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H. A. FRENCH ET AL
DIRECT CURRENT STABILIZER

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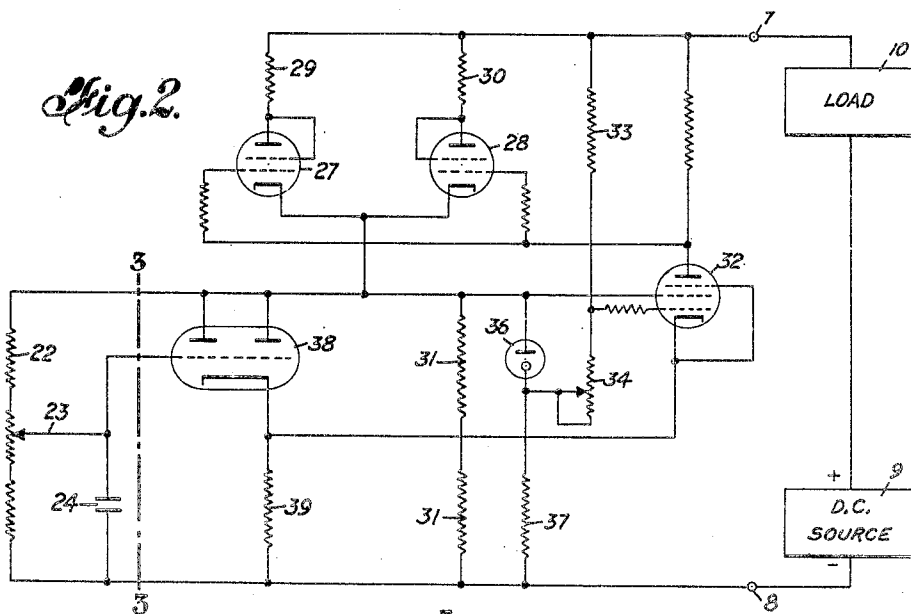
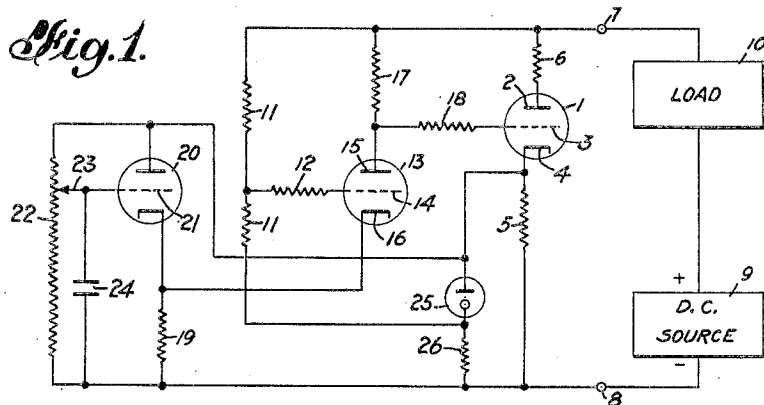
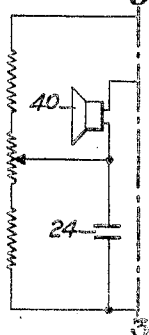


Fig. 3.



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DIRECT CURRENT STABILIZER

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This invention relates to current stabilizers and more particularly to stabilizers for maintaining substantially constant a direct current despite changes in voltage from the source or changes in the impedance of a direct current load.

Various types of direct current stabilizers have been proposed using a regulating electron discharge device in the supply circuit for regulating the current supplied to a load. These may consist of a degenerative circuit in which a degenerative feedback is effected to control the bias on the regulating tube, a mu-balance circuit in which a balance voltage is fed to the grid of the regulating tube over an inverter amplifier having amplification factor of mu from a voltage divider bridged across the regulating device, or a combination of both.

The combination mu-balance, degenerative system generally exhibits a closer regulation than either of the other types. Such a circuit consists of a regulator tube having a cathode resistor connected to output terminals for application between a direct current source and a load. Across the regulator tube is provided a potentiometer, an intermediate point of which is coupled to the grid of an amplifier-inverter tube. The anode of this amplifier tube is coupled to the grid of the regulator tube over a neon or glow tube, which in turn has its cathode connected to the lower terminal of the cathode resistor. The cathode of the amplifier tube is coupled through a second glow tube to this lower terminal to serve as a source of reference voltage for the amplifier tube. In this case the cathode resistor is used as the source of comparison voltage.

Thus the standard reference voltage will be compared with a lower voltage for application to the amplifier tube. Moreover this shunt current serves to preserve properly high operating potential for the shunted connected electron discharge device.

