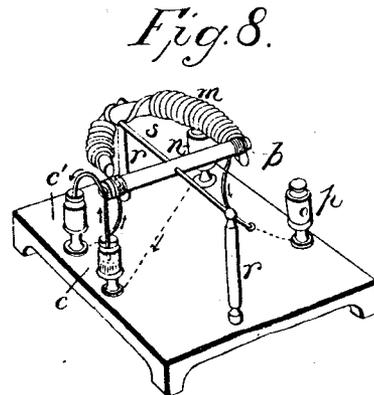
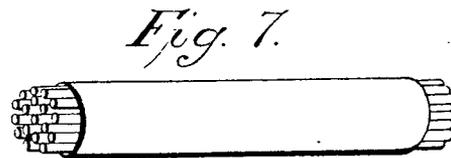
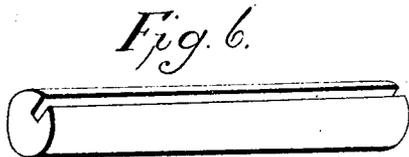
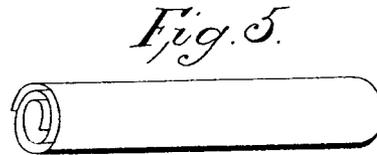
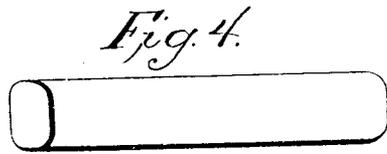
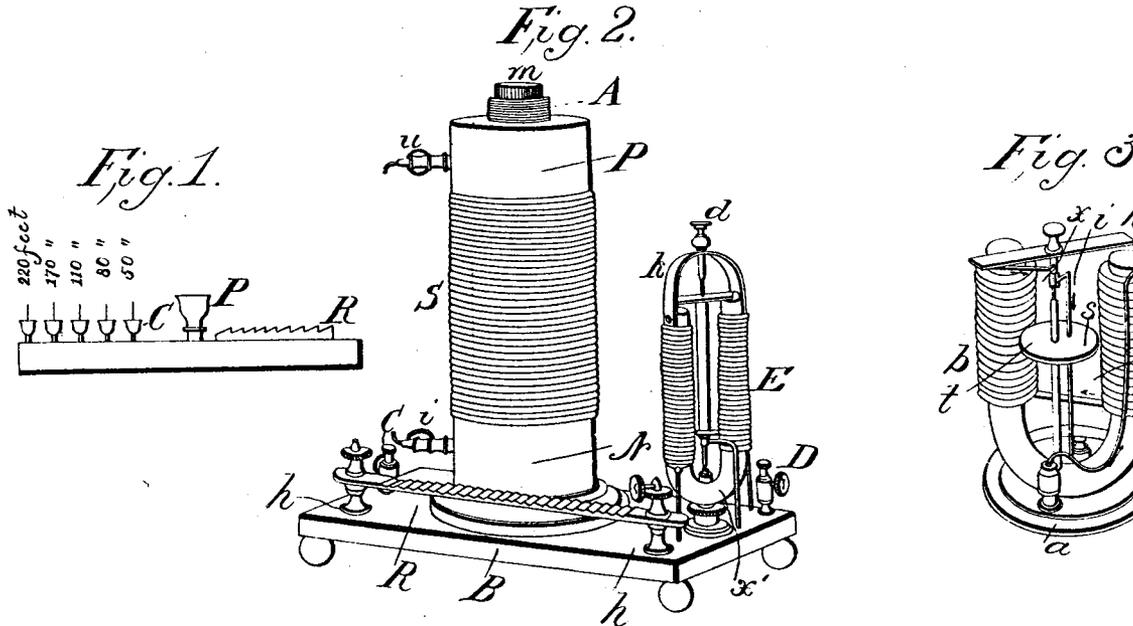


C. G. PAGE.

Induction Coil Apparatus and Circuit Breaker.

No. 76,654.

Patented Apr. 14, 1868.



Witnesses:
 Maxwell Bailey
 Charles G. Page jr.

Inven
 Charles G. Page
 by his atty.
 A. G.

C. G. PAGE.

Induction Coil Apparatus and Circuit Breaker.

No. 76,654.

Patented Apr. 14, 1868.

