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VOLTAGE REGULATOR

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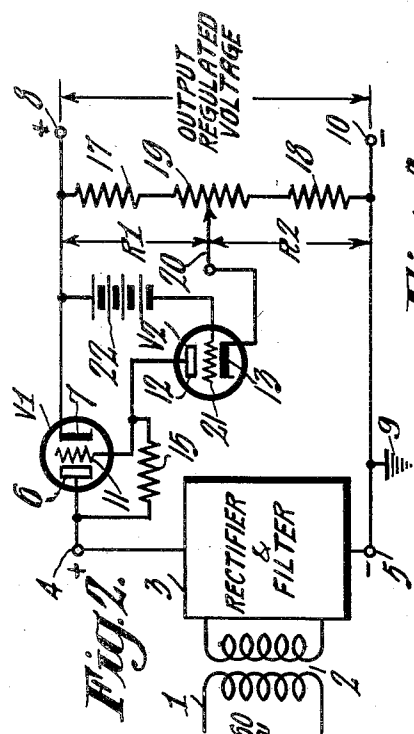


Fig. 1.

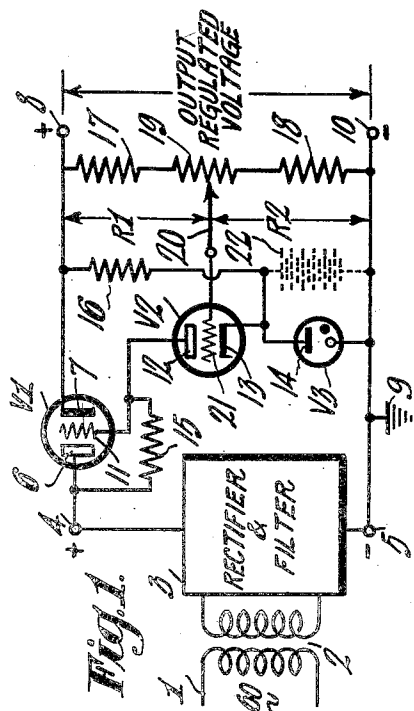


Fig. 2.

Fig. 3.

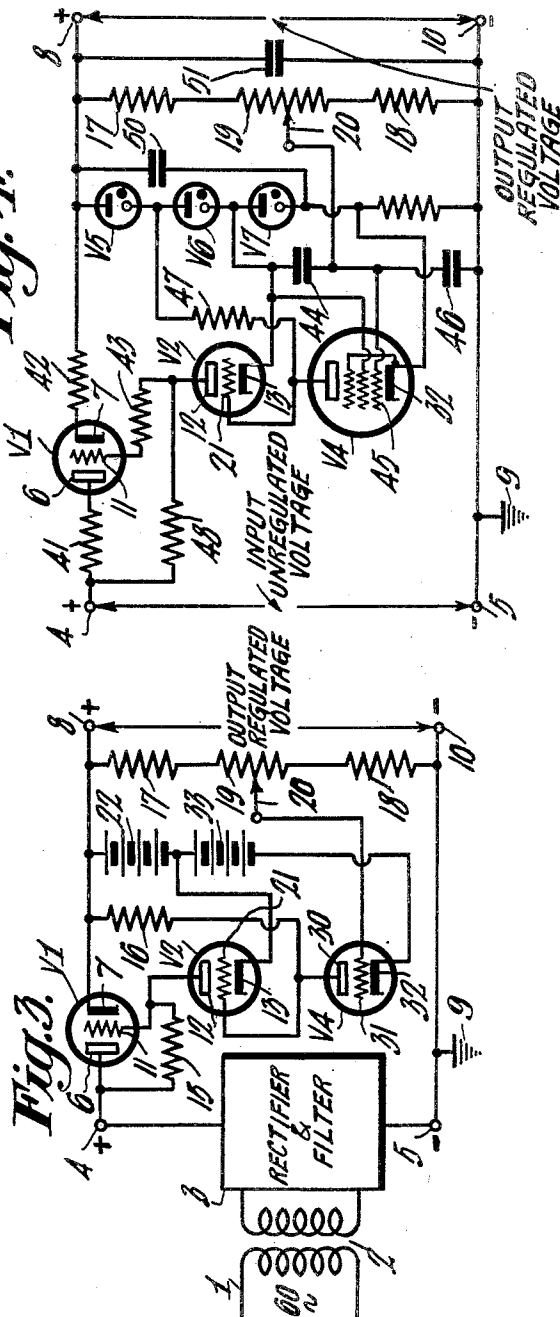


Fig. 4.

