March 9, 1943. F. H. SHEPARD, JR 2,313,097

SYSTEM FOR COMPENSATING ANODE SUPPLY POTENTIAL VARIATIONS

Filed Oct. 5, 1940 2 Sheets-Sheet 1

FIG. 1.

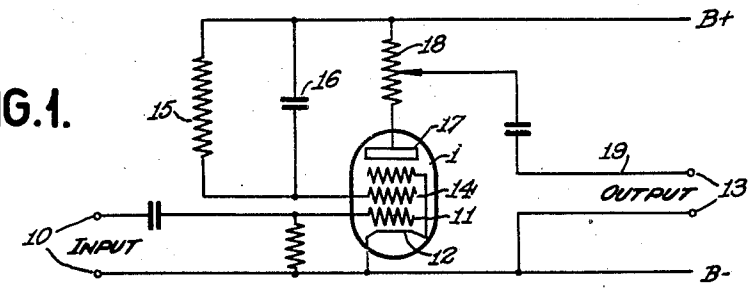


FIG. 2.

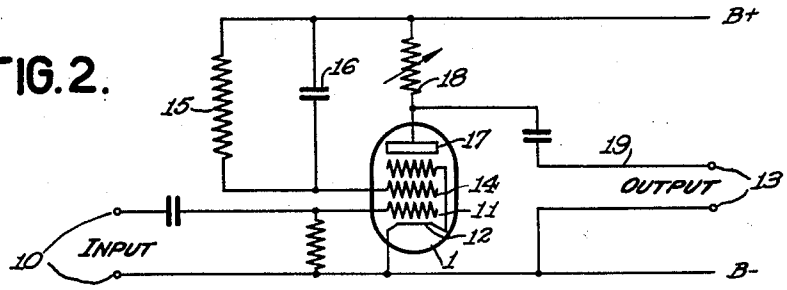


FIG. 3.

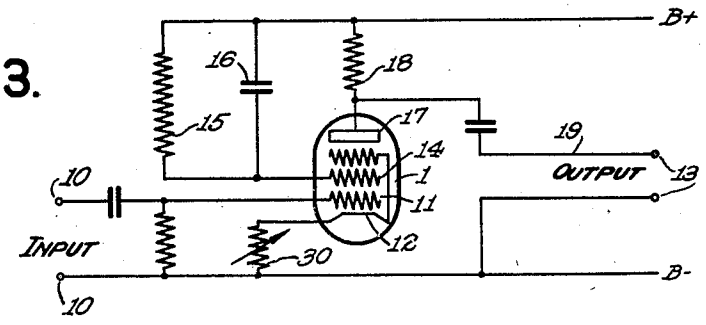
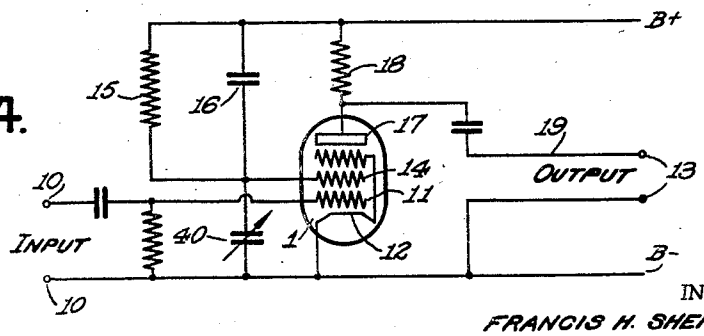


FIG. 4.



INVENTOR.
FRANCIS H. SHEPARD, JR.
BY E. D. Phinney
ATTORNEY.

March 9, 1943. F. H. SHEPARD, JR 2,313,097

SYSTEM FOR COMPENSATING ANODE SUPPLY POTENTIAL VARIATIONS

Filed Oct. 5, 1940 2 Sheets-Sheet 2

FIG.5.

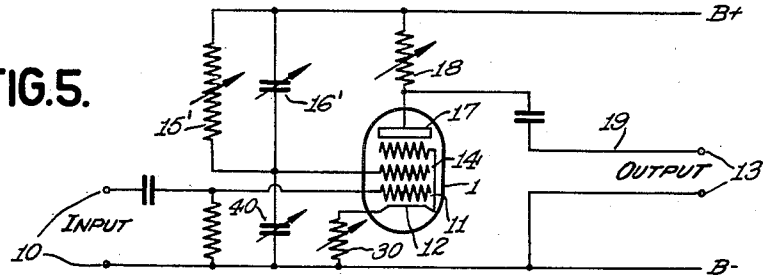


FIG.6.

