The Modern Clock.

Goodrich.

CHAPTER XX.

ELECTRIC CLOCKS AND BATTERIES.

Electric clocks may be divided into three kinds, or principal divisions. Of the first class are those in which the pendulum is driven directly from the armature by electric impulse, or by means of a weight dropping on an arm projecting from the pendulum. In this case the entire train of the clock consists of a ratchet wheel and the dial work.

The second class comprises the regular train from the center to the arbor. This class has a spring on the center arbor, wound more or less frequently by electricity. In this case the aim is to keep the spring constantly wound, so that the tension is almost as evenly divided as with the ordinary weight clock, such as is used in jewelers' regulators.

The third system uses a weight on the end of a lever connected with a ratchet wheel on the center arbor and does away with springs. One type of each of these clocks will be described so that jewelers may comprehend the principles on which the three types are built.

In the Gillette Electro-Automatic, which belongs to the class first mentioned, the ordinary clock principle is reversed. Instead of the works driving the pendulum, the pendulum drives the train, through the medium of a pawl and ratchet mechanism on the center arbor. The pendulum is kept swinging by means of an impulse given every tenth beat by an electro-magnet. This impulse is caused by the weight of the armature as it falls away from the magnet ends, the current being used solely to pull back and re-set the armature for the next impulse. Any variation in the current, therefore, does not affect the regulation of the

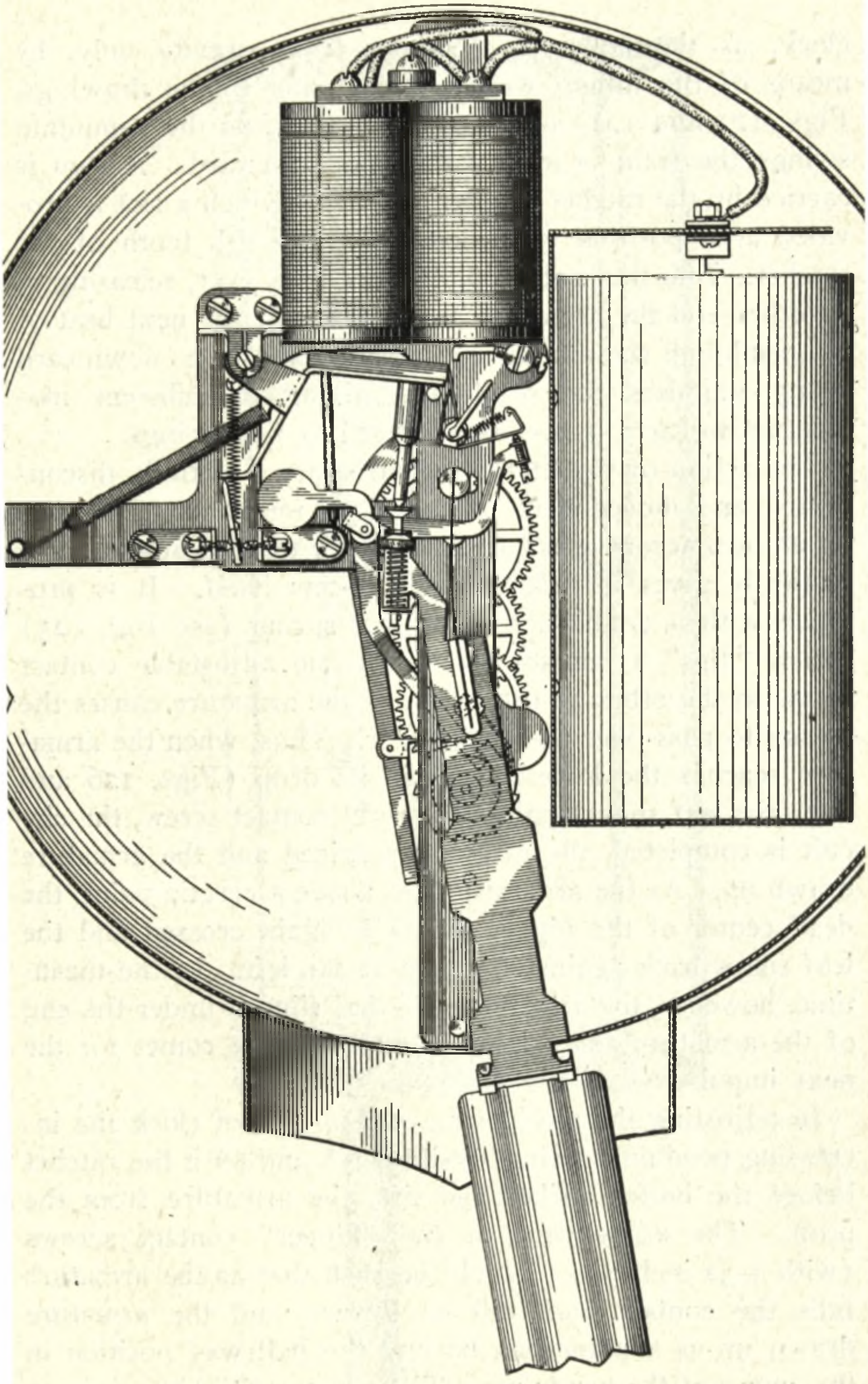

Fig. 123. Gillette Clock (Pendulum Driven)

clock, as the power is obtained from gravity only, by means of the falling weight. Referring to the drawings, Figs. 123 and 124, it is seen that each time the pendulum swings the train is pushed one tooth forward. A cam is carried by the ratchet (center) arbor in which a slot is provided at a position equivalent to every fifth tooth of the ratchet. Into this slot drops the end of a lever, releasing at its other end the armature prop. Thus at the next beat of the pendulum the armature is released and in its downward swing impulses the pendulum, giving it sufficient momentum to carry it over the succeeding five swings.

The action of the life-giving armature is entirely disconnected and independent of the clock mechanism. It acts on its own accord when released every tenth beat and automatically gives its impulse and re-sets itself. It is provided with a double-acting contact spring (see Fig. 125) which "flips" a contact leaf from one adjustable contact screw to the other as the action of the armature causes the spring to pass over its dead center. Thus, when the armature reaches the lowest point in its drop (Figs. 126 and 127) the leaf snaps against the right contact screw, the circuit is completed, the magnet energized and the armature drawn up. As the armature rises above a certain point, the dead center of the flipper spring is again crossed and the leaf snaps back against the post at the left. In the meantime, however, the armature prop has slipped under the end of the armature and retains it until the time comes for the next impulse.

In adjusting the mechanism of this type of clock the increasing pendulum swing should catch and push the ratchet before the buffer strikes and lifts the armature from the prop. The adjustment of the "flipper" contact screws (with 1-32 inch play) should be such that as the armature falls the contact leaf will be thrown and the armature drawn up at a point just beyond the half-way position in the swing of the pendulum. The power of the impulse can

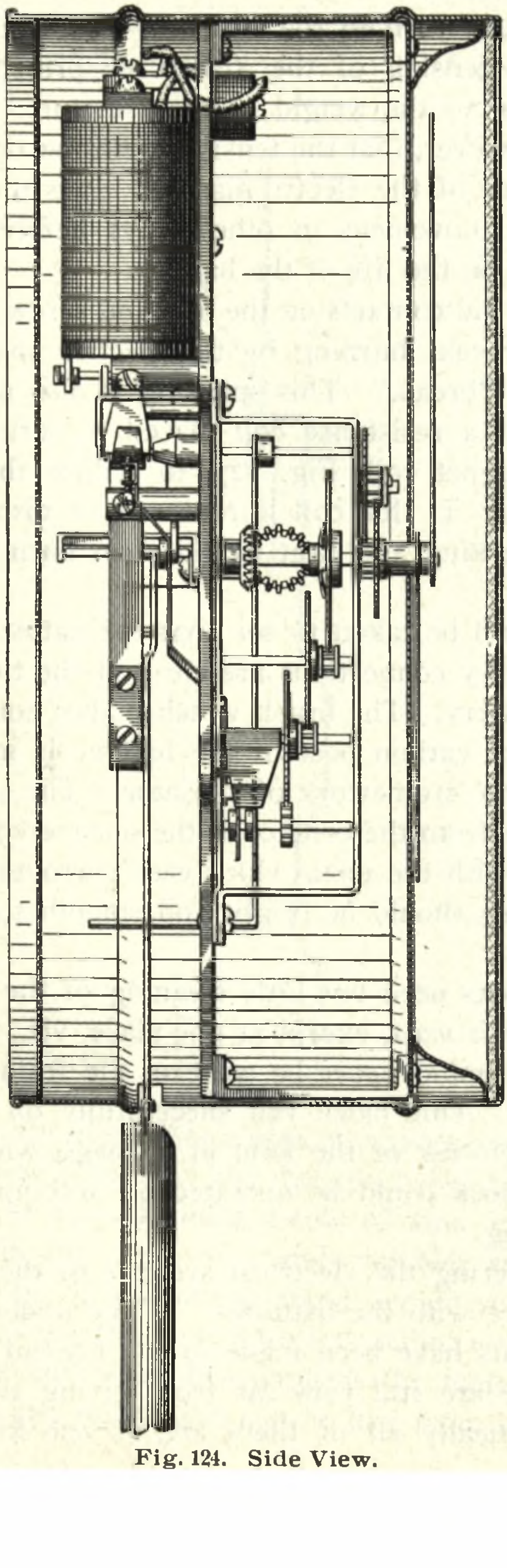

Fig. 124. Side View.

be regulated by turning the adjusting post with pliers, thus varying the tension of the armature spring, the pull of which reinforces the weight of the armature. Care should be taken, however, that the tension is not beyond the "quick action" power of the electro-magnet. It is much better to ease up the movement in other ways before putting too great a load on the life of the battery.

The electrical contacts on the leaf and screw are platinum tipped to prevent burning by the electric sparking at the "make" and "break." This sparking is also much reduced by means of a resistance coil placed in series connection with the magnet coil, Fig. 127, to reduce the amount of current used. If this coil is removed or disconnected the constant sparking and heat would soon burn out the contact tips.

Care should be taken to see that the batteries are dated and the battery connections are clean at the time of sliding in a new battery. The brush which makes connection with the center or carbon post of the battery is insulated with mica from the framework of the case. The other connection is made from the contact of the uncovered zinc case of the battery with the metal clock case surrounding it. The contact points should be bright and smooth to insure good contacts.

These clocks need but little cleaning of the works as *no oil whatever is used,* except at one place, viz., the armature pivot. Oil should *never* be used on the train bearings, or other parts. This clock ran successfully on the elevated railway platforms of the loop in Chicago where no other pendulum clock could be operated on account of the constant shaking.

In considering the electrical systems of these clocks, let us commence with the batteries. While undoubtedly great improvements have been made in the present form of dry battery they are still very far from giving entire satisfaction. Practically all of them are of one kind, which is that which produces electricity at $1\frac{1}{2}$ volts from zinc, carbon and sal-ammoniac, with a depolarizer added to the elements to absorb the hydrogen. The chemical action of such a battery is as follows:

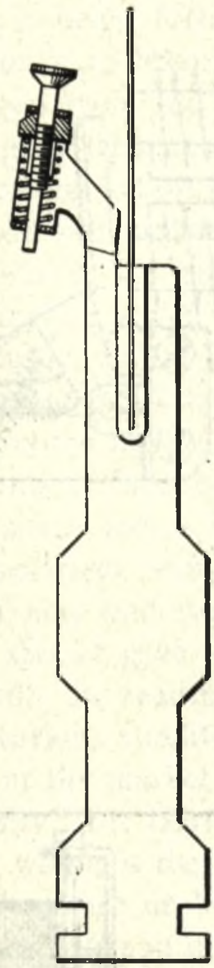

Fig. 125.

The water in the electrolite comes in contact with the zinc and is decomposed thereby, the oxygen being taken from the water by the zinc, forming oxide of zinc and leaving the hydrogen in the form of minute bubbles attached to the zinc. As this, if allowed to stand, would shut off the water from reaching the zinc, chemical action would therefore soon cease and when this happens the battery is said to be polarized and no current can be had from it.

