ON THE

APPLICATION OF ELECTRO-MAGNETISM

AS A

MOTOR FOR CLOCKS.

IN presenting this pamphlet to our friends and the public, we beg to disclaim any idea of puffing the invention by this means, or of pushing the subject forward in any undue consideration of its importance. This alternative has been resorted to solely, on account of the trouble experienced in explaining the action of the electric clock, to persons unacquainted with electricity as a motive power.

With this view, we propose treating the subject in the simplest and most concise form, without encumbering the explanation with superfluous detail.

In considering the subject of electrical clocks, it will be necessary to contrast their performance with other clocks, and also to compare our electric clock with others that have preceded it; we trust, however, to do so, without detracting from the merits of other inventions, or our intentions being construed into any thing invidious.

To all who are acquainted with the performance of the astronomical clock, it will, perhaps, be deemed presumptuous to affirm that our aim in the application of electricity as a motive power to the clock has been to render that machine more efficient, and after two years' experience, we find our attempt crowned with complete success.

The astronomical clock, or regulator, which is the most perfect instrument hitherto constructed for the measurement of time, is, however carefully made, subject to variation and irregularities in its action. This arises from causes consequent on the transmission of, and power applied to, actuating the whole. The power applied to the working of a clock is usually a weight or spring, which is wound up at given intervals of time.

A great tendency to irregularity arises in the mode of applying the necessary moving power or impulse to the pendulum. This impulse is produced by the gravity of the weights, and is transmitted through the system of wheels constituting the clock, to the escapement, which, in turn, transmits the impulse to the pendulum at each oscillation. Now, it will be obvious that any irregularity existing in the system of wheels will operate upon the power so transmitted,—that is to say, if the train or escapement, at any one point, requires a greater amount of power for its propulsion than at another, the pendulum will, at such point, be subject to less impulsive force than at another, and consequently, will be subject to an irregularity in its motion.

Having thus briefly pointed out the proximate causes of irregularity, in the most perfect of instruments for the measurement of time, we will point out the means proposed to avoid the tendency to such irregularity. Instead of transmitting the necessary power or impulse to the pendulum through the train, we apply the power of a spring, wound up to a given extent at each oscillation of the pendulum,—the principle of action being precisely similar to what is known as the "Remontoir escapement." The "Remontoir escapement" is particularly delicate and perfect in its action, yet, from certain mechanical difficulties which attend its application, it has never been successfully reduced to practice with the requisite certainty.

This escapement, so long as its action could be continued with the ordinary maintaining power, has, we believe, been generally considered capable of determining most accurately the measure-

›y tending to a greater perfection in the motion of
han is attained by the ordinary means.
lication of electricity as the maintaining power for
bination with the "Remontoir escapement," we
ccuracy of that contrivance, and this with unerring
ny length of time; moreover, with this advantage,
ement so employed is perfectly independent of the
o the system of wheels, and therefore not subject
rity that may exist therein. From this it will be
ıt the oscillations of the pendulum, according to
nts, are almost, if not entirely, free from any
to disturb its motion; the influence of the pendu-
movement of the clock being confined simply to
eaking the electric circuits, to be herein described.
n of motion is to be ascribed the correct perform-
trument so actuated.
ears to exist some considerable doubt, as to whom
ed for the first electrical clock, as we find, by
the *Literary Gazette*, in the years 1842—3, a
ous disputation between Professor Wheatstone, on
and Mr. Alexander Bain, on the other, each claim-
ction. Be this as it may, Mr. Bain appears to
f the palm in a court of *law*, thereby settling the
t, in a pecuniary point of view.
n the application of electro-magnetism, as a main-
to clocks, the attractive and repulsive forces of
been brought to bear directly on the pendulum,
it must be fatal to accuracy of performance. In
ssful arrangements attempted, permanent magnets
posed—one on either side of the pendulum bob,
itself consists of a coil of insulated wire, through
tric fluid is transmitted at intervals. During the
of the current, the pendulum, by its influence, is
tracted on one side by an amount of force varying

