A SHORT HISTORY

OF THE

ELECTRIC CLOCKS,

WITH

EXPLANATIONS OF THEIR PRINCIPLES AND MECHANISM,

AND

INSTRUCTIONS FOR THEIR MANAGEMENT AND REGULATION.

BY

ALEXANDER BAIN, PATENTEE,

TO WHOM WAS AWARDED THE EXHIBITION COUNCIL MEDAL, CLASS X.

9

LONDON:

CHAPMAN AND HALL, 193, PICCADILLY.

1852.

ELECTRIC CLOCKS.

DURING the last few years, very rapid progress has been made in advancing the conveniences and luxuries of civilised life, by the combination of mechanical skill with science; and from what has been already accomplished, it would appear, that of all the agencies which have been in a manner subjected to man's control, hitherto none is more fitted, or indeed likely, to work greater changes in the destinies of the world than electricity. The instantaneous transmission of intelligence by the Electric Telegraph to distant places, and its influences upon society, are as yet only partially developed; but enough has already been accomplished to show how speedily the whole world may be brought together by its mysterious and centralizing agency.

For many years I have devoted myself to rendering electricity practically useful, and have been extensively engaged, not only in this country, but in America and on the Continent, in the construction and working of the Electric Telegraph; while at the same time, the employment of electricity in the measurement of time has also engaged my attention.

It was in the year 1837 that it occurred to me (while viewing the beautiful electro-magnetic apparatus in motion at the Adelaide Gallery) that the same power might be used, with advantage, in working clocks. Very shortly after the idea was conceived, I began reducing it to practice, and have ever since, although much engaged with the twin invention, the Electric Telegraph, been testing and improving it. The first and most obvious plan was to make a common clock transmit its time to other distant clocks, or indicators, worked by what is termed electro-magnets, the construction of which will be explained hereafter. These indicators, or, as they have since been termed, companion, subsidiary, or affiliated clocks, may be placed in the various rooms of a house; or even in all the houses of a town, the whole being connected by wires to the one parent clock. By this arrangement, all the clocks so connected would, it was presumed, keep exact time with the parent clock. The idea took, indeed, a much wider range—viz., that all the clocks in the kingdom could be so connected by wires, as to receive the time from one governing clock; and, chimerical as the scheme might then appear, I believe its realization is within the limits of reasonable probability.

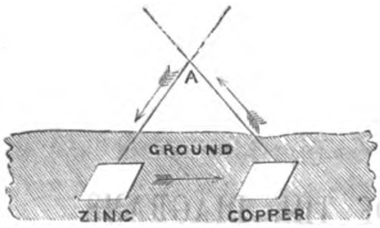
The next step in the progress of the invention, was the application of the electric power to work single clocks, so that no winding might be required, and the common clock was dispensed with altogether. This, in a commercial point of view, was of great importance, as such clocks, suitable for private houses and all descriptions of buildings, could be used either singly, or could be made, when required, the governing or parent clock, in the same way as the ordinary clock had been used for that purpose.

My next efforts were to discover a cheap and constant source of electric power; for so long as I was obliged to depend upon the ordinary galvanic apparatus, the power was neither uniform nor lasting, and gave more trouble in working single clocks than weekly winding, in addition to which the expense was considerable. In prosecuting some experiments relating to the telegraph, in 1842, I discovered, that if the metals used in the galvanic troughs were buried in the earth, a very uniform and (practically speaking) an everlasting power was obtained, and at a mere nominal cost, though of small power compared with the common galvanic trough in full action. After many experiments, I at last succeeded, by a new arrangement of the magnetic power, in working clocks of any size, from the smallest mantelpiece timepiece up to the large church clock, effectually by the currents of the ground. An inspection of the electric clock in motion is necessary to make its principles and advantages well understood; but it may be stated, that their construction is so simple as not to be liable to any of the derangements so constantly occurring in other clocks, while the electric power, when applied, dispensing with all the ordinary apparatus of weights and springs, reduces the friction of the works to an almost infinitesimal quantity, and the supply of electricity being, practically speaking, perpetual, the clocks need no attendance from one year to another.

For churches and public buildings, where large clocks are required, the electric clock will be found eminently suited. In such cases, there will be no difficulty in sinking plates in the ground, from which, by means of two ordinary wires, the machinery will be set in motion, and time kept without the necessity of winding up.

To government and banking offices, as well as all other establishments where uniformity of time is important, the advantages which these clocks present are decisive, as from one clock uniform time is kept through the whole extent of the premises, by means of the companion clocks; and architects engaged in the construction of new houses may find the benefit of their introduction, by having plates, with insulated wires proceeding from them, arranged, like ordinary bell-wires under the plaster of the rooms—the expense of doing so being trifling.

Before explaining the diagrams, I will show briefly the mode by which the electric power is obtained. If we place a sheet of zinc and another of copper in the ground (each sheet having a copper wire previously soldered to it) a little distance from each other, and a few feet deep, so that they are perfectly imbedded in the moist soil, we have, by this simple arrangement, a source of electricity, and if the sheets of metal are about two square feet each we shall have amply sufficient to work a clock. A simple diagram will explain it at a glance. Suppose the wires are brought into contact with each other at A, an electric current will instantly circulate, as shown by the arrows. It is supposed to



begin at the zinc, pass through the moist soil to the copper, from thence by the wires back to the zinc, and the electric circuit is complete.

The following diagrams, with the copious explanation of them which is given, will, I think, enable all those who are conversant with the mechanism of ordinary clocks, to fix and regulate, without difficulty, any of the patent electric clocks; and to those of the public who take an interest in this important branch of what may be called domestic science, the elucidation of the general principles of so important a discovery, and a familiar explanation of its details, will not be without its value.

A large and varied stock of these clocks is kept in motion at the show-rooms and manufactory, 43, Old Bond Street; and I shall be happy to afford, both to the public and the trade, every facility for the examination both of their principles and mechanism.

ALEX. BAIN.

43, Old Bond Street, April 19, 1852.

EXPLANATION OF THE DIAGRAMS.

FIG. 1 is a representation of an electric pendulum, suspended to a metal bracket, hh; the bracket being firmly fixed to the board AA, which is, in a finished clock, the back of the clock-case. The pendulum-rod is of wood. B, the bob of the pendulum, is composed of a reel of insulated copper wire, having (merely to improve the appearance) a brass covering; the ends of the wire are carried up the rod, and terminate in two suspension springs, i and j, which serve the double purpose of suspending the pendulum, and conveying electricity to and from the wire in the bob B. nn are two brass tubes fixed to the sides of the case, and facing each other. a b c f g is an apparatus called the break, for letting on, and cutting off the electric current, to and from the wire in the pendulum B, and performing the same office for clocks in distant places. Z is a plate of zinc buried in the ground. C is a plate of copper, or what is equally good, a quantity of carbon (common coke or wood charcoal). In private houses and other establishments in town, the ground underneath the floor of the coal-cellar, or the flags of the area, is a suitable position for sinking the plates, or in any place where free access may be had to the moist soil. In country establishments there will be no difficulty, as the plates may be sunk as above, or in any part of the garden. D and D^1, are wires connecting the zinc and carbon with the pendulum. These wires should be entirely insulated, and for this purpose gutta percha covering is the best material; thus protected, they may be carried to any distance,

FIG. 1.

