No. 729,748. PATENTED JUNE 2, 1903.

J. J. FRANK.

ALTERNATING CURRENT TRANSFORMER.

APPLICATION FILED FEB. 2, 1903.

NO MODEL.

Fig. 1.

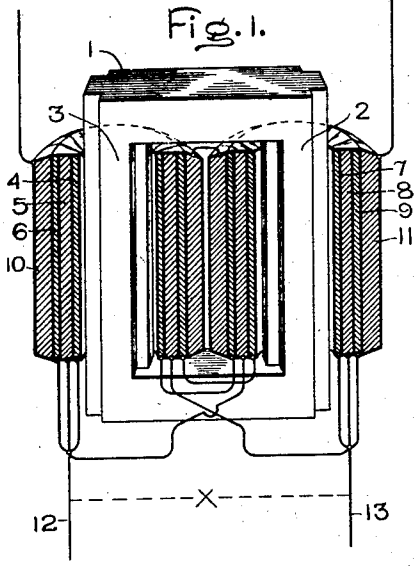


Fig. 2.

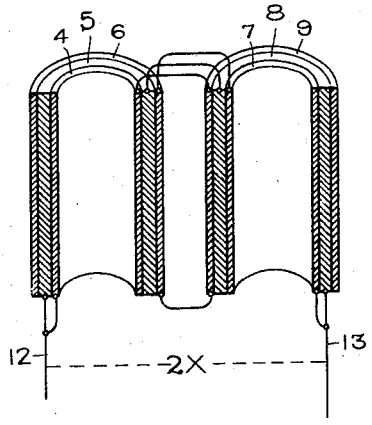


Fig. 3.

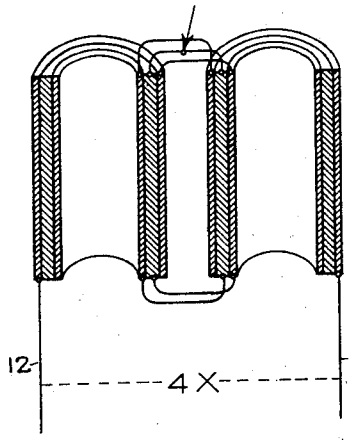


Fig. 4.

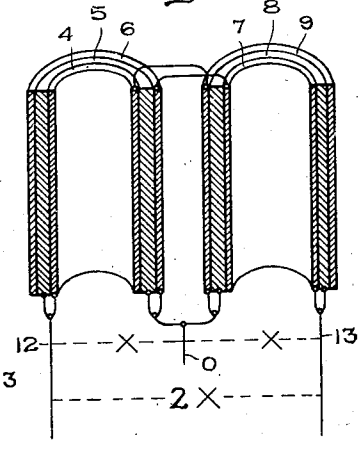
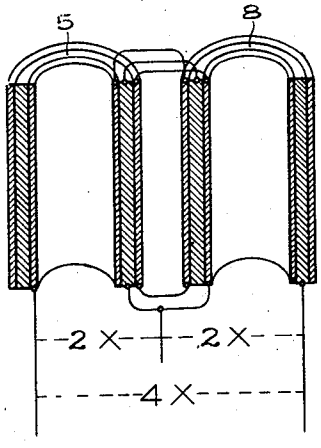


Fig. 5.



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Atty

No. 729,748. Patented June 2, 1903.

UNITED STATES PATENT OFFICE.

JOHN J. FRANK, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ALTERNATING-CURRENT TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 729,748, dated June 2, 1903.

Application filed February 2, 1903. Serial No. 141,602. (No model.)

To all whom it may concern:

Be it known that I, JOHN J. FRANK, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Alternating-Current Transformers, of which the following is a specification.