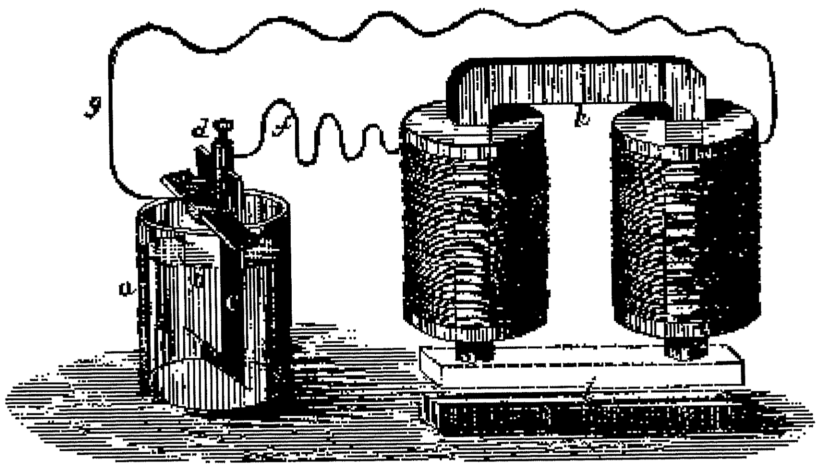
according to the power of the current, and the influence of the permanent magnets. By the attractive force thus induced, the pendulum is deflected, so as to produce its oscillation, and during such oscillation, a pin projecting from the pendulum-rod, by its motion, comes in contact with a transverse sliding bar, which forms a link in the electric circuit; this bar is slid in the direction of its length, and rests upon two points, which, during the completion of the circuit, are in contact with conducting surfaces, connected with the conducting wires. The pendulum having been attracted as described, moves through a given distance, when contact of the pin in the rod with the break bar takes place; this moves the bar sufficiently to carry its points of support beyond the conducting surfaces on which it rests, thereby breaking the contact. The electric currents are thus suspended, leaving the pendulum free to perform the opposite oscillation.

During the opposite oscillation of the pendulum, the pin again comes in contact with the break bar, carrying it backwards on its supporting surface, so as to restore the metallic contact previously broken, by which the current will be renewed, at which time the pendulum will simultaneously commence its opposite oscillation, and will again receive the impulsive force due to the attractive force of the magnets,—the circuit is again intercepted as before. By the successive breaking and making contact with the break bar, as described, the pendulum receives its impulse always in one direction, its opposite oscillation making the necessary contact for the impulse. The maintaining power of electric clocks hitherto, has been the same power as that transmitted to the pendulum, the pendulum being employed to communicate power to the escape-wheel or other contrivance, and thence through the train or system of wheels constituting the clock.

In the application of electricity to produce the oscillation of the pendulum, it must be obvious that the amount of power applied thereto will be affected by the quantity of electricity passing. Now, as it is impossible to obtain batteries of unvarying power, any and every variation therein will be communicated directly to the pendulum. This power is also applied at a point where that instrument is most sensitive, and easily susceptible of any disturbing influence to its otherwise isochronous movement. The pendulum thus actuated, is not only subject to all the variations of power due to the electric currents, but is also subject to the irregularities of the train before mentioned. It is, however, but fair to state, that the inventors of these clocks have never professed the achievement of any improvement in the measurement of time.

In order to render the subject clear to persons unacquainted with the practical application of electricity as a prime mover, we have subjoined an engraving (fig. 1) of the battery we employ for actuating the clock. This battery is well known to electricians as that of Mr. A. Smee, of which the figure exhibits a single cell.

Fig. 1.



It consists simply of a suitable vessel or jar *a*, *a*, into which water acidulated with sulphuric acid is placed. Two plates of metal, *b* and *c*, are immersed in the water, one of which is termed the positive, and the other the negative metal. In this battery, a

thin plate of platinized silver, *b*, is employed as the negativ a plate, *c*, of amalgamated zinc, as the positive metal. metals are so placed in the liquid, that no metallic con effected. If a wire or other metallic connection is caused to the plates, *b* and *c*, an electrical circuit will be established long as this remains unbroken, and the metal and acid water are sufficient, a current of electricity will flow contin through such circuit.

This pamphlet is not intended as an inquiry into the of the electric fluids, or the chemical changes that take p the galvanic battery consequent on its production,—it is suf for our purpose that such is the fact. In order to produ maintain the perfect action of the battery, it is necessary th positive metal should be amalgamated. To maintain the ar mated surface of the zinc, *c*, we prefer that it should be placed in the jar, *a*, and allowed to rest on the bottom; mercury is poured in the bottom of the jar for this purpose which the zinc is always in contact. A binding screw, soldered to the zinc plate, *c*, and another binding screw placed in connection with the platinized silver plate, fo convenience of attaching the wires, *f* and *g*. The plat silver plate is permanently supported by a bar of wood acro jar, which also serves as a rest for the zinc plate, care being that no other metallic connection exists between the plates through the wires, *f* and *g*, to be connected as hereafter desc If acidulated water be placed in the jar, *a*, in the proport about three ounces of acid to the pint, the battery will be plete, and in a condition to maintain the action of our e clock for a period of six or eight months. The peculiar pr possessed by electricity, of rendering a bar of soft iron mag has enabled its application as a motive power. To effect t is necessary that the current should be transmitted thro wire, coiled on the iron, at right angles to the axis of the the coils of wire being so insulated—that is to say, envelop a non-conducting substance, that the current proceeds through the whole length of the wire.