The electron discharge device connected across the regulator cathode resistor is supplied with a variable grid bias circuit to control the current flow and thus adjust the magnitude of the reference voltage. As the potential of the regulator cathode resistor is relatively high while the potential at the cathode resistor of that device connected thereacross is relatively low, a voltage reducing divider consisting of a glow tube and series resistor preferably is connected across the regulator cathode resistor. Voltage drop across the glow tube differs from the drop in the regulator cathode resistor by an amount equal to the bias desired for the amplifier tube.

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The shunt potentiometer and amplifier tube serves as the mu-balance regulator, while the cathode resistor and return grid circuit furnish the degenerative regulator control.

In accordance with a feature of our invention a combined mu-balance, degenerative circuit of the type described above is provided with an electron discharge device and cathode resistor connected across the cathode resistor of the regulator electron discharge device, the cathode resistor of the first electron discharge device serving as the reference voltage source connected to the inverter-amplifier tube of the mu-balance circuit.

It has been found that a regulator or stabilizer as described above has certain undesirable features. A glow tube serving as a voltage reference is not stable when operation is initiated and the circuit may tend to stabilize at a current value other than that desired. Moreover, the glow tube reference source is of a high impedance which is less desirable from an operating standpoint.

It is an object of our invention to provide a combination mu-bridge, degenerative current regulator, wherein an electron discharge device is provided with a cathode resistor serving as a reference voltage standard.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic circuit diagram of a simplified circuit embodying our invention.

Fig. 2 is a schematic circuit diagram of an embodiment of our invention as used on an operating system and,

Fig. 3 is a modification of Fig. 2 to be substituted for the portions to the left of line 3-3.

Turning first to Fig. 1, the current stabilizer includes a current regulator tube 1 having an anode 2, grid 3 and cathode 4, and provided with a relatively high resistance cathode resistor 5 and, if desired, a plate load resistor 6. The series circuit comprising resistor 6, tube 1 and cathode resistor 5 is connected to terminals 7 and 8 which may be coupled in series with a D. C. source 9 and a load 10. Bridged across tube 1 is a potentiometer comprised of resistors 11. The junction point between these resistors is connected through the coupling resistor 12 to grid 14 of amplifier-inverter tube 13 provided with an anode 15 and cathode 16. The anode 15 may be coupled through

a load resistor 17 to the positive supply terminal and the anode output applied through a coupling resistor 18 to grid 3 of tube 1. This tube 13 serves to apply the control voltage to regulator tube 1 in accordance with changes in the current producing voltage drop in cathode resistor 5. In order that tube 13 may properly regulate the current flow over a fixed standard the cathode 16 of tube 13 is coupled across a cathode resistor 19 of a constant voltage supply tube 20. Tube 20 together with its cathode resistor 19 is coupled across resistor 5. Grid 21 of tube 20 is provided with an adjustable bias by means of potentiometer resistor 22 and adjustable potentiometer slider 23. A high frequency bypass condenser 24 is provided to bypass any undesired alternating current component that may be present. It will be evident that through the cathode resistor 19 there is a large negative feedback across tube 20 and that this large negative feedback current through the tube, and consequently the voltage across resistor 19, is maintained substantially constant. Thus cathode 16 of tube 13 is tied to a very stable constant voltage position. The voltage supplied to the grid of tube 13 will be determined by the potential difference between the drop in 19 and in resistor 5. Since potential across resistor 19 is low and whereas potential across resistor 5 is relatively high it is, therefore, desirable to subtract substantially from the potential of resistor 5 a relatively fixed amount so that the voltage variation at 5 will be compared with a potential of comparable magnitude. To accomplish this a voltage divider comprising a glow tube 25 and resistor 26 is coupled across resistor 5 and across tube 20 and resistor 19. The tube 25 will serve to subtract substantially a fixed amount from the voltage drop normally present in resistor 5 so that the comparison voltage applied to tube 13 will be substantially the difference in voltage between the standard from resistor 19 and the voltage drop in resistor 26.

It will thus be evident that the balance circuit comprising potentiometer 11 in tube 13 and associated circuits will normally serve to control the voltage supplied to grid 3 of regulator tube 1 so that the current output from source 9 to load 10 is substantially constant. However, when comparatively large departures in the voltage from source 9 or in the impedance of load 10 occur degenerative action on tube 1 due to the resistor 5 in its common anode-cathode-grid path, will also serve to provide a regulating function.

Detailed explanation of the operation of the combination mu-balance, degenerative generator is not offered herein since it has already been quite fully described in the literature. It will be understood however that in the circuit in accordance with our invention an extremely stable reference voltage is obtained by the use of tube 20 and resistor 19 which has not been provided in the known prior art structures. Furthermore, cathode resistor 19 provides a low impedance voltage source which has desirable features in operation of the circuit.

