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4 Sheets—Sheet 1.

G. & A. PFANNKUCHE.

INDUCTION COIL.

No. 343,602. Patented June 15, 1886.

Fig. 1.

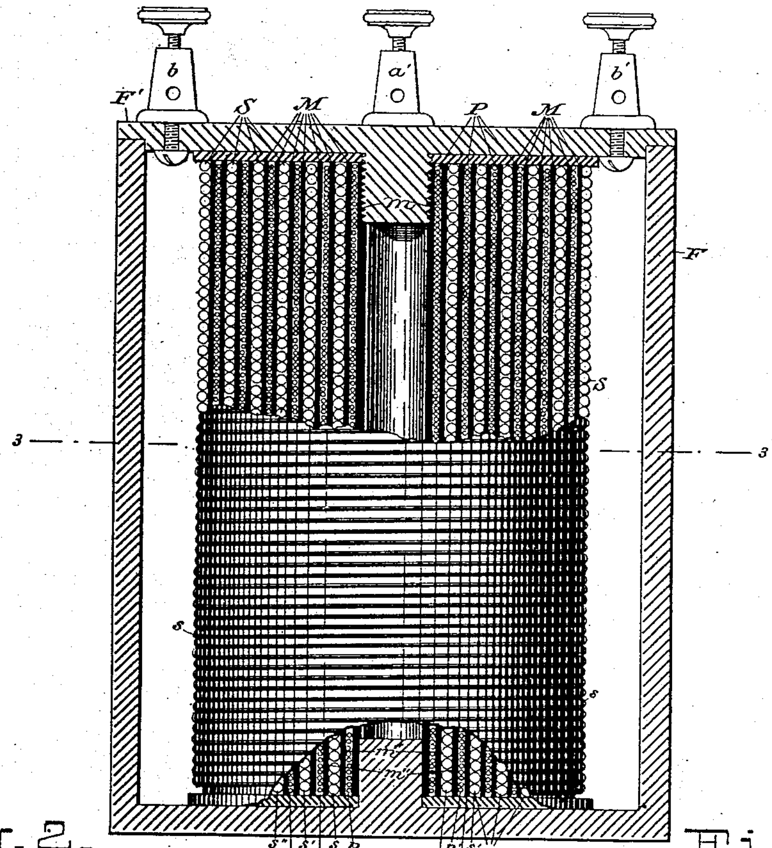

Fig. 2.

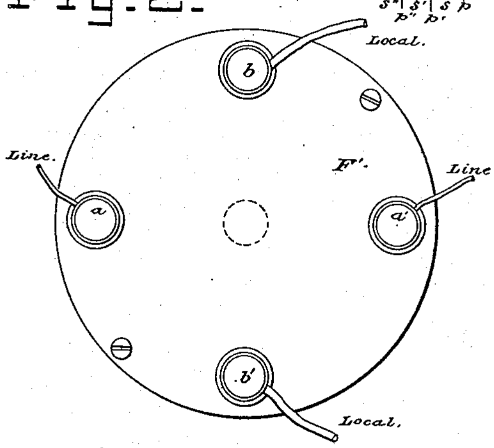

Fig. 3.

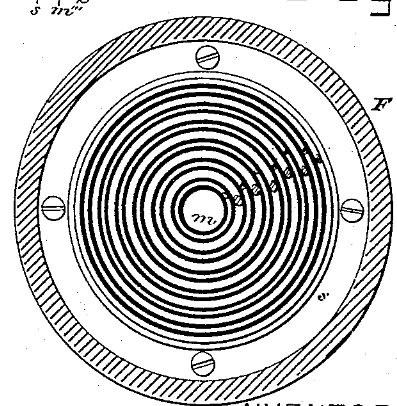

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Fig. 5.

