No. 891,496. PATENTED JUNE 23, 1908.

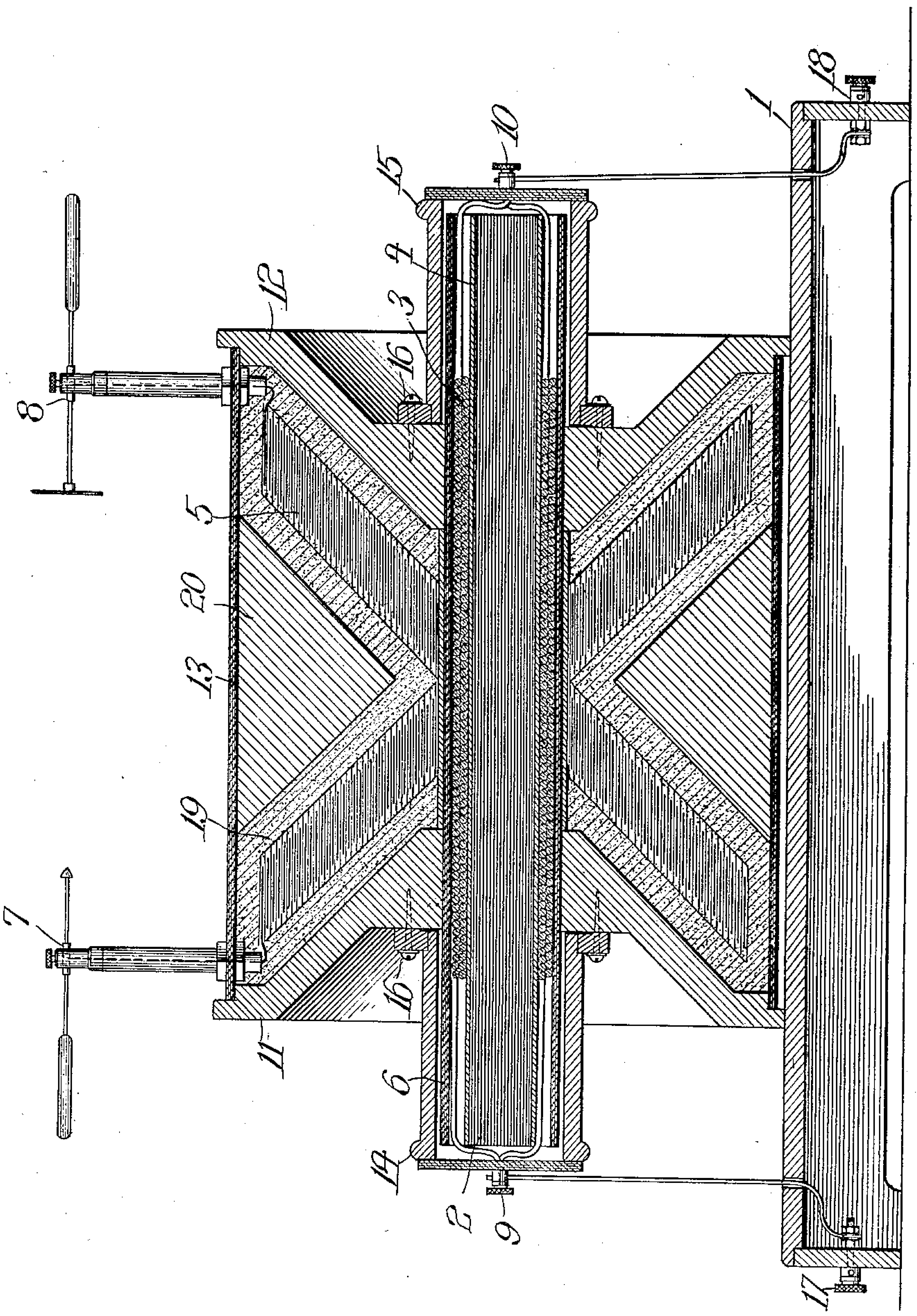
A. R. LUSCHKA.