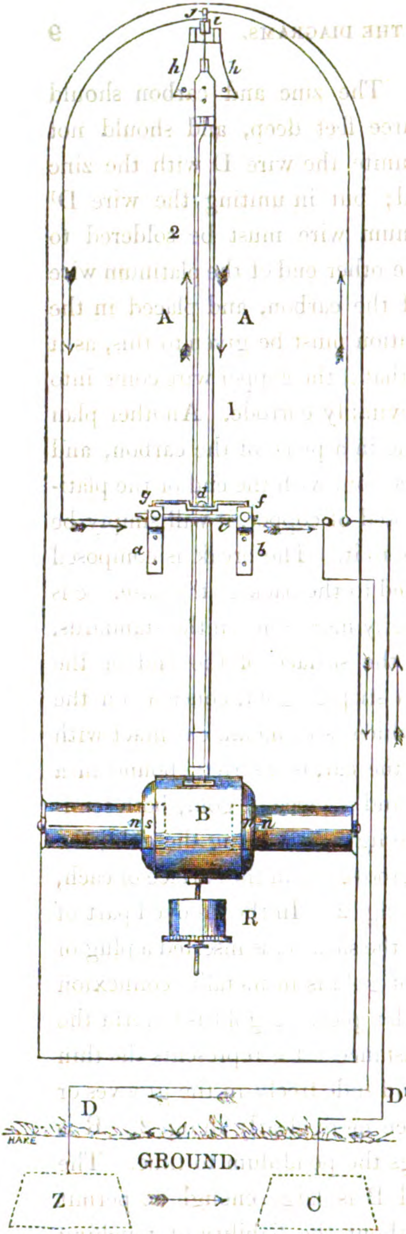


FIG. 4.

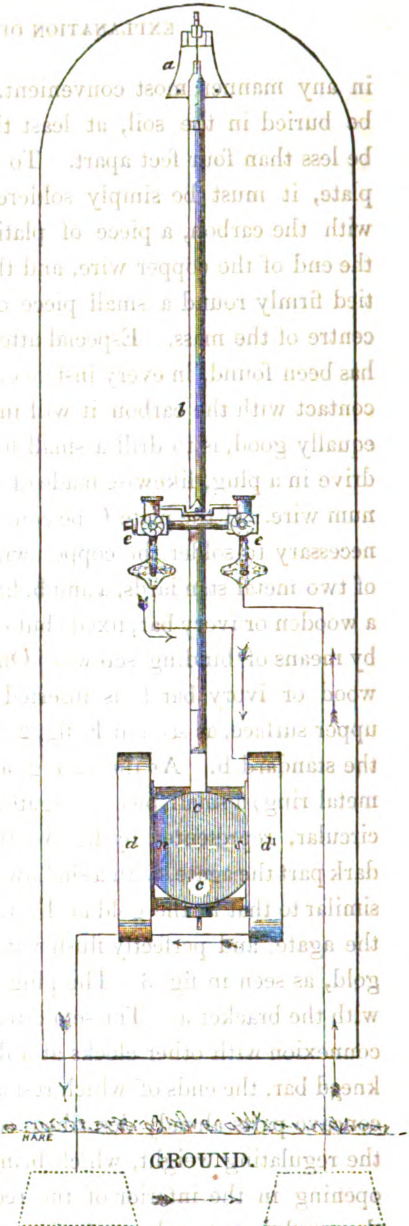


FIG. 2.

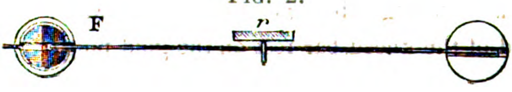


FIG. 3.

in any manner most convenient. The zinc and carbon should be buried in the soil, at least three feet deep, and should not be less than four feet apart. To unite the wire D with the zinc plate, it must be simply soldered; but in uniting the wire D^1 with the carbon, a piece of platinum wire must be soldered to the end of the copper wire, and the other end of the platinum wire tied firmly round a small piece of the carbon, and placed in the centre of the mass. Especial attention must be given to this, as it has been found, in every instance, that if the copper wire come into contact with the carbon it will inevitably corrode. Another plan equally good, is to drill a small hole in a piece of the carbon, and drive in a plug, likewise made of carbon, with the end of the platinum wire. If the plate C be composed of copper, it will simply be necessary to solder the copper wire to it. The break is composed of two metal standards, a and b, fixed to the back of the case. c is a wooden or ivory bar, fixed (but easily moveable) in the standards, by means of binding screws. On the surface of the end of the wood or ivory bar f, is inserted a strip of gold, concave on the upper surface, as seen at F, fig. 2, which is in metallic contact with the standard b. At the end g of the bar, is inserted (bound in a metal ring) a small piece of agate, and a piece of gold, both semicircular, represented by fig. 3; the light part being the gold, the dark part the agate, with a shallow groove cut in the surface of each, similar to that in the gold at F, in fig. 2. In the grooved part of the agate, and perfectly flush with the surface, is inserted a plug of gold, as seen in fig. 3. The plug of gold is in metallic connexion with the bracket a. The semicircular piece of gold is to form the connexion with other clocks at a distance. f g represents the thin kneed bar, the ends of which rest and slide freely in the grooves or concave parts already described, seen more clearly in fig. 2. R is the regulating weight, which brings the pendulum to time. The opening in the interior of the reel B is large enough to permit the pendulum to vibrate freely, without the liability of touching the tubes n n. The suspension spring j, being connected by a wire with the carbon, if the end of the kneed bar rest on the gold plug in the agate, the electric circuit will be complete, and the course of the current may be thus described. The current is supposed to begin at the plate of zinc in the ground, thence through the moisture of the earth (a sufficient conductor) to the carbon, then through the wire D^1, as shown by the arrows to the spring j, through the spring, through the wire 2, to the coil of insulated wire in the bob B, which it permeates, and from thence, by the wire 1, to the spring i, to the bracket a of the break, through the gold plug in the agate, to the point g of the bar g f, then through the bar to the bracket b, and returning by the wire D to the zinc plate, as shown by the arrows.

The mechanism and the means of establishing the galvanic power being thus explained, the manner of its operation remains to be shown. While the electricity is thus passing, it renders the coil of wire in the bob B magnetic, that is, it has all the properties of a magnet with dissimilar poles, north and south. In the diagram, the north pole is to the right hand, and the south to the left. Now, the permanent magnets having their north poles inwards next to the coil, it is evident, by the well known law of magnetism, that the north pole of the left hand magnet will attract the south pole of the coil, while at the same instant the north pole of the right hand magnet will repel the north pole of the coil, and by these means the pendulum will receive an impetus towards the left. It cannot under these circumstances hang perpendicular, but if the galvanic current is broken (which can be done by sliding the bar g f a little to the left, till the point is off the gold plug), the coil being no longer magnetic, the magnet will have no further effect upon it; the pendulum is therefore free to go back in the contrary direction. The pendulum itself gives motion to the sliding bar, by means of the pin d, which projects from the rod, and acts in the kneed part of the bar. If we now take hold of the pendulum with the hand, and move it to the right, till the point of the bar is on the gold plug, and then let it swing back, it receives an impulse from the magnets, as just explained. When it arrives at the end of its excursion to the left, it will of itself push the sliding bar off the gold plug; the power will then cease, and it is free to return to the right hand by its own momentum, until it pushes the sliding bar again on to the gold plug, and thereby receiving another impulse, will continue its vibrations, which will increase in length, till the point of the sliding bar is carried beyond the surface of the plug on the right, and partly on to the agate, this action cutting off a great portion of the electric current, and if the vibration further increase in the smallest degree, the power during one vibration is entirely cut off. In this way the pendulum is kept precisely at one given arc of vibration, however variable the electric current may be, provided only that there be always sufficient. I may here remark, that the lower the break is placed with reference to the pendulum, the greater will be the accuracy of its vibration. This governing principle of the break is a most important feature in the invention, and is accomplished without any extra work or friction. For large church clocks, I employ an apparàtus termed a mutator, which, instead of cutting off the current, changes its direction, so that the pendulum receives its impulse, both from right to left, and left to right, but it has the same governing principle as the break just described.

