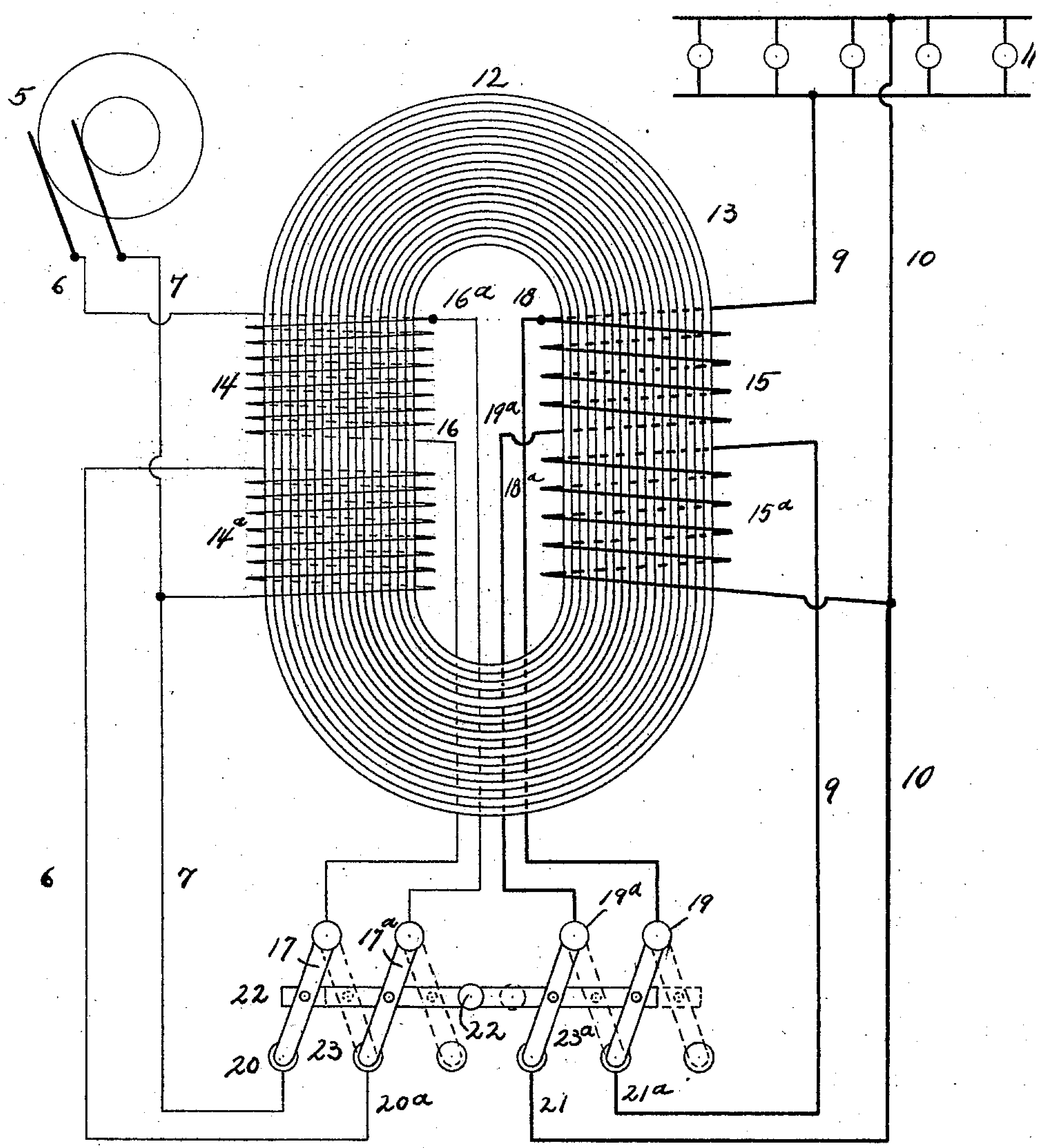
(No Model.)

F. ZICKERMANN.

ELECTRICAL TRANSFORMER.

No. 529,152. Patented Nov. 13, 1894.



WITNESSES:

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ELECTRICAL TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 529,152, dated November 13, 1894.

Application filed December 9, 1892. Serial No. 454,652. (No model.) Patented in Germany October 7, 1892, No. 73,200; in France October 31, 1892, No. 225,299; in Switzerland October 31, 1892, No. 5,934; in England November 3, 1892, No. 19,821; in Belgium November 7, 1892, No. 102,009, and in Italy April 28, 1893, No. 34,011.

To all whom it may concern:

Be it known that I, FRITZ ZICKERMANN, a subject of the King of Prussia, German Emperor, residing at the city of Berlin, Kingdom of Prussia, German Empire, have invented new and useful Improvements in Transformers, (for which Letters Patent have been obtained in England, No. 19,821, dated November 3, 1892; in Germany, No. 73,200, dated October 7, 1892; in France, No. 225,299, dated October 31, 1892; in Belgium, No. 102,009, dated November 7, 1892; in Italy, No. 34,011, dated April 28, 1893, and in Switzerland, No. 5,934, dated October 31, 1892,) of which the following is a specification.

