No. 623,316. Patented Apr. 18, 1899.

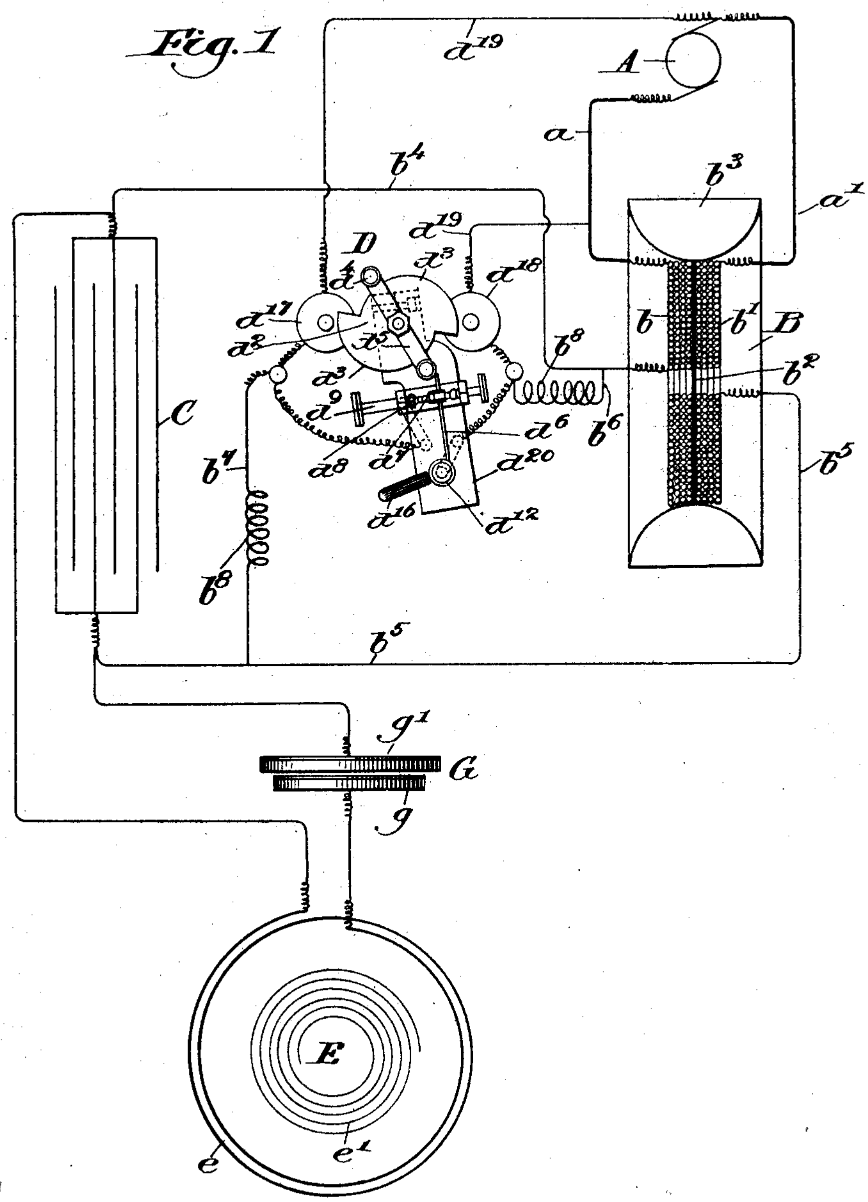
T. B. KINRAIDE.

INDUCTION APPARATUS.

(Application filed May 5, 1898.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1



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(No Model.) 3 Sheets—Sheet 2.

Fig. 2.