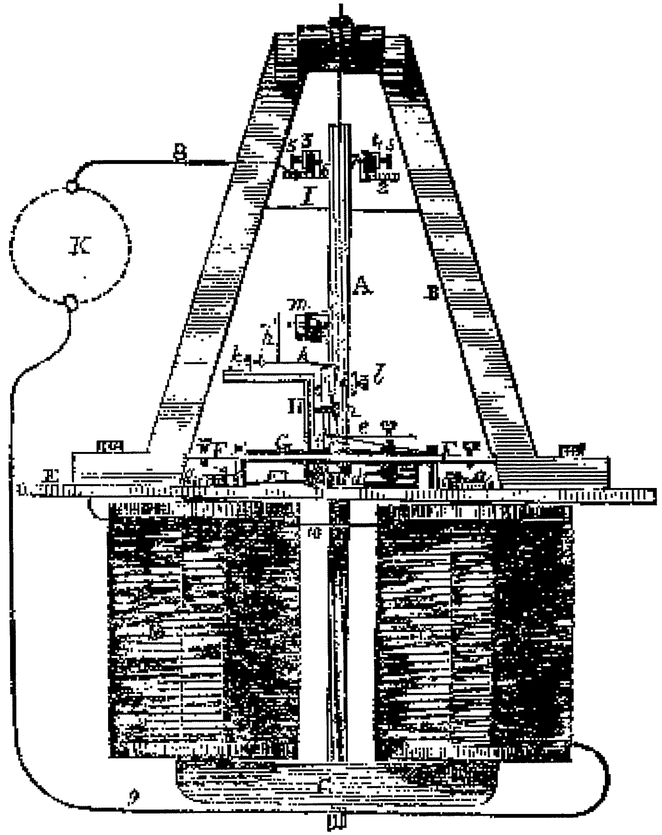
To illustrate this principle familiarly, an example is given in fig. 1, of the electro-magnet as employed for the purposes under consideration. It consists of a bar of soft iron, *h*, bent somewhat in the form of the permanent horse-shoe magnet, and to which it may be compared during the transmission of the electric current, as, being rendered magnetic by induction, it would then attract the piece of iron, *i*, placed below, and would possess sufficient power to raise it to the position shown by the dotted lines. When the metallic circuit of the wire coils, *k* and *l*, is broken, the current will be suspended, the soft bar of iron *h*, will be no longer magnetic, and consequently, the bar, *i*, will fall by its own gravity. The repeated renewal and interruption of the circuit, would produce a succession of such attraction, and release of the bar, *i*; this constitutes the power rendered available by mechanical combinations for the purpose of actuating the electric clock. The wires, *f* and *g*, are united with the coils, *k* and *l*, of which they are a continuation; the wire, as it proceeds from one pole of the battery, is wound on one limb of the bar to a sufficient extent for one coil, and then on to the other limb to the same amount, and thence to the opposite pole of the battery, —care being taken that the coil of one limb is in the opposite direction to that of the other. We may here remark that in practice it is advantageous to use a considerable length of wire in these coils, as we find, that although a greater resistance is offered to the passage of the current, and consequently a less quantity of the electric fluid will be transmitted, yet that the attractive force of the magnet is undiminished. The attractive force is equal to that produced by a shorter coil of the same wire, through which a proportionably greater quantity of the electric fluid would be transmitted. By the employment of coils of great length, we are thus enabled to economise the elements of the battery, and thereby to ensure its independent action for a greater length of time.

Having thus given in simple outline the derivation of power, we will proceed more immediately to the subject before us, and explain the manipulations of the electric clock.

We have before mentioned that the more independent and greater the freedom of motion permitted to the pendulum, the more perfect will be the performance of that instrument. In the application of electricity as the prime mover, we have adopted the escapement known as the "Remontoir escapement," which consists of a spring, wound up at intervals, and released, so as to expend the force of its reaction on the pendulum.

Fig. 2 represents a front elevation of the "Remontoir escapement," arranged for the transmission of the maintaining power to the pendulum of our electric clock, and fig. 3 a plan of the same. The pendulum-rod, A, is suspended in a frame, B, in the ordinary manner, but with the escapement perfectly disconnected from the mechanism of the clock; C is a bar of soft iron, as before described in fig. 1, and D, D, its coils of wire. The position of the magnet is here inverted, and has the poles, *a*, *a*, projecting through the bed-plate, E. Immediately above the poles, *a*, *a*, a bar armature, F, is supported by an arm, *b*, which is mounted on an axis, G, pivotted freely in the brackets, H, H. Another arm, C, is affixed to the axis, G, on which is placed a weight, *d*, which is adjustable on the arm, *c*, so that it preponderates sufficiently to elevate the armature, F, from the poles, *a*, *a*, of the temporary magnet, C. It will be readily understood, from the illustration given in fig. 1, that when an electrical current is transmitted through the coils, D, D, the bar, *c*, will be rendered magnetic, and will attract the armature, F, down towards the poles, *a*, *a*. This depression of the armature, F, produces a corresponding rise of the arm, *c*, and its weight, *d*; the arm, *c*, in rising, comes in contact with an arm, *e*, which is a rigid piece of metal, bent at right angles with the vertical portion, e^1, standing parallel to the plane of the pendulum's motion. This arm, *e*, e^1, is supported by a spring, *f*, from the bracket, *g*; the tendency of this spring, *f*, is to carry the arms, e and e^1, to the position shown by the dotted lines in fig. 2. The arm, c, when raised by the attractive force of the electro-magnet, C, as described, will come in contact with the arm, e, and raise it to the position shown. The vertical arm, e^1, when so acted upon, is received by a spring-catch or detent, h, by

