

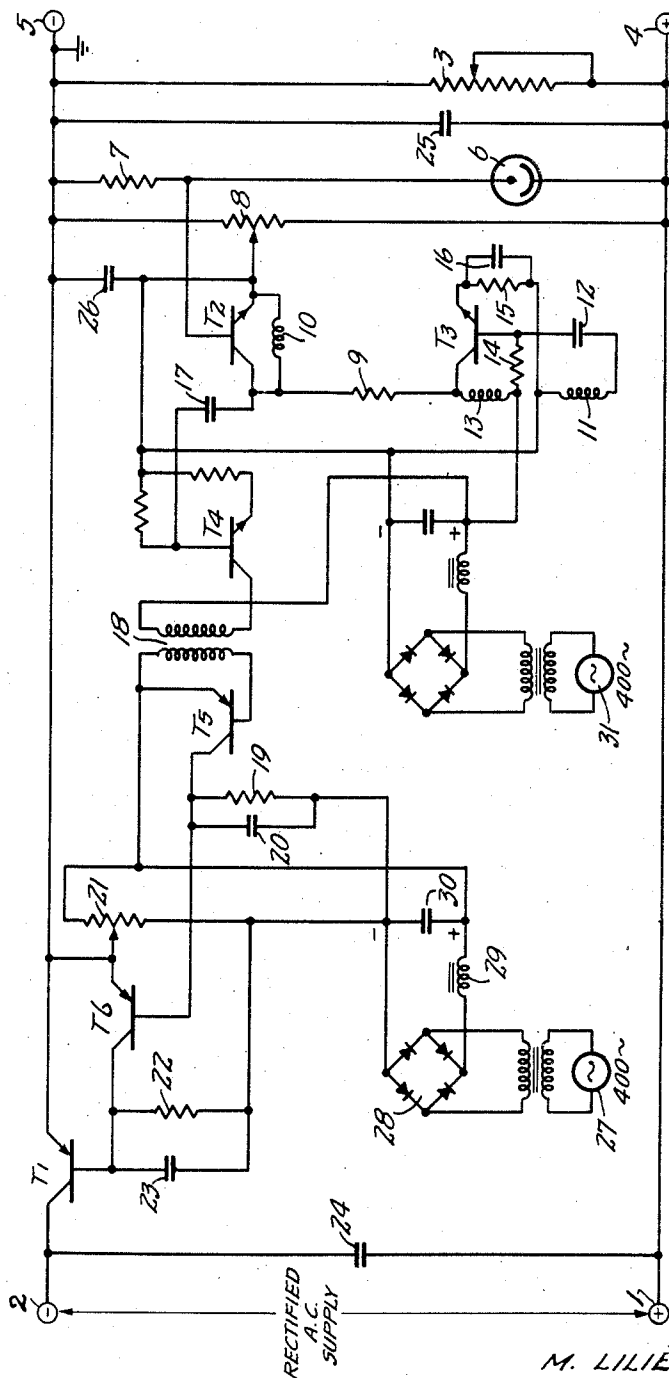
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REGULATED POWER SUPPLY SYSTEM USING TRANSISTORS

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REGULATED POWER SUPPLY SYSTEM USING TRANSISTORS

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Our invention relates to automatic voltage regulating systems wherein the voltage supplied to a load circuit is regulated by electronic means. The invention is particularly applicable to systems in which power is supplied from a rectified alternating current source.

A principal object of the invention is the provision of a power supply having a high degree of regulation, extremely low ripple content and low output impedance in conjunction with small volume and weight as compared with regulating systems hitherto used employing magnetic amplifiers or saturable reactors and conventional filters and output chokes.

According to one feature of our invention, a regulating impedance device in the input circuit of the system is varied by the application to it of a modulated direct current voltage derived from a source of high-frequency oscillations modulated in accordance with fluctuations in the voltage across the load or supply circuit. In a preferred embodiment of our invention the said regulating impedance device and the oscillation generating and amplifying circuits comprise transistors. Since the breakdown voltages of transistors are usually much lower than the voltage of the power supply which is to be regulated, means is provided, according to a further feature of our invention, to isolate the transistors which function as control means from the power supply and from the transistor or transistors which are actually used as variable reactors in the power leads.

According to a further feature of our invention the inter-electrode path between the emitter and collector electrodes of a transistor is connected in series relation in one of the leads connecting the input circuit with the output circuit, and means responsive to fluctuations of voltage across the output circuit is employed to apply a varying direct current voltage to the base electrode of such transistor whereby the impedance of the inter-electrode path between its emitter and collector is varied to compensate for such fluctuations.

The above and other features and objects of our invention will be clear when the following description is read in conjunction with the accompanying drawing which is a schematic circuit diagram of one embodiment of our invention.

