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2,904,743

VOLTAGE REGULATING TRANSFORMER

Filed June 20, 1956

2 Sheets-Sheet 1

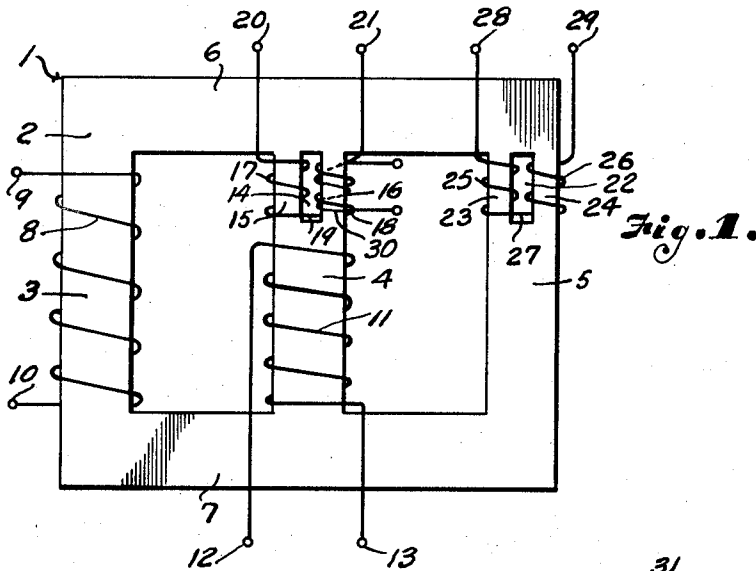


Fig. 2.

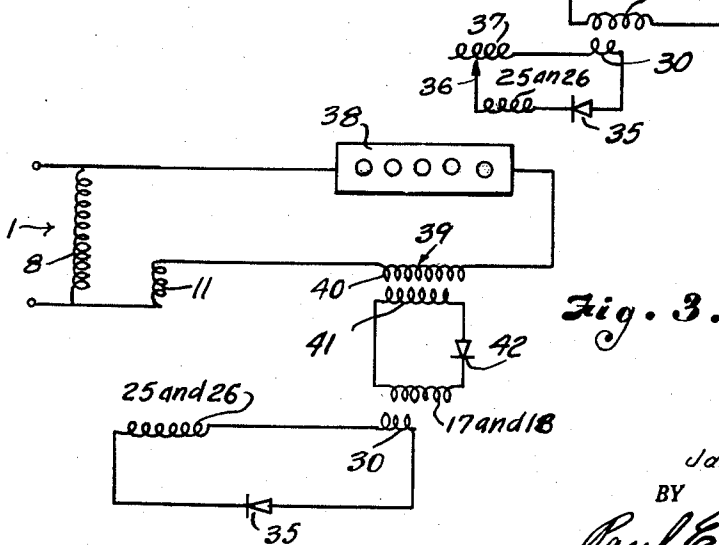
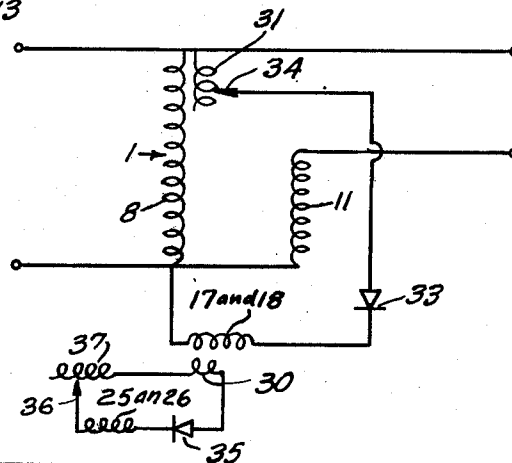


Fig. 3.

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Fig. 4.

