

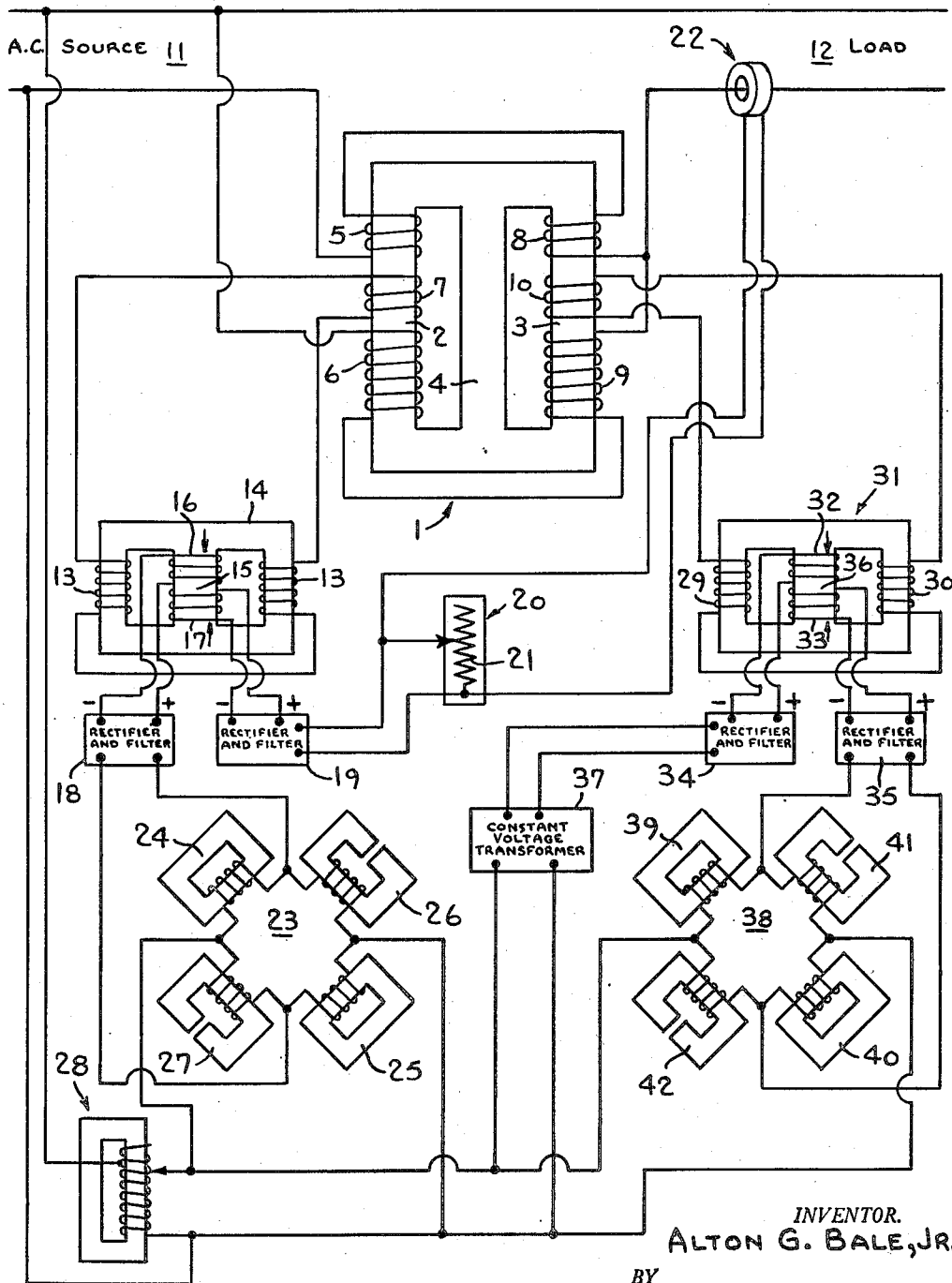
April 8, 1958

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2,830,256

VOLTAGE REGULATOR

Filed May 21, 1955



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2,830,256

VOLTAGE REGULATOR

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Application May 21, 1956, Serial No. 585,983

6 Claims. (Cl. 323—66)

This invention relates to a static type voltage regulator.

