbled together just any way, and the clock shows no variation with one having a costly movement specially made. In the arrangement described, the balance wheel is stopped before every impulse period. This looks rather barbarous and cruel to the balance wheel. In practice, I have a very simple little counter-shock arrangement which works out very well."

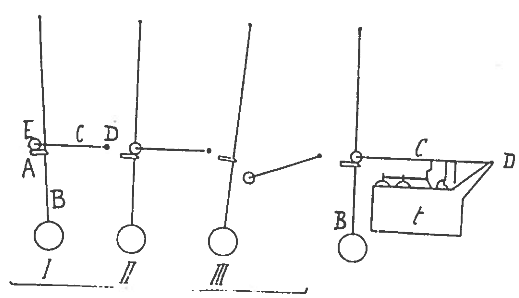


FIG. 6.

He goes on to describe his latest pattern, in which the actual release of the gravity lever once a minute is performed by the fundamental pendulum by means which are equivalent to the chronometer detent escapement. This is clearly a retrogression, doubtless forced upon him by the poor quality of the slave clock.

I see no reason why success should not be achieved on these lines with a well-designed and well-made slave clock, and I expect to hear more of it, but I would urge the inventor not to abandon his ideal of a free pendulum.

Of these four methods of free pendulum propulsion the first mentioned is the greatest invention. I take my hat off to Rudd. Just as the theory and laws of the Hertzian waves, on which the whole fabric of wireless telegraphy is built, lay hid for years in the mathematics of Clark Maxwell, so Rudd saw the whole problem and solved it 25 years ago. Unfortunately he had the inventor's constitutional inability to bring his goods to market. This is a case which makes one wonder whether we are right in holding in contempt those who exploit other people's brains. Development, construction and publicity were not in his line, but might well have given our astronomers what they have been demanding and have kept our country in the forefront of horological science had it been in other hands. It is hardly to the credit of our leading firms of precision clockmakers that it was not discovered and tried out; but this Institution did its duty by publishing it.

These remarks reinforce my arguments in favour of monthly meetings and lectures and illustrate the extraordinary ignorance of inventors regarding the work of others in the same line.

I have mentioned that I saw Rudd's clock in 1908. I have been keen on this problem ever since. It was not long before I realised that the solution lay in measuring short periods of time with a fair degree of accuracy under the control of the fundamental pendulum by some extraneous mechanism charged with the duty of releasing the gravity arm. I interested Mr. W. H. Shortt in it in 1911 and we have tried it in all sorts of ways since then. At one time we appeared to be within sight of success by means of an inertia device, the Synchronome Inertia Relay, which would measure very slightly diminished seconds. This would have substituted the slave clock, but the impulse would have been given every second instead of at wider intervals. But I will not weary you with a tramp over the rough and stony ground which we have had to cover; we will take a short cut straight to the latest accomplishment of Mr. Shortt, which has won for him the blue riband of our Turf, that is to say, a record of a higher degree of time measurement than any that has yet been achieved by man.

His clock was installed in the Edinburgh Observatory early last year. It was placed in the newly-constructed clock chamber in the basement, on a concrete pillar between the Riefler Sidereal and a newer Riefler, which was being tested for the Government.

It consists of a free pendulum of Invar in an airtight case, exhausted to 3.5 c.m. and kept at constant temperature automatically. The pendulum is absolutely free, excepting only for the disturbance due to the receiving of its impulse. That takes place at the zero position, its duration being about a sixteenth part of a second. As this only occurs once every half-minute, the disturbance is confined to a period of about 1/500th part of the time measured.

Fig. 7 is a photograph of the one set up and going in the Lecture Hall.

Fig. 8 is a photograph of the slave clock set up beside it which has the duty of releasing the gravity lever of the fundamental pendulum illustrated in Fig. 7. It will be observed that the slave clock is a standard Synchronome Master Clock, synchronised by a "hit or miss" action against a spring carried on the slave pendulum. The synchronising magnet is in circuit with the fundamental pendulum's Synchronome remontoire magnet. By this means the slave pendulum is kept in phase with the fundamental pendulum to within ± 1/100th of a second.

Fig. 9 is a diagram of the electrical connections between the fundamental or free pendulum Q and the slave clock P and it will serve to explain the action of both.

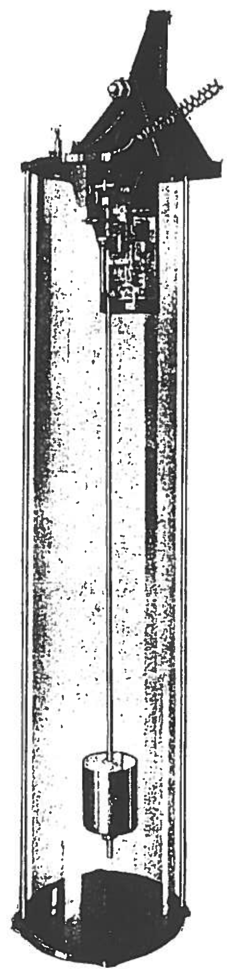


FIG. 7.

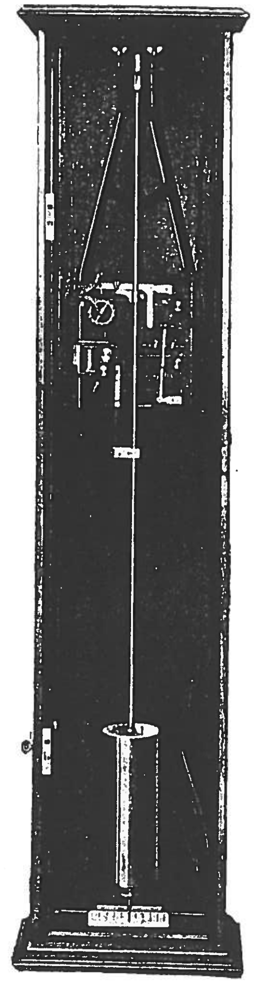


FIG. 8.

The electro-magnet (N) which releases the gravity arm in the fundamental pendulum Q is in circuit with the slave clock's Synchronome remontoire LMR, which thus releases the gravity arm every half minute. The electro-magnet (Y) of the "hit or miss" synchroniser on the slave clock is in circuit with the Synchronome remontoire KUT, which replaces the fundamental pendulum's gravity arm, hence Q controls P by means of Y.

