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VOLTAGE REGULATING SYSTEM

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8 Claims. (Cl. 171-119)

This invention relates to voltage regulating systems, and has for its principal object the provision of an improved apparatus and method of operation whereby regulated direct and alternating current potentials may be applied simultaneously to load circuits such as the cathode heater and output circuits of an electron discharge device.

For vacuum tube voltmeters, vacuum tube oscillation generators and similar devices, it is frequently desirable to regulate the voltage supplied from a fluctuating source. The plate or output voltage of such electron discharge devices is usually regulated by means of one or more regulator tubes connected in series with the supply leads. Cathode heater or filament voltages are more difficult to regulate due to the large current and low voltage involved. If alternating current is utilized for the cathode heater, it can be regulated at high voltage (low current) and transformed to the required low voltage. In addition, the low voltage to be regulated can be transformed to a high voltage for application to the regulator circuits, in order to improve the accuracy of the regulation.

In accordance with the present invention, a pair of push-pull connected electron discharge devices may be operated simultaneously (1) in parallel for regulating a unidirectional potential, and (2) as a push-pull amplifier for regulating an alternating potential. These regulated unidirectional and alternating potentials are shown as applied respectively to the plate and cathode heater circuits of an electron discharge device but obviously may be utilized for any other desired purpose.

The invention will be better understood from the following description considered in connection with the accompanying drawing and its scope is indicated by the appended claims.

Referring to the drawing,

Figure 1 is a wiring diagram of a voltage regulating system embodying the invention, and

Figure 2 is a similar diagram of a modified regulating system which differs from that of Fig. 1 in that the regulating tubes are in parallel with the load and the cathode heater current is of a different frequency from that of the power supply.

The system of Fig. 1 includes an alternating current supply circuit 10, a rectifier 11 and a filter network 12 from which the rectified unidirectional potential is applied through the push-pull connected regulating tubes 13-14, a resistor

15 and a coil 16 to the anode-cathode circuit of an electron discharge device 17.

The device 17 is of the cathode heater type and alternating current for the heater 18 of the cathode 19 is supplied from a tertiary winding 20 of the main transformer 21 through an amplifier 22, the input transformer 23 and output transformer 24 of the push-pull connected tubes 13-14.

A resistor 25-26 is connected in shunt to the anode-cathode circuit of the load device 17. Potential for regulating the unidirectional potential applied to the anode-cathode circuit of the device 17 is derived from an intermediate terminal of the resistor 25-26 and is applied to the input grid 27 of an amplifier 28. It will be noted that cathode-anode potential is applied to the amplifier 28 from the output terminals of the filter 12 through a resistor 29; that screen grid potential is derived from the output of the filter 12; that a glow tube 30 is connected across the filter output through a resistor 31 for stabilizing the cathode potential of the amplifier 28; and that the output potential of the amplifier is applied to the control grids 32-33 of the push-pull connected tubes 13-14, through the secondary windings of the transformer 23.

Under these conditions, any increase in the anode-cathode potential of the device 17 necessarily involves a similar increase of the potential of the resistor 25-26, the control grid potential of the amplifier 28 becomes less negative with respect to its cathode, the anode-cathode current of this amplifier increases and the resulting increased potential drop of the resistor 29 renders the regulating tube grids more negative, thus increasing the impedance of the parallel direct current paths formed by the tubes 13 and 14 and preventing further increase in the cathode-anode potential of the device 17. When the anode-cathode potential of the device 17 tends to decrease, the potential changes first outlined are reversed and further change in the unidirectional voltage is prevented as will be readily understood.

As previously indicated, alternating potential derived from the main transformer tertiary winding 20 is supplied through the amplifier 22, the push-pull input transformer 23, the tubes 13-14 and the push-pull output transformer 24 to the cathode heater 18 of the device 17. For the purpose of regulating this alternating cathode heater current, there are provided a detector 34 and filter 35 which, coupled to the cathode heater circuit through a transformer 36, regulates the con-

trol grid potential of the amplifier 22 and hence the potential of the heater 18.

Thus, if the alternating heater potential tends to increase, the alternating potential applied to the rectifier tube 37 through the transformer 36 will increase, causing a larger rectified voltage, and the grid 37 of the amplifier 22 will be rendered more negative. This will cause a decrease in the mutual conductance of this tube, and a reduction thereby in the amplification afforded the heater voltage, and further increase in the heater voltage thus prevented. If the alternating heater potential tends to decrease, the voltage changes will be in the opposite direction, to counteract the decrease.

It is thus apparent that the tubes 13-14 operate in parallel as a direct current regulator and in push-pull as an alternating current amplifier. This of course has the advantage of greater simplicity and lower cost of the system.

The voltage regulating system of Fig. 2 is similar to that of Fig. 1 in several respects, but differs therefrom in that (1) the direct current regulating and alternating current amplifying tubes 13-14 are in parallel with the anode-cathode circuit of the device 17, (2) alternating current of a frequency different from that of the main supply is supplied to the cathode heater, and (3) a modified form of potential supply is provided for the regulating amplifier.

