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TRANSFORMER VOLTAGE REGULATING SYSTEM

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Fig. 1.

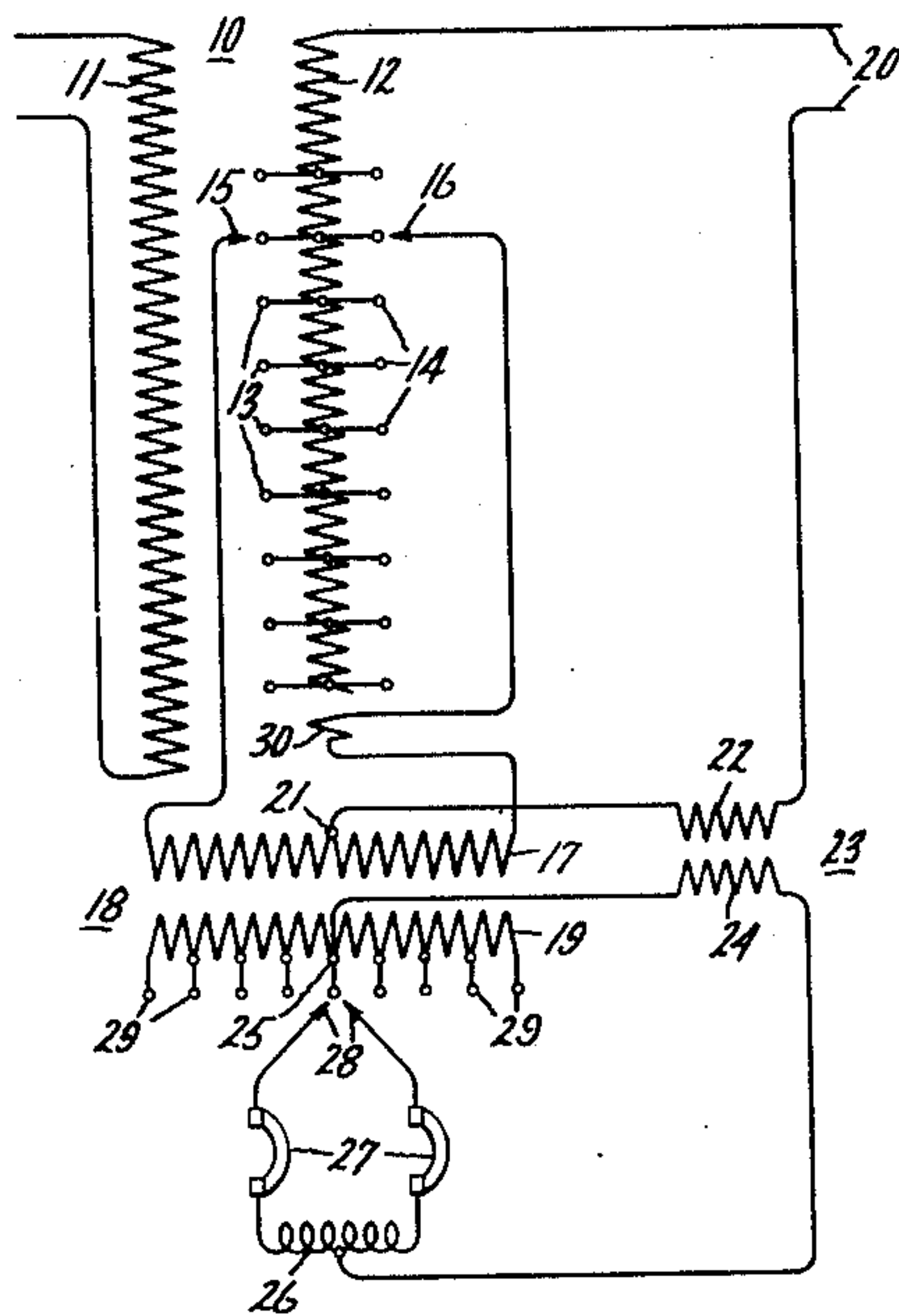


Fig. 4.