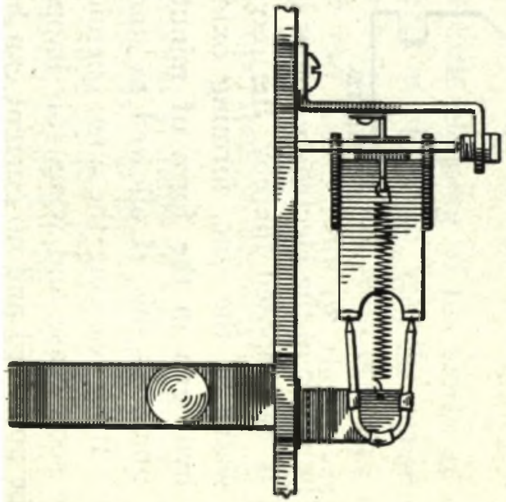

Fig. 126. The Electric Contact.

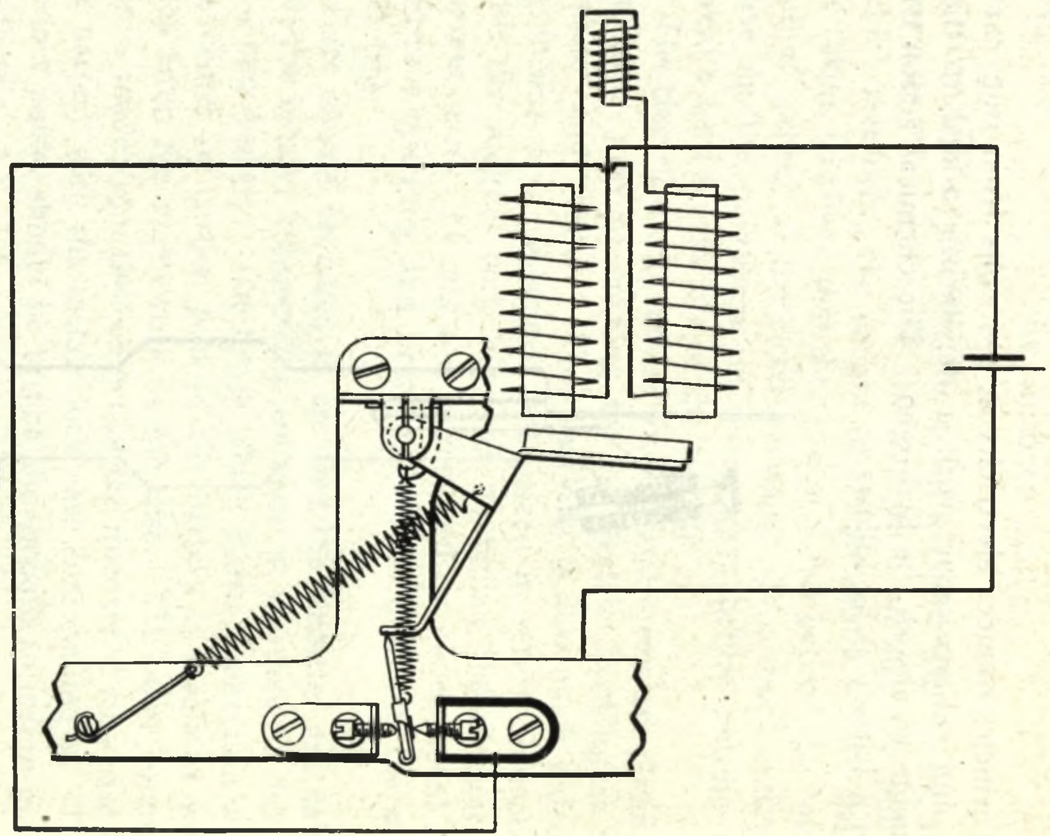

Fig. 127. The Wiring System.

In order to take care of the hydrogen and thus insure the constant action of the battery, oxide of manganese is added to the contents of the cell, generally as a mixture with the carbon element. Manganese has the property of absorbing oxygen very rapidly and of giving it off quite easily. Therefore while the hydrogen is being formed on the zinc, it becomes an easy matter for it to leave the zinc and take its proper quantity of oxygen from the manganese and again form water, which is again decomposed by the zinc. As long as this cycle of chemical action takes place the battery will continue to give good satisfaction, and usually when a battery gives out it is because the depolarizer is exhausted, for the reason that the carbon is not affected at all and the zinc element forming the container is present in sufficient quantity to outlast the chemical action of the total mass.

There are great differences in the various makes of batteries; also in the methods of their construction. It would seem to be an easy matter for a chemist to figure out exactly how much depolarizer would serve the purpose for a given quantity of zinc and carbon and therefore to make a battery which should give an exact performance that could be anticipated. In reality, however, this is not the case, owing to the various conditions. There are three qualities of manganese in the market; the Japanese, which is the best and most costly; the German, which comes second, and the American, which is the cheapest and varies in quality so much as to be more or less a matter of guesswork. We must remember that in making batteries for the price at which they are now sold on the market we are obliged to take materials in commercial quantities and commercial qualities and cannot depend upon the chemically pure materials with which the chemists' theories are always formulated. This therefore introduces several elements of uncertainty.

In practice the Japanese manganese will stand up for a far longer time than any other that is known and it is used in all special batteries where quality and length of life are considered of more importance than the price. The German manganese comes next. Then comes a mixture of American and German manganese, and finally the American manganese, which is used in making the cheaper batteries which are sorted afterwards, as we shall explain farther on. These batteries are sealed after having been made in large quantities, say five thousand or ten thousand in the lot, and kept for thirty days, after which they are tested. The batteries which are likely to give short-life will show a local action and consequent reduction of output in thirty days. They are, therefore, sorted out, much as eggs are candled on being received in a storage warehouse, for the reason that after a cell has been made and put together it would cost more to find out what was the matter with it and remedy that than it would to make a new cell. Many of the battery manufacturers, therefore, make up their batteries with an attempt to reach the highest standard. They are sorted for grade in thirty days and those which have attained the point desired are labeled as the factories' best battery and are sold at the highest prices. The others have been graded down exclusively and labeled differently until those which are positively known to be short-lived are run out and disposed of as the factories' cheapest product under still another label.

When buying batteries always look to see that the tops are not cracked, as if the seal on the cell is broken, chemical action induced from contact with the air as the battery dries out, will rapidly deteriorate the depolarizer and sulphate the zinc, both of which are of course a constant draft on the life of the battery, which contains only a stated quantity of energy in the beginning. Always examine the terminal connections to see that they are tight and solid.

Batteries when made up are always dated by the factory, but this does the purchaser little good, as the dates are in codes of letters, figures, or letters and figures, and are constantly changed so that even the dealers who are handling thousands of them are unable to read the code. This is done because many people are prone to blame the battery for other defects in the electrical system and many who are using great quantities would find an incentive to switch the covers on which the dates appear if they knew what it meant. This is perhaps rather harsh language, but a good many men would be tempted to send back a barrel of old batteries every now and then with the covers showing that they had not lasted three months, if they could read these signatures.

Practically the only means the jeweler has of obtaining a good cell, with long life, is to buy them of a large electrical supply house, paying a good price for them and making sure that that house has trade enough in that battery to insure their being continuously supplied with fresh stock.

The position of the battery also has to do with the length of life or amount of its output. Thus a battery lying on its side will not give more than seventy-five per cent of the output of a battery which is standing with the zinc and carbon elements perpendicular. Square batteries will not give the satisfaction that the round cell does. It has been found in practice by trials of numerous shapes and proportions that the ordinary size of $2\frac{1}{2} \times 6$ inches will give better satisfaction than one of a different shape—wider or shorter, or longer and thinner; that is for the amount of material which it contains. The battery which has proved most successful in gas engine ignition work is $3\frac{3}{4} \times 8$ inches. That maintains the same proportions as above, or very nearly so, but owing to local action it will give on clock work only about fifty per cent longer life than the smaller size.

It has been a more or less common experience with purchasers of electric clocks to find that the batteries which came with the clock from the factory ran for two or three years (three years not being at all uncommon) and that they were then unable to obtain batteries which would stand up to the work for more than three weeks, up to six months. The difference is in the quality and freshness of the battery bought, as outlined above.

In considering the rest of the electrical circuit, we find three methods of wiring commonly used and also a fourth which is just now coming into use. The majority of electric clocks are wound by a magnet which varies in size from three to six ohms; bridged around the contact points,

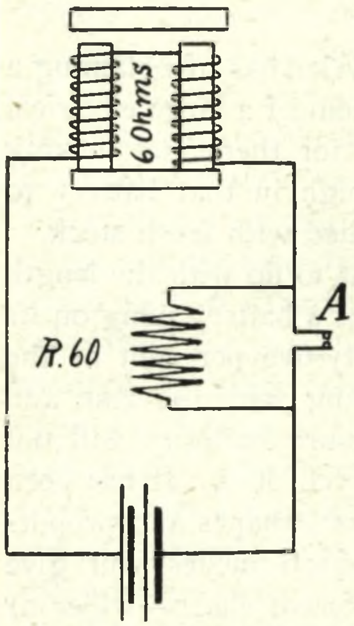

Fig. 128.

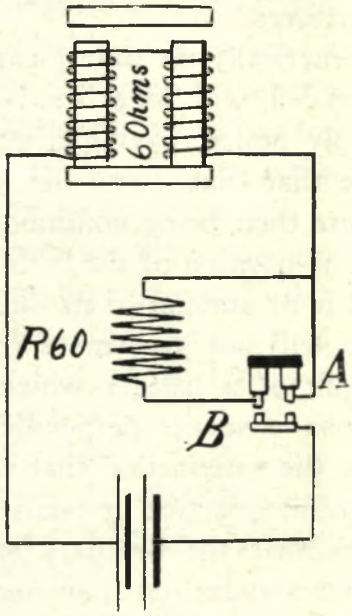

Fig. 129.

there has generally been placed a resistance spool which varies in size from ten to twenty-five times the number of ohms in the armature magnets. See Fig. 128. This practically makes a closed circuit on which we are using a battery designed for open circuit work.

If we use an electro-magnet with a very soft iron core, we will need a small amount of current, but every time we break the contact, we will have a very high counter electromotive force, leaping the air gap made while breaking the contact and therefore burning the contact points. If our magnet is constructed so as to use the least current, by very careful winding and very soft iron cores, this counter electro-motive force will be at its greatest while the draft on the battery is at its smallest. If the magnet cores are made of harder iron, the counter electro-motive force will be much less; but on the other hand much more current will be needed to do a given quantity of work with a magnet of the second description; and the consequence is that while we save our contact points to some extent, we deplete the battery more rapidly.

If we put in the highest possible resistance—that of air—in making and breaking our contacts, we use current from the battery only to do useful work; but we also have the spark from the counter electro-motive force in a form which will destroy our contact points more quickly. If we reduce the resistance by inserting a German silver wire coil of say sixty ohms on a six-ohm magnet circuit, we have then with two dry batteries (the usual number) three volts of current in a six-ohm magnet during work and three volts of current in a sixty-six ohm circuit while the contacts are broken, Fig. 128. Dividing the volts by the ohms, we find that one twenty-second of an ampere is constantly flowing through such a circuit. We are therefore using a dry battery (an open circuit battery) on closed circuit work and we are drawing from the life of our battery constantly in order to save our contact points.

It then becomes a question which we are going to sacrifice, or what sort of a compromise may be made to obtain the necessary work from the magnet and at the same time get the longest life of the contact points and the batteries. Most of the earlier electric clocks manufactured have finally arranged such a circuit as has been described above.

The Germans put in a second contact between the battery and the resistance with a little larger angular motion than the first or principal contact, so that the contact is then first made between the battery and resistance spool, B, Fig. 129, then between the two contact points of the shunt, A, Fig. 129, to the electro-magnet, and after the work is done they are broken in the reverse order, so that the resistance is made first and broken after the principal contact. This involves just twice as many contact points and it also involves more or less burning of the second contact.

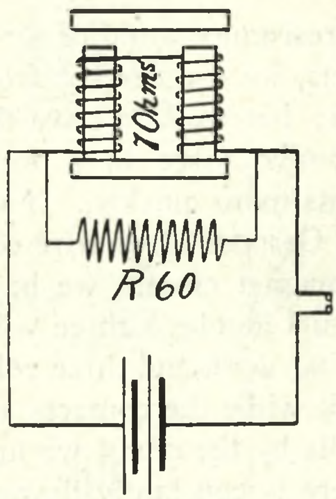

Fig. 130.