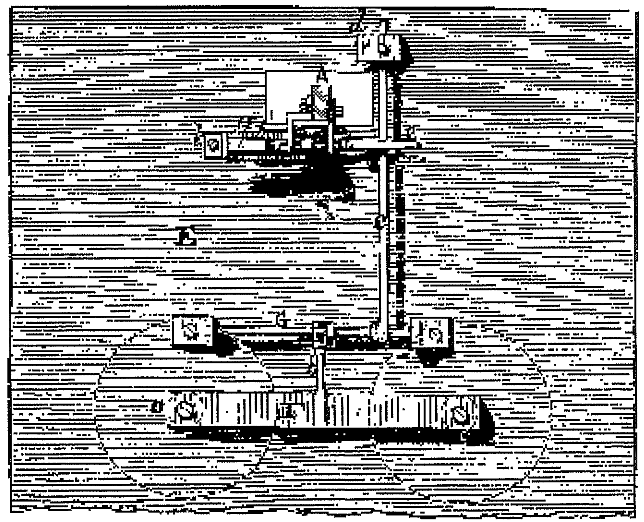
Fig. 2.



which the arm, e^1, is retained in the position into which it is thus thrown. The attractive force of the magnet, C, being momentary, the weighted arm, c, again preponderates, leaving the arm, e, free to descend when released from the detent or catch, h. The

detent, h, is similar in its construction to the arms, e, e^1, being bent piece of metal, h, h^1, sustained by a spring, i, from th bracket, k. Both of these springs are fixed on the frame, H which maintains their relative positions; l, is the impulse palle affixed to the pendulum rod, A, with the point of the screw directl opposed to the arm, e^1; m, is the discharging pallet, also affixe to the pendulum-rod, with the point of the screw opposed to th arm, h^1, on which it acts in the following manner:—Supposin the transmission of the electric current to have been effected, an

Fig. 3.



the arm e^1, raised to the catch, h, as shown; the pendulum the vibrates towards the left, and having nearly completed such vibra tion, the discharging pallet, m, comes in contact with the vertica arm, h^1, thereby deflecting the arm, h^1, and raising the catch o detent, h, to the position indicated by the dotted lines. The arm e^1, will thus be released. Simultaneously with the release of th arm, e^1, the impulse pallet, l, arrives at that arm, and the pendu lum commences its vibration towards the right. The force of th spring, f, acting on the bar, c^1, causes it to thrust the pendulur towards the right, by acting on the point of the impulse pallet, *l*. A certain amount of force is thus communicated to the pendulum, which is repeated at each oscillation towards the right. At the termination of the vibration towards the right, the electric circuit is completed, as will be described, by which the bar, e, e^1, is again wound up or raised, and again ready to take effect on the return of the pendulum towards the left. The arm, e^1, when released, is restricted in its motion by a stop or banking screw, *n*, which is so adjusted, as to limit the movement of the impulse bar, e^1, whereby the exact amount of power to be communicated to the pendulum is determined. By thus forcing the bar, e^1, and its spring, *f*, up to a certain degree of tension, and allowing it to return to the same point, the force applied to the pendulum will be invariably the same at each and every vibration. This force is nicely adjusted by the screw, *n*, so that it will be just sufficient to maintain the independent oscillatory motion of the pendulum.

It will be observed that the amount of force imparted to the pendulum is not at all affected by any difference in the strength of the electric currents applied to raise the impulse bar, *e*. All that is required of the electricity is that it must be sufficient to impart the necessary power to the magnet, C, to enable it to attract the armature, F, and raise the arm, *e*, and bar, *e*, as described.

In regulating the transmission of the electric currents to the coils, D, D. of the magnet, C, the following arrangements are observed. On the frame, B, an ivory bracket, 1, is fixed, on which two brass brackets, 1, 2, are secured, each of which are furnished with a contact spring, 3, 4, of which only one is used to induce the action of the magnet, C. The spring thus employed is that on the right hand side of the pendulum and marked, 4. Both of these springs, 3, 4, are metalically united at the back to the brackets, 1, 2, that is, one to each bracket. The extended arms of the brackets, 1, 2, are furnished with set screws, 5, 5, (see plan fig. 4), the points of which bear against the spring, 3, 4,

