

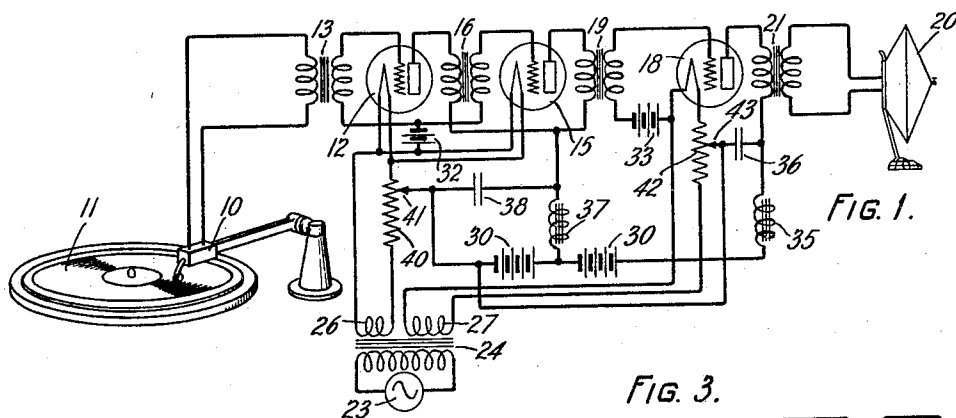
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VACUUM TUBE AMPLIFIER CIRCUIT

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VACUUM TUBE AMPLIFIER CIRCUIT

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This invention relates to vacuum tube circuits and particularly to vacuum tube circuits in which the filaments or cathodes of the tubes are heated by current having alternating components.

An object of this invention is to eliminate or reduce the effect upon the plate or output current of the circuit of variations in the filament supply current.

It is known in the art that where alternating current is used for energizing the cathodes or filaments of vacuum tubes, a connection from the grid to the midpoint of the secondary winding of the filament energizing transformer, or to the midpoint of a potentiometer across this winding, will make the average potential difference between cathode and grid substantially independent of the potential applied to the cathode. It has also been shown in the art that if the anode or plate circuit is also connected to this midpoint tap, the same effect with respect to the anode circuit is produced. Connections of this type may be found, for example, in United States patent to Raymond A. Heising, No. 1,432,022 of October 17, 1922, and patent to John F. Farrington, No. 1,487,451 of March 18, 1924. The effects of the alternating potential component in the filament heating circuit on the current in the output circuit have been substantially eliminated by the use of this type of connection.

In the circuit of the present invention the hum components are balanced out or neutralized by their application to both the grid and anode circuits in phase opposition. A feature of this invention is the use of a resistance in series with the cathode heating circuit which is utilized to provide a means of varying the amplitude of the alternating current component applied to the anode circuit to neutralize the effect of the component applied to the grid circuit.

An advantage of the circuit of this invention is the elimination of the necessity of simulating the midpoint connection to the filament.

Other features and advantages of this method of and means for eliminating the disturbing effects arising from the use of

alternating current as a filament supply will be brought out and made more fully apparent in the following description in connection with the accompanying drawing in which:

Fig. 1 is a schematic drawing of a tandem three-stage amplifier embodying the invention.

Fig. 2 shows the invention applied to a single tube circuit.

Fig. 3 is a schematic drawing of a two-stage amplifier embodying the invention, one stage of which is push-pull; and

Fig. 4 shows a modification of the push-pull stage of Fig. 3.

In Fig. 1 is shown an electrical phonograph reproducer 10 as a source of alternating current variations to be amplified, together with turntable 11, both of which may be of any type well known in the art. The audio frequency variations in potential arising in the reproducer 10 are impressed upon a three-element vacuum tube 12, comprising the first stage of amplification, through input transformer 13. The output of vacuum tube 12 is transmitted to vacuum tube 15, comprising the second stage of amplification, by means of an interstage transformer 16. In a similar manner the output of vacuum tube 15 is impressed on vacuum tube 18 through interstage transformer 19. The vacuum tube 18 may be a power tube of any type known in the art, the output of which may be delivered through an output transformer 21 to a receiving element such as a loud speaker 20.

