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REGULATED POWER SUPPLY

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Fig. 1.

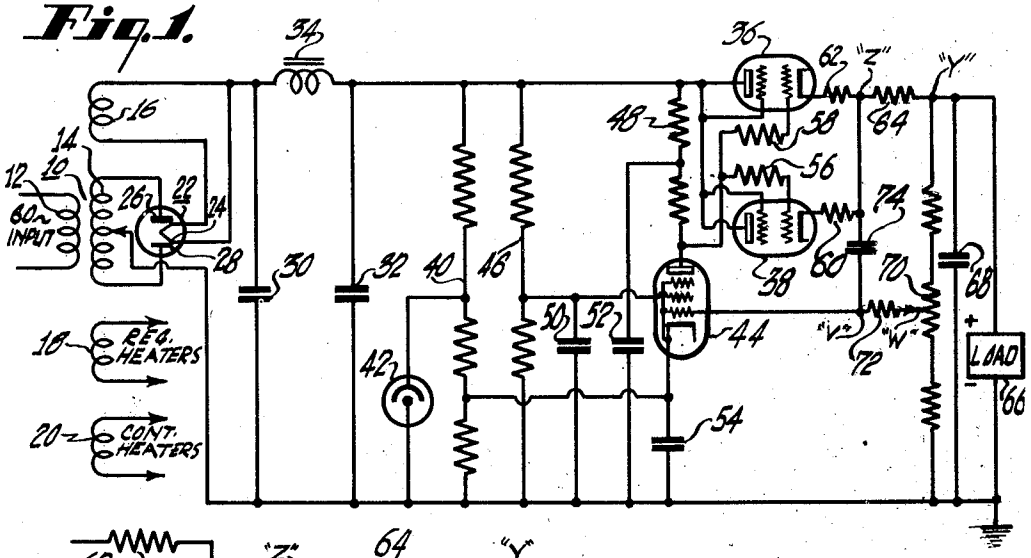


Fig. 2.

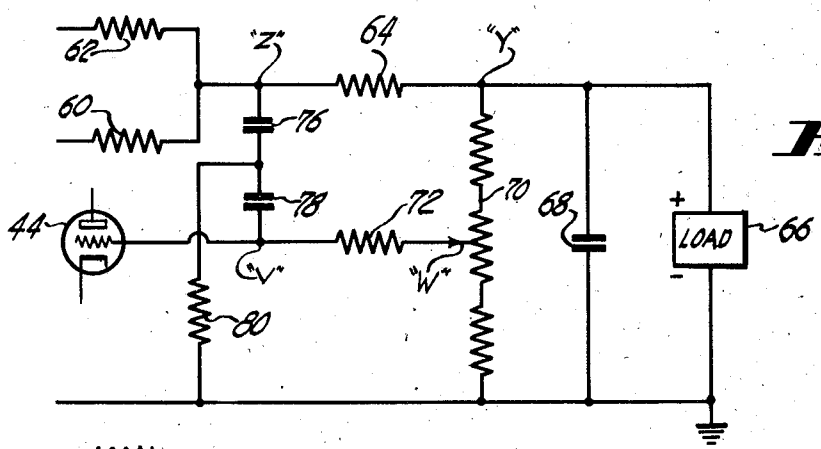
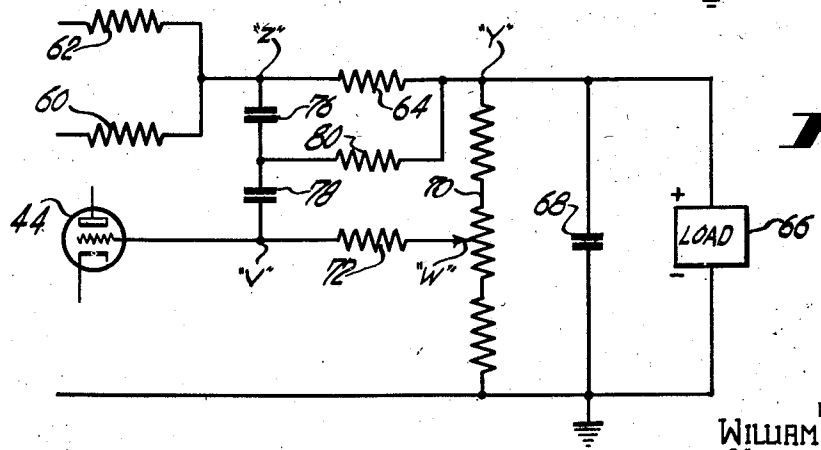


Fig. 3.



