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BALANCED CIRCUIT FOR RADIO APPARATUS

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Fig. 1.

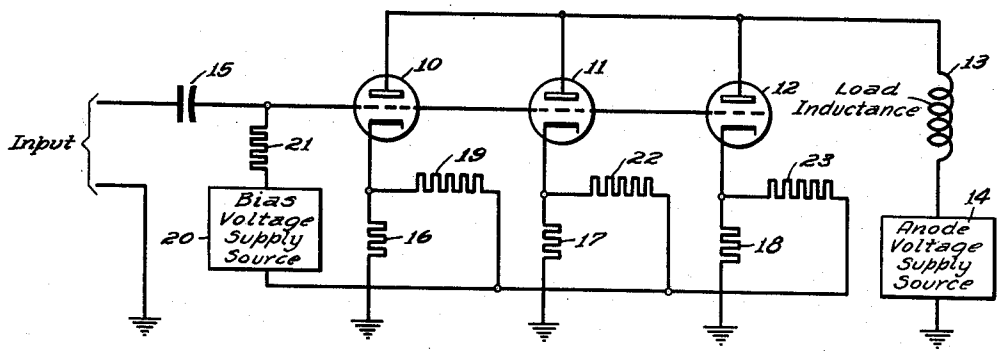
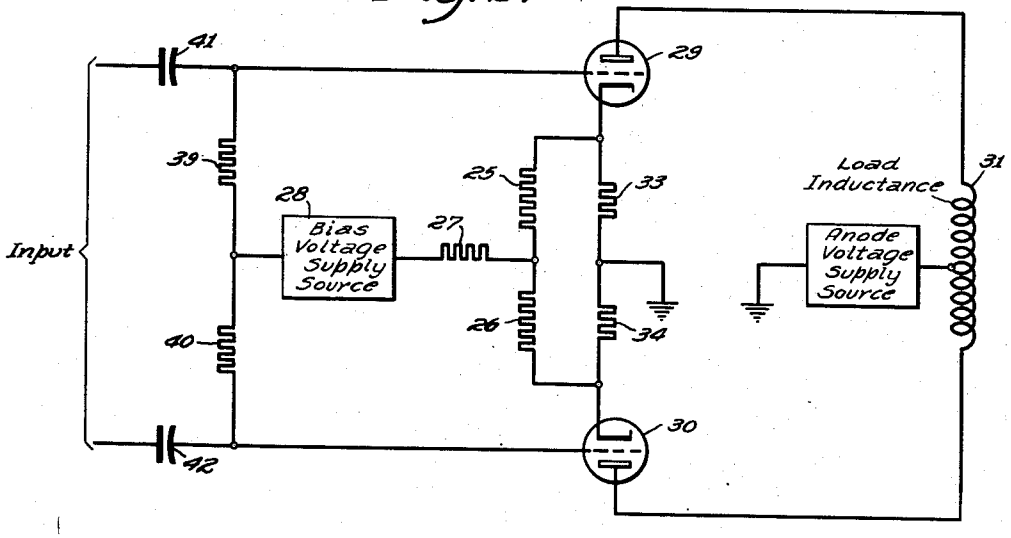


Fig. 2.



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BALANCED CIRCUIT FOR RADIO APPARATUS

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1

This invention relates to vacuum tube circuits, and it relates more particularly to circuits for automatically equalizing the grid and anode currents of vacuum tubes working into a common load.

In order to increase the power handling capacity of vacuum tubes, it is common practice to connect them in parallel, push-pull, or push-pull parallel, in order that two or more tubes can work into a common load. When tubes are so connected, differences in their characteristics or in the characteristics of their circuit components may cause one tube to draw more anode current than another tube. Likewise, when the tubes are so operated as to draw grid current, one tube may draw more grid current than another tube.

This invention provides a balancing circuit which will automatically balance the grid currents and the anode currents of vacuum tubes working into a common load.

An object of the invention is to balance automatically the anode currents of vacuum tubes working into a common load.

Another object of the invention is to balance automatically the grid currents of vacuum tubes working into a common load.

The invention will now be described with reference to the drawing of which:

Fig. 1 is a circuit schematic illustrating one embodiment of the invention as used with parallel-connected vacuum tubes, and

Fig. 2 is a circuit schematic illustrating another embodiment of the invention as used with push-pull-connected vacuum tubes.

Referring first to Fig. 1, the tubes 10, 11 and 12 have their anodes connected together and to one end of the load inductance 13, the other end of which is connected to the positive terminal of the anode voltage supply source 14, the negative terminal of which is grounded. The grids of the tubes are connected together and through the coupling condenser 15 to an input circuit.

The cathode of the tube 10 is connected to ground through the cathode bias resistor 16; the cathode of the tube 11 is connected to ground through the cathode bias resistor 17, and the cathode of the tube 12 is connected to ground through the cathode bias resistor 18.

The resistor 19 is connected to the cathode of the tube 10 and to the positive terminal of the bias voltage supply source 20, the negative terminal of which is connected through the grid resistor 21 to the grids of the tubes 10, 11, and 12. The cathode of the tube 11 is connected

2

through the resistor 22 to the positive terminal of the source 20, and the cathode of the tube 12 is connected through the resistor 23 to the positive terminal of the source 20.

The values of the resistors 16, 17, and 18 should be less than the values of the resistors 19, 22, and 23, so that the normal flow of the cathode currents is through the resistors 16, 17, and 18.

In the operation of the embodiment of the invention illustrated by Fig. 1, if the tubes are operated so as to draw grid current, then if the grid current of the tube 10 increases, this will cause an increased voltage drop through the resistor 19 which will cause the grid of the tube to be biased more negatively with respect to its cathode, thus decreasing the grid current. Likewise, if the grid currents of the tubes 11 and 12 increase, the increased voltage drops through the resistors 22 and 23 will cause the grids of the tubes 11 and 12 to be biased more negatively with respect to their cathodes, thus causing them to draw less grid current.