My invention relates more especially to alternating-current transformers of that class known in practice as the "core" type. As usually constructed the core of such a transformer is rectangular in shape, with the coils mounted on two of the parallel legs of the core. In case it is desired to provide either a primary or a seconday winding for such a transformer with a plurality of coils for connection in various combinations to secure different voltages the difficulty has heretofore arisen that when the coils are connected in certain combinations for use with a three-wire system there is an unbalancing of the voltage on the three-wire system when its sides are unequally loaded, while in the case of coils multiply connected to a two-wire circuit there may be an unequal division of current between the coils, due to the different reactances of the coils, arising from the fact, for example, that one coil may be inside and another outside. In accordance with my invention I have provided an arrangement of transformer-coils such that connections may be made to three-wire systems of different voltages and also such that the coils may be connected so as to give any one of a number of different voltages, all of these connections being such as to avoid inequalities in the division of current between the coils when connected to a two-wire circuit and to avoid an unbalancing of voltage with unbalanced load when connected to three-wire circuits.

The features of novelty which characterize my invention I have pointed out with particularity in the appended claims, while the invention itself, as exemplified by one of the numerous embodiments of which it is capable, I have described in detail in the following specification, which is to be taken in connection with the accompanying drawings, in which—

Figure 1 represents a transformer built in accordance with my invention, Figs. 2, 3, 4, and 5 representing various connections which may be made between the coils of the transformer shown in Fig. 1.

In Fig. 1 the core of the transformer provides a single magnetic circuit and is rectangular in shape, as indicated at 1. Primary and secondary coils are located on each of the parallel legs 2 and 3 of the core. In the present instance I have represented all of the coils on each leg as located concentrically with respect to each other one over the other. There are three secondary coils on each leg of the core, these secondary coils being indicated for convenience of illustration in cross-section at 4 to 9, inclusive. Outside of these secondary coils are located the respective primary coils 10 and 11. The primary coils may be connected in series, as indicated, or in multiple, as desired. The secondary coils are capable of various interchangeable connections, as indicated in the several figures of the drawings. Before proceeding to a detailed description of these connections it may be as well to remark that it is merely for convenience that I have referred to one set of coils as "primary" and the other set of coils as "secondary," since it will be evident to one skilled in the art that these coils are interchangeable in function. Where, therefore, a coil is here spoken of as a "primary" coil, it is to be understood and is here contemplated that the coil may be used as a secondary, and vice versa, without departing from my invention.

As before mentioned, there are three secondary coils on each leg of the transformer, the inside coil 4 and the outside coil 6 each being of a voltage one-half that of the intermediate coil 5. Thus, for example, the intermediate coil 5 may be a one-hundred-volt coil and the adjacent inside and outside coils be adapted each for fifty volts. The three coils 7 8 9 on the leg 2 correspond in voltage to the coils 4, 5, and 6. If it be desired to connect the coils for a voltage equal to that for which the middle coils 5 and 8 are respectively adapted, which voltage I may term "X," I make use of the arrangement shown in Fig.

1. By reference to this figure it will be seen that the outside coil 6 on one leg, of a voltage $\frac{x}{2}$ is connected in series with the inside coil 7 on the other leg, of the same voltage $\frac{x}{2}$, these two coils as thus connected in series being then connected across the mains 12 and 13. In addition the middle coils 5 and 8 are connected in multiple with each other across the mains 12 and 13. Similarly the outside coil 9 on the leg 2 is in series with the inside coil 4 on the other leg 3, the free terminals being then connected across the mains 12 and 13. With the arrangement shown it will be evident that the reactance of each of the parallel circuits across the mains 12 and 13, formed by the individual coils 5 8 and the pairs of series-connected coils 6 7 and 4 9, is the same, thus insuring an equal division of current between the respective coils.

In case the maximum voltage is desired from the set of coils they may be all connected in series, as indicated in Fig. 3, thereby giving a voltage equal to four times that of the coil 5, or $4x$. The order of connection of the coils is such that the circuit passes first through an outside coil on one leg, an inside coil on the other leg, the middle coil on the first leg, the middle coil on the second leg, the inside coil on the first leg, and then through the outside coil on the second leg. In case it is desired to connect the coils to a three-wire system the neutral conductor may be connected to the point indicated by the arrow, this point being so located in the circuit that on each side thereof is connected in sequence one of the middle coils, an inside coil of one leg, and an outside coil of another leg. This arrangement insures freedom from unbalanced voltages between the two sides of the three-wire system when these sides are unequally loaded.