The fundamental or free pendulum Q is provided with a very small wheel (resembling a watch balance wheel and pivotted as such), which receives a D-shaped jewel on the end of the gravity arm every

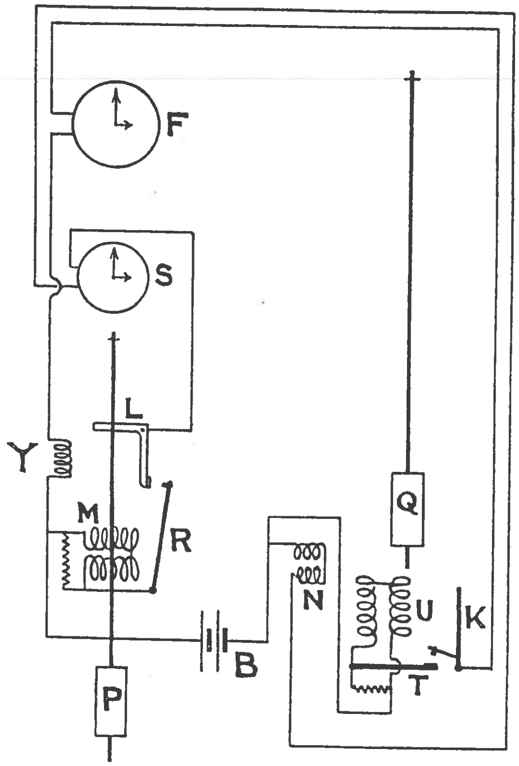


FIG. 9.

half minute. In the Edinburgh clock this is mounted at the lower extremity of the pendulum. This provides in effect a dead pallet surface sufficient to render innocuous changes in the time of release resulting from the very small changes in phase between the two pendulums permitted by the synchronisation.

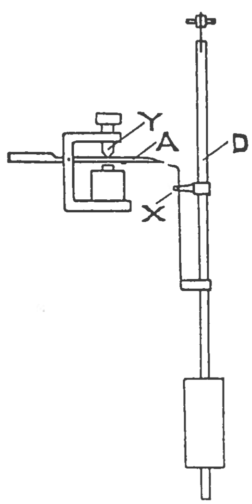


FIG. 10.

Fig. 10 shows the "hit or miss" synchroniser spring X on the slave clock pendulum D and the tongue A whose stroke is limited by the screw Y.

The method being based upon the use of the Synchronome system of combined switch and remontoire in both instruments, its reliability is consequently assured by the reputation that system has achieved during the past 25 years in this country, but for the benefit of foreign countries, who are still mainly using other systems of electric clocks, it will be well to state that the principles which are relied upon in this invention are mainly those which I have enunciated here and at the Institution of Electrical Engineers as follows:—

Detached gravity escapement, operating at zero position of pendulum.
Quick, but not too quick, make of electrical circuit.
Quick break of circuit by inertia.
Short duration of contact, but inevitably sufficient, being dictated by the self-induction of the circuit.
Transmission of the whole of the energy through the surfaces of the contact.
Automatic battery warning.
Simplicity and robust construction.

Fig. 11 shows the performance of the clock up to the 4th March last, and with regard to the observations which they record, Professor R. A. Sampson, F.R.S., Astronomer-Royal for Scotland, states that:—

"The first rates are derived from the T.C., and are meant to be as nearly absolute as can be got, taking a week together to overcome irregularities due to the telescope.

"The second set are relative rates, taken daily with the micro-chronograph. They are generally reliable to (?) .001, though we cannot vouch for every case. The errors of both clocks contribute."

Mr. Hope-Jones here described in some detail the elaborate apparatus devised by Professor Sampson and regularly used by him to record the performances of the various clocks in the Edinburgh Observatory, and to compare them with one another to an accuracy of one-thousandth of a second. His instruments comprise an oscillograph and a cinematograph film with continuous motion used as a chronograph having the 100th parts of a second automatically recorded on the strip by means of a tuning fork vibrated over a window slit obscured and revealed at each vibration. The transit circle and the clock records all appear on this strip.

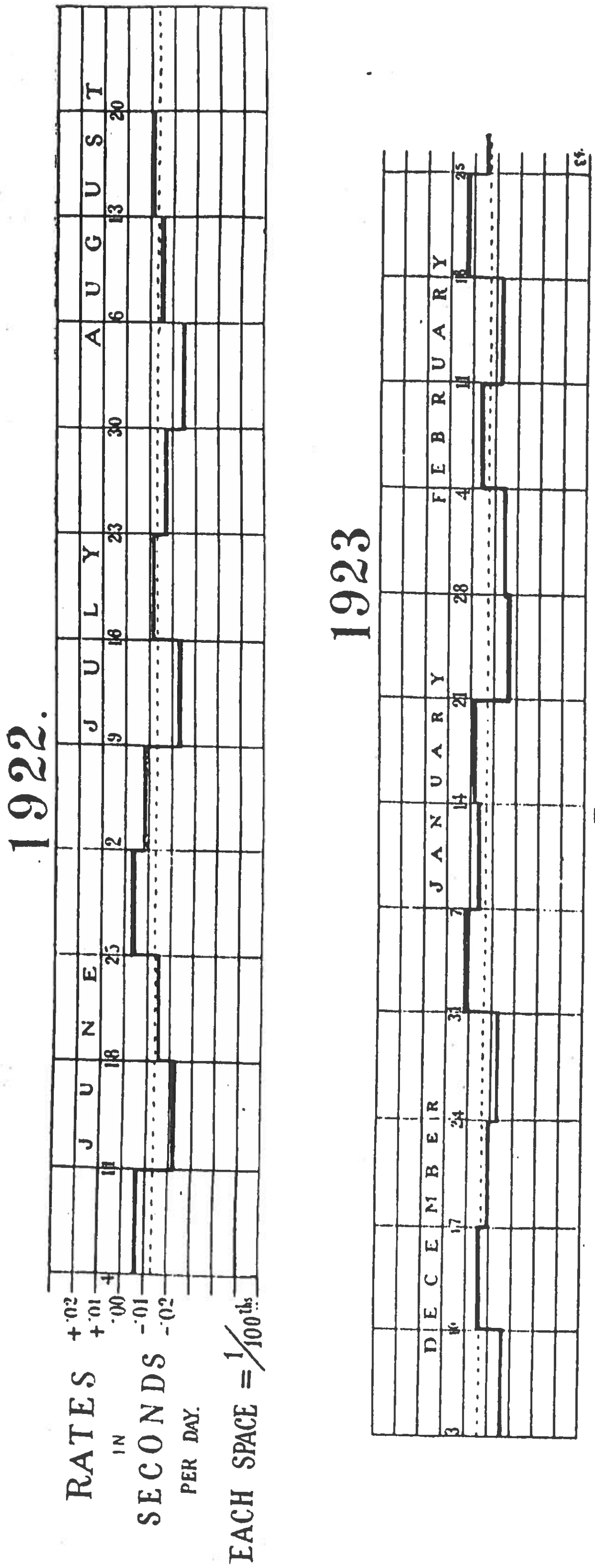


FIG. II.

On the 9th February this year Professor Sampson wrote in a personal letter to Mr. W. H. Shortt :—

"The performance of the clock has been very fine. There is not the least doubt that the right lines are (1) Controlled temperature; (2) Vacuum; (3) Release by slave clock; (4) Reduction of number and intensity of impulse as permitted by (2) and (3). I believe they are sufficient, and with one or two trials we shall have timekeeping as steady as the length of a rod, which is my ambition. The control of the slave clock is, I think, ideal.

"I shall not make a numerical report to you now, but merely say that the clock is unquestionably superior to Riefler, and Riefler never turned out a better clock than the one we have here."

