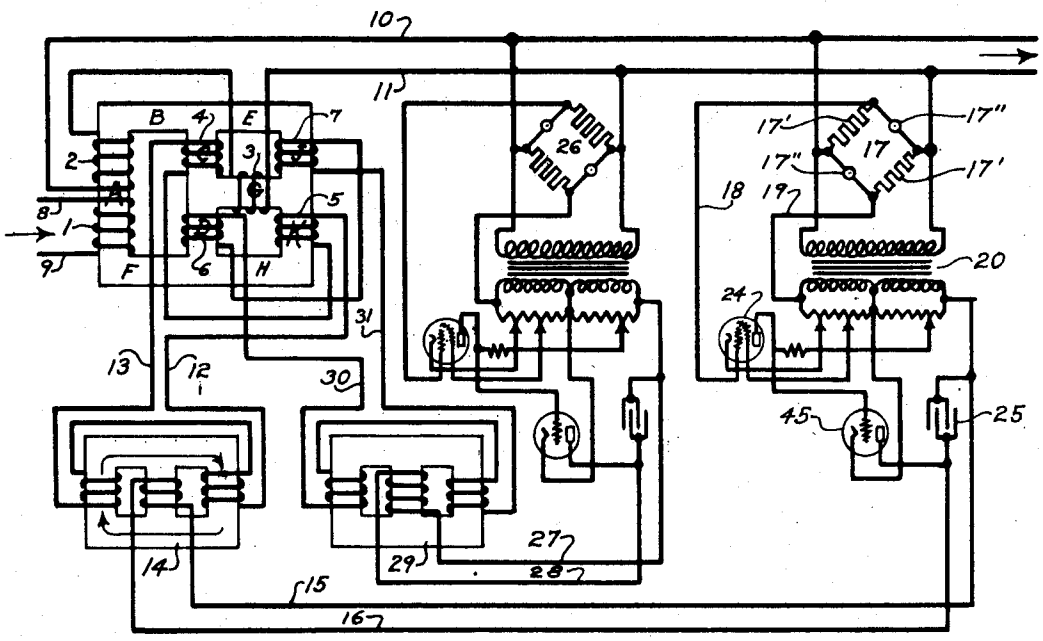
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VOLTAGE REGULATING EQUIPMENT

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VOLTAGE REGULATING EQUIPMENT

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One purpose of this invention is to provide a transformer means whereby the voltage of a circuit for the distribution of electrical energy may be increased automatically when the load in the circuit is increased and the voltage tends to decrease, thereby tending to prevent excessive voltage drop in parts of the circuit fed by the transformer. Another purpose is to provide a transformer of which the secondary output remains constant in voltage although the supply voltage to it may vary over a given range. Another purpose is to provide a voltage regulator applicable for use remote from the source of power, whereby voltage at the distant end of a circuit beyond the regulator may be automatically increased when the load in the circuit has increased. And another object is to attain the above results without the use of movable coils, cores, or similar main members. However, this does not preclude the use of moving parts in the control members of the equipment.

One of the principles used in the invention is to regulate the magnetic flux in one part of a magnetic circuit in accordance with variations in the voltage in a conducting circuit, and by this regulation to modify the magnetic flux in an adjacent magnetic path, this last modification producing the desired changes in voltage in a conductor which surrounds the said adjacent magnetic path, which conductor is in series with the output circuit.

Referring to the drawing, the single figure shows in diagram one arrangement of apparatus in which the invention is embodied.

The drawing shows an iron transformer core A, B, C, D, E, F, G, H, J, K, parts of which are encircled by the primary winding 1, the secondary winding 2, the regulating winding 3, and the control windings 4, 5, 6 and 7. The input is over the conductors 8, 9 and the output is over the conductors 10, 11. Connected in the output circuit 10, 11 is the regulating winding 3 which encircles the G portion of the core. The coils 4 and 5 are in series, and they are connected through the conductors 12, 13 into a closed circuit with the variable reactor 14.

The coils of 14 which are in circuit with 12, 13 are wound in series with one another, and the magnetic flux tends to flow as shown by the arrows, or else the reverse. The middle coil of 14 is connected through the conductors 15, 16 to the regulating devices. Connected to the circuit 10, 11 is the bridge 17 comprised of two resistors 17' of low temperature coefficient and two resistors 17'' of high temperature coefficient, such as lamps. One mid point on the bridge is connected through 18 to the grid of vacuum tube 24; and the other midpoint, through 19 is connected to one end of the secondary of transformer 20. The primary of transformer 20 is energized from the circuit 10, 11. The plate circuit of the vacuum tube 24 is connected to the grid of the vacuum tube 45, and the condenser 25 and other parts are connected as shown. As described in "Electronics" for March, 1934, such equipment will operate to cause unidirectional pulsating current to flow through the circuit 15, 16 whenever the voltage of the circuit 10, 11 drops below the voltage at which the bridge at 17 is balanced. A similar bridge 26 is also connected to the circuit 10, 11, but the lamps and resistors are transposed as compared with the bridge 17; and therefore it is when the voltage in circuit 10, 11 rises above the balance point that direct current flows through the circuit 27, 28. Between the bridge 26 and the output circuit 27, 28, the apparatus and the circuits are the same as those connected with the bridge 17.

The variable reactor 29 is similar to that at 14, and its controlled circuit is connected through the conductors 30, 31 to the coils 6, 7.