Fig. 4 is a representation of another pendulum, with its earth-battery and connecting wires. In this arrangement the permanent magnets are in the bob of the pendulum, and the coils of wire are fixed to the case; or, in other words, the permanent magnets move, and the temporary magnets, viz., the coils of wire d, d^1, are fixed. b is the pendulum-rod, suspended in the ordinary way by a single steel spring to the bracket a. c c are two semi-circular permanent steel magnets, having north poles pointing to the left, and south poles pointing to the right. d, d^1 are two oblong coils of insulated copper wire, fixed to the back of the case, the opening in the coils being large enough to allow the bob of the pendulum to move freely without the liability of touching; the break in this case is the same in principle and action as that already explained, but the connecting parts are covered with brass caps to exclude the dust, and the brackets are more ornamental. The action is as follows:—When the galvanic current is let on, the coil d attracts the north poles of the magnets of the pendulum-bob, at the same time the coil d^1 repels the south pole; the pendulum thus gets its impulse to the left, and the current being cut off by the break, as explained in Fig. 1, the pendulum is free to return by its own momentum, and the motion is thus perpetuated. It will be observed that these pendulums are moved not by mechanical means, which involve friction and wear, but by magnetic power, in which there is none of either, and even that power is applied, *at the utmost*, in every second vibration, though in actual practice it is not in full force more than once in every fifth vibration, the only friction (which is very slight) being the sliding of the bar g f, of the break, it may therefore be safely inferred that these are the most detached pendulums ever yet contrived. They are regulated to time in the ordinary way, by raising or lowering the weight R, and in Fig. 4 by raising or lowering the bob itself.

In the common clocks, which are moved by the power of a falling weight, transmitted to the pendulum by a train of wheels and an escapement, the vibrations of the pendulum are injuriously affected by irregularities in the wheel-work, escapement, and crutch, which have never yet been made absolutely perfect. Another cause of error arises from the thickening of the oil, necessarily applied to the numerous points of the mechanism. These causes forcing the ordinary pendulum to vary in the length of its excursions, irregular time is the result. Could a pendulum be made to move in a cycloid, the time of the clock would be less affected, but this beautiful discovery (by Huygens) has not been successfully brought into use, in consequence of practical difficulties, which it is not necessary here to explain.

In all mantelpiece and bracket clocks, moved by the unbending of springs, the error is still greater, arising from the motive power itself never being perfectly uniform. This proceeds from two causes, the difficulty of adjusting the power of the spring, so as to equalize it during the period of unbending, and the impossibility of destroying or regulating the friction consequent on the rubbing of the several coils of the spring upon each other as it unfolds. Principally from these two last mentioned errors, the small ornamental clocks now so much in use do not keep such good time as the large ones moved by weights. Another cause of imperfect performance may be mentioned. All English-made clocks, except those of a superior quality, do not go during the time of winding. It is true, the pendulum does not stop, but the hands do, and therefore an irregular amount of time is lost every time the clock is wound up; to which cause of error may be added the jar, and liability of disturbing the plane of the pendulum's vibration in every winding process. Most of the French clocks go in time of winding, but their motive power is extremely irregular.

From all these difficulties and causes of error, the electric pendulum is perfectly free. It gives motion to the hands or indicators by the following simple means:

Fig. 5 represents the mechanism; there are but two wheels in the train, besides the dial-wheels, and as these are moved in the ordinary way, they are not shown in the figure. a a are the frames, fixed to each other in the usual manner; fixed to the top of the frames is a cross bar, to which the pendulum may be suspended (but I prefer suspending it as shown in Figs. 1 and 4); c is the top portion of the pendulum-rod, which is suspended at d; f is the crutch, shown by two dotted lines having its axis at e—on the same axis is the arm h, which carries the click i; k and l are projections from the inner part of the back frame; these are the bearings of a spindle which carries the ratchet-wheel at i, and a worm which works into the teeth of the wheel m, the arbor of the wheel projecting through the front frame. The action takes place as follows: the pendulum-rod, in its excursion to the left, comes against the projecting pin g, which is fixed in the lower end of the crutch, and pushes it aside; this action gives similar motion, through the crutch and axle e, to the arm h and click i; this causes the point of the click to slip over one tooth of the ratchet-wheel. Now, when the pendulum takes its excursion

Fig. 5.

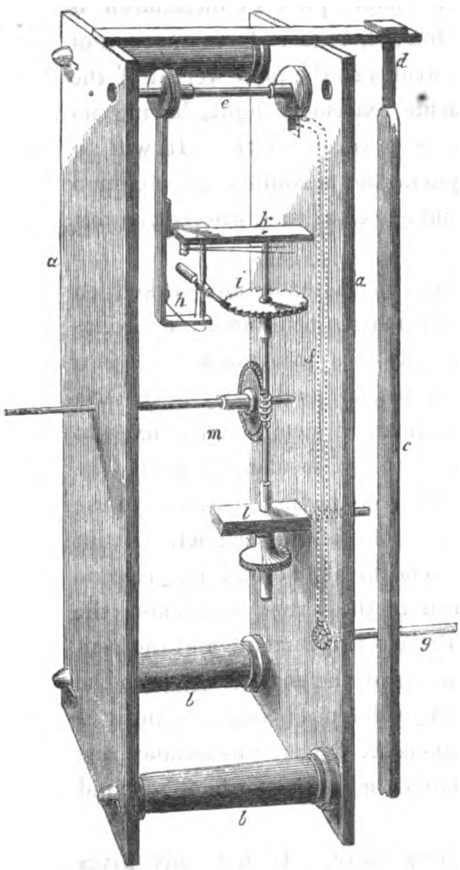
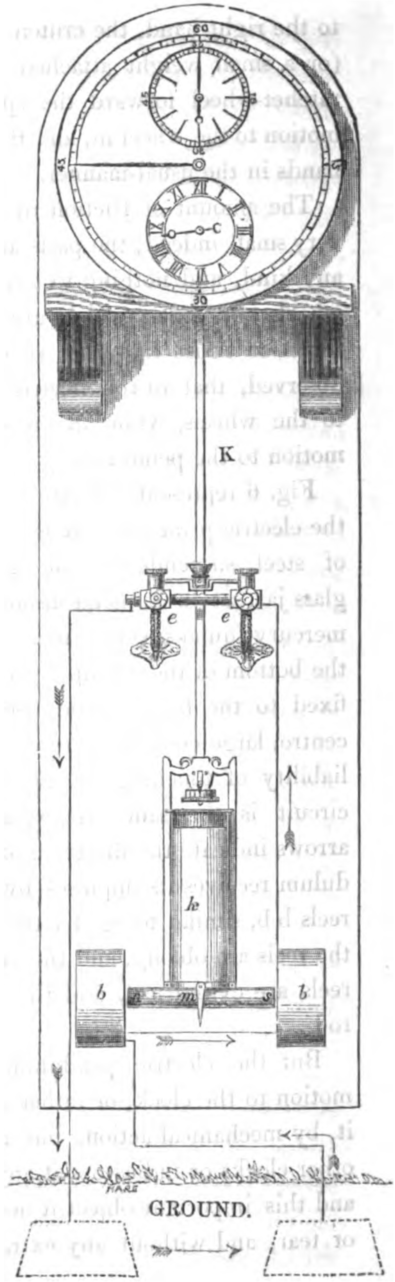


