Jan. 27, 1948. M. M. LEVY 2,434,939

THERMIONIC VALVE CIRCUITS

Filed Jan. 18, 1944

FIG. 1

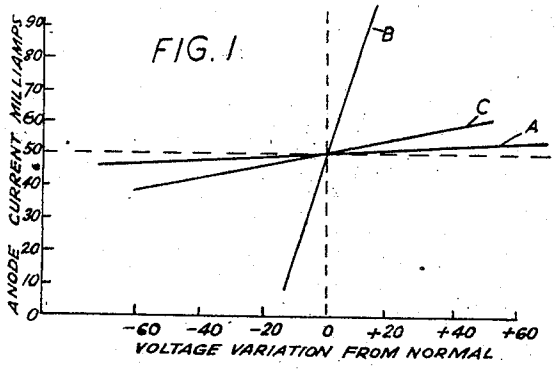


FIG. 2.

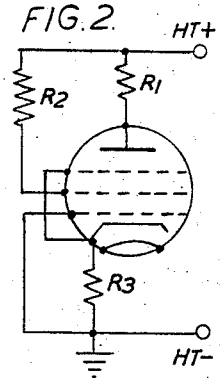


FIG. 3.

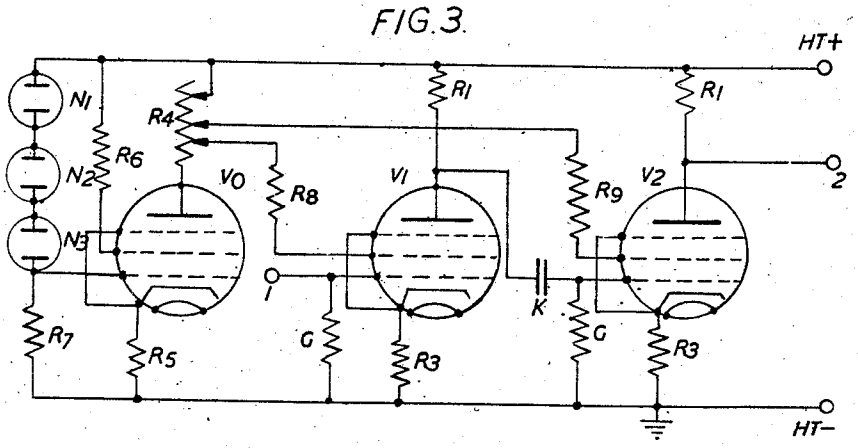
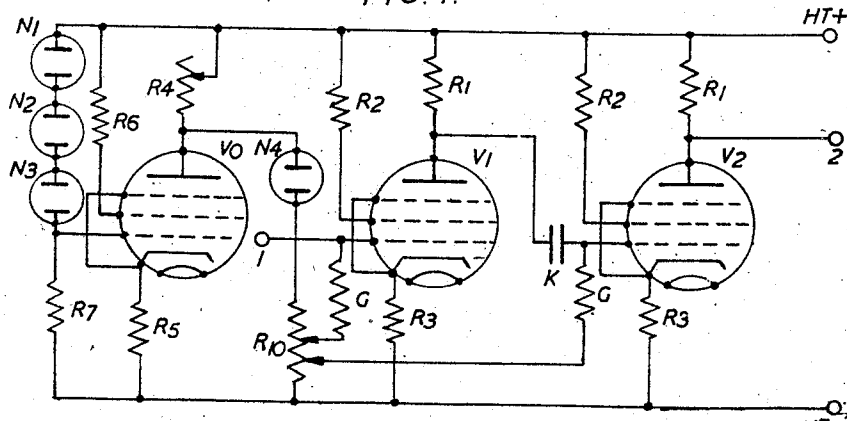


FIG. 4.



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THERMIONIC VALVE CIRCUITS

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10 Claims. (Cl. 179—171)

1

The present invention relates to thermionic valve circuits and in particular to means for stabilizing the operation of such circuits against variations of the operating voltages.

