Feb. 9, 1943. G. E. HANSELL 2,310,286

VOLTAGE REGULATING SYSTEM

Filed June 25, 1941

Fig. 1.

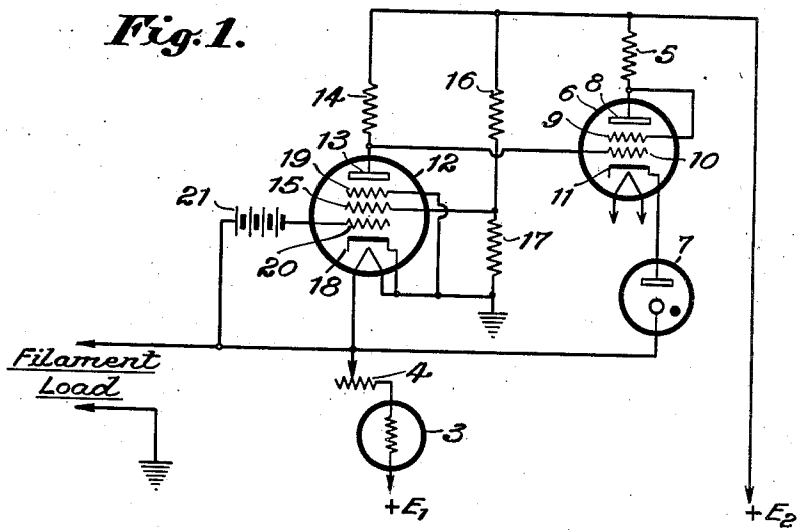
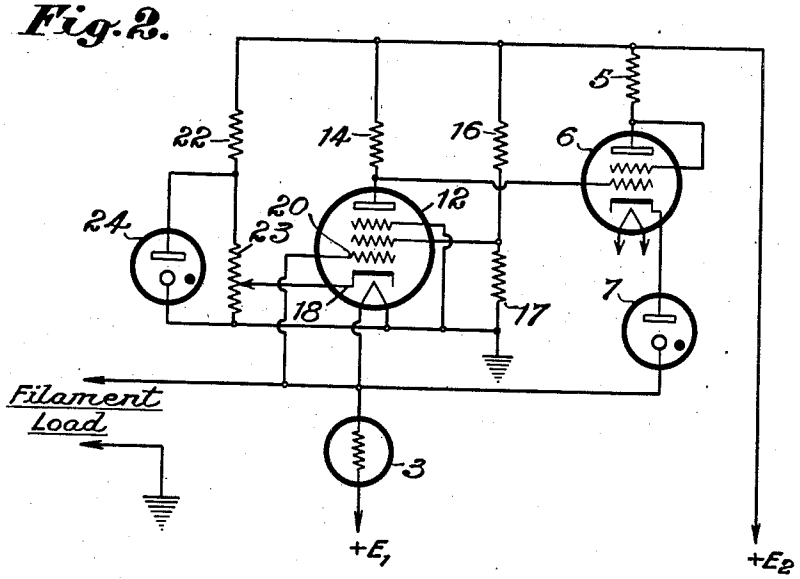


Fig. 2.



INVENTOR
Grant E. Hansell
BY
H. S. Grover
ATTORNEY

Patented Feb. 9, 1943 2,310,286

UNITED STATES PATENT OFFICE

2,310,286

VOLTAGE REGULATING SYSTEM

Grant E. Hansell, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application June 25, 1941, Serial No. 399,610

12 Claims. (Cl. 250—27)

The present invention relates to a system for regulating the filament voltage on a tube, or number of tubes, to compensate for variations in potential of the filament supply battery or other supply source. The requirement for constancy of filament voltage is particularly stringent in the case of an oscillator tube or a regenerative oscillating circuit.

An object, therefore, of the present invention is the supply of closely regulated voltage to the filaments of one or more vacuum tubes.

Another object is the provision of means for maintaining the voltage supplied to the filament of a vacuum tube within closely predetermined limits.

Still another object of the present invention is the provision of means for maintaining the voltage supplied to the filaments of vacuum tubes within closely predetermined limits in spite of comparatively large variations in the voltage of the supply source.

A further object is the improvement of the operation of the vacuum tube oscillator circuits.

