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VOLTAGE REGULATION FOR ELECTRON TUBE

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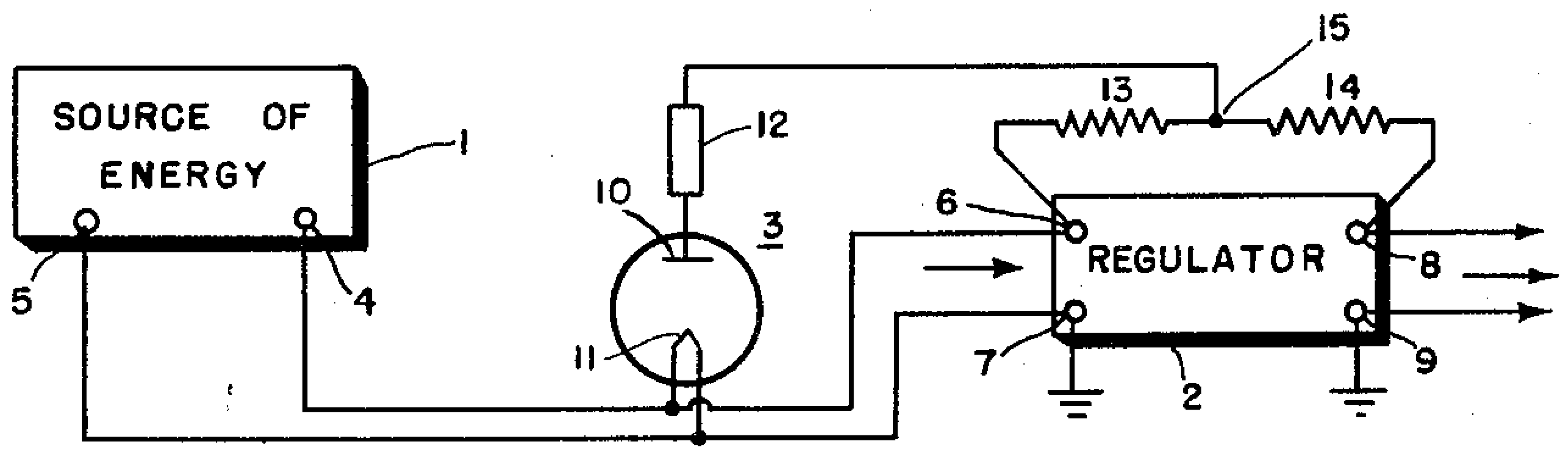