Fig. 6.



to the right hand, the crutch follows by means of its own weight (or a small weight attached to it), and the click i pushes the ratchet-wheel forward the space of one tooth, the worm gives motion to the wheel m, and this gives motion to the dial-work and hands in the usual manner.

The amount of friction in this simple piece of mechanism is very small indeed; the parts are few; there is no force or strain of any kind, and nothing to cause wear but the mere weight of the wheels and axles, which are made extremely light, having no force to resist like the wheels of ordinary clocks. It will be observed, that in the electric system the pendulum gives motion to the wheels, while in the common clock the wheels transmit motion to the pendulum.

Fig. 6 represents an astronomical clock, made and worked on the electric principle. K is a compensation pendulum ; the rod is of steel, suspended in the usual way to a firm bracket. k is a glass jar, set in a metal frame or stirrup, and nearly filled with mercury (quicksilver). m is a permanent steel magnet, fixed to the bottom of the stirrup. b b are reels of insulated copper wire, fixed to the back of the case; the reels having apertures in the centre, large enough to receive the poles of the magnet, without liability of touching the sides. The break e e and the electric circuit is the same as explained in the former diagrams ; the arrows indicate the direction of the electric current, and the pendulum receives its impulses by means of the magnet m, from the reels b b, similar to fig. 4 ; the only difference being, that in fig. 4 the reels are oblong, and the magnets are flat; in this instance, the reels are cylindrical, and the magnet is in the form of a round rod.

But the electric pendulum does more. It not only gives motion to the clock, or rather indicator, which is in the case with it, by mechanical action, but it lets on currents of electricity to other clocks or indicators at any distance, as previously explained; and this important object it accomplishes without any extra wear or tear, and without any extra friction; for it will be perceived in the previous explanation of the break, that when the point g of the bar is off the gold plug which is in connexion with the pendulum, it is moved on to the gold grooved plate which is connected with the distant clocks, thus letting on the current to the pendulum, and clocks at a distance, alternately. By this arrangement there is a great economising of electric power, as when the current is cut off from the clocks, it is working the pendulum; when cut off from the pendulum it is working the clocks; and thus there is no moment when the electric current is not in practical operation.

Fig. 7 represents the mechanism of one of the affiliated or companion clocks. a a is a brass plate to which the dial and all parts of the mechanism are fixed ; c c are reels filled with insulated copper wire; d is a semicircular permanent steel magnet, a similar one being on the other side. These magnets are fixed to an axle by means of arms, poles of the same name being opposite each other, viz., N to N, and S to S, and the poles vibrate freely in the interior of the coils. These coils are joined to, and form part of, the electric circuit with the parent clock; and by the transmission of electric currents from thence, the magnets d vibrate in unison with the pendulum.

Having thus obtained uniform motion between the pendulum of the parent clock and the magnets of the affiliated ones, it re-remains to be shown how motion is given to the hands of the latter. f is a small frame, fixed on the same axle as the magnets. This frame carries the little click g, which acts in the teeth of the ratchet-wheel h; this wheel is carried by the spindle i, on which is a screw or worm working in the teeth of the wheel n, more clearly shown in Fig. 8; the axle of this wheel projects through the plate a a, and gives motion to the hands in the ordinary way. l is a straight steel spring to keep the ratchet-wheel from going back with the click. k is a bearing for one end of the axle of the wheel n; the other bearing is in the plate a a. b represents the back of the dial-plate. These clocks can be put into any form of case, which may be plain or ornamented, according to the

Fig. 7.

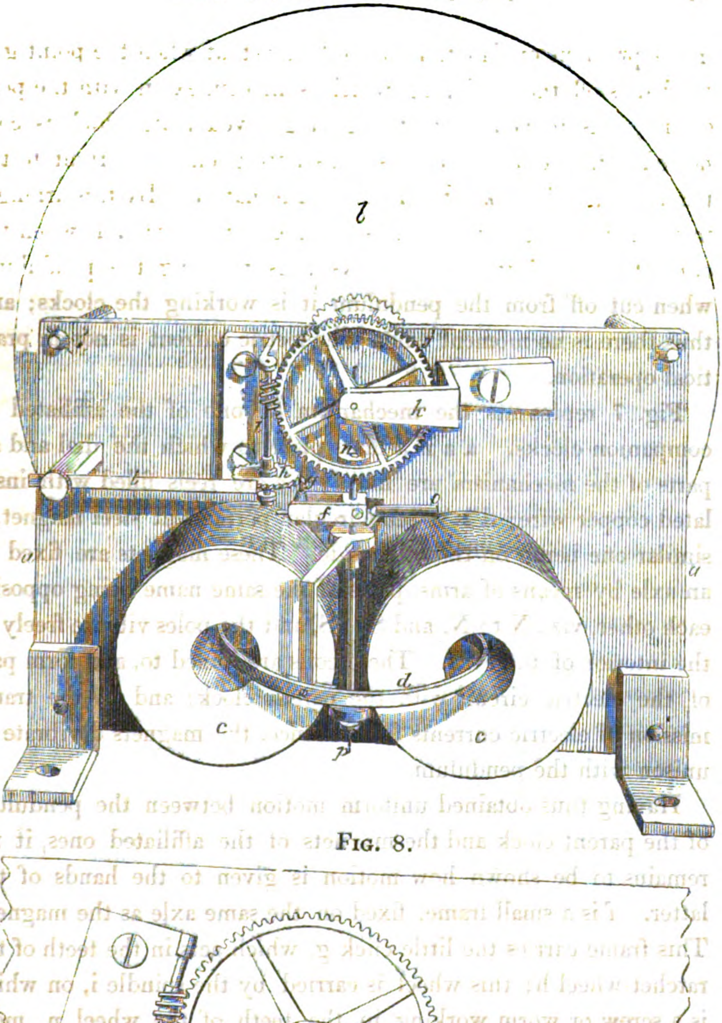
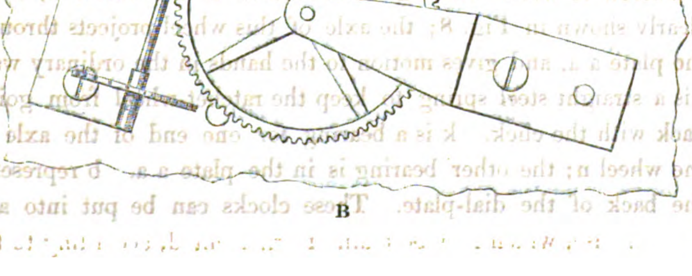


Fig. 8.



wishes of the purchaser; and they may be made of any size, from three inches to three feet and upwards; they are not liable to be stopped by being slightly moved, in order to dust the mantelpiece or sideboard on which they stand, and are suitable for any position, as they can be fixed to brackets on the wall, or suspended like pictures, by gilt wire cords, which answer at the same time as conducting wires.