The present invention includes, among its features, a series connection of a vacuum tube filament, a ballast resistor and a voltage supply which is subject to unavoidable fluctuations. A separate voltage supply is also connected to the filament in series with the anode-cathode circuit of a control tube. The current passed by the control tube is so controlled in accordance with variations of voltage as to compensate for variations in the voltage which are not completely compensated for by the ballast resistor. I have discovered that the additional control is necessary because, among other reasons, the thermal-inertia of a ballast resistor, small though it may be, makes it impossible to entirely and instantaneously compensate for sudden fluctuations in the supply voltage. Furthermore, the control range of a ballast resistor alone may be insufficient to compensate for wide variations in the supply voltage, particularly in the case of extremely large decreases in the voltage.

The present invention will be more fully understood by reference to the following detailed description, which is accompanied by a drawing in which Figure 1 illustrates an embodiment of the present invention and Figure 2 shows a modification of the form of the invention shown in Figure 1.

In Figure 1 I have indicated a filament load circuit as connected to a source of filament current identified by $+E_1$ and the ground symbol through a series circuit including ballast resistor or ballast lamp **3** and a variable resistor **4**. The ballast lamp or resistor **3** compensates for large variations in the voltage supply E_1, particularly if they are not so rapid that the thermal-inertia of the ballast **3** is too great to follow the variations. The source indicated by the symbol $+E_1$ supplies the major part of the current for energizing the filament load. In order to compensate for variations which the ballast lamp **3** does not take care of, I provide a second voltage supply $+E_2$ which is likewise connected to the filament load through the anode-cathode circuit of tube 6. The second source is of much higher potential but need be capable of supplying only a small amount of current, of itself insufficient to energize the load circuit. Tube **6** has been indicated as a multi-grid tube having the anode **8** and the screen **9** connected together in order to increase its current carrying capacity. If conveniently available, a triode may be substituted for multi-grid tube **6**. The anode-cathode circuit also includes anode resistor **5** and, between cathode **11** of tube **6** and the filament load, a gas discharge tube **7**. The gas discharge tube **7** maintains substantially constant voltage on cathode **11** in spite of variations of current flow through tube **6**.

The amount of current passing through tube **6** is controlled by a control grid **10** which is directly coupled to the anode of tube **12**. Anode **13** of tube **12** is connected to $+E_2$ through anode resistor **14**, while the screen electrode **15** is energized at the proper potential by a potential divider network comprised of resistors **16** and **17** connected from $+E_2$ to ground. The cathode **18** and suppressor electrode **19** of tube **12** are grounded as is common practice. The control electrode **20** of tube **12** is so connected to the filament load circuit that the variations in voltage of the filament load circuit are amplified and impressed on the grid of tube **6**. The current through tube **6** is, therefore, so controlled as to feed more or less current through the filament load in a manner to compensate for the variations of the filament load. Grid **20** of tube **12** is biased to a suitable point on the operating characteristic curve by means of biasing battery **21**.

In an embodiment of the present invention, connected as indicated in Figure 1, tests indicated that the regulation of the filament load was improved by a factor of 7 to 1 compared to the regulation obtainable with a ballast regulator alone.

Under some circumstances it may be undesirable to utilize battery **21** as shown in Figure 1 for biassing the control grid **20**, and Figure 2 shows a modification of the invention in which all

separate battery bias sources have been eliminated. In this figure, the same reference characters have been used for elements which have been described with reference to Figure 1 and only the added elements and their functions will be separately described. The bias on tube 12 is provided in this modification by means of a potential divider circuit comprising resistors 22 and potentiometer 23. A voltage regulator glow tube 24 is connected across resistor 23 to maintain the voltage thereacross at a constant value. Cathode 18 of tube 12 is connected to a variable contact on potentiometer 23. By adjusting the position of this contact the potential on grid 20 may be made negative with respect to cathode 18 by any desired amount within the range provided across potentiometer 23, thus obtaining the same effect as though a variable biasing battery were used.

While I have shown and particularly described several embodiments of my invention, it is to be distinctly understood that my invention is not limited thereto but that modifications within the scope of my invention may be made.

What is claimed is:

1. In an energy supply system, means for connecting a first energy source to a load circuit through a constant current device, means for connecting a second energy source to said load circuit through a variable resistance and means responsive to the voltage across said load circuit for so controlling said variable resistance as to maintain said voltage constant, said variable resistance comprising the anode-cathode path of a thermionic discharge tube and said last mentioned means including a control electrode of said thermionic discharge tube.

2. In an energy supply system, means for connecting a first energy source to a load circuit through a constant current device, means for connecting a second energy source to said load circuit through a variable resistance and means responsive to the voltage across said load circuit for so controlling said variable resistance as to maintain said voltage constant.

