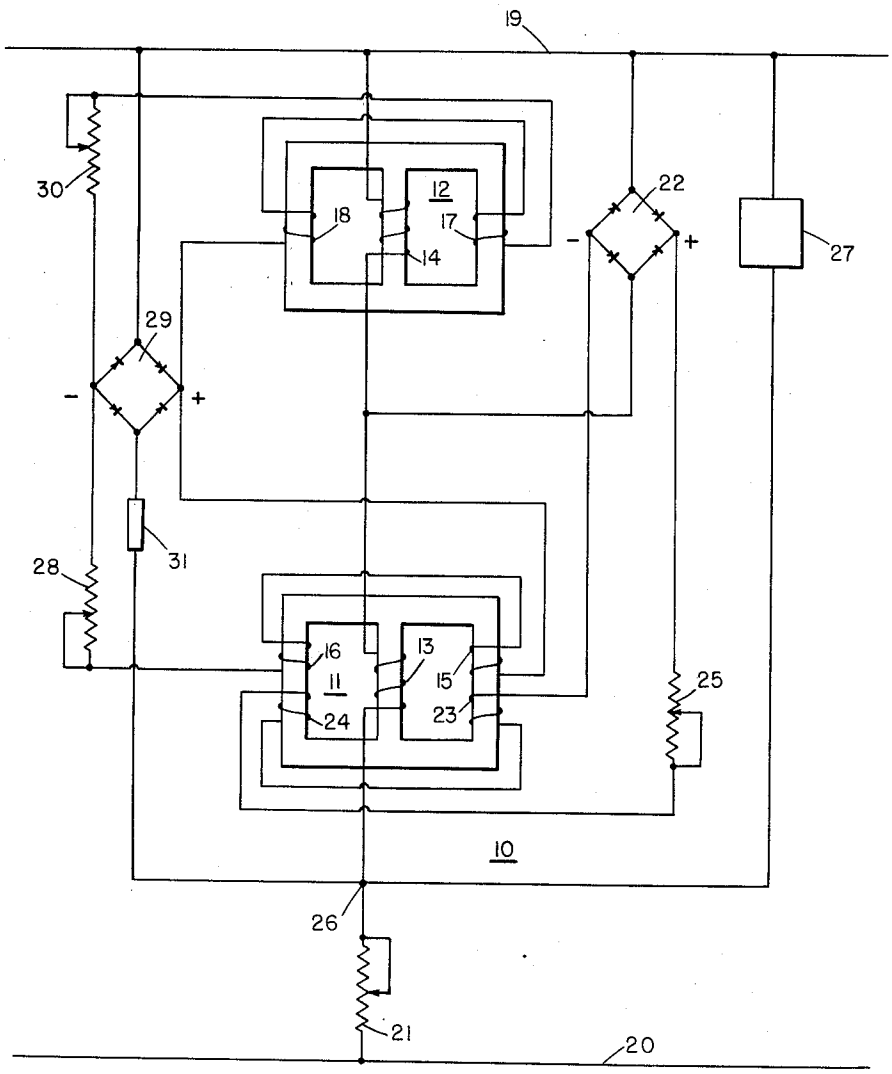
Oct. 2, 1956 Y. A. ROCARD 2,765,439

VOLTAGE REGULATORS

Original Filed Oct. 29, 1949



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United States Patent Office

2,765,439

Patented Oct. 2, 1956

2,765,439

VOLTAGE REGULATORS

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Original application October 29, 1949, Serial No. 124,315, now Patent No. 2,633,562, dated March 31, 1953. Divided and this application October 16, 1952, Serial No. 315,013

3 Claims. (Cl. 323—66)

The present invention relates to voltage regulators and more particularly to devices for supplying a load with a constant voltage from sources of alternating current subject to voltage fluctuations.

This application is a division of applicant's copending application Serial No. 124,315, filed October 29, 1949, now Patent No. 2,633,562, issued March 31, 1953, for "Voltage Regulating Device."

It has been proposed heretofore to employ so-called saturable reactors in voltage regulating circuits. Such circuits have the advantage of being more sturdy and of longer life than corresponding electronic circuits, since saturable reactors are very rugged and have no moving parts. However, these voltage regulating circuits employing reactors generally require some type of an electronic device to supply the reference voltage for controlling the reactor, and to that extent are subject to occasional failure. Further, such regulating circuits are not adapted to give good regulation for relatively large fluctuations in supply voltage, nor for loads requiring relatively large, variable amounts of power.

It is an object of the invention, accordingly, to provide new and improved voltage regulating devices employing saturable reactors.

Another object of the invention is to provide apparatus for supplying a load with substantially constant voltage from sources of alternating current voltage which may fluctuate over a relatively wide range.

A further object of the invention is to provide apparatus which will regulate the voltage input to loads requiring large and varying amounts of power.

These and other objects of the invention are attained by inserting two saturable reactors in series across a source of alternating current, and controlling the magnetic saturation of one of said reactors in accordance with the voltage across the other of said reactors in such a manner that the voltage across the series arrangement of both reactors remains substantially constant.

Additional objects and advantages of the invention will become apparent from the following detailed description of a representative embodiment thereof, taken in conjunction with the accompanying drawing, in which the only figure is a circuit diagram of an exemplary embodiment of the invention.