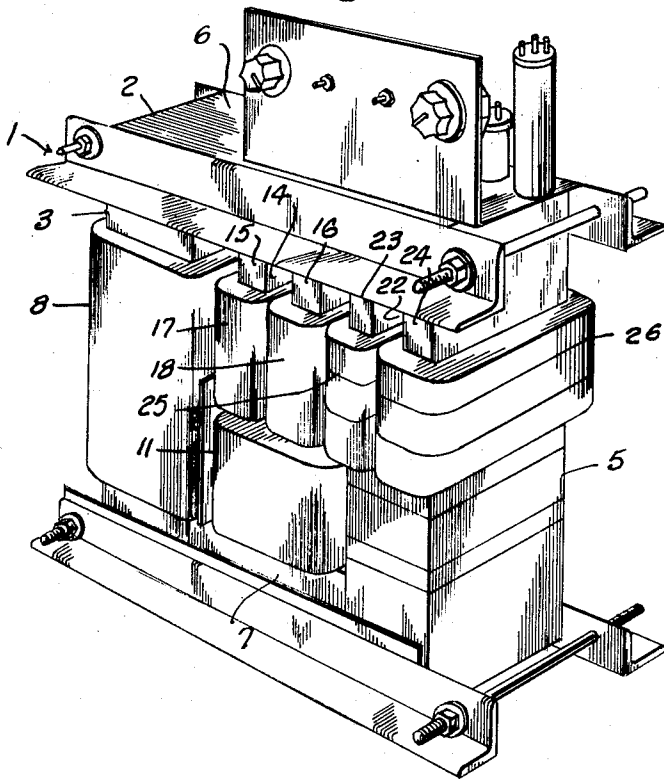
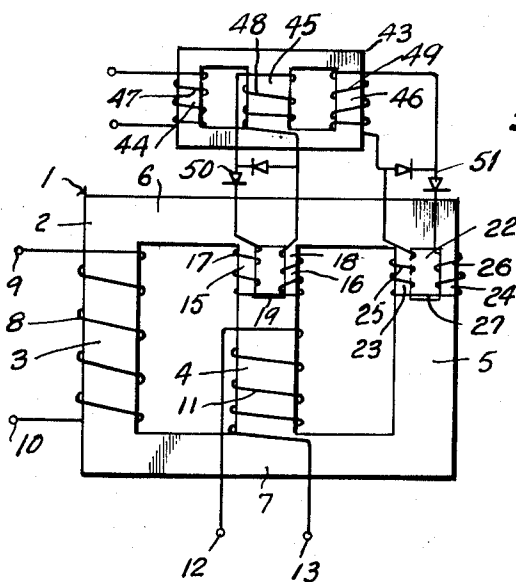


Fig. 5.



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VOLTAGE REGULATING TRANSFORMER

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2 Claims. (Cl. 323—56)

This invention relates to an electric current transformer and has for its principal object to provide a voltage regulating transformer and circuits therefor to maintain an output current having a constantly uniform voltage regardless of fluctuation in voltage of the input current.

Other objects of the invention are to provide transformer mechanisms for use as a manual variable voltage source, an automatic self-voltage-regulator, and a constant current transformer.

A further object of the invention is to provide a transformer with means for controlling the voltage of the secondary current responsive to a control of saturation in the core portion of the transformer which carries the secondary winding.

It is also an object of the invention to provide a transformer wherein the voltage of the output current may be stepped up or down and maintained substantially constant for the new value.

A further object of the invention is to provide a transformer mechanism which functions as a magnetic amplifier in producing direct currents of very large magnitude relatively to the initial alternating current supplied to the transformer mechanism.

In accomplishing these and other objects of the invention as hereinafter pointed out, I have provided improved structure, the preferred forms of which are illustrated in the accompanying drawings, wherein:

Fig. 1 is a side elevational view of the basic core and coil arrangement of a transformer embodying the features of the present invention for producing an alternating current of constant uniform voltage with an input current of variable voltage.

Fig. 2 is a diagrammatic view of the voltage regulating circuit in which the transformer is connected for maintaining automatically any predetermined output voltage.

Fig. 3 is a diagrammatic view of a circuit for automatically maintaining an output current having a constantly uniform voltage.

Fig. 4 is a perspective view of the transformer.

Fig. 5 is a diagrammatic view of the transformer in a circuit for producing direct currents of relatively large magnitude.

Referring more in detail to the drawings:

1 designates the basic transformer for converting an alternating current from an established primary source to an induced secondary current of different value but having a constantly uniform voltage. The transformer 1 includes a core 2 composed of preferably silicon steel laminations and shaped to provide parallel leg portions 3, 4 and 5. The leg portions 3, 4 and 5 are connected at their respective ends by bar portions 6 and 7 to form closed magnetic circuits. The leg portion 3 carries a primary winding 8 having terminals 9 and 10 for connection with an established source of primary current which may have a fluctuating voltage, for example, a high tension electric transmission system. Similarly carried on the leg portion 4 is a secondary winding 11 and which

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has a number for turns relatively to the turns of the primary winding to give an induced alternating current at the terminals 12 and 13 which has a voltage of desired magnitude such as may be safely used to supply, for example, a house circuit. It is to be understood, however, that the purpose of the transformer is for explanatory purposes only, and that the invention is adapted to transformers of various input and output capacities.

When the input current flows in the primary winding 8 a magnetic field is set up in the coil to magnetize the core first in one direction and then in the other to set up a magnetic induction or flux which produces an alternating electromotive force or current in the secondary winding 11.