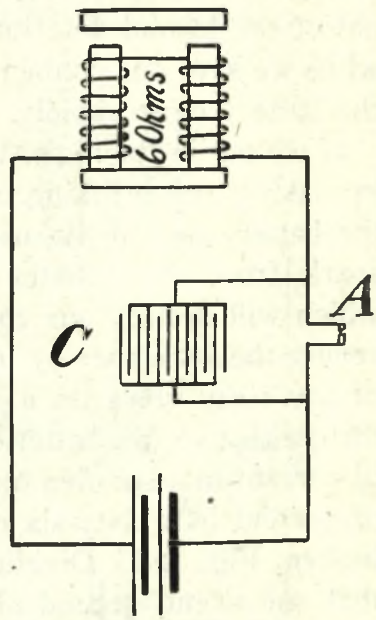

Fig. 131.

The American manufacturers seem to prefer to waste more or less current rather than to introduce additional contact points, as they find that these become corroded in time with even the best arrangements and they desire as few of them as possible in their movements, preferring rather to stand the draft on the battery.

One American manufacturer inserts a resistance spool of 60 ohms in parallel with a magnet of seven ohms (3½ ohms for each magnet spool) as in Fig. 130. He states that the counter electro-motive force is thus dissipated in the resistance when the contact is broken, as the resistance thus becomes a sort of condenser, and almost entirely does away with heating and burning of the contacts, while keeping the circuit open when the battery is doing no work.

It has been suggested to the writer by several engineers of high attainments and large experience that what should be used in the above combination is a condenser in place of a resistance spool, as there would then be no expenditure of current except for work. One of the clocks changed to this system just before the failure of its manufacturers, but as less than four hundred clocks were made with the condensers (Fig. 131), the point was not conclusively demonstrated.

It should also be borne in mind that the condenser has been vastly improved within the last twelve months. With the condenser it will be observed that there is an absolutely open circuit while the armature is doing no work and that therefore the battery should last that much longer, Figs. 130 and 131. As to the cost of the condensers as compared with resistance spools, we are not informed, but imagine that with the batteries lasting so much longer and the clock consequently giving so much better satisfaction, a slight additional cost in manufacture by changing from resistance to condensers would be welcomed, if it added to the length of life and the surety of operation.

Electric clocks cost more to make than spring or weight clocks and sell for a higher price and a few cents additional per movement would be a very small premium to pay for an increase in efficiency.

The repairer who takes down and reassembles one of these clocks very often ignorantly makes a lot of trouble for himself. Many of the older clocks were built in such a way that the magnets could be shifted for adjustment, instead of being put in with steady pins to hold them accurately in place. The retail jeweler who repairs one of these clocks is apt to get them out of position in assembling. The armature should come down squarely to the magnets, but should not be allowed to touch, as if the iron of the armature touches the poles of the magnet it will freeze and retain its magnetism after the current is broken. Some manufacturers avoid this by plating their armatures with copper or brass and this has puzzled many retailers who found an electro-magnet apparently attracting a piece of metal which is generally understood to be non-magnetic.

The method offers a good and permanent means of insulating the iron of the armature from the magnet poles while allowing their close contact and as the strength of a magnet increases in proportion to the square of the distance between the poles and the armature, it will be seen that allowing the armature to thus approach as closely as possible to the poles greatly increases the pull of the magnet at its final point. If when setting them up the magnet and armature do not approach each other squarely, the armature will touch the poles on one side or another and soon wear through the copper or brass plating designed to maintain their separation and then we will have freezing with its accompanying troubles.

A very good test to determine this is to place a piece of watch paper, cigarette paper or other thin tissue on the poles of the magnet before the naked iron armature is drawn down. Then make the connection, hold the armature and see if the paper can be withdrawn. If it cannot the armature and poles are touching and means should be taken to separate them. This is sometimes done by driving a piece of brass into a hole drilled in the center of the pole of the magnet; or by soldering a thin foil of brass on the armature. As long as the separation is steadily maintained the object sought is accomplished, no matter what means is used to attain it.

Another point with clocks which have their armatures moved in a circular direction is to see that the magnet is so placed as to give the least possible freedom between the armatures and the circular poles of the magnet, but that there must be an air-gap between the armature and magnet poles.

In those clocks which wind a spring by means of a lever and ratchet working into a fine-toothed ratchet wheel, or are driven by a weighted lever, there is an additional point to guard against. If the weight lever is thrown too far up, either one of two things will happen. The weight lever may be thrown up to ninety degrees and become balanced if the butting post is left off or wrongly replaced; the power will then be taken off the clock, if it is driven directly by weight, so that a butting post should meet the lever at the highest point and insure that it will not go beyond this and thus lose the efficiency of the weight.

In the cases where a spring on the center arbor is interposed between the arbor and the ratchet wheel, it should be determined just how many teeth are necessary to be operated when winding, as if a clock is wound once an hour and the aim is to wind a complete turn (which is the amount the arbor has run down) if the lever is allowed to vibrate one or two teeth beyond a complete turn, it will readily be seen that in the course of time the spring will wind itself so tightly as to break or become set. This was a frequent fault with the Dulaney clock and has not been guarded against sufficiently in some others which use the fine ratchet tooth for winding.

When such a clock is found the proper number of teeth should be ascertained and the rest of the mechanism adjusted to see that just that number of teeth will be wound. If less is wound there will come a time when the spring will run down and the clock will stop. If too much is wound the spring will eventually become set and the clock will stop. Therefore such movements should be examined to see that the proper amount of winding occurs at each operation. Of course where a spring is wound and there are but four notches in the ratchet wheel and the screw stop is accurately placed to stop the action of the armature, over action will not harm the spring, provided it will not go to another quarter, as if the armature carries the ratchet wheel further than it should, the smooth circumference between the notches will let it drop back to its proper notch.

There are a large number of clocks on the market which wind once per hour. These differ from the others in that they do not depend upon a single movement of the armature for an instantaneous winding. Thus if the batteries are weak it may take twenty seconds to wind. If the batteries are strong and new it may wind in six seconds. In this respect the clock differs radically from the others, and while we have not personally had them under test, we are informed that on account of winding once per hour the batteries will last very much longer than would be expected proportionately from those which wind at periods of greater frequency. The reason assigned is that the longer period allows the battery to dispose of its hydrogen on the zinc and thus to regain its energy much more completely between the successive discharges and hence can give a more effective quantity of current for hourly discharge than those which are discharged several times a minute, or even several times an hour. It is only proper to add that the manufacturers of clocks winding every six or seven minutes dispute this assertion.

Another point is undoubtedly in the increased length of life of the contacts; but speaking generally the electric clock may be said now to be waiting for further improvements in the batteries. Those who have had the greatest experience with batteries, as the telephone companies, telegraph companies and other public service corporations, have generally discarded their use in favor of storage batteries and dynamos wherever possible and where this is not possible they have inspected them continuously and regularly.

In this respect one point will be found of great service. When putting in a new set of batteries in any electrical piece of machinery, write the date in pencil on the battery cover, so that you, or those who come after you, some time later, will know the exact length of time the battery has been in service. This is frequently of importance, as it will determine very largely whether the battery is playing out too soon, or whether faults are being charged to the battery which are really due to other portions of the apparatus.

Never put together any piece of electrical apparatus without seeing that all parts are solidly in position and are clean; always look carefully to connections and see that the insulation is perfect so that short circuits will be impossible.

All contacts must be kept smooth and bright and contact must be made and broken without any wavering or uncertainty.

Fig. 132 shows the completely wired movement of the American Clock Company's weight-driven movement, which may be accepted as a type of this class of movements—weight-driven, winding every seven minutes.

The train is a straight-line time train, from the center arbor to the dead beat escapement, with the webs of the wheels not crossed out. It is wired with the wire from the battery zinc screwed to the front plate H and that from the battery carbon to an insulated block G.

Fig. 133 shows an enlarged view of the center arbor. Upon this arbor are secured (friction tight) two seven-notched steel ratchets, E, and carried loosely between them are two weighted levers pivoted loosely on the center arbor. Each lever is provided with a pawl engaging in the notches of the nearest ratchet, as shown. The weighted lever has a circular slot cut in it, concentric with the center hole and also has a portion of its circumference at the arbor cut away, thus forming a cam. Between these two levers is a connecting link D with a pin in its upper end, which pin projects into the circular slots of the weight levers.

The lever F is pivoted to the front plate of the clock and carries at right angles a beveled arm which projects over the ratchets E, but is ordinarily prevented from dropping into the notches by riding on the circumferences of the

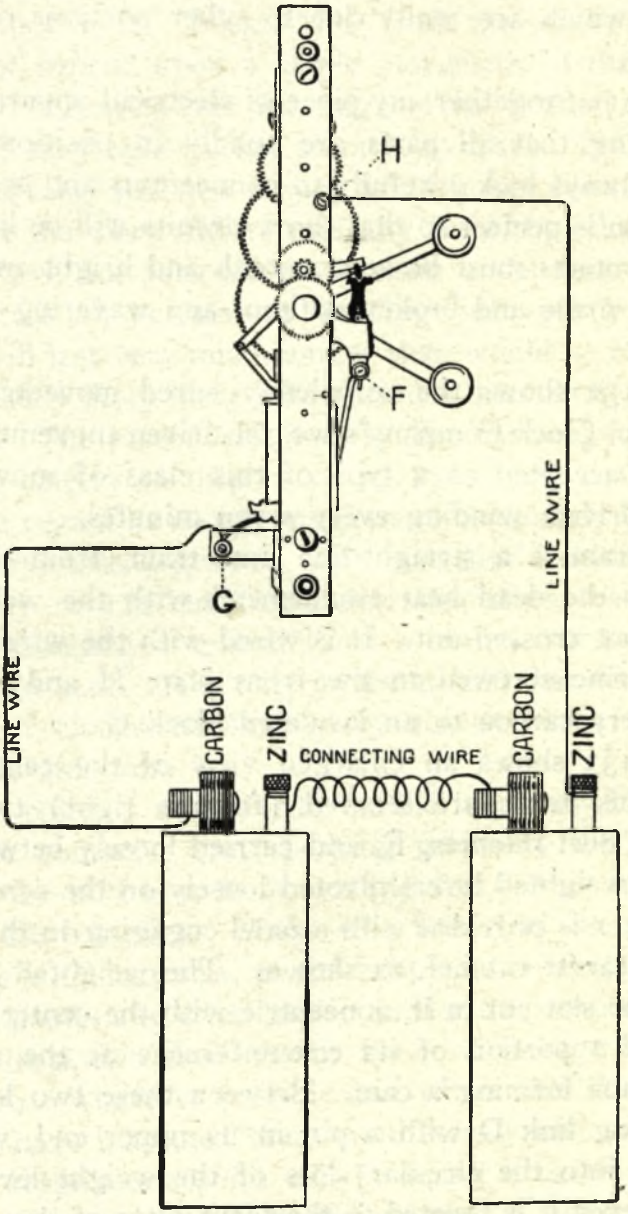
H
F
G
LINE WIRE
LINE WIRE
CARBON
ZINC
CONNECTING WIRE
CARBON
ZINC

Fig. 132

weighted levers. When one lever has dropped down and the other has reached a horizontal position the cut portions of the circumferences of these levers will be opposite the upper notch of the ratchets and will allow the bar project-

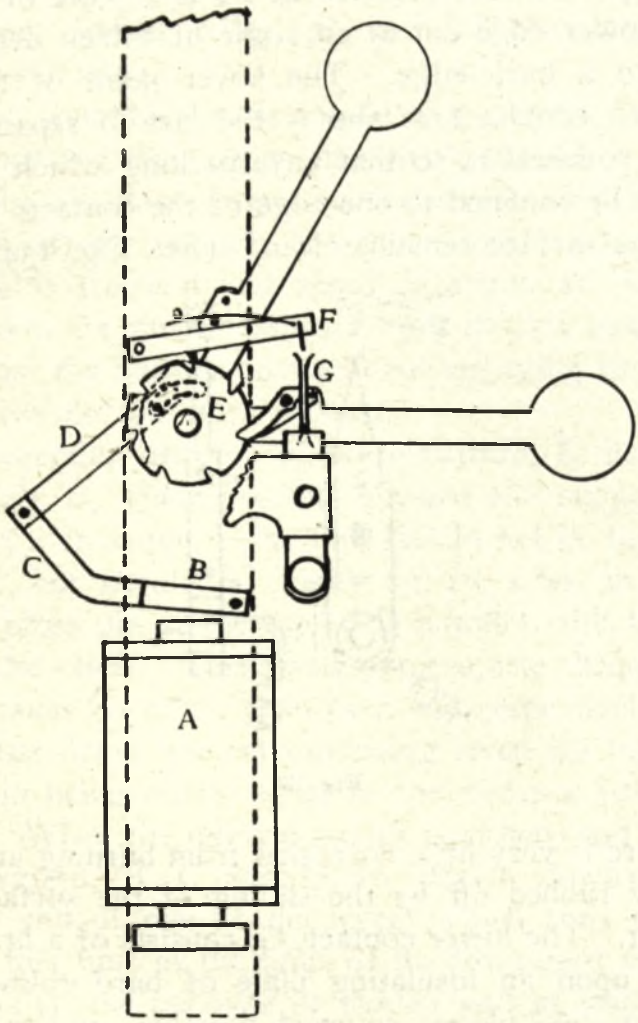

Fig. 133

ing from F to drop into the notches. This allows F and G to connect and the magnet A is energized, pulls the armature B, the arms C D, and thus lifts the lever through the pin in D pulling at the end of the circular slot. As the lever flies upward, the cam-shaped portion of its circumference raises the arm out of the notches, thus separating F and G and breaking the circuit. A spring placed above F keeps its arms pressed constantly upon E in position to drop. The wiring of the magnets is shown in Fig. 130.