ELECTRICAL TRANSFORMER.

APPLICATION FILED DEC. 11, 1905.

2 SHEETS—SHEET 1.

Fig. 1



Witnesses
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Inventor
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2 SHEETS—SHEET 2.

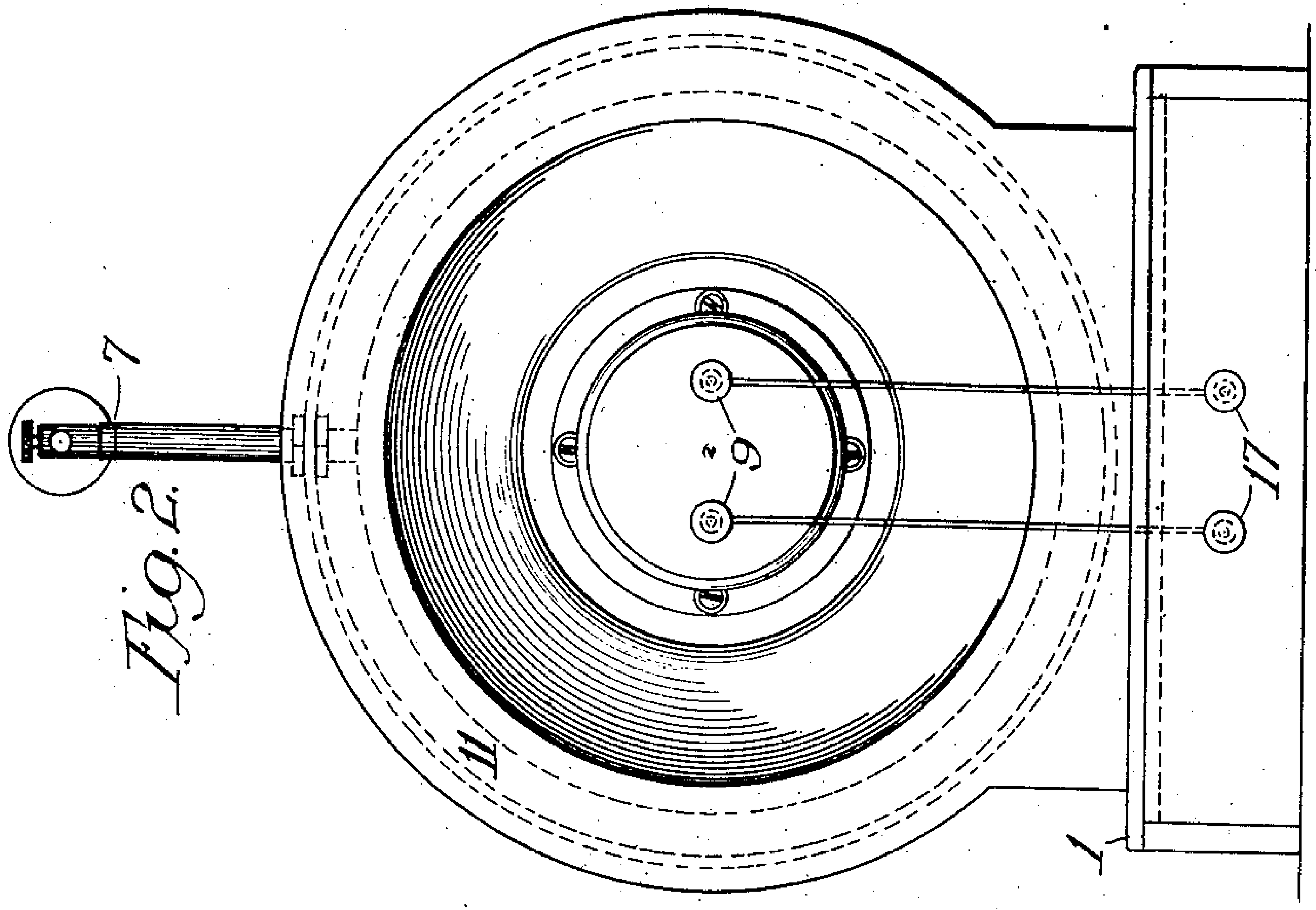

Fig. 2.