In conclusion, Mr. Hope-Jones said that had it been possible for Mr. Shortt to be present he would have asked him to reply to the discussion and explain anything that he had failed to make clear. (Great applause.)

Mr. Cyril Johnston said they had had a most instructive evening. Their silence and attention showed they all much appreciated the lecture, and he wished to move a hearty vote of thanks to Mr. Hope-Jones on this first of a successful series of lectures.

Mr. A. T. Hare, in seconding, said if they had all enjoyed Mr. Hope-Jones' lecture as much as he had done, then he was sure they had had one of the best evenings of their lives. He pointed out, however, that if disturbances were uniform they were of no consequence, and that it mattered not at what part of the pendulum's path they occurred.

Mr. T. D. Wright, in supporting the vote of thanks, said they were all very much impressed with what Mr. Hope-Jones had told them, and their very best thanks were due to him for his interesting lecture. (Renewed applause.)

Mr. Cottingham, Mr. Bower-Lowe and others having taken part in the discussion, Mr. Hope-Jones, in reply, admitted that Mr. Hare's statement was strictly accurate, but that it was a foregone conclusion that disturbances never were and never could be constant. If the impulse was given otherwise than at zero, then, to mention one thing alone, the least variation in arc would materially affect the value of an otherwise constant disturbance. He was glad they appreciated the lecture, and said it was sufficient reward to be able to talk to those who were thoroughly interested in the subject.

A vote of thanks to the Chairman for presiding concluded the proceedings.

Astronomical Regulators

and

Observatory Time Installations

together with

A BRIEF ESSAY on the FREE PENDULUM

and the

GENERAL PRINCIPLES

of the

SYNCHRONOME SYSTEM,

by

F. HOPE-JONES, M.I.E.E.

THE SYNCHRONOME COMPANY, Ltd.,

32 and 34, Clerkenwell Road,

LONDON, E.C.1.

Telephone No:
Clerkenwell 1517.

THE SYNCHRONOME
Standard Self-wound Electrical Controlling Pendulum or Master Clock—an Electrical TIME TRANSMITTER.

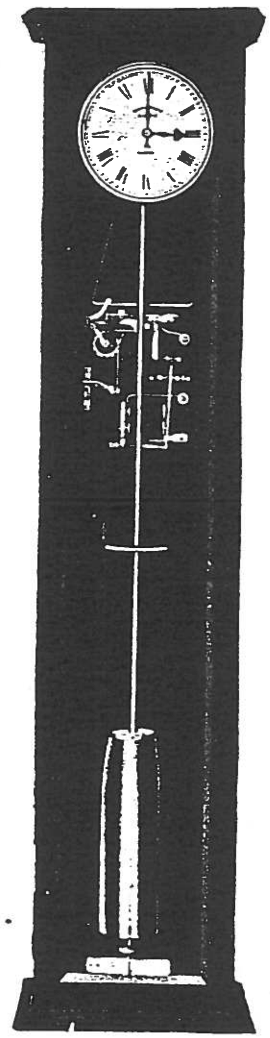


Fig. 1.

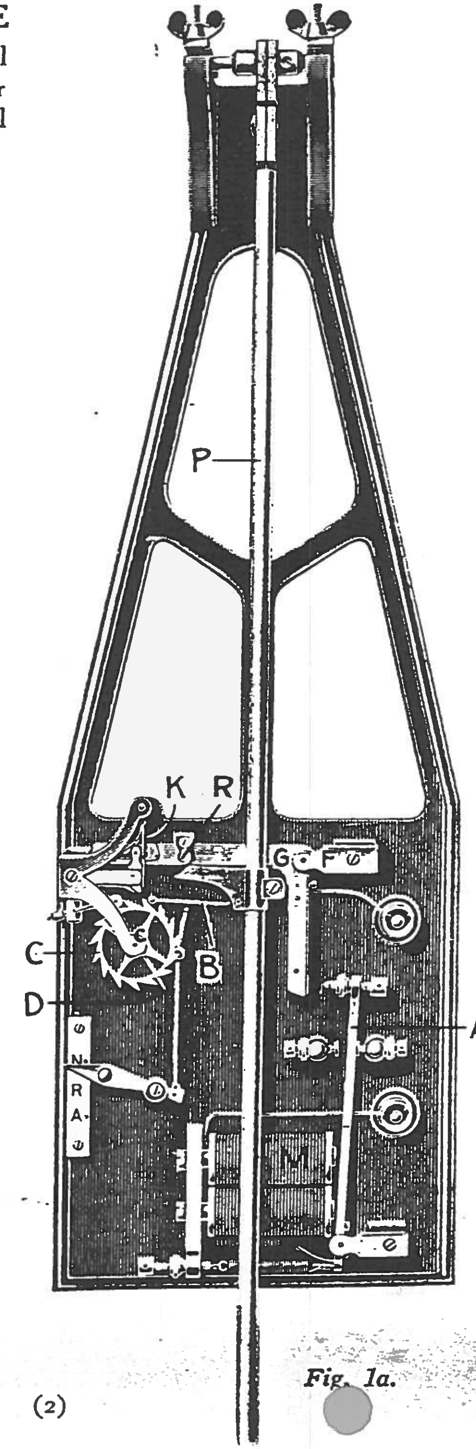


Fig. 1a.

THE SYNCHRONOME SYSTEM.

IN order that the method of operation of the Free Pendulum Astronomical Regulators described in the second half of this pamphlet may be properly understood, it is necessary first to describe briefly the general principles of the SYNCHRONOME system.

The Fundamental Unit. The fundamental unit is the Synchronome Switch or "Remontoire" illustrated in Fig. 1.

This switch consists of two moving parts:—

The right-angled lever, lever **G**, and the magnet armature **A**. The right-angled lever **G** is centred at **F** and normally supported on the spring catch **K**. Once every half-minute the lever is released and after giving impulse to the pendulum makes contact with the armature, with the result that an electric current passes through the series circuit of dials and the magnet **M**, which accordingly attracts armature **A** and throws the lever **G** up on to its catch again.

If the current is insufficient, the armature does not move and the circuit remains closed until the pendulum on its return swing comes to the assistance of the magnet.

Battery Warning. This abnormal increase in the time of contact is utilized to give a visible or audible warning of the impending failure of the battery by lighting a lamp or ringing a bell.

The pendulum will usually continue to operate under battery warning conditions for some days and only ceases to do so when the current has got so low that magnet **M** plays practically no part in the lifting of the lever.

The pendulum releases the switch by means of the fifteen-toothed wheel **C** and the vane **D** which engages with the catch **K** at each revolution. The hook **B** pivoted upon the pendulum **P** rotates this wheel, one tooth at a time, once every thirty seconds.

Impulse to Pendulum. Impulse is given to the pendulum by the little roller **R**, attached to the gravity arm, running down the curved end of the pallet **J** fixed to the pendulum. At the moment of release the sloped face of the pallet has just *not* passed under the roller and the pendulum has just not reached its mid. position.

Thus the impulse is given while the pendulum is passing through its mid. or central position, and the pendulum is quite free at the ends of its swing. The escapement is therefore not only detached but operates at zero and thus fulfils the horologist's ideal.