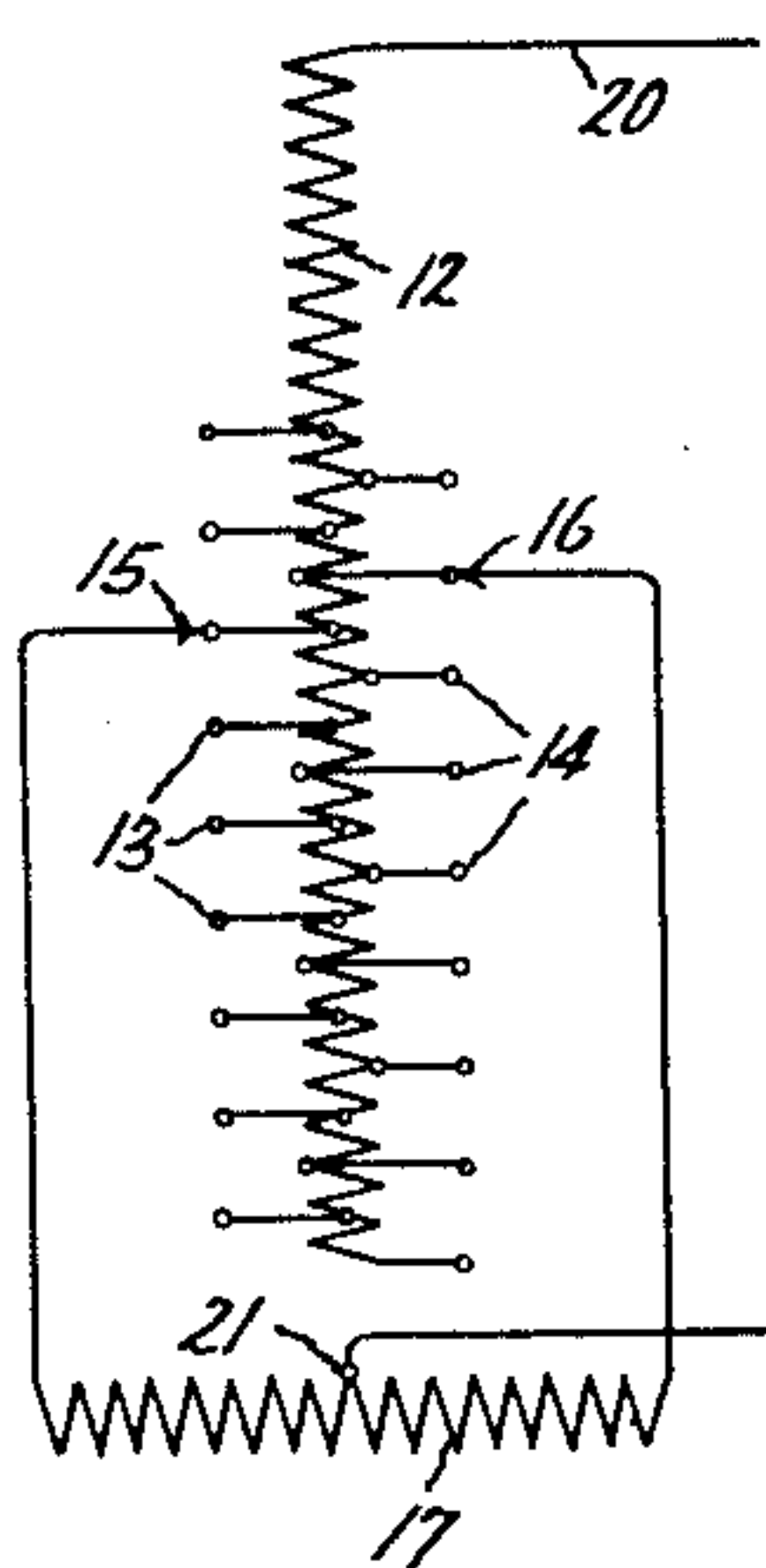


Fig. 2.