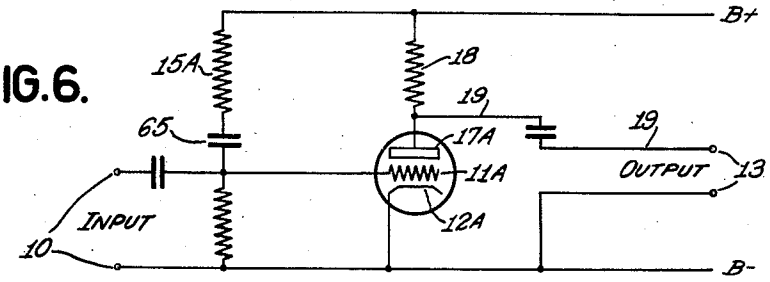


FIG.7.

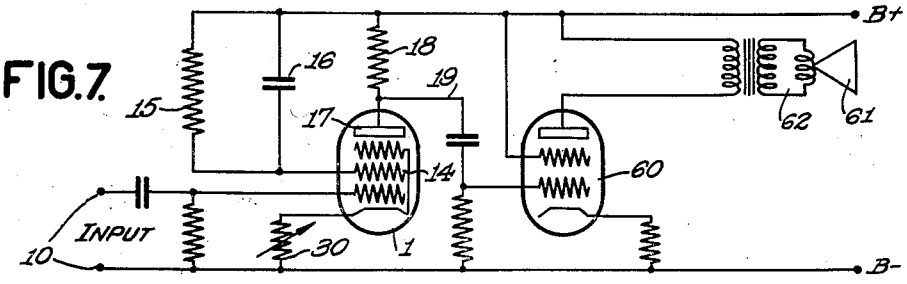
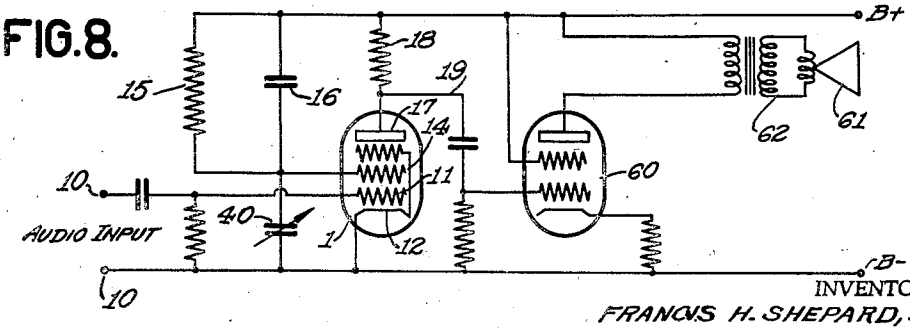


FIG.8.



INVENTOR.
FRANCIS H. SHEPARD, JR.

BY E. O. Phinney

ATTORNEY.

Patented Mar. 9, 1943 2,313,097

UNITED STATES PATENT OFFICE

2,313,097

SYSTEM FOR COMPENSATING ANODE SUPPLY POTENTIAL VARIATIONS

Francis H. Shepard, Jr., Merchantville, N. J.

Application October 5, 1940, Serial No. 359,856

9 Claims. (Cl. 179—171)

This invention relates to amplifier circuits and more particularly to systems for compensating for variations in anode potentials such as A. C. hum developed in audio frequency amplifier circuits.

In audio frequency amplifiers energized from A. C. power supply great care is generally exercised to filter the anode potential or "B" supply voltages to prevent variations in these voltages, such as ripple or hum voltages from getting into the amplifier and being amplified. Great care is also taken to make the regulation of the anode supply good so that the anode voltage variations caused by the varying currents drawn by the latter stages of the amplifier will not be sufficiently great to react back on the initial stages and to cause the amplifier to regenerate sufficiently through the "B" supply to cause a distortion known as "motorboating."

Various arrangements for elimination of potential variations and A. C. hum have been proposed but in general these systems are difficult to adjust or may be objectionable for various engineering or economic reasons.

In accordance with my invention I have provided a simple, inexpensive circuit for neutralizing or compensating the A. C. ripple or other anode supply potential variations which may be present in an amplifier.

According to a feature of my invention I use a tube having a screen grid and eliminate the effect of anode supply potential variation by introducing on a grid a potential variation sufficient to over-compensate the hum normally present in the output circuit of the tube, and apply to the output circuit a sufficient amount of this developed potential to compensate for the normal output variation or hum potential. This may be accomplished by connecting the grid in such a manner that a current variation in the plate load of considerable magnitude is produced, this potential across the anode load being out of phase with respect to the normal variation potential present in the anode supply. Then a desired portion of this produced potential may be fed to the succeeding stage or to the output circuit to produce the desired compensation.