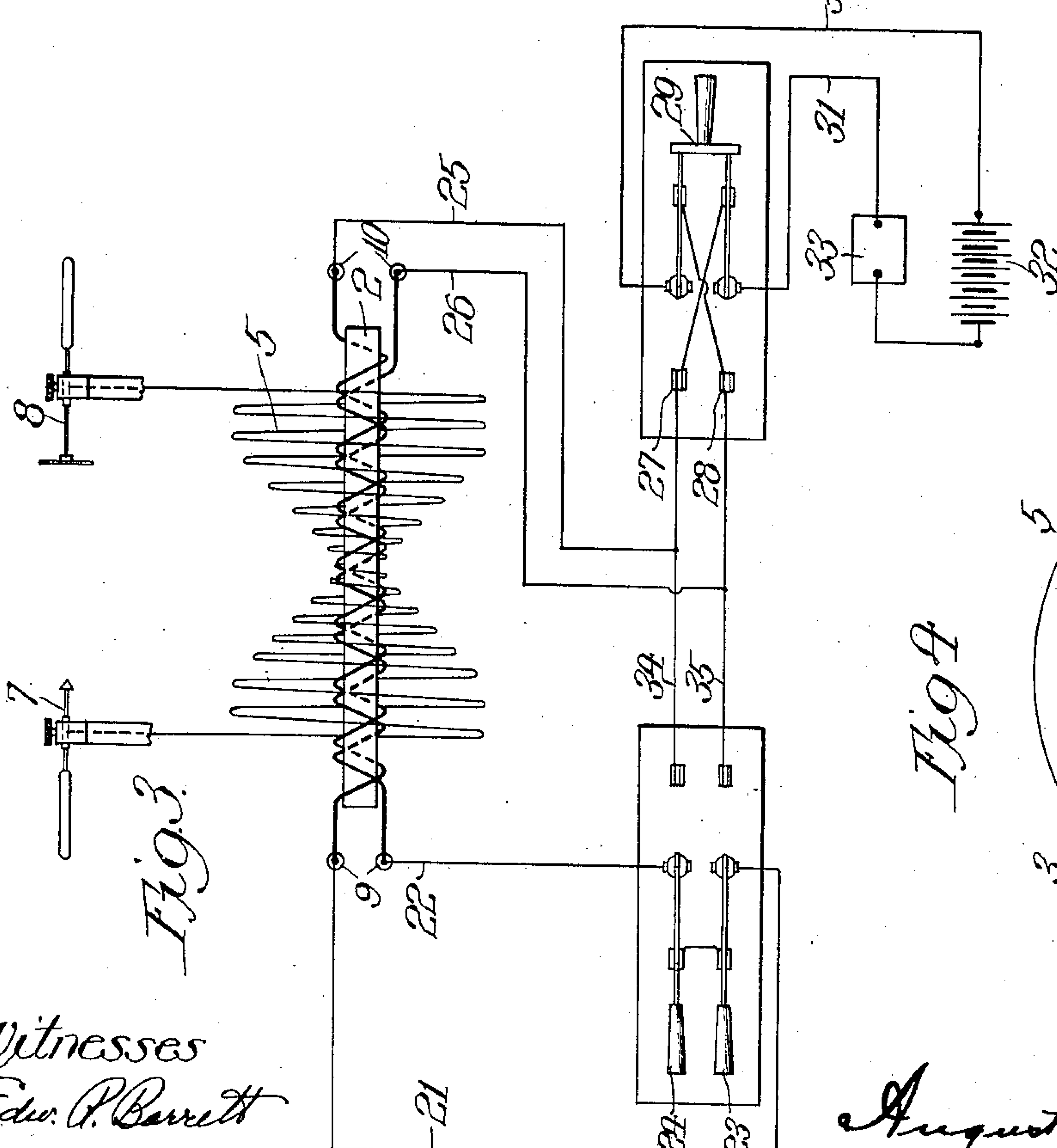

Fig. 3.