The shape of the impulse face of the pallet **J** has been determined mathematically, so that the impulse commences very gradually, increases to its maximum at zero and then decreases in an identical manner.

The Contact. The electrical contact, occurring at each half-minute precisely, is the only contact in the system and, owing to the fact that the whole of the energy required to keep the pendulum swinging is transmitted through the contact surfaces, there is no question about its reliability.

The unit above described has created electric time service in Great Britain during the last twenty years and achieved an unassailable reputation as a never-failing automatic switch for the operation of circuits of electrical impulse dials.

Dial Movements. Thanks to its perfection, dial movements of ideal simplicity as illustrated in Fig. 2 can be used with confidence that they will keep in step. The motion is here illustrated, and it will be understood that the electro-magnet **B** receives an impulse every half-minute which attracts the armature **C** and by means of the lever **D** enables the click **E** to engage another tooth of the wheel **A**. The spring **F** then propels the wheel **A** and the minute hand attached to it one half-minute. The stops **H** and **I** are so arranged that the wheel is locked at every point in the cycle of operations, yet capable of being freed at any moment by merely lifting the backstop lever by depressing its tail **G**.

A Main wheel.
B Electro-magnet.
C Armature.
D Armature lever
E Driving click.
F Driving spring.
G Backstop lever.
H Momentum stop.
Stroke limit stop.

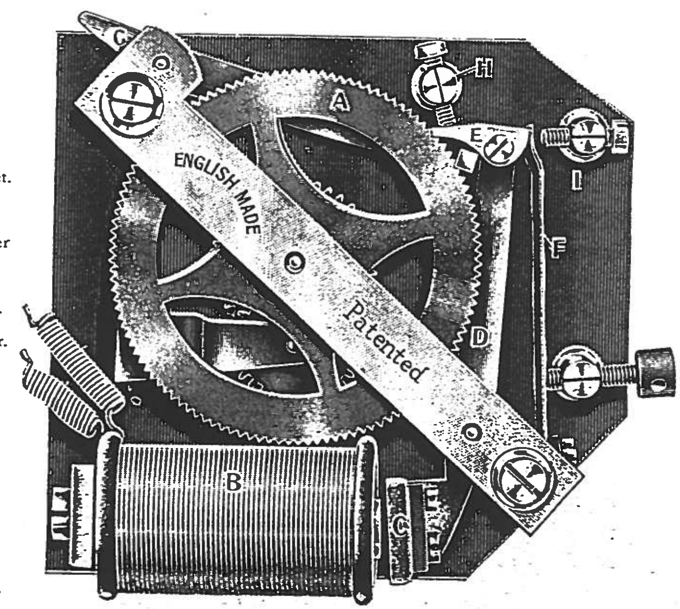


Fig. 2.

Sufficient Current Assured. The Synchronome Switch as applied to the Master Clock is designed so that its minimum operating current is greater than the minimum operating current of any dial or other instrument in the circuit, and, as all the operating magnets are in series, the circuit has considerable self-induction and the current takes some hundredths of a second to attain its full value. Consequently it is impossible for the switch to operate without supplying sufficient energy to the various dials to propel them

This was perfectly demonstrated by the oscillographs shown by Mr. F. Hope-Jones in his 1910 Paper before the Institute of Electrical Engineers, one of which is reproduced in Fig. 3.

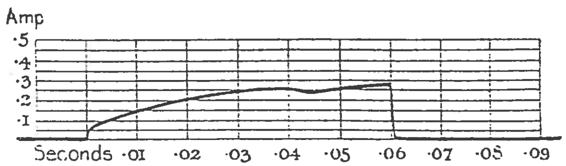


Fig. 3.

Energy Consumed. It may be described as a photograph of one of the Synchronome half-minute impulses. The small depression between ·04 and ·05 secs. represents the operation of the dials, and the area enclosed between the curve and the base line represents the quantity of electricity consumed per impulse, which in this case is ·012 coulombs, and since the impulses are repeated every half-minute this equals about 3½ amp. hours per annum. As each dial requires about 1½ volts across its terminals the annual consumption of energy per dial is about 5¼ watt hours.

Compensatory Action. Under normal circumstances the switch operates and the circuit is broken before the current has reached its maximum value so that a drop in the battery voltage merely results in a reduction in the rate of growth of the current and the reduced voltage is compensated by an increase in the duration of the contact. In consequence a very considerable voltage drop can take place before the switch commences to battery warn.

Clean Make and Break. The oscillograph test, which will infallibly reveal the slightest intermittency or raggedness of impulse, demonstrates the perfect cleanliness and precision of the make and break of the Synchronome Switch—cardinal virtues not easily obtained.

THE FREE PENDULUM and SLAVE.

Energy required to Count and Release. It will have been noticed in the foregoing description that the pendulum of the standard instrument is charged with the duty of rotating the count wheel one tooth every two seconds and with the release of the impulse lever once every half-minute, and although these operations are performed while the pendulum is swinging through its central position they rob it of energy. While this energy is inconsiderable in quantity, it is nevertheless more than equal to that required to overcome the air friction of the bob.

If only these two duties could be done for it, then we could truthfully call it a free pendulum, subject to no interference whatever excepting only that which is inevitable and inherent in the act of impelling it. Is this possible? For long enough it seemed so impossible that no one even asked for it. After all, we can hardly blame clockmakers for not inventing an escapement which does not escape.

The idea is to employ a subsidiary instrument—some extraneous mechanism—to perform the duty of releasing the gravity arm and that this instrument should be completely dominated or controlled by the free pendulum so that perfect phase synchronization could be maintained between the two pendulums, and one be employed to perform the duty for the other.

Elimination of Counting and Releasing Frictions. Thanks to an invention by Mr. W. H. Shortt, M.Inst.C.E., who has been carrying out research work on high-grade timekeeping since 1910, these counting and releasing functions and the work involved by their performance have been satisfactorily transferred to a slave pendulum so firmly held in synchronism with the master or timekeeping pendulum that their phase difference cannot vary by more than plus or minus one two-hundredth part of the period of semi-vibration.

This transfer of labour from master to slave reduced the energy required by the master to that required to overcome the air friction of the bob plus that dissipated in flexing the suspension spring and the way was clear for the second step.

Elimination of Air Friction. This second step was the reduction or practically the elimination of the air friction of the pendulum by enclosing it in an air-tight case and reducing the air pressure inside the case from the normal atmospheric pressure of 760 m.m. to 35 m.m. or less by pumping the air out.

The Result of the Tests. A clock embodying these improvements was built in 1921, and has been running in the Royal Observatory at Edinburgh under the close observation of Professor R. A. Sampson, F.R.S., for the past two years. Its timekeeping capabilitites have [illegible] than justified expectations as will be gathered from the Observatory Reports and the Paper read by Professor Sampson before the Royal Society of Edinburgh in January, 1924, which show that the performance of "clock SH." is superior to that of any possessed by the Observatory.