FIG. 1

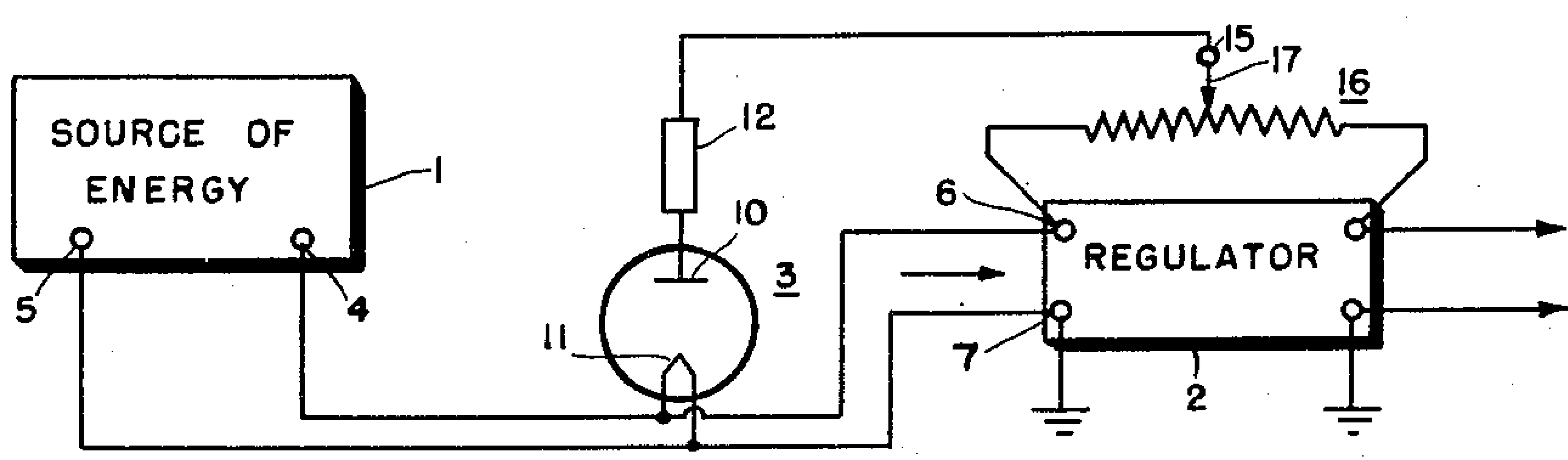

FIG. 2

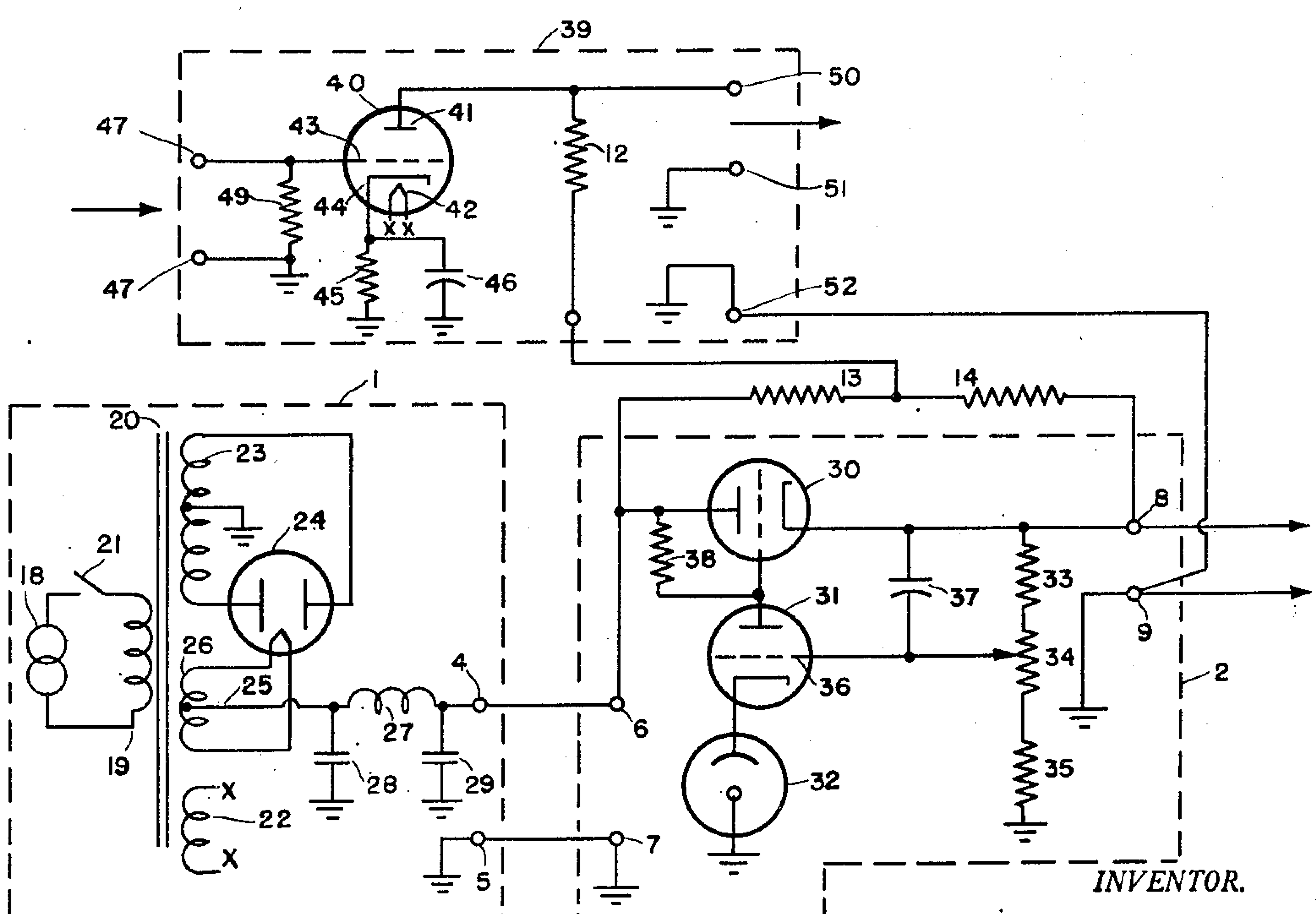

FIG. 3

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VOLTAGE REGULATION FOR ELECTRON TUBE

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My invention relates to electronic circuits and more particularly to means for minimizing the effect of variations in heater voltage on electronic circuits.

When circuits employing electron discharge devices are to be operated from an A.-C. energy source, such as is available at conventional wall outlets, it is customary to provide a transformer capable of supplying both plate and heater power, although sometimes separate heater and plate power transformers are used. The voltages furnished by these transformers are subject to variations if the input or line voltage furnished by the A.-C. energy source changes. Of these output voltage variations, those in the plate supply are usually the more objectionable. A voltage regulator is therefore frequently employed to maintain the source of plate potential constant.