The energy for this three-stage amplifier is obtained partly from batteries and partly from an alternating current source 23. Source 23 through power transformer 24 supplies the filaments of tubes 12 and 15 with alternating heating current from secondary winding 26, while secondary winding 27 on the same transformer furnishes alternating filament heating current to the tube 18. These secondary windings may furnish current at different voltages depending upon the requirements of the tubes. Anode potential for the tubes is derived from battery 30, a lower potential being tapped for the tubes 12 and 15 in accordance with well known prac-

tice. Grid biasing potential is supplied by battery 32 for the tubes 12 and 15 and by battery 33 for the tube 18. An inductance 35 in the form of a choke or retardation coil and a capacity 36 aid in preventing the alternating current fluctuations from feeding back from the last stage to the preceding stages by way of the battery 30 common to all the stages. A similar inductance 37 and capacity 38 in the anode circuit of tubes 12 and 15 serve a similar purpose; that is, to prevent reaction between the last and preceding stages.

In the filament heating circuit for tubes 12 and 15 is shown a resistance 40 to which the plate return connection is connected by adjustable tap 41. A similar resistance 42 and tap 43 is shown in the filament heating circuit of the tube 18. By means of this variable connection of the plate circuits to the filament heating circuits, it is possible to control the application of alternating current potential arising in the filament heating circuits to the plate circuits. As the connections are shown in the drawing a certain voltage hum is introduced in the grid circuit which for the first stage may be traced from the grid of the tube 12, through the secondary of the transformer 13, battery 32, to the filament of the tube 12. Also hum components from the same source are impressed on the plate circuit which for the first stage may be traced from the plate of tube 12, through primary of transformer 16, condenser 38, that portion of resistance 40 common to both filament and plate circuits and to the filament of the tube 12. An explanation of the action in these circuits will be taken up in connection with Fig. 2. Since the hum components are impressed on circuits connected to the opposite terminals of the source 26, that is, the grid and plate circuits, these components in the respective circuits are in phase opposition. The amplitude of the hum components in the plate circuit, however, may be controlled by the amount of resistance 40 included in the circuit just traced for the plate. The amplitude desired in the plate circuit is that sufficient to balance and neutralize the hum components introduced in the grid circuit traced above. The same reaction occurs in tube 15 while the hum neutralizing action in tube 18 is obtained through resistance 42 and the contact 43. This reaction may perhaps be more clearly understood from a description of a concrete example shown in connection with Fig. 2.

In Fig. 2 is shown a single tube having an input and output circuit and an alternating current filament supply. An input transformer 50 transfers the signals to the grid of a three element vacuum tube 51 while an output transformer 52 may transmit the output to other tubes or a work circuit. The filament is heated by alternating current from source 54 through power transformer 55. In

series with the secondary winding of the transformer 55 is a resistance 56, to which the plate circuit is connected by an adjustable tap 57. Grid bias is furnished the tube from battery 58 and anode potential from battery 59.

Let us assume that the source 54 is one of 110 volts at a 60 cycle frequency and the tube 51 is an amplifying tube requiring one ampere at 5 volts to heat the filament to its proper temperature. The amplification constant of the tube may be assumed as 7. Since the grid is connected to one terminal of the filament the grid voltage (except for the steady bias potential and the signaling voltages) is held to that of the filament terminal to which it is connected. The average filament voltage with respect to one of its ends at any instant is substantially one half the total voltage across it at that instant. This means that the grid potential when referred to the average filament potential, which is the grid voltage that is actually effective in controlling transmission through the tube, is made up of any external voltages that may be present in the grid circuit plus one half the voltage drop through the filament. This drop through the filament is effective in introducing the hum components in the filament circuit into the grid circuit and since the total drop through the filament is 5 volts, as assumed above, the effective hum voltage may be considered as $2\frac{1}{2}$ volts. However, the effect of this voltage on a plate circuit is increased by the amplification factor of the tube and the voltage present in the plate circuit due to that introduced in the grid circuit is, therefore, seven times greater than $2\frac{1}{2}$ volts or $17\frac{1}{2}$ volts. This means that it requires a $17\frac{1}{2}$ volt alternating potential of opposite phase to neutralize the effect of the potential arising in the grid circuit. Of the $17\frac{1}{2}$ volts required, $2\frac{1}{2}$ is obtained from the drop across the filament as explained in connection with the grid circuit and the remainder, or 15 volts is supplied by the drop through the resistance due to the filament heating current. The proper phase relation, of course, is obtained by a connection from each respective circuit to opposite terminals of the supply source. Since 15 volts are required, a resistance of 15 ohms will furnish the amount since the current therethrough must be one ampere to supply the filament, and since 15 volts are necessary for the resistance and 5 volts required for the filament, the potential across the secondary winding of the transformer 55 must be 20 volts.