Scheme of Operation. Fig. 4 in which the same reference letters are used as in Fig. 1, p. 3, shows diagramatically the arrangement and interconnection of the two clocks.

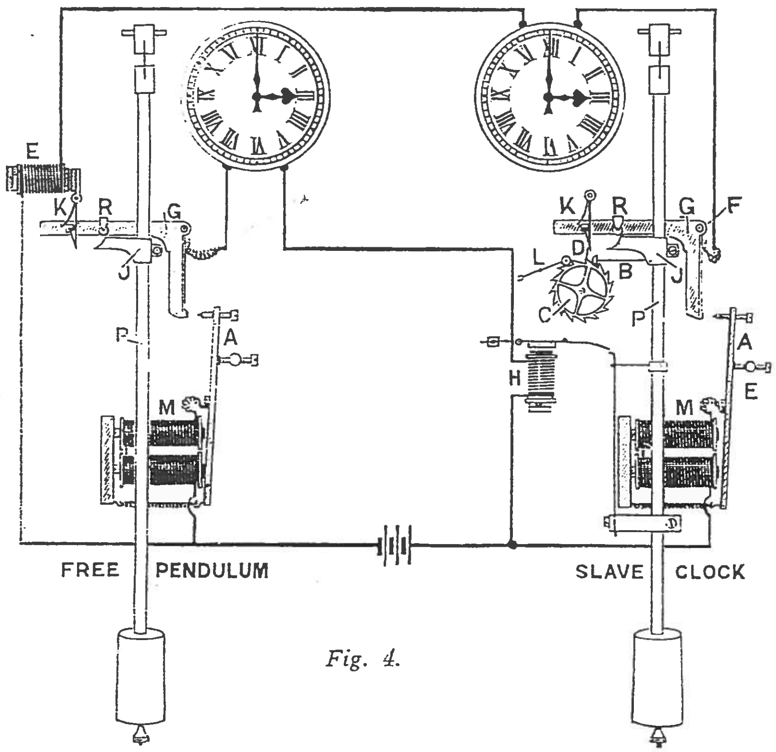


Fig. 4.

It will be understood that in the Master Clock or Free Pendulum the "catch" K which holds up the impulse lever is released by the electro-magnet E at the moment the impulse pallet reaches precisely the right position.

This magnet E which replaces the count wheel and releasing mechanism of the standard switch movement, is connected in the remontoire circuit of the slave, while the slave is synchronized through the agency of another electro-magnet H connected in the remontoire circuit of the master.

The slave remontoire operating every half-minute causes the master to receive impulse every half-minute, hence the master's remontoire operates every half-minute and the slave is synchronized every half-minute.

The master measures the time and the slave does the work—a very satisfactory mutual arrangement.

Constant Impulse. The impulse roller and pallet are arranged in the master or free pendulum somewhat differently from that shown by the drawing and the diagram on pages 2 and 7, in order that the termination of the impulse may be independent of the drop of the lever and dependent only on gravity and the arc of the pendulum.

The synchronization of the slave pendulum is achieved by means of the device diagramatically illustrated in Fig. 5.

The Slave Synchronizer. The Synchronizing electro-magnet M_2 is fixed adjacent to the slave pendulum D so that its armature A is horizontal and will when attracted just engage with the upper end of the springy vertical lever L attached to the slave pendulum as the latter passes through its mid. position; the engagement only being possible when the pendulum is swinging from right to left.

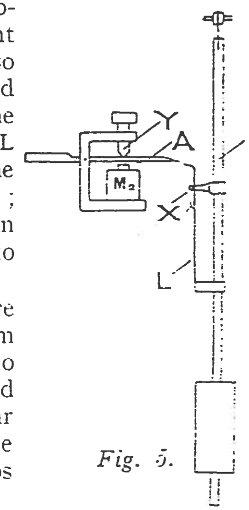


Fig. 5.

When this engagement takes place the continued movement of the pendulum bends the springy lever L and calls into play a force which assists gravity and consequently accelerates that particular half swing by a small fraction of the period of vibration. X and Y are stops against which L and A normally rest.

The slave pendulum is given a small losing rate of about six seconds a day compared to the master and is started up so that, when swinging from right to left, the operation of magnet M_2 by the remontoire contact of the master pendulum is just too late for A and L to engage. Then as a result of the losing rate of the slave the phase difference of the two pendulums will gradually decrease until engagement finally takes place with a consequent advancement of the phase of the slave corresponding to the quickening action of the spring. As this quickening action is arranged to be about twice as great as the amount lost by the slave pendulum during the interval in which it is undisturbed it follows that at the next impulse the slave will not have dropped back quite enough to permit engagement by the electro-magnet and a miss will occur; by the end of the next half-minute however, the phase difference will be approximately the same as when the initial engagement took place and a second engagement will ensue with a corresponding quickening.

Close Limits of Control. This cycle of operations will obviously continue indefinitely and the phase difference between the master and slave will not be allowed to vary by more than plus or minus the advancement

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produced by one operation of the spring. A losing rate of six seconds per day equals 1/480 sec. per half-minute so that the quickening action required from the spring is 1/240 sec. and with this value the phase difference of the two pendulums will never exceed plus or minus 1/240 sec. As long as the losing rate of the slave relative to the master does not increase to more than 12 seconds per day nor decrease to less than zero it will be held in phase with the master, and it will be agreed that the above limits of rate are amply sufficient to warrant the statement that the control of the slave by the master is complete.

Design of Case and Removal of Air. The master pendulum is mounted in a cylindrical copper case with substantial end rings which enable it to be firmly bolted to the wall of the building in which it may be placed. The case is hermetically sealed top and bottom by means of very thick plate glass discs or bell jars and a cock is provided to enable the internal air to be pumped out and the pressure reduced to 35 m.m. or less.

This reduction in pressure reduces the pendulum friction practically to that of the flexing of the suspension spring and enables the normal arc to be maintained with an impulse lever of about one-fourth the weight that would be required had the air been left in the case at atmospheric pressure.

Temperature Compensation. Every free pendulum is carefully compensated for temperature effects, each component part being tested by the National Physical Laboratory for its co-efficient of dilatation between the temperatures 0° and 30° centigrade. It is nevertheless desirable, if the highest precision is sought, to erect it in a chamber maintained at a constant temperature. This can be done efficiently and automatically by an electrical heater controlled by a Thermostat. In addition a fan should be provided to prevent stratification of the air.

The Slave Pendulum. It will be observed that the slave pendulum consists of a Synchronome Standard Master Clock illustrated in Fig. 1 and Fig. 1a, with the addition of the Synchronizer. Its function is to release the gravity arm of the free pendulum every half-minute at exactly the right instant, but it can also perform many useful duties. It is not only provided with an electrical impulse dial of half-minute periodicity in its own circuit, but also a similar dial in circuit with the free pendulum's remontoire. The operation of these two dials at an interval of about a quarter of a second demonstrates that the instruments are functioning correctly. A seconds dial of skeleton form is also provided round the 15-toothed wheel, indicating the even numbered seconds from 2 to 30.