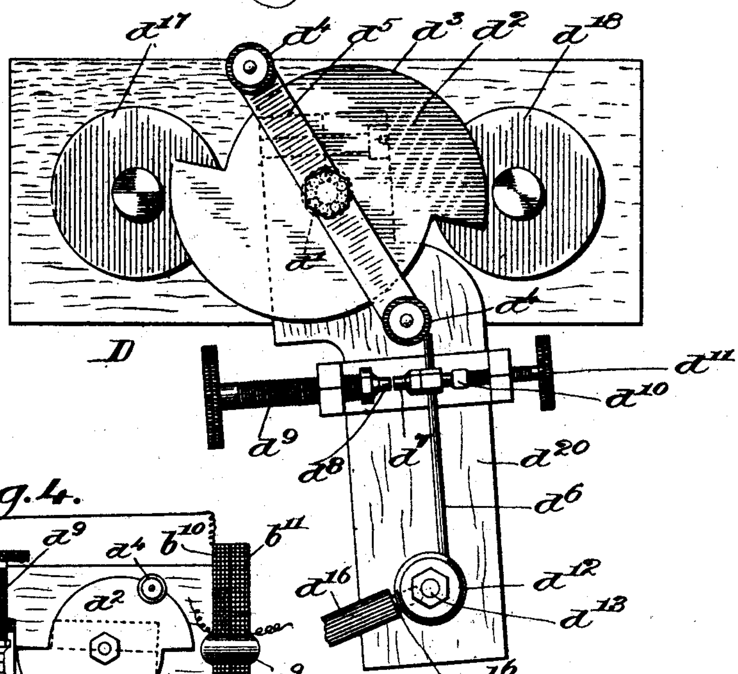

Fig. 4.

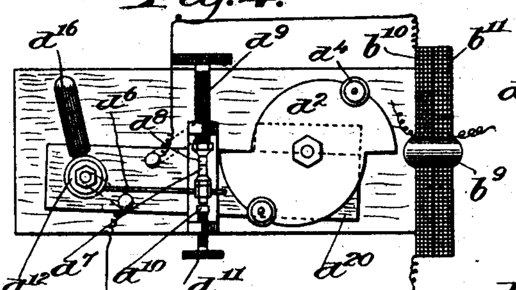

Fig. 3.

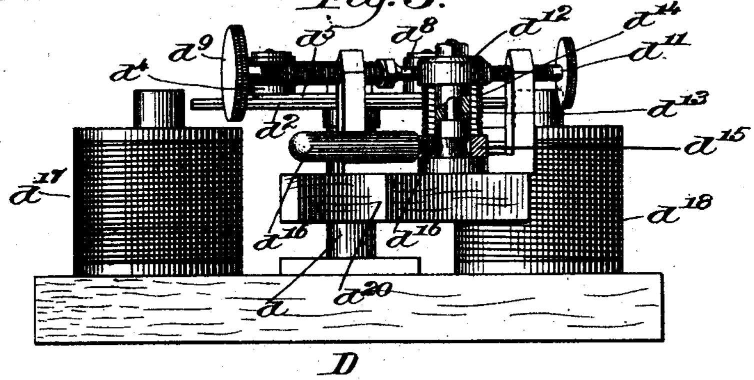

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Fig. 5.

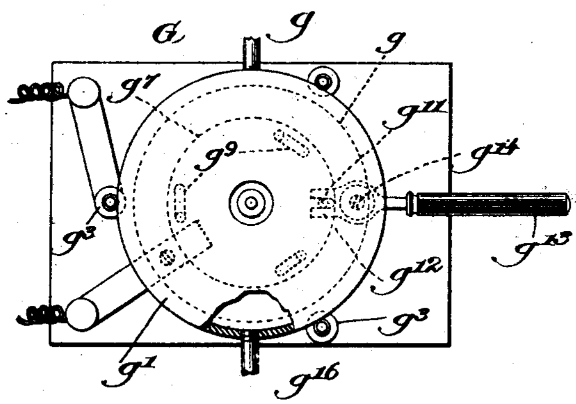
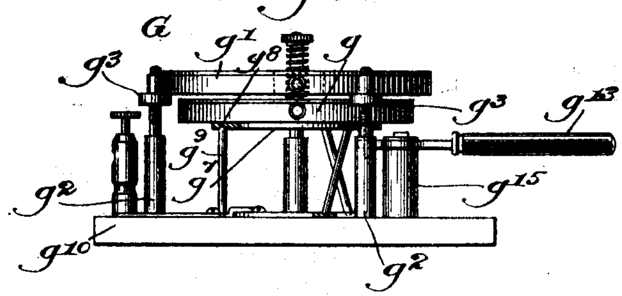


Fig. 6.



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UNITED STATES PATENT OFFICE.

THOMAS B. KINRAIDE, OF BOSTON, MASSACHUSETTS.

INDUCTION APPARATUS.