INVENTORS
WILLIAM R. AYRES &
HARRY J. WOLL
BY Morrison Rabin
ATTORNEY

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REGULATED POWER SUPPLY

William R. Ayres, Oaklyn, and Harry J. Woll, Audubon, N. J., assignors to Radio Corporation of America, a corporation of Delaware

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5 Claims. (Cl. 323—22)

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This invention relates generally to voltage regulating devices, and more particularly to an improvement in electronically regulated D.-C. voltage power supplies.

Electronically regulated power supplies are generally used where a pure and steady D.-C. voltage supply must be obtained from an available A.-C. power source. In the electronically regulated power supplies presently known to the art, a control tube samples the output voltage of a power supply and, in accordance with this voltage sample, controls a variable resistance tube through which the load current must pass. The voltage sample is usually obtained from a tapped bleeder resistor which is placed across the power supply output.

It has been found, however, that the D.-C. output from these prior art power supplies still contains power supply ripple and hum voltages usually caused by pickup in the wiring and or by the A.-C. voltages used to heat the tube filaments. To correct this condition, a condenser is used to by-pass the undesired A.-C. voltages from the output of the power supply directly to the grid of the control tube. The corrective action thus introduced is still insufficient, since A.-C. noise consisting of ripple and hum voltages is still picked up by the wiring coupled to the grid of the control tube and is thereby introduced into the system.

As a further means for eliminating these unwanted A.-C. noise voltages, it has been proposed to place a filter condenser across the output of the power supply in addition to the above mentioned by-pass condenser. However, since an electronically regulated power supply is a substantially constant voltage source, its output impedance is very low, generally on the order of 5 to 150 ohms. This is a very desirable characteristic from the standpoint of good voltage regulation. If a filter condenser is to be effective, however, it must be supplied from a source preferably having a high or substantial impedance. Otherwise, the filter time constant obtainable when using the usual or reasonable values of filter condensers is relatively short, and extremely poor filtering action results.

As a compromise measure, in order to obtain reasonably good filter action with the normally obtainable filter condenser values, and in order to keep the output impedance of the power supply reasonably low, it has been proposed to raise the source impedance value by means of a resistor inserted in series in the load current carrying line between the variable resistance tube and the

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point of connection of the bleeder resistor used for output voltage sampling. The value of resistor selected was on the order of a few hundred ohms. The by-pass condenser was connected from the control tube grid to the side of the resistor nearest to the variable resistance tube. This was done in order that the A.-C. noise voltage sample be as large as heretofore and in order not to introduce, as additional modulation, any stray voltages that might be picked up by the filter resistor and its leads.

These measures proved effective to substantially eliminate the A.-C. noise voltages while the regulating action of the power supply is not perceptibly affected with a substantially constant load. However, is is found that, with changes in load, transient voltage disturbances occur. The effect and extent of these transient voltage disturbances varies with the amount of load change. It is also found that these transient voltage disturbances are attritutable to the network components added to the power supply, as indicated above, for the purpose of eliminating the A.-C. noise voltages from the power supply output voltage.

It is, therefore an object of our invention to provide an improved electronic power supply wherein transient voltage disturbances due to changes in load are substantially eliminated from the output voltage.

It is a further object of our invention to provide an improved electronic power supply wherein both transient voltage disturbances due to load changes and A.-C. noise voltages are substantially eliminated from the output voltage of the power supply.

It is still a further object of our invention to provide an improved electronic power supply having better voltage regulatory action than heretofore.