The principal cause of variation of the performance of thermionic valve circuits is variation in the voltage of the anode supply source. This produces changes in gain, or rectifying effect (or the like), in the valves, due mainly to the changes in the anode currents which occur. Previous stabilizing circuit arrangements have generally suffered from the disadvantage that they greatly increase the load on the high tension supply source. The principal object of the present invention is to provide an arrangement by which a high degree of stabilization is obtained, but which at the same time increases the load on the supply source by only a small fraction. According to the invention, there is provided an arrangement for stabilizing the operation of an electrical circuit which circuit includes one or more thermionic valves supplied with current from a source of variable voltage, comprising means for applying to a grid of the said valve or each of them a potential varying in such a manner as to render the performance characteristic or characteristics of the electrical circuit substantially unaffected by the said voltage variation.

According to another aspect the invention may comprise an arrangement for stabilizing the operation of an electrical circuit, which circuit includes one or more thermionic valves supplied with anode current from a high tension source of variable voltage, comprising a stabilizing thermionic valve to which the voltage variations of the source are applied, means being provided for applying to a grid in each of the said one or more valves a voltage derived from the anode-cathode circuit of the stabilizing valve and adapted to vary in such manner as to maintain substantially constant the performance characteristic or characteristics of the electrical circuit.

The invention will be described with reference to the accompanying drawing in which—

Fig. 1 shows curves showing the effect on the anode current of variations in the voltage applied to the electrodes of a thermionic valve.

Fig. 2 shows the current supply arrangements for such a valve, and

Figs. 3 and 4 show schematic circuit diagrams of two embodiments of the invention.

The principle of the invention will be understood from the following explanation. In a multigrid valve the anode current varies by only a small amount when the anode voltage varies, but

2

varies considerably with the voltage of the control grid or of the screen grid. This is illustrated in Fig. 1 which applies to a certain type of pentode valve operated according to the following table:

Normal anode potential	volts	200
Normal screen grid potential	do	110
Normal control grid potential	do	−8
Anode current with above potentials	milliamps	50
Mutual conductance	micromhos	9000

In Fig. 1, the lines A and B represent the effect on the anode current of changes in the anode and screen grid voltages, respectively. The effect of changes in the control grid voltage is not shown, and on the scale of this figure it would be represented by a line much steeper than the line B. The line C represents the effect of changing the applied high tension voltage the normal value of which is 250 volts when the valve is arranged in the circuit shown in Fig. 2, in which the resistances had the values R_1=1,000 ohms, R_2=70,000 ohms and R_3=150 ohms. In this case changing the applied high tension voltage changes the anode end screen grid voltages in the same direction, and the control grid voltage in the opposite direction, the net result being to produce a curve C which is several times steeper than A. The circuit of Fig. 2 represents an actual arrangement for supplying and biassing the valve in a practical circuit, so that the curve C shows the total resultant effect of variations in the anode supply voltage on the anode current. According to the invention the anode current variations are counteracted by applying to one of the grids an oppositely varying voltage derived from the varying supply voltage and proportioned so that the anode current remains substantially constant, or varies so that the performance of the valve, or that of the circuit of which it forms a part, remains substantially unaffected by the variations in the supply voltage. It will be understood, of course, that specific figures have been quoted for the sake of clearness, but the invention is applicable to valves having other characteristics supplied in any convenient way.

In Fig. 3 is shown one embodiment of the invention applied to an amplifier having two valve stages which comprise respectively two pentodes V_1 and V_2 arranged as shown in Fig. 2 and having the characteristics given above. The amplifier may have other valve stages (not shown) which may or may not be stabilized according to this invention. The anode of V_1 is coupled to the

control grid of V_2 through an appropriate blocking condenser K. Each valve has an appropriate grid leak resistance G. Connection is made to earlier stages (if any) at terminal 1, and to later stages (if any) at terminal 2. These other stages are not shown in Fig. 3, and may be provided in any appropriate way.