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VOLTAGE REGULATOR

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4 Claims. (Cl. 323—22)

1

My present invention relates to a voltage regulator especially useful for supplying high voltages for use in apparatus such as television transmitters and television receivers.

Conventional circuits for supplying a regulated voltage of substantially constant value require, so far as I am aware, connection of regulator tubes essentially across the output terminals of the voltage supply to be regulated. In the case of high voltage outputs (such as are required for television transmitters, for example), such conventional circuits would require regulator tubes of high voltage rating or the use of a large number of such tubes connected in series in order to absorb the high voltage, to which they are subjected, in such a way that only a small voltage is applied across each tube.

An object of my present invention is to provide an improved voltage regulator in which tubes of low voltage rating may be used for regulating a source of very high voltage. Briefly, in accordance with my invention, a resistive circuit is connected across the terminals or leads which are to supply the regulated voltage output. My improved regulator system is, in effect, connected across a small part of this resistive load in such a way (as will be described more fully hereinafter) as to provide ample voltage regulation without subjecting the tubes to the full voltage of the output or load circuit.

My invention will be explained in greater detail with the aid of the accompanying drawings, wherein:

Fig. 1 illustrates a prior art type of voltage regulator circuit in which the regulating tubes are subjected to the full voltage of the circuit;

Fig. 2 illustrates a simple form of circuit making use of the principles of my present invention;

Fig. 3 is a modified form of my present invention in which increased sensitivity is secured; and

Fig. 4 is a preferred form of my invention, especially useful for supplying a regulated high voltage for television transmitters.

Referring now in detail to Fig. 1 of the drawings, a conventional prior art regulated power supply is shown for the purpose of exposition and to give a clearer understanding of this invention. A sixty cycle input 1 is coupled to the primary of a step-up transformer 2, the secondary of which is connected to the input terminals of a rectifier and filter system 3. The output terminals of the rectifier are connected to a positive terminal 4 and a negative terminal 5 of a voltage regulator. The positive terminal 4 from the output of rectifier 3 connects to anode 6 of a voltage

2

regulator vacuum tube (electron discharge device) V1. The cathode 7 is connected to a positive voltage regulated power supply output terminal 8. The negative terminal 5 connects to ground 9 and to the negative terminal of the output of regulated voltage 10. The grid 11 of the vacuum tube V1 connects to anode 12 of a control tube (electron discharge device) V2. The cathode 13 is connected to the anode 14 of a gaseous voltage regulator tube V3, the cathode of the regulator tube being connected to the negative terminal 5. A fixed resistance 15 is connected from positive terminal 4 to the anode 12. A fixed resistance 16 is connected from the positive terminal 8 to the cathode of tube V2 and the anode of tube V3. A voltage divider is placed across the output regulated voltage terminals 8 and 10 and includes fixed resistors 17 and 18 and a resistor 19 having a variable tap. The variable tap 20 of resistor 19 connects to the grid 21 of vacuum tube V2. If desired, the gaseous voltage regulator or constant voltage tube V3 may be replaced by a fixed potential, for example a battery 22, indicated by the broken lines in Fig. 1.

The regulator tube V1 functions as an automatically variable series resistor which operates to keep the output voltage constant. If the output voltage tends to increase due to a change in supply voltage or a change in load current, the bias on the control tube V2 will become more positive, causing the plate current of the control tube to increase and the drop across resistor 15 to increase. The bias on the regulator tube V1 therefore becomes more negative and the effective resistance of the regulator tube increases. There results an increased drop in the regulator which opposes the tendency for the output voltage to increase. A decrease in the output voltage causes a reverse action.

It will be seen that tubes V2 and V3 are connected in series and that nearly the full output voltage is applied across the two tubes. The available output voltage will therefore be limited by the voltage ratings of tubes V2 and V3.

Fig. 2 of the drawing shows a particular feature of the present invention; namely, the method of obtaining small voltage drops in the control tubes, which makes possible the use of tubes having low voltage ratings for a power supply with relatively high output voltage. In order to use low voltage tubes in a high voltage power supply of the prior art circuit shown in Fig. 1, the constant voltage tube V3 would have to be replaced by a number of tubes connected in series, which would add to the cost and bulk of the equipment.