The proportioning may be carried out by a potentiometer connection in the anode resistance of the screen grid tube, a potential division by means of condenser arrangements or other desired means.

A better understanding of my invention will be had from a particular description of practical embodiments thereof made with reference to the accompanying drawings, in which:

Figs. 1, 2, 3, 4 and 5, show various arrangements applied to a single screen grid amplifier stage for eliminating the effect of anode supply potential variations;

Fig. 6 shows application of my invention to a single stage triode amplifier, and

Figs. 7 and 8 illustrate application of the principles of my invention to multiple stage amplifier circuits.

In accordance with my invention I use a multielectrode vacuum tube such as shown at numeral 1. Although I have illustrated this tube as being a pentode, it is clear that any multiple electrode tube which has positive trans-conductance between the plate of the tube and the screen grid may be utilized. The supply voltages for the anode of the tube are shown by the indicated characters B+ and B—, and may contain A. C. ripple variation or other "B" supply variation.

The input signals are applied across input terminals 10 between the control grid 11 and cathode 12. The heater supply and the potential supply sources themselves have been eliminated in order to simplify the circuit. It is clear that any amplified signals from this circuit will normally have superimposed thereon at the output terminals 13 variations due to any variations in the "B" supply voltage. In accordance with my invention I connect screen grid 14 through a suitable high resistance 15 to the source of anode supply and by-pass resistance 15 by means of a relatively large condenser 16. Because of the condenser 16 the alternating current ripple or other variations in the "B" supply are applied directly to screen grid 14. Because of the positive transconductance of tube 1, these variations appear at anode 17 as potential variations which are 180° out of phase with the potential variation applied from B+ to the other terminal of anode resistor 18.

Since resistor 18 has applied to its opposite terminals voltages of opposite phase corresponding to the potential variation in the "B" supply, it is clear that at some intermediate point on the resistor the variation ptoential will be equal to zero or ground potential of the tube. Accordingly, it is merely necessary to adjust the connection point of output lead 19 along resistor 18 to this point of zero variation potential, so that no potential variation effect will be present at output 13 to distort the amplified signals.

It is also clear that by adjusting the tapping point of conductor 19 relative to resistor 18, the

output circuit may be so adjusted that the anode variation potentials will be overcompensated or under compensated, so that a sufficient amount of the hum or potential variation effect may be applied to the succeeding stages to compensate these stages also for any potential variation effect.

In Fig. 2 an arrangement generally similar to that shown in Fig. 1 is provided. However, instead of adjusting a tapping point of conductor 19 with respect to resistor 18, the plate resistor 18 is made variable. Thus, the gain of the tube 1 may be controlled to produce in the output of an out of phase plate potential variation voltage just sufficient to properly neutralize the normal plate variation voltage applied at these parts.

In Fig. 3 a further modification of my invention is shown. In this circuit the anode potential variations are applied to screen grid 14 over a resistor 15 and condenser 16 in parallel, similar to the arrangement of Fig. 1. However, the potential balance of the output anode potential variation effect is controlled by means of a variable resistor 30 in the cathode ground connection of tube 1. Thus the gain may be controlled by adjustment of resistor 30 so that the proper amount of the A. C. potential developed in the tube is applied to output leads 19.

If the amplifier gain between the screen grid electrode and the anode is too great, only a part of the anode potential variation need be fed to the screen grid arrangement. Such a circuit is illustrated in Fig. 4. In this system an additional variable condenser 40 is connected between screen grid 14 and the cathode ground. Accordingly, part of the anode potential variations applied to screen 14 through condenser 16 are by-passed to ground. The amount of such potentials which are by-passed may be controlled by changing the adjustment of variable condenser 40. Accordingly, by properly adjusting condenser 40 complete neutralization of anode potential variations in the output 19 may be achieved.

It is clear also, that instead of adjusting anode resistor 18 in the manner shown in Fig. 2, the screen grid resistance 15 could be adjusted. This would serve to vary the D. C. bias on the screen grid and adjust the amplification of the variation or hum potentials. Furthermore, the condenser 16 of Fig. 4 may be made variable in order to in part control the potential applied to screen grid 14.