The primary purpose of this invention is to provide a voltage regulator for maintaining a substantially constant voltage which will hereinafter be referred to as the constant voltage at a preselected point beyond the regulator in the alternating current distribution system.

Objects are to provide a voltage regulator in which voltage boosting and bucking means have been provided, and in which the load line effect is balanced against variations in the supply voltage, and in which a preselected substantially constant voltage is balanced against the supply voltage so that any variation in the supply voltage with reference to the constant voltage immediately produces the necessary corrective effect in the voltage regulator so that the load line voltage is adjusted to the necessary or desired value to maintain a constant voltage at the selected point in the distribution system.

Further objects are to provide a static voltage regulator having no moving parts and having a substantially instantaneous response to variations in load conditions and in supply voltage conditions.

Further objects are to provide a voltage regulator having the desirable features hereinabove noted in which variations in the source voltage or in the load are magnified in their effect so as to produce an enhanced effect in the voltage regulator to insure quick response and to avoid the necessity of complicated constructions.

An embodiment of the invention is shown in the accompanying drawing in which the single figure is a diagrammatic view of the voltage regulator.

Referring to the drawings it will be seen that a main transformer has been provided and is indicated generally by the reference character 1. This main transformer consists of a pair of outer legs 2 and 3 and an inner or center core 4. The leg 2 is provided with a boosting winding 5, a boosting primary 6 and a boosting control winding 7. The leg 3 is provided with a bucking winding 8, a bucking primary winding 9, and a bucking control winding 10. It is to be noted that the boosting winding 5 and the bucking winding 8 are secondary windings and are connected in series with the alternating source or supply 11 and the load line 12. The primary windings 6 and 9 are connected in series and in shunt across the controlled side of the line or in other words the load side 12. Each of the primary windings 6 and 9 is a full primary winding.

The boosting control winding 7 forms a closed circuit with the coils or windings 13 on the outer legs of the saturable reactor 14. The central leg 15 of the saturable reactor 14 is provided with a pair of direct current or control windings 16 and 17 which are respectively connected to and supplied from the rectifier and filter assemblies 18 and 19. The coils 16 and 17 are wound so that the magnetic flux produced by them is algebraically opposed or in other words are opposed to each other in their effect. The winding 16 is supplied with current at a voltage corresponding or proportional to or varying with the voltage of the alternating current source. The winding

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17 is supplied with current proportional to or varying with the voltage from the line drop compensator 20. This compensator consists of an adjustable resistor 21 which is supplied with current from a current transformer indicated generally by the reference character 22 on the regulated side or load side 12 of the line.

It is to be noted that the rectifier and filter assembly 18 is supplied through the medium of a voltage multiplying device or multiplying bridge indicated generally by the reference character 23. This multiplying bridge consists of a pair of diagonally spaced saturating reactors 24 and 25 and a pair of nonsaturating reactors 26 and 27 which are supplied with current from an adjustable or tapped transformer 28 which may if desired be an auto-transformer or an ordinary transformer with a tapped secondary or tapped primary so that it may be either manually or otherwise adjusted to deliver voltage proportional to the alternating current source to the multiplying device or multiplying bridge which supplies the rectifier and filter assembly 18.

The line drop compensator 20 whose main constituent is the resistor 21 supplies current to the rectifier and filter assembly 19 proportional to the load current. The line drop compensator 20 is supplied from the current transformer 22 on the load line side or regulated side 12 of the line.