Referring to the drawing, unregulated direct current, for example, 150 volt rectified A. C., enters over the input terminals 1 and 2. The variable resistance 3 represents the load resistance and is connected to output terminals 4 and 5. Regulation is effected in the embodiment illustrated by a P-N-P type transistor T1, the collector-emitter electrode impedance of which is connected in series in the negative line.

The actual referencing of the output voltage is accomplished by means of a glow discharge tube 6 which is connected across the load in series with a resistor 7. The junction of the tube 6 and resistor 7 is connected to the base electrode of an N-P-N type transistor T2, the emitter of which is connected to the sliding contact of a

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potentiometer resistance 8 connected between the positive and negative lines. The resistor 7, the tube 6 and the two portions of the potentiometer resistance 8 form a bridge, one pair of diagonal points of which are connected to the positive and negative lines at the output and the other pair to the base and emitter respectively of the transistor T2.

The emitter electrode to base electrode voltage of the transistor T2 is so adjusted that in the balanced condition of the aforementioned bridge, the transistor is in a condition between cut-off and full conduction, and a voltage change of .25 volt will change the state of this transistor from full conduction to cut-off. Zero drift is substantially eliminated since the collector resistance 9 is of a relatively high value. A radio frequency choke 10 is connected between the collector and emitter of this transistor T2 for the purpose of minimizing low frequency pick-up in the low power section of the regulator circuit.

An N-P-N transistor T3 constitutes the active element of a radio frequency oscillator, the base-emitter circuit of which comprising the inductance 11 and condenser 12 is tuned to provide an alternating current of approximately 110 kc. The inductance 11 is coupled to inductance 13 connected between the base and collector in series with a resistance 14. A bias resistance 15 shunted by a by-pass condenser 16 is connected between the emitter and one end of the inductance 11. The A. C. voltage generated by the transistor oscillator T3 is impressed on the collector of the transistor T2 via the load resistance 9. Part of the A. C. current is shunted to ground at the emitter of the transistor T2 and the remainder is applied to the base of a further transistor T4 via a coupling condenser 17. The percentage of A. C. current shunted to ground or transmitted to the transistor T4 depends upon the condition of transistor T2 which in turn depends upon the state of the bridge constituted by resistances 7, 8 and tube 6.

The transistor T4 is also of the N-P-N type which is connected in known manner to function as an amplifier for the A. C. voltage referred to. The collector circuit of this transistor is coupled by a transformer 18 to the emitter-base circuit of a further amplifier comprising a transistor T5. Preferably, the transformer 18 is provided with a ferrite toroidal core for the reason that greater mutual coupling can thereby be obtained and the operation thus improved.

The transistor T5 is of the P-N-P type. A network comprising resistance 19 and condenser 20 and having a time constant, in the present embodiment, of .05 millisecond is connected to the collector of transistor T5.

The collector of transistor T5 is connected via the network 19, 20 to the base of transistor T6 which is of the P-N-P type and is biased by a rheostat 21 in its emitter circuit. A load resistance 22 is connected to the collector of transistor T6 and to the base of transistor T1. The resistance 22 is shunted by a condenser 23 to prevent the regulator circuit from hunting.

Condensers 24 and 25 connected respectively across the input and output terminals serve to cushion the ripple voltage to some extent so that the transistor T1 is relieved of some of the work of filtering. Condenser 26 connected between the emitter of transistor T2 and the grounded negative side of the output renders the regulator more sensitive in response to the ripple frequencies present in the output, and further to prevent hunting.

In the arrangement illustrated the transistors T1, T6 and T5 are powered by a 400 cycle A. C. source 27, rectified by a bridge rectifier 28 and smoothed by a choke 29 and condenser 30. The transistors T4, T2 and T3 are similarly fed by a source 31 which may be the same A. C. source as the source which supplies the rectified A. C. to the input 1, 2. The D. C. outputs of sources 27 and 31

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must be electrically isolated from one another, as in the present case by the transformer 18.

In the operation of the circuit, if the output voltage rises above the desired predetermined value, the voltage regulator tube 6 conducts more current and the bridge consisting of tube 6, resistance 7 and the two parts of potentiometer 8 becomes unbalanced in such direction as to increase the emitter to base voltage of the transistor T2 and thereby increase its conduction. The transistor T2 acts as a variable shunt or gate to the high frequency voltage fed to the amplifying transistor T4 from the transistor oscillator T3. Less voltage is, therefore, applied to the transistor T4 and then to the amplifier transistor T5. The amplified voltage on the collector of transistor T5, therefore, rises and increases the base to emitter voltage of transistor T6 which is thereby caused to conduct. The time constant circuit 19, 20 smooths out the amplified alternating current of 110 kc. derived from the oscillator transistor T3 but passes the ripple frequency present in the rectified power supplies. Thus a direct current voltage modulated by the ripple frequency and other regulating components is applied to the base and thus to the collector of transistor T6. This results in turn in a partial cut-off of P-N-P transistor T1. An increased voltage drop thus appears across transistor T1 which will lower the output voltage in a compensatory manner. If, on the other hand, the output voltage decreases the reverse operations take place resulting in a decreased voltage drop across the transistor T1. The speed of response of the circuit is sufficiently high for the transistor T1 to counteract the ripple voltage from the 400 cycle A. C. supplies 27 and 31. Generator ripple modulation is also eliminated since this has a still lower frequency of the order of 40 to 120 cycles.