Fig. 10.

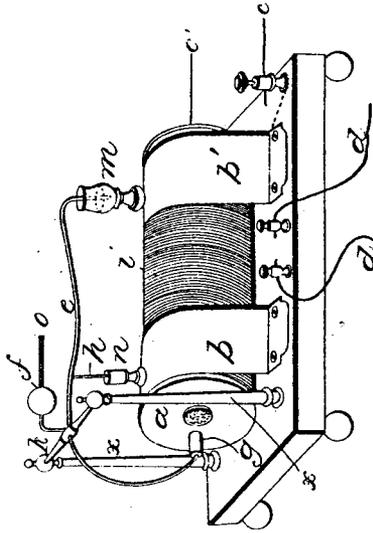


Fig. 12.

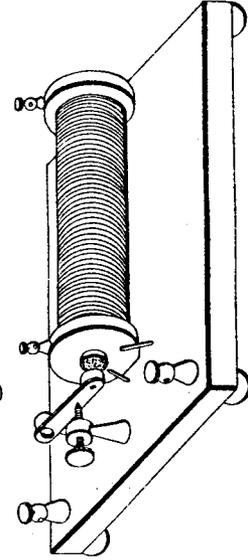


Fig. 9.

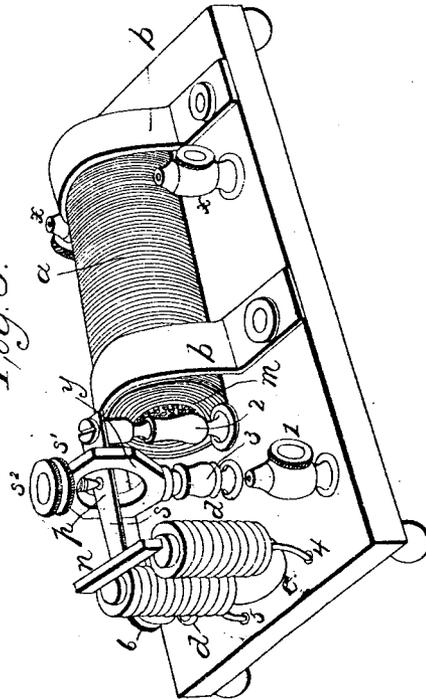
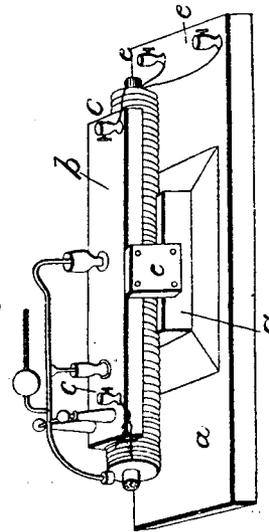


Fig. 11.



Witnesses:
 Maxwell Bailey,
 Chas. G. Page jr.

Inven
 Charles G. Page
 by his attorne,
 R. Follo

United States Patent Office.

CHARLES GRAFTON PAGE, OF WASHINGTON, DISTRICT OF COLUMBIA.

Letters Patent No. 70,654, dated April 14, 1868.

IMPROVEMENT IN INDUCTION-COIL APPARATUS AND IN CIRCUIT-BREAKERS.

The Schedule referred to in these Letters Patent and making part of the same.

TO WHOM IT MAY CONCERN:

Be it known that I, CHARLES GRAFTON PAGE, of Washington, in the District of Columbia, have invented certain new and useful Improvements in Induction-Coil Apparatus and Circuit-Breakers; and I hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings.