3

An improved feature in the circuit of the present invention is the use of a reference direct current potential or constant voltage bias source which is connected to the positive output terminal of the power supply output regulated voltage instead of to the negative terminal as in the prior art circuit of Fig. 1. For example, it will be noted (in Fig. 2) that the grid 21 of vacuum tube V2 connects to a battery 22 which is connected to the positive side 8 of the output regulated voltage; and the cathode 13 connects to only a portion of the voltage divider which includes resistor 17 and a part of the resistor 19.

The operation of a conventional regulated power supply has been described with reference to Fig. 1. It will be seen that the operation of the circuit shown in Fig. 2 differs from the conventional power supply described in Fig. 1 in one or more respects. First, a portion of the output voltage is applied between the positive terminal 8 of the output voltage and the cathode 13 of the control tube V2. Second, the reference voltage indicated by the battery 22 is applied between the positive terminal 8 of the output voltage and the grid 21 of the tube V2. The difference between these two quantities is the grid-cathode voltage on the control tube. As in the preceding example, assuming a small positive change in the output voltage, the grid will then be carried more positive than the cathode. The plate current of the control tube V2 will be increased and the operation of this circuit will act to oppose a change in the output voltage in the manner described with reference to Fig. 1.

Only a portion of the output voltage change will be applied to the control tube V2. The fraction of the change in the output voltage useful in the control circuit is the ratio

$$\frac{R1}{R1+R2}$$

for the circuit of Fig. 2; and

$$\frac{R2}{R1+R2}$$

for the prior art circuit of Fig. 1. This fraction may be small, if the output voltage is large, for either circuit Fig. 1 or Fig. 2.

In order to increase the sensitivity of the control, a stage of amplification may be added to the control circuit as is shown in Fig. 3. A vacuum tube V4 having an anode 30, grid 31, and cathode 32 is connected to an additional battery 33. In a practical circuit, the batteries 22 and 33 may be replaced by gaseous voltage regulator tubes, such as are indicated by V3 in Fig. 1, which tubes have the property of maintaining essentially constant voltage across the tubes independent of variations in current. If the current through the tubes is supplied from the regulated output voltage, the drop across the regulator tubes is further stabilized.

Fig. 4 shows a circuit used in a five kilowatt television transmitter to supply a regulated bias voltage of approximately 1200 volts. For this application, it is desirable to have the rectified direct current potential maintained substantially constant; for example, the output voltage may be held within $\pm 0.25\%$ regardless of changes in the output load current or normal changes in input voltage.

Referring now in detail to Fig. 4, three double triodes (electron discharge devices) connected in parallel are represented by the symbol V1. Only one triode is actually shown. The input terminal

4

4 is connected to anodes 6 of the tubes V1 through resistors 41. The cathodes 7 are connected to terminal 8 through resistors 42, and the grids 11 are connected through resistors 43 to anode 12 of the tube V2. The resistors 41, 42, and 43 function as parasitic suppressor resistors which will prevent oscillation between the several vacuum tubes connected in parallel at V1. The tubes V5, V6 and V7 are constant voltage tubes which furnish the necessary fixed potential for the control circuit. The resistor 19 is made variable so that the regulated output voltage across terminals 8 and 10 can be changed from approximately 900 to 1200 volts. From the cathode 13 of tube V2 to the variable tap 20 a small capacitor 44 is added. Also, a condenser 50 is connected from the cathode of tube V7 to the positive terminal 8. The capacitors 44 and 50 prevent relaxation oscillations from occurring between tubes V1 and V2, which could occur due to the finite resistance of the regulator tubes V5, V6 and V7. Capacitor 46 is added so that for sudden changes in output voltage the entire change is applied to the grid of control tube V4. This improves the regulation for rapid changes in load current or supply voltage. Capacitor 51 is provided to by-pass the high frequency components of the load current. A constant voltage is applied between the positive output terminal 8 and the cathode 32 of tube V4. A voltage nearly equal to this potential is applied to the grid 45 of tube V4 by means of the voltage divider which includes resistances 17, 18 and 19. The difference between the grid and cathode voltage applied to V4 is amplified by V4 and applied to the grid 21 of tube V2. Tubes V4 and V2 constitute a two-stage direct coupled amplifier. The amplified voltage is applied to the grid 11 of regulator tube V1 whose plate resistance changes causing a change in drop across this tube in a direction to offset the original change in the output voltage assumed between terminals 8 and 10. It will be seen that this system functions as a degenerative amplifier to oppose changes in the output voltage.