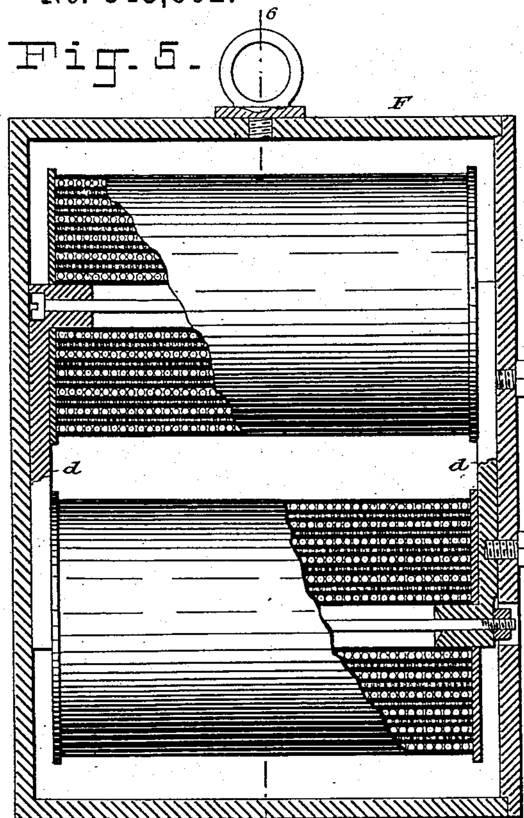

Fig. 6.

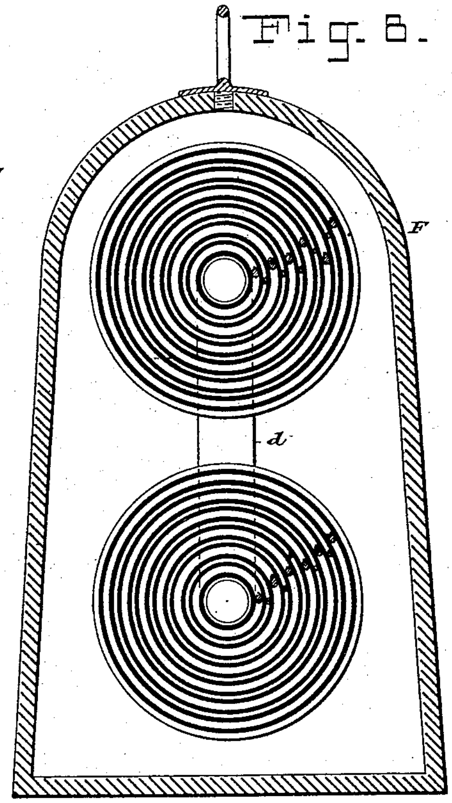

Fig. 7.

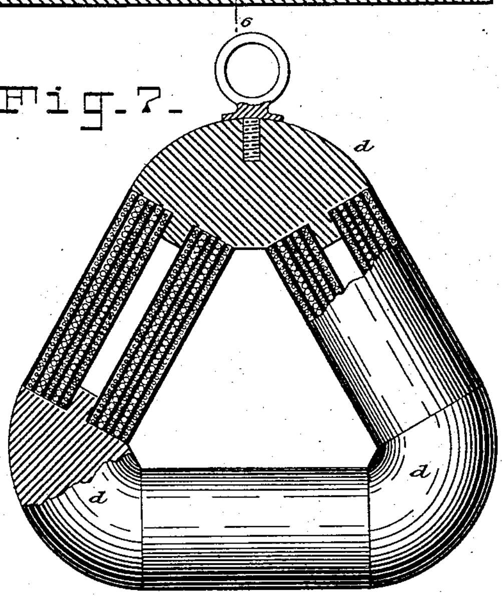

Fig. 4.

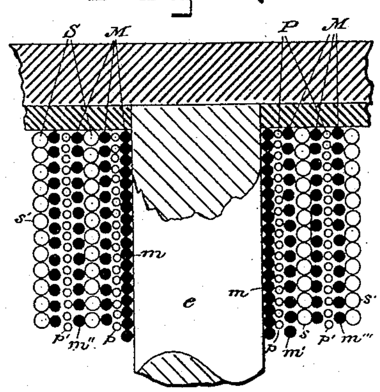

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Fig. 8.