These and other objects are achieved in accordance with this invention by using a high pass filter for feeding A.-C. noise voltages back to the control tube grid in place of the by-pass condenser. Since the point of A.-C. noise voltage feed-back is also the point where the greatest transient voltage occurs on changes of load, the transient voltage, which is a low frequency disturbance, is not by-passed to the control tube grid, while the A.-C. noise voltages which are on the order of power line frequencies are by-passed to the control tube grid substantially undiminished.

The novel features of our invention, both as to its organization and method of operation, as well

as additional objects and advantages thereof, will best be understood from the following description of several illustrative embodiments thereof, when read in connection with the accompanying drawings in which like reference characters are applied to parts having similar functions and wherein:

Figure 1 is a schematic diagram of a prior art electronic power supply with A.C. noise voltage filtering, which is necessary for an understanding of our invention, and

Figures 2 and 3 are schematic diagrams of two preferred embodiments of our invention and their connections to the power supply of Figure 1.

Referring to Figure 1 of the drawings, there is shown a power transformer 10 having a primary winding 12, to which the A.-C. power is applied, and secondary windings 14, 16, 18 and 20. Secondary winding 14 is the voltage step-up portion of the transformer 10 in which a high voltage is induced in well known manner. The remaining secondary windings 16, 18, and 20 are used for heating, in well known fashion, the tube filaments used in this apparatus.

A rectifier tube 22 is provided having a cathode 24, which is heated by means of the secondary winding 16, and a pair of anodes 26, 28 which are connected to the ends of the secondary winding 14. A center tap on the secondary winding 14 is connected to ground or to one side of a filter network associated with the rectifier tube.

The filter network shown is the pi-type and comprises a pair of condensers 30, 32 connected from opposite sides of a filter choke 34 to ground. One end of the filter choke 34 is connected to the cathode 22, as is conventional, and the other end is connected to the plate of one or more variable resistance tubes 36, 38. A voltage divider resistor 40 is also connected between the output end of the filter section and ground. A regulator tube 42 is connected to one portion of the voltage divider resistor 40. The cathode of a control tube 44 is connected to the lower portion of the voltage divider resistor 40. The purpose of the connections shown is to insure that the cathode potential on control tube 44 is constant regardless of the power supply fluctuations. This is obtained by having the voltage divider resistor 40 draw a fairly high current. Any fluctuations in this current are compensated for by operation of the regulator tube 42 in a manner well known in the art.

A voltage divider resistor 46, which is across the filter network output, is tapped to supply screen voltage to the control tube 44. A resistor 48 couples the plate of the control tube 44 to the output from the filter section and serves as the plate load resistor. A condenser 50 is connected from the screen of control tube 44 to ground and is the conventional screen by-pass condenser. Another condenser 52, which is connected from a tapped portion of the resistor 48 to ground, is the plate decoupling condenser. A condenser 54 connected between the cathode of control tube 44 and ground serves as the cathode by-pass condenser. The plate of the control tube 44 is coupled to the grids of the variable resistance tubes 36, 38 through oscillation suppressing resistors 56, 58. The cathodes of the variable resistance tubes 36, 38 each have current equalizing resistors 60, 62. These current equalizing resistors 60, 62 connect from the cathodes of variable resistance tubes 36, 38 to a filter resistor 64. The other end of the filter resistor 64 is connected to the load 66. A filter condenser 68 is connected across the output of the power supply. A bleeder resistor 70 is also connected across the power supply output and has a potentiometric portion which is connected to the grid of the control tube 44 by means of a grid current limiting resistor 72. A by-pass condenser 74 is coupled from the variable resistance tube end of filter resistor 64 to the grid of the control tube. By-pass condenser 74 passes the hum and ripple voltages directly to the grid of the control tube.