In the figure, voltage regulating device 10 includes two saturable reactors 11 and 12 which may each be a conventional iron core reactor with three legs. On the central legs of saturable reactors 11 and 12 are wound alternating current windings 13 and 14, respectively. On the two outer legs of reactor 11 are respectively wound two direct current, magnetic-biasing windings 15 and 16, which are connected in series in such a manner that no alternating current will be induced therein, and through which passes a substantially constant amplitude direct current in order that reactor 11 has the proper degree of magnetic saturation to operate in a region of maximum efficiency. Direct current, magnetic-biasing windings 17 and 18 are similarly connected and wound on reactor 12.

It is well known that with the proper degree of magnetic saturation on reactors 11 and 12, the inductance of windings 13 and 14 respectively will vary over a certain range in inverse proportion to the amplitude of the alternating current passing therethrough and in direct proportion with the degree of magnetic saturation.

Windings 13 and 14 are connected in series across any conventional source of alternating current, as for example the 60 cycles, 110 volt, A. C. supplied between conductors 19 and 20, through an impedance 21. Impedance 21, which may be a variable resistance as shown, is preferably of the same order of magnitude as the impedance of series connected windings 13 and 14, but is adjustable to give maximum power transfer. It may be advantageous in many instances to employ other than a resistive impedance 21 in order to adjust for a low power factor.

In accordance with the invention, the degree of magnetic saturation of reactor 11 is varied in proportion to the voltage across winding 14 of reactor 12. Thus the alternating current voltage across winding 14 may be rectified by a full wave rectifier 22, and direct current proportional to this voltage applied to additional balanced windings 23 and 24 on reactor 11. The magnitude of this direct current may be adjusted by means of a variable resistor 25 in circuit with rectifier 22, winding 23 and winding 24. In accordance with the invention, as the voltage across winding 14 increases, the direct current through windings 23 and 24 increases; accordingly, the magnetic saturation of reactor 11 increases and thus, the impedance of winding 13 decreases, decreasing the voltage thereacross. By proper adjustment of the windings, the voltage between junction 26 and line 19 (across reactors 11 and 12) will remain constant with variations in line voltage, the differential being taken up by impedance 21.

In order to minimize the adjustments in the windings and resistors during construction, the following steps are recommended. Separately, reactor 12 is tested to ascertain what change in voltage ΔE_1 across winding 14 will occur for a change Δi in the alternating current therethrough. Reactor 11 is separately tested to ascertain what change in voltage ΔE_2 occurs across winding 13 for a change Δi in the current therethrough. Then the following relations may be derived:

$$(1) \qquad a=\frac{\Delta E_1+\Delta E_2}{\Delta E_1}$$

$$(2) \qquad b=\frac{\Delta E_2}{R_2\Delta i}$$

where R_2 is the resistance of the direct current circuit, including rectifier 22, windings 23 and 24 and resistor 25. The voltage across the windings 13 and 14 in series will remain substantially constant if the ratio of the number of turns on windings 23 and 24 to the number of turns on winding 13 is substantially equal to a/b. The tests on reactors 11 and 12 are, of course, made with the proper direct current biases being applied thereto.

Since the A. C. voltage across windings 13 and 14 remains substantially constant, a load 27 requiring a highly regulated voltage supply may be connected between junction 26 and conductor 19 across said windings. Load 27, which may be resistive, inductive or capacitative, may for example comprise a battery charger, in which case the alternating current applied thereto must be rectified. It can thus be seen that novel, highly effective voltage regulating means is obtained in accordance with the invention.

The substantially constant amplitude direct current for windings 15 and 16, and for windings 17 and 18 may be conveniently obtained from the constant voltage across

windings 13 and 14. Thus windings 15 and 16 may be connected through an adjustable resistor 28 across full wave rectifier 29 which is in turn connected between terminal 26 and conductor 19 through a matching impedance 31. Windings 17 and 18 may be connected through adjustable resistor 30 across rectifier 29.

It will be understood that the illustrative embodiment disclosed herein is susceptible of numerous modifications in form and detail within the scope of the invention. For example, the D. C. windings on the saturable reactors may be wound on the center legs and the A. C. windings balanced on the outer legs, as is well known in the art. Further the saturable reactors may be of any other conventional type, as for example, each may comprise two separate cores. The embodiment described and shown in the drawing, therefore, is not to be regarded as limiting the scope of the following claims.

I claim:

1. A voltage regulator comprising a first saturable reactor, means providing a substantially constant magnetic bias for said first saturable reactor, an alternating current winding wound on said first saturable reactor, a second saturable reactor, means providing a substantially constant magnetic bias for said second saturable reactor, an alternating current winding wound on said second saturable reactor and connected in series with the alternating current winding wound on said first saturable reactor, an impedance connected in series with said alternating current windings, means for connecting said series-connected windings and impedance across a source of alternating current, means for varying the magnetic bias of said first saturable reactor in proportion to the changes in voltage across the alternating current winding wound on said second saturable reactor, whereby the sum of the voltages across said alternating current windings remains substantially constant, and means for connecting a load across said alternating current windings.

2. A voltage regulator as described in claim 1 wherein said means providing a substantially constant magnetic bias for said first and said second saturable reactors comprises a direct current winding wound on said first saturable reactor, a direct current winding wound on said second saturable reactor, and means connected across said alternating current windings for passing direct current through said direct current windings in proportion to the sum of the voltages across said alternating current windings.

3. A voltage regulator as described in claim 1 wherein said means for varying the magnetic bias of said first saturable reactor comprises a direct current winding wound on said first saturable reactor, rectifying means connected in parallel with the alternating current winding wound on said second saturable reactor, and means connecting the direct current output of said rectifying means to said direct current winding.

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