The upper contact (carried in F) is a piece of platinum with its lower edge cut at an angle of fifteen degrees and beveled to a knife-edge. The lower point of this bevel comes into contact first and is the last to separate when breaking connection, so that any sparking which may take place will be confined to one edge of the contacts while the rest of the surface remains clean. (See Fig. 134.) Ordi-

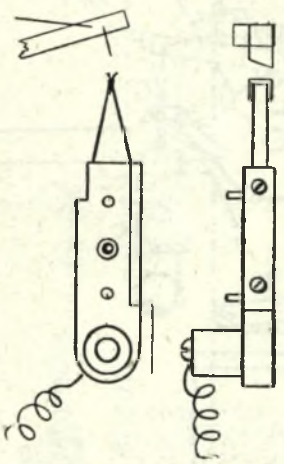

Fig. 134

narily there is very little corrosion from burning and this is constantly rubbed off by the sliding of the surfaces upon each other. The lower contact, G, consists of a brass block mounted upon an insulating plate of hard rubber. The block is in two pieces, screwed together, and each piece carries a platinum tipped steel spring. These springs are so set as to press their platinum tips against each other directly beneath the upper contact. The upper and lower platinum tips engage each other about one-sixteenth inch at the time of making contact. The lower block being in two pieces, the springs may be taken apart for cleaning, or to adjust their tension. The latter should be slight and should in no case exceed that which is exerted by the spring in F, or the upper knife-edge will not be forced between the two lower springs. The pin on which F is pivoted and that bearing on the spring above it must be clean and bright and *never be oiled,* as it is through these that the current passes to the upper contact in the end of F. The contacts are, of course, never oiled.

The two weighted levers should be perfectly free on the center arbor and their supporting pawls should be perfectly free on the shoulder screws in the levers. Their springs should be strong enough to secure quick action of the pawls. This freedom and speed of action are important, as the levers are thrown upward very quickly and may rebound from the butting post without engaging the ratchets if the pawls do not work quickly.

The projecting arm, C, of the armature, B, has pivoted to it, a link, D, which projects upward and supports at its upper end a cross pin. The link should not be tight in the slot of C, but should fit closely on the sides, in order to keep the cross pin at the top of D parallel with the center staff of the clock. This cross pin projects through D an equal distance on either side, each end respectively passing through the slot of the corresponding lever, the total length of this pin being nearly equal to the distance between the ratchets. When the electric circuit is closed, and the magnets energized, B, C and D are drawn downward; the weighted end of one of the levers which runs the clock, being at this time at the limit of its downward movement, see Fig. 135, the opposite or slotted end of said lever, is then at its highest point, and the downward pull in the slot by one end of the above described crosspin which enters it will throw the weighted end of the said lever upward. The direct action of the magnets raises the lever nearly to the horizontal position, and the momentum acquired carries it the remainder of the distance. By this arrangement of stopping the downward pull of the pin when the ascending lever reaches the horizontal, all danger of disturbing the other lever A is avoided. The position is such that the top of the ascending lever weight is about even with the center of the other weight when the direct pull ceases.

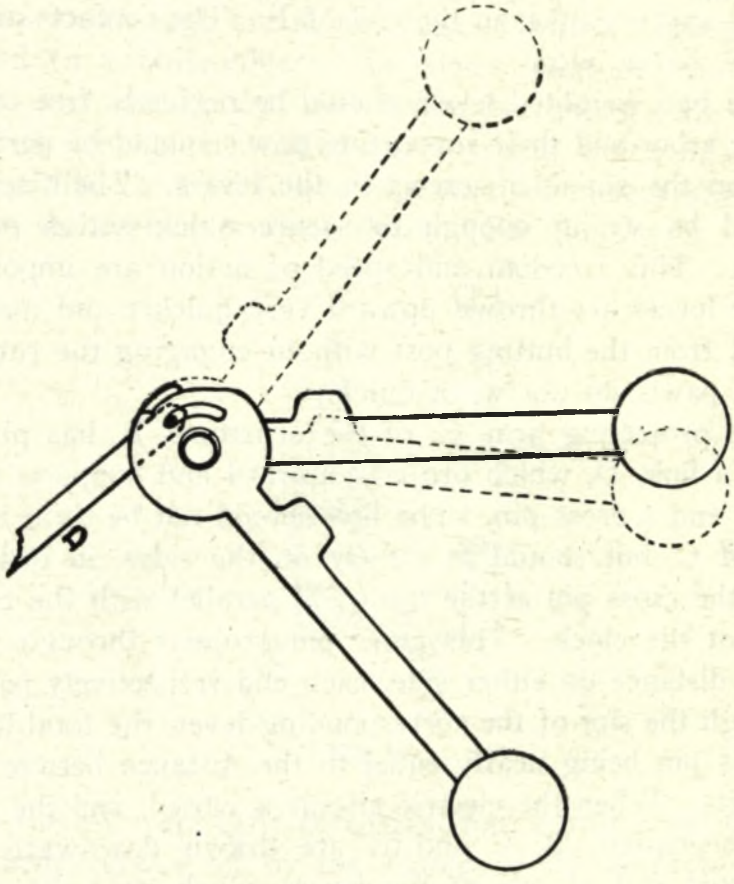

Fig. 135

Before starting the clock raise the lever weights so that one lever is acting upon a higher notch of the ratchet than the other. They are designed to remain about forty-five degrees apart, so as to raise only one lever at each action of the magnet. This maintains an equal weight on the train, which would not be the case if they were allowed to rise and fall together; keeping the levers separated also reduces the amount of lift or pull on the battery and uses less current, which is an item when the battery is nearly run down. If these levers are found together it indicates that the battery is weak, the contacts dirty, making irregular winding, or the pawls are working improperly. See that the levers rise promptly and with sufficient force. After one of them has risen stop the pendulum and see that the butting post is correctly placed, so that there is no danger of the lever wedging under the post and sticking there, or causing the lever to rebound too much. The butting post is set right when the clock leaves the factory and seldom needs adjustment unless some one has tinkered with it.

The time train should be oiled as with the ordinary movements, also the pawls on the levers. The lever bushings should be cleaned before oiling and then well oiled in order to avoid friction on the center arbor from the downward pull of the magnets when raising the levers. In order to clean the levers drive out the taper pin in the center arbor and remove the front ratchet, when the levers will slip off. In putting them back care should be used to see that the notches of the ratchets are opposite each other. Oil the edges of the ratchets and the armature pins. Do not under any circumstances oil the contact points, the pins or springs of the bar F, as this will destroy the path of the current and thus stop the clock. These pins must be kept clean and bright.

Hourly Winding Clocks.—There are probably more of these in America than of all other electric kinds put together (we believe the present figures are something like 135,000), so that it will not be unreasonable to give considerable space to this variety of clocks. Practically all of them are made by the Self Winding Clock Company and are connected with the Western Union wires, being wound by independent batteries in or near the clock cases.

Three patterns of these clocks have been made and we will describe all three. As they are all practically in the same system, it will probably be better to first make a simple statement of the wiring, which is rigidly adhered to by the clock company in putting out these goods. All wires running from the battery to the winding magnets of the movement are brown. All wires running from the synchronizing magnet to the synchronizing line are blue. Master clocks and sub-master clocks have white wires for receiving the Washington signal and the relay for closing the synchronizing line will have wires of blue and white plaid.

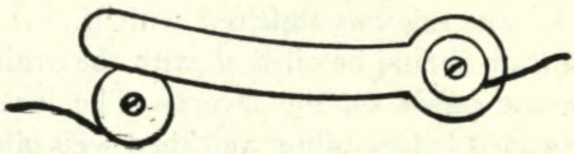

Fig. 136

By remembering this system it is comparatively easy for a man to know what he is doing with the wires, either inside or outside of the case. For calendar clocks there are, in addition, two white wires running from the calendar to the extra cell of battery. There is also one other peculiarity, in that these clocks are arranged to be wound by hand whenever run down (or when starting up) by closing a switch key, shown in Fig. 136, screwed to the inside of the case. This is practically an open switch, held open by the spring in the brass plate, except when it is pressed down to the lower button.

The earliest movement of which any considerable number were sent out was that of the rotary winding from a three-pole motor, as shown in Fig. 137. Each of these magnet spools is of two ohms, with twelve ohms resistance, placed in parallel with the winding of each set of magnet spools, thus making a total of nine spools for the three-pole motor.

On the front end of the armature drum arbor is a commutator having six points, corresponding to the six arma-

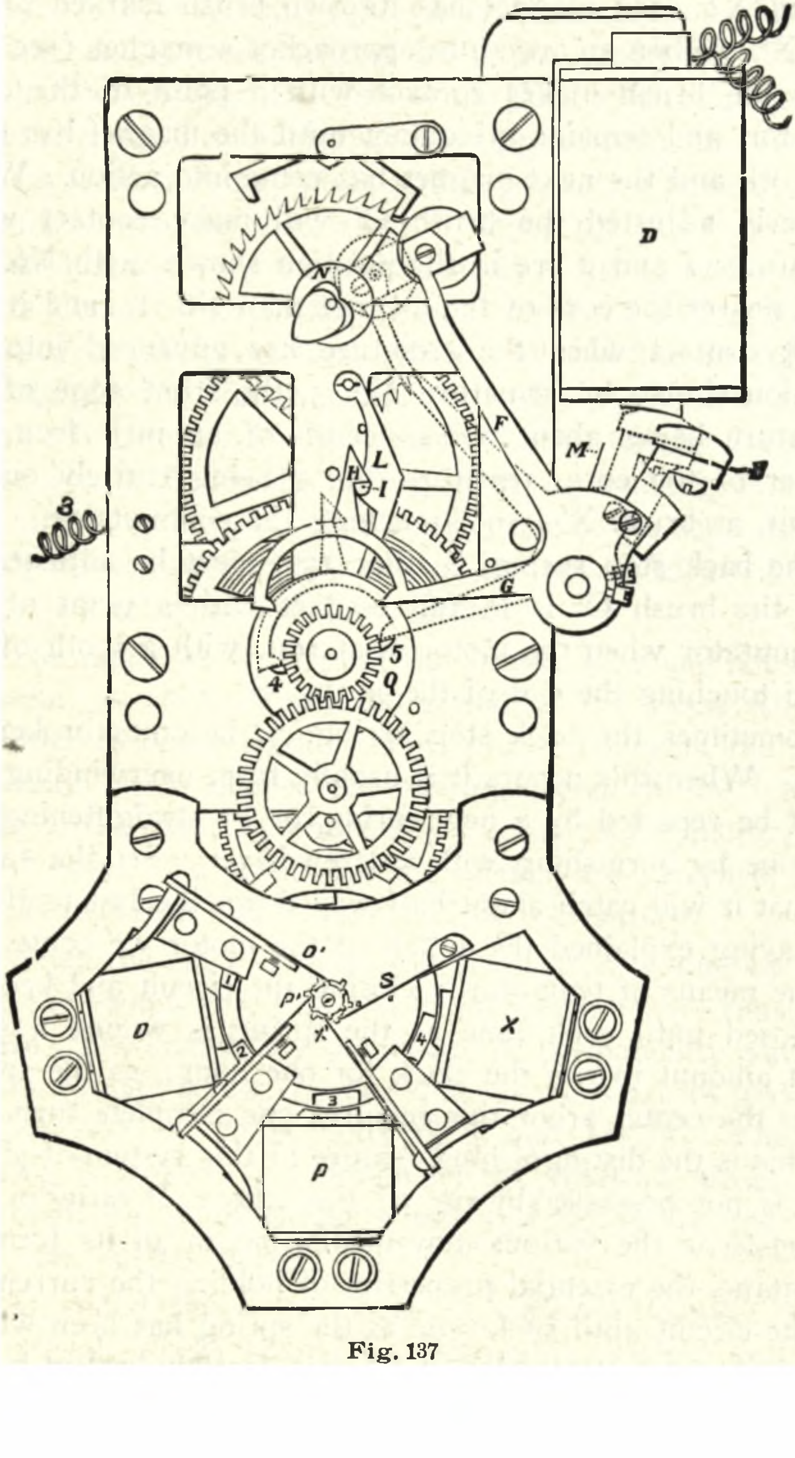

Fig. 137

tures in the drum. There are three magnets marked O, P and X; each magnet has its own brush marked O′, P′ and X′. When an armature approaches a magnet (see Fig. 137) the brush makes contact with a point of the commutator, and remains in contact until the magnet has done its work and the next magnet has come into action. When properly adjusted the brush O′ will make contact when armatures 1 and 2 are in the position shown, with No. 2 a little nearer the core of the magnet than No. 1; and it will break contact when the armature has advanced into the position shown by armature No. 3, the front edge of the armature being about one-sixteenth of an inch from the corner of the core, armature No. 4 being entirely out of circuit, as brush X′ is not touching the commutator.

