

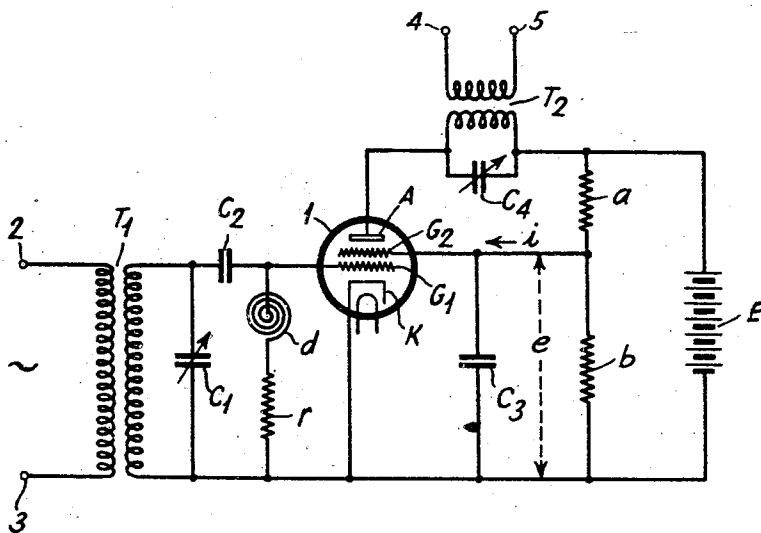
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POWER SUPPLY NETWORK

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POWER SUPPLY NETWORK

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This invention relates generally to a power supply arrangement for variable resistance load devices, and particularly to an arrangement for supplying power to such a device from a voltage source relatively high as compared to the normal operating voltage of the device.

It is an object of the invention to provide an arrangement such that regardless of the resistance of the device, the power input thereto cannot exceed a predetermined value.

A further object of the invention is to provide a power supply arrangement of the type described, having the property that, regardless of the resistance of the load device, the power input thereto can never exceed the power input occurring in the normal operating condition. In such a case, the load device may be operated normally with a power input substantially equal to the maximum allowable input without any danger of exceeding this value of input by improper adjustments of the load system resulting in a departure from the normal resistance of the load.

The invention will be described with reference to a power supply system for the screen circuit of a screen grid tube; however, as will be pointed out later, the method is equally applicable to any other type of load.

In order that the advantages of the present invention may be more fully appreciated, the drawbacks of the prior art methods will be pointed out briefly. To energize the screen of a screen grid tube two methods are generally used. One of these methods provides a fixed voltage supply of the proper value for normal operation, while in the other method there is utilized a high resistance connected between the screen and the source of plate voltage. In the first method, in addition to the extra equipment required or the large drain of power from the high voltage supply that is necessary if a potentiometer is connected across the plate supply that has sufficiently low resistance to provide a substantially constant screen voltage, there is the danger that if the tube is operated in other than correct adjustment, the screen current may rise to excessive values, so that the screen power input exceeds the maximum allowable value. For this reason, the users of screen grid tubes are warned, as, for example, in the instruction sheet for the RCA type 814 tube, which says, "If the screen voltage is obtained from a separate source or from a potentiometer, plate voltage should be applied before the screen voltage or simultaneously with it; otherwise, with voltage on the screen only, the screen current may be large enough to cause excessive screen dissipation." If the second method is utilized, that is, if screen voltage is obtained from the plate power supply through a series resistance, there is danger of the full plate voltage reaching the screen, which may not be sufficient-

ly insulated for such high voltage. Again quoting from the RCA type 814 tube instruction sheet, "With this method, however, it is important that the high voltage supply switch be opened before the filament circuit is opened or the R. F. excitation is removed; otherwise full supply voltage will be placed on the screen." The present invention avoids both of the above mentioned dangers.

The single figure of the accompanying drawing illustrates the application of the present invention to a screen grid circuit of a screen grid tube.

In the drawing, the tube 1 is provided with a cathode K, an input grid G₁, a screen grid G₂ and an anode A. The energy to be amplified is impressed between input terminals 2 and 3 of the primary of input transformer T₁ and thus fed to the input of the tube which includes the usual tuned circuit comprising condenser C₁ shunted across the secondary of transformer T₁, grid condenser C₂ and a direct current path between grid G₁ and cathode K comprising choke coil d and resistance r in series. The anode circuit of tube 1 includes the tuned circuit comprising the primary of output transformer T₂ shunted by condenser C₄ and a suitable source of anode current represented generally as a battery E. For supplying the screen grid G₂ with proper potential two resistors a and b are connected in series across the source E and the grid G₂ is connected to a point intermediate the two resistors a and b. A by-pass condenser C₃ is connected between the grid G₂ and the cathode K.

From the above, it is seen that the screen grid tube amplifier circuit has its screen circuit supplied with power from the plate voltage source by way of a current-limiting resistance a, and a voltage-limiting resistance b, whose values are chosen in accordance with the present invention in the manner described hereinafter.