Having thus explained the electric pendulum, and the methods by which it actuates the clocks, both in the vicinity and at distant places, I would now point out some of the difficulties which appeared when the invention was first brought into use, and show how they have been surmounted. The first desideratum was a constant galvanic battery. Daniel's was the best, but it had to be frequently attended to, and a current of considerable energy was required to produce magnetism in soft iron so as to work a pendulum or its companion clock, and the current being strong, corroded the parts of the break in contact, which had the effect of interrupting the electric current.

I then had recourse to permanent magnets and coils, and after many trials succeeded, by means of a new modification of them, in actuating the pendulums and clocks with a very small amount of electricity. Not only did the battery last many months in sufficient action, but the current had not such an injurious effect on the break, so that it was far less interrupted than before. I then discovered that ample uniform currents could be obtained from the earth, thus doing away with the trouble of batteries altogether: and this plan I have continued to adopt in all situations where the earth is accessible.

Where clocks are wanted in chambers or the upper parts of buildings, or wherever there was difficulty in getting to the ground, I have constructed a voltaic battery, which can be set in a cupboard, or any convenient place, lasting several years without any attention, and easily replenished at the cost of a few shillings, when the clocks are cleaned. For mantelpiece and sideboard clocks, a neat plan is to place the voltaic plates in ornamental vases. Fig. 9 represents a drawing-room clock, with the vases containing the galvanic plates. Fig. 10 represents a clock suitable for the library, with its vases; and Fig. 11 one fitted for a dining-room. A single vase may be substituted for the two, and may be made the pedestal for the clock to stand upon.

The break is the most important, and at the same time the most delicate, action of the electric clocks. The least particle of dust, or oxide of the metals, coming between the points of contact, will either wholly or partially stop the electric current. I therefore made the points of contact either of gold or platinum, neither of which is oxidisible by the air, but I found gold to be the best; and this brought the invention very near perfection, indeed, so far as the working of the pendulum is concerned, absolutely so; but the companion clocks would still occasionally err. After going correctly to a second with the parent clock for many months, they would lose a second now and then, sometimes at longer, sometimes at shorter, intervals. To overcome this last remaining difficulty, and to keep the companion clocks absolutely correct with the parent clocks, I have had recourse to magneto-electric currents to work the companion clocks. The pendulum receives its movement as already explained, and produces electricity which works the other clocks without breaking contact at all. In this case the break has nothing to do with letting on or cutting off the currents of the companion clocks. This arrangement is represented by Fig. 12. No. 1, is the parent clock. The other ten represent the companion clocks, or indicators. In order to explain this arrangement, it will be necessary to go back to the principle of what is called magneto-electricity, or electricity produced in conductors moving in the vicinity of magnets. If a metal wire is moved in the vicinity of a magnet, and the two ends are brought together, so long as the wire is in motion in certain relative positions to the poles of the magnet, electric currents will circulate in the wire; but if the wire is at rest, the currents will cease. If we move the magnets while the wires are at rest, currents of electricity will

Fig. 9.

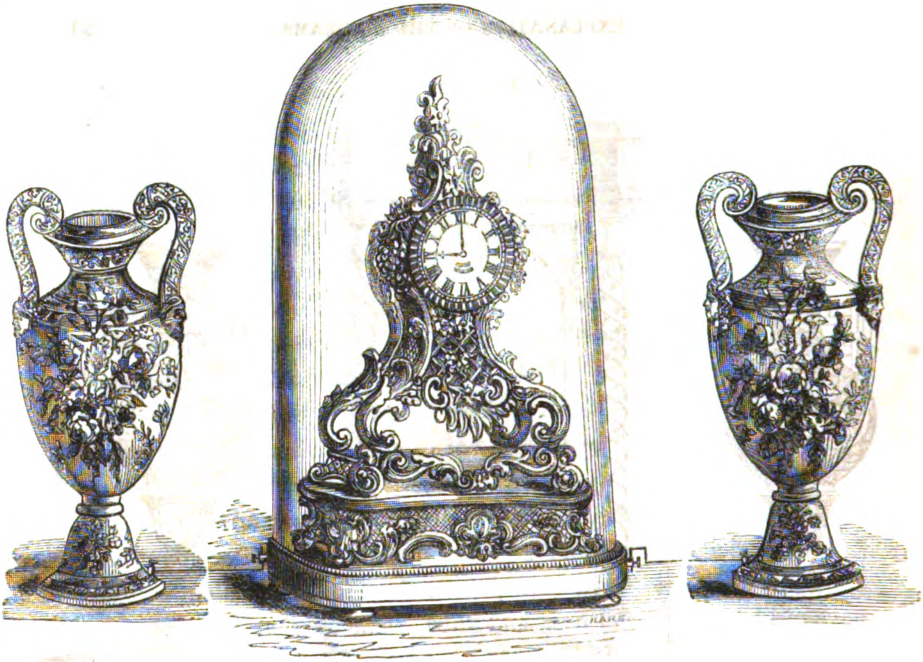


Fig. 10.

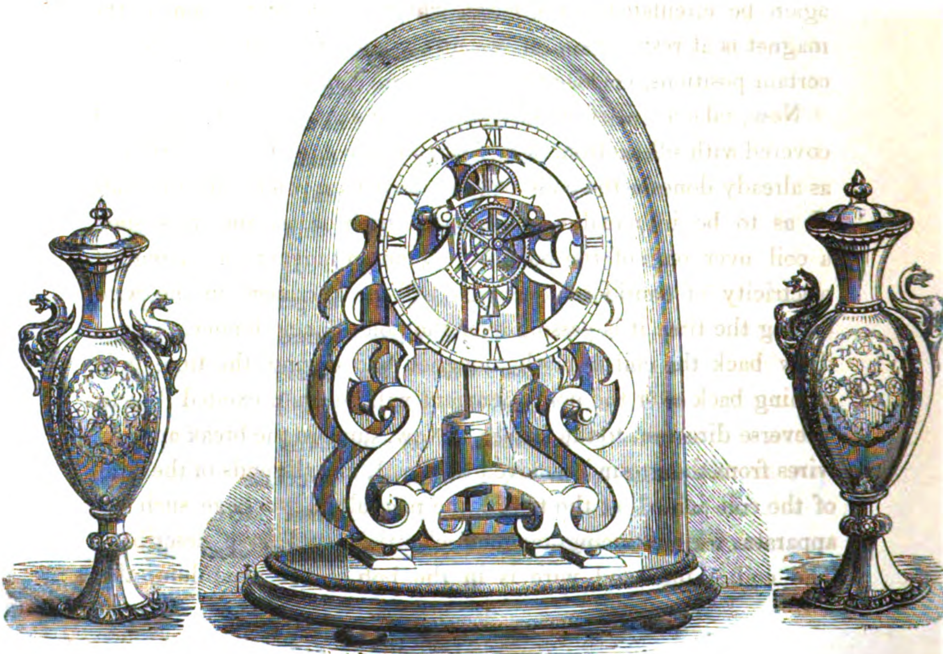
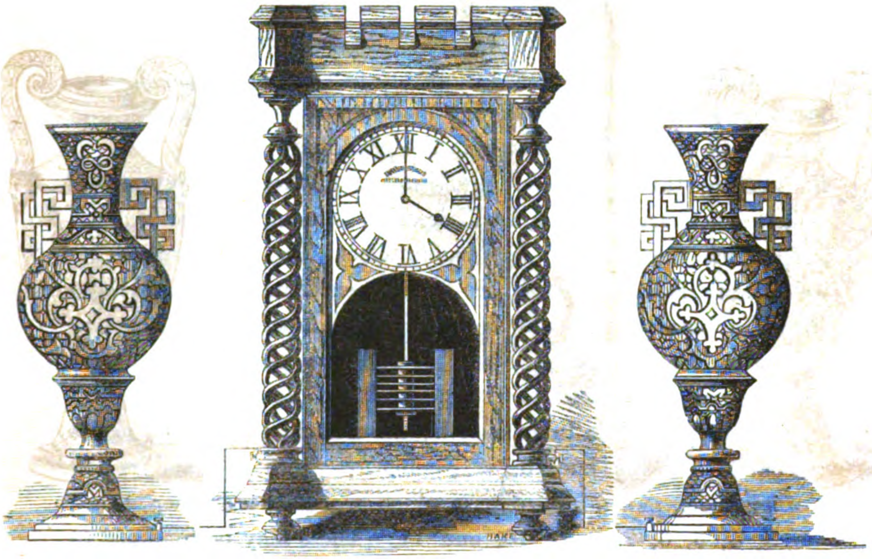