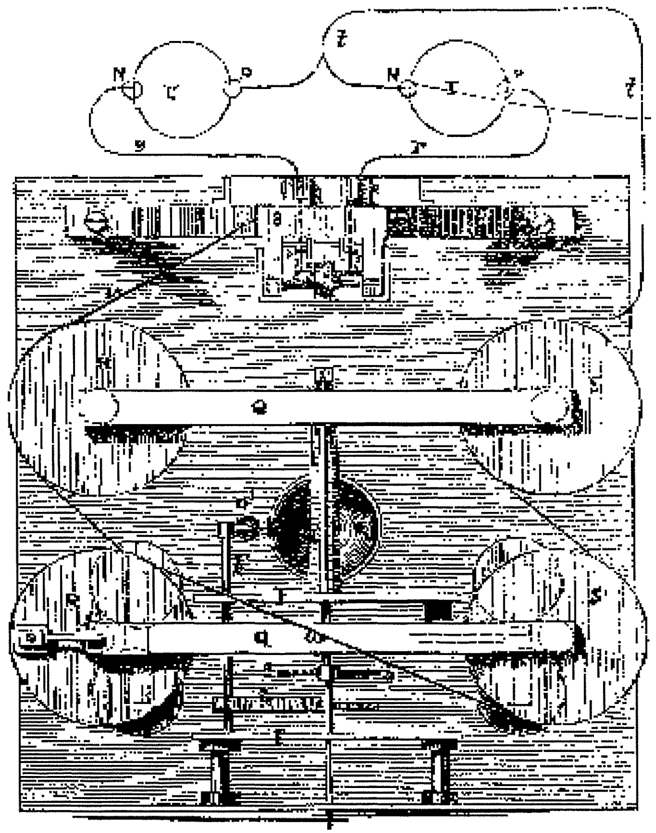
those springs having a tendency to approach the bracket arn The springs, 3, 4, are extremely slight, and are furnished at th extreme ends with platina points, , 7,—these points are oppos to either side of the pendulum rod, A, and are so adjusted the screws, 5, 5, that mere momentary contact is effected wi the sides of the pendulum, at its extreme points of oscillatic

At the points of contact, pieces of platina are secured the pendulum, A, to ensure perfect metallic connection duri contact. As before mentioned, "only one" of these springs used to complete the circuit of the coils, D, D, which spri is marked 4. The bracket, 2, of this spring is united with pole of the battery, K, by the wire, 8, (see fig. 2,) while the otl pole of the battery is in connection by wire, 9, with the coils, D, of the electro-magnet, C. The wire of the coils being in lated throughout, the current has to pass through the wh length of wire, the extreme end, 10, of which is placed in co munication with the frame, B. As the spring, 4, and bracket, are insulated from the frame, B, no metallic circuit v exist, while the pendulum remains out of contact with the poi 7, but on its being moved sufficiently towards the right, the wire will come in contact with the point, 7, when the electric circuit v be momentarily complete; during the completion of the circuit, electric passes from the positive pole, P, of the battery, K, throu the coils, D, D, to the frame, B, thence down the pendulum rod the platina point, 7, then in contact, which point is permanen connected with the negative pole of the battery, K. The curr thus traversing excites the electro-magnet, C, to action, wh consequently attracts the armature, F, which operates on the i pulse bar, e, e^1, as described. On the pendulum breaking cont with the point, 7, the current ceases, and the magnet, C, losi its attractive force suffers the weighted arm, *e*, by its super gravity, to fall back, where it rests until the circuit is again co pleted, when it is similarly acted on.

From the foregoing it will be readily understood, that

winding up" of the "remontoir spring" is effected at the com-
.etion of the pendulum's oscillation towards the right, and that the
ischarge takes place on the pendulum approaching the extreme
ift, consequently the impulse takes effect at such time, and is
'ansmitted during a portion of its oscillations towards the right.
'he impulse therefore takes effect once during two oscillations
f the pendulum.

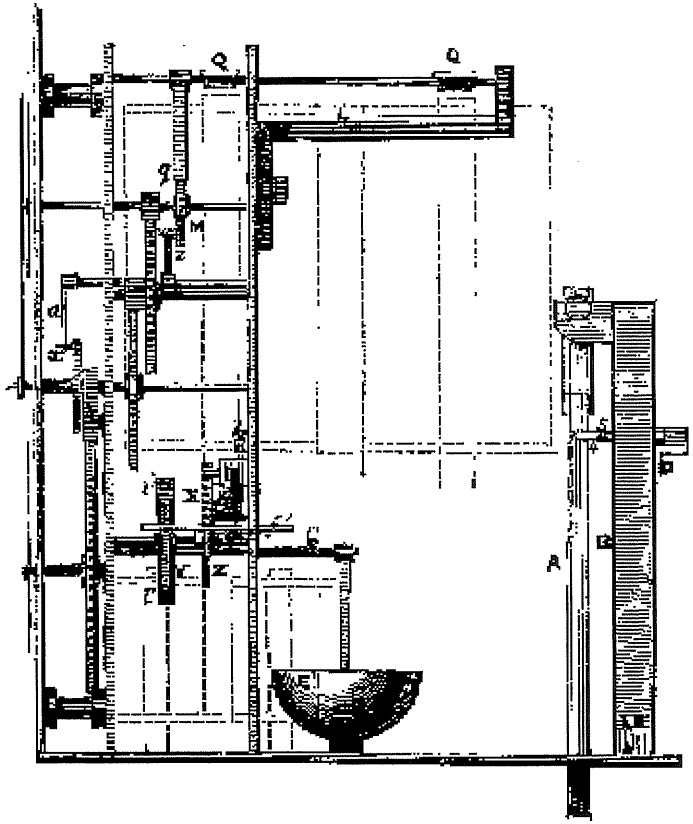
Fig. 4.