The function of the current flow in the primary winding and the induced flow in the secondary winding as thus far described is in accordance with any conventional transformer and any change in voltage of the input current to the primary winding results in a corresponding fluctuation in the voltage of the output current from the secondary winding, with the result that the various appliances that may be connected in the house circuit do not operate efficiently or in accordance with their rated capacities. The fluctuation in voltage of the output current is caused by variation of the magnetizing force which results from the primary current, which in turn results in variation of the magnetic induction or flux that generates the secondary current in the secondary winding of the transformer. In overcoming this difficulty the present invention contemplates an inversely variable magnetic force which is induced into the core of the transformer for maintaining a balanced magnetic induction or flux regardless of variation in the voltage of the input current. By maintaining a balanced or uniform flux in the core of the transformer, an output current of constantly uniform voltage is generated in the secondary winding of the transformer. In obtaining this result, the secondary winding 11 is placed at one end of the leg portion 4 of the core and an opening 14 is provided through the opposite end of the leg portion and immediately adjacent its connection with the bar portion 6. The opening through the leg portion 4 thus provides branch legs 15 and 16. Mounted on the branch leg portions 15 and 16 are oppositely wound coils 17 and 18, respectively, having the ends adjacent the secondary winding interconnected as indicated at 19 and their opposite ends connected with terminals 20 and 21 for connection with a direct current which fluctuates in accordance with fluctuation of the input current. The coils 17 and 18 are thus connected in series for flow of the direct current there-through in a continuous direction. However, since the coils 17 and 18 are wound in opposite directions the induced alternating current generated therein is of opposite polarity with the result that the fundamental frequency component of the alternating current at the terminals 20 and 21 is zero and only the magnetism induced by the direct current is utilized in effecting saturation of the branch portions of the leg 4.

The leg portion 5 of the transformer is similar to the leg portion 4 in that it is also provided with an opening 22 to provide branches 23 and 24 at the end immediately adjacent the bar 6. Mounted on the branches 23 and 24 are coils 25 and 26 which are wound reversely to each other and connected together at one end as indicated at 27 with their opposite ends connected to terminals 28 and 29 in that no alternating current component of fundamental frequency can flow through these coils. The coil 18 on the branch 16 of the leg 4 also has a small alternating current winding 30 concentric therewith to provide an alternating current that is rectified for supplying a direct current voltage to the coils 25 and 26 on the branches 23 and 24 of the leg portion 5, which current

produces a magnetic force which is inverse in intensity to that generated by the coils 17 and 18.

Fig. 2 shows one form of circuit which includes the transformer 1 as just described, wherein a manually operated auto transformer 31 can be used for supplying a variable direct current to the coils 17 and 18 in such fashion that the current in the secondary winding 11 may go from zero value to full value depending upon the setting of an auto transformer 31. The induced alternating current in the winding of the auto transformer is used to supply a direct current to the coils 17 and 18. This is effected by connecting one of the terminals, for example, the terminal 20, with one terminal of a current rectifier 33 and the other terminal 21 with the primary supply. The movable contact element 34 of the rheostat is connected with the opposite terminal of the rectifier whereby the primary current is rectified and a correspondingly variable voltage direct current is supplied to the terminals 20 and 21 of the coils 17 and 18.

The induced current in the coil 30 is converted to a direct current by means of a rectifier 35 that is connected with the movable element 36 of a rheostat 37, one end of which is connected to one terminal of the coil 30, the other terminal of the coil 30 being connected with the rectifier 35.

The method used to maintain a constant voltage of the output current across the terminals 12 and 13 of the secondary winding with a variable input voltage across the terminals 10 and 9 of the primary winding 8 is as follows for a flat compound automatic operation with the transformer connected as an auto voltage regulator as shown in Fig. 2.

For example, assuming that the input voltage in the primary winding 8 decreases in value, the voltage of the rectified current across the terminals 20 and 21 of the coils 15 and 16 likewise decreases in value. This causes a decrease in saturation in the branch portions of the leg 4 to permit an increase of A.C. flux through the leg 4. The increase in A.C. flux is directly in proportion to the decrease in voltage of the input current across the terminals 9 and 10 of the primary winding 8. The increased A.C. flux through the leg 4 of the transformer will generate an increased voltage of the current induced in the A.C. coil 30, which alternating current is fed through the rectifier 35 and adjustable reactor to supply a direct current to the coils 25 and 26 which results in increased saturation in the leg 5 of the transformer which causes the flux in the legs 4 and 5 to stabilize and enable the winding 11 to carry its full rated load without a shift or change of flux between the legs 4 and 5 of the transformer.

In case the voltage should increase across the terminals 9 and 10 of the primary winding, the reverse procedure takes place with an increased saturation in the branch portions of the leg 4 because the voltage across the terminals 20 and 21 increases in value. Increased saturation in the branch portions 15 and 16 of the leg 4 permits a decrease of A.C. flux through the leg 4. The decreased A.C. flux through the leg 4 will generate a current having a smaller voltage in the A.C. coil 30. This current of decreased voltage is fed through the rectifier 35 to the control coils 25 and 26, thus decreasing saturation of the leg 5 so that the flux remains stable between the legs 4 and 5 to enable the secondary winding to carry the rated load as set by the rheostat 36.