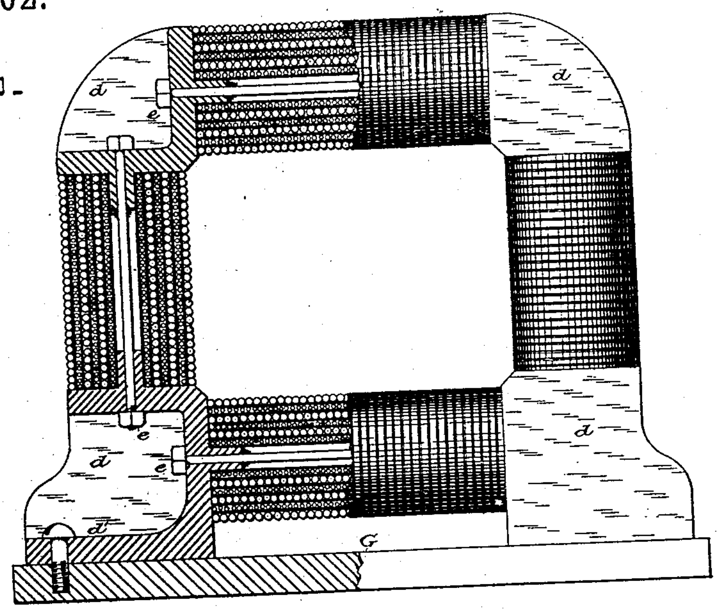

Fig. 9.

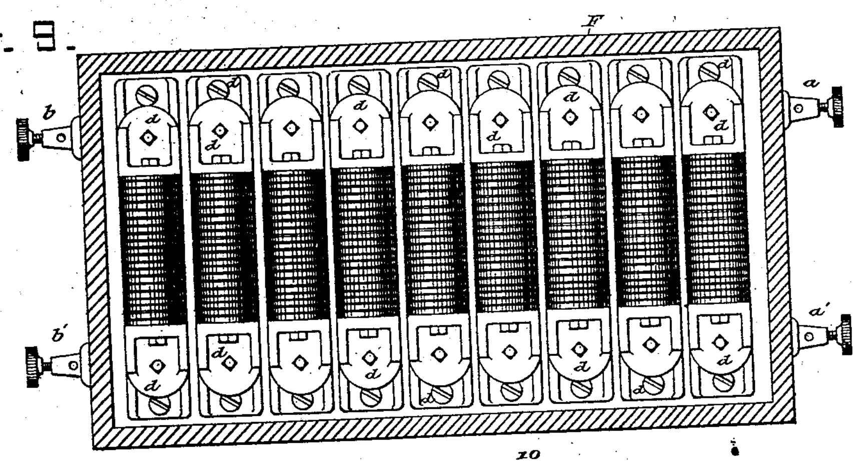

Fig. 10.

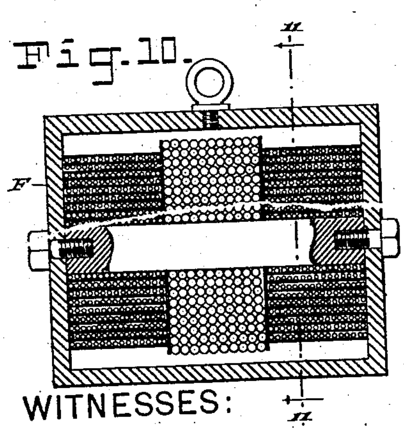

Fig. 11.

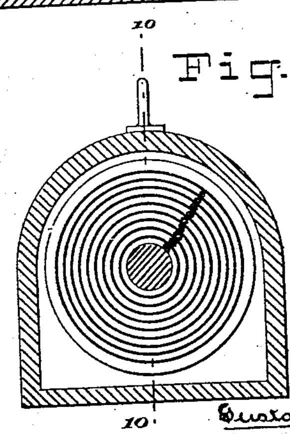

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Fig. 12.

