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LOW DROP VOLTAGE REGULATOR

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Fig 1

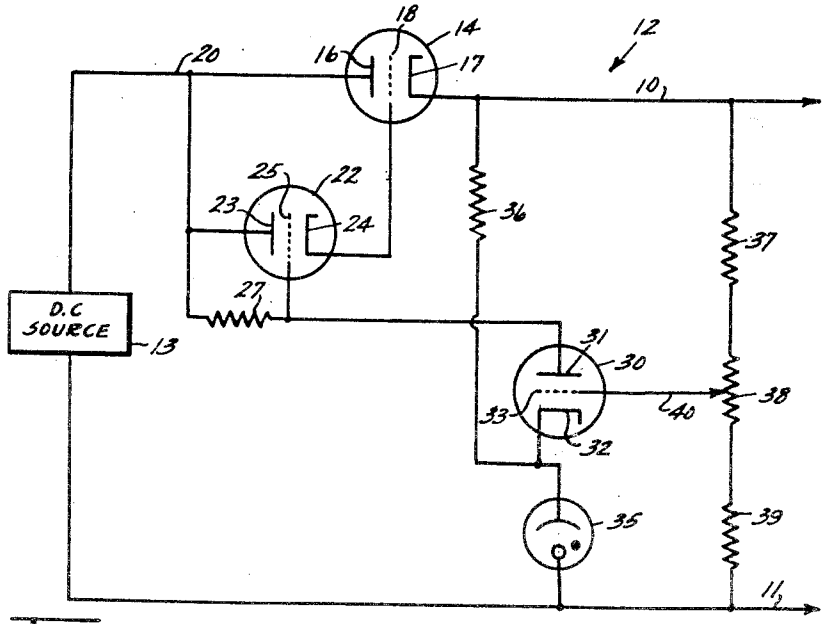
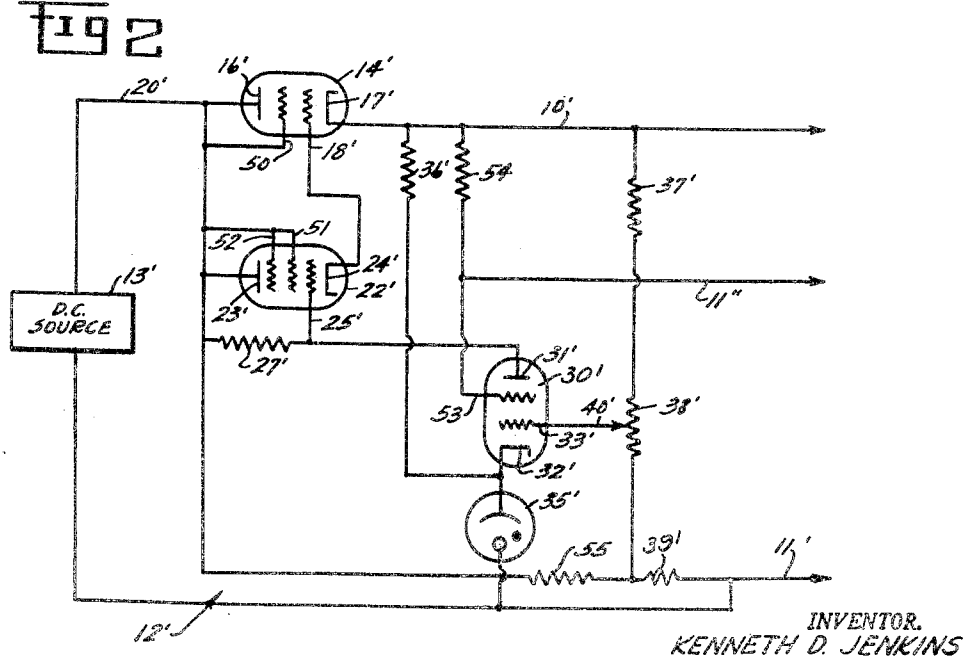


Fig 2



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LOW DROP VOLTAGE REGULATOR

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention pertains generally to electronic voltage regulators and more particularly to a regulator which has a low voltage drop.