Fig. 2 represents the connections suitable for coöperatively joining the windings, so as to render them suitable for a voltage twice that of the middle coils 5 8, represented by $2x$. It will be seen by reference to this figure that the coils 5 8 are in series with each other across the mains 12 13, so as to form one parallel circuit, the other parallel circuit being afforded by a series connection of the remaining coils, such that the circuit first passes through the inside coil, as 4, on one leg of the transformer, then through the outside coil 9 on the other leg of the transformer, then back through the outside coil 6 of the first leg, the circuit being completed through the remaining inside coil 7 on the other leg. It is, however, not particularly essential as to the order in which the circuit traverses the respective inside and outside coils, since they are all in series. Due to the fact, however, that these coils are located one inside and one outside of each middle coil, the reactance of all of these coils in series is the same as the reactance of the two middle coils in series, so that the current divides equally between the two circuits multiply connected across the mains 12 13 in Fig. 2.

In Fig. 4 the coils are connected to a three-wire system in such a manner that the voltage on each side of the system is the same as the voltage corresponding to that of the middle coils 5 and 8, the voltage between the outside mains of course being twice this voltage, or $2x$. By reference to this figure it will be noted that one of the middle coils, as 5, is connected between the neutral conductor and one main of the system and the other middle coil, 8, between the neutral conductor and the other main of the system. The remaining coils are connected so that the outside coil on one core-leg is in series with the inside coil on the other leg across one side of the three-wire system, the two remaining inside and outside coils being in series across the other side of the system. Thus, as indicated, the coils 6 7 are in series between the neutral 0 and the main 13 and the two remaining coils 4 9 in series between the neutral and the main 12. It will therefore be evident that current flowing on either side of the three-wire system traverses coils on both legs of the transformer, thus preventing the unbalancing of voltage which would otherwise take place with unbalanced load.

Fig. 5 shows another arrangement for connecting up the coils to a three-wire system so as to secure maximum voltage between the outside mains. In this case it will be readily seen that the two middle coils 5 8 are in series with each other across one side of the three-wire system and the remaining or half-voltage coils in series with each other across the other side of the system, the connections differing somewhat from those shown in Fig. 3.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a transformer, the combination of a core having a single magnetic circuit, sets of coils located on said core at a distance from each other, each set of coils consisting of three coils located one over the other, the middle coil being adapted to a voltage which is a multiple of that for which the corresponding inside and outside coils are adapted, and connections between all of said coils.

2. In a core-type transformer, the combination of the core, primary and secondary coils located on each of two legs of said core, one of the sets of coils consisting of three superposed coils on each leg of said core, the middle coil of each set of three coils being adapted to a voltage twice that of the other two.

3. In a core-type transformer, the combination of the core, three coils on each of two legs of the core, two of the coils being of half the voltage of the third, a three-wire system of mains, connections between the higher-voltage coils and said mains, and other connections between the lower-voltage coils and said mains.

4. In a core-type transformer, the combination of coils thereon of different voltages, and connections between said coils and a single-current-carrying system.

5. In a core-type transformer, the combination of sets of coils of different voltages located on the core and separated from each other, and connections joining a plurality of the low-voltage coils in series with each other in a circuit connected in multiple with one or more of the high-voltage coils.

6. In a transformer, the combination of two sets of coils, each set consisting of a relatively high voltage coil sandwiched between two low-voltage coils, and connections between all of said coils and a current-carrying system.

7. In a transformer, the combination of a core having a suitable magnetic circuit, and two sets of coils located on said core at a distance from each other and adapted to operate either as primary or secondary coils, each of said sets of coils consisting of a relatively high voltage coil sandwiched between two low-voltage coils.

8. In a transformer, the combination of a core having a suitable magnetic circuit, and two sets of coils located on said core at a distance from each other and adapted to operate either as primary or secondary coils, each of said sets consisting of three superposed coils, the middle coil being adapted to a voltage which is a multiple of that to which the inner and outer coils are adapted.

In witness whereof I have hereunto set my hand this 30th day of January, 1903.

JOHN J. FRANK.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.