The back stop spring, S, Fig. 137, must be adjusted so that the brush O′ is in full contact with a point of the commutator when the motor is at rest, with a tooth of the ratch touching the end of the spring, S.

Sometimes the back stop spring, S, becomes broken or bent. When this occurs it is usually from overwinding. It must be repaired by a new spring, or by straightening the old one by burnishing with a screwdriver. Set the spring so that it will catch about half way down the last tooth.

Having explained the action of the motor we come now to the means of temporarily closing the circuit and keeping it closed until such time as the spring is wound a sufficient amount to run the clock for one hour; as the spring is on the center arbor this requires one complete turn.

This is the distinguishing feature of this system of clocks and is not possessed by any of the others. It varies in construction in the various movements, but in all its forms it maintains the essential properties of holding the current on to the circuit until such time as the spring has been wound a sufficient quantity, when it is again forcibly broken by the action of the clock. This is termed the "knock away," and exists in all of these movements.

To start the motor the circuit is closed by a platinum tipped arm, A, Fig. 138, loosely mounted on the center arbor, and carried around by a pin projecting from the center wheel until the arm is upright, when it makes contact with the insulated platinum tipped brush, B. A carries in its front an ivory piece which projects a trifle above the platinum top, so that when B drops off the ivory it will make contact with the platinum on A firmly and suddenly. This contact then remains closed until the spring barrel is turned a full revolution, when a pin in the barrel cover brings up the "knock away," C, which moves the arm, A, forward from under the brush, B, and breaks the circuit. The brush, B, should lie firmly on its banking piece, and should be so adjusted that when it leaves the arm, A, it will drop about one-thirty-second of an inch. Adjusted in this way it insures a good, firm contact.

The angle at the top of the brush, B, must not be too abrupt, so as to retard the action of the clock while the contact is being made. Wire No. 8 connects the spring contact, B, to one of the binding plates at the left-hand side of the case; and wire No. 6 connects the motor, M, to the other. To these binding plates are attached brown wires that lead one to each end of the battery.

When the clock is quite run down, it is wound by pressing the switch key, Fig. 136, from which a wire runs to the plate. The switch key should *not* be permanently connected to its contact screw, J. See that all wires are in good condition and all connections tight and bright. The main spring is wound by a pinion on the armature drum arbor, through an intermediate wheel and pinion to the wheel on the spring barrel.

At stated times—say once in eighteen months or two years—all clocks should be thoroughly cleaned and oiled, and at the same time inspected to be sure they are in good order.

Never let the self-winding clocks run down backward, as the arm, A, Fig. 138, will be carried back against the brush, B, and bend it out of adjustment.

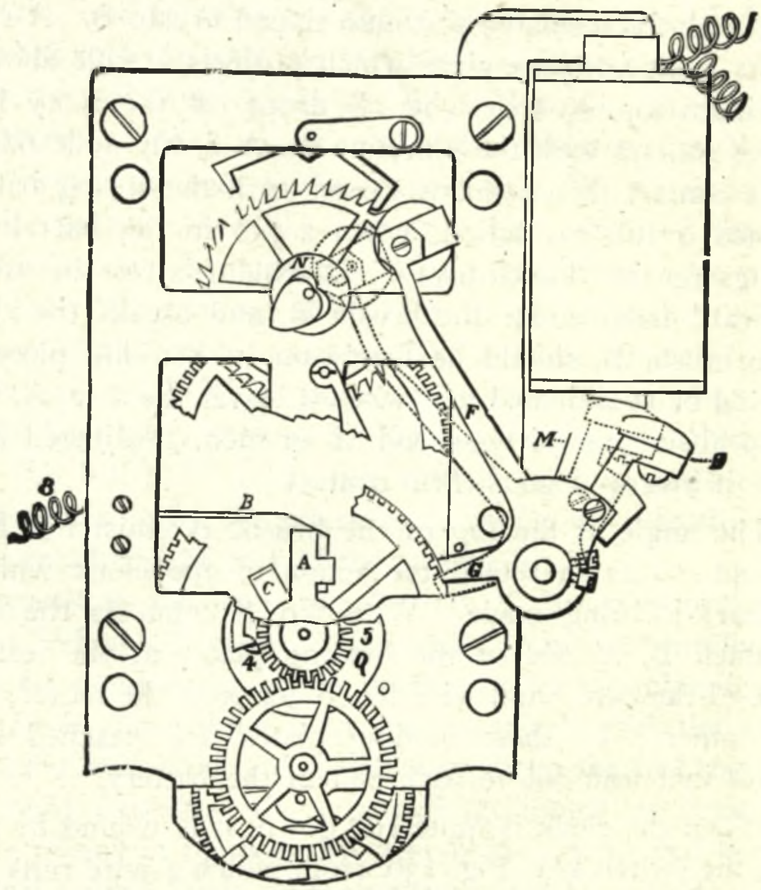

Fig. 138

To clean the movement, take it from the case, take out the anchor and allow it to run down gently, so as not to break the pins, then remove the motor. Take off the *front* plate and separate all the parts. Never take off the back plate in these clocks. Wash the plates and all parts in a good quality of benzine, pegging out the holes and letting them dry thoroughly before reassembling. The motor must not be taken apart, but may be washed in benzine, by using a small brush freely about the bearings, commutator and brushes. Put oil in all the pivot holes, but not so much that it will run. The motor bearings and the pallets of the anchor should also be oiled.

Inspect carefully to see that the center winding contact is right and that the motor is without any dead points. Dust out the case and put the movement in place. Before putting on the dial try the winding by means of the switch, Fig. 136, to be sure that it is right; also see that the disc on the cannon socket is in the right position to open the latch at the hour, and after the dial and hands are on move the minute hand forward past the hour and then backward gently until it is stopped by the latch. This will prove that the hand is on the square correctly.

On account of the liability of the motor to get out of adjustment and fail to wind, from the shifting of the springs and brushes, under careless adjustment, various attempts have been made to improve this feature of these clocks and the company is now putting out nearly altogether one of the two vibrating motors, shown in Figs. 139 and 140.

In Style C, Fig. 139, the hourly contact for winding is the same as in the clock with the three-magnet motor, as shown in Fig. 138. The magnet spools are twelve ohms and the resistance coil is eighty ohms, placed in parallel, as described in Fig. 130.

The vibrating motor, Fig. 139, is made with a pair of magnets and a vibrating armature. The main spring is wound by the forward and backward motion of the armature, one end of the connecting rod, 8, being attached to a lug of the armature, 2, and the other to the winding lever, 10. This lever has spring ends, to avoid shock and noise. As the winding lever is moved up and down, the pawl, 9, turns the ratch wheel, 11, and a pinion on the ratch wheel arbor turns the spring barrel until the winding is completed.

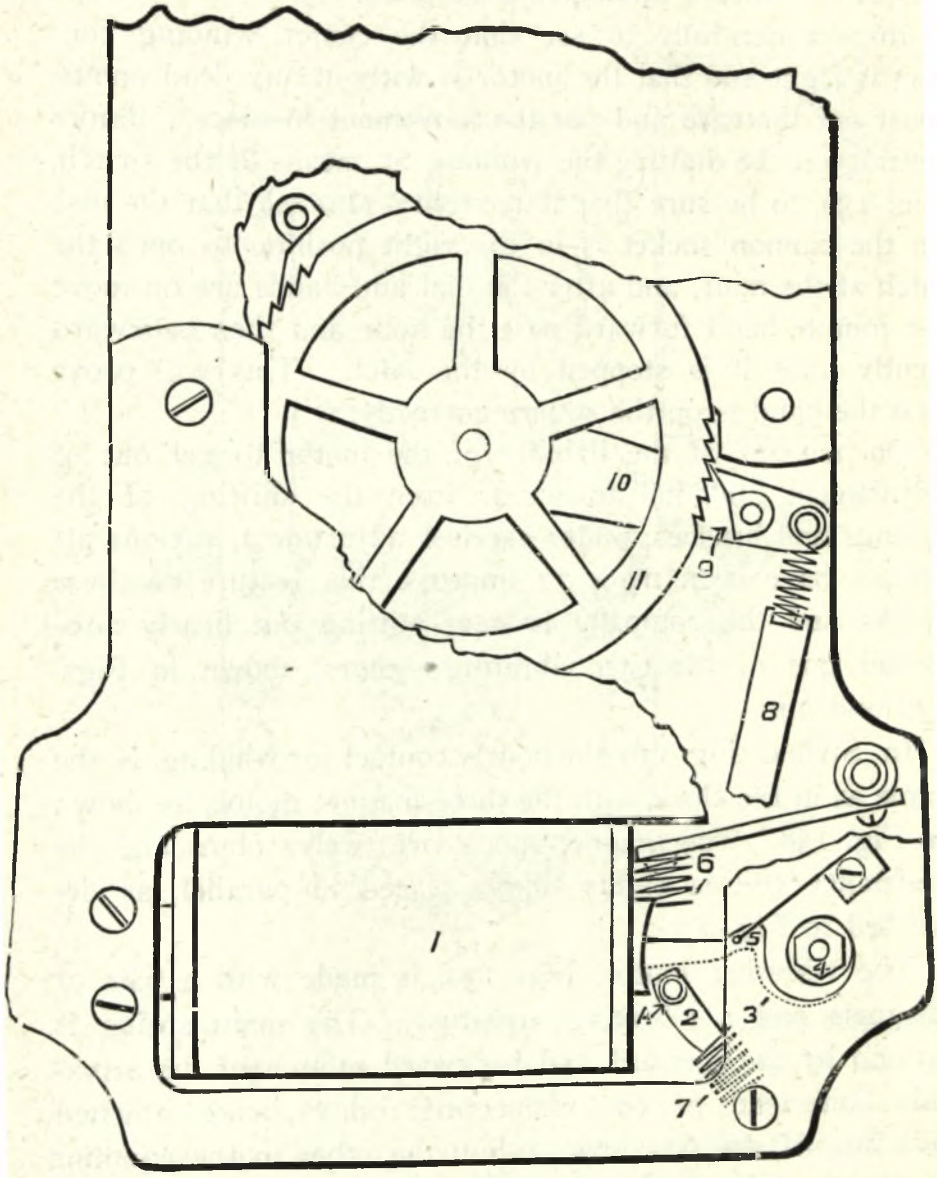

Fig. 139

The contact for operating the motor is made by the brass spiral spring, 3, which is attached to the insulated stud, 4, and the platinum pin, 5, which is carried on a spring attached to the clock plate. As the armature moves forward the break pin, A, in the end of the armature lifts the contact spring, 3, thus breaking the circuit. The acquired momentum carries the armature forward until it strikes the upper banking spring, 6, when it returns rapidly to its original position, banking on spring 7, by which time contact is again made between springs 3 and 5 and the vibration is repeated until the clock is wound one turn of the barrel and the circuit is broken at the center winding contact.