Contacts can be applied to the pendulum itself and to its dial movement for the operation of chronograph pens or for

any similar purpose, and such contacts in no way affect the free pendulum even indirectly.

The slave pendulum need not be placed alongside the free pendulum, but may be mounted wherever its dials may be most convenient.

On the following pages will be found detailed specifications of the Master and Slave pendulums, the necessary electrical impulse dials and all accessories.

The History of the System. In conclusion it should be stated that the history of the Synchronome System is the story of a consistent endeavour for nearly thirty years to obtain reliable electric contacts from clocks or their pendulums without taking energy from either.

The first of a long series of Patents was taken out in 1895 and the Synchronome Company was then established by Mr. F. Hope-Jones, who read a Paper in description of the new system before the British Horological Institute in that year. The Synchronome switch first appeared in the form illustrated in Fig. 6 applied to an ordinary Graham Dead-beat escapement clock. In 1904 this was improved be letting the gravity arm rest upon its catch for about half a minute at the end of which period it delivered its impulse to the pendulum through the medium of a spring. Successive improvements followed rapidly and in 1908 Sir Henry Cunyghame's zero impulse was incorporated. In 1910 Mr. Hope-Jones read his second Paper before the Institute of Electrical Engineers describing the invention practically as illustrated in Fig. 1. On this occasion Mr. H. R. Kempe, Electrician to the Post Office, said: "I have mentioned Mr. Ritchie as being a pioneer, but I must assert, and I think with authority, that by no man living or dead, have electric clocks been brought to such perfection as they have been by Mr. Hope-Jones."

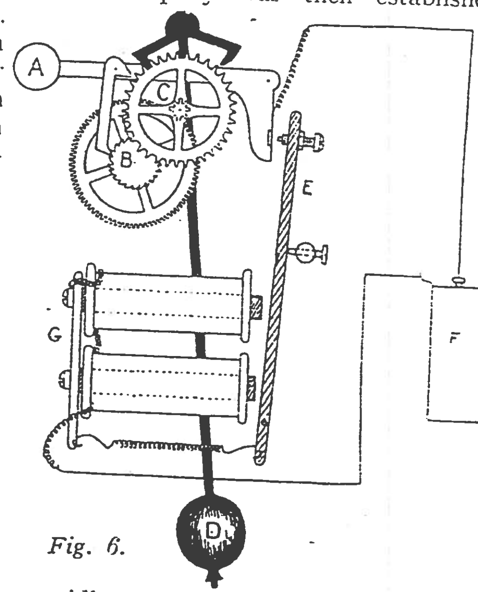

Fig. 6.

Since then electric time service has been established as a recognized branch of the Electrical Engineering Profession; and British practice, as based upon its principles, is generally admitted to be superior to the electric clock systems of any other country.

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FREE PENDULUM MASTER CLOCKS.

The vibrations of the pendulum in these clocks are maintained without an escapement. The pendulum is impelled by the fall of a gravity arm reset by a Synchronome Switch, and the release of this arm is effected by a " slave " clock kept in perfect phase synchronism with it. For details of slave clocks, see next page.

The pendulum rod is made of the highest grade INVAR obtainable and the co-efficient of expansion of every rod is certified by the National Physical Laboratory. It is provided with a weight tray for close regulation and a beat plate is fixed at its lower extremity.

When ordering it should be stated whether Sidereal or Mean Time is required and the value of gravity for the locality should be given.

The instrument is enclosed in a cylindrical copper case, terminated at each end by substantial cast brass rings; holes are provided in feet formed at the back of these rings to enable the case to be solidly bolted to the wall of the building in which it may be placed. The case is closed at the top by a glass bell jar, and at the bottom by a thick plate glass disc. It is provided with a valve and connections for a vacuum gauge and pump.

For suitable pumps and gauges, see page 14.

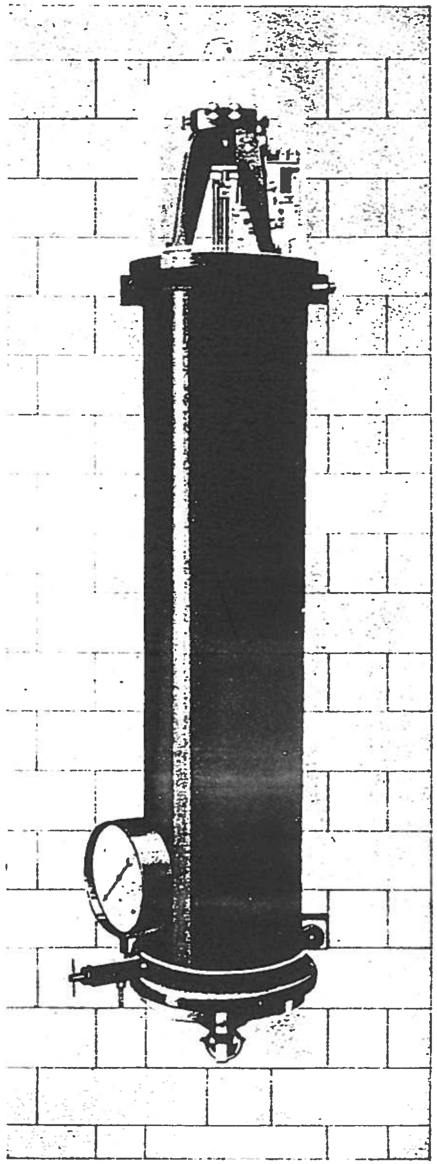

Fig. 7.

Price - £150.

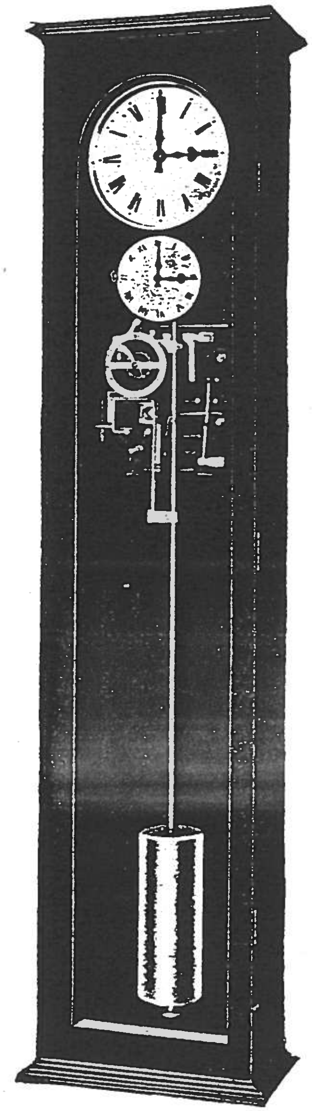

Fig. 8.

SLAVE CLOCKS,
Type A.

A Free Pendulum Master Clock requires a Slave Clock to work in conjunction with it. Such a clock may consist of a standard Synchronome Controlling Pendulum of the best quality as shown in the illustration, fitted with the patented synchronizing mechanism.