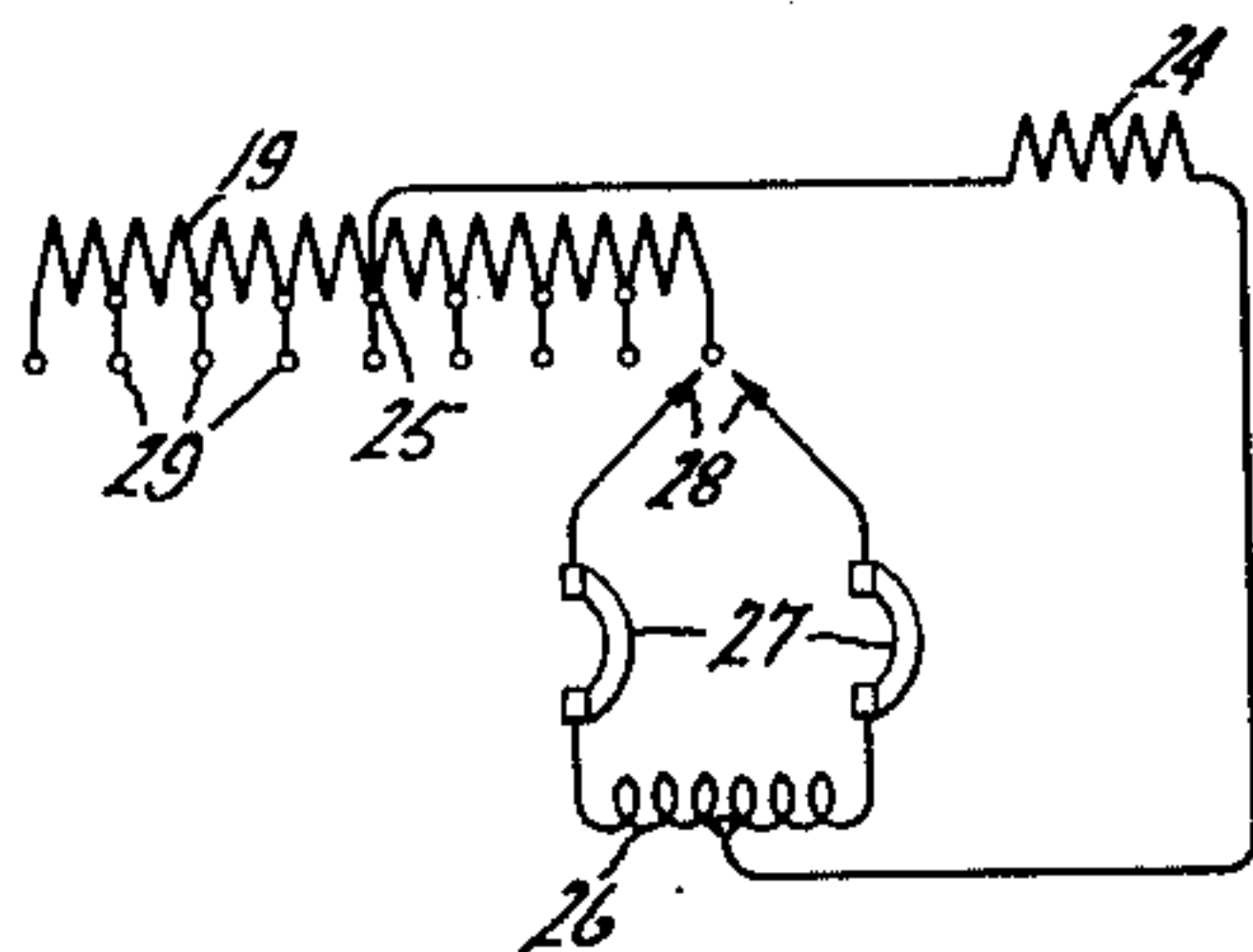