SPECIFICATION forming part of Letters Patent No. 623,316, dated April 18, 1899.

Application filed May 5, 1898. Serial No. 679,799. (No model.)

To all whom it may concern:

Be it known that I, THOMAS B. KINRAIDE, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Induction Apparatus, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention is an improved induction apparatus whereby discharges are made possible of greater efficiency, as will more fully appear in the course of the following description.

I will describe the details of my invention with reference to the accompanying drawings, which illustrate a preferred form of the apparatus.

In the drawings, Figure 1 is a view, partly diagrammatic and partly in section and plan, illustrating the arrangement of the system according to my invention. Fig. 2 is a top plan view of the break. Fig. 3 is a front elevation thereof, parts being broken away to show the detailed construction. Fig. 4 is a view similar to Fig. 2, showing a modified form thereof. Fig. 5 is a top plan view of my improved spark-gap. Fig. 6 shows the spark-gap in elevation.

Heretofore there has always been a considerable amount of waste energy in systems for developing high potential, and also there has been an ever-present danger of breaking down and destroying the apparatus by its own output, and accordingly it has been my present aim to provide a system in which all the increase of potential which may be developed shall be delivered for use for the translating devices and in which the apparatus is self-containing and practically indestructible.

Let A designate a dynamo, battery, or any other suitable source of electrical energy. From the dynamo the current passes by conductors a a' to an inductance device B, each conductor a a' having its own coil b b', said coils being preferably insulated from each other, as indicated at b^2, and surrounded by a laminated core b^3. Each coil b is wound transversely back and forth until the opposite terminals b^4 b^5 reach the center and are thence carried to the opposite ends of a condenser C, a break D being interposed and connected to the main conductors b^4 b^5 at b^6 b^7 and the discharge from the condenser being received by a translating device (herein shown as a special induction-coil E) by means of an automatic spark-gap G.

Each one of the details of apparatus above enumerated as constituting my system is of special construction and peculiar effect in the system, whereby it becomes possible to discharge currents of considerable strength with great velocity through the primary of the coil E, the discharge across the spark-gap being of very great amperage and exceedingly short and sharp oscillations.

Referring now to the inductance device B, I will explain that the object of this device is to raise the potential of the current and cause all this increase of potential to pass to the condenser, preventing any of it from discharging through the dynamo.

By my device the total potential is delivered only from the forward end of the wire or the one toward the condenser, and also there is only one end of the coil which has high potential. This is because the lines of magnetic force occasioned by the flow of the electric current, which during said flow are radiated from the core or field b^3, fall from the center across all the turns of wire into the periphery as the circuit is interrupted, and hence maintain a region of constant magnetic intensity at the periphery, effectually checking all rise of potential at that end, but leaving the opposite or outgoing end free from the presence of the lines of magnetic force as soon as the break occurs, and therefore without impedance. As soon as the current is broken the lines of force fall back toward the iron core and leave the central portion of the coil free from the restraining influence of these lines of force, said lines cutting across the successive turns of wire, the coil being left free to permit the induced current of increased potential to flow toward the center of the coils or toward that point which has no magnetic field whatever to choke back the current, thereby permitting the latter to rush out unconfined and unrestrained toward its natural outlet; but as the lines of the magnetic field are constantly maintained with maximum impedance at the periphery of the coil and remain surrounding the peripheral turns until the very last moment of the fall due to the break in the circuit their presence there prohibits any possibility of manifestation of the rise of the potential in the current at that end of the coil, so that all the increase of potential in the whole coil is obliged to find an outlet from the center, and the ease of outflow from this outlet increases as the lines of force fall away from the center, thereby removing their restraining and impeding influence therefrom. This will be clear by bearing in mind the action which takes place in what is commonly called a "choke-coil"—*i. e.*, a winding about an iron core, said winding being in a spiral from one end of the iron to the other. In such a coil it is obvious that when a current passes the lines of force rise equally along the extent of the entire coil and that when the current is broken the lines of force fall directly in, perpendicular to the core, thereby cutting each turn of the spiral equally and at the same time, thereby producing high pressure at both ends of the choke-coil, the potential being necessarily the same at both ends of the wire, because both ends are affected by the same conditions of falling lines of force.