In actual practice it is sometimes desirable to utilize a combination of the various effects in order to achieve a more ready adjustment of the voltage to the proper compensating amplitude. Such an arrangement is shown in Fig. 5. In this arrangement a variable anode resistor 18 and a variable cathode resistor 30 are applied in the anode-cathode circuit of tube 1, as shown. In the screen grid circuit of the tube 1 is provided high impedance variable resistor 15' and a relatively lower impedance variable condenser 16' connected between the anode supply and the screen grid, and a variable condenser 40 is connected between the screen grid and the cathode ground connection. In order to achieve compensation the amount of anode supply potential variation fed to screen grid 14 is controlled by the proper adjustment of resistance 15' and condensers 16' and 40. The final adjustment is then accomplished by adjusting the variable resistors 18 and 30. Accordingly, suitable adjustment in order to take care of additional A. C. hum variations which may occur in further stages connected to 13, may be readily accomplished by adjusting the resistor arrangement 18 and 30.

Although in many cases it is preferable to use a vacuum tube having a screen grid a similar system using a triode may be used for neutralizing the effect of anode potential supply variations in an amplifier using a triode as shown in Fig. 6.

In this arrangement the energy to be amplified is applied over input terminals 10, across the control grid 11*a*, cathode 12A circuit. A proportion of the potential variations in the anode supply voltage is also applied to grid 11A over resistance 15A and condenser 65 of negligible impedance at the variation frequency. If the tube has a positive transconductance characteristic the potential variations applied at one end of load resistor 18 due to the anode supply variations will be of opposite phase to that supplied over grid 11A to the other end. By controlling the connection point of line 19 or by adjusting the resistance or condenser division of potential in any manner similar to that shown in Figs. 1–5 the proper compensation may be achieved.

In Fig. 7 I have illustrated my invention applied to a two-stage amplifier arrangement. The circuit connections of tube 1 are identical to those shown in connection with Fig. 3. However, in the output lead 19 is provided vacuum tube 60, impedance coupled with the output of tube 1. To the anode circuit of tube 60 is coupled a loud speaker arrangement 61 over a transformer shown at 62. In this arrangement the cathode resistor 30 is shown as provided with a variable adjusting means. It is clear that by properly adjusting this resistor the potential variation applied to the control grid of tube 60 may be adjusted to produce substantially no hum or distortion in the speaker 61 due to anode potential variation. The adjustment may be made so that the anode potential variation voltages applied to tube 60 will be sufficient to compensate the anode supply voltages of that tube as well as overcoming those of tube 1.

In Fig. 8 a further variation of a two-stage amplifier circuit is shown. This circuit arrangement is similar in all respects to the circuit arrangement of Fig. 7, except that the control of the compensating anode potential variation is effected by a variable condenser 40 in the screen grid ground connection of tube 1 instead of a resistor in the cathode ground circuit.

It is clear that any of the various arrangements disclosed in Figs. 1 to 6, inclusive, may be applied to multiple stage amplifier circuits in a manner similar to that disclosed in connection with Figs. 7 and 8.

While I have disclosed in every embodiment of my invention amplifier tubes of the triode or pentode type, it is clear that any tube having the proper characteristics may be utilized in their stead. For example, tetrode arrangements of the type such as beam power tubes may be utilized in place of pentodes if desired. It is necessary in this respect that the valve have a positive transconductance between the grid to which the compensating potentials are applied and the plate of the tube.

Furthermore, the potential dividers for the anode potential variations should be of such a nature as to provide negligible phase shift, whether they are of resistance or capacitive elements and whether they are provided in the input or output circuit of the tube.

While I have disclosed my invention in connection with a few embodiments thereof, it is to be distinctly understood that these embodiments represent merely preferred examples thereof and are not to be considered as limitations thereon. What I consider as my invention and desire to protect by Letters Patent is embodied in the accompanying claims.

What is claimed is:

1. Means for neutralizing the effect of anode supply potential variations in a vacuum tube amplifier stage having anode, cathode, and grid electrodes, wherein anode supply variations normally produce distortion in the output of said amplifier, characterized by means for introducing substantially all anode supply variation potentials on said grid whereby amplified variation potentials of opposite phase from those normally producing said distortion are applied to the anode of said tube to substantially neutralize the distortion which would normally be produced.

2. Means for neutralizing the effect of anode supply potential variations in a vacuum tube amplifier stage having anode, cathode, control grid and screen grid electrodes, wherein anode supply variations normally produce distortion in the output of said amplifier, characterized by means comprising a variable condenser and resistance connected between said screen grid and the anode supply of said tube and a variable condenser between said screen grid and ground to introduce substantially all said variation potentials to said screen grid, whereby amplified variation potentials of opposite phase from those normally producing said distortion are applied to the anode of said tube, and means comprising a resistance in the anode supply lead of said tube, a resistance in the cathode ground lead of said tube, and means for applying a portion of the resistance drop in said resistances to said output circuit, for applying a desired proportion of said variation potentials of opposite phase to said output circuit to substantially neutralize the normally produced distortion.

