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CONSTRUCTION AND TEST

OF AN

ELECTRIC CLOCK

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When the pendulum was first used to measure time the beats were counted by an attendant and time computed by that means. Some one then conceived the idea of a mechanism to record the beats and finally power in the shape of a suspended weight was used to maintain the motion of the pendulum.

Since weights or springs are the ordinary means of storing the force necessary to run the clock --which for convenience' sake should not require winding oftener than once in twenty-four hours-- they must be made heavy in the one case and in the other, strong. This power is conveyed by a number of "train" wheels to the "escape" wheel which revolves, in the ordinary clock from sixty to three hundred and sixty times an hour. Naturally this development of speed occasions friction with consequent loss of power in the transmission. This is particularly true when the lubricating oil becomes stiff by long exposure to air or deposits of dust. When in this condition a fall of temperature, by farther stiffening the lubricant, stops the clock.

Now if by some means a force sufficient to keep it oscillating, could be applied directly to the pendulum, by this means turning the train-wheels carrying the hands, a great saving in friction and in variation would result, for the train-wheels would not be carrying power as in an ordinary clock but would carry only the weight of the hands.

Electricity seems to present a solution of the troubles of clock makers but so far has been little used. It has been and is used in two different ways:- independently, that is as a motive power; and as a means of connecting one timepiece with a number of dials which are so contrived that their hands move with the central

timepiece. Some clocks combine the two ways, the works in them being arranged to be wound by electricity periodically. A current sent out by a central clock winds and sets all the clocks connected with it. These, however, are not electrical clocks. The first electrical clock in the proper sense of the term was invented by Mr. Bain in 1840. He made the pendulum bob of a coil of insulated wire wound around a hollow cylinder with its axis parallel to the swing of the pendulum. The two poles of a magnet were placed one on either side of this bob in such a manner that they entered the cylinder as it swung. A current of electricity when passed through the insulated wire forming the bob causes an attraction on the one side and a repulsion on the other, resulting in a swing of the pendulum. On completing the vibration the current is reversed, by means of a sliding bar, and an impulse given in the opposite direction. The action of this pendulum is erratic because the impulse is continued throughout the oscillation when it should be given only when at the position of rest.

In 1851 Shepherd exhibited a clock in London which was actuated entirely by electricity. The pendulum alternately magnetized and demagnetized a horseshoe magnet which by means of an armature raised a weight when magnetized and released it when demagnetized, the force of the falling weight striking the pendulum giving an adequate impulse to maintain the motion. This was repeated at each oscillation. In 1896 an electric clock was placed in the laboratory of Durham College, North Carolina, which was run by an earth battery. The works and dial are mounted upon and swing with the pendulum.

Before describing the clock constructed for this thesis under the supervision of Professor Hamilton, I will quote from some letters received from wholesale jewelry companies who deal in electric clocks. The Edwards Sloane Jewelry Company of Kansas City says:

"They give good satisfaction excepting where people wish exact standard time. Where this is desired we find the electric clock cannot be used, as they require constant resetting, but for ordinary use we do not see why they are not a success. We have in our office an electric clock attached to the dating stamp * * * * * and find it satisfactory. We have sold a few Rempe clocks, which are made in Danville, Pa., but have had considerable trouble with them and have decided not to sell any more of them." This clock has but three wheels, and is wound seven times an hour by two dry batteries. The maintaining power is a spring. The manufacturers claim great things for these clocks as the power is applied very near the pendulum.

The A. C. Becken Company of Chicago says: "There are several electric clocks manufactured but so far as we know the only successful one is made by the American Clock Company of Chicago. These people have secured the highest award at all of the Universal Expositions held in the last ten years. * * * They also have had the contract for supplying the United States Government with all clocks used in post-offices and Government buildings throughout the country, which is in itself evidence that their clock is satisfactory. * * * * There have been several companies who tried to make a success of applying electromotive force direct to the pendulum, but in each case failed, and it is the judgment of our expert that it could not be successfully done owing to the difficulties in transmitting the current evenly, especially where atmospheric conditions enter into the problem."

The Otto Young Company concurs with the Becken Company in regard to the American clock. This clock is wound seven times an hour and like the Rempe clock has but three wheels, but is run by

two small weights arranged upon arms or levers. These are drawn up by electromagnets.