In my coil the lines of force do not fall equally on all the turns; but there is a minimum intensity at the center and a maximum intensity at the periphery, the latter being the point of entrance of the current, so that the current due to self-induction is always free to be drawn off, as it were, into the condenser at one end as fast as it is developed and is prevented from departing at the opposite end, or, stated in other words, while the current from the dynamo is always free to flow into the coil for having its potential raised the said potential must all seek its outlet at the opposite end of the coil, so that all the current of the coil flows therefrom into the condenser, whereas in a choke-coil the induced current may be said to ooze out at both ends, so that the benefit is not received of all that is developed.

By my coil all the lines of force are collected for cutting from the center across the entire coil, whereas in the usual choke-coil the lines of force that fall at the center cut only the central turns, so that in my coil I develop all the potential that is possible to be developed.

I regard it as a new principle to withdraw the lines of magnetic force away from that portion of the coil from which the current is being drawn and maintain a magnetic field at that portion of the coil which receives the current.

Other features of construction to be noted in the coil shown in Fig. 1 are that the high-potential end of the coil is that portion of least resistance, because the central turns are of course shorter than the peripheral turns. The resistance in the coil diminishes as the potential increases; also, it will be observed that I have given the magnetic core substantially the form of a semicircle in cross-section, my reason for this form being that thereby the lines of magnetic force are given their best radiation or are distributed to the best effect on the coil, it being understood that these lines leave the iron perpendicular to its surface and are gradually bent around toward the coil.

Referring now to the break D, (best shown in Figs. 2 and 3,) I journal in a central post or bearing d the spindle d' of an iron plate or armature d^2, having two or more eccentric edges d^3, as clearly shown in Fig. 2, or other provision of regions of increasing magnetic attraction. Mounted on or otherwise connected to rotate therewith are one or more small antifriction-rolls d^4, two being herein shown mounted at the opposite ends of a bar d^5, clamped adjustably on the plate d^2. These rolls or circuit-interrupters are preferably of indurated fiber. Mounted to extend into the path of the rolls d^4 is an arm (shown as a wire d^6) carrying a hammer d^7 to contact with an anvil d^8 on a post d^9 and limited in its movement by a fiber stop d^{10} on the end of an adjusting-screw d^{11}. The wire d^6 is carried by a hub d^{12}, loose on a pin d^{13} and held under tension by a spring-coil d^{14}, Fig. 3, fastened at one end to said hub and at its other end to a nut d^{15}, carrying an adjusting or set screw d^{16}, so that by loosening the set-screw and swinging its handle one way or the other the resistance of the arm d^6 may be varied. Opposite the surfaces d^3 I place solenoids or electromagnets d^{17} d^{18}, operated by taps d^{19} from the main circuit entering the solenoids at their inner terminals, so that as the magnets d^{17} d^{18} are energized they attract the plate d^2, and by the increasing pull exerted thereon on account of the eccentric surfaces d^3 they cause the plate to rotate with a speed only checked by the striking of the interrupters d^4 against the end of the arm d^6, said rolls being placed relatively to the highest points of the surfaces d^3, so that they cut off the current just before said highest points get opposite the propelling-magnets, thereby permitting the momentum of the plate or armature d^2 to carry said highest points beyond the magnets sufficiently to prevent the latter exerting any retarding influence on the rotation of the break. Preferably I mount the anvil and hammer on a swinging ledge or carrier d^{20}, journaled on the post d, so that I am enabled to regulate the speed of the break simply by swinging the carrier d^{20} one way or the other. The same effect may be obtained by shifting the roll or rolls d^4 on the plate d^2, provided they are carried, as preferred, on a bar d^5, so that they can be shifted; but this adjustment cannot of course take place while the apparatus is in operation, and therefore for instantaneous regulation of the apparatus and of the system I provide the swinging carrier d^{20}. A movement of the carrier from right to left in the diagram causes the current to be broken before the armature has reached its point of greatest attraction, and as it is moved farther toward the left the pull on the armature exerted by the magnets is diminished more and more and the speed of rotation of the armature is correspondingly reduced, thereby reducing the number of breaks and at the same time lengthening the time which the circuit of the inductance-coil is closed. This is of great importance, because thereby it results that the degree of magnetic saturation of the core or field b^3 may be increased up to its highest limit.