My invention consists of a transformer so constructed that its current transforming capacity may be altered without changing the potential of the current from the source of energy, the potential of the current from the secondary terminals, or the translative relation of its elements.

The object of my invention is three-fold: First, to provide for the varying demand for current in the secondary distributing circuit fed from the transformer; second, to reduce the considerable loss of energy now occurring in distribution systems employing transformers, and due to the fact that the energy required to magnetize the core of a transformer as now constructed is a constant factor, irrespective of the work in the secondary circuit; third, to permit the capacity of the transformer to be instantaneously altered while in operation without causing any disturbance in the system in which it is included.

In electrical distribution systems employing transformers, it has been determined by observation that the maximum transforming capacity of a transformer is only required for 1.5 hours in twenty-four, and that the current required to magnetize the core amounts to three per cent. of the total energy. Hence, the present practice, where transformers are employed having constant windings, entails a loss of $\frac{24 \cdot 3}{1.5}$ which equals forty-eight per cent. of the total energy. Where a transformer is constructed according to my invention, this loss, due to the magnetization of the core, is almost entirely avoided, for reasons which will hereinafter be fully explained.

In designing my improved transformer, I make use of the fact that with a constant potential at the primary terminals, its current converting capacity depends upon the number of lines of force threading the core, and that the number of lines of force is inversely proportional to the number of turns or windings of the primary coil of the transformer. Hence, it follows, that, if a transformer be constructed with a certain size of conductors and definite number of turns on its primary and secondary coils, and the size and number of turns of the respective coils are so determined that the loss of potential, and that due to the magnetization of the core, have their usual value, certain definite translative relations will exist, and a current of a certain potential and quantity can be obtained from the secondary terminals; and, if the number of turns of the conductors of both the primary and secondary coils be correspondingly increased, the translative relations will not be altered. The same potential will exist at the secondary terminals, but the quantity of current delivered will decrease. Thus, for instance, by doubling the number of turns of both the primary and secondary coils, while preserving the potential of the current constant in the primary, the current will be decreased in proportion to the number of lamps in circuit, while the translative relations will remain the same. At the same time the energy used to magnetize the core will be one-third of that required with half the number of turns.

To carry out the principles above set forth,—that is to construct a transformer in such manner that the turns may be simultaneously added to or subtracted from the primary and secondary coils,—presents mechanical difficulties. The same result, however, may be accomplished by making use of the arrangement shown in the accompanying diagram, in which the number of turns of both the primary and secondary coils is maintained constant, but their connection to their respective primary and secondary circuits is altered; that is, the independent sections of both the primary and secondary coils are connected in parallel in their respective circuits for such time when the greatest transforming capacity is required, whereas, the independent sections of the primary and secondary coils are coupled in series and across the respective circuits, when the consumption in the distribution circuit is the smallest.

The accompanying diagram will serve to more fully explain my invention, and in which 5 indicates an alternating current generator of any suitable construction; 6 and 7, feeder conductors; 9 and 10, conductors of the distributing circuit; 11, translating devices, such as lamps connected in parallel in the distributing circuit; 12, an alternating current transformer interposed between the feeder and distributing circuit.

The transformer as shown consists of a closed magnetic core 13, made up of laminated plates of soft iron. The primary and secondary coils are each shown as composed of two sections 14—14[a], 15—15[a], and such coils are wound upon the core of the transformer in the usual manner. The ends of the section 14 of the primary coil are connected through the conductors 16—16[a], with the binding posts 17—17[a]. The section 15 of the secondary coil is similarly connected through two conductors 18—18[a] with the binding posts 19—19[a].

The conductors 6 and 7 are at one end connected to the brushes bearing on the collecting rings of the generator, and at their other ends, the conductor 6 to the beginning of coil 14 and the conductor 7 to the end of coil 14[a] and also to the contact point 20. The upper end of the coil 14[a] is connected to contact point 20[a]. The connection between the conductors 9 and 10 and the coils 15—15[a], and the conductors 18—18[a] and contact points 21—21[a] are made in a similar manner.

22 represents a plate of insulating material which connects the switch plates 23—23[a], by means of which the plates may be simultaneously shifted. When the switch plates 23—23[a] are in the position shown in full lines, the two sections of the primary coil are in parallel of the conductors 6 and 7, and the two sections of the secondary coil in parallel of the conductors 9 and 10.

The path of the primary current (parallel connection) is then as follows: By conductor 6 through coil 14, conductor 16, post 17, plate 23, point 20, conductor 7, to generator. The current from 6 divides and passes through the conductor 16[a] to point 17[a], plate 23, point 20[a], conductor 6[a], coil 14[a], conductor 7, back to generator. When the two sections of each coil are coupled in parallel, it will be observed that there are two paths for the current, and in each path there is a section of the primary coil of eight turns, and in the secondary coil of four turns; thus showing that the ratio of conversion is 8:4=2:1, but as there are two paths there is a double cross-section of conductors, and four times the current flows.