It will be noted that the part of the regulating circuit comprising transistors T3, T2, T4 and their circuits, which is subject to relatively low voltages, is coupled to the part comprising transistors T5, T6 and T1 and their circuits, which are subject to relatively high voltages by the transformer 18, the primary and secondary windings of which are insulated to withstand the potential difference.

It will be readily appreciated that the regulator circuit of our invention requires only six transistors, two auxiliary power supply of the order of 26 volts and only somewhat large condensers 24 and 25. All the other component parts are of relatively small dimensions and weight. This results in a very marked reduction in weight, dimensions and cost of the regulator over conventional regulators employing magnetic amplifiers or saturable reactors, and permits the unit to be assembled on one small printed circuit card.

It will be understood that other types of transistors could be employed in place of transistors T1 to T6 provided that the circuits in which they are connected are modified, where necessary, to suit their characteristics.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of our invention.

What is claimed is:

1. A system for supplying to a load circuit regulated direct current voltage comprising an input circuit, an output circuit, positive and negative leads connecting said input and output circuits, a regulating transistor comprising base, emitter and collector electrodes, means for connecting the inter-electrode path between said emitter and collector electrodes in series relation with said input circuit, an oscillating transistor arranged to generate high frequency sinusoidal waves and having an output circuit, an amplifying transistor, coupling means between the output circuit of said oscillating transistor and said ampli-

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fying transistor, voltage responsive means connected to said first-mentioned output circuit, a gating transistor comprising base, emitter and collector electrodes and having its collector-emitter electrode path connected to serve as a variable shunt to said output circuit of said oscillating transistor under the control of said voltage responsive means, means for deriving from the output of said amplifying transistor a direct current voltage modulated in accordance with voltage variations across said output circuit, and means responsive to said modulated direct current voltage for varying the impedance of said emitter collector interelectrode path in said regulating transistor.

2. A system for supplying to a load circuit regulated direct current voltage comprising an input circuit, an output circuit, positive and negative leads connecting said input and output circuits, a regulating transistor comprising base, emitter and collector electrodes, means for connecting the inter-electrode path between said emitter and collector electrodes in series relation with said input circuit, an oscillating transistor comprising base, emitter and collector electrodes and arranged to generate high frequency sinusoidal waves, an amplifying transistor, coupling means between said oscillating transistor and said amplifying transistor, a gating transistor comprising base, emitter and collector electrodes, a bridge comprising first, second and third resistances and a voltage responsive gas discharge tube connected respectively in its four arms, leads from diagonal points of said bridge which connect said first resistance in series with said gas discharge tube across said output circuit, connections from the opposite diagonal points of said bridge, respectively, to the base and emitter electrodes of said gating transistor, means for adjusting said gating transistor to a condition between full conduction and cut-off when said bridge is normally balanced, coupling means between the collector of said gating transistor and the base of said amplifying transistor, a load resistance connected between the collector of said gating transistor and the collector of said oscillating transistor, means for deriving from the output of said amplifying transistor a direct current voltage modulated in accordance with voltage variations across said load circuit, and means responsive to said modulated direct current voltage for varying the impedance of said emitter-collector interelectrode path in said regulating transistor.

3. A system for supplying to a load circuit regulated direct current voltage according to claim 2, in which said last-mentioned means comprises at least one further amplifying transistor and in which transformer coupling means is provided between said amplifying transistor and said further amplifying transistor.

4. A system for supplying to a local circuit regulated direct current voltage according to claim 3, in which a power supply for said oscillating transistor, said gating transistor and said amplifying transistor is derived from a source of rectified alternating current and the power supply for said further amplifying transistor and said regulating transistor is derived from another source of rectified alternating current.

5. A system for supplying to a load circuit regulated direct current voltage according to claim 4, in which a time delay circuit is connected to the collector of said further amplifying transistor, the constants of said time delay circuit being so adjusted that it smooths out the current fluctuations at the frequency of said oscillating transistor but passes the ripple frequency of said sources of rectified alternating current.

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