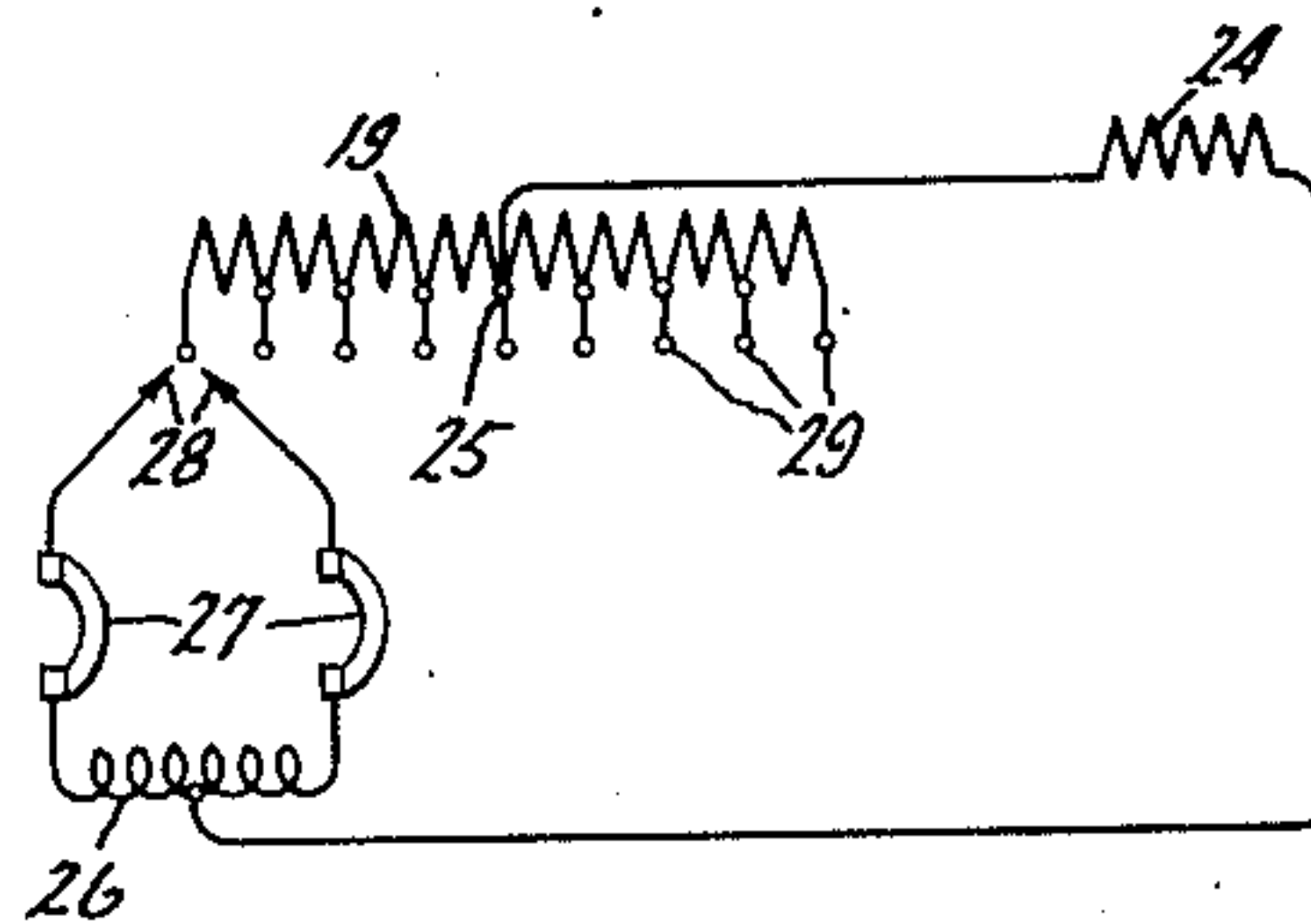