FIG. 11.



again be circulated in the wires, which will cease as soon as the magnet is at rest; again, if we move both magnet and wires in certain positions, electricity will be excited in the wires.

Now, take a coil of wire, composed of many convolutions, and covered with silk, cotton, or any other non-conductor of electricity, as already done in the coils before referred to; then join the ends so as to be in metallic contact with each other, and pass such a coil over one of the poles of a common magnet; a current of electricity of considerable energy will be produced in the wire during the time it is passing over the pole, but no longer. Now, draw back the coil from the magnet, and during the time it is coming back over the pole, a current will be again excited, but in a reverse direction to the former. Now, suppose the break and the wires from the ground removed of Fig. 1, and the ends of the wire of the coil joined at the top of the pendulum, we have such an apparatus for producing magneto-electricity as I have described. The coil of insulated wire is in the bob of the pendulum, the magnets in the brass tubes fixed to the sides of the case; now, separate the wires at the top of the pendulum, and attach others extending to any distance, and connect the distant ends to an indicator or companion clock. If the pendulum be moved with the hand, it will be found that the magnet in the distant indicator will vibrate in unison with the pendulum.

Having thus explained the simplest methods of producing magneto-electric currents, I will describe their application. Fig. 12 represents the action. The parent clock, No. 1, is worked by electricity from the earth, as already explained, or it may be from a battery. It will be observed that this clock has two bobs to the pendulum, a and b, and two pair of tubes containing magnets fixed to the sides of the case; the upper bob keeps the pendulum in motion by the electric currents from the ground, and the bob, b, in passing over the poles of its pair of magnets, generates currents which work all the other clocks, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11. These may be supposed to be in various rooms of a house, or distributed in different parts of a town. This is a perfect method of working companion clocks, as the circuit through which they receive their motion is never broken. It will be evident by the above explanation, that if we cause the electric pendulum to be moved by the mechanism of an ordinary clock, *i.e.*, the action of a falling weight, or the unbending of a spring, transmitted to the pendulum through a train of wheels, &c., we obtain by this common clock machinery applied to an electric pendulum, magneto-electric currents, without the aid of other currents. Such an arrangement is represented in fig. 13. No. 1 is the parent clock, worked by a weight, and the pendulum receiving its motion in the ordinary way. Nos. 2, 3, 4, 5, 6, and 7, are companion clocks, which are all connected by an insulated wire with the wire of the pendulum-coil; 2 and 3 are supposed to be suited for bedrooms; 4 and 5 for drawing and dining rooms; 6 and 7 for library and kitchen.

Another very important advantage remains to be shown, in connexion with the parent and companion clocks, which has been sufficiently tested by experience to prove its practicability; and if the proposed plan be carried out to make a uniform time throughout the kingdom, this power applied to work very distant clocks by means of one parent clock, will, I have no doubt, be brought into very extensive operation. The correctness of this principle was tested in 1846. Having erected, in that year, a telegraph between Edinburgh and Glasgow, I placed an electric pendulum, with its clock, in the Telegraph Station at Edinburgh, and a companion clock at Glasgow. The parent and affiliated clock being connected by the telegraph-wire and the ground, they went accurately together, the magnet of the companion clock at Glasgow vibrating in unison with the pendulum which was in Edinburgh. The distance between Edinburgh and Glasgow is forty-six miles.

Fig. 14 shows the arrangement. A is the parent clock at Edinburgh. B the companion clock at Glasgow. P P P the posts which support the conducting wire. C the voltaic battery. D D^1 the plates in the ground.

In this case the electric power was not obtained from plates in the ground, but by the voltaic battery C, the same which was used in working the telegraph. The arrangement of the circuit was as follows: a wire proceeded from the positive pole of the battery C to the right hand bracket of the break; another wire from the left-hand bracket proceeded to the plate D in the ground. The long telegraph wire from Glasgow was connected with the negative pole of the battery C, and the other end of the long wire was connected with the companion clock at Glasgow; another wire from the companion clock proceeded to the ground, and was connected with the plate D^1; the plate D, at Edinburgh, and the plate D^1, at Glasgow, being buried in the moist soil at each station respectively. The earth formed one great link of the electric chain; the companion clock at Glasgow was so connected with the long telegraph wire, and with the end that led to the ground, that the current was forced to pass through, and permeate its coils. The action was as follows: The electric current was completed at every

FIG. 12.

