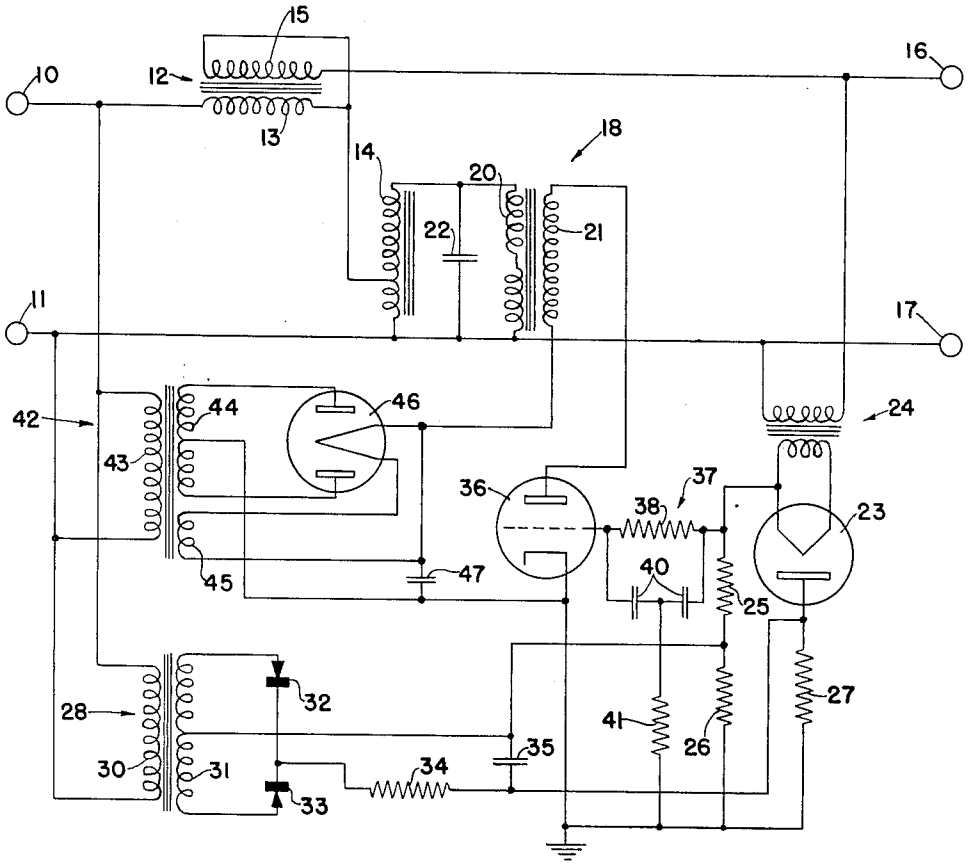
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VOLTAGE REGULATOR

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VOLTAGE REGULATOR

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This invention relates to voltage regulators and has particular reference to a modified form of saturable reactor which is controlled by electronic means to produce more accurate regulation.

Magnetic voltage regulators for alternating currents have been known and used in the art for several years. They comprise a tuned circuit which includes a capacitor and a reactor, the reactor having a magnetic core which is normally partly saturated. A compensating transformer is also employed to help compensate the load voltage when the supply voltage is varied. These prior art regulators are dependable and efficient but their degree of regulation is often less than the required amount. In addition their regulation is lowered considerably when the load power factor is less than unity.

The above mentioned defects can be eliminated almost entirely by the use of the auxiliary circuit described herein. An electronic diode is employed as the sensing unit to transmit variations of output voltage to an amplifying circuit which controls the reactance of a saturable reactor connected in parallel with the tuned circuit of the magnetic voltage regulator. By the use of this circuit the degree of regulation may be increased many times especially for loads having power factors differing from unity.

One of the objects of this invention is to provide an improved voltage regulator which avoids one or more of the disadvantages and limitations of prior art arrangements.

Another object of the invention is to provide a voltage regulator which regulates within a narrow range of voltage values.

Another object of the invention is to provide a voltage regulator which is insensitive to the load power factor.

Another object of the invention is to retain a high order of efficiency at the same time the degree of regulation is raised.

Another object of the invention is to maintain voltage regulation of a load circuit even if one or more of the electronic tubes fails in service.

The invention comprises a voltage regulator for alternating current supply lines and includes a tuned parallel circuit containing a capacitor and a reactor having a saturable core. A low voltage transformer is connected with its primary winding in series with the tuned circuit and its secondary winding in series with the tuned circuit and the load circuit in a manner which opposes the voltage across the tuned circuit. A diode filament is coupled to the load terminals to sense the voltage variations thereon and transmit such variations, by means of a bridge circuit, to an amplifier and a saturable core reactor which is connected across the tuned circuit.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawing.

The figure is a schematic diagram of conections showing all the components of the voltage regulator and in addition, two potential supplies used by the diode sensing device and the amplifier circuit.

Referring now to the figure, input terminals **10**, **11** are for connection to an alternating current supply line which may vary considerably in voltage. A low voltage transformer **12** has its primary winding **13** connected between terminal **10** and a tap on a saturable reactor **14**, one side of the saturable reactor being connected to terminal **11**. The secondary winding **15** of transformer **12** is connected between one of the terminals of winding **13** and an output terminal **16**. The second output terminal **17** is connected directly to input terminal **11** and may also be connected to ground if desired.