Where maximum constancy of output of an electronic circuit is desirable, it has heretofore been necessary to regulate the heater voltage supply as well as the plate, or anode, voltage supply. Heater voltage has been regulated both by electronic circuits and by special heater transformers, but these means have proved both bulky and expensive.

It is therefore an object of my invention to provide, in an electronic circuit, a new and useful means for cancelling the effect of variations in heater voltage on the anode of an electron discharge device.

It is another object of my invention to provide a cheap and compact means for cancelling the effect on the anode of an electron discharge device of variations in voltage applied to the heater of that device.

It is still another object of my invention to provide, in an arrangement for counteracting the effect of variations in voltage at the anode of an electron discharge device due to variations in heater voltage, means for adjusting the degree of such counteraction.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing in which:

Fig. 1 is a schematic diagram, partially in block form, illustrating a fundamental embodiment of my invention;

Fig. 2 illustrates another embodiment of my invention; and

Fig. 3 is a schematic diagram showing how my invention may be applied to a specific electronic circuit arrangement.

Referring now to Fig. 1, there is shown a source of energy **1**, a regulator or regulating means **2** and an electron discharge device **3**. Source **1** furnishes unregulated voltage to output terminals **4**, **5** while regulator **2** is provided with input terminals **6**, **7** and output terminals **8**, **9**.

Electron discharge device **3** is illustrated as a vacuum tube having at least an anode **10** and a heater, or filament, **11**. Other electrodes may be included in the tube

for various purposes without affecting the beneficial results of my invention. Anode **10** may be provided with an anode circuit, which is here illustrated in generalized form as load impedance **12**. Connected between terminals **6** and **8** of regulator **2** is an impedance means, here shown as consisting of series resistors **13** and **14**. Load impedance **12** is fed from junction point **15** between resistors **13** and **14**.

With the arrangement shown, voltage furnished by regulator **2** to output terminals **8** and **9** may be employed for other apparatus requiring a constant anode voltage but which need not be compensated for heater voltage variations. Devices furnished from output terminals **8**, **9** thus have substantially constant voltage furnished them regardless of any variations which may occur in the voltage furnished by source **1** to input terminals **6**, **7** of regulator **2**. Tube **3**, on the other hand, is compensated for changes in voltage of source **1** as explained below.

Assume that the voltage furnished by source **1** rises. The voltage of heater **11** consequently rises, causing the heater to emit more electrons. Since a greater electron flow is a greater current flow, a greater drop in potential is produced across load impedance **12**. The voltage appearing on anode **10** is therefore decreased. If load impedance **12** were supplied directly from terminal **8** of regulator **2**, the regulator would have no way of compensating for this drop of anode potential. On the other hand, if anode load impedance **12** were connected to input terminal **6** of regulator **2**, the voltage applied to load impedance **12** would rise as the source voltage rose. This would cause voltage at anode **10** to rise, the effect being opposite to that due to the increase in heater emission. The foregoing explanation applies equally well, except for change in sign, if the source voltage decreases.

To overcome the difficulties outlined, I provide, according to my invention, a voltage which varies in the same direction as the source voltage, but not by as great an amount. The effect of a change in source voltage, and therefore in heater voltage, can thus be substantially cancelled. I provide a source of such a voltage by connecting resistors **13** and **14** in series between high-potential input and output terminals **6** and **8**, respectively, and by connecting load resistor **12** between anode **10** and junction point **15**. I prefer to proportion the values of resistors **13** and **14** such that the voltage change at anode **10** due to voltage variation at point **15** substantially completely cancels the change in voltage due to changes in heater voltage.

It will be apparent to those skilled in the art that more than one electron discharge device may be supplied from point **15**, and that if their heaters are supplied from source **1**, the values of resistors **13** and **14** required for compensation of each such tube against the unwanted effects of heater emission variation can be determined by measurement.

A modification of the arrangement of Fig. 1 is shown in Fig. 2. Here a potentiometer **16** has been substituted for resistors **13** and **15**. Point **15** is adjustable relative to the resistance element by means of arm **17**. This allows the user to obtain precise cancellation of heater voltage effects should the tubes supplied with power according to my invention change their emission characteristics due to aging, etc.