Fig. 140, Style F, is a similar motor so far as the vibrating armature and the winding is concerned, but the winding lever is pivoted directly on the arbor of the winding wheel and operates vertically from an arm and stud on the armature shaft, working in a fork of the winding lever, 8, Fig. 140. It will be seen that the train and the motor winding mechanism are combined in one set of plates. The motor is of the oscillating type and its construction is such that all its parts may be removed without dissembling the clock train.

Construction of the Motor.—The construction of the motor is very simple, having only one pair of magnets, but *two sets* of make and break contacts, one set of which is placed on the front and the other on the back plate of the movement, thus ensuring a more reliable operation of the motor, and reducing by fifty per cent the possibility of its failing to wind.

The center winding contact also differs from those used in the three-magnet motors and former styles of vibrating motor movements. The center winding contact piece, 13, has no ivory and no platinum. The hourly circuit is not closed by the current passing through this piece, but it acts by bringing the plate contact spring, 16, in metallic connection with the insulated center-winding contact spring, 17, both of which are platinum tipped. It will thus be seen that no accumulation of dirt, oil or gum around the center arbor or the train pivots will have any effect in preventing the current from passing from the motor to the hourly circuit closer.

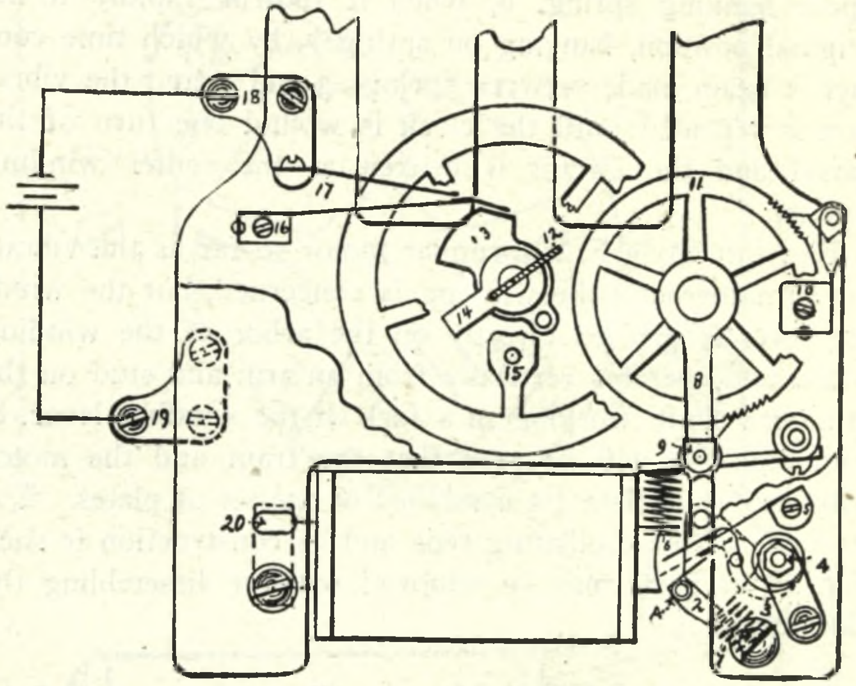

Fig. 140

The operation is as follows: As the train revolves, the pin, 12, securely fastened to the center arbor, in its hourly revolution engages a pin on the center winding contact piece, 13. This piece as it revolves pushes the plate contact spring, 16, upward, bringing it in metallic connection with the center winding contact spring, 17, which is fastened to a stud on an insulated binding post, 18, thereby closing the hourly circuit. The current passes from the binding post, 18, through the battery (or any other source of current supply) to binding post 19, to which is connected one end of the motor magnet wire. The current passes through these magnets to the insulated stud, 4. To this stud the spiral contact spring, 3, is fastened and the current passes from this spring to the plate contact spring, 5, thence through the movement plate to plate contact spring, 16, and from there through spring, 17, back to the battery.

The main spring is wound by the forward and backward motion of the armature, 2. To this armature is connected the winding lever, 8. As the winding lever is oscillated, the pawl, 9, turns the ratchet wheel, 11, and a pinion on the ratchet wheel arbor turns the winding wheel until the pin, 15, connected to it engages the knock-away piece, 14, revolving it until it strikes the pin on the center winding contact piece, 13, and pushes it from under the plate contact spring, thereby breaking the electric circuit and completing the hourly winding.

The proper position of the contact springs is clearly indicated in Fig. 140. The spring, 16, should always assume the position shown thereon. When the center winding contact piece, 13, comes in metallic connection with the plate contact spring, 16, the end of this spring should stand about one-thirty-second of an inch from the edge of the incline. The center winding contact spring, 17, should always clear the plate contact spring one-thirty-second of an inch. When the two springs touch they should be perfectly parallel to each other.

Adjustments of the Armature.—In styles C and F, when the armature, 2, rests on the banking spring, 7, its front edge should be in line with the edge of the magnet core. The upper banking spring, 6, must be adjusted so that the front edge of the armature will be one-sixteenth of an inch from the corner of the magnet core when it touches the spring.

When the contact spring, 3, rests on the platinum pin, 5, it should point to about the center of the magnet core, with the platinum pin at the middle of the platinum piece on the spring.

To adjust the tension of the spiral contact spring, 3, take hold of the point with a light pair of tweezers and pull it gently forward, letting it drop under the pin. It should take the position shown by the dotted line, the top of the spring being about one-thirty-second of an inch below the platinum pin. If from any cause it has been put out of adjustment it can be corrected by carefully bending under the tweezers, or the nut, 4, may be loosened and the spring removed. It may then be bent in its proper shape and replaced.

The hole in the brass hub to which the spring is fastened has a flat side to it, fitting a flat on the insulated contact stud. If the contact spring is bent to the right position it may be taken off and put back at any time without changing the adjustment, or a defective spring may readily be replaced with a new one. When the armature touches the upper banking spring the spiral contact spring, 3, should clear the platinum pin, 5, about one-sixteenth of an inch. Both contacts on front and back plates in style F are adjusted alike. The circuit break pins "A" on the armature should raise both spiral contact springs at the same instant.

If for any reason the motor magnets have become displaced they may readily be readjusted by loosening the four yoke screws holding them to the movement plates. Hold the armature against the upper banking spring, move the magnets forward in the elongated slot, 20, until the ends of the magnet cores clear the armature by one-sixty-fourth of an inch, then tighten down the four yoke screws. Connect the motor to the battery and see that the armature has a steady vibration and does not touch the magnet core. The adjustment should be such that the armature can swing past the magnet core one-eighth to three-sixteenths of an inch.

DESCRIPTION OF SYNCHRONIZER.—At predetermined times a current is sent through the synchronizer magnet, D′, Fig. 141, which actuates the armature, E, to which are attached the levers, F and G, moving them down until the points on the lever, G, engage with two projections, 4 and 5, on the minute disc; and lever F engages with the heart-shaped cam or roll on the seconds arbor sleeve, causing both the minute and second hands to point to XII. These magnet spools are wound to twelve ohms, with an eighty-ohm resistance in parallel.

On the latch, L, is a pin, I, arranged to drop under the hook, H, and prevent any action of the synchronizing levers, except at the hour. A pin in the disc on the cannon socket unlocks the latch about two minutes before the hour and closes it again about two minutes after the signal. This is to prevent any accidental "cross" on the synchronizing line from disturbing the hands during the hour.

M is a light spring attached to the synchronizing frame to help start the armature back after the hands are set. The wires from the synchronizing magnet are connected to binding plates at the right-hand side of the clock and from these binding plates the blue wires, Nos. 9 and 10, pass out at the top of the case to the synchronizing line.

If the clock gets out of the synchronizing range it generally indicates very careless regulation. The clock is regulated by the pendulum, as in all others, but there is one peculiarity in that the pendulum regulating nut has a check nut.

If the clock gains time turn the large regulating nut under the pendulum bob slightly to the left.

If the clock loses time turn the nut slightly to the right.

Loosen the small check nut under the regulating nut before turning the regulating nut, and be *sure to tighten* the check nut after moving the regulating nut.

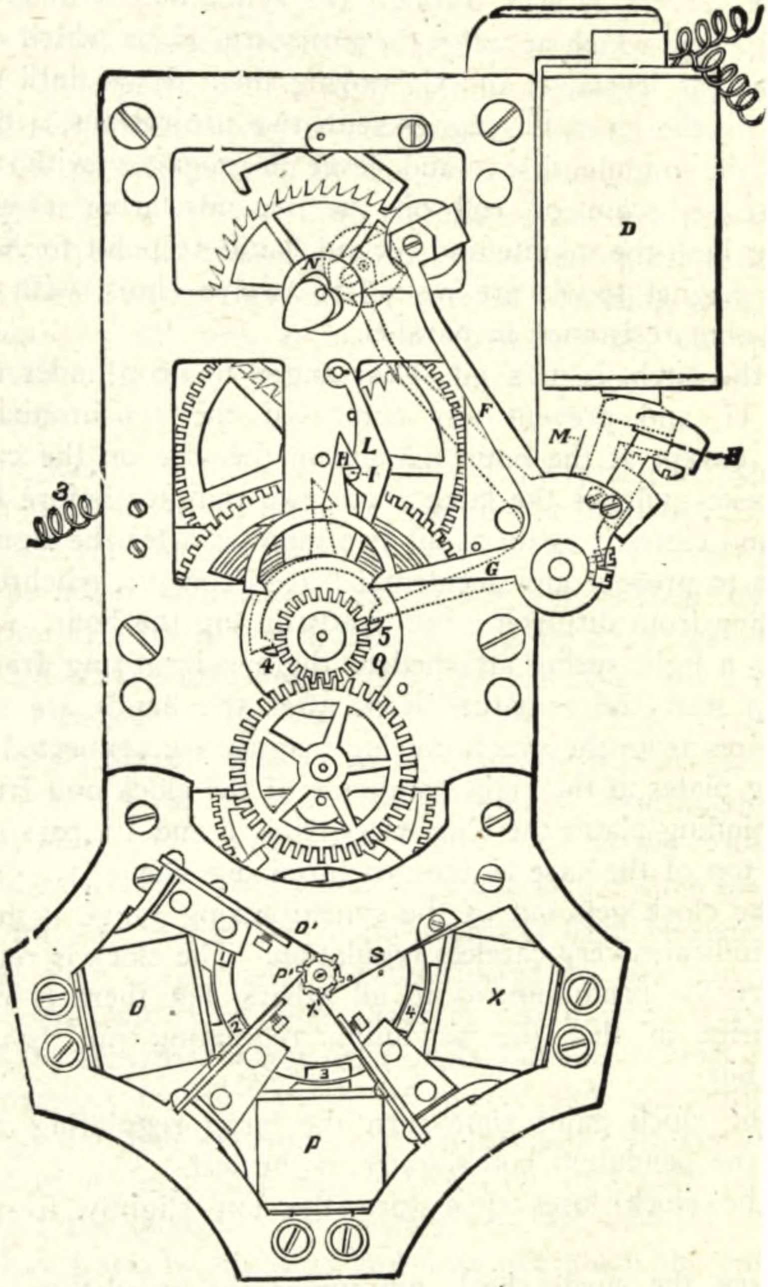

Fig. 141

The friction of the seconds hand is very carefully adjusted at the factory, being weighed by hanging a small standard weight on the point of the hand. If it becomes too light and the hand drives or slips backward, losing time, it can be made stronger by laying it on a piece of wood and rubbing the inner sides of the points with a smooth screw driver, and if too heavy and the clock will not set when the synchronizing magnets are actuated, the points of the spring in the friction may be straightened a little.

If the seconds hand sleeve does not hold on the seconds socket, pinch it a little with pliers. If the seconds hand is loose on the sleeve put on a new one or solder it on the under side.

In style F the synchronizing lever, heart-shaped seconds socket and cams on the cannon sockets are the same as in the old style movements, shown in Fig. 141. The difference is in the synchronizing magnets and the way they operate the synchronizing lever. The magnet has a flat ended core instead of being eccentric like the former ones. The armature is also made of flat iron and is pivoted to a stud fastened to the synchronizing frame. The armature is connected to the synchronizing lever by a connecting rod and pitman screws. A sector has an oblong slot, allowing the armature to be lowered or raised one-sixteenth of an inch. The synchronizing lever is placed on a steel stud fastened to the front plate and held in position by a brass nut. The synchronizing magnets are 12 ohms with 80 ohms resistance and are fastened to a yoke which is screwed to the synchronizing frame by four iron screws. The holes in the synchronizing frame are made oblong, allowing the yoke and magnets to be raised or lowered one-sixteenth of an inch. The spring on top of the armature is used to throw it back quickly and also acts as a diamagnetic, preventing the armature from freezing to the magnets. A screw in the stud is used to screw up against the magnet head, preventing any spring that might take place on the armature stud. Binding posts are screwed to the synchronizing frame and the ends of the magnet coils are fastened thereto with metal clips.