The screen grid voltages for the two valves V_1 and V_2 are derived from a stabilizing valve V_0 which is preferably, but not essentially, a pentode as shown. The stabilizing valve is provided with an adjustable anode resistance R_4, and a resistance R_5 is connected in series with the cathode. The screen grid is polarized from the high tension supply through an appropriate resistance R_6.

The variations of the high tension voltage are communicated to the control grid of V_0 by means of a potentiometer consisting of three (or other appropriate number) of neon discharge tubes N_1, N_2, N_3 (or other like gas-filled tubes) and a resistance R_7. These tubes produce a substantially constant difference between the control grid voltage and the voltage of the high tension supply so that the variations of the later are applied to the control grid without any reduction in amplitude; the actual voltage applied to the control grid is however only a fraction of the high tension voltage.

The screen grids of the valves V_1 and V_2 are connected to adjustable tapping points on the adjustable resistance R_4 through resistances R_8 and R_9, and accordingly they derive their voltage from the anode voltage of the stabilizing valve V_0.

The stabilizing pentode V_0 can be a low power valve, whose anode current should preferably be of the same order as the sum of the screen currents of the valves which it is designed to stabilize. The resistance R_5 should be a relatively high resistance so that the control grid potential changes are substantially transferred to the cathode. Let it be supposed that the high tension supply voltage increases by a small amount v. The control grid voltage of the valve V_0 will increase by v on account of the action of the neon tubes, and so substantially also will the cathode voltage. This rise in the cathode voltage is due to an increase in the cathode current, part of which passes through the resistance R_4. This resistance should be larger than R_5 (for example R_4=about $2R_5$) and it will be possible to find a point on R_4, probably rather near the anode end, the potential of which is unchanged by the increase v, because the increased potential drop in the resistance due to the increased anode current is equal to v thus compensating for the increase of the high tension voltage. If the screen grid of the valve V_1 for example, should be connected to this point, the screen grid potential will remain constant; however, in order to compensate for the increased high tension voltage it is necessary to cause the screen grid potential to be reduced by a very small amount. In other words the screen grid must be connected to a point on R_4 whose potential decreases slightly as a result of the increase in v. This point will be slightly nearer the anode of V_0 than the first mentioned point. In practice, of course, the proper point will be found by trial, R_4 having been chosen sufficiently large to allow this to be done.

In the particular case shown in Fig. 3, the two valves V_1 and V_2 are supposed to be of the same type so that the adjustment for both of them would be practically the same. It is therefore possible to simplify the circuit slightly by connecting R_8 and R_9 both to the anode of V_0, instead of to the tapping point and to adjust the value of R_4 until the desired compensation is obtained.

In one practical circuit according to Fig. 3, the valves V_1 and V_2 were of the kind specified above in connection with Fig. 2, the high tension voltage being 250 volts. The valve V_0 was a pentode supplying an anode current of about 5 milliamps, the screen current being about 2 milliamps. The resistance R_5 was 5,000 ohms, R_6 was zero and R_4 had a maximum value of about 10,000 ohms. R_8 and R_9 were each 10,000 ohms. This produces an anode voltage of about 130 and screen voltage of 250 for V_0, and screen voltage of 110 for the valves V_1 and V_2.

The neon tubes N_1, N_2 and N_3 together produce a voltage drop of about 215 volts, and R_7 was chosen to be 100,000 ohms, so that the current through the neon tubes was about 0.35 milliamp, the control grid voltage of V_0 being about 35.

The total current taken by the two valves V_1 and V_2 from the high tension source is about 104 milliamps (including the screen currents) and the additional current taken by the valve V_0 is about 9 milliamps including the screen current and the current through the neon tubes. The increase in load due to stabilization is thus quite inconsiderable.

