February 21, 2000.

B+ Power Supplies

There have been several postings asking for B+ power supply designs. I posted two simple schematics at:

http://www.eskimo.com/~ntsales/PDF_files/tubeps1.pdf
and
http://www.eskimo.com/~ntsales/PDF_files/tubeps2.pdf

One of the textbooks used by almost all Radio Engineering courses in the 30’s and 40’s was:

Radio Engineering

by Frederick Emmons Terman
McGraw-Hill, various editions (3rd 1947)

For those who wish to build a tube power supply with tubes, this is one of the best books around.

To give an idea of his book, I have scanned in two pages on “Voltage-Regulated Power-supply systems--” from Chapter 11, entitled: “Sources of Power for Operating Vacuum Tubes.”

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requires careful attention to shielding and the generous use of radio-frequency chokes and by-pass condensers.

11-11. Voltage-regulated Power-supply Systems.—A number of systems have been devised for maintaining the output of a power-supply system constant with variations in supply voltage, or variations in load impedance, or both. By far the most commonly used arrangement of this type is illustrated in Fig. 11-19.[1] Here tube T_3 is a gaseous voltage

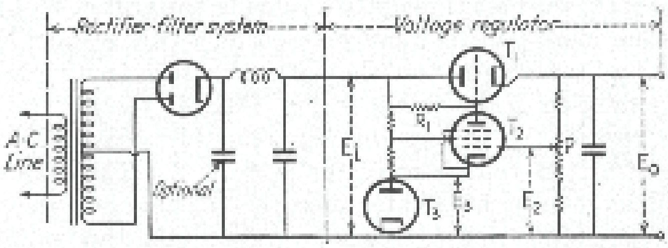

FIG. 11-19.—Schematic diagram of voltage-regulated power supply.

regulator (see Sec. 5-18) which produces across its terminals a constant potential that is used for reference purposes and, in particular, to maintain the cathode potential of amplifier tube T_2 at a fixed potential irrespective of the input voltage E_1 applied to the regulator system. Tube T_2 is operated as a direct-coupled amplifier, the output of which is applied to the control grid of tube T_1, which controls the output voltage. The control grid of T_2 is at a potential E_2 that is a definite fraction E_2/E_0 of the output voltage E_0 determined by the setting of potentiometer P. If now the resistance R_1 in the plate circuit of T_2 is large so that the amplification of the grid-cathode voltage of T_2 is considerable, then as $E_2 - E_3$ becomes less than cut-off, the voltage on the grid of T_1 is rapidly reduced. This, in turn, increases the voltage drop in T_1, reducing the output voltage. Thus, the output voltage is very sensitive to current in R_1, and this current is very sensitive to the changes in the difference $E_2 - E_3$, which in turn is very sensitive to the output voltage. Accordingly, the over-all behavior is such that the voltage E_2 is maintained at a value less than the fixed voltage E_3 such that $E_2 - E_3$ has a value that is nearly constant and just less than cut-off for T_2. This causes the output voltage E_0 to be substantially constant since the ratio E_2/E_0 is determined by the setting of potentiometer P. Anything that tends to alter

[1] A well-organized discussion of the design factors and design procedure involved in a voltage-regulated system of the type illustrated in Fig. 11-19 is given by A. B. Bereskin, Voltage Regulated Power Supplies, *Proc. I.R.E.*, vol. 31, p. 47, February, 1943. Additional information of value in design is given by A. Abate, Basic Theory and Design of Electronically Regulated Power Supplies, *Proc. I.R.E.*, vol. 33, p. 478, July, 1945, and W. R. Hill, Jr., Analysis of Voltage Regulator Operation, *Proc. I.R.E.*, vol. 33, p. 38, January, 1945.

the output voltage E_0, such as a change in the load current or a change in the a-c line voltage, varies the grid-cathode voltage $E_2 - E_3$ applied to tube T_2 in such a manner as to result in a modification of the voltage drop in T_1 that tends to keep the output voltage from changing. For example, a decrease in output voltage resulting from increasing the load current, or a decrease of the a-c line voltage, will reduce E_2 making the control grid of T_2 more negative with respect to cathode than previously. This reduces the current through R_1, causing the grid of T_1 to assume a new potential more positive than previously. This reduces the voltage drop in T_1 and tends to restore the output voltage to its original value.

An examination of the circuit of Fig. 11-19 in the light of the above discussion reveals the factors that qualitatively contribute to a good performance in the voltage-regulator system: (1) The stability of the output voltage can be no greater than the constancy of the voltage E_3 developed across the voltage-regulator tube, since this voltage is used as a reference. (2) Tube T_2 with its associated load resistance R_1 should produce as high an amplification as possible of the grid-cathode voltage $E_2 - E_3$. To achieve this, the resistance R_1 should be high, of the order of 0.25 to 0.5 megohms. Tube T_2 is generally a small sharp cut-off general-purpose pentode. (3) Tube T_1 should have low plate resistance, a high transconductance, and an anode current rating equal to the maximum output current desired. These requirements are commonly met by using a sufficient number of 2A3 or 6AS7-G tubes in parallel.

In practice, the improvements realized by a voltage-regulated power-supply system of the type illustrated in Fig. 11-19 are considerable. Under typical conditions, the variation of output voltage with changes in a-c line voltage, and also any ripple voltage contained in the input E_1 to the regulator, will be reduced by a factor of at least 25, and often by a factor of over 100, as compared with the output of the same rectifier-filter system without regulation. Similarly, the variation in output voltage with change in load current corresponds typically to an equivalent internal impedance for the output terminals of the voltage-regulated system of less than 10 ohms. Often values of the order of 1 ohm are realized. This low value of equivalent internal impedance is maintained down to zero frequency and is to be compared with impedances of the order of 100 ohms or more typically encountered at low frequencies in the corresponding power-supply system without voltage regulation. This low impedance is important not only because it makes the output voltage largely independent of load current, but also because it reduces the common coupling and resulting regeneration introduced at low frequencies in multistage audio and video amplifiers when several stages receive anode power from a common source (see Sec. 6-15).