Thus far we have entered upon the maintaining power of the
endulum only, which, although not itself acting directly on the
rain of the clock, is the immediate cause of, and regulates the
notions transmitted thereto. Fig. 4, is a plan of the clock,

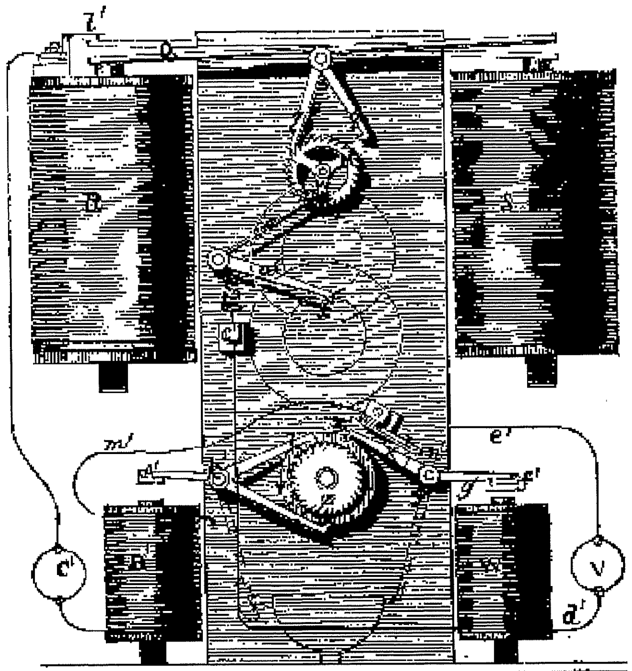
shewing also the arrangement of two batteries necessary to its working. Fig. 5, is a side elevation of the train, and Fig. 6, a transverse vertical section on the line, P, P, fig. 5. On an axis, L, two bar magnets, Q, Q, are fixed, the opposite ends of which are opposed to the poles of two electro-magnets, R, R, S, S, and these magnets are caused to attract and repel alternately opposite

Fig. 5.



ends of the bar magnets, Q, Q. The alternate attraction and repulsion of the bar magnets, Q, Q, by the magnets, R and S, produce an oscillatory of the shaft, L, which is pivoted in the bracket, L, and frames, I, I, of the clock. The oscillating axis, L, has a pair of pallets, q, q, affixed thereto, which impart at each oscillation of the axis, a movement to the ratchet wheel, M. If the pendulum is regulated to vibrate seconds, this wheel, M, is fixed on the arbor of the seconds hand, and is furnished with thirty teeth.

Fig. 6.



Each oscillation of the pallets q, q, cause the wheel, M, to rotate the distance of half a tooth, the inclined face of each pallet being so disposed that they strike the incline of each tooth in succession as they are presented, forcing the wheel round until the tooth locks against the end of the acting pallet.

The oscillatory motion of the shaft, L, is thus communicated to the second arbor, and thence to the minute and hour hands, by the ordinary system of wheels.

It will be evident, that by producing an oscillation of the axis, L, once in every second of time with unerring precision, that the performance of the clock will be extremely perfect. In the annexed engravings, figs. 4, and 5, the electro-magnets, R and S, are denuded of the frame work which sustains them, in order to simplify and exhibit to advantage other parts of the clock, while in fig. 6, their position is merely indicated by dotted lines.

The action of the pendulum on the clock train, and the controul it maintains, is effected in the following manner:—

The two contact springs, 3, 4, were before described, one with reference to the pendulum, which it will therefore be unnecessary to repeat; suffice it to say, that both of these springs are employed in producing the action of the train, and that the spring, 4, serves to conduct simultaneously the current that traverses the coils, D, D, as well as that of the magnets, R and S, different batteries being used for the purpose.

To produce the necessary currents of electricity, whereby to actuate the clock train, two batteries, T, U, are employed. The positive pole of the battery, T, is placed in connection with the bracket, 2, and spring, 4, by the wire, r, while the negative pole of the battery, U, is in like connection with the bracket, 1, and spring, 3. The negative pole of battery, T, and the positive pole of battery, U, are united in one wire, t, which communicates with coils of the electro-magnets, R and S.