The number of neon tubes such as N_1, N_2, N_3 (or other gas discharge tubes) which are required in the general case depends on the value of the high tension voltage. In the particular circuit according to Fig. 3 which has just been described, each neon tube maintains a constant potential difference of about 70 volts, and the number used should preferably be the maximum consistent with obtaining the constant potential difference across each one. The remaining drop is taken up by the resistance R_7. By this means the maximum reduction in the high tension voltage is obtained, without reducing the variations.

It is, of course, not essential to use the maximum number of neon tubes, or even to use any at all; and in such a case the control grid of V_0 should be connected to an appropriate tapping point on R_7 from which it will obtain a suitable potential. However, if fewer than three neon tubes are used, only a fraction of the high tension voltage variations will be available at the control grid of V_0, and the resistance R_4 will have to be increased in order to obtain the same stabilizing effect.

With the example of Fig. 3 described above, it was found that the high tension voltage could be varied between about 220 volts and 310 volts without producing any appreciable change in the total load current. For this change in voltage the screen voltage of the stabilized valves changes by about 1 volt in the opposite direction.

It should be noted that the resistance R_5 provides considerable negative feedback for the valve V_0 so that the stabilizing effect will be rendered substantially independent of variation in this valve. The mutual conductance g of the valve used in the above example is about 6,500 micromhos so that variations are reduced by the factor $1/(1+gR_5)$=about 0.03, using the value 5,000 ohms for R_5. Variations are accordingly reduced to 3% and it was found that the valve V_0 could be replaced by any other of the same type without affecting the stabilizing action.

It will be understood, of course, that the num-

ber of valves which may be stabilized in this way is not limited to two: any number of additional valves may be controlled from the same stabilizing valve provided the latter is designed in accordance with the total screen current as explained above. The stabilized valves can be of different types and may be employed as amplifiers or oscillators or modulators and not necessarily in the same circuit, the particular amplifying arrangement shown in Fig. 3 being given simply as one example.

Fig. 4 shows another form of the invention in which the stabilizing voltage variations are applied to the control grids of the valves V_1 and V_2 instead of to the screen grids. Those elements which are the same as in Fig. 3 and have the same functions are given the same designations and will not be again described.

The screen grids of V_1 and V_2 are polarized directly from the high tension supply through resistances R_2 which may be the same as in Fig. 2. The anode voltage of V_0 is stepped down by means of a neon tube N_4, for example, similar to N_1, N_2 and N_3 connected in series with a tapped resistance R_{10}. In this case only one neon tube is required, since the anode voltage is about 130 volts: if it exceeded 140 volts two or more might be employed. If other types of gas filled tubes are used, the number required is determined by the same considerations explained above with reference to N_1, N_2 and N_3.

The control grids of the valves V_1 and V_2 are connected to the tapping points on R_{10} as indicated, which are adjusted to obtain the desired compensation. The resistances R_3 may be made adjustable so that appropriate grid bias may be at the same time obtained.

The action of the circuit of Fig. 4 is in principle the same as that of Fig. 3, the only difference being that the compensating variations of the control grid voltage will be rather smaller than those of the screen grid voltage to produce the same result. On this account it is probable that two valves of the same type will practically always require different adjustments of the tapping points on the resistance R_{10}.

It will be evident that the arrangement of Fig. 4 is applicable to the stabilizing of triode valves not having any additional grids. As already mentioned, also, the stabilizing valve V_0 in either Fig. 3 or Fig. 4 may also be a triode, in which case R_6 is not needed. It will be further evident that if the elements N_4 and R_{10} be added to Fig. 3 in the manner shown in Fig. 4, the valve V_0 can be used to stabilize at the same time one group of valves by means of the screen grids, and another group by means of the control grids.

Although the changes in the anode currents of the valves consequent on the variations of the high tension voltage are the principal cause of variation of the performance of the amplifier, modulator, or oscillator (or other electrical circuit) of which they form a part; and although the stabilization arrangements described tend to maintain the anode currents constant; actually the ultimate criterion of the operation is some performance characteristic of the circuit, and the adjustments will generally be made so that this characteristic is unaffected by the variations.