Fig. 3 is included in this explanation to illustrate a manner of carrying out my application in a specific instance, although I wish it distinctly to be understood that my invention is not limited to the particular circuit configuration shown. The source of energy is indicated in Fig. 3 as enclosed within dashed rectangle **1**. The source is seen to consist of a primary source of A.-C. power **18**, such as a generator, which is fed to the primary winding **19** of a power transformer **20**. Switch **21** is provided to turn the apparatus on or off. Heater voltage is supplied to the electron discharge device to be compensated by means of secondary winding **22**, usually termed a "heater winding," whose leads are indicated by *x—x*. Another secondary winding **23**, commonly termed a "plate winding," furnishes alternating-current energy to a rectifier tube **24**, which is shown as a full-wave type. Output of the rectifier circuit is derived from center tap **25** of the rectifier filament winding **26**. The output voltage of the rectifier may be conveniently filtered by means of a pi-section filter comprising choke **27** and capacitors **28** and **29**. Plate potential thus appears between output terminals **4** and **5** of power supply **1**. For the purposes of this specification, a conventional power supply, such as that shown, is considered to be a "source of energy."

Illustrated in dashed rectangle **2** is an electronic voltage regulator of conventional type. Input terminals **6**, **7** of the voltage regulator **2** are connected to output terminals **4**, **5** of energy source **1**, while output terminals **8**, **9** may be connected, if desired, to such apparatus as may use the regulated power there developed. The regulator circuit shown within dashed rectangle **2** comprises a series regulator tube **30**, a voltage amplifier tube **31** and a pedestal voltage regulator tube **32**. A voltage divider composed of resistors **33**, **34**, and **35** biases grid **36** of amplifier tube **31**. Transfer of output voltage variations to grid **36** is assisted by capacitor **37**. Plate voltage for amplifier tube **31** is obtained through load resistor **38**, the plate output of voltage amplifier **31** being directly coupled to the grid of series tube **30**. The operation of this and other types of regulators is covered at page 590 et seq. of H. J. Reich, "Theory and Applications of Electron Tubes," McGraw-Hill Book Company, New York, N. Y., 1944.

An example of an electronic circuit which may be compensated according to my invention is diagrammed within dashed rectangle **39**. Here electron discharge device **40** is provided with an anode **41** and a heater **42** as in Fig. 1. However, a control grid **43** and a cathode **44** heated by heater **42** are also included. Cathode bias is obtained by a cathode resistor **45** by-passed by capacitor **46**. An input signal applied between terminals **47** and **48** is impressed across grid return resistor **49** and thence to grid **43**. Load impedance **12** is indicated as a resistor, the output developed across this resistor being fed to output terminal **50** and **51**. Ground return is made from terminal **52** to the low-potential ground terminal **9** in regulator **2**.

Voltage to be fed to the anode circuit (resistor **12**), as in Fig. 1, is derived from the junction of resistors **13** and **14** which are connected in series between the high-potential input and output terminals, **6** and **8**, respectively, of regulator **2**. Since the action of the circuit in Fig. 3 parallels that of Fig. 1, it is felt that the explanation of Fig. 1 need not be repeated. The application to Fig. 3 of a potentiometer as explained in connection with Fig. 2 is also believed to be an obvious modification.

While I have shown and described a specific embodiment of my invention, I do not desire my invention to be limited to the specific arrangement shown and described, and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim is:

1. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; a source of unregulated voltage; means for regulating said unregulated voltage; means for feeding said heater from said source of unregulated voltage; and means for deriving, from said unregulated voltage source and said regulating means, a voltage having a degree of regulation intermediate between that of said source of unregulated voltage and the regulated voltage furnished by said regulating means; and means for supplying said anode with said derived voltage, said derived voltage having a degree of regulation such that variations in said voltage are effective substantially to counteract variations in voltage at said anode caused by variations in voltage at said heater.

2. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; a source of unregulated voltage; means for regulating said unregulated voltage; means for feeding said heater from said source of unregulated voltage; and means connected between said unregulated source and the output of said regulating means for feeding said anode, said last-named means being effective substantially to counteract variations in voltage at said anode caused by variations in voltage of said heater.

3. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; an anode circuit for said anode; a source of electrical energy subject to variations in voltage; said heater being heated by energy from said source; a regulator having an input and an output side, said input side being connected to said source, said regulator being adapted to supply, at its output side, a voltage substantially independent of said variations in voltage of said source; and means shunted from said input to said output side of said regulator and connected to said circuit for supplying energy to said anode circuit, said last-named means being proportioned such that the effect of variations in voltage of said source on said heater is substantially counteracted.

4. In an electronic circuit, the combination of a source of alternating-current energy; a regulator having input and output sides and fed from said source, said input side of said regulator being connected to said source; an electron discharge device having at least an anode and a heater; an anode circuit for said anode; said heater being energized from said source of alternating-current energy; and a means connected from said input to said output side of said regulator and connected to said anode circuit for supplying energy to said anode circuit, said last-named means being proportioned such that the effect of variations in voltage of said source on said heater is substantially counteracted.

5. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; a source of unregulated voltage; means for regulating said unregulated voltage; means for feeding said heater from said source of unregulated voltage; impedance means connected between said unregulated source and the output of said regulating means; and means for feeding said anode from a point between the ends of said impedance means, said point on said impedance means being located such that the effect on said anode of variations in voltage present at said point substantially cancels the effect on said anode of variations in voltage at said heater.

6. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; a source of unregulated voltage; means for regulating said unregulated voltage; means for feeding said heater from said source of unregulated voltage; resistance means connected between said unregulated source and the output of said regulating means; and means for feeding said anode from a point between the ends of said resistance means, said point on said resistance means being located such that the effect on said anode of variations in voltage present at said point substantially cancels the effect on said anode of variations in voltage at said heater.

7. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; an anode circuit for said anode; a source of unregulated voltage having high- and low-potential output terminals; means for deriving the energization of said heater from said source; means for regulating said unregulated voltage, said regulating means having high- and low-potential input terminals and high- and low-potential output terminals, said high- and low-potential input ter-

minals of said regulating means being connected to said high- and low-potential output terminals, respectively, of said source of unregulated voltage, impedance means connected from said high-potential input terminals to said high-potential output terminals of said regulating means; and means for feeding said anode circuit from a point between the ends of said impedance means, said point on said impedance means being located such that the effect on said anode of variations in voltage present at said point substantially cancels the effect on said anode of variations in voltage at said heater.

8. In an electronic circuit, the combination of an electron discharge device having at least an anode and a heater; an anode circuit for said anode; a source of unregulated voltage having high- and low-potential output terminals; means for deriving the energization of said heater from said source; means for regulating said unregulated voltage, said regulating means having high- and low-potential input terminals and high- and low-potential output terminals, said high- and low-potential input terminals of said regulating means being connected to said high- and low-potential output terminals, respectively, of said source of unregulated voltage, resistance means connected from said high-potential input terminals to said high-potential output terminals of said regulating means; and means for feeding said anode circuit from a point between the ends of said resistance means, said point on said resistance means being located such that the effect on said anode of variations in voltage present at said point substantially cancels the effect on said anode of variations in voltage at said heater.

9. In an electronic circuit, the combination of a source of alternating-current energy; a power supply fed from said source, said power supply having a power transformer including a heater winding and a plate winding, and a rectifier for converting alternating current power from said plate winding into direct current power; a voltage regulator having high- and low-potential input terminals and high- and low-potential output terminals, said input terminals being connected to receive said direct-current power presented by said rectifier; impedance means connected between said high-potential input terminal and said high-potential output terminal of said voltage regulator; an electron discharge device having at least an anode and a heater, said heater being heated by power from said heater winding and said anode having a load impedance connected from said anode to a point between the ends of said impedance means, said point being located such that the effect on said anode of variations in the voltage present at said point substantially cancels the effect on said anode of variations in voltage at said heater.

10. In an electronic circuit, the combination of a source of alternating-current energy; a power supply fed from said source, said power supply having a power transformer including a heater winding and a plate winding, and a rectifier for converting alternating-current power from said plate winding into direct-current power; a voltage regulator having high- and low-potential input terminals and high- and low-potential output terminals, said input terminals being connected to receive said direct-current power presented by said rectifier; resistance means connected between said high-potential input terminal and said high-potential output terminal of said voltage regulator; an electron discharge device having at least an anode and a heater, said heater being heated by power from said heater winding and said anode having a load impedance connected from said anode to a point between the ends of said resistance means, said point being located such that the effect on said anode of variations in the voltage present at said point substantially cancels the effect on said anode of variations in voltage at said heater.

11. In an electronic circuit, the combination of a source of alternating-current energy; a power supply fed from said source, said power supply having a power transformer including a heater winding and a plate winding, and a rectifier for converting alternating-current power from said plate winding into direct-current power; a voltage regulator having high- and low-potential input terminals and high- and low-potential output terminals, said input terminals being connected to receive said direct-current power presented by said rectifier; first and second resistive means connected in series between said high-input terminals and said high-output terminals of said voltage regulator, an electron discharge device having at least an anode and a heater, said heater being heated by power from said heater winding and said anode having a load impedance connected from said anode to the junction of said first and second resistive means, the value of said first and second resistive means being such that the effect on said anode of variations in voltage present at said junction substantially cancels the effect on said anode of variations in voltage at said heater.

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