When it is desirable to reduce the capacity of the transformer and the magnetization of the core, as is advisable at times of small consumption in the distribution circuit, the switch plates 23—23[a] are shifted to the position shown in dotted lines, in which case both sections of each coil are thrown into series and the whole coil across the circuit to which it is connected.

The path of the primary current (series connection) is as follows: Conductor 6, coil 14, conductor 16, post 17, plate 23, point 20[a], conductor 6[a], coil 14[a], conductor 7, back to generator. The primary coil then consists of two by eight turns equals sixteen turns,—all of the turns being in series,—and the secondary coil two by four turns equals eight turns, also in series. Thus, while it will be observed that there is the same number of turns that there was before in the primary and secondary coils, there are in effect twice as many turns in the single path of the current, and the ratio of conversion is the same, that is, sixteen is to eight as two is to one. The connection of the primary and secondary coils to their respective circuits is substantially the same. It is therefore unnecessary to give the path of the secondary current for parallel or series connection.

Theoretically, the number of lines of force generated in the iron core by this duplication of the number of turns in a single circuit is reduced one-half, the potential at the secondary terminals remaining not exactly, but practically constant, and at the same time the energy lost in magnetizing the core is reduced to one-third of what it was when the coils were in parallel, since the energy lost is proportional to $M\frac{1}{6}$, *i. e.*, one-sixth power of M (lines of force.)

The essential characteristic of the present invention it will therefore be observed is, that if the number of turns of the primary and secondary elements included in a single primary and secondary circuit be simultaneously increased or decreased, such change acts to vary the transforming capacity of the device, as also the amount of current required to magnetize the core, without in any wise altering the translative relations of the elements of the transformer.

The principle embodied in my improvement in transformers may be utilized in converting single phase or polyphase currents. Further, my invention is not limited to a transformer having its primary and secondary coils divided into two sections. There may be any number of sections, it being understood that by increasing the number of sections the capacity of the transformer may be step by step varied from minimum to maximum load, and vice versa.

I wish it understood that I do not limit myself in any wise to the embodiment of my invention illustrated and described in the present application, as various other constructions may be made which will fully comply with the intent of my invention.

Having thus described my invention, I claim—

1. A transformer consisting of the core, a primary element, a secondary element, and means for simultaneously increasing or decreasing the number of the turns in series of the coils which form the primary and secondary elements, substantially as and for the purpose set forth.

2. A transformer consisting of a core, a sectional primary element, a sectional secondary element, and means for simultaneously increasing or decreasing the number of sections of each element in series, substantially as and for the purpose set forth.

3. A transformer consisting of a core, a sectional primary element, a sectional secondary element, and means for simultaneously connecting the sections of the primary element in parallel of the primary conductors, and the sections of the secondary element in parallel of the secondary conductors, or the sections of the primary element in series and across the primary conductors and the sections of the secondary element in series and across the secondary conductors, substantially as and for the purposes set forth.

4. A transformer consisting of a core, a sectional primary element, a sectional secondary element, and means for simultaneously altering the number of sections of the primary element in a single circuit across the primary conductors, and the number of sections of the secondary element in a single circuit across the secondary conductors, and in such a manner as not to alter the translative relation of said elements.

5. In a system of electrical distribution, the combination with a generator of electricity, a feeder circuit and a distributing circuit of a transformer interposed between the two, said transformer comprising a core, sectional primary and secondary coils thereon, and means for simultaneously altering the relation of said coil sections to the feeder and distributing circuits while maintaining their translative relations to each other.

6. In a system of electrical distribution, the combination with a generator of electricity, a feeder circuit and a distributing circuit, of a transformer interposed between the two, said transformer comprising a core, sectional primary and secondary coils thereon, and means for simultaneously altering the relation of said coil sections to the feeder and distributing circuits without altering the absolute number of turns of said coils and their translative relations to each other.

7. The combination in a transformer of a core, a primary element, a secondary element, and a device, for varying the resistance of said elements by simultaneously increasing or decreasing the number of ampère-turns of the respective elements.

8. The herein described method of varying the energy required to magnetize the core of a transformer which consists in simultaneously varying the number of ampère-turns of the primary and secondary elements of said transformer.

9. The herein-described method of regulating the capacity of a transformer, which consists in varying the number of lines of force threading the core while maintaining the potential of the primary and secondary elements and their translative relations constant.

10. The herein-described method of regulating the capacity of a transformer, which consists in varying the number of lines of force threading the core by varying the current in the primary element of said transformer while maintaining constant the potential of the primary and secondary elements, the number of coil sections forming said elements, and the translative relations of said elements.

In testimony whereof I have affixed my signature in the presence of two witnesses.

FRITZ ZICKERMANN.

Witnesses:

GUSTAV STENZEL,

MAX WAGNER.