Operation is as follows:

When the load on the main transformer and the primary voltage on the circuit 8, 9 are such that the desired secondary voltage is maintained on the circuit 10, 11, with the current flow in at 8 and out at 9, the magnetic flux in the core will be up in A, right in B and E, down in C, D, J, and K, and left in H and F. There will be no flux through G, except that due to the current flow in the coil 3, for the high reactance of 14 and 29 prevent the flow of any current, except magnetizing currents, through the control coils 4, 5, 6, 7.

Now when low primary voltage, or an increase of load on the secondary circuit, produces conditions of low secondary voltage, the regulating bridge 17 and the associated equipment send current through the circuit 15, 16. This tends to magnetize with direct current the core of the reactor 14, so that less flux can pass through it in response to the flow of magnetizing current in the circuit 12, 13. Therefore the reactance of the reactor 14 is reduced and some induced current is allowed to flow through the coils 4, 5.

The magnetomotive force of this induced current opposes and subtracts from the flux which produces it, and so diverts some flux through J, and D. This reduction of flux in C and K and the increase through J and D, force flux through

G from right to left, at the assumed instants when current flow is in at 8 and out at 9. At each alternation, the directions of current flow and magnetic flux are changed, but the assumed instants are the same throughout this specification. This flux through G produces in coil 3 a voltage which supplements the voltage of the coil 2, and so the voltage in circuit 10, 11 is raised very nearly to normal.

Conversely, when higher voltage is present in the circuit 10, 11, the bridge 26 acts to produce direct current in the circuit 27, 28. This in turn increases the flow of current in the coils 6, 7, and the net result is a greater flux through C, G, K, H. This flux from left to right through G creates in the coil 3 a voltage that subtracts from the voltage of the coil 2, and so voltage of the circuit 10, 11 is reduced to substantially normal.

Depending upon the proportions of the windings and the voltages applied, the balance of magnetic flux at different instants may vary somewhat, and when it is said that flow of current in a coil produces a certain magnetic flux it is meant that it produces a magneto-motive force in that direction; and this tendency may result either in the actual production of flux as stated, or it may merely reduce the flux which is already flowing in the opposite direction. Also when it is said that there is a flow of current in one direction, it is understood that there is a tendency for current to flow in that direction, and if some current was already flowing in the opposite direction, the net result may merely be a reduction of the latter current. In either case, the effects produced upon the final results are the same, and this explanation applies throughout the specification and claims.

By proper proportioning of the members, and adjustment of the control equipment, the applied voltage of the secondary circuit is increased when the load increases and decreased when the load decreases, so that a relatively stationary voltage is maintained at terminals of the circuit 10, 11, where lamps, motors, and other appliances are being used. Since the control as described is electrical, rather than electro-mechanical, the changes in regulation occur immediately and automatically and without any motion of any of the coils or cores of the transformer.

For heavy sizes of equipment there are some advantages in the use of electro-mechanical control devices for the application of the flux-shifting currents to the transformer core. For this purpose, a suitable contact-making voltmeter operating a small motor-operated rheostat in the unidirectional or D. C. circuit may be used without departing from the spirit or purpose of this invention.

We have shown only a few methods of using this invention; and there are many modifications which can readily be made in the various parts of the equipment here described, without departing from the spirit and purpose of the invention.

We claim:

1. Voltage regulating equipment comprising an incoming exciting circuit, an outgoing circuit, a closed magnetic path surrounded by the said exciting circuit, one portion of the said path consisting of two branches joined together at both ends, a cross-path connecting the mid portions of the said branches, a regulating winding surrounding the said cross-path and connected in series with the outgoing circuit, together with means to change the relative direction of magnetic flux in the said cross path.

2. Voltage regulating equipment comprising an incoming exciting circuit, an outgoing circuit, a closed magnetic path surrounded by the said exciting circuit, one portion of the said path consisting of two branches joined together at both ends, a cross-path connecting the mid portions of the said branches, a regulating winding surrounding the said cross-path and connected in series with the outgoing circuit, together with automatic means to change the relative direction of magnetic flux in the said cross-path in coordination with changes in the voltage of the said exciting circuit.

3. In voltage regulating equipment, a closed magnetic circuit, one portion of which consists of two magnetically parallel branches with a cross-path connecting the mid-portions of the said branches, a regulating coil about the said cross-path and in series with a regulated circuit, together with means to change the relative direction of magnetic flux through the said cross-path.

4. In voltage regulating equipment, a closed magnetic circuit, one portion of which consists of two magnetically parallel branches with a cross-path connecting the mid-portions of the said branches, a regulating coil about the said cross-path and in series with a regulated circuit, together with control coils about the said parallel branches of the magnetic circuit.

5. In voltage regulating equipment, a closed magnetic circuit, one portion of which consists of two magnetically parallel branches with a cross-path connecting the mid-portions of the said branches, a regulating coil about the said cross-path and in series with a regulated circuit, together with control coils about the said parallel branches of the magnetic circuit, said control coils being operable when energized to change the relative polarity of the voltage developed in the said regulating coil.

6. In voltage regulating equipment, a closed magnetic circuit, one portion of which consists of two magnetically parallel branches with a cross-path connecting the mid-portions of the said branches, a regulating coil about the said cross-path and in series with a regulated circuit, together with automatic means to change the relative direction of magnetic flux through the said cross-path in coordination with changes of voltage in the regulated circuit.

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