It is essential that a dial in the remontoire circuit of the Free Pendulum should be mounted adjacent to the dial in the slave remontoire circuit, and the Slave Clock here shown is so provided. The upper dial is in the Master or Free Pendulum circuit and the lower and smaller dial in the Slave circuit.

A skeleton ring dial is also fitted concentric with the fifteen toothed wheel to indicate the even numbered seconds.

This Slave Clock is known as TYPE A. It does not produce seconds contacts.

Price £35.

Additional Slave Clocks can be controlled by the same Free Pendulum Master Clock, all being equally firmly held in synchronism.

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SLAVE CLOCKS,
Type B.

The Slave Clock here shown consists primarily of the standard Synchronome Controlling Pendulum with the synchronizer as in TYPE A, but its half-minute impulse dials (one in the Free Pendulum circuit and one in the Slave circuit) are arranged side by side in a rectangular panel.

This is surmounted by a dial of "Regulator" type with seconds and hours shown on inset circles. This latter dial is of the seconds impulse type and the seconds contacts are provided by a special Synchronome switch released mechanically by the Slave pendulum.

This clock is therefore a transmitter of seconds impulses as well as half-minute impulses.

Price £68.

Hitherto it has not been possible to set to time clocks sealed up for constant barometric pressure without breaking the seals. A feature of the Free Pendulum and Slave Clock combination is that the half-minute remontoire contacts of both pendulums may be simultaneously set backward or forward in two second steps by freeing or rotating the count wheel of the Slave Clock.

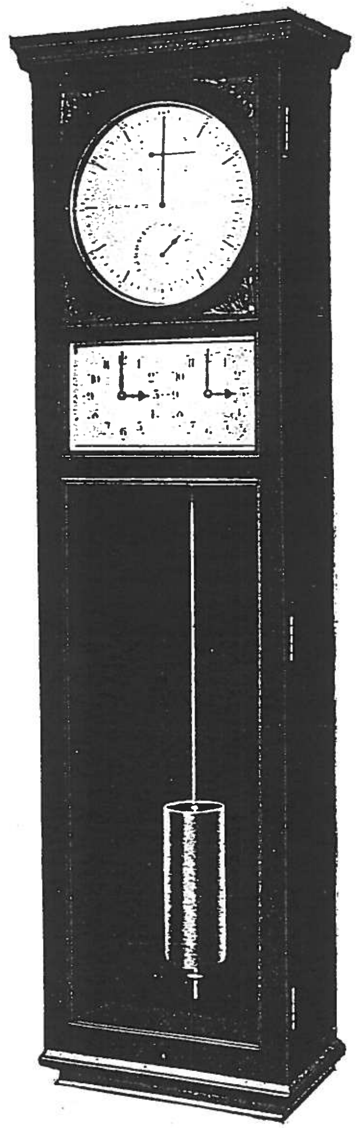

Fig. 9.

ACCESSORIES.

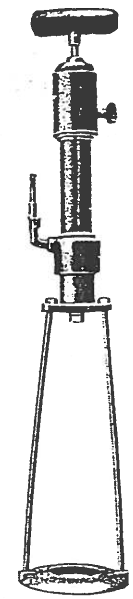

Fig. 10.

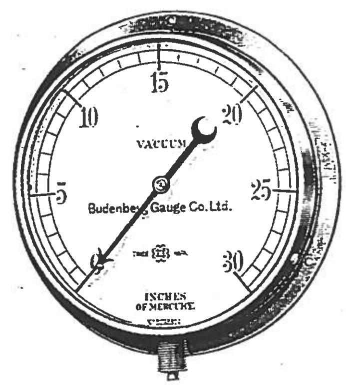

Fig. 11.

VACUUM PUMPS, "Geryk" Type.

Portable, as illustrated,

Price - £6 15s.

Rotary, with 2-in. diameter cylinder and 10-in. stroke,

Price - £13 12s.

A spare charge of oil is included with each.

Rubber Pressure Tubing,

Price per foot, 3/-

Glass Drying Tube, and Bottle of Phosphorus Pentoxide,

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VACUUM GAUGES,

"Bourdon" Type. As illustrated, in case made of iron covered entirely by brass bezel,

Price - £1 10s.

"U" Mercury Type, mounted to go inside bell jar top of Free pendulum case,

Price - £1.

THERMOMETERS,

Mercury reading from 0°—50° cent. in fifths of degrees,

Price - 15/-

SETS OF WEIGHTS ranging from 10 mg. to 10 grams, in wood block with forceps,

Price - 7/6

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ACCESSORIES.

ELECTRICAL IMPULSE DIALS.

Separate electrical impulse dials of half-minute periodicity, 12-inch in polished mahogany cases,

Price - £5 12s. 6d. each.

Fig. 12.

See Synchronome Time Service Catalogue for particulars and prices of other standard types.

Special electrical impulse dials of seconds periodicity, of 10-inch diameter with inset circles for seconds and hours, in polished mahogany cases,

Price - £9 16s. each.

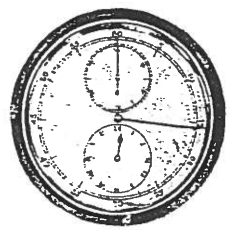

Fig. 13.

ELECTRICAL CONTACTS.

Electrical contacts of any duration or any periodicity, in multiples of a half-minute or of a second respectively, arranged according to any programme, can be provided from either of the above instruments for chronograph recording or other purposes without the fundamental Free Pendulum being affected, even indirectly.

On receipt of details of the programme required, a precise quotation will be given.

Further information on this subject will also be found in the Automatic Bell Controller section of the Synchronome Catalogue.

ACCESSORIES.

RELAYS. P.O. pattern double polarised for use when the actual remontoire contacts of the Master and Slave Pendulums have to be recorded.

STORAGE CELLS. 6 volt 45 amp. actual capacity.

Packed in wood crates if desired.

THERMOSTATS for control of Electric Heaters.

HEAVY CURRENT THERMOSTAT RELAYS.

ELECTRIC HEATERS.

ELECTRIC FANS.

Prices of the above on application.

For further particulars and information please write :

The Synchronome Co., Ltd.

Mr. F. HOPE-JONES, M.I.E.E. (Managing Director and Patentee)

32 and 34, Clerkenwell Road, E.C.1.

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SHORTT-SYNCHRONOME FREE PENDULUM CLOCKS

The Shortt free pendulum clock was produced for about 40 years, approximately 100 were made. The following is a list of their original purchasers. If anybody knows the present location of any of the clocks or any other interesting information please let us know and we will publish it. We want to thank Dr. Iain G. M. Cleator and R. John Griffiths of the Prescot Museum for their help in compiling this list. Latest known location is in parenthesis.