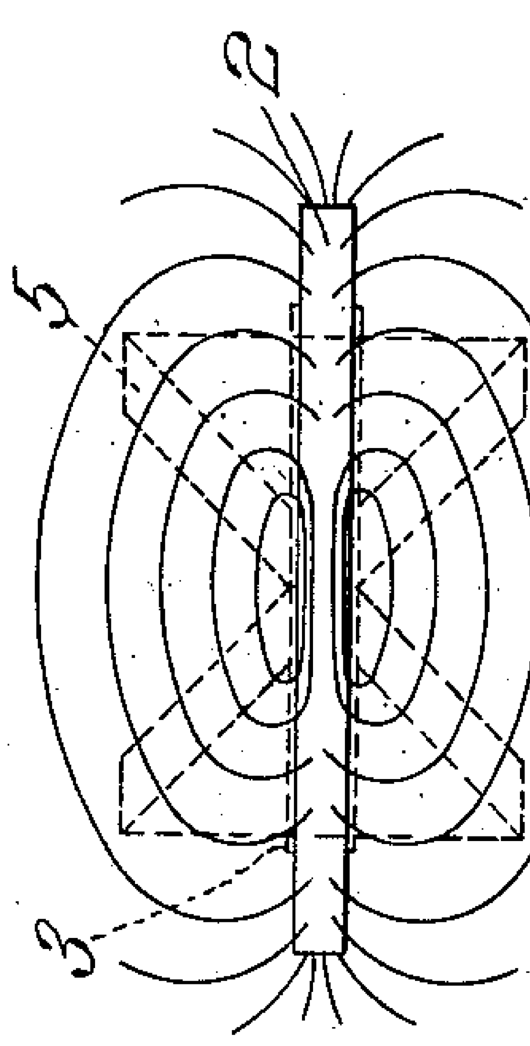

Fig. 4.

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ELECTRICAL TRANSFORMER.

No. 891,496. **Specification of Letters Patent.** **Patented June 23, 1908.**

Application filed December 11, 1905. Serial No. 291,266.

To all whom it may concern:

Be it known that I, August R. Luschka, a citizen of Switzerland, residing at River Forest, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electrical Transformers, of which the following is a specification.

My invention relates to an apparatus for converting or transforming low potential current into alternating current of high potential, and has to do more particularly with that type of converting or transforming apparatus commonly known as induction or spark coils, wherein two or more coils or windings of wire are arranged in fixed relation to each other, the conversion or transformation being brought about by electromagnetic inductive action between the windings.

My principal object is to provide an apparatus of this character of simple and relatively inexpensive construction, of particular efficiency of operation, and, with a given expenditure of energy, requiring a minimum amount of wire in the secondary winding for a given length of spark.

Induction coils as commonly constructed comprise a laminated iron core, over which is wound a primary winding of relatively coarse copper wire, and over this a secondary winding of relatively fine copper wire, the windings and the core being appropriately insulated from each other. The secondary winding is usually either wound continuously from one end to the other of the space reserved for it, or is divided into a plurality of narrow disk-shaped sections serially connected, and arranged adjacent to each other with insulating partitions between, the sections and their partitions practically filling the winding space. One of the principal difficulties encountered in the construction of coils of this character is the liability of the high potential which they generate breaking down the intervening insulation and causing the current to flow in a short circuit between adjacent or even widely separated, convolutions or sections of the secondary winding, or from the secondary to the primary winding or to the core, instead of in the external circuit where it is intended that it shall flow. It has also been found that where a certain potential is generated by a single section of a sectionally wound coil, the potential, as measured by the length of the spark produced, does not increase in the expected ratio when the sections of the coil are electrically coupled together. This peculiarity has been attributed commonly, and, it is believed, properly to a supposed lack of synchronism in the development of the induction currents in the various sections, as a result of which the currents are out of phase and tend to oppose, or, at least, not to assist each other.