In the operation of the power supply, the potential at the plate of the control tube 44 is substantially that of the control grids of variable resistor tubes 36, 38 and therefore the control tube plate potential determines the amount of current which flows through the variable resistor tubes 36, 38. The control tube plate potential, however, is determined substantially by the control tube grid voltage since the control tube cathode voltage is maintained substantially constant. The output voltage at which the power supply operates is, therefore, substantially determined by the voltage which is tapped from the variable portion of the bleeder resistor 70. Once the output voltage is thus selected, any increase in output voltage results in an increased voltage at the grid of the control tube 44, causing a lower potential at the control tube plate and also at the variable resistor tube grids, thereby reducing the amount of current they can pass. The output voltage is thus maintained substantially constant. A decrease in the output voltage results in a decreased voltage being applied to the grid of the control tube 44. Its plate voltage therefore increases. This results in an increase in voltage on the grids of the variable resistance tubes 36, 38 and they therefore pass more current, thus maintaining the voltage constant. It is thus seen how, by sampling a portion of the output voltage which is across the bleeder resistor 70, voltage regulation may be obtained.

As previously discussed herein, hum and ripple voltages comprising unwanted A. C. noise voltages are substantially eliminated by being fed to the control tube grid by means of the by-pass condenser 74 and by the action of the R.-C. filter section comprising the filter resistor 64 and the filter condenser 68. Point Z on Figure 1, at the junction of the resistors 62 and 64, denotes an end of resistor 64 from which noise voltages are by-passed and which is coupled to the cathodes of the variable resistance tubes 36, 38. Point Y, at the other end of the resistor 64, denotes an end of the filter resistor 64 to which the bleeder resistor 70 is connected and at which a desired output voltage from the power supply exists. Point W, at the movable end of the resistor 72, represents the point on the bleeder resistor from which the voltage sample for D. C. output voltage variations are obtained. Point V, at the fixed end of the resistor 72, represents the point of connection to the grid of the control tube 44.

The filter resistor 64 has a resistance value usually on the order of 300 ohms. Therefore, when load current is drawn through the resistor 64, point Z will be several volts higher than point Y, depending, of course, upon the value of the load current. Under a typical operating condition, an average load curent of 150 mils causes this potential difference to be 45 volts. If the load is thrown off, or substantially reduced, since the current drawn by bleeder resistor 70 is usually so low as to be negligible, the current through the resistor 64 drops to a small value.

Because of the slow transient response of the power supply, the voltage at point Z is maintained at the same level, so that the voltage at point Y rises substantially 45 volts to equal the voltage at point Z. An undesirable large transient voltage rise thus occurs in the output voltage which, in time, is subsequently eliminated by the regulating action of the power supply.

If, by some means, it is attempted to hold the point Y at a constant voltage level when the load current is changed or the load is thrown off, the voltage at point Z will drop quickly through substantially 45 volts with the drop in load current in order to equal the voltage at point Y. This voltage drop constitutes a transient voltage having a low order of frequency, but nevertheless it will be substantially applied to the grid of the control tube **44** through the by-pass condenser **74** and will cause a correspondingly large transient rise in the voltage output of the power supply. The effect of the transient voltage, therefore, is to cause the control voltage point to be shifted from the point Y, where a desired voltage level exists, to the point Z, where an undesired transient drop occurs. Of course, in going from a "no load" to a "load" condition, all the above described effects occur in reverse. It is to be understood that the magnitude of the transient voltage disturbance caused, with given network components, varies with the amount of load current change. The above difficulties in obtaining proper voltage regulation are substantially eliminated in our invention.

Figure 2 of the drawings represents a schematic of one embodiment of our invention. From the point Z to the point V are connected two condensers **76**, **78** in series, and from their junction point to ground is connected a resistor **80**. These series condensers **76**, **78** and shunt resistor **80** form a high pass filter network which transmits A.-C. signals at power line frequencies but attenuates signals at lower frequencies. Since any transient voltages developed at the point Z due to load changes are at lower frequencies than power line frequencies, these transient voltages will be considerably attenuated by the high pass filter and the transient voltage disturbance will be substantially eliminated from the grid of the control tube **44**. Since the A.-C. noise voltages are still fed to the grid of control tube **44**, the output of the power supply will be substantially as free from these noise voltages as heretofore.