The coil wire is so wound on the limbs of the electro-magnet, S, that the current travels round them in opposite directions, whereby that magnet is excited to attract the ends of the bar magnets, Q, Q, opposed to its poles. From the coils of the magnet, S, a wire, u, conducts the electric fluid to the coils of the electro-magnet, R, but here the coils are wound in opposite directions to those of S. The result of this arrangement of the coils is, that the magnet, R, exhibits a repulsive influence on the poles of the bar magnets, Q, Q, while at the same time the opposite ends of the magnets, Q, Q, are attracted by the electro-magnet, S.

The wire, v, is a continuation of the coils, and connects them permanently with the frame, B. The coils of the magnets, R and S, is the common circuit of both batteries, and which are both complete, with the exception of the breaks that exist between the pendulum rod and the platina points, 6 and 7. Now, if the action of the pendulum and its operation upon the electric circuits be braced, it will be this: Suppose the pendulum to vibrate towards the right, it will come in contact with the platina point, 1, the effect of which is, that the circuit of battery, T, will be completed, and a current of electric fluid will be transmitted from the positive pole, P, by the wire, r, to the spring, 4, thence by platina point, 1, to the pendulum rod, up its suspension spring to the frame, B, and thence through the several coils of the magnets, R and S, to the negative pole of battery, T. By this transmission of the current, the magnet, R, will be excited to attract the bar magnets, Q, Q, while the magnet, S, will, at the same time repel the opposite ends of those bar magnets, thereby producing an oscillation of the axis, L. During this time, the battery, U, remains inactive, and until the pendulum completes its vibration towards the left, when it will come in contact with the platina point, 6, when the circuit of battery, U, is complete. A current of electricity will now pass from the positive pole, P, of battery, U, by the wire, t, through coils of the electro-magnets, R and S, to the frame, B, by the wire, v, thence down the pendulum rod, from which it is transmitted at the moment of contact, by the platina point, 6, and spring, 3, to the wire, s, connected with the negative pole of the battery, U. Thus, the course of the electric fluid from the battery, U, is an opposite direction to that of the battery, T, the effect of which upon the magnets, R and S, is, that the magnet, R, which before the influence of a current of electricity from the battery, T, exerted an attractive power on the bars, Q, Q, now repels them, and the magnet, S, which before repelled, now attracts the bars, Q, Q, thereby producing an opposite oscillation of the bars, Q, Q,

and their axis, L. By the alternate completion of the two circuits of batteries, T and U, at each vibration of the pendulum, A, an uniform alternating motion of the bar magnets, Q, Q, and their axis, L, is produced, which motion is transmitted to the clock train as described, and is maintained with all the precision of a pendulum whose oscillatory motion is free and unfettered by mechanism.

The pallets, q, q, of the escape or ratchet wheel, M, are so disposed on the axis, L, that by their contact with that wheel, actual contact of the bar magnets, Q, Q, and the poles of magnets, R and S, is prevented, thereby avoiding any retentive force that might exist from residuary magnetism in either of those magnets. The remaining portion of the clock to be described is the striking part. This apparatus is represented in figs. 5 and 6. For this purpose, the seconds wheel, M, is furnished with a projecting pin, w, which by reason of the wheel, M, performing one revolution per minute, returns to the position shewn sixty times during the hour. A disc, M, is fixed on the arbor of the minute hand, which is also furnished with a pin, x, but the motion of this arbor being reduced in the train as sixty to one, this pin, x, can only arrive in the position shown once during the hour. The pin, x, is so disposed in the disc, N, that it occupies this position exactly at the completion of each hour.

These pins, w and x, are, therefore, only in conjunction or in similarly relative positions at that time.

An arbor, y, is pivoted in the framing of the clock, which arbor has affixed to it an arm, and insulated from it by an ivory bush within its collar. The arm, z, is slight and elastic, and carries a race, z^1, at its extremity, on which the pin, w, rubs in passing, if the pad, z^1, be sufficiently elevated for the purpose. Another arm, a^1, is also affixed to the arbor, y, in such a position that the pin, x, in its rotation will come in contact with it once during the hour. The contact of pin, x, with the arm, a^1, raises it and also the arm, z, producing simultaneously contact of the pin, w, and pad, z^1. The contact of these pins, w and x, with their respective arms, completes an electric circuit; the object will be presently described. The arm, z^1, is attached by a spring, b^1, to a piece of metal, c^1, which piece of metal is insulated from the clock frame. The spring, b^1, acts as a conducting wire to the arm, z, and also serves to draw down that arm a little below the position shown, and out of contact with pin, w, during fifty-nine revolutions of the wheel, M, the sixtieth revolution of that wheel producing contact of both those pins with their respective arms, as described. The arm, z^1, is so formed that the pin, x, does not remain in contact with it during one revolution of the wheel, M, consequently, w, returning to its lowest position, at the succeeding revolution, the pad, z^1, will have fallen so as to prevent contact therewith.