The induction-coil consists of a metallic conductor, (copper is generally preferred,) in the form of wire, round or otherwise, or a flat strip of metal, coiled up in the form of a helix-reel, or bobbin, as it is sometimes called, or in the form of a flat spiral, the helix or bobbin or spiral usually having a central or core-opening in its axis to admit of the introduction of a bar of iron, or bundle of iron wires, or other form of iron. The wire or strip of metal is covered with cotton, silk, or some insulating-substance, or some insulating-material is introduced between each turn of the wire, or sometimes the wires are merely spaced, that is, each turn separated by a small interval, and an insulating-substance placed between each layer. This wire or strip may be of the same size throughout its length; or, in the case of wires, two wires may be used, one of greater diameter than the other, and of much less length; or, in the case of strips, one strip may be thinner and longer than the other. When the wire or strip is continuous throughout, and its entire length is included in a galvanic circuit, it is called a simple primary coil or circuit. When the galvanic current passes through such primary coil or circuit, a momentary current of induction is set up in the wire or strip, contrary to the direction of the galvanic current, and causes resistance to it. This current is called the initial secondary current. When the galvanic current is arrested in the wire or strip, another momentary current of induction is set up in the wire, having the same direction as the galvanic current. If the battery-current be strong, and the wire or strip of considerable length, when both ends of the wire are grasped, one in each hand, an electric shock is felt at the moment the galvanic current is arrested in the wire, and the strength of the shock bears some proportion to the strength of the galvanic current, and the length, size, and insulation of the wire. This current is called the terminal secondary, but generally the "extra current," and the shock is an electrostatic effect, indicating a current of higher intensity than that of the battery which produced it.

These shocks are administered to the human system for the cure of many diseases, and as it is important that they should be produced in rapid succession, and without mechanical aid from the operator, I have combined with said coil an instrument or machine, hereinafter described, for arresting the galvanic current with rapidity, and without assistance from the operator, which machine I call "the automatic circuit-breaker;" and to this end I have invented a variety of forms of such circuit-breakers, which will be found useful for such purpose, some of which will be hereinafter described. I have also sometimes found it expedient to combine with such coil an automatic and a mechanical circuit-breaker both, using for such mechanical circuit-breaker a spur or rag or sprocket-wheel, revolving against a conducting spring pressing on the points of the spurs, or a bar or strip of metal, with a coarse or rasp-like surface, over which a wire is drawn by hand. The spring, pressing upon the periphery of the wheels or their teeth, and the wheels themselves making part of the same circuit with the coil, the circuit is broken each time the spring passes from one tooth to another, and so with the wire and rasp, which it is not necessary to describe further. The introduction of iron into the core of said coil or spiral increases the intensity of the shocks. It was found, however, that a simple primary coil, on account of its great length, required too much battery-power to produce strong shocks, and I have therefore contrived a two-circuit machine, in which there is a primary and a secondary circuit, the primary circuit, which is comparatively a short circuit, and is to transmit the battery-current, and a secondary circuit, of many times the length of said primary circuit, and is to furnish the shocks and electrostatic effects.

By this arrangement a small battery of low intensity may be made to produce shocks of great power and high intensity from said secondary circuit. If the wire or strip of metal is continuous throughout, then, by having a metallic connection made with only a small portion of the coil, so that the galvanic current may be sent through that portion which is called the primary circuit, the shock may be taken from the extreme ends

of the whole coil, or from the secondary circuit or portion thereof, which is longer than that of the primary circuit, or portion conveying the battery-current. The shock is stronger by including the whole coil between the hands, because we have the combined effects of the two circuits. This result is the same, whether the wire be of the same size throughout, or whether we use a large wire for the primary circuit and a small wire for the secondary circuit. For the purpose of graduating the shocks, a number of metallic connections may be made at different points in the length of the whole circuit, and thus any desired length of circuit may be included between the connections to be grasped by the hands, and any desired strength of shock given. And thus, also, the portion included in the battery or primary circuit may be varied at pleasure. This construction is shown in Figure 1. It is, however, generally preferred to have but two circuits, viz, a primary and secondary circuit.

The figure represents a vertical section through the middle of a flat spiral of copper ribbon, coiled in the manner of a watch-spring, with varnished silk, cotton, or paper between each turn of the spiral. It is enclosed in a box, and has a metallic stem connected with the central end of the ribbon, rising through the cover of the box, and supporting a large cup, P, designed to hold mercury. This cup is best made of glass, so as to exhibit the induction-sparks to advantage, which are produced each time the battery-circuit is broken at the surface of the mercury.

The spiral has several smaller cups, c, attached to metallic stems connected with various parts of the spiral at different distances from its centre. By placing one pole of the battery in connection with the central cup P, and the other pole in connection with the other cups c, successively, the shocks and other electrostatic effects will be found to increase, the farther from the centre of the coil the connection is formed, whenever said connection is broken. The battery-current may be passed through the part included between c and P, and the shocks and electrostatic effects derived from the whole coil, or any portion thereof, including the part conveying the battery-circuit or not.