Regardless of whether or not the tubes draw grid current, if the anode current of the tube 10 increases without a corresponding increase in the anode currents of the tubes 11 and 12, the voltage drop across the resistor 16 will increase, causing the cathode of the tube 10 to become more positive than the cathode of the tubes 11 and 12, with the result that there will be a current flow between the cathodes through the resistors 19, 22, and 23. The resulting voltage drop through these resistors adds to the negative bias on the grid of the tube 10, and subtracts from the negative bias on the grids of the tubes 11 and 12. This will result in the tube 10 drawing less anode current, and in the tubes 11 and 12 drawing more anode current, thus balancing the load on the tubes. Likewise, if the anode current of either of the tubes 11 or 12 increases without a corresponding increase in the anode current of the other tubes, the cathode of the tube with the increased current flow will become more positive, resulting in the flow of current between it and the cathodes of the other tubes, resulting in the tube drawing the greatest anode current having its grid biased more negatively, and resulting in the grids of the other tubes being biased more positively, with the result that the loads on the tubes are balanced.

In the embodiment of the invention illustrated by Fig. 2, the tubes 29 and 30 are connected in push-pull with their anodes connected to the opposite ends of the load inductance 31, the center point of which is connected to the positive

terminal of the anode voltage supply source 32, the negative terminal of which is grounded.

The cathode of the tube 29 is connected through the cathode resistor 33 to ground. The cathode of the tube 30 is connected through the cathode bias resistor 34 to ground. The resistors 25 and 26 are connected in series and to the cathodes of the tubes 29 and 30, and their mid-point connection is connected through the resistor 27 to the positive terminal of the bias voltage supply source 28. The grid resistors 39 and 40 are connected in series and to the grids of the tubes 29 and 30, and their mid-point connection is connected to the negative terminal of the source 28.

The input signal is applied through the coupling condensers 41 and 42 to the grids of the tubes 29 and 30.

The values of the resistors 33 and 34 should be less than the values of the resistors 25 and 26, so that the normal flow of the cathode current is through the resistors 33 and 34.

In the operation of the embodiment of the invention illustrated by Fig. 2, if the tubes are operated to draw grid current, and if the tube 29 draws more grid current than the tube 30, the increased voltage drop through the resistor 25 will cause the grid of the tube 29 to be biased more negatively with respect to its cathode, thus decreasing the grid current. Likewise, if the grid current of the tube 30 increases, the increased voltage drop through the resistor 26 will cause the grid of the tube 30 to be biased more negatively with respect to its cathode, thus decreasing the flow of grid current.

Regardless of whether or not the tubes 29 and 30 draw grid current, if the anode current of the tube 29 increases without a corresponding increase in the anode current of the tube 30, the voltage drop across the resistor 33 will increase, causing the cathode of the tube 29 to become more positive than the cathode of the tube 30, with the result that there will be a flow of current through the resistors 25 and 26. The resulting voltage drops through these resistors add to the negative bias to the grid of the tube 29 and subtract from the negative bias on the grid of the tube 30, resulting in the tube 29 drawing less anode current and resulting in the tube 30 drawing more anode current, so that the load on the two tubes tends to balance. In the same way, if the tube 30 draws more anode current than the tube 29, the flow of cathode current through the resistors 25 and 26 will result in the grid of the tube 30 being biased more negatively, and will result in the grid of the tube 29 being biased more positively, so that the anode currents tend to balance.

The load inductances connected in the anode circuits of the tubes may be the primary windings of output transformers or may be tank coils, or other forms of loads.

Each of the push-pull-connected tubes 29 and 30 of Fig. 2 may have other tubes connected in parallel with it, as illustrated by Fig. 1.

I claim as my invention:

1. An electrical system comprising a plurality of vacuum tubes having at least control grids, cathodes, and anodes; an anode voltage supply source; an output load circuit for said tubes; means connecting the anodes of said tubes through said load circuit to the positive terminal of said source; an independent bias voltage supply source having its negative terminal connected to the control grids of said tubes; resistors connecting said cathodes to the positive terminal of said bias voltage supply source, bias resistors connecting said cathodes to the negative terminal of said anode voltage supply source, and an input circuit connected to said grids.

2. An electrical system comprising a plurality of vacuum tubes having interconnected control grids and interconnected anodes, and having cathodes; an anode voltage supply source; an output load circuit; means connecting said anodes through said load circuit to the positive terminal of said supply source; an independent bias voltage supply source having its negative terminal connected to said control grids; resistors connecting said cathodes to the positive terminal of said bias voltage supply source, bias resistors connecting said cathodes to the negative terminal of said anode voltage supply source, and an input circuit connected to said grids.

3. An electrical system comprising a pair of vacuum tubes having control grids, cathodes, and anodes; an input circuit connected push-pull to said grids; a load circuit connected push-pull to said anodes; an anode voltage supply source having its positive terminal connected through said load circuit to said anodes; grid resistors connected in series between said control grids; a bias voltage supply source having its negative terminal connected to the mid-point connection of said resistors; other resistors connected in series between said cathodes, the positive terminal of the latter said source being connected to the mid-point connection of said other resistors, and bias resistors connected in series between said cathodes and having their mid-point connection connected to the negative terminal of said anode voltage supply source, there being no fixed electrical relationship between the negative terminal of the bias voltage supply source and the negative terminal of the anode voltage supply source.

4. The electrical system of claim 2, in which said control grids are directly connected together.

5. The electrical system of claim 2, in which said anodes are directly connected together.

6. The electrical system of claim 2, in which said control grids are directly connected together, and said anodes are directly connected together.

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