I place the arm or wire d^6 slightly tangential to the armature, as will be seen viewing Fig. 2, in order that the rolls d^4 may strike the extreme end thereof with least friction, striking outward instead of square against the end.

The mains b^4 b^5, Fig. 1, are connected, as stated, to the break by the conductors b^6 b^7, and in order that the condenser may not discharge back through the break I interpose in these conductors a resistance, herein shown as consisting of a few small turns b^8. The discharge from the condenser will seek the path of least resistance, and therefore I interpose just sufficient resistance at b^8 to prevent said discharge acting through the break, but not enough to render the condenser inoperative. One object of this special break is to make it possible to get all the efficiency out of the inductance apparatus B that there is. This would be impossibe with any usual break, for the reason that if a usual break were used, so as to give an equivalent period in which the circuit was closed, the brush would remain upon the surface of the break, tending through the heat or friction engendered to arc upon it, so that the condenser could not receive the full charge from the inductance-coil, but a portion would be lost upon the break-surface. My break, however, gives an absolutely instantaneous break, this break, moreover, being of extremely short duration, so that in practice I am enabled to leave the circuit closed during thirty-five thirty-sixths of the period of rotation of the break-armature, thereby leaving the inductance-coil B all of this period in which to raise its potential. It will be understood that as the point of highest saturation of the core is approached the discharge into the condenser is much greater in volume than if the magnetic flux were not complete.

In my break there is not only no chance for it to arc, as there is no surface for it to arc over, but the break itself is so exceedingly quick that there is not even a spark at the time of break, but there is merely occasionally a residual spark upon the closing of the break. Thus I am enabled to avoid entirely the considerable loss of energy heretofore consumed by the break, and I am enabled by the use of this break, in connection with the special inductance-coil B, to charge the condenser with an amperage which has not been possible in any system heretofore. Also by reason of the spark-gap G, which I will now describe, I am enabled to maintain the condenser action at the maximum charge and without any danger of breaking it down.

I provide electrodes in the form of opposite parallel disks g g', the air-gap between whose plane surfaces constitutes the spark-gap, the extended area of these electrodes preventing the tendency of the condenser to discharge until it has reached its maximum charge, and also causing the discharge to be exceedingly sudden when it does take place and the disks not being liable to become unduly heated. The spark-gap G constitutes virtually a self-recuperative or indestructible condenser, as it were, the parallel and preferably plane metallic surfaces g g' being the discharge-surfaces which discharge through or across the intervening air-dielectric. The air-gap is broken through when the voltage has exerted a sufficient strain upon the air to rupture it. The larger the disks are the farther apart they will spark. At each discharge of the condenser a small portion of these plates is oxidized, the successive discharges producing very thin oxidation here and there until the entire surfaces of the two disks are completely oxidized. Referring to Figs. 5 and 6 for the details of this spark-gap, it will be seen that I provide a plurality of posts g^2, threaded at their upper ends and carrying shouldered nuts g^3, on the shoulders of which is placed the top disk g', being held accurately on said shoulders by a spring g^4 under a tension-nut g^5, said nut and spring being mounted on the reduced end of a central post g^6, over which the plates g g' are placed. The opposite plate g rests on a support or table g^7, provided on its under side with a plurality of recesses or sockets g^8, herein shown as three in number, which receive props or struts g^9, projecting upwardly from the base g^{10} of the instrument. These props g^9 are of precisely equal length, so that they support the plate g in absolute parallelism to its opposite plate g'. The support g^7 has depending from its lower side a stud g^{11}, which is engaged by the bifurcated end g^{12} of a lever g^{13}, pivoted at g^{14} to a post g^{15} on the base. By this provision the most delicate adjustment is possible simply by swinging the lever g^{13} one way or the other, so as to incline the struts g^9 more or less, and thereby increase or decrease the distance between the plates g g', the nuts g^3 being depended upon for the coarser adjustments of the plates.

I have shown the plates g g' as hollow and provided with water-circulation pipes g^{16} in order that they may be absolutely prevented from all heating under extraordinary conditions.