V is a battery, one pole of which is placed in connection with the clock frame by the wire, e^1, while the other pole is connected with the coils of the electro-magnet, W, by the wire, d^1, which is continued thence to the insulated piece of brass, c^1. Now, the only break that occurs in this circuit is at the pad, z^1, therefore, when contact between the pad, z^1, and the pin, w, at the completion of each hour, this circuit will be complete, metallic connection being established from the pad, z^1, to the clock frame. The magnet, W, is thus rendered magnetic, and by its attraction draws down the armature, f^1. The armature, f^1, is carried by the opposite end of a lever, X, moving on a fulcrum at g^1. The lever, X, is furnished with a detent, x^1, which is received in the notches of the locking, Y. When the armature, f^1, is attracted, the detent, x^1, is withdrawn from the locking plate, which, with its axis, will be free to revolve. This permits the striking of the clock, which is accomplished in the following manner:—C^1 is another battery, one pole of which is in communication with the coils of another electro-magnet, B^1, and thence by wire, m^1, to an insulated plate, h^1; this plate supports a spring, n^1, which is furnished with a platina point, n^1, at its extremity,—the distance of

which from the arm, X, is regulated by a set screw, so that on the detent, x, being raised out of the locking plate, contact is effected between that lever and the platina point of n^1, which causes the circuit to be completed to the clock frame.

The other pole of the battery, C^1, is placed in communication with a stud spring, l^1, which is immediately over one of the bar magnets, Q. These bar magnets, it will be remembered, perform an oscillation once in every second, consequently at periods of every two seconds, that end of bar magnet, Q, under the spring, l^1, will come in contact therewith. It must also be remembered, that the circuit of battery, C^1, is completed to the clock frame at n^1, when the lever, X, is raised, as described. The effect of this is, that at every alternate vibration of the bar, Q, the circuit of battery, C^1, will be completed by the contact of the bar, Q, with the spring, l^1, thereby exciting the electro-magnet, B1, which is repeated each time the bar, Q, comes in contact with the spring, l^1, so long as the point, n, remains in contact with the arm, X.

The armature, A^1, will thus be alternately attracted and released by the magnet, B^1, the armature, A1, receding from the magnet by the superior gravity of the pallets, i^1, i^1, which are attached to the same arbor, k^1, thereby causing such arbor, k^1, to oscillate. The arbor, k^1, also carries a bell hammer, D^1, which strikes the bell, E^1, at each attraction of the armature, A^1. By the oscillation of the arbor, k^1, the pallets, i^1, i^1, fall alternately into the ratchet wheel, Z, causing it to rotate by a step-by-step motion, which is continued so long as the contact at n^1, is unbroken. This is determined by the locking plate, Y, which, according to the distances of the notches in its periphery, will keep the detent lever, x, elevated for a longer or shorter period of time, thereby maintaining contact at n^1. The locking plate, Y, is similar in its divisions to the ordinary locking plate of striking clocks, and calculated to produce the several series of strokes, from one to twelve, as required. The ratchet wheel is divided, so that the whole number of teeth correspond with the entire number of strokes given during the twelve hours, while the locking plate, Y, is so divided, that the spaces between the notches in its periphery embrace severally a number of teeth that will produce at intervals the given number of hammer strokes to denote the several hours in succession.

It was before mentioned, that the pad, z^1, when in contact with the pin, w, that such contact completed the circuit of battery V, which is maintained throughout one oscillation of the bar magnet, Q. During this time the circuit of battery, C^1, is completed, and the attraction of the armature, A^1, as described, by means of which motion is communicated by the pallets, $\bar{c}$, $\bar{a}$, to the ratchet wheel, z, and locking plate, Y. This motion of the locking plate prevents the detent, a_1, again falling into the same notch. The circuit of the battery, V, although broken at the pin, w, during the succeeding oscillations of the bar magnets, Q, does not necessarily break the circuit of the battery, C^1, at the point, w^1, which remains in contact until the detent, x^1, falls into the next notch presented in the locking plate.

Thus, if the hour to be struck is one, a single tooth of the ratchet, Z, will pass, the detent, x^1, falling directly into the next notch, which is sufficiently close to that from which it was previously raised. In striking two o'clock, two ratchet teeth will pass before the detent falls, allowing two movements of the armature, A^1, before the circuit is broken, and so on for the several hours to be so indicated.

In the description which has been given in the foregoing pages, the pendulum and dial have been described as in one case, but this is by no means necessary. The pendulum may be placed in any convenient situation where it would be free from vibration, and wires may be led away and connected with any number of dials, each of which may be actuated with all the accuracy of which a well-regulated compensating pendulum is capable.

A pendulum on this principle, having eight dials in connexion with it, has been going for some considerable time past, at the extensive Warehouses of Messrs. J. F. Pawson and Company, St. Paul's Churchyard, where they may be seen by application to the Patentee, C. SHEPHERD, Chronometer Maker to the Royal Navy, 53, Leadenhall Street, City.