The blue wires in the clock case are coiled and have a metal clip soldered to them. They connect direct by these clips to the binding posts, thus making a firm connection, and are not liable to oxidize. With the various points of adjustment a pair of magnets burned out or otherwise defective may readily be replaced in from five to ten minutes.

When replacing a pair of synchronizing magnets proceed as follows: Remove the old pair and then loosen all four screws in the yoke, pushing it up against the tops of the oblong holes, then tighten down lightly. Fasten the new pair of magnets to the yoke with the inner ends of the coils showing at the outside of the movement. Press the armature upward until the synchronizing lever locks tightly on the cannon socket and the heart-shaped cams, then loosen the magnet yoke screws and press the magnets down on the spring on top of the armature. Then tighten the yoke screws on the front plate and see that the back of the magnets clears the armature by one-hundredth of an inch (the thickness of a watch paper), when the screws in the back of the yoke can be set down firmly. The adjustment screw may then be turned up until it presses lightly against the magnet head. When current is passed through the magnets and held there the armature must clear the magnets without touching. The magnet coils must then be connected to their respective binding posts by slipping the metal clips soldered to them under the rubber bushing, making a metallic connection with the binding plates. Fasten these screws down tight to insure good connections.

The Master Clock.—Is a finely finished movement with mercurial pendulum that beats seconds and a Gerry gravity escapement. At the left and near the center of the movement is a device for closing the synchronizing circuit

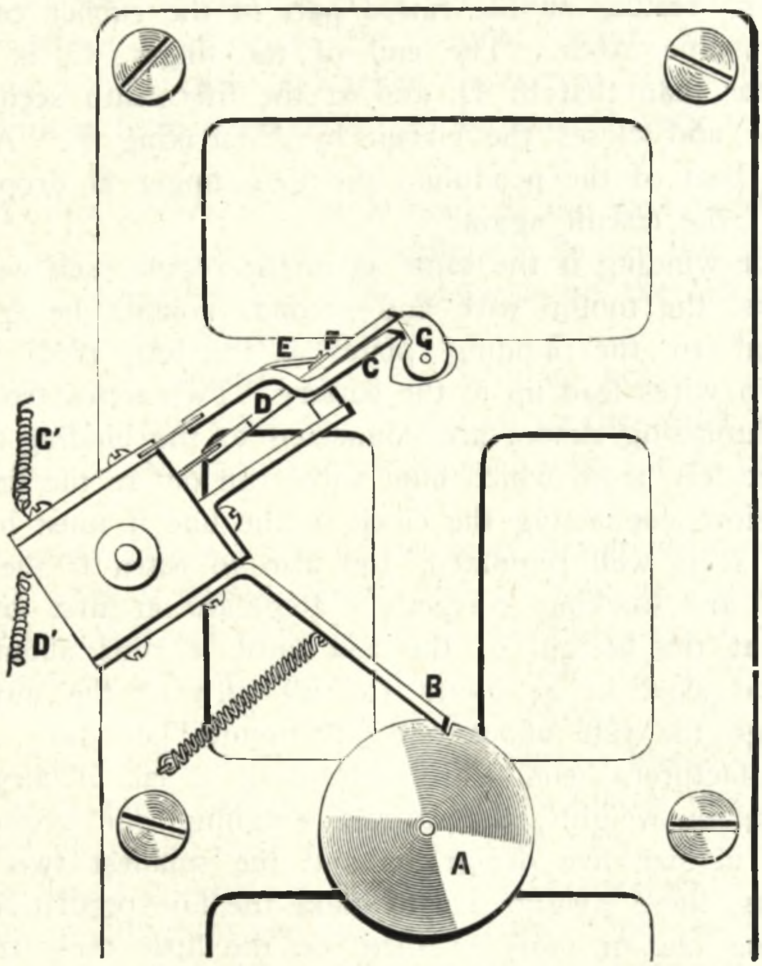

Fig. 142

once each hour. The device consists of a stud on which is an insulator having two insulated spring fingers, C and D, one above the other, as shown in Fig. 142, except at the points where they are cut away to lie side by side on an insulated support. On these fingers, and near the insulator, are two platinum pieces, E and F, so adjusted as to be held apart, except at the time of synchronizing.

A projection, B, from the insulator rests on the edge of a disc on the center arbor. At ten seconds before the hour, a notch in this disc allows the spring to draw the support downward, leaving the points of the fingers, C and D, resting on the raised part of the rubber cam on the escape arbor. The end of the finger, C, is made shorter than that of D, and at the fifty-ninth second, C drops and closes the circuit by E striking F. At the next beat of the pendulum the long finger D drops and opens the circuit again.

The winding is the same as in the regular self-winding clocks, the motor wire and seconds contact being connected to the binding plates at the left, from which brown wires lead up to the battery. Two wires from the synchronizing device are connected to the binding plates at the left, from which blue wires run out to the line.

Before connecting the clock to the line it must be run until it is well regulated, and also to learn if the contacts are working correctly. Regulate at first by the nut at the bottom of the rod until it runs about one second slow in 24 hours (a full turn of the nut will change the rate about one-half minute per day). The manufacturers send with each clock a set of auxiliary pendulum weights, the largest weighing one gram, the next in size five decigrams and the smallest two decigrams; these weights are to make the fine regulations by placing one or more of them on the little table that is fastened about the middle of the pendulum rod. The five decigram weight will make the clock gain about one second per day, and the other weights in proportion. Care must be taken not to disturb the swing of the pendulum, as a change of the arc changes the rate.

To start the clock after it is regulated, stop it, with the second hand on the fiftieth second; move the hands forward to the hour at which the signal comes from the observatory; then press the minute hand back gently until it is stopped by the extension on the hour contact, Fig. 142, and beat the clock up to the hour. This ensures the hour contact being in position to send the synchronizing signal.

A good way to start it with observatory time is with all the hands pointing to the "signal" hour; hold the pendulum to one side and when the signal comes let it go. With a little practice it can be started very nearly correct.

Clocks not lettered in the bottom of the case must be wound before starting the pendulum. To do this press the switch shown in Fig. 136, which is on the left side of the case and under the dial.

Continue the pressure until the winding ceases. Then set the hands and start the pendulum in the usual way. If the bell is not wanted to ring, bend back the hammer.

SECONDARY DIALS.—One of the most deceptive branches of clock work is the secondary dial, or "minute jumper." Ten years ago it was the rule for all manufacturers of electric clocks to put out one or more patterns of secondary dials. Theoretically it was a perfect scheme, as the secondary dial needed no train, could be cheaply installed and could be operated without trouble from a master clock, so that all dials would show exactly the same time. Practically, however, it proved a very deceptive arrangement. The clocks were subject to two classes of error. One was that it was extremely difficult to make any mechanical arrangement in which the hands would not drive too far or slip backward when the mechanism was released to advance the minute hand. The second class of errors arose from faulty contacts at the master clock and variation in either quantity or strength of current. Another and probably the worst feature was that all such classes of apparatus record their own errors and thereby themselves provide the strongest evidence for condemnation of the system. Clocks could be wound once an hour with one-sixtieth of the chance of error of those wound once per minute, and they could be wound hourly and synchronized daily with 1-1440th of the line troubles of a minute system.

The minute jumpers could not be synchronized without costing as much to build and install as an ordinary self-winding clock, with pendulum and time train, and after trying them for about ten years nearly all the companies have substituted self-winding time train clocks with a synchronizing system. They have apparently concluded that, since it seems too much to expect of time apparatus that it will work perfectly under all conditions, the next thing to do is to make the individual units run as close to time as is commercially practicable and then correct the errors of those units cheaply and quickly from a central point.

It is for these reasons that the secondary dial has practically disappeared from service, although it was at one time in extensive use by such companies as the Western Union Telegraph Company, the Postal Telegraph and the large buildings in which extensive clock systems have been installed.

Fig. 143 shows one form of secondary dial which involves a screw and a worm gear on the center arbor, which, it will be seen, is adapted to be turned through one minute intervals without the center arbor ever being released from its mechanism. This worm gear was described in the AMERICAN JEWELER about fifteen years ago, when patented by the Standard Electric Time Company in connection with their motor-driven tower clocks, and modifications of it have been used at various times by other companies.

The worm gear and screw system shown in Fig. 143 has the further advantage that it is suitable for large dials, as the screw may be run in a box of oil for dials above four feet and for tower clocks and outside work. This will readily be seen to be an important advantage in the case of large hands when they are loaded with snow and ice, requiring more power to operate them.

All secondaries operate by means of an electromagnet raising a weight, the weight generally forming the armature; the fall of the weight then operates the hands by gravity.

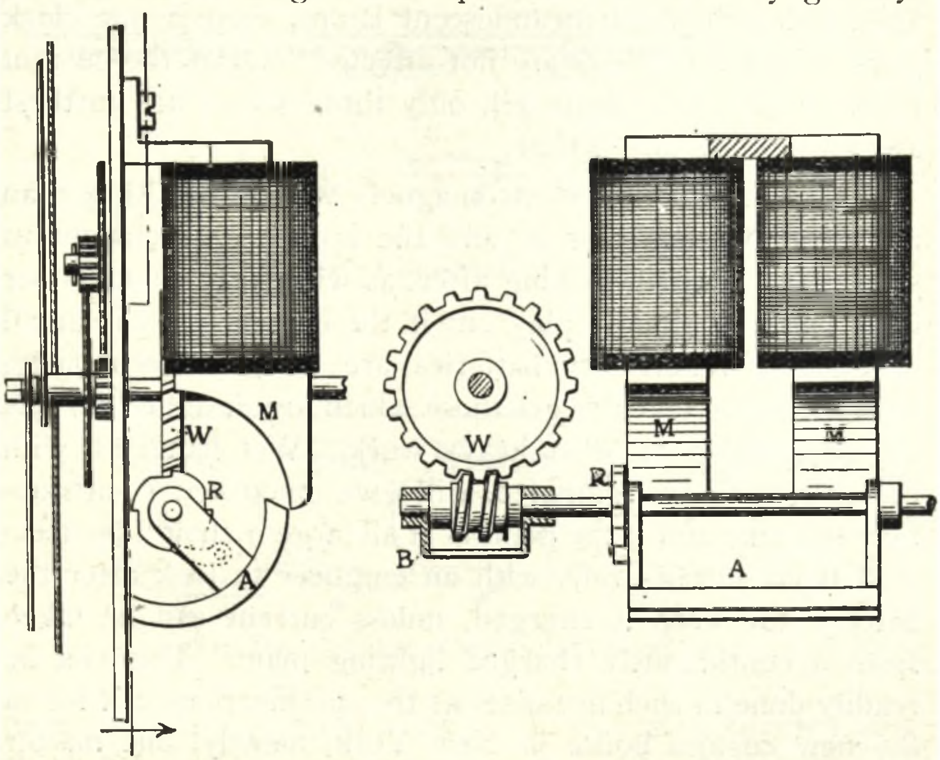

Fig. 143. Minute jumper. A, armature; M, magnets; W, worm gear on center arbor; B, oil box for worm; R, four toothed ratchet.

Direct action of the current in such cases is impracticable, as the speed of starting with an electric current would cause the machine to tear itself to pieces.

This screw gear is the only combination known to us that will prevent the hands from slipping or driving by and reduces the errors of the secondary system to those of one class, namely, imperfections in the contact of the master clock, insufficient quantity or strength of current, or accidental "crosses" and burnings.

The series arrangement of wiring secondaries was formerly greatly favored by all of the manufacturers, but it was found that if anything happened to one clock it stopped the lot of them; and where more than fifty were in series, the necessary voltage became so high that it was impracticable to run the clocks with minute contacts. The modern system, therefore, is to arrange them in multiples, very much after the fashion of incandescent lamps, then if one clock goes wrong the others are not affected. Or if the current is insufficient to operate all, only those which are farthest away would go out of time.