The induction-coil E comprises a primary e of large cross-sectional area, capable of receiving a considerable amperage, the secondary e' being wound on the principle explained in connection with the coils b b', so that its inner terminal alone has the high-potential discharge, the other terminal having comparatively no discharge. I do not herein claim this induction-coil, inasmuch as it forms the subject of another application and is therein claimed; nor will I herein further describe the details thereof, merely showing this particular coil for the reason that this is the only coil known to me which can be used for obtaining the best results from my system; nor do I herein claim the special break device, nor the special spark-gap, inasmuch as these form the subjects-matter of other applications, Serial Nos. 691,757 and 691,758, filed September 24, 1898, and are therein claimed, and it will accordingly be understood that while these particular instruments are preferably employed in my system I do not intend to restrict the latter thereto, nor otherwise than as expressed in the following claims. The conditions that are obtained in this system make it possible to discharge currents of enormous strength with great velocity through the primary, the velocity obtained making it possible to raise the potential in the secondary enormously, and the said potential being confined to one terminal only a resulting discharge is obtained representing the total of the potential that otherwise would be manifest at both terminals of an ordinary coil.

The spark-gap G is adjusted to the point of discharge of the condenser which it is desired the latter should maintain, and accordingly said condenser is automatically discharged as often as it rises to said point of maximum charge, and it can never be overcharged, for the reason that the spark-gap remains unvarying.

The use of the plates g g' makes possible the sudden discharge of the condenser after it has reached the certain predetermined point mentioned, and said discharge is of great volume or large amperage and of a very sudden and abrupt nature, as the current will not break across the spark-gap until it cannot help doing so, and when it does do so the discharge takes place with a minimum heating effect, not interfering with the efficiency, with very rapid and with very short and sharp oscillations, incapable of being obtained between a ball or point discharge-gap and productive of very great results in the secondary.

The plates g g' of the gap G are adjusted to the potential at which it is desired the condenser C shall discharge, and then the break D is regulated to give the volume or amperage of current which it is desired shall charge the condenser, the latter being automatically discharged as frequently as its charge reaches the predetermined limit to which the spark-gap has been adjusted. For example, supposing that the break D is adjusted so as to require the inductance device B to operate at its saturated point, as before explained. Then the number of discharges of the condenser across the spark-gap during each fluctuation in the coil B will be many more times than if the break D were operating more rapidly, and hence the rapidity of the discharge from the induction-coil E is increased in its efficiency, giving more volume of discharge.

It must be understood that the potential that is developed in the induction-coil E is not as great when the plates g g' are brought near together as it is when they are far apart, because in the latter case the condenser charge becomes greater necessarily before it is discharged. By increasing the length of the spark-gap, the speed of the break remaining the same, I get an increase of potential in the oscillator or induction-coil E, and also I may obtain the same effect without varying the length of spark-gap by decreasing the speed of the break.

The maximum potential obtainable from the induction-coil is when the break is adjusted to rotate at a speed sufficient to permit the saturation of the core b^3 and the spark-gap at G is lengthened so that the condenser is allowed to charge to its full capacity.

The sudden opening of the break-gap wide enough so that no discharge may take place thereat, but all the charge seeks a much better channel of discharge in the condenser, taking place as it does in an exceedingly small interval of the period of rotation of the break, gives the inductance-coil B volume of discharge such that it may charge the condenser a considerable number of times before another break takes place; or, to put this in another way, my apparatus enables me to produce a charge from the device B of such enormous volume that the spark-gap G will be called upon to automatically discharge the condenser a number of times during the interval of one falling of the lines of force in the inductance device B.

I regard myself as the first to provide an induction system capable of automatically regulating itself so as to maintain a given discharge, and I also believe myself to be the first to provide an apparatus capable of maintaining said condenser-discharge at a given amperage.

The frequency by my system is practically unlimited, inasmuch as a plurality of inductance devices B may be connected independently to the break D and condenser C, merely being arranged to operate out of step with each other, and there will be no danger to the condenser, for the reason that the spark-gap G will take care of all the charge which may be delivered to the condenser.

My system enables me to use a small condenser and yet with enormous efficiency therefrom.