No.	Purchaser	Date	Comments
0	Royal Observatory, Edinburgh, Scotland (Royal Scottish Museum)	Dec. 1921	Sidereal, Impulsing below the bob
X	Synchronome House, London, England (Science Museum, London)	1923	Mean time, Glass cylinder case
1	Helwan Observatory, Cairo, Egypt	Mar. 1924	Sidereal
2	Azabu Observatory, Tokyo, Japan	June 1924	Mean time
3	Royal Observatory, Greenwich, England (RGO Museum)	Nov. 1924	Sidereal
4	Royal Observatory (2nd), Edinburgh, Scotland	Jan. 1925	Sidereal
5	Melbourne Observatory, Victoria, Australia	June 1925	Sidereal
6	Capt. C. A. Fountaine, Narford Hall, Norfolk, England	Sept 1925	Mean time
7	William Hamilton Shortt (Clockmakers' Guild, London)	Oct. 1925	Mean time
8	Sydney Observatory, N.S.W., Australia	Dec. 1925	Sidereal
9	Batavia Observatory, Jakarta, Java	Mar. 1926	Mean time
10	Cape of Good Hope Observatory, South Africa	Mar. 1926	Sidereal
11	Royal Observatory (2nd), Greenwich, England (Perth Observatory, West Australia)	Feb. 1926	Sidereal
12	Tokyo Observatory, Yokohama, Japan	Feb. 1926	Sidereal

13	National Physical Laboratory, Teddington, England (Liverpool Science Museum)	Dec. 1926	Mean time
14	Le Bureau Central des Mesures, Warsaw, Poland (Destroyed in WWII)	June 1927	Mean time
15	St. Louis, Missouri	Nov. 1927	Mean time
16	Royal Observatory (3rd), Greenwich, England (RGO Museum)	Dec. 1927	Mean time
17	American Geographical Society, New York (Harvard)	Dec. 1927	Mean time
18	Mount Faber Observatory, Singapore	1928	Sidereal
19	Adelaide, South Australia (University of Adelaide)	Apr. 1928	Mean time
20	A. L. Loomis, Tuxedo Park, N. Y.	Nov. 1928	Mean time
21			Mean time
22			Mean time
23	Lick Observatory, Mt. Hamilton, California	Oct. 1928	Sidereal
24	Copenhagen, Denmark	Oct. 1928	Sidereal
25	Rodrigues, Lourenco Marques,	Apr. 1929	Sidereal
26	Mozambique, Time Service		Mean time
27	Cape of Good Hope Observatory (2nd), South Africa	May 1929	Mean time
28	Kyoto, Japan	Oct. 1929	Sidereal
29	Dominion Observatory, Ottawa, Canada (National Museum of Science)	July 1929	Sidereal
30	Cracow, Poland	July 1929	Sidereal
31	Mt. Stromlo, Canberra, Australia	July 1929	Mean time
32	National Bureau of Standards, Washington, D.C. (NBS Museum)	Dec.1929	Mean time
33	Manila, Philippines	Dec. 1929	Mean time
34	Dehra Dun, India	Jan. 1930	Sidereal
35	Nikolaevskaja Observatory, Russia	Feb. 1930	Sidereal

36 37	Rio de Janeiro, Brazil	Mar. 1930	Sidereal Sidereal
38	U. S. Naval Observatory, Washington, D.C.	May 1930	Sidereal
39	Ulug-Bcka (Uling Beka), Russia	July 1930	Sidereal
40	H. R. Fry, F.R.A.S., Barnet, England (Gift in 1936 to Royal Observatory, Greenwich, England)	Nov. 1931	Mean time
41	U. S. Naval Observatory (2nd), Washington, D.C.	Jan. 1932	Sidereal
42 43	Prof. C.S. Yu, Nanking Research Institute of Astronomy, China	Jan. 1932	Mean time Sidereal
44	B.I.H., Paris Observatory, France	Jan. 1932	Sidereal
45	Inst. of Geodesy, Moscow, Russia	Feb. 1932	Sidereal
46	Stockholm Observatorium, Sweden	June 1932	Sidereal
47	Ogaish Observatory, Moscow, Russia	Dec. 1932	Sidereal
48	U. S. Naval Observatory (3rd), Washington, D.C.	Dec. 1932	Sidereal
49	Royal Observatory (4th), Greenwich, England (Sydney Observatory, NSW, Australia)	Apr. 1934	Mean time
50 51	Pulkovo Observatory, Leningrad, Russia	Aug. 1934	Sidereal Mean time
52	Observatory de Marina, San Fernando, Spain	Aug. 1934	Sidereal to Mean time
53	Victoria College, Jersey, United Kingdom	Nov. 1935	Mean time
54	National Observatory, Rio de Janeiro, Brazil	Sept 1935	Sidereal
55	National Observatory, Cordoba, Argentina	Sept 1935	Sidereal
56 57	National Observatory, Quito, Ecuador	Oct. 1935	Sidereal Sidereal
58	Nairobi, Kenya	Jan. 1936	Mean time

59	Melbourne Observatory, Victoria, Australia (Mt. Stromlo Observatory, Canberra)	Dec. 1936	Sidereal
60	National Observatory, Bogota, Columbia	Jan. 1937	Mean time
61	H. R. Fry, Chichester, West Sussex, England	June 1937	Mean time
62	National University Observatory, La Plata, Argentina	Oct. 1937	Sidereal
63	Shternberga, Moscow, Russia	Dec. 1937	Mean time
64	Helwan Observatory (2nd), Cairo, Egypt	Oct. 1938	Mean time
65	Moscow, Russia	Oct. 1938	Sidereal
66 67	Abinger Observatory, Surrey, England (66-British Horological Institute, 67-Hackney Technical College)	Sept 1939	Sidereal Mean time
68	Colombo, Ceylon	Dec. 1946	Sidereal
69	Naval Observatory, Buenos Aires, Argentina	Apr. 1947	Sidereal
70	Polish Bureau of Standards, Warsaw, Poland	Feb. 1947	Mean time
71 72	Helwan Observatory (3rd & 4th), Cairo, Egypt	Apr. 1947	Sidereal Mean time
73 74	Leningrad, Russia	June 1948	Sidereal Mean time
75 76 77 78	Moscow, Russia	June 1948	Mean time Sidereal Sidereal Mean time
79	Commerce Dept., Manilla, Philippines	Aug. 1949	Mean time
80	Observatory de Marina, San Fernando, Spain	May 1950	Sidereal
81	Rogue A. Saldias, Minister of Marine, South America	Aug. 1951	Mean time
82	Northampton Polytechnic Institute, London, England	Aug. 1950	Mean time

83	Moscow, Russia	Mar. 1951	Sidereal
84			Sidereal
85	Djakarta, Indonesia	Oct. 1953	Mean time
86	Dunsink Observatory, Dublin, Ireland	Jan. 1954	Mean time
87	Alipore, Calcutta, India	May 1954	Mean time
88	Beijing, China	Dec. 1954	Mean time
89			Sidereal
90		Mar. 1955	Sidereal
91			Mean time
92		Jan. 1956	Sidereal
93			Mean time
94	Perth Observatory, West Australia	May 1956	Mean time
95	Beijing, China	Sept 1956	Sidereal
96			Mean time
97	Warsaw, Poland	Oct. 1956	Sidereal
98			Sidereal
99	Synchronome Co. Ltd., Westbury, Wiltshire, England	1959	Mean time
100	G. Richman, Brooklyn, N.Y.	1972	Mean time

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