The clock constructed for this thesis and which I will now describe is run by dry batteries and consists of a seconds pendulum; a frame bearing the driven-wheel A, similar to the escape-wheel of an ordinary clock, and the necessary train-wheels; an anchor-shaped part, B, bearing the pallets xx, and two electromagnets, MM, placed on either side of the pendulum rod, which at this place bears two iron plates. The frame of the clock, containing all the wheels, is of brass. Connected to the positive poles of the batteries it is insulated from the anchor part. It contains the driven-wheel, four inches in diameter, bearing in its outer edge thirty brass pins corresponding to the teeth of an escape-wheel. This wheel makes one revolution per minute and carries on the outer end of its arbor, which projects through the center of the dial, a seconds hand. Concentric with, and turning upon this axis are the hour and minute hands they being connected to the driven-wheel by train-wheels. A space of one and one-half inches between the back of the frame and its wooden base allows the pendulum to swing behind the works of the clock. The seconds pendulum employed in this clock consists of a heavy leaden bob mounted on a rod of kiln-dried oak, enameled to eliminate effects of moisture. The upper end is secured by means of a short flat spring to an arbor.

The anchor or rachet, which is connected by way of the electromagnets to the negative pole of the battery, is made of two bars of brass, a and b, mounted on a base of vulcanized rubber, B, and insulated from each other. Each of these bars is electrically connected with one of the two pivots upon which the base turns, and each bears at its outer end a pallet, x. These pallets (Figure 3,

Plate II) are made of two strips of ivory with a sheet of copper between them. The copper does not approach the surface but connects a narrow inlaid platinum strip of the pallet face to the supporting arm. The face of the pallets form, with a line drawn through the center of the driven-wheel, an angle of about fifteen degrees. Now as the anchor, which is attached to the pendulum, oscillates about the pair of axes cc', the pallets engage the teeth of the driven-wheel turning it around. Sliding along the inclined plane, the tooth of the driven-wheel encounters the strip of platinum just as the pendulum reaches the position of rest, and electrical connection is momentarily completed. The current flows from the main frame by way of the driven wheel through the pallet a, its supporting arm b, and from it through the electromagnet M to the negative pole of the battery. The passage of the electrical current through the magnet attracts the pendulum there by giving it acceleration enough to complete the swing and return to the position of rest when connection is again made through the other pallet and an impulse given in the opposite direction. The anchor thus works as a two-way switch allowing the current to flow for an instant first through one and then through the other electro-magnet.

At first the pallets were set immovable but it was found that sometimes a pallet drove the tooth which it encountered, and consequently the wheel of which it is a part, too far around, when the tooth, instead of clearing it on the return swing, caught against the back of the pallet. To overcome this difficulty the pallets were fastened by a pivot and retained in place by gravitation. When pressed against by a pin they are immovable, while pressure from the opposite side causes them to swing clear and then return to their normal position as soon as relieved. Sometimes though two pins or

teeth would pass thus allowing the clock to gain one second. To prevent this two stops, J,J', made of nonconducting material were added. The train-wheels, two in number, connect the driven-wheel with the wheels regularly used to carry the hour and minute hands.

Remembering that the force caused by the impulse applied to the rod of the pendulum varies directly with the distance from the sustaining arbor, and that the electro-magnetic force varies with the square of the distance from the plates attracted, it was determined, by a number of trials, that the proper location for the electromagnets is seven and one-half inches from the upper end of the pendulum rod. Theoretically they should be nearer but when so placed the spring by which the pendulum is hung was drawn over slightly and the bob failed to gain sufficient acceleration.

Before going farther I may say that so far as practical results are concerned the clock failed to meet expectations, as it never continued going for any length of time.

The attempts to determine the effects of varying the electro-motive force on the time-keeping were not very satisfactory owing to frequent stoppages of the clock. Two dry batteries were first used and the number then increased, one battery at a time, until they numbered five. So far as could be determined in the short intervals the clock continued to run, the increase in number of batteries had a tendency to make the clock gain a little time. This, however, if true, could be overcome by shortening the time of contact to such an extent that the force applied, variable though it be, is imparted only while the pendulum is at the position of rest. Contrary to expectation, the increase in the number of batteries did not lengthen the running periods. The further acceleration of the pendulum, causing it to swing through a given distance in a briefer

time, caused such sudden impacts between the inclined planes of the pallets and the pins they encountered that the driven-wheel revolved at the beginning of the pallet thrust, far enough to fail in making contact with the platinum, and stoppage resulted.