When the portion of the coil is outside of or extraneous to the battery-circuit, as the part between the cup c, next the central cup, and the cup connected with the outer extremity of the spiral, or any portion included between such middle and outer cup, then this portion is called the pure secondary circuit, whether it be independent or metallically connected with the primary circuit. It will be found more economical of space, and more advantageous in regard to the power and intensity of the secondary circuit, to make it of much thinner metallic ribbon than the primary circuit.

R represents a rasp circuit-breaker, consisting of a coarse rasp of metal, to be connected with the central cup, and then the circuit may be broken with rapidity by drawing the pole of the battery over this rasp, which also makes part of the main circuit. The mechanical circuit-breakers, such as the spur-wheels, are used with efficiency with the primary in this case. The mechanical circuit-breakers are so well understood, and now so generally in disuse, that it is not necessary to describe them more particularly. The representation of the rasp R is the type of them all. Thus this instrument has within itself the means of graduating the power of the shocks without changing the force of the battery-current. It is, however, generally preferred for simplicity to have but two circuits, viz, a primary and one secondary circuit, regulating the shocks by other means, and to make the primary of coarse wire, usually of copper, choosing such size as may be suited to the intended size of the coil, using from No. 20 wire up to No. 10, or even larger, the larger sizes being used for large coils.

The wire is insulated, as before mentioned, and usually wound in a coil or helix, on two, three, or four superposed layers, leaving a core-space in the axis, as before described. This is shown in Figure 2, where A represents the coil fixed to a stand. This coil has three or four layers of wire, and the opposite ends of the wires pass down through the base-board B, and are connected respectively underneath the board to the binding-screw cups, C D.

The enclosed electro-magnet, m, is seen projecting above the coil, and is composed of a bundle of soft-iron wires, separated from the primary coil by a layer of some insulating-material, such as varnished cotton, or silk, or oiled silk, or any known insulator that is applicable. If the wires are clean and bright, it is best to varnish them. Exterior to the primary is the secondary coil, S. This coil is made of fine wire, from a thirtieth to a hundredth of an inch in diameter, and of great length as compared with the primary coil. At first they were made of one to three thousand feet, but at the present day secondary coils are made sometimes of the immense length of fifty to eighty miles and upwards. It is important to insulate very carefully the individual spires or turns of the secondary wires by varnishing with solution of shellac, and also to separate each layer from the next by a thick coating of shellac or layers of oiled silk, or varnished paper, cotton, or other suitable insulating-material.

This careful insulation is of importance in proportion to the size and power of the coil. For small coils it may be neglected to a great extent, and a very energetic coil may be made when of small size, say three inches in length, by using silk-covered wire without varnish, using only oiled silk or varnished paper between each layer, or even a good coating of shellac varnish between each layer, in which case cotton-covered wire may be used. The wire may be of iron or copper, the latter being preferable in most cases.

The secondary coil in fig. 2 is provided with caps, P N, made of metal or wood; the latter, or some insulating-substance, being preferable, and the extremities of the wire of the coil are connected with the binding-screw cups u i, inserted in or attached to these caps. The secondary coil is also well insulated from the primary coil by intervening layers of insulating-material.

The rasp circuit-breaker R consists of a bar of brass, iron, or other metal, having a coarsely-serrated surface, and suspended upon the short pillars h h. Mounted on one end of the stand is an automatic circuit-breaker. It consists of a small electro-magnet, E, for the coil of which only a few feet of insulated wire are required, and the extremities of this wire pass down through the base-board, as shown in the drawing, and are connected underneath with the circuit-wires. The armature a of the magnet is attached to a revolving shaft,

e, which has its lower bearing on the bend of the magnet, and its upper bearing in the adjustable pivot-screw *d*, supported in the frame or yoke *k*, connected with the poles of the magnet. Two light spring-wires, *x* *x'*, bear upon the shaft *e*. The upper one, *x*, bears upon a cylindrical part of the shaft, and *x'* upon what is called the cut-off, consisting of two projections of metal from opposite sides of the shaft. The operation of this cut-off and circuit-breaker is best understood by reference to a detached view of the instrument in Figure 3, where the cut-off is a cylindrical piece or ferrule of metal, slipped over the shaft, the upper portion of it being entire, for the bearing of the upper spring, *x*, and the lower portion being dissected, having two metallic portions projecting on opposite sides, and the intervening portions filled up with wood, ivory, or some non-conducting material. One extremity of the wire coil is shown in connection with binding-screw cup *a*, and the lower end of spring *i* is in connection with screw-cup *e*. The spindle or shaft of the armature *h* revolves within a tubular socket or bearing, *t*, supported upon the wooden or ivory disk *b*, supported between the branches of the electro-magnet. Spring *i* passes through and is also supported by this disk or brace.