While I have herein described preferred embodiments of my invention, I do not restrict myself thereto. For example, the electromagnets d^{17} d^{18} need not be used; but instead thereof the inductance device B may be oppositely wound, as indicated in Fig. 4, so that the core b^9 will be properly located for running the armature d^2 of the break. In this case I make the ends of the core b^9 hemispherical, thereby obtaining the same advantage before explained in connection with the similarly-shaped surfaces of the core b^3, and the coils b^{10} b^{11} will be wound back and forth transversely in the same manner as the coils b b', the difference being that in this case the inner terminal becomes the low-potential end of the coils for connection to the dynamo and the outer terminals are the high-potential ends of the coils for connection to the condenser, this form of apparatus, however, not being so efficient as the form previously described, for the reason that the outer or longer turns present an increased resistance to the higher potential, whereas the best effects can be obtained, as before explained, by presenting a decreasing resistance to an increasing potential.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In a system of the kind described, an electric circuit, means including a condenser to impress thereon a current of high frequency, combined with means for automatically discharging the condenser at any predetermined degree of charge, and means for varying the amperage charge of the condenser, substantially as described.

2. In a system of the kind described, a source of electrical energy, and a condenser, combined with a device for raising the potential of the current, means for discharging said raised potential solely in one direction from said device, and means for controlling the potential of said device, substantially as described.

3. In a system of the kind described, a source of electrical energy, a break, condenser, and a translating device to receive the discharge from the condenser, combined with means for preventing the discharge of the condenser back through the break, substantially as described.

4. In a system of the kind described, the combination with a source of electrical energy, a break, and condenser, of an inductance device between said source of energy and the break, said device having a magnetic core, and coils in the influence of said core and wound to present high potential at one end and low potential at the other end, said coils having their low-potential terminals connected to the source of energy, and their high-potential terminals connected to the condenser, and interrupted by the break, substantially as described.

5. In a system of the kind described, the combination with a source of electrical energy, a break, and condenser, of an inductance device between said source of energy and the break, said device having a core producing a magnetic field, and coils in the influence of said field and wound to present high potential at one end and low potential at the other end, said coils having their low-potential terminals connected to the source of energy, and their high-potential terminals connected to the condenser, and interrupted by the break, and means to vary the degree of magnetic saturation of said field in the operation of the system, substantially as described.

6. In a system of the kind described, a source of electrical energy, a break, and a condenser, combined with means independent of the break for automatically regulating the frequency of discharge from said condenser, substantially as described.

7. In a system of the kind described, a source of electrical energy, an inductance device for raising the potential of the current therefrom, said device delivering said potential in one direction only and away from the source of energy, a break provided with means for maintaining long intervals of closed circuit, and sudden short intervals of break, a condenser, and an automatic discharge device for said condenser, substantially as described.

8. In a system of the kind described, a source of electrical energy, an inductance device for raising the potential of the current therefrom, said device delivering said potential in one direction only and away from the source of energy, a break provided with means for maintaining long intervals of closed circuit, and sudden short intervals of break, a condenser, means preventing back discharge from the condenser and sparking at the break, and an automatic discharge device for said condenser, substantially as described.

9. The combination in an electrical circuit, of an inductance-coil having a core producing a magnetic field and wound to present a high-potential region at one end and low-potential region at the other end, the terminal thereof connected with the source of current-supply being at said low-potential region, and the opposite terminal being at said high-potential region, said coil having the potential thereof decreasing in a constant ratio from the one to the other terminal, and mechanism for interrupting the said circuit, said mechanism comprising means for maintaining the circuit closed in periods sufficient to fully charge said magnetic field, substantially as described.

10. An inductance-coil comprising a core, and a winding of current-conductor centrally of said core, said winding being in two coils, each having one terminal adjacent said core and the other terminal removed from said core, with all the windings of the coil located between said two terminals, and said coil having its potential varying per turn progressively in a constant ratio throughout its length from one terminal to the other terminal, substantially as described.

11. In an inductance-coil, a peripheral core or magnetic body, and a winding of current-conductor within the field of said magnetic body, said conductor being wound to present

its successive layers of windings successively shorter from the periphery to the center of the coil throughout the entire length of the conductor, substantially as described.

12. In an inductance device, a magnetic core, and a coil adjacent thereto, said core presenting curved surfaces adjacent the coil curving therefrom in a direction away from the coil, whereby the lines of magnetic force leaving the core perpendicular to said surfaces are widely distributed about the coil, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THOMAS B. KINRAIDE.

Witnesses:

GEO. H. MAXWELL,

FREDERICK L. EMERY.