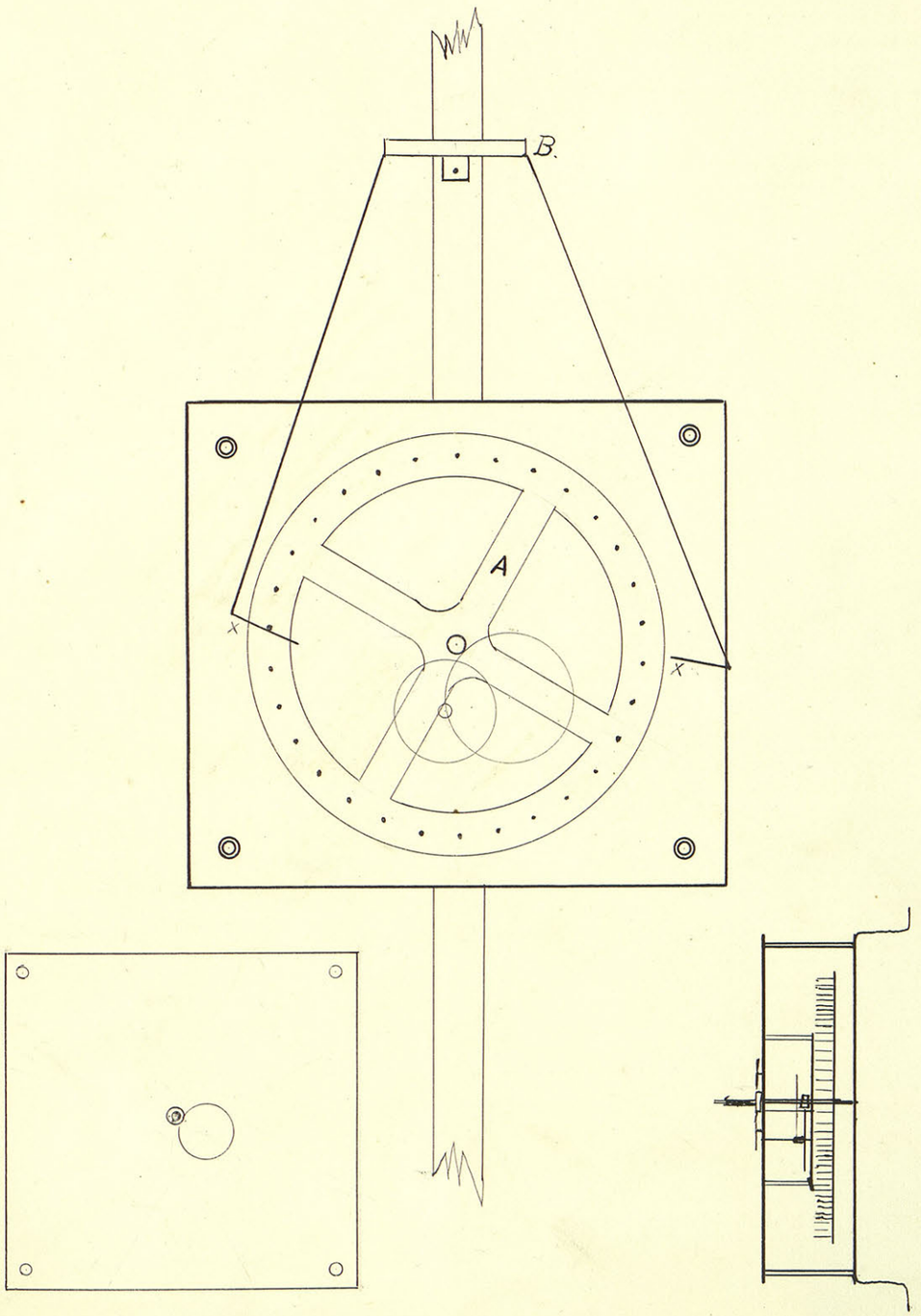
Failure in making electrical connections is, in fact, the great defect of this clock. Observing it after night, connections as broken can be counted by the spark of the back electro-motive force. Frequently there is no connection made for six or seven seconds, the pin in each case being driven too far to come in contact with the platinum. Any attempt to retard the wheel by a spring or other means created so much friction that stoppage ensued from that cause.