3. In an energy supply system, means for connecting a first energy source to a load circuit through a constant current device, means for connecting a second energy source to said load circuit through a variable resistance and means responsive to the voltage across said load circuit for so controlling said variable resistance as to maintain said voltage constant, said variable resistance comprising the anode-cathode path of a first thermionic discharge tube and said last mentioned means including a second thermionic discharge tube having a control grid connected to said load circuit and an anode connected to said second source, said first thermionic discharge tube having a control electrode connected to the anode of said second thermionic discharge tube.

4. In an energy supply system, means for connecting a first energy source to a load circuit through a constant current device, means for connecting a second energy source to said load circuit through a variable resistance and means responsive to the voltage across said load circuit for so controlling said variable resistance as to maintain said voltage constant, said variable resistance comprising the anode-cathode path of a first thermionic discharge tube and said means including a second thermionic discharge tube having a control grid connected to said load circuit and an anode connected to said second source, said first thermionic discharge tube having a control electrode connected to the anode of said second thermionic discharge tube and having a gas discharge tube connected in said anode-cathode path adjacent the cathode.

5. In a voltage regulator system, a load circuit, a first energy source connected to said load circuit through a ballast resistor, a second energy source, a thermionic discharge tube having at least an anode and a cathode, said anode and cathode being serially connected between said second source and said load circuit, and means responsive to the voltage across said load circuit for so varying the current through said thermionic discharge tube as to compensate for variations in said voltage.

6. In a voltage regulator system, a load circuit, a first energy source connected to said load circuit through a ballast resistor, a second energy source, a thermionic discharge tube having at least an anode, a cathode and a control electrode, said anode and cathode being serially connected between said second source and said load circuit, and means responsive to the voltage across said load circuit for applying a potential to said control grid so as to vary the current through said thermionic discharge tube to compensate for variations in said potential.

7. In a voltage regulator system, means for connecting a first energy source to a load circuit through a ballast resistor and means for connecting a second energy source to said load circuit, the second of said means including a thermionic discharge tube having an anode-cathode circuit connected in series between said second source and said load circuit, said thermionic discharge tube having a control electrode and means for applying a variable potential to said control electrode, said potential being variable in response to variations in voltage of said load circuit to compensate for said variations.

8. In a voltage regulator system, means for connecting a first energy source to a load circuit through a ballast resistor and means for connecting a second energy source to said load circuit, said second mentioned means including a thermionic discharge tube having an anode-cathode circuit connected in series between said second source and said load circuit and a control electrode, a second thermionic discharge tube having an anode-cathode circuit and a control electrode, the control electrode of said first thermionic discharge tube being connected to the anode-cathode circuit of said second thermionic discharge tube and the control electrode of said second thermionic discharge tube being connected to said load circuit.

9. In a system for supplying current to a load circuit, a first source of energy for supplying a major portion of the current to said load, a ballast resistor connected between said first source and said load to maintain current from said first source at a constant value, a second source of energy for supplying a small portion of the current to said load and means responsive to the voltage across said load for controlling the current supplied by said second source.

10. In a system for supplying current to a load circuit, a first source of energy for supplying a major portion of current to said load circuit, a ballast resistor connected between said first source and said load to maintain current from said first source at a constant value, a second source of energy for supplying a small portion of the current to said load circuit and means responsive to the voltage across said load circuit for controlling the current supplied by

said second source, said means including a thermionic discharge tube having an anode-cathode circuit in series between said load circuit and said second source and a control electrode, and means responsive to the voltage across said load circuit for applying a variable potential to said control electrode.

11. In a system for supplying current to a filament of a vacuum tube, a first source of energy for supplying a major portion of current to said filament, a ballast resistor connected between said first source and said filament to maintain current from said first source at a constant value, a second source of energy for supplying a small portion of the current to said filament and means responsive to the voltage across said filament for controlling the current supplied by said second source, said means including a thermionic discharge tube having an anode-cathode circuit in series between said filament and said second source and a control electrode, and means responsive to said filament voltage for applying a variable potential to said control electrode.

12. In a system for supplying current to a filament of a vacuum tube, a first source of energy for supplying a major portion of current to said filament, a ballast resistor connected between said first source and said filament to maintain current from said first source at a constant value, a second source of energy for supplying a small portion of the current to said filament and means responsive to the voltage across said filament for controlling the current supplied by said second source.

GRANT E. HANSELL.