Very much smaller electromagnets will do the work than are generally used for it, and the economy of current in such cases is worth looking after, as with sixty contacts per hour batteries rapidly play out if the current used is at all excessive. Where dry batteries are used on secondaries care should be taken to get those which are designed for gas engine ignition or other heavy work. Wet batteries, with the zincs well amalgamated, will give much better satisfaction as a rule and if the plant is at all large it should be operated from storage cells with an engineer to look after the battery and keep it charged, unless current can be taken from a continuously charged lighting main. This can be readily done in such instances as the specifications call for in the new custom house in New York, namely, one master clock and 160 secondary dials.

Electric Chimes.—There have lately come into the market several devices for obtaining chimes which allow the separation of the chimes and the timekeeping apparatus, connection being made by means of electricity. In many respects this is a popular device. It allows, for instance, a full set of powerful tubular chimes, six feet or more in length, to be placed in front of a jewelry store, where they offer a constant advertisement, not only of the store itself, but of the fact that chiming clocks may be obtained there. It also allows of the completion by striking of a street clock which is furnished with a time train and serves at once as timepiece and sign. Many of these have tubular chimes in which the hour bell is six feet in length and the others correspondingly smaller. They have also been made with bells of the usual shape, which are grouped on posts, or hung in

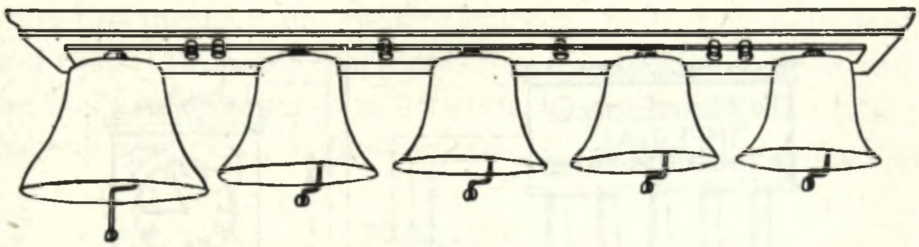

Fig. 144. Chimes of bells in rack.

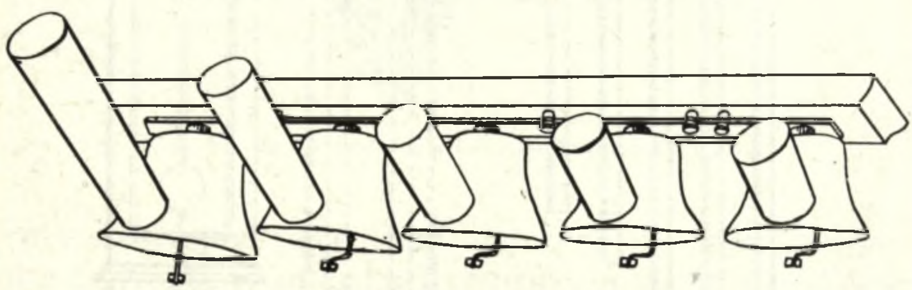

Fig. 145. Chimes of bells with resonators.

racks and operated electrically. It may also be used as a ship's bell outfit by making a few minor changes in the controller.

Fig. 144 shows a peal of bells in which the rack is thirty-six inches long and the height of the largest bell is eight inches, and the total weight thirty pounds. This, as will readily be seen, can be placed above a doorway or any other convenient position for operation; or it may be enclosed in a lattice on the roof, if the building is not over two stories in height. The lattice work will protect the bells from the weather and at the same time let out the sound.

Fig. 145 shows the same apparatus with resonators attached. These are hollow tubes which serve as sounding boards, largely increasing the sound and giving the effect of much larger bells. Fig. 146 shows a tubular chime and the electrical connections from the clock to the controller and to the hammers, which are operated by electro-magnets, so that a heavy leaden hammer strikes a solid blow at the tops of the tubes.

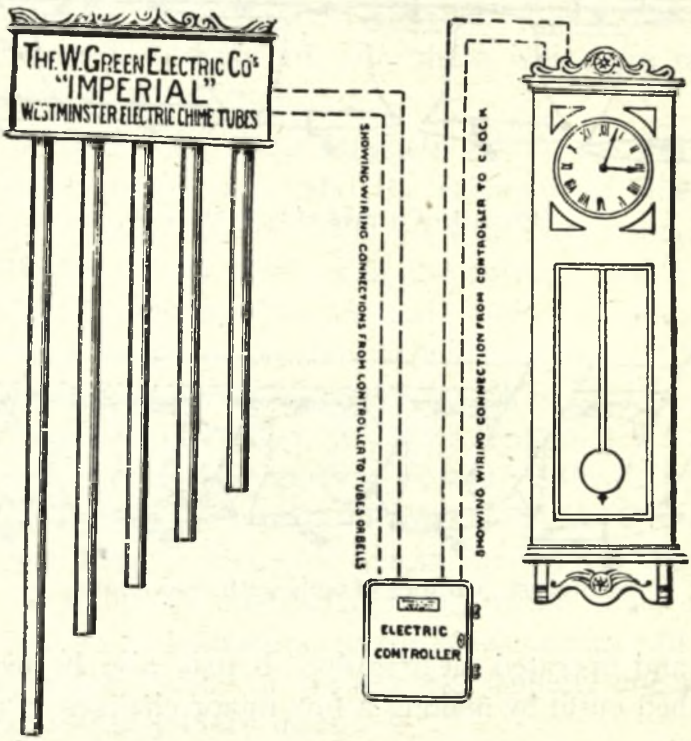

Fig. 146, Tubular electric chimes.

The dials of such clocks contain electrical connections and the minute hand carries a brush at its outer end. The contact is shown in enlarged view in Fig. 147, by which it will be seen that the metal is insulated from the dial by means of hard rubber or other insulating material, so that the brush on the minute hand will drop suddenly and firmly from the insulator to the metallic contact when the minute hand reaches fifteen, thirty, forty-five or sixty minutes. There is a common return wire, either screwed to the frame of the clock, or attached to the dial, which serves to close the various circuits and to give four strokes of the chimes at the quarter, eight at the half, twelve at the three-quarter, and sixteen at the hour, followed by the hour strike. The friction on the center arbor is of course adjusted so as to carry the minute hand without slipping at the contacts.

By this means a full chime clock may be had at much less cost than if the whole apparatus had to be self-contained and the facilities of separation between the chimes and the time-keeping apparatus, as hinted above, gives many advantages.

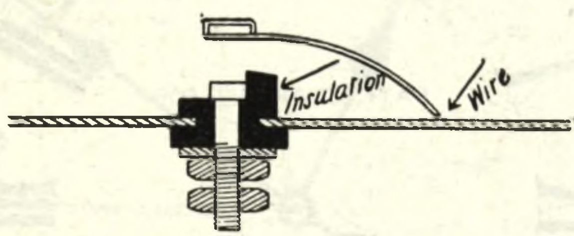

Fig. 147. Enlarged view of connections on dial.

For instance, the same clock and controller may operate tubes inside the room and bells outside, or vice versa. These are operated by wet or dry batteries purchased at local electrical supply houses, and the wiring is done with plain covered bell wire, or they may be operated by current from a lighting circuit, suitably reduced, if the current is constantly on the mains. As a full chime with sixteen notes at the hour strikes more than a thousand times a day, considerable care should be taken to obtain only the best batteries where these are used, as after the public gets used to the chimes the dealer will be greatly annoyed by the number of people asking for them if they are stopped temporarily.

There has lately developed a tendency to avoid the set tunes, such as the Westminster and the Whittington chimes, and to sound the notes as complete full notes, such as the first, third and fifth of the octave for the first, second and third quarters, followed by the hour strike. This allows them to be struck in any order and for a smaller chime reduces the cost considerably. The tubes used are rolled of bell metal and vary in pitch with the manufacture, so that the only way to obtain satisfactory tones is to cut your tubes a little long and then tune them by cutting off afterwards,

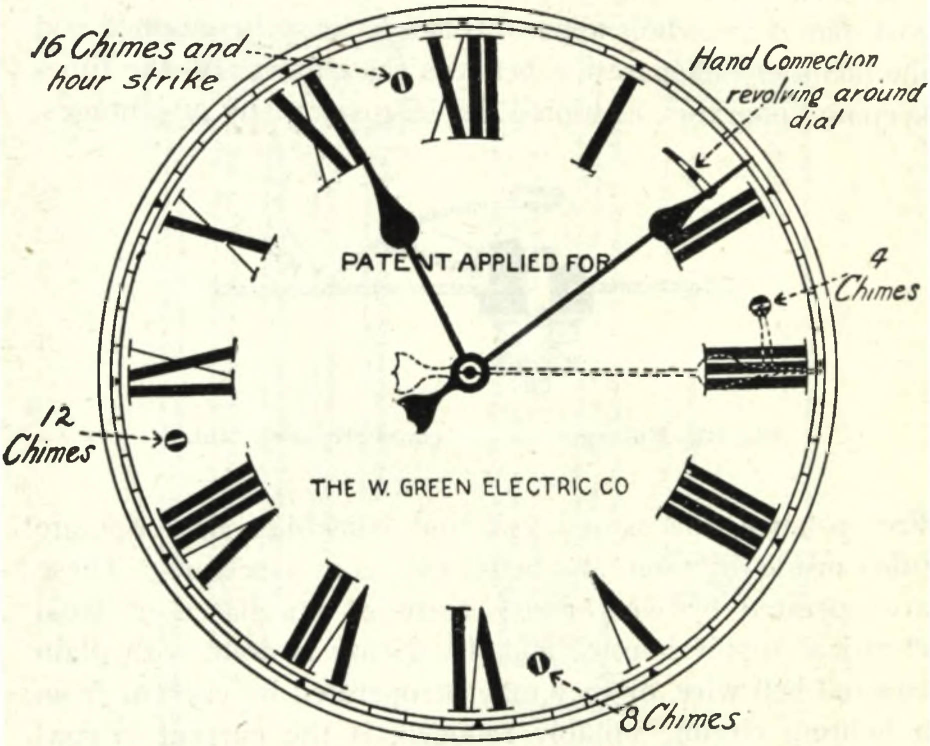

Fig. 148. Connections and contacts on front of clock dial.

the tone depending upon the thickness of the wall of the tube and its length. The bells are tuned by turning from the rim or from the upper portions as it is desired to raise or lower the tone, and if the resonators are used they are tuned in unison with the bells.

Of the ordinary bells, Fig. 144, the dimensions run: First, height four inches, diameter 5½; second, height four inches, diameter 5¼ inches; third, height 4½ inches, diameter 5⅝ inches; fourth, height 4½ inches, diameter 5⅝ inches; fifth, height 4⅝ inches, diameter 6½ inches. For the tubes the approximate length is six feet for the longest tube and the total weight of the chimes is 43 pounds. For the controller the size is nine by eleven by six inches,

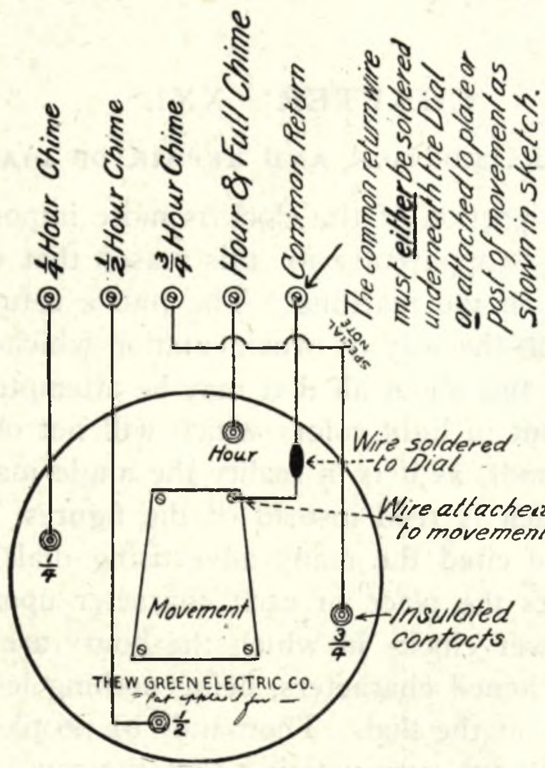

Fig. 149. Connections and wiring on back of clock dial.

with a weight of ten pounds. The hour strike may be had separately from the chimes if desired.

This makes an easily divisible system and one that is becoming very popular with retail jewelers and to some extent with their customers.