Fig. 3.



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## UNITED STATES PATENT OFFICE

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## TRANSFORMER VOLTAGE REGULATING SYSTEM

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4 Claims. (Cl. 171—119)

My invention relates to transformer voltage regulating systems. Such systems have been proposed and used for regulating or adjusting the voltage ratio of a transformer without interrupting its load. The voltage regulating mechanism often includes switches which must open and close while carrying a substantial part of the load current of the transformer and which must therefore be large and expensive if the capacity of the transformer with which they are used is large. The general object of the invention is to provide an improved transformer voltage regulating system including switches arranged to open and close only while they are carrying little or no current. One advantage of the invention is that the necessary switches may be small and inexpensive and may last a long while in service.

Other objects and advantages will be explained in the following description taken in connection with the accompanying drawing in which Fig. 1 is a diagrammatic view of the primary and secondary windings of a transformer provided with voltage regulating means arranged in accordance with the invention; Fig. 2 shows a modified arrangement of one of the transformer windings; and Figs. 3 and 4 are detail diagrammatic views indicating different positions of the regulating switches shown in Fig. 1.

Like reference characters indicate similar parts in the different figures of the drawing.

The transformer 10 indicated in the drawing includes two windings 11 and 12, the winding 12 being provided with taps connected to two series of fixed contacts 13 and 14. Two contacts 15 and 16, movable over the contacts 13 and 14 respectively, are connected to the opposite ends of a winding 17 of a regulating transformer 18 having a second winding 19. One side of an external circuit 20 is connected to one end of the winding 12. The other side of the circuit 20 is connected to a center tap 21 of the winding 17 through one winding 22 of a series transformer 23 which has a second winding 24. The winding 24 is connected between a center tap 25 of the winding 19 and the center of a small reactor winding 26. The ends of the reactor winding 26 are connected through circuit breakers 27 to two contacts 28 which are movable over a series of fixed contacts 29 connected to taps distributed throughout the length of the winding 19.

In the arrangement shown in Fig. 1, each tap of the winding 12 is connected to one of the contacts 13 and also to one of the contacts 14 and the movable contacts 15 and 16 may therefore be

connected either to the same tap or to adjacent taps. The movable contact 16 is connected to the winding 17 through a coil 30 having a small number of turns and inductively coupled with the windings 11 and 12, the voltage induced in this coil being equal to one half the voltage between adjacent taps of the winding 12. Thus, when the contacts 15 and 16 are connected to the same tap of the winding 12, a voltage equal to one half that between adjacent taps is impressed across the winding 17. When the movable contacts 15 and 16 are connected to adjacent taps of the winding 12 and with the voltage between these taps opposed to that of the coil 30, a voltage also equal to one half that between adjacent taps is impressed across the winding 17 but reversed with respect to the direction of the voltage impressed when the contacts 15 and 16 are connected to the same tap. This arrangement, therefore, requires only half as many taps as there are operating positions of the movable contacts 15 and 16.

In the arrangement shown in Fig. 4, the successive taps of the winding 12 are connected alternately to the fixed contacts 13 and 14. Thus, as the movable contacts 15 and 16 are moved alternately along the fixed contacts, equal and opposite voltages are successively impressed across the winding 17, the result being the same as with the arrangement of Fig. 1 but as many taps being required as there are operating positions of the movable contacts.

During normal operation of the system, the movable contacts 28 of the regulating transformer 18 are connected to the center tap 25 of the winding 19 as shown in Fig. 1 so that there is no current in this winding 19. Under these conditions, the current in the winding 12 divides, one part flowing through the movable contact 15 and the corresponding half of the winding 17 and the other part flowing through the movable contact 16 and the corresponding half of the winding 17.