In a conventional voltage regulator of the degenerative type, the voltage drop across the series rheostat tube is usually high when the control grid potential with respect to the cathode is negative. Prior efforts to reduce the high voltage drop across the series rheostat tube resulted in ganging additional high current carrying tubes in shunt with the series rheostat tube. However, this proved unsatisfactory because it increased the size and cost of the voltage regulator. The current invention remedies this fault and produces a low voltage drop across the series rheostat tube by operating the control grid of this tube at a positive potential with respect to its cathode. A cathode follower stage of amplification is introduced in the degenerative feedback circuit with the control grid-cathode resistance of the series rheostat tube acting as the cathode load resistor for the cathode follower stage. It is the voltage drop across this resistance which keeps the control grid of the series rheostat tube at a positive potential with respect to its cathode.

Accordingly, an object of this invention is to provide a new and improved voltage regulator of greater range and that provides regulation under greater loads or lower input voltage than previous circuits of its type.

It is another object of this invention to provide a voltage regulator of the degenerative type which has a low voltage drop across the series rheostat tube wherein the control grid is operated at a positive potential with respect to its cathode.

A further object is to provide a voltage regulator which will pass high currents and is capable of being built into a very small space such as may be required in airborne equipment, remotely controlled equipment or devices of a similar nature.

For a more detailed explanation of this invention, reference is made to the two figures of the accompanying drawing wherein:

Fig. 1 is a schematic diagram that embodies the present invention; and

Fig. 2 is a schematic diagram of a specific adaptation thereof.

In Fig. 1 of the accompanying drawing a load circuit comprising conductors 10 and 11 is energized from a direct current source 13 through a

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degenerative feedback type voltage regulator 12. The voltage regulator 12 comprises an electronic tube 14, preferably of the high vacuum type, having an anode 16, a cathode 17 and a control member or grid 18. The anode-cathode circuit of the electronic tube 14 is connected in series relation with the positive conductor 10 and the direct current source 13 by means of a positive conductor 20. The electronic tube 14 operates as a variable impedance device to control the voltage impressed on the direct current load circuit including conductors 10 and 11 and is referred to herein as a series rheostat tube.

A second electronic discharge tube 22, having an anode 23, a cathode 24 and a control grid 25, is connected between conductor 20 and control grid 18 of the series rheostat tube 14. It is tube 22 which is the cathode follower stage of the degenerative feedback circuit and keeps grid 18 of a positive potential with respect to cathode 17 by forcing grid 18 of the series rheostat tube 14 to draw grid current.

A suitable impedance element, such as a resistor 27, is connected between the positive terminal of the direct current source, conductor 26, and the control grid 25 of the cathode follower tube 22. In series with resistor 27, is connected a third electronic discharge tube 30 having an anode 31, a cathode 32 and a control grid 33 and that serves as a feedback amplifier tube.

In order to maintain the potential of cathode 32 of electronic discharge tube 30, substantially constant, a constant voltage device such as a glow discharge or voltage regulator tube 35, or the like, which is an element of a voltage divider, is connected across the direct current load circuit. A resistance 36 is placed in series with the voltage regulator tube 35 across the load circuit and their common junction point is connected to cathode 32 of tube 30. The voltage regulator tube 35 furnishes a substantially constant reference voltage due to its nonlinear-current impedance characteristic.

A voltage divider comprising resistances 37, 38 and 39 is connected across the direct current load circuit. Resistance 38 is provided with a variable tap 40 which is connected to control grid 33 of tube 30. In this manner a portion of the variation of the direct current load circuit voltage is impressed on the grid 33 for transmission through the feedback circuit of the voltage regulator 12 to the series rheostat tube 14.