It has been my particular object to produce a coil in which a high degree of insulation between the portions of the secondary winding having a great difference of potential, and between the secondary winding and the primary winding shall be obtained, not by the interposition of massive and expensive insulating partitions, as has ordinarily been the custom, but rather by a peculiar arrangement of the parts of the coil; and at the same time, by this arrangement of parts, to secure such resonance, or synchronism in the development of the induced currents in the different sections of the winding that the effects will strongly reinforce each other and produce the maximum potential for a given expenditure of energy and length of wire in the winding. This result, generally speaking, I accomplish by arranging the secondary windings of my induction coil in sections symmetrically disposed in the magnetic field of force produced by the primary winding, and by arranging the convolutions of the sections to recede progressively from each other, and from the primary winding and core, as the potential of the current generated in them increases, the bases of the sections preferably adjoining in approximately the plane of the center of the magnetic field in order that the convolutions may be intersected by the maximum number of lines of force.

In the preferred embodiment of my invention illustrated and described herein the secondary winding is in the form of two symmetrical hollow truncated cones with their apexes meeting in the plane of the longitudinal center of the core. As a result of this arrangement, the portion of the secondary winding closest the primary and the core is nearest zero potential, while the terminals of the winding where the potential is highest are the most remote from each other and from the core; the current induced in the sections of the secondary winding are electrically symmetrical and in resonance, and thus additive in their effects, the resultant potential being much higher than would be obtained if the electrical inductive effects appeared in the sections at even very slightly different times; the sections of the secondary winding are located in the most advantageous position in the field of force, the angle of divergence of the sections from the core and from each other being such as to bring the convolutions within the greatest number of lines of force; and the turns of wire in the secondary are eliminated, which heretofore have been detrimental both in developing dissynchronous currents which interfere with the main induction currents, and in damping down the main currents by the resistance which they interpose, the total effect of the coil thus being increased, while its cost is lessened.

I will describe my invention more particularly by reference to the accompanying drawings, wherein

Figure 1 is a front elevation in central section of an induction coil embodying my invention; Fig. 2 is an end elevation thereof; Fig. 3 is a diagrammatic view of the circuits of the coil, including the usual current generating and circuit controlling appliances; and Fig. 4 is a graphic representation of the magnetic circuit of the coil, showing the relation of the magnetic lines of force to the windings.

In the embodiment of my invention illustrated, the induction coil proper is mounted upon a base 1 constructed of suitable material, such as wood, insulating fiber, or the like. Generally speaking, the induction coil comprises a core 2, consisting of a bundle of soft iron wire, a primary winding 3, wound upon the core and separated from it by an insulating tube 4 of paper or the like, a secondary winding 5 surrounding the primary and separated from it by a heavy insulating tube 6 of micanite or like material having high insulating qualities, and spark terminals 7 and 8, connected with the ends of the secondary winding, the primary winding being also brought out to suitable terminals, 9 and 10. The various parts of the induction coil proper, as enumerated, are supported upon two end heads 11 and 12, preferably of wood, mounted upon the base 1 which, with an inclosing shell 13 of hard rubber or like insulating material surrounding the secondary winding and supported upon the end heads, form a containing and protecting case for the induction coil proper. The spark terminals 7 and 8, with which the ends of the secondary winding are connected, may comprise the usual electrodes consisting of a flat plate and a pointed tip of metal supported upon metal rods adapted to slide through heads or posts of metal. The heads or posts are mounted upon pillars of insulating material supported in a suitable manner, as shown, upon opposite ends of the inclosing and protecting case.