The voltage ratio of the transformer 10 may be adjusted or regulated as desired by changing the positions of the movable contacts 15 and 16 and thus changing the effective number of turns in the winding 12. In order to do this without interrupting the normal currents through the contacts 15 and 16 with consequent arcing and injury to these contacts, the movable contacts 28 of the regulating transformer 18 are first shifted to one end of the winding 19 as shown in Fig. 2. The contacts 28 may be shifted one at a time to successive fixed contacts 29, the circuit through each contact 28 being broken as its posi-



tion is changed by the corresponding circuit breaker 27 to prevent injury to the contact, and the reactor 26 preventing excessive circulating current through the reactor, the circuit breakers 27 and the contacts 28 while these contacts are connected to separate contacts 29. Now, with the contacts 28 at one end of the winding 19 as shown in Fig. 2, the load current in the winding 22 of the series transformer 23 induces a voltage in the winding 24 which forces a current through the half of the winding 19 between its center tap 25 and the contacts 28. This induces a voltage in the winding 17 which opposes the current through the contact 15 and the corresponding half of the winding 17. The windings of the regulating transformer 18 and the series transformer 23 are preferably so proportioned that, with the contacts 28 at one end of the winding 19 as shown in Fig. 2, the current through the contact 15 is reduced substantially to zero. This contact 15 may now be shifted to the adjacent fixed contact 13 with little or no arcing and no injury to the contacts because they are carrying little or no current. The contacts 28 may now be shifted back to the normal operating position at the center tap 25 of the winding 19 and the number of effective turns in the winding 12 and therefore the voltage ratio of the main transformer 10 have been changed one step. If further adjustment or regulation of the voltage ratio of the main transformer 10 is desired, the movable contacts 28 may now be shifted to the other end of the winding 19 as shown in Fig. 3. This will reduce the current in the contact 16, preferably substantially to zero, in a manner similar to that already described in connection with the contact 15. The contact 16 may then be shifted to the adjacent fixed contact 14, and the contacts 28 then shifted back to normal operating position at the center of the winding 19. It is obvious that the contacts 15 and 16 may be shifted as described in either direction till the voltage ratio of the main transformer 10 has been adjusted as desired.

The invention has been explained by describing a particular form of the invention but it will be apparent that changes may be made without departing from the spirit of the invention and the scope of the appended claims.

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

1. A transformer including a winding provided with a plurality of tap connections, two contacts movable along said tap connections, a regu-

lating transformer having a winding connected between said movable contacts, a series transformer having one winding connected to an intermediate point of said regulating transformer winding, and means including a second winding of said series transformer to shift current from either of said contacts to the other, whereby the current in either contact may be reduced to permit it to be opened without injury.

2. A transformer including a winding provided with a plurality of tap connections, two contacts movable along said tap connections, a regulating transformer having a winding connected between said movable contacts, a series transformer having one winding connected to an intermediate point of said regulating transformer winding, said regulating transformer having a second winding provided with tap connections, said series transformer having a second winding with one end connected to said second regulating transformer winding, and means for connecting the other end of said second series transformer winding to selected tap connections of said second regulating transformer winding.

3. A transformer including a winding provided with a plurality of tap connections, two contacts movable along said tap connections, a regulating transformer having a winding connected between said movable contacts, a series transformer having one winding connected to an intermediate point of said regulating transformer winding, said regulating and series transformers each having a second winding, and means for connecting said second series transformer winding across a selected portion of said second regulating transformer winding.

4. A transformer including a winding provided with a plurality of tap connections, two contacts movable along said tap connections, a regulating transformer having a winding connected between said movable contacts, a series transformer having one winding connected to an intermediate point of said regulating transformer winding, said regulating transformer having a second winding provided with a plurality of tap connections, said series transformer having a second winding with one end connected to an intermediate point of said second regulating transformer winding, and means for connecting the other end of said second series transformer winding to a selected tap connection of said second regulating transformer winding.

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