If, now, we suppose that one pole of a galvanic battery is connected with cup *a*, and the other pole with cup *e*, and the spring *i* resting upon the metallic division of the cut-off, the galvanic circuit will be complete throughout. The current, as indicated by the arrows, will pass up the wire-connection *a* of the coil or branch *c*, and, circulating downward through this coil, will pass across to the coil or branch *b*, through connecting-wire *d*, and circulating upward through this coil, will pass out through the wire spring *x*, which terminates the upper end of this coil; into the whole portion of the cut-off on the shaft of the armature, thence through the projecting or sectional portion into spring *i*, thence downward to cup *e*, and so back to the battery. The effect of this passage of the current will be to charge the electro-magnet, which will attract the armature, so as to bring its ends directly over the poles of the magnet. Just before it reaches this position, the spring *i* has passed out of metallic connection with the cut-off, by leaving the metallic projection, and the galvanic current being thus interrupted, the magnetism ceases, and allows the armature to swing round by its momentum a little more than a half circle, and the opposite projection coming against the spring *i*, again establishes the circuit. The movement of the armature is repeated, and each time with renewed impulse, until it gets into very rapid motion, thus breaking and renewing the circuit automatically. Now, if the circuit of this instrument is made part of the circuit of the primary coil, it is evident that its circuit will be broken rapidly, and at each break a shock will be felt upon touching the extremities of the secondary coil *S*. If the ends of the wires connected with the cups of coil *S* are brought near to each other, sparks will pass between them, at each rupture of the primary circuit; and a Leyden jar may be charged by them, one of the wires connected with the knob of the jar being insulated from the hand, and shocks may be received from the Leyden jar. Other electrostatic phenomena may be exhibited by the induced current from the secondary coil; and sparks and other indications obtained, even from one end of its wire, if it be insulated.

In order to operate the rasp or mechanical circuit-breaker, it must be connected with one end of the circuit of the primary coil, and a wire, connected with the other end of the circuit held in the hand, is drawn over its teeth, each tooth operating as a circuit-breaker, and shocks and other indications may be taken from the secondary circuit, as before. Instead of the straight rasp, a spur, rag, or cog, or sprocket-wheel may be used, and turned by hand or otherwise, and in this case the terminal wire which was held in the hand is fixed to the base-board, and so as to press upon the periphery of the spur-wheel.

It will be found, generally, that the harder the pressure upon the rasps or wheel with the wire, the stronger the indications from the secondary circuit, and that a certain degree of rapidity is necessary to insure the maximum effect. If the interruptions are too frequent, the shocks may be diminished, as the coil and magnet do not get time to receive a full charge from the battery between the interruptions. The maximum rate of interruption is to be determined in each case by experiment. As a general rule, the larger the instrument or coils, the slower must be the rate of interruption.

Instead of a bundle of iron wires placed in the axis of the coil, the magnet may consist of thin plates, as shown in Figure 4, and the plates may be made to adhere by varnish between them; or a piece of thin sheet iron, rolled up into a scroll, as shown in Figure 5, may be used, the surface of the iron being covered with varnish; or a bar of iron, divided by a longitudinal furrow or groove down to its axis, as shown in Figure 6, may be used. The bundle of wires is, however, the preferable form, as shown in Figure 7, the bundle, or *fasciculus*, as it is sometimes called, being bound or wrapped with some non-conducting material. This species of magnet I call the compound or divided electro-magnet. The bundle may sometimes be left movable in and out from the coil, as its movements or degree of insertion in the coil regulates the force of the shock and the development of the electrostatic properties of the secondary circuit. In the case of the remedial application of the instrument, this mode of regulation is very convenient.