In Fig. 2 is shown a schematic diagram of a voltage stabiliser constructed utilising the principles of our invention. This circuit is essentially equivalent to that shown in Fig. 1 and is adapted to be inserted as a two terminal network in series with a source 9 and 10 as in the case of the circuit of Fig. 1. In this circuit however the triode 1 has been replaced by two tetrodes 27, 28 each connected to the positive supply terminal through load resistors 29, 30. The screen grid and anode

are connected together so that the tubes operate substantially as triodes. Two tubes are used in parallel to carry the higher current. A common cathode resistor 31 is provided for the triodes 27, 28 which is connected to terminal 8 for coupling to the power supply negative terminal.

The amplifier tube 32 is shown as a pentode tube having its control grid coupled to an intermediate point on the potential divider comprising a resistor 33, a regulating potentiometer 34 and glow tube 35. Glow tube 36 is included in the potential divider coupled across tubes 27 and 28 in this instance in series with resistor 37 across the resistors 31 in the same manner as 25 and 26 are connected in Fig. 1. Potentiometer 34 is included so that the amplification of pentode 32 may be adjusted to provide the proper mu-balance division of the voltage. The standard reference supply tube 39 consists of a double triode in this instance having its cathode coupled to the lower end of resistor 31 through cathode resistor 39 and is provided with an amplifying control potentiometer consisting of resistor 22 and slider 23 shunted by a condenser 24 as in Fig. 1. The anode potential in tube 30 and the screen grid potential in regulator tube 32 are derived from the same source.

In an actual constructed example the regulator tubes 27 and 28 were of the type known as 6AR6 and the pentode was of the type known as 6SJ7 while tube 32 was of the type known as 6J6 and glow tube 36 of the type known as OB2. Cathode resistor 31 was of 2 kilohms, the resistor 33—1 megohm, potentiometer 34—5 kilohms, resistor 37—4700 ohms, cathode resistor 39—5 kilohms. The anode load resistor 29 and 30 were of 47 ohms each, while the anode resistor for pentode 32 was 1.5 megohms. With this circuit arrangement the regulator was found to operate with a voltage supply varied circuit 1350 to 1650 volts supplying 100 millampere current to load 10 which was stable within plus and minus 30 microamperes. Furthermore, the regulator produced only a 500 volt drop in the complete supply circuit whereas other regulators tested produced between 700 and 1400 volts drop in a similar circuit.

Since the magnitude of the current is controlled by variations in voltage on the grid of tube 32 an audio frequency modulation can be supplied to the load as shown in Fig. 3. This may be accomplished by inserting in the control grid lead of tube 32 an audio modulating source such as a carbon microphone 40. With this arrangement the frequency response of the system is found to be substantially constant between 50 cycles per second and 25 kilocycles and at 100 milliamperes D. C. with two thirds milliamperes R. M. S. value of input value. The distortion in this modulator is -46 to -51 decibels in the range between 50 cycles per second and 15 kilocycles. In this system only one gaseous discharge regulator tube such as 36 or 25 is used and this tube may be operated in its most stable condition. As a consequence the regulator has been found to provide extremely stable current regulation.

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. We claim:

1. A current regulator comprising a first electron discharge device and a resistor for connec-

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tion in series with a direct current source and a load, whereby a predetermined voltage drop will be produced in said electron discharge device, a second electron discharge device for amplifying a portion of said voltage drop and applying it to said device to regulate current flow therein, a stabilizing voltage comparison source comprising a third electron discharge device and a series cathode resistor connected in series and across said first named resistor and means for connecting said second device in series with said cathode resistor to provide a comparison voltage for said second electron discharge device.

2. In a regulator including a regulating tube having anode, cathode and grid electrodes, and a resistor in series with said cathode electrode for connection in series with a source of current and a load, a potential dividing network coupled between said anode and cathode electrodes, and an amplifying tube having an anode, a cathode and a grid, means for coupling said anode to the grid electrode of said regulating tube, and means for coupling an intermediate point of said potential dividing network to said grid of said amplifying tube; a circuit for providing a standard reference voltage for said regulator, comprising an electron discharge device and a cathode resistor in series coupled across said first named resistor whereby a substantially constant voltage is developed across said cathode resistor, and means coupling the cathode of said amplifying tube to the junction

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tion between said cathode resistor and said electron discharge device.

3. A current regulator according to claim 2, further comprising a gas discharge tube having a substantially constant voltage drop forming a portion of said voltage divider adjacent said cathode electrode.

4. A current regulator according to claim 3, wherein said amplifier tube is a pentode further comprising means for connecting the screen grid of said pentode to said cathode electrode of said regulating tube.

5. A current regulator according to claim 2, wherein said electron discharge device includes a grid, further comprising means coupled to said grid variably to control the bias thereof to adjust the drop through said cathode resistor.

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