The operation of the embodiment of this invention shown in Fig. 1 of the drawing will be explained by considering the system when it is operating under variable load conditions. Voltage

variations introduced from the direct current source 13 are minimized by the voltage regulator. The voltage regulator 12 operates to control the voltage drop across the series rheostat tube 14 so that the voltage impressed on the load circuit remains substantially constant.

If it be assumed that the voltage of the direct current load circuit rises above the predetermined desired value, the potential difference in tube 30 between cathode 32 and control grid 33 will increase, causing tube 30 to conduct a larger current, thereby lowering the potential on grid 25 of cathode follower tube 22. This drop in potential will decrease the current flowing through cathode follower tube 22 and the grid current drawn by grid 18. Accordingly, the series rheostat tube 14 will operate to effect an increase in the voltage drop appearing across it and consequently lower the voltage impressed on the load circuit to the predetermined desired value. Conversely, if the voltage across the direct current load circuit decreases below the desired value, the potential difference in tube 30 between cathode 32 and grid 33 will decrease, causing tube 30 to conduct a smaller current and thereby raising the potential on grid 25 of tube 22. A consequent rise of the potential of grid 18 in tube 14 follows and the voltage drop across the series rheostat tube 14 decreases.

In common with previously designed voltage regulators of the same general type, the apparatus in accordance with the instant invention may be constructed entirely of miniature type tubes, with the exception of the series rheostat tube that will vary in size depending upon the amount of current that it is intended to conduct. Thus, it is possible to provide a voltage regulator embodying the present invention which is capable of being built into a very small space such as may be required in airborne equipment, remotely controlled equipment, or devices of a similar nature.

In conformity with the foregoing description of a voltage regulator that embodies the present invention it will be noted that, as an improvement over previously known voltage regulators of a comparable type, the present regulator is characterized by having a low voltage drop across its circuit and across the series rheostat tube 14 therein and hence has relatively small resistance. The control grid 18 of the series rheostat tube 14 can rise above zero voltage, or is positive with respect to the potential of its cathode and can be drawn beyond the voltage of its cathode for increased conductance and circuit range. The control grid 18 of the tube 14 can be drawn almost to the voltage of the direct current source 13 of potential with which the voltage regulator is supplied.

A specific illustrative adaptation of the present invention is shown in Fig. 2 of the accompanying drawing. Electrical components in Fig. 2 that correspond to and function as components in Fig. 1 are indicated by the same numerals primed. The designated types of tubes and values of components are exemplary throughout. The circuit shown in Fig. 2 is applicable for use with an S-band razon control receiver and the like.

In the circuit shown in Fig. 2 the series rheostat tube 14' is a 6V6 beam power amplifier with its number 2 grid 50 connected to its plate 16'. The tube 22' is a 6AK6 tube and has its number 2 and 3 grids 51 and 52 respectively, connected to its plates 23'. The tube 30' is a 6AK5 tube and its number 2 grid 53 is connected in series with a 5 kilohm resistor 54 to the positive load circuit conductor 10'. A secondary load circuit conductor 11'' is connected at the junction of the grid 53 and resistor 54. The voltage regulator tube 35' is a 991 tube. A resistor 55 is in series with a resistor 39' to give 100% correction for changes of voltage of direct current source 13'. The resistors 27' and 36' are each of 470 kilohms. The remaining resistor values are: resistor 54 of 5 kilohms; resistor 55 of 500 kilohms; resistor 39' of 10 kilohms; resistor 37' of 220 kilohms; and resistor 38' of 50 kilohms. Resistors 55 and 39' are such that the ratio of resistor 55 divided by 39' is equal to the amplification of tube 30'. The schematic circuit shown in Fig. 2 with the representative designated values of the components therein is a successfully operative circuit and a practical adaptation of the present invention. It operates in substantially the same manner as the described operation of the circuit that is shown in Fig. 1.

It is to be understood that the circuits and the electrical component associations that are shown and described herein are submitted for the purposes of illustrating and explaining satisfactorily operating embodiments of the present invention and that similarly functioning changes and modifications may be made therein and particularly arrangements that will permit a wide range of potential upon the grid 18 of the series rheostat tube 14, without departing from the spirit and scope of the present invention.