The secondary coil may also be made movable longitudinally, or in the direction of its axis, and this movement will also regulate the force of the secondary current. If the secondary coil be made shorter in the direction of its axis than the primary, it will furnish more powerful currents when it occupies the middle portion of the primary than when towards either end, as set forth in Davis's Manual of Magnetism, published in Boston, edition of 1842, page 180.

Instead of a revolving armature for a circuit-breaker, a vibrating-armature may be substituted, and the latter will be found more convenient, for several reasons. One especially is, that it can be readily adjusted so as to increase or diminish the rate of interruption of the circuit, and the force to be overcome in working it.

A vibrating automatic circuit-breaker, consisting of a very small electro-magnetic bar, vibrating between the arms of a permanent magnet, the magnet changing its poles at each vibration, the length of vibration of the bar being regulated by a set-screw, makes a good circuit-breaker, and will be found fully described by me in Silliman's Journal, volume xxxii, page 355 to page 358, in a communication dated April 19, 1837. This species

is, however, not so simple as others, and further allusion to it is not necessary. A vibrating-armature is preferable, as it requires no change of poles to effect its motion, this being produced by merely intercepting the galvanic current at suitable intervals.

One form of vibrating-armature is shown at Figure 8. A small rod of soft iron, about the size of that shown in the figure, is mounted upon an axis or shaft, *s*, which is supported in suitable bearings upon two pillars, *r*, so as to vibrate freely. A small electro-magnet is supported upon one of these pillars, and the armature is placed between its branches, so that one end is above and the other below the plane of the magnet. One end of the armature bears a branching copper wire, its branches passing down into mercury-cups *c c'*. Cup *c* may be partly of glass, so that the play of the end of the branch wire in and out of the mercury in the cup may be seen, and the sparks produced on breaking the circuit rendered visible. When the magnet is charged, the armature is attracted towards its poles, and around the ends of the armature is a ferrule, of thin brass or non-magnetic metal, to prevent magnetic adhesion of the armature to the magnet.

The galvanic connections are under the base-board, and may be traced as follows: One pole of the battery being connected with cup *p*, and the other with cup *n*, the current will pass along from cup *p* to cup *c*, as indicated by the arrow, thence upwards through one branch of the wire, and downwards through the other branch into cup *c'*, thence upward again into one end of the wire, around the electro-magnet, and, circulating around the wire coil, will pass out through the other end to cup *n*, and so back to the battery. The passage of the current charges the magnet, lifts one end of the armature, raises the branch wire from the mercury in the cups *c c'*, and breaks the circuit. This end then falls by its weight, the branch wires overbalancing the other end, the circuit is again completed, and thus it may be broken with great rapidity.

An adjusting or set-screw may be placed on a suitable support over this end, after the manner of the last-named vibrating circuit-breaker, so as to regulate the extent of the vibrations. The weight of this end, or what may be denominated its retractile force, may also be regulated by a small movable weight placed on or over this half of the armature, after the manner shown in Figure 10. This circuit-breaker is introduced into the circuit of the primary coil in the same way as the revolving armature.

A more simple form of vibrating-armature is shown in Figure 9, in which the armature *n* vibrates to and from the electro-magnet *d d* in a direction parallel to itself. It is attached to a light brass spring *s*, fastened to pillar 2. This spring passes through an opening in the yoke *y*, on the top of pillar 3. At *p* is a tip or small disk, of platinum, soldered to the spring, which is in contact with the platinum point on the lower end of set-screw *s'*, passing down through the top of the yoke. Set-screw *s'* is accompanied with a tightening-nut, *s''*. This set-screw regulates the proximity of the armature to the magnet, and to some extent the tension of the spring and the rapidity of its vibrations. It will be seen, however, that the regulation or adjustment is imperfect, for as the spring is pressed down towards the magnet, the armature is brought nearer to the magnet, and as the attractive force increases more rapidly with the diminution of the distance between the armature and magnet than does the force of the spring increase, the adjustment is in a measure defective.