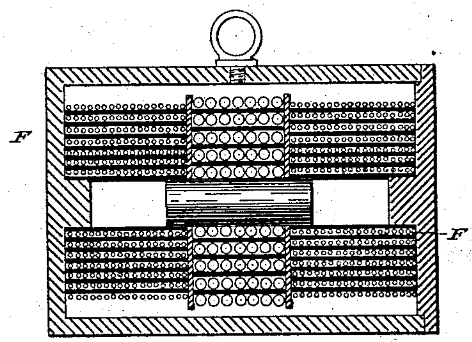
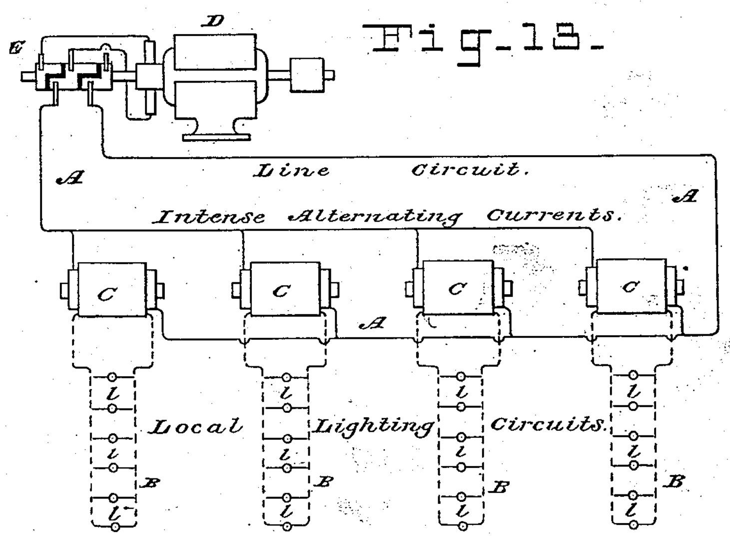


Fig. 13.



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UNITED STATES PATENT OFFICE.

GUSTAV PFANNKUCHE AND ALFRED PFANNKUCHE, OF NEW YORK, N. Y.

INDUCTION-COIL.

SPECIFICATION forming part of Letters Patent No. 343,602, dated June 15, 1886.

Application filed September 28, 1885. Serial No. 178,350. (No model.)

To all whom it may concern:

Be it known that we, GUSTAV PFANNKUCHE and ALFRED PFANNKUCHE, both subjects of the Emperor of Austria, and residents of the city, county, and State of New York, have invented certain new and useful Improvements in Electric-Current Converters, of which the following is a specification.

This invention relates to secondary or induction coils, especially such as are used for converting an intense alternating current on a main line to an alternating current of low tension but considerable quantity on a local circuit. Induction-coils as designed for this purpose we call "converters." Such coils have been heretofore made by winding a fine insulated wire around a soft-iron core or bundle of iron wires, or on a tube containing such wires, to form a primary coil or helix, and then winding outside of this a coarse insulated wire to form the secondary helix, being, in fact, a reversal of the so-called "Ruhmkorff" coil for producing sparks. Such converter-coils have also been made by employing as a core a ring-like coil of wire, and winding the primary and secondary helices upon this ring in similar manner to the winding of the Gramme armature. Such converter-coils as heretofore made work in general satisfactorily, except that they do not attain as high an efficiency or economy of electric energy as is commercially desirable. This is due to several causes, chiefly to, first, the waste of energy due to the magnetization and demagnetization of solid cores, which, as is well known oppose a considerable resistance to rapid changes of polarity; second, the fact that the wires of the secondary helices are not arranged in the most intense part of the magnetic field; third, the waste due to the generation of Foucault currents; and, fourth, to there being not enough iron in the present constructions, and to what iron there is being improperly disposed as to the inductive effect of the helices.

Our invention seeks to overcome these disadvantages by improving the converter-coils, and it relates to the construction of single coils and to the combination of the coils in batteries.