I claim:

1. In combination, a direct current supply circuit, a load circuit of a voltage substantially that of the direct current supply circuit, a degenerative feedback type of voltage regulator connected between said circuits for regulating the voltage of said load circuit and comprising a non-linear low impedance first tube connected in series between the supply circuit and the load circuit of substantially equal voltage and comprising a plate, a cathode and a control grid, a cathode follower second tube comprising a plate connected to the plate of said impedance first tube, a second tube cathode connected to the grid of said impedance first tube and a second tube control grid, the current path including the plate and cathode of the cathode follower being entirely through the grid cathode of the first tube, a first resistor interposed between the grid of said cathode follower second tube and the plate thereof, an electronic discharge third tube comprising a plate connected to the grid of said cathode follower second tube, a control grid and a cathode, a second resistor interposed between the cathode of said impedance first tube and the cathode of said electronic discharge third tube, a voltage regulator fourth tube in series with said second resistor across the load circuit, a voltage divider connected across the load circuit in parallel with the series connected second resistor and voltage regulator tube, and a variable tap adjustably contacting said voltage divider and connected to the grid of said electronic discharge third tube.

2. In an electronic voltage regulator circuit of the degenerative feedback type having a low voltage drop thereacross, the combination of a direct current circuit supplying voltage to the voltage regulator, a load circuit to which the output from the voltage regulator is applied, and the voltage regulator, the voltage regulator comprising a low impedance series rheostat electronic first tube having a plate, a cathode and a control grid of positive potential with respect to

the cathode, said series rheostat first tube being connected in series between said circuits for introducing a variable low impedance therebetween and for controlling the voltage of said load circuit such as to be substantially as high as the voltage supplied to the regulator, a cathode follower stage second tube connected in parallel across the plate and control grid of said series rheostat first tube and having a control grid, the current path including the plate and cathode of the cathode follower stage second tube being entirely through the grid cathode of the first tube, a first resistor connected between the plate and the grid of said cathode follower stage second tube, an electronic discharge third tube having a plate connected to the grid of said cathode follower stage second tube, a control grid and a cathode, a voltage regulator fourth tube in series with said electronic discharge third tube and said first resistor across the voltage supplying circuit, a second resistor in series with the said voltage regulator fourth tube and the series rheostat tube across the voltage supply circuit, a voltage divider connected across the load circuit, and means adjustably connecting the control grid of said electronic discharge third tube with said voltage divider.

3. An electronic voltage regulator having a low voltage drop and interposed between a direct current supply and a load circuit, comprising a rheostat first tube connected in series between the high side of the current supply and the high side of the load circuit and having as parts thereof a plate and a grid and a cathode, a cathode follower second tube having a grid and having a plate connected to the plate of the series rheostat first tube and having a cathode connected with the series rheostat first tube grid and maintaining the potential of the rheostat tube grid above that of the rheostat tube cathode such that the rheostat tube has a low impedance, the current path including the plate and cathode of the cathode follower tube being entirely through the grid cathode of the first tube, a first resistor connected between the grid and plate of the cathode follower second tube, a feedback amplifier third tube having a plate connected to the cathode follower tube grid and having a cathode and a grid, a second resistor connecting the cathodes of the rheostat tube and the feedback amplifier third tube, a voltage regulator fourth tube connected between the feedback amplifier tube cathode and the low side of the direct current supply and with the second resistor in series with the series rheostat tube connected in parallel with the first resistor and the feedback amplifier tube across the direct current source, a voltage divider across the load circuit and of a potential substantially equal to that of the direct current supply, and a tap connected to the feedback amplifier tube grid and variably engaging said voltage divider.

4. The electronic voltage regulator defined in claim 3 wherein a third resistor is connected between the cathode follower tube plate and the voltage divider across the load circuit at a point negative to said tap.

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