What is claimed is:

1. Apparatus for controlling the voltage supplied to a load from a first direct current supply source the voltage of which may vary, said direct current supply source having a pair of input terminals, said load being supplied from a pair of output terminals, comprising a first space discharge device having an anode, cathode and a control grid for controlling the resistance of the anode-cathode path of said device in accordance with the potential thereof with respect to the potential of the cathode, means for connecting the anode-cathode path of said device in series with said load and supply source, a first series circuit of at least three resistors connected between said output terminals, a second series circuit of at least two gaseous discharge two-electrode tubes and a resistor in the order named, also connected between said output terminals but in shunt to said first series circuit, a second space discharge device having an anode connected to the control grid of said first device through a resistor and its cathode connected to a point between two of said gaseous tubes, a resistor connecting the anode of said first device to the anode of said second device, a third space discharge device having an anode connected to the grid of the second device and its cathode connected to the junction point of the resistor and a gaseous tube in the second series circuit, said third de-

vice also having a grid connected to a tap on an intermediate resistor in the first series circuit, whereby said last grid is subjected to a small fraction of the regulated output voltage.

2. Apparatus for controlling the voltage supplied to a load from a first direct current supply source the voltage of which may vary, said direct current supply source having a pair of input terminals, said load being supplied from a pair of output terminals, comprising a first space discharge device having an anode, cathode and a control grid and connected in series with said load and supply source, a first circuit composed of resistance connected between said output terminals, a second series circuit of at least two gaseous discharge tubes and a resistor also connected between said output terminals but in shunt to said first circuit, a second space discharge device having an anode connected to the control grid of said first device through a resistor and its cathode connected to a point between two of said gaseous tubes, a resistor connecting the anode of said first device to the anode of said second device, a third space discharge device having an anode connected to the grid of the second device and its cathode connected to the junction point of the resistor and a gaseous tube in the second series circuit, said third device also having a grid connected to a tap on said first circuit, whereby said last grid is subjected to a small fraction of the regulated output voltage.

3. Apparatus for controlling the voltage supplied to a load from a first direct current supply source the voltage of which may vary, said direct current supply source having a pair of input terminals, said load being supplied from a pair of output terminals, comprising a first space discharge device having an anode, cathode and a control grid and connected in series with said load and supply source, a first circuit composed of resistance connected between said output terminals, a second series circuit of at least two gaseous discharge tubes and a resistor also connected between said output terminals but in shunt to said first circuit, a second space discharge device having an anode connected to the control grid of said first device and its cathode connected to a point between two of said gaseous tubes, a third space discharge device having an anode connected to the grid of the second device

and its cathode connected to the junction point of the resistor and a gaseous tube in the second series circuit, said third device also having a grid connected to a tap on said first circuit, whereby said last grid is subjected to a small fraction of the regulated output voltage.

4. A voltage regulator system comprising input terminals adapted to be subjected to variations in potential, output terminals from which a regulated voltage may be derived, a first vacuum tube having an anode, cathode and control grid and connected in series between said input and output terminals, a first circuit of resistance provided with a variable tap and connected between said output terminals, a second circuit of a plurality of gaseous discharge tubes also connected between said output terminals and in shunt to said first circuit, a second vacuum tube having an anode connected to the control grid of the first tube, and its cathode connected through an impedance to a point between two of said gaseous discharge tubes, a resistor connecting together the anodes of said first and second vacuum tubes, a third vacuum tube having an anode connected to the grid of the second vacuum tube and its cathode connected to a point on said second circuit displaced from said first point, a connection from the grid of the third vacuum tube to said variable tap on said first circuit.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,210,393	Braden	Aug. 6, 1940
2,210,394	Braden	Aug. 6, 1940
2,274,364	Gardiner	Feb. 24, 1942
2,337,911	Mayer et al.	Dec. 28, 1943
2,404,568	Dow	July 23, 1946
2,407,853	Smith	Sept. 17, 1946
2,416,922	Irish et al.	Mar. 4, 1947
2,443,534	Eglin	June 15, 1948

FOREIGN PATENTS

Number	Country	Date
476,539	Great Britain	Dec. 10, 1937
550 743	Great Britain	Jan. 21, 1943