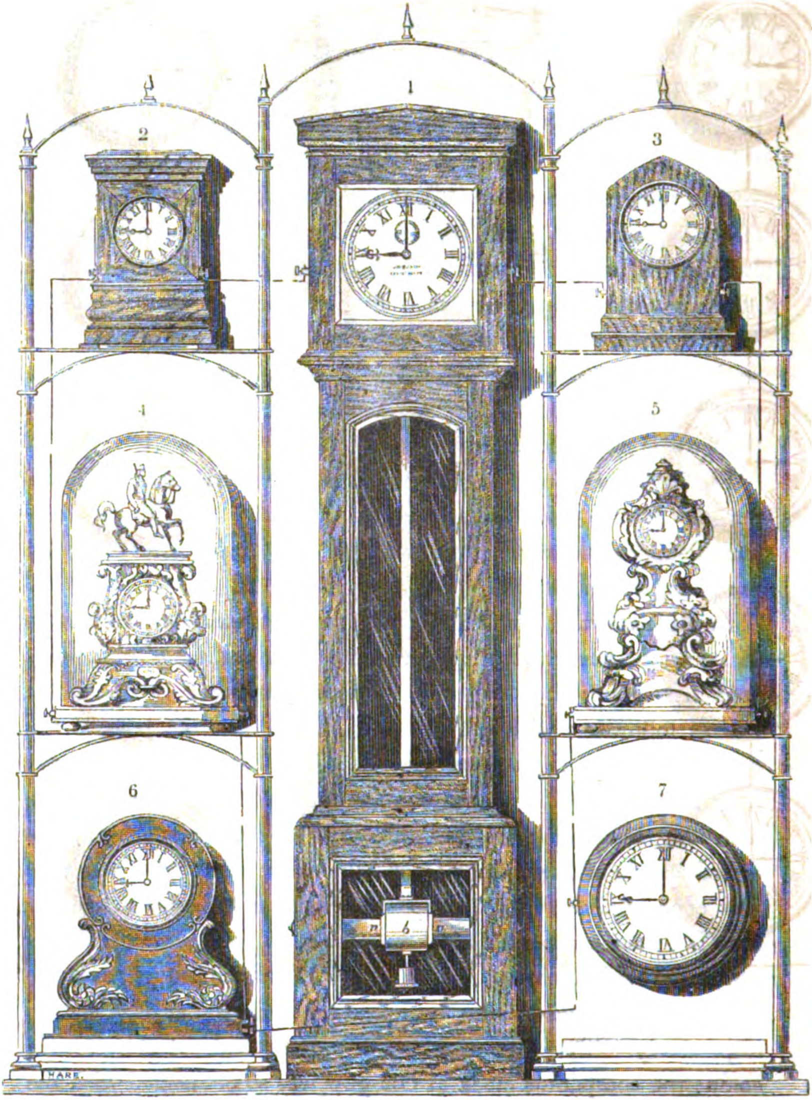


Fig. 13.

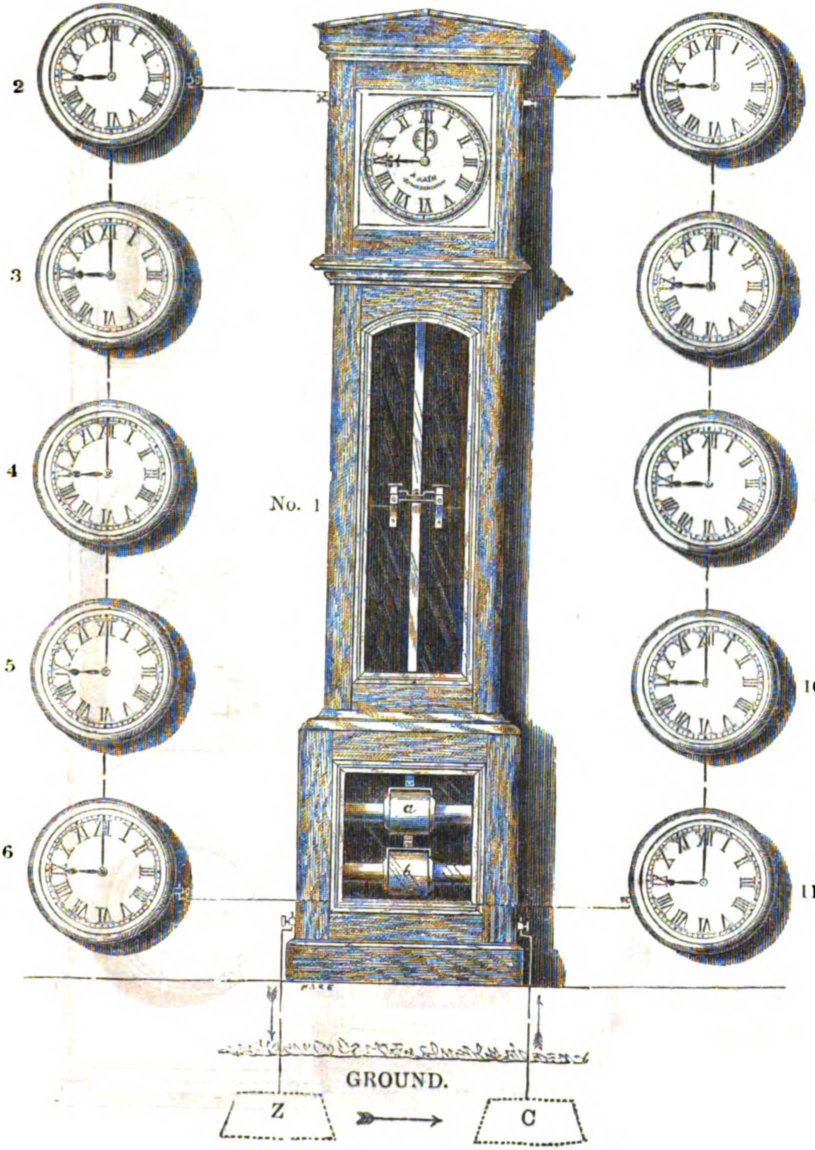
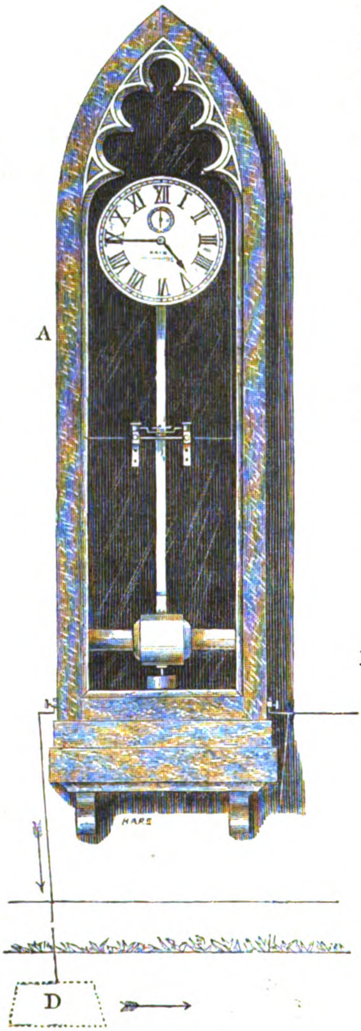
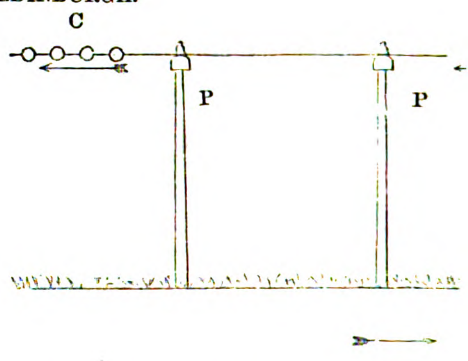


FIG. 14.



second vibration of the pendulum, by means of the break, as already explained in Fig. 1. The current passed from the battery C to the break, from thence by the wire to the ground, as indicated by the arrows to the plate D; from thence through the ground (an ample conductor), as shown by other arrows, to the plate D¹, at Glasgow; from thence through the wire, as indicated by another arrow, to the companion clock; and in passing through its coils of insulated wire, it actuated its magnet at each pulsation, and then returned by the long tele-

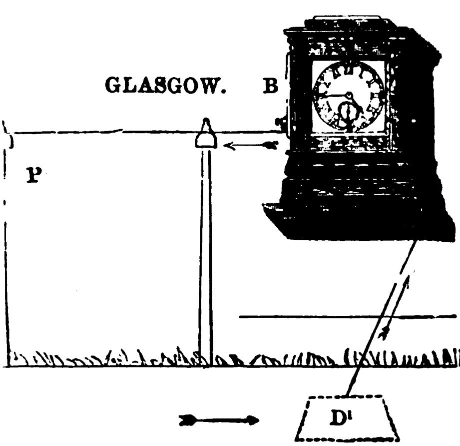
EDINBURGH.



graph-wire to the battery C, at Edinburgh, and the magnets in the companion clock were found to vibrate in unison with the pendulum; so that if there were similar companion clocks at each of the stations on the line, and the same currents made to pass through them, they would all move together, and show precisely the same time. The principle of the transmission of time to distant places being thus practically established, there is literally no limit to its adoption. With the same ease that a message is communicated from London to Paris, can two clocks be brought into simultaneous action, and uniform time in the capitals of England and France be easily ensured; not only so, but to whatever distance an electric telegraph extends its operations, by the same means can time be transmitted.