For example, the frequency and/or the output of a thermionic valve oscillator may be changed by variations in the high tension supply voltage. It will probably be found that the frequency and the output can both be approximately stabilized by an appropriate adjustment of the arrangement

according to the invention, which adjustment approximately stabilizes the anode currents of one or more of the valves. However, it may be found that different adjustments are required to stabilize exactly the frequency and the output of the oscillator; and if there are several valves, both the frequency and the output could probably be simultaneously stabilized by suitable separate adjustments of the oscillating and amplifying valve.

What is claimed is:

1. In an electric circuit, a source of power of variable voltage, at least one thermionic valve having input and output circuits, the output circuit being supplied with current from said source, a separate stabilizing amplifier having an input circuit supplied with a potential varying with said variable voltage, and an output circuit controlling the input circuit of said thermionic valve so as to render its output substantially independent of said variable voltage.

2. A circuit according to claim 1, wherein said source of variable voltage is a high tension source and said stabilizing amplifier is another thermionic valve having an anode-cathode circuit, the first-mentioned thermionic valve having an anode supplied from said high tension source, and a grid supplied with a potential derived from said anode-cathode circuit.

3. In an electric circuit, a source of power of variable voltage, at least one thermionic valve having input and output circuits, the output circuit being supplied with current from said source, a separate stabilizing amplifier having an input circuit supplied with a potential varying with said variable voltage, wherein said source of variable voltage is a high tension source and said stabilizing amplifier is another thermionic valve having an anode-cathode circuit, said first-mentioned thermionic valve having a screen grid supplied with a potential derived from said anode-cathode circuit.

4. In a circuit according to claim 3, a number of thermionic valves, each one of which has a screen grid, and means for deriving a potential from the output circuit of said stabilizing amplifier and applying at least a portion of said potential to said screen grids.

5. A circuit according to claim 1, wherein the output circuit of said stabilizing amplifier includes a load resistance and said thermionic valve includes a grid, said grid being connected to a predetermined point on said load resistance.

6. A circuit according to claim 3, wherein said source of variable voltage is a high tension source and said thermionic valve has a screen grid, said stabilizing amplifier including a thermionic valve having an anode, said screen grid being supplied with a voltage derived from said anode, said stabilizing amplifier further including means for applying to said screen grid a certain fraction of the anode voltage and a larger fraction of the variations of the anode voltage.

7. A circuit according to claim 3, wherein the output circuit of said stabilizing amplifier includes an anode and a load resistance connected thereto, and said thermionic valve includes a screen grid, said screen grid being connected to a predetermined point on said load resistance, and wherein said output circuit further includes means for applying to said screen grid a certain fraction of the anode voltage and a larger fraction of the variations of said anode voltage.

8. In a circuit according to claim 1, another thermionic valve having anode and cathode, at

least one gas discharge tube and a resistance connected in series between said anode and cathode, said first-mentioned thermionic valve having a control grid connected to a point on said resistance.

9. A circuit according to claim 3, wherein said source of variable voltage is a high tension source and said stabilizing amplifier is another thermionic valve having a control grid and an anode-cathode circuit, said first-mentioned thermionic valve having a screen grid supplied with a voltage derived from said anode-cathode circuit, said stabilizing amplifier including means for applying to the screen grid of said other thermionic valve a certain fraction of said variable voltage and a larger fraction of the variations thereof.

10. In a circuit according to claim 3, wherein said thermionic valve has an input grid and an anode current derived from said source of variable D. C. voltage, another thermionic valve having a grid circuit and an anode-cathode circuit, means for applying to said grid circuit said variable voltage, means for applying to the input grid of said first-mentioned thermionic valve a voltage derived from said anode-cathode circuit so as to maintain said anode current substantially independent of said variable voltage, said

means including at least one gas discharge tube and a resistance in series therewith and connected across said source of variable voltage, said source of variable voltage having a negative terminal connected to said resistance and said other thermionic valve having a grid connected to said resistance at a tapping point thereof.

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