3. Means for neutralizing the effect of anode supply potential variations in a vacuum tube amplifier stage having anode, cathode, control grid and screen grid electrodes, wherein anode supply variations normally produce distortion in the output of said amplifier, characterized by means for introducing substantially all anode supply variation potentials on said screen grid whereby amplified variation potentials of opposite phase from those normally producing said distortion are applied to the anode of said tube, and means for applying a desired proportion of said variation potentials of opposite phase to said output circuit to substantially neutralize the produced distortion, said last named means comprising a resistance in the anode-cathode circuit of said tube and means for applying the potential drop across at least a portion of said resistance to said output circuit.

4. Means for neutralizing the effect of anode supply potential variations in a vacuum tube amplifier stage having anode, cathode, control grid and screen grid electrodes, wherein anode supply variations normally produce distortion in the output of said amplifier, characterized by a condenser connected between the anode supply and screen grid and a condenser connected between the screen grid and ground for introducing substantially all anode supply variation potentials on said screen grid, whereby amplified variation potentials of opposite phase from those normally producing said distortion are applied to the anode of said tube, a resistance in the anode lead of said tube, and means for applying the potential drop in said resistance to said output circuit whereby a desired proportion of said variation potentials of opposite phase are supplied to said output circuit to substantially neutralize the distortion which would normally be produced.

5. Means for neutralizing the effect of anode supply potential variations in a vacuum tube amplifier stage having anode, cathode, control grid and screen grid electrodes, wherein anode supply variations normally produce distortion in the output of said amplifier, characterized by a condenser connected between the anode supply and screen grid and a condenser connected between said screen grid and ground for introducing substantially all anode supply variation potentials on said screen grid whereby amplified variation potentials of opposite phase from those normally producing said distortion are applied to the anode of said tube, a resistance in the anode-cathode circuit of said tube, and means for applying an adjusted portion of the potential drop in said resistance to said output circuit whereby a desired proportion of said variation potentials of opposite phase are applied to said output circuit to substantially neutralize the distortion normally produced.

6. Anode supply variation neutralizing means for amplifier circuits provided with a first vacuum tube having anode, cathode, control grid and screen grid electrodes, and an output tube following said first tube, wherein anode supply variation potentials are normally produced in the output circuit of said amplifier, characterized by a condenser connected between said screen grid and the anode supply of said first tube to introduce substantially all anode supply variation potentials on said screen grid whereby amplified variation potentials of opposite phase from said normally produced variation potentials are produced by said first tube, a resistance in the anode-cathode circuit of said first tube, and means for applying the potential drop across a portion of said resistance to said second tube to substantially neutralize the normally produced variation potentials in the output circuit.

7. Anode supply variation neutralizing means for amplifier circuits provided with a first vacuum tube having anode, cathode, control grid, and screen grid electrodes, and an output tube following said first tube, wherein anode supply variation potentials are normally produced in the output circuit of said amplifier, characterized by means for introducing substantially all said variation potentials on said screen grid comprising a condenser connected between said screen grid and the anode supply of said first tube, an anode resistance in said first tube, and means for adjustably applying a portion of the potential drop developed in said resistance to said second tube to substantially neutralize the normally produced variation potentials in the output circuit.

8. Anode supply variation neutralizing means for amplifier circuits provided with a first vacuum tube having anode, cathode, control grid, and screen grid electrodes, and an output tube following said first tube, wherein anode supply variation potentials are normally produced in the output circuit of said amplifier, characterized by means to introduce substantially all anode supply variation potentials to said screen grid whereby amplified variation potentials of oppo-

site phase from said normally produced variation potentials are produced in said first tube, comprising a condenser connected between said screen grid and the anode supply of said first tube, a resistance in the anode supply circuit of the first tube, a resistance in the cathode ground lead of the first tube, and means for applying the potential drop across said first resistance to said second tube to substantially neutralize normally produced variation potentials in the output circuit.

9. Anode supply variation neutralizing means for amplifier circuits provided with a first vacuum tube having anode, cathode, control grid, and screen grid electrodes, and an output tube following said first tube, wherein anode supply variation potentials are normally produced in the output circuit of said amplifier, characterized by means comprising a condenser connected between said screen grid and the anode supply of said first tube to introduce substantially all anode supply variation potentials on said screen grid, whereby amplified variation potentials of opposite phase from said normally produced variation potentials are produced in said first tube, a resistance in the anode supply lead of said first tube, a condenser between said screen grid and said cathode or ground, and means for applying the potential drop in said resistance to said second tube to substantially neutralize the normally produced variation potentials in the output circuit.

FRANCIS H. SHEPARD, JR.