Figure 1 of the accompanying drawings is a vertical longitudinal section and partial side elevation, on a large scale, of a single converter-coil constructed according to the preferred form of our invention. Fig. 2 is a plan or end view thereof, and Fig. 3 a transverse section, both on a smaller scale. Fig. 4 is a fragmentary sectional view on a larger scale than Fig. 1. Fig. 5 is a vertical longitudinal section, partly in side elevation, and Fig. 6 a vertical transverse section, of a converter having a double coil. Fig. 7 is a side elevation, partly in axial section, of a triple-coil converter. Fig. 8 is partly an axial section and partly a side elevation of a four-coil converter, which is the preferred construction. Fig. 9 is a plan view of a series or battery of four-coil converters, arranged side by side in an inclosing-case. Fig. 10 is a longitudinal section, and Fig. 11 a transverse section, of a modified construction of single coil. Fig. 12 is a longitudinal section of another modification. Fig. 13 is a diagram showing the electric circuits for lighting or other purpose, in connection with which our invention is especially designed to be used.

To facilitate an understanding of the purpose or practical application of our invention, we will first describe the circuit arrangements with reference to Fig. 13. In that figure A is the line-circuit, and B B are the local circuits, of which there may be any number. C C are the converters or induction-coils, which are here shown for clearness as being of the ordinary construction, with the ends of the inner or primary coil protruding. D is the dynamo or generator, which feeds the line-circuit, and E is a commutator for alternating the currents. We prefer to use a continuous-current dynamo, because of its high efficiency, and to alternate the currents by means of any suitable alternating commutator, as E; but an alternating-current dynamo may be used instead, in which case the commutator E will be omitted. The converters C C are preferably installed in the line-circuit in multiple arc, in order to maintain at the terminals a uniform potential. Each local circuit includes the secondary coil of one converter, as shown, (or, if preferred, of two or more converters arranged either in multiple arc or series,) and the incandescent electric lamps (indicated at *l l*) are connected in these circuits in multiple arc. The alternating currents of high electro-motive force on the main line, which traverse the several primary coils of fine wire, induce in the secondary coils of coarse wire alternating currents of low electro-motive force, which traverse the secondary circuits and feed the lamps.

Referring now to Figs. 1, 2, and 3, we will describe the construction of converter or induction-coil there shown. Let P designate, as a whole, the primary coil, which is of fine insulated wire, and S the secondary coil, which is of coarse insulated wire. M will designate, as a whole, the subdivided tubular iron core. The characteristic feature of this construction is that the primary and secondary wires are wound in alternate layers or helices with iron tubes interposed between the layers. The first helical layer of primary wire, *p*, is wound on a straight tube, *m*, of iron. It may have a thickness of one wire, as shown, or of two or more wires. Then a second iron tube, *m'*, is placed over this layer, and on this the first layer of secondary wire, *s*, is wound. This layer has preferably a thickness of only one wire. Then a third iron tube, *m''*, is placed over this, and a second layer of primary wires, *p'*, is wound. Then a fourth iron tube is placed over this layer, and a second layer of secondary wire, *s'*, is wound over this, and thus the construction proceeds by the alternate superposition of wire helices and iron tubes, the wire helices being alternately of primary and secondary wire, until the coil attains the required dimensions. All the primary wires are joined in one primary coil, P, all being wound in the same direction to secure like polarity, and all the secondary wires are in like manner joined in one secondary coil, S. The two opposite terminals of the primary coil are joined, respectively, to the two binding-posts *a a'*, Fig. 2, for connection with the wires of the line-circuit, and the terminals of the secondary coil are joined to the binding-posts *b b'* for connection with the wires of the local circuit. The effect of this construction is to magnetize all the iron tubes with a like polarity, all being, in fact, parts of one magnet or core; to inclose each helix of primary wire between two iron tubes in order that it may exert its magnetizing action in both directions in the utmost proximity to the iron, and to expose each (with the partial exception of the outer) helical layer of secondary wire to inductive influence from iron tubes on both sides of it, and in the closest proximity to it, whereby the secondary wire is placed in the strongest part of the magnetic field. Thus the primary wire exerts its magnetizing influence to the strongest effect upon the iron tubes, and the latter have the most powerful inductive influence on the secondary wire. The entire coil is inclosed in an iron case, F, which should be in magnetic contact with the ends of the several iron tubes *m m*, whereby the iron case becomes itself magnetized, the lines of magnetic force extending thus around the sides of the case from one pole to the other. Thus a closed magnetic circuit is formed whereby sensible magnetic poles are suppressed. The iron case F is in two parts—a cup-shaped box and a cover or lid, F'. The inner tube *m* is screwed to this cover, thereby connecting the entire coil to the cover, to which also the four binding-posts are fastened. The iron tubes *m m*, if made of plate or sheet metal, may be slitted through longitudinally with good effect, to suppress Foucault currents. We prefer, however, (and this constitutes one feature of our present invention,) to construct these tubes by winding a layer of iron wire in a close continuous helix. If the iron wire be naked and its convolutions be in actual contact, the effect will be the same as if a tube of solid metal were used, but if, as we prefer, the iron wire be insulated, the magnetic effect will be but little, if any, impaired, and by connecting the terminals of the iron-wire helix in the circuit the current through it will react inductively upon and re-enforce that in the primary helices, whereby the inductive effect upon the secondary wire will be intensified. As the scale of Fig. 1 is too small to enable this construction to be clearly shown, we have illustrated it on a large scale in the fragmentary view, Fig. 4. Here the iron wires are shown in black, and the (preferably) copper wires of the primary and secondary coils, by white circles. A wooden core, *c*, passes through the center, being used as a base on which to wind the first tubular helix of iron wire. When more powerful converters are required, we prefer to combine together two or more of the individual coils already described rather than to enlarge the latter to unwieldy proportions.