In what follows, e denotes the normal screen voltage and i the normal screen current, while E is the plate supply voltage. The value of the resistances a and b must be so chosen that in normal operation the screen current and voltage have the values e and i, respectively. By a simple application of Kirchhoff's laws it is easily shown that this requirement leads to the relation between b and a given by the equation,

$$b = \frac{ea}{E - e - ai} \quad \text{I}$$

but does not establish individual values for these resistances. Let us, therefore, impose the further condition that, in the absence of screen current the screen voltage shall rise to an arbitrary fraction, f, of the plate supply voltage. This second condition leads to the relation given by the equation,

$$b = a \frac{f}{1 - f} \quad \text{II}$$

From a comparison of Equations I and II it easily can be seen that the individual values of a and b are as follows:

$$a = \frac{fE - e}{fi} \text{----- III}$$

$$b = \frac{fE - e}{(1-f)i} \text{----- IV}$$

Considering the screen circuit resistance as variable, the power input to the screen circuit for any given value of f may be expressed as a function of the screen resistance. By maximizing this expression with respect to the variable screen resistance, it is found that the maximum screen input for any value of screen resistance whatever is given by the equation,

$$\text{Max. input} = \frac{E^2}{4} \frac{fi}{fE - e} \text{----- V}$$

Thus, in order to avoid exceeding the maximum allowable screen input, a value of f may be assumed, and then, by means of Equation V it is possible to determine whether there is any condition of operation under which the screen input exceeds the maximum allowable value. In order to be entirely safe, the value of f should be so chosen that the expression in Equation V is less than the allowable screen input.

The expression given in Equation V has an extremum, with respect to f , which occurs when f is equal to twice the ratio of the normal screen voltage to the plate supply voltage and when f is given this value the maximum possible screen input is ei watts. That is to say, in this particular condition the screen input is both the normal input and also the maximum possible input when the circuit is functioning normally, while, for any other condition, the screen input is reduced. Thus, it is possible to make the normal screen input equal to the maximum allowable input, since there is no danger that the screen input can ever exceed this value under any conditions of adjustment.

Equation V may be readily thrown into another form by making use of Equations I and II to eliminate the quantities f and b from Equation V as follows:

From Equation II we have

$$f = \frac{b}{a+b}$$

Putting this value of f into Equation V and simplifying we obtain

$$W = \frac{E^2}{4} \frac{b}{a(a+b)}$$

(where W represents the maximum input).

Now using Equation I to eliminate b from the above we obtain

$$W = \frac{E^2}{4} \frac{e}{aE - a^2i} \text{----- VI}$$

Assuming that it is desired to limit the maximum input to the allowable value W , Equation VI is solved for a and we obtain

$$a = \frac{E}{2i} \left[1 \pm \sqrt{1 - \frac{ei}{W}} \right] \text{----- VII}$$

To make the application of the invention clear, consider the 814 type tube previously mentioned for which normal operating conditions include the following:

$E=1250$ volts; $e=300$ volts; $i=10$ milliamperes. Taking f as twice the ratio of the screen voltage to the plate supply voltage, as explained above, we have $f=.48$. From Equations III and IV together with this value of f , the individual values of resistances a and b may be determined. When such resistances are employed, it is impossible by any maladjustment of the circuit, or incorrect order of closing or opening switches, to cause a screen input of more than 3 watts, which value is the normal operating screen input.

While the foregoing adjustment is recommended where the normal input is substantially equal to the maximum allowable input, in many cases the allowable input is greater than the normal input. In the 814 tube the allowable input is 10 watts. Hence, in such a case it is possible to choose a smaller value of f , and thus assure an even smaller rise of screen voltage. To determine the smallest value of f that can safely be employed, various values are assumed and the smallest one is chosen, which, when substituted in Equation V, gives a value close to but not exceeding the maximum allowable screen input. The value of f thus determined is then used in Equations III and IV to determine the individual values of resistances a and b .

While the above explanation has confined itself to the case of a power supply for the screen circuit of a screen grid tube, it will be apparent that the same formulae may be used in exactly the same way to design a resistance network for supplying power to a variable resistance load of any nature whatsoever both for direct and alternating current power. The only requirement is that the power supply source must have a voltage at least twice the normal voltage desired across the load, if the system is to be operated in the condition where the normal power input to the load coincides with the maximum possible input to the load. This requirement incidentally, is usually satisfied in the case of screen grid transmitting tubes.

I claim:

1. In an arrangement for energizing a dissipative load device from a source of voltage, wherein said load device is subject to variations from its normal resistance value and is intended to be operated at a normal voltage e and a normal current i , and has an allowable dissipation W , and the voltage E of said source is high compared to said normal load voltage, a first resistance device, a series circuit including said source, said first resistance device and said load; a second resistance device shunted across said load, the resistance a of said first resistance device being given by the equation

$$a = \frac{E}{2i} \left[1 - \sqrt{1 - \frac{ei}{W}} \right]$$

and the resistance b of said second named resistance device being given by the equation

$$b = \frac{ea}{(E - e - ai)}$$

whereby normal voltage and current are supplied to said load device when the resistance of said load device is of normal value while the power input to said device is prevented from ever exceeding said allowable dissipation W and in addition the voltage supplied to said device is limited to less than twice the normal load voltage re-

regardless of any variation in the resistance of said load device.

and the resistance of said second named resistance device being

$$\frac{E_0}{(E-2e)}$$

whereby normal voltage and current are supplied to said load device when the resistance of said load device is of normal value while the power input to said load device is reduced for all other values of resistance than said normal value and in addition the voltage supplied to said device can never exceed twice the normal load voltage as a result of any variation in the resistance of said load device.

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2. In combination, a load device subject to variations from its normal resistance value and intended to be operated at a normal voltage e and a normal current i , a source of voltage whose voltage E is relatively high compared to said normal load voltage, and means for energizing said load from said source comprising a first resistance device, a series circuit including said source, first resistance device, and load; a second resistance device shunted across said load, the resistance of said first resistance device being

$$\frac{E}{2i}$$