The apparatus as above described may be incorporated with a manually operated rheostat to supply the direct current to the coils 17 and 18 and coils 25 and 26 in such a manner that they are varied so that the output current will go from zero value to full value depending upon the setting of the rheostat. By this means of control approximately 30 watts of D.C. power can control, for example, 10,000 kva. of A.C. power, and has application for voltage regulators and variable sources of voltage.

When used as a magnetic amplifier, it is possible to connect the device for use as a constant current transformer such as is used in series street lighting circuits, as illustrated in diagram in Fig. 3 of the drawings. In this figure, 38 designates a street lighting circuit that is supplied with current by means of the secondary 11 of the transformer 1. 39 designates a conventional transformer that is connected in the load circuit. The primary winding 40 of the transformer 39 is connected in the lighting circuit and the secondary winding 41 is connected with the coils 17 and 18 of the transformer as previously described, with a rectifier 42 being connected in the circuit. When the load current increases, the voltage output of the transformer 39 likewise increases in value and the increased A.C. voltage is rectified and applied as a direct current in the control coils 17 and 18 on the branches of the leg 4 of the core of the transformer 1. This increases the saturation of the leg 4 and decreases the A.C. flux therethrough, thus reducing the induced current in the primary 11 so that the output voltage is maintained substantially constant. The principle of using the reduced A.C. flux in the coils 17 and 18, which is the source of supply for the coils 25 and 26 on the branches of the leg 5 whereby the A.C. flux is divided and stabilized between the legs 4 and 5, remains the same, so that a variable output voltage may be maintained which will range at a straight line relation over considerable range of variable impedance within the load connected to the transformer 39.

In the form shown in Fig. 5, the invention is shown in association with a conventional transformer 43 having spaced apart legs 44, 45 and 46 for carrying a primary winding 47, a secondary winding 48 and a secondary winding 49, respectively. The primary winding 48 may be supplied with an alternating current from any suitable source for inducing secondary currents in the windings 48 and 49 for respectively applying a direct current to the coils 17—18 and 25—26, the windings 48 and 49 being connected in series with dry plate rectifiers 50 and 51 which have a very low resistance in the forward direction of the rectifier and a very high resistance in the reverse direction of the rectifier. By connecting the polarity of each rectifier with the windings, as shown in the diagram, there appears across the rectifier a voltage corresponding to each half cycle depending upon the phase relationship of the windings 48 and 49. By this method it is possible to use dry plate rectifiers of very small capacity for a source to feed direct current to the coils on the branches of the legs 4 and 5 of the core 2 and have direct currents of relatively large magnitude, for example, it is possible to use a rectifier which has a capacity of only 400 or 500 milliamperes and connect them to the transformer unit and have a D.C. output of 50 amperes.

From the foregoing it is obvious that I have provided an apparatus for producing a constant output current or an output current having a variable or constant-variable voltage. It is also obvious that the features of the invention may be incorporated in a magnetic amplifier for producing greatly amplified currents.

What I claim and desire to secure by Letters Patent is:

1. An apparatus for transforming an alternating current having a fluctuating voltage to an alternating current of different value and of uniform voltage, including a core having three spaced apart parallel leg portions interconnected at their opposite ends by bar portions to provide closed paths for the magnetic forces produced in said core, a primary winding on one leg of the core and having terminals adapted to be connected with the alternating current supply of fluctuating voltage, a main secondary winding on another of the legs of the core in which the alternating current of different voltage value is generated responsive to the induction of the current flow in the primary winding, said leg of the core having the main secondary winding and the remaining leg

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of the core having divided portions, a winding on each of the divided portions of the leg carrying the main secondary winding and having opposite polarity whereby induced alternating current has no influence on the flux in said core, a circuit connecting the current supply of the primary winding to the pair of windings, a current rectifier in the last-named circuit whereby a variable direct current is supplied to the pair of windings for inducing magnetism in said core, windings on the divided portions of the remaining leg of the core and having opposite polarity, a smaller secondary winding on one of the divided portions of the leg carrying the main secondary winding to provide an alternating current induced by the current flow through the primary winding, a circuit connecting the smaller secondary winding with the windings on the divided portions of said remaining leg, means in said last-named circuit for rectifying the secondary alternating current supplied by the smaller secondary winding for producing a magnetic force in said core of inverse

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intensity to the magnetic force produced by the windings on the leg carrying the main secondary winding for maintaining a desired resultant magnetism in the core to establish a uniform voltage of the secondary current generated in the main secondary winding.

2. An apparatus for transforming an alternating current having a fluctuating voltage to an alternating current of different voltage and of uniform value as described in claim 1, and means in the circuits for supplying current to said windings of opposite polarity to control the voltages of direct currents supplied to said windings.

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