A schematic of another preferred embodiment of our invention may be seen on reference to Figure 3 wherein the series capacitive arms **76**, **78** of the high pass filter are connected between the points Z and V as before but the shunt resistive arm **80** is connected between the junction point of the series capacitive arms and the point Y which is a point of relatively low A.-C. potential. Any low frequency transient voltage which occurs at the point Z, as a result of a load change, is not transmitted to the point V because of the attenuation by the high pass filter. A.-C. noise voltages are transmitted to the point V through the high pass filter. Since the point Y is not entirely isolated from the system, at the time of a change in load, a minor transient voltage fluctuation occurs at this output voltage point which requires correction. This transient voltage is passed through the resistor **80** and the condenser **78** to the point V, and the proper corrective action then occurs. For slow or substantially D.-C. changes in the output voltage of the power supply, the output voltage sample taken at the point W from the bleeder resistor **70** is ample to effect corrective action.

We have obtained excellent transient voltage elimination when the reactance value of the condenser **76** and the resistance value of the resistor **80** are made substantially equal at power line frequencies and substantially greater than that of the resistor **64**. Some typical values used for the high pass filter, when the resistor **64** is 300 ohms and the condenser **68** is 160 microfarads, are 0.1 microfarad for the condensers **76** and **78** and 22,000 ohms for the resistor **80**. A value of 1.0 megohm is selected for the resistance **72**.

We have shown herein an electronic power supply wherein the control tube grid is effectively connected to three points in order to obtain a proper voltage sample for voltage regulation. The first is the point W where a proper voltage sample is obtained to correct for slow or substantially D.-C. changes in output voltage levels; the second is the point Z where a proper voltage sample is obtained to correct for A.-C. noise voltages; and the third is the point Y where a proper voltage sample is obtained to correct for low frequency transient voltage disturbances in the output voltage level.

From the foregoing description, it will be readily apparent that we have provided an improved electronically regulated power supply. Although two embodiments of our invention have been shown and described, it should be apparent that many changes may be made in the particular embodiments herein disclosed, and that many other embodiments are possible, all within the spirit and scope of our invention. Therefore, we desire that the foregoing description shall be taken as illustrative and not as limiting.

What is claimed is:

1. The combination of an electronically regulated power supply and a high pass filter, said power supply including a point of substantially low alternating current potential, a control tube, said control tube having a control grid upon which voltage samples are impressed to obtain regulation of said power supply output voltage, and an output filter section comprising a series resistor having a first and a second end, and a shunt condenser, said shunt condenser being connected to said second end of said series resistor, and said high pass filter comprising series capacitive arms and a shunt resistive arm, said series capacitive arms being connected between said first end of said series resistor and said control tube grid, said shunt resistive arm being connected to said point of substantially low alternating current potential in said power supply.

2. The combination as recited in claim 1 wherein said point of relatively low alternating current potential is at a point of ground potential in said power supply.

3. The combination as recited in claim 1 wherein said point of relatively low alternating current potential is at the junction of said second end of said series resistor and said shunt condenser.

4. The combination of an electronically regulated power supply and a high pass filter, said power supply having a control tube and at least one variable resistance tube through which the load current flows, said control tube being coupled to said variable resistance tube to regulate said load current flow through said tube, said control tube having a grid to which voltage samples are applied to obtain regulation of said power

supply output voltage, said power supply having an output filter section comprising a first resistor connected in series with said variable resistance tube and having a first end coupled to the cathode of said variable resistance tube, and a filter condenser connected to a second end of said first resistor and across said power supply output, and said high pass filter comprising a first condenser and a second condenser connected in series, said series connected condensers being connected between said first resistor first end and said control tube grid, and a shunt resistor connected between the junction of said first and second condenser and said first resistor second end whereby alternating current noise voltages and transient voltages caused by load changes are substantially eliminated from said power supply output voltage.

5. The combination as recited in claim 4 wherein the values of said first condenser reactance and said shunt resistor resistance are substantially equal at power line frequencies and relatively large when compared with the resistance value of said first resistor.

WILLIAM R. AYRES.
HARRY J. WOLL.

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