The bucking or control coil 10 of the main transformer 1 is connected in a closed circuit with the coils or windings 29 and 30 on the outer legs of a saturable reactor 31. The saturable reactor 31 is provided with a pair of direct current control coils 32 and 33 which are supplied with direct current from the rectifier and filter assemblies 34 and 35 respectively. These control coils 32 and 33 are wound on the central leg 36 of the saturable reactor 31 and their magnetic flux or effects are in opposition to each other.

The rectifier and filter assembly 34 is supplied with current at a substantially constant voltage, hereinafter referred to as constant voltage, from a constant voltage transformer indicated generally by the reference character 37. The constant voltage transformer 37 provides a constant reference voltage of any predetermined or adjusted value. It is supplied from the adjustable transformer 28.

The rectifier and filter assembly 35 is supplied with current from a voltage multiplying device or multiplying bridge indicated generally at 38 and consists of the saturating reactors 39 and 40 and the nonsaturating reactors 41 and 42 corresponding to and arranged in the same manner as the saturating and the nonsaturating reactors of the multiplying bridge 23 previously described.

The operation of the voltage regulator is as follows. Normally the boosting and bucking windings 5 and 8 produce voltages which are nearly balanced. However, it is preferable to cause the boosting effect to predominate under load conditions. The control winding 7 is controlled by means varying in proportion to the source voltage and the voltage at a preselected distant point in the distribution system. This preselected point is usually located about one third of the distance from the regulator to the end of the line or approximately centrally of the main load normally carried by the distribution system.

When the load comes on there is a line drop proportional to the load and this is reflected in the control of the boosting winding through the medium of the line drop compensator 20 and the rectifier and filter assembly 19 and the control coil 17 of the saturable reactor 14. Further any variation in the source voltage produces its effect through the enhancing or voltage multiplying device 23, the rectifier and filter assembly 18, and the control coil 16 of the saturable reactor 14.

One of the very important features of this invention is that no separate adjustment has to be made for variation in reactances of the load line or for the resistance of the load line independently of each other. The load line drop is produced by the impedance of the load line which is the vector sum of the reactance and the resistance. However, the load line drop manifests itself as a voltage drop proportional to the current flow in the load line. Further, the algebraic addition of the effect of source voltage variation and load variation are balanced by subtracting the magnetic effect proportional to one of them from magnetic effect proportional to the other. This is done in the saturable reactor 14 as described hereinabove.

On the other hand, the saturable reactor 31 responds to the algebraic sum of the magnetic effect proportional to the adjustable or preselected constant reference voltage from the constant voltage transformer 37, and the source voltage. The control of the bucking winding 8 of the main transformer 1 is obtained through the action of the saturable reactor 31. The saturable reactor 31 is therefore responsive to the difference between the effect of the preselected constant reference voltage and the source voltage since the magnetic effect produced in the saturable reactor 31 is the difference between the magnetic effect of the control windings 32 and 33.

The multiplying bridges 23 and 38 could be replaced by any other suitable multiplying means.

It is to be understood that in place of the single main transformer 1, a pair of transformers could be used or that the main transformer could be split into two symmetrical half sections, as is well known in the art.

Although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

I claim:

1. Voltage regulating means comprising an alternating current supply line and a load line, a main transformer having a boosting secondary winding and a bucking secondary winding connected in series between said supply line and said load line and having a boosting primary winding and a bucking primary winding connected in shunt across said supply line on the load side and magnetically linked to said boosting and bucking secondary windings, respectively, and having a first and a second control winding magnetically linked to said boosting and bucking primary winding, respectively, a first and a second saturable reactor having control windings connected in closed circuits with said boosting and bucking control windings of said main transformer, respectively, a current transformer in said load line having a secondary winding, impedance means connected to the secondary of said current transformer and having a voltage output proportional to the load line voltage drop from the regulator to a preselected point in the load line, said saturable reactors each having a pair of magnetically opposed control windings, rectifying and filtering means for each of said control windings of said saturable reactors, the output from said impedance means being connected through a rectifying and filtering means to one of the control windings of said first saturable reactor, adjustable means operatively interposed between said supply line and the other control winding of said first saturable reactor and connected through a rectifying and filtering means to said other control winding, a constant voltage transformer having its input side connected to said adjustable means and having its output side connected to one of the control windings of said second saturable reactor through a rectifying and filtering means, and means operatively connecting the output side of said adjustable means through a rectifying and filtering means to the other control winding of said second saturable reactor.