If we now suppose the magnet *d d* to be connected with the battery and charged, and that the circuit with the battery is made by the current passing up pillar 2, thence into spring *s*, thence into set-screw *s'* and pillar 3, and thence through the wires of the electro-magnet back to the battery, the magnet will draw down the armature, and with it spring *s*, and thus break the circuit by pulling the platinum disk away from the platinum point on the lower end of set-screw *s'*. On breaking the circuit, the magnet loses its power, and the spring rises and completes the circuit again, the magnet is again charged, and the armature drawn down, and breaks the circuit again, and thus a very rapid series of vibrations and interruptions of the circuit may be effected. It is evident, therefore, if the circuit of this breaker be included in or form a part of the main circuit, which passes through the primary coil, that at each break an induced current will be set up in the secondary coil, as with the other circuit-breakers.

The above circuit-breakers, it will be seen, are all independent or detached circuit-breakers, that is, they each require an extra electro-magnet with a circuit of its own, and this, of course, consumes a certain portion of the battery-power. To avoid this objection, I have invented an attached circuit-breaker, in which no independent or extra magnet or coil is used, with an adjustment to regulate its retractile force, and the distance also from the magnetic core of the helix—two important features, particularly the first named. This device is shown in Figure 10. The coils *f* are secured to a base-board, and enclose a bundle of soft-iron wires, seen projecting slightly at *a*.

Between the two pillars *x* is suspended the vibrating electrotome, or what is now called the hammer circuit-breaker. *g* is a small cylinder of soft iron attached to one end of the stout copper or brass wire *e*, which passes through or is otherwise secured to the vibrating-shaft *k*. The other end of this wire dips into a mercury-cup, *m*, fixed upon the metallic strap *b'*. This cup is of greater size than mercury-cups used for mere connections, and the upper portion of it is of glass, for purposes of observation of the spark and other indications. On the strap *b* is another mercury-cup, of brass, into which descends a branch wire, *h*, from the vibrating-wire *e*.

Arising from the shaft *k* is a stiff brass wire, in the form of a bent lever, carrying upon its horizontal portion *o* a ball, *f*, which is movable on a screw-thread from end to end of portion *o*. It will be seen that, as the ball is moved toward the extremity *o*, it increases the weight of the long arm of wire *e*.

If we suppose the coils and magnet to be charged by the current from the battery, and that the current passes from strap *b* to *b'*, through the wire *e* and mercury-cups, the magnet *a* will attract the hammer-piece *g*, and, in so doing, will lift the end of wire *e* out of the mercury in cup *m* and break the circuit; and *e*, falling by its own weight, its end will again dip into the mercury in *m*, re-establish the circuit, the magnet will again act, and thus a succession of vibrations and interruptions of the circuit will be produced. The manner of making the connections to establish such a circuit, through the primary wire, and through the wire *e*, will, of course, be

readily understood by any one skilled in the art. Thus it will be seen that no extra circuit or magnet is required for *trifs*, which is called the attached circuit-breaker, and the full economy of battery-power is realized.

As the weight *f* is further removed from the centre of vibration, the more magnetic power will be required to move the hammer *g*; its distance from magnet *a* remaining the same, the greater is its retractile force, and the more suddenly and completely will the circuit be broken in cup *m*. The distance between *g* and *a* can be varied by slightly bending the wire *e*.

As it takes time to give a maximum charge to magnet *a*, which is more appreciable in the larger coils, the hammer *g* should not move too quickly, and break the circuit before its maximum power is developed. Hence the great importance of regulating its retractile force, or the resistance to be overcome before it will be moved by the attractive force of the magnet, so as to obtain the maximum of electrostatic effects from the secondary coil. This circuit-breaker has also another very important feature.

In order to increase the intensity of the secondary circuit, and its electrostatic powers, a non-conducting liquid, such as pure water, alcohol, oil, turpentine, naphtha, (many others may be used,) is poured upon the surface of the mercury, and, when the circuit is broken under this liquid, the terminal secondary current of the primary coil is, in a great measure, stopped by the non-conducting liquid, and the consequence is a sudden arrest of its magnetizing influence upon the core or magnet *a*; and the more sudden and complete is the reaction in the magnet, the greater will be its effect upon the current in the secondary coil. For this reason, this is also called the spark-arresting circuit-breaker, for the separation-spark of the primary coil, which was very bright and voluminous without the liquid, is, to a great extent, arrested and neutralized by its presence.