The following notice of the experiment is from the "Glasgow Mechanics' Magazine" of May, 1846, it having been at the same time noticed by several periodicals:

" Since the successful introduction of Bain's single-wire tele-
" graph, the ingenious inventor has directed his attention to the
" contrivance of a plan whereby a system of uniform time may be
" established throughout the country. This idea he has most
" successfully worked out by means of an electric communication
" between the places in which it is proposed to maintain that
" system. In order to ascertain by actual trial the value of this
" scheme, Mr. Bain placed the
" pendulum of one of his Electric
" Clocks at the Edinburgh sta-
" tion of the Edinburgh and
" Glasgow railway; and the
" works of a common timepiece
" at the Glasgow terminus were
" set in motion simultaneously
" with it, by means of the elec-
" tric wire connecting the two
" stations; the beat of the pen-
" dulum being also exhibited on
" a dial beside it, showing the
" movement as it was simultaneously made at the Glasgow sta-
" tion.



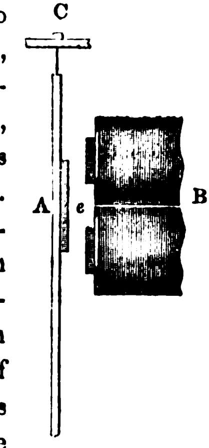
" We look upon this invention as being one of the greatest im-
" portance, as by its introduction the great evil of variation of
" time, in distant situations, will be entirely avoided; for, by

"establishing a chain of electrical communication from the "Land's End to John O'Groat's, the exact solar time may "be given with the greatest possible degree of precision in "both."

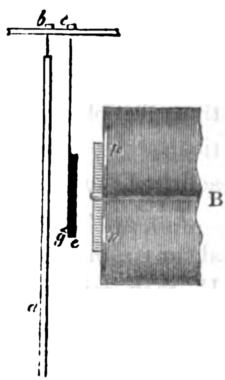
One more advantage which the Electric Clock has over those of an ordinary character may be mentioned. In the mansions of the nobility and gentry, and in many other large establishments, it is customary to employ some clockmaker to attend weekly at the house, both to wind up the clocks and to correct irregularities. The expense of this is considerable, and the inconvenience is very great. The annoyance of this periodical visit of a stranger into rooms of the most costly description, or the most retired boudoir, where a clock may be placed, it is not easy to overstate. The affiliated clocks, attached by an almost invisible communication with the parent clock, render this inspection wholly unnecessary; and where there are a number of clocks in one house, this convenience, though not the greatest insured by the Electric Clocks, is of no inconsiderable value.

In the foregoing pages, I have confined my remarks and explanations to the more practical and extensively useful machines, not wishing to trouble my readers with the numerous modifications of the invention which I have contrived, patented, and partially adopted. Some of these may be useful in particular instances, but they cannot come into extensive operation, in consequence of the great amount of electric power required, which is very much more than the plans I have now adopted. These remarks refer particularly to the pendulums, and companion clocks, which are actuated, by what is technically termed, electro-magnets.

Explanation of the Electro-Magnet.—Take a rod of soft iron, say about six inches in length, and bend it into the form of the letter U, then coil round the prongs, many convolutions of insulated wire. When an electric current of considerable energy is made to permeate the wire, the iron will become magnetic; when the current is cut off, the iron, if perfectly soft and free of carbon, will lose its magnetic influence. If we now place a piece of soft iron in front of, and at a little distance from, the poles of the electro-magnet, when the current is passing, it will be attracted by the magnet, and when the current is broken it will cease to be so attracted, provided it has not been allowed to come in contact with the poles. It is obvious that, in this way, we have a power to actuate a pendulum or companion clock, or any number of them, provided we have electricity sufficient. It was the first plan adopted and patented by me in 1841. The subjoined diagram will illustrate the principle. A is a portion of the pendulum-rod, which is suspended at C (the lower part of the pendulum not being shown); e is a piece of soft iron fixed to the rod at A; B represents the poles of a common electro-magnet, which in practice is fixed to the side of the clock-case. When the current is let on by the break, the magnet B attracts the soft iron e, and of course draws the pendulum towards the right hand; but before the soft iron has come close to the magnet, the pendulum-rod has come into action with the break, and cut off the current; the pendulum is then free to return by its own momentum, as previously explained, and so the motion is kept up.



The annexed diagram shows an improvement on this plan. (It was put in action and exhibited by me at the Polytechnic Institution in 1842.) a is the top part of the pendulum-rod suspended at b; c e is a steel spring suspended pendulum fashion, at c. Affixed to the lower end is a piece of soft iron, similar to that attached to the rod in the previous figure. B represents the poles of an electro-magnet. When the pendulum swings to the left hand it lets on by means of the break an electric current to the



magnet, which immediately attracts the soft iron e (bending the spring) which is not permitted to come into actual contact with the poles, in consequence of a projecting stop; when the pendulum swings to the right, and within a given distance of the soft iron, the current is cut off, the soft iron is released, and, by the elasticity of the spring, brings the projection g into contact with the pendulum-rod, and pushes it towards the left.

By this arrangement (or modifications made since), very perfect time can be obtained, but there are two objections to it. First, the amount of electricity required to actuate the electro-magnet, and secondly the injurious effects of so large a quantity upon the connecting portions of the break, for if the smallest corrosion takes place the current will be occasionally interrupted, and the impulse given to the pendulum consequently failing, stoppage or irregularity of time will be the result. In this plan the pendulum does not receive its impulse direct from the magnet, but from the magnet through the medium of the spring. The advantage of this being, that the power of the spring remains always the same, while the power of the magnet varies with the strength of the electric current.

I hope that the foregoing diagrams, and the explanation given of them, will be sufficiently clear to enable non-professional persons to understand the principle and mechanism of the electric clocks. Many years' experience in this branch of science justifies me in affirming that their superiority over clocks of the ordinary construction has been neither misstated nor exaggerated. Simplicity of mechanism, regularity of time, the diminution, and it may indeed be said, the abolition of the usual attention, are the prominent advantages of the single electric clock; the extension of these advantages, by means of the companion clocks, will ensure perfect regularity of time in the various departments of the most extensive establishment, while it deserves to be remembered, that all this economy of trouble and additional convenience is accom-