Several shapes of pallets were tried in the hope that the inclined plane could be made in such manner as to overcome these difficulties. The most successful of these when used with a variable current had the platinum set at the outer end, connection being made the instant a pallet encountered a tooth of the driven-wheel. With this style of pallet the clock continued running for some time and rated very well, but stoppage resulted from backward movements of the driven-wheel or from a failure of the preceding pallet to turn it far enough, thus causing the point of a pallet to strike against a pin. No feasible plan of preventing this presenting itself, the first style of pallet, set at a different angle, was again tried and the same difficulty of making connections experienced.

It is still the opinion of the writer, and also that of several much more capable men whom he has consulted, that this style of clock with perhaps some modifications, using either

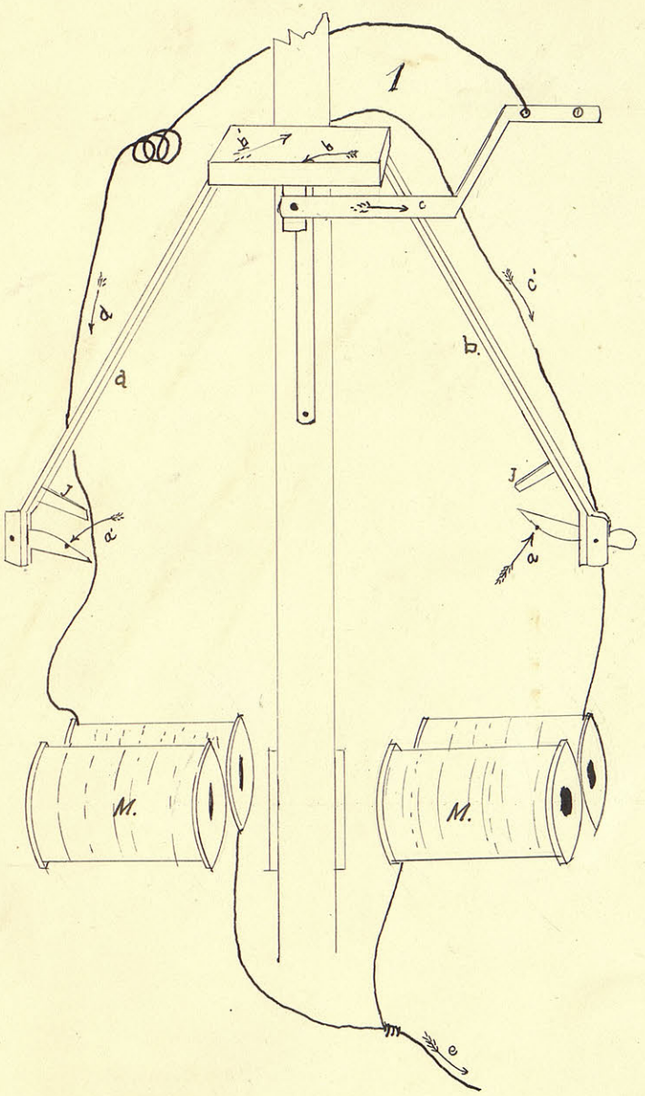
a gravity cell or a storage battery as a motive power, can be made to give good results, and though time will not now permit of longer experiment it is his intention at some future period to devote more time and study to it.

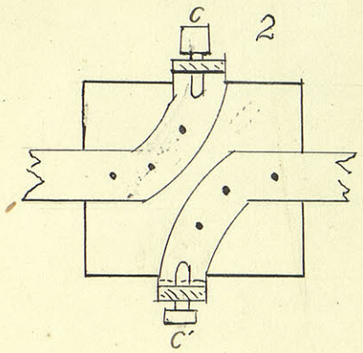
PLATE I.

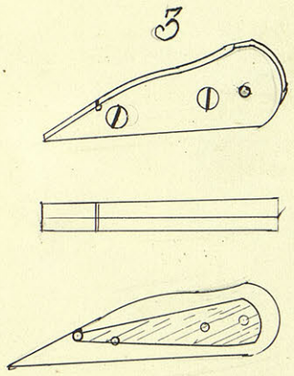


FRONT.

SIDE


1
a
b
c
d
M.
M.


2
c
c'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