Thus the unidirectional voltage regulation amplifiers 38 and 39 have their anode-cathode circuits connected to the output terminals of the filter 12 respectively through a resistor 40 and a resistor 41. The output circuit of the amplifier 38 includes a divided resistor 42-43, the output circuit of the amplifier 39 includes a similar resistor 44-45 and each of these output circuits is completed through the negative terminal of a constant voltage device such as a glow tube 46, the potential across which is supplied by means of rectifier 51, from the transformer winding 50, through the filter 52, the output of the amplifier 38 being coupled to the input of the amplifier 39 through a connection 47.

With these connections, an increase in the unidirectional potential applied to the anode-cathode circuit of the device 17 renders the potential of the control grid 48 of the amplifier 38 more positive, greater current is transmitted through this amplifier, the control grid potential of the amplifier 39 is made more negative due to the increased potential drop of the resistor 40, the output current of the amplifier 39 is decreased, thus decreasing the potential drop of the resistor 41, and the control grids of the regulating amplifiers are made more positive so as to take more anode current, increasing the potential drop in the filter 12, and in this manner neutralize the tendency to increase in potential of the regulated unidirectional potential. Upon a decrease in this potential, a similar but reverse action occurs as will be readily understood.

Applied in push-pull to the control grids of the regulating tubes 13-14 is an alternating potential generated by an oscillation generator 49 which is supplied with power from the output of the filter 12. This alternating potential is regulated in response to change in the cathode heater potential by a potential applied through the transformer 36, the rectifier 34 and the filter 35 to a control grid 53 of the oscillator tube. Thus any change in the cathode heater potential produces in the output control circuit of the oscillation generator tube a regulating potential

which operates to control the amplitude of the alternating potential applied to the amplifiers 13-14 so as to minimize further potential variation.

The output circuit of the device 17 may include a meter 55 which is utilized to measure the potential applied to the input circuit 56 of this device. It will be apparent that the system is also susceptible of many other uses where a high degree of stability in the cathode heater and cathode-anode potentials of an electron discharge device is required.

I claim as my invention:

1. The combination of unidirectional potential supply means, alternating potential supply means, and a pair of electron discharge elements connected in circuit with said first and second named means in parallel for regulating a unidirectional potential from said first named means and in push-pull for amplifying an alternating potential from said second named means.

2. The combination of unidirectional potential supply means, alternating potential supply means, and a pair of electron discharge elements connected in circuit with said first and second named means in parallel for regulating a unidirectional potential from said first named means and in push-pull for amplifying an alternating potential from said second named means, and means responsive to change in said amplified potential for regulating said alternating potential.

3. The combination of alternating potential supply means of one frequency, means for rectifying an alternating potential from said supply means, a pair of electron discharge paths provided with means for varying their impedances, direct and alternating current load circuits, means for applying a rectified potential from said rectifying means to said direct current load circuit under control of said variable impedance paths in parallel, an alternating potential source of a frequency different from that of said potential supply means, and means for applying an alternating potential from said alternating potential source to said alternating current-load circuit through said paths in push-pull.

4. The combination of alternating potential supply means of one frequency, means for rectifying an alternating potential from said supply means, a pair of electron discharge paths provided with means for varying their impedances, direct and alternating current load circuits, means for applying a rectified potential from said rectifying means to said direct current load circuit under control of said variable impedance paths in parallel, an alternating potential source of a frequency different from that of said potential supply means, and means for applying an alternating potential from said alternating potential source to said alternating current-load circuit through said paths in push-pull, and means for regulating the impedance of said paths in response to change in the potential of said direct current load circuit.

5. The combination of alternating potential supply means of one frequency, means for rectifying an alternating potential from said supply means, a pair of electron discharge paths provided with means for varying their impedances, direct and alternating current load circuits, means for applying a rectified potential from said rectifying means to said direct current load circuit under control of said variable impedance paths in parallel, an alternating potential source

of a frequency different from that of said potential supply means, means for applying an alternating potential from said alternating potential source to said alternating current-load circuit through said paths in push-pull, and means for regulating the impedance of said paths in response to change in the potential of said alternating current load circuit.

6. The combination of alternating potential supply means of one frequency, means for rectifying an alternating potential from said supply means, a pair of electron discharge paths provided with means for varying their impedances, direct and alternating current load circuits, means for applying a rectified potential from said rectifying means to said direct current load circuit under control of said variable impedance paths in parallel, an alternating potential source of a frequency different from that of said potential supply means, means for applying an alternating potential from said alternating potential source to said alternating current-load circuit through said paths in push-pull, and means for regulating the impedance of said paths in response to change in the potentials of said direct and alternating current load circuits.

7. The combination of alternating potential supply means of one frequency, means for rectifying an alternating potential from said supply means, a pair of electron discharge paths provided with means for varying their impedances, direct and alternating current load circuits, means for applying a rectified potential from said rectifying means to said direct current load circuit through said variable impedance paths in parallel, and means for applying an alternating potential from said alternating potential supply means to said alternating current-load circuit through said paths in push-pull.

8. The combination of alternating potential supply means of one frequency, means for rectifying an alternating potential from said supply means, a pair of electron discharge paths provided with means for varying their impedances, direct and alternating current load circuits, means for applying a rectified potential from said rectifying means to said direct current load circuit through said variable impedance paths in parallel, and means for regulating the impedance of said paths in response to change in the potential of at least one of said load circuits.

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