As the secondary current becomes very intense with long coils, care in insulation is necessary, and to this end I have formerly mounted the coil on a stand of dry varnished wood, as shown in Figure 11, where *a* is the stand; *b*, a strip of baked wood, varnished, to which are attached the parts of the electrotome or circuit-breaker, and the cups *c c* for the terminations of the secondary circuit; the coil being secured to the stand by straps of wood instead of metal, as in fig. 10. The cups *e e* are for the primary-coil connections, and the general management and operation of the parts are the same as in fig. 10.

Instead of having the wire *c* to dip into mercury-cup *m*, its end may be tipped with platinum, and strike upon a platinum disk soldered to strap *b'*, fig. 10, or the arrangement may be like that of circuit-breaker, fig. 9, substituting the hammer-piece *g*, fig. 10, for the armature *n* on the end of spring *s*, fig. 9; and the end of wire magnet *a*, fig. 10, for the little electro-magnet *d d*, fig. 9. The only other change would be in the position of springs *s* and the pillars 2 3, so as to allow the hammer-piece *g* to vibrate horizontally to and from the end of the magnet. This is all shown in Figure 12, which, with the foregoing description, needs no further explanation or illustration, the drawing plainly showing the change of position of the parts.

The spark-arresting circuit-breakers may all be used as independent or detached circuit-breakers, and these, and likewise all the independent electro-magnetic instruments hitherto used and described by me for opening and closing circuits with other instruments, may be operated by batteries separate and independent from the batteries which operate the circuits to be opened and closed. In fact this often becomes necessary when the circuits of the two instruments are largely disproportioned in length. In using, for instance, the electro-magnetic circuit-breaker called Barlow's spur-wheel, described by me in volume xxxi, page 141, of Silliman's Journal, it becomes much more efficient when used with a separate battery.

Having described my invention, what I claim therein is—

1. An induction-coil apparatus, consisting of a primary and secondary circuit, when said secondary circuit is many times, that is to say, two, three, or more times the length of the primary circuit, having the connections so arranged that shocks, sparks, and electrostatic results may be obtained from the secondary circuit alone, or from the combined primary and secondary circuits, or from the primary alone, or from portions of either circuit, substantially as set forth.
2. I claim the combination of an automatic circuit-breaker with either a primary coil alone, or a primary and secondary coil combined, substantially as set forth.
3. I claim the combination of a mechanical circuit-breaker with a primary and secondary coil combined, substantially as set forth.
4. I claim the combination of both a mechanical and automatic circuit-breaker with a primary and secondary coil, combined substantially as set forth.
5. I claim the combination of a primary and secondary coil, enclosing an electro-magnet, with an automatic circuit-breaker, substantially as set forth.
6. I claim the combination of a primary and secondary coil, enclosing a compound or divided electro-magnet, with an adjustable automatic circuit-breaker, substantially as set forth.
7. I claim the combination of a primary and secondary coil, enclosing a compound electro-magnet, with an attached hammer circuit-breaker, substantially as set forth.
8. I claim the spark-arresting circuit-breaker, whether used with a primary coil alone or a primary and secondary combined, substantially as set forth.
9. I claim the spark-arresting circuit-breaker, whether used with a coil or coils, enclosing an electro-magnet, substantially as set forth.
10. I claim the spark-arresting circuit-breaker, whether attached to or independent of the primary or primary and secondary coils, substantially as set forth.
11. I claim the adjustment of the retractile force of an automatic circuit-breaker, substantially as set forth.
12. In combination with such adjustment, I claim adjusting the distance of the hammer or the armature from the pole or poles of the electro-magnet which actuates them, as set forth.

13. I claim adjusting or regulating the length of vibration of the circuit-breaking bar, by means of a set-screw, or any mechanical equivalent for substantially the same purpose, substantially as herein set forth.

14. I claim the employment of one electro-magnetic instrument to open and close the circuit of another electro-magnetic instrument, using either one battery for both, or separate batteries for each, substantially as set forth.

15. I claim the employment of separate and independent batteries to operate an electro-magnetic circuit-breaker, and the circuit which is broken by it, substantially as set forth.

In testimony whereof, I have signed my name to this specification before two subscribing witnesses.

CHARLES G. PAGE.

Witnesses:

MARCELLUS BAILEY,
CHAS. G. PAGE, Jr.