To produce the best distribution of the magnetic lines of force I construct my coil with the core 2 of considerable length, and adapted to project beyond both the primary and secondary windings. The primary winding is preferably wound over about two-thirds the length of the core, leaving approximately one-sixth of the length of the core projecting beyond the winding at each end. The primary winding, as shown, is in two layers, and both ends of each layer are preferably brought out separately to the binding posts 9, 10, mounted upon the heads of cylinders 14 and 15, of insulating material. These cylinders project from the end heads, 11 and 12, and are secured thereto in any suitable manner, as by the rings 16, and serve to inclose and protect the portions of the core and the associated primary winding and insulating tubes which project beyond the end heads. From the binding posts, 9, 10, the connections of the primary winding may be extended by means of conductors as shown, to the binding posts, 17, 18, mounted on the base 1.

In accordance with my invention, instead of winding the secondary winding to entirely fill the secondary winding space, either as a continuous winding or in the form of a number of disk-shaped sections insulated from each other and serially connected, as has been the practice heretofore, I arrange the secondary winding in the form of two sections disposed symmetrically with respect to the magnetic field, and occupying only a relatively small portion of the winding space available.

As shown in Fig. 4, which is a chart illustrating the distribution of the magnetic lines of force as observed in a core such as I employ in my induction coil, it will be seen that the lines emanate not only from the ends of the core, but from practically its entire length, being distributed well down towards the longitudinal center of the core. Those lines which escape from that part of the core encircled by the primary winding are usually known as "leakage" lines, and in induction coils as ordinarily constructed are not utilized to the fullest extent in the production of inductive effects in the secondary winding. In order to arrange my secondary winding in the most favorable position with respect to the magnetic field, I construct it with a narrow base having its center resting approximately at the magnetic center of the core where it will be in position to be intersected by the maximum number of the lines of force; to insure the proper insulation from each other and from the core of the convolutions of the coil having a large difference of potential, I make the winding in sections, and so dispose the sections that their convolutions progressively recede from each other and from the core, the separation increasing as the potential difference increases; and in order to insure the synchronous generation of the inductive currents in the two sections I arrange them symmetrically with respect to the magnetic field of force. When these conditions are satisfied, the result, in the present instance, is a secondary winding 5 of substantially the form of two hollow symmetrical truncated cones centrally perforated and placed with their apexes meeting in the plane of the magnetic center of the core and their axes coinciding with the longitudinal axis of the core.

One coil which I have built in accordance with the principles of my invention, and which I have found extremely efficient in practice, is constructed as follows: The core is made of a bundle of No. 18 gage soft iron wire surrounded by a paper tube, on which is wound the primary winding consisting of two layers of 150 turns each of No. 13 copper wire, the primary winding covering about two-thirds of the length of the core. The core with the primary winding upon it is placed within a tube of micanite having walls approximately one-fourth inch thick, at the longitudinal center of which the secondary winding is supported. The secondary winding consists of two sections of the truncated conical form described, each section being wound with approximately twenty-five thousand turns of No. 29 insulated copper wire, the two sections being arranged with their apexes together, and having their windings serially connected. In winding the secondary coil I have found it desirable to place a single thickness of oiled paper over each layer as it is wound, the paper preferably slightly overlapping the layer of wire at both sides, as indicated in Fig. 1 of the drawing by the long light lines, alternating with the heavy short lines, which indicate the layers of wire. To still further increase the insulation of the secondary winding, I find it convenient to fill in the space about it with an insulating substance such as vaseline, indicated by the reference character 19. On account of the peculiar shape of the secondary winding I find it convenient to construct the end heads 11 and 12, generally to conform thereto, primarily in order to lessen the space around the coil to be filled with the insulating material 19; and for the same reason I have shown in the present instance a ring or band 20 of triangular cross-section encircling the secondary coil within the inclosing shell 13. The end heads 11 and 12, for the reason just indicated, are of substantially truncated conical form, the summit of the cone being directed inwardly, and the base being hollowed out as shown.