Figs. 5 and 6 show a converter consisting of two complete coils of the construction shown in Fig. 1, the two coils being united by pole-pieces *d d* of soft iron, and inclosed in a case, F. The pole-pieces suffice in themselves to make a closed magnetic circuit, so that no poles are observable, the winding being of course so disposed as to bring opposite poles of the cores of the two coils into communication through the medium of the pole-pieces.

The coils shown in Figs. 5 and 6 differ in one respect from that shown in Fig. 1, in that the secondary wire *s* is first wound, instead of the primary. This modification is of little effect.

Fig. 7 shows a triple arrangement of coils. Three complete coils are arranged in the form of an equilateral triangle, their ends being magnetically connected through the medium of soft-iron pole-pieces *d d*, to form a closed magnetic circuit.

Fig. 8 shows a quadruple arrangement of coils. The four coils are arranged in the form of a quadrangle and united by means of iron corner-pieces or pole-pieces *d d*, which complete the magnetic circuit. Through each coil is passed a slender bolt, *e*, by means of which the two pole-pieces at opposite ends of the coil are drawn together, embracing the coil between them. The two lower pole-pieces are formed with flanges *d' d'*, by means of which the compound coil may be screwed to a base, G. This form of coil has all the advantages with none of the disadvantages of induction-coils in the form of a ring wound upon a ring-shaped core. The four coils being wound so as to bring their opposite poles into juxtaposition at each corner, and the tubular magnetic cores being made continuous throughout the entire quadrangle by means of the pole-pieces, there is no waste of energy by the generation of external poles and their reversal. The winding of the wires is simple and direct, owing to each individual coil having a straight axis, and the wrapping of wire is of equal thickness on all sides.

Instead of three or four coils, we can in similar manner combine any greater number—as five, six, eight, or ten—but we prefer the combination of four individual coils.

Fig. 9 shows how the converter-coils shown in Fig. 8 are combined to form a battery. Any desired number of separate converters are placed side by side, all being screwed down to the same base, and are inclosed in a box or case, F. The primary wires are joined or coupled together in any arrangement—multiple arc, series, multiple series, or series multiple—as the judgment of the electrician may determine, and carried to the binding-posts *a a'*. The terminals of the secondary coils are in like manner joined to the binding-posts *b b'*.

The construction and arrangement shown in Figs. 8 and 9 are those preferred by us for practical use, the winding being preferably as shown in Figs. 1 and 4. These figures, in fact, show our entire invention.

We will now describe the modifications illustrated in the remaining figures.