2. Voltage regulating means comprising an alternating current supply line and a load line, a main transformer having a boosting secondary winding and a bucking secondary winding connected in series between said supply and load lines and having a boosting primary winding and a bucking primary winding magnetically linked with said boosting and bucking secondary windings, respectively, a boosting and bucking control winding magnetically linked with said boosting and bucking primary winding, respectively, boosting and bucking reactors connected in a closed circuit with said boosting and bucking control windings, respectively, means for varying the effect of one reactor in proportion to the difference between the supply voltage and the load line voltage drop from the regulator to a preselected point in the load line, and means for varying the effect of the second reactor in proportion to the difference between the supply voltage and a predetermined selected constant reference voltage.

3. In a voltage control device, a main transformer having primary winding means for connecting in shunt across an alternating current line and having boosting and bucking windings for connection in series with the line for controlling the voltage supplied a load, a boosting and a bucking control winding for nullifying the effect of the primary winding means on the boosting and bucking windings, respectively, a saturable reactor for controlling each controlling winding, a source of constant reference voltage, and line drop compensating means, one of said saturable reactors being responsive to the difference in the effect of the source voltage and the voltage from said line drop compensating means and the other saturable reactor being responsive to the difference in the effect of said constant reference voltage and the source voltage.

4. In a voltage control device, a main transformer having primary winding means for connecting in shunt across an alternating current line and having boosting and bucking windings for connection in series with the line for controlling the voltage supplied a load, a boosting and a bucking control winding for nullifying the effect of the primary winding means on the boosting and bucking windings respectively, and a saturable reactor controlling each controlling winding, a source of constant reference voltage, a pair of control windings on each of said saturable reactors arranged to produce magnetic effects in opposition to each other, one of said control windings on each of said saturable reactors being responsive to the source voltage, the other control winding on one saturable reactor being responsive to variations in the line drop to a preselected point and the other control winding on the other saturable reactor being responsive to the said constant voltage.

5. In a voltage control device, a main transformer having primary winding means for connecting in shunt across an alternating current line and having boosting and bucking windings for connection in series with the line for controlling the voltage supplied a load, a boosting and a bucking control winding for nullifying the effect of the primary winding means on the boosting and bucking windings respectively, a saturable reactor controlling each controlling winding, a source of constant reference voltage, a pair of control windings on each of said saturable reactors arranged to produce magnetic effects in opposition to each other, one of said control windings on each of said saturable reactors being responsive to the source voltage, the other control winding on one saturable reactor being responsive to variations in the line drop and the other control winding on the other saturable reactor being responsive to the said constant voltage, and means for multiplying the effect of variations in the source voltage on said saturable reactors.

6. In a voltage control device, main transformer means having primary winding means for connecting in shunt across an alternating current line and having boosting

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and bucking windings for connection in series with the line for controlling the voltage supplied a load, a boosting and a bucking control winding for nullifying the effect of the primary winding means on the boosting and bucking windings respectively, a saturable reactor controlling each controlling winding, a source of constant reference voltage, a pair of control windings on each of said saturable reactors arranged to produce magnetic effects in opposition to each other, one of said control windings on each of said saturable reactors being responsive to the source voltage, the other control winding on one saturable reactor being responsive to variations in the line drop and the other control winding on the

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other saturable reactor being responsive to the said constant voltage, and means for multiplying the effect of variations in the source voltage on said saturable reactors.

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