In its operation, the induction coil of my invention may be connected in a circuit as shown in Fig. 3, wherein one end of each of the two primary windings is shown to extend by conductors 21 and 22, to the middle points of two double-throw knife blade switches 23 and 24, while the other ends of the two primary windings extend by way of conductors 25 and 26, to two outer contacts 27 and 28 respectively, of a double-throw switch 29, each of said contacts being also connected to the diagonally opposite outer contact of the switch. The middle points of this switch, which communicate with the knife blades, are connected through the medium of conductors 30 and 31, with a battery 32 or other source of electrical energy, and a device such, for instance, as a Wehnelt interrupter for effecting a rapid interruption of the circuit, indicated diagrammatically in the drawing, and designated by the reference character 33. The right-hand ends of the two primary windings are also connected, as indicated, by way of conductors 24 and 25 respectively with the two alternative contacts of the two single-pole double throw switches 23 and 24. With the apparatus connected as described, the current flows from the source 32 through the interrupter 33 and by way of the double-pole double-throw switch 29 in either one direction or the other through the primary winding of the induction coil, depending upon whether the switch 29 is thrown to the right or to the left. If the two switch-pole switches 23 and 24 are thrown to the left, as indicated in the drawing, the current flows through the two primary windings serially, the two outer contacts on that side being wired together. If both switches are thrown to the right, the interrupted current will flow through the windings in parallel; whereas if one switch only is thrown to the right, one primary winding only will be connected in circuit.

As the interruptions in the primary circuit cause the current therein to increase and diminish, the magnetic lines, as indicated in Fig. 4, expand and contract, and in so doing cut the convolutions of the secondary winding and generate therein the electro-motive forces which, being added together, cause a discharge to pass between the secondary terminals 7 and 8. As the two sections of the secondary winding are arranged symmetrically in the field of force, the impulses generated therein are synchronous and in phase, and consequently reinforce each other. Moreover, as the two sections are of relatively narrow cross-section, and also lie in a position in the field of force wherein the distribution of the lines is relatively uniform, the impulses in each section are not opposed and interfered with by dissynchronous impulses developed in other convolutions of the same section. As a result of this the electromotive force developed in my induction coil, and consequently the sparking distance between the secondary terminals, is unusually great; while the lower ohmic resistance of the secondary arising from the smaller number of turns required, and consequently less length of wire, results in a larger current flow. As indicating the relative efficiency of my coil, I have observed that a secondary of 90,000 turns of wire wound in the ordinary way developed an electro-motive force capable of causing a discharge between its terminals when the separation between them was approximately twelve inches, while an induction coil built in accordance with my invention, and having a secondary of 50,000 turns gave a fourteen inch discharge, the general conditions with respect to the core and primary winding, and the primary current employed being the same in both.

I claim:

1. An induction coil comprising an elongated core of iron wire, a primary winding thereon, covering only part of the length of said core, and a secondary winding about said primary winding in the form of two hollow truncated cones with their apexes meeting at approximately the center of the core, the planes of the bases of said cones intersecting the core at some distance from its ends.

2. An induction coil, comprising a core of small iron wires, an insulating tube inclosing the same, a primary winding of relatively coarse wire wound upon said insulating tube, a second insulating tube about said primary winding, a secondary winding comprising two similar serially connected hollow truncated-cone-shaped sections with their apexes meeting in substantially the plane of the magnetic center of said core, and with their axes coinciding with the longitudinal axis of said core, and terminal connectors for said primary and secondary windings.

3. An induction coil, comprising a core, a primary winding thereon, a secondary winding about said primary winding consisting of two hollow truncated-conical sections with their small ends meeting at substantially the longitudinal center of the core, and truncated-conical end heads for said coil adapted to nest with said sections.

4. An induction coil, comprising a core, a primary winding thereon, a secondary winding about said primary winding consisting of two hollow truncated-conical sections with their small ends meeting at substantially the longitudinal center of the core, truncated-conical end heads for said coil adapted to nest with said sections, and an insulating substance interposed in the space between said heads and said sections.

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