Figs. 10 and 11 show a converter consisting of a single complete coil inclosed in an iron case, F, in which the winding is somewhat different, the alternate superposition of the primary and secondary helices being departed from. A solid core is here shown, being composed preferably of a bundle of iron wires. The primary coils are wound only on the end portions of this core, and the secondary coils are wound only on the middle portions. On each end of the core for about one-third of its length toward the middle one or two layers of the primary wire are wound, then an iron tube is slipped over, then the winding of primary wire is repeated, and so on until each end is wound with the primary wire in layers alternating with the iron tubes. Then the secondary wire *s* is wound on the middle portion of the core without the intervention of any iron tubes. The advantage is thus gained of placing the secondary wire on the neutral portion of the core where the strongest inductive effect is found.

Fig. 12 shows the same construction as Fig. 10 with the following exceptions: The central core is much shortened, being scarcely any longer than the secondary coil, and the secondary coil like the primary is built up of alternate layers of wire helices and iron tubes.

Our invention is susceptible of many other modifications in construction, which will readily suggest themselves to the practical electrician.

We are by no means confined to the use of cylindrical tubes or cores, as in some cases it may be preferred to use elliptical, polygonal, or flat cores. The inclosing-case may also be of various designs.

We claim as our invention—

1. The combination, to form a current-converter, of an iron core subdivided into two or more distinct tubes, a primary coil subdivided into two or more distinct helices alternated with said tubes, and a secondary coil arranged in inductive proximity to the subdivisions of said core, substantially as and to the effect set forth.

2. The combination, to form a current-converter, of an iron core subdivided into distinct tubes, a primary coil subdivided into distinct helices alternated with said tubes, and a secondary coil subdivided into distinct helices also alternated with the tubular subdivisions of said core, substantially as and to the effect set forth.

3. The combination, to form a current-converter, of an iron core subdivided into distinct tubes, a primary coil subdivided into distinct helices, alternated with said tubes, and a secondary coil subdivided into distinct helices alternated with the helices of the primary coil, substantially as set forth.

4. The combination, to form a current-converter, of an iron core subdivided into tubes, and primary and secondary coils subdivided into helices, with the iron tubes and wire helices arranged in alternate superposed layers, and the successive wire helices being alternately of primary and secondary wire, substantially as set forth.

5. The combination of an iron core subdivided into tubes, some or all of said tubes formed by winding iron wire into a helix with the primary coils subdivided into helices and alternated with said tubes of helical iron wire, and the secondary coil wound in inductive proximity to said tubes, substantially as set forth.

6. The combination of an iron core subdivided into tubes, some or all of said tubes formed of insulated iron wire wound into a helix, the primary coil subdivided into helices wound in alternation with said iron-wire helices, and both connected in the primary circuit, whereby alternating currents through the iron-wire helices will inductively re-enforce the alternating currents in the helices of the primary coil proper, and the secondary coil wound in inductive proximity to said iron-wire helices, substantially as set forth.

7. A converter-coil composed of an iron core subdivided into tubes, a primary coil subdivided into helices alternated with said tubes,

and a secondary coil wound in inductive proximity to said tubes, in combination with a magnetic connection extending from one pole of its subdivided core around to the opposite pole thereof, whereby sensible magnetic poles are suppressed, substantially as set forth.

8. A converter-coil composed of an iron core subdivided into tubes, a primary coil subdivided into helices alternated with said tubes, and a secondary coil wound in inductive proximity to said tubes, in combination with one or more substantially similar converter-coils, and with magnetic connections between the opposite poles of the individual converter-coils, whereby a closed magnetic circuit is formed, including the cores of the successive cores, substantially as set forth.

9. A compound converter-coil composed of two or more individual coils combined with iron pole-pieces *d d*, and fastening-bolts *e e*, passing through the respective coils and drawing together the opposite pole-pieces against the ends of the coils, substantially as described.

10. The combination, to form a battery of converter-coils, of a series of quadruple groups, each consisting of four individual coils united rectangularly through pole-pieces to form a closed magnetic circuit, a base, G, to which the said groups are fastened side by side, and a case, F, inclosing said series of groups, substantially as set forth.

In witness whereof we have hereunto signed our names in the presence of two subscribing witnesses.

GUSTAV PFANNKUCHE.
ALFR. PFANNKUCHE.

Witnesses:
ARTHUR C. FRASER,
E. B. BOLTON.