A tuned circuit **18** comprises, in this case, two saturable reactors **14** and **20**, the second reactor being an addition to the prior art magnetic regulator. Reactor **20** is mounted on a core which also supports a direct current control winding **21** for varying the reactance of winding **20** and the tuning of circuit **18**. A capacitor **22** is connected in parallel with windings **14** and **20** and comprises the capacitative part of tuned circuit **18**. One terminal of each reactor and the capacitor is connected to the common line **11—17**.

In order to sense the voltage variations that appear on the output terminals a diode vacuum tube **23** is employed. The filament of this tube is made of substantially pure tungsten and is coupled to the output terminals by a transformer **24**. Variations in the filament temperature due to voltage variations on the load terminals change the filament electron emission and the effective resistance between the diode filament and its anode. The diode **23** is connected as part of a four-arm Wheatstone bridge having three resistors **25**, **26**, and **27** as the other three arms. Direct current for the bridge, and for the diode anode, is applied at the junction point of resistors **25**, **26** and to the anode. The direct current power for this circuit may be derived from a battery or some other form of D. C. generator, a double rectifier circuit **28** being shown in the drawing.

Power for the rectifier circuit **28** is taken from the input terminals and applied to a primary winding **30**. A secondary winding **31** has a mid-point connection to which is connected the negative conductor of the supply. The ends of secondary winding **31** are connected to the anodes of two rectifier components **32** and **33** with the cathodes of these rectifiers connected together to form the positive terminal of the rectifier unit. A filter resistor **34** is connected in series with this line and a capacitor **35** is connected between the positive and negative lines to absorb most of the alternating current components.

The output of the bridge circuit is taken from the diode filament and the junction point of resistors **26** and **27**. One side of the output is connected to the cathode of an amplifier tube **36** while the other side (diode filament) is connected to the amplifier tube control electrode through an anti-hunt circuit **37**. The anti-hunt circuit comprises a series resistor **38** shunted by two capacitors **40**, the junction of which is connected through another resistor **41** to the amplifier cathode. This anti-hunt circuit prevents low frequency surges and hunting and is well known in the art.

The anode of amplifier tube **36** is connected to one terminal of the D. C. control winding **21**, the other terminal of which is connected to a second source of D. C. potential **42** which in this case includes the well known transformer-double diode combination employing a transformer having a primary winding **43** connected to input terminals **10**, **11**, a high voltage secondary winding **44** with a mid-point tap, and another low voltage secondary winding **45** connected to the cathode in a rectifier tube **46**. A smoothing capacitor **47** is connected between the

positive and negative supply conductors for absorbing the unwanted alternating components.

The operation of the above described circuit is as follows: When the voltage changes on the input terminals by decreasing a certain percentage, the current through winding 13 decreases by the same proportion, but the current to the tuned circuit 18 will also decrease by nearly the same amount with the result that the load voltage on terminals 16 and 17 will decrease a small amount. In order to compensate for this small decrease, transformer 12 has its secondary winding 15 connected so that the secondary winding voltage bucks the output voltage. Then a decreased current through winding 13 results in a decreased voltage subtracted from the output terminals or an increase.

The small variations in voltage which do occur on the output terminals are communicated to the filament of diode 23, changing the diode resistance and causing a change in the output voltage of the bridge circuit. These changes are applied to the control electrode of amplifier tube 36 and the anode-cathode current is changed in accordance with these variations. The anode current flowing through winding 21 changes the tuning of circuit 18 and alters the output voltage accordingly.

While there have been described and illustrated specific embodiments of the invention, it will be obvious that various changes and modifications may be made therein without departing from the field of the invention which should be limited only by the scope of the appended claims.

We claim:

1. An alternating current voltage regulator comprising; a pair of input terminals, one of which is connected to one side of a parallel resonant circuit which includes a capacitor and a first and second saturable reactor, and the other terminal connected to one end of a primary winding of a transformer the other end of which is connected to the first saturable reactor; a direct current control winding on the second saturable reactor for varying its reactance value; a pair of terminals for an out-put circuit which includes a secondary winding of said transformer and a portion of the first saturable reactor, said secondary winding connected so as to oppose the voltage drop across said portion of the reactor; a voltage sensing means coupled to the output terminals for sensing the voltage variations thereon; and an amplifier circuit connected between the voltage sensing means and the direct current control winding for changing the resonance value of the parallel circuit.

2. An alternating current voltage regulator in accordance with claim 1 wherein the voltage sensing means includes a filamentary diode whose filament is coupled to the output terminals.

3. An alternating current voltage regulator in accordance with claim 2 wherein the voltage sensing means includes a four-arm bridge circuit having the filamentary diode as one of the arms thereof for transmitting variations in diode resistance to said amplifier circuit.

4. An alternating current voltage regulator in accordance with claim 3 wherein said first and second saturable reactors are normally operated near the saturation value and wherein three of the arms of the four-arm bridge are non-inductive resistors.

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