In Fig. 3 is shown an embodiment of the invention in an amplifier, one stage of which is a push-pull stage. This amplifier circuit is disclosed as an announcing or public address system with the source of variations to be amplified arising in a microphone 65 supplied by a battery 66. The variations in the

microphone are impressed on the grid circuit of a tube 68 through input transformer 67 and then on the input circuits of tubes 69 and 70 of the push-pull stage through inter-stage transformer 71. The output of the amplifier is shown connected through an output transformer 72 to a loud speaker 73.

The energy supply for this amplifier is entirely from an alternating current source 75, through power transformer 76. A full wave rectifier is employed including rectifier tubes 77 and 78, the filaments of which are supplied from a secondary winding 79 of power transformer 76. A secondary winding 80 furnishes alternating current to the filament of tube 68, while the secondary winding 81 serves similarly for the tubes 69 and 70. The secondary winding 82 furnishes the anode potential for all the tubes as well as grid biasing potential therefor. The choke coil 84 in conjunction with condensers 85 are employed to smooth out the ripples from the rectified output in a manner well known in the art. A resistance element 91 serves as a potentiometer across the rectifier from which the anode potential for the tube 68 is obtained. From the voltage drop across resistance element 97, the proper bias is obtained for the grid of tube 68, while the drop across resistance elements 97 and 98 supplies the grid bias for tubes 69 and 70. Condensers 74 and 93 are by-pass condensers for alternating current hum components. Resistances 96 and 99 are stabilizing resistances having a high impedance with respect to the condensers 93 and 74 respectively, in order that the resistances do not enter into the neutralizing effect and aid in forming an alternating current path through condensers 93 and 74.

A resistance 87 in the filament heating circuit of the tube 68 together with the adjustable tap 88, and a resistance 89 in the filament heating circuit of the tubes 69 and 70 together with the adjustable tap 90 have the same function as the elements 40, 41, 42 and 43 shown in Fig. 1. The alternating current hum potential originating in transformer winding 80 is impressed on the grid circuit of the tube 68, this circuit being traceable from the grid of the tube through the secondary of the transformer 67, by-pass condenser 93 and to the filament of the tube. An alternating current hum potential of opposite phase is present in the plate circuit of the tube 68, this circuit being traceable from the plate, through primary of the transformer 71, by-pass condenser 94, the contact 88, that portion of the resistance 87 common to the plate and filament circuits and to the filament of the tube. The hum in these two circuits is neutralized as explained above.

In the push-pull stage the circuit for the control electrodes may be traced from the

grids of tubes 69 and 70, through the secondary winding of the transformer 71, by-pass condenser 95 and to the two filaments of the tubes. The plate circuit in which the hum is neutralized in this stage is traceable from the plates of tubes 69 and 70, through the primary of the output transformer 72, by-pass condenser 74, contact 90, that portion of resistance 89 common to the plate and filament circuits and to the filaments of the tubes 69 and 70. This circuit also performs as explained in connection with Fig. 1.

Fig. 4 shows a modification in the push-pull circuit of Fig. 3 and is applicable in the case where there is a considerable variation in the characteristics of the tubes 69 and 70. In this figure is shown the input transformer 100, supplying push-pull tubes 101 and 102 with signals while an output transformer 103 transmits the amplified signals to other amplifiers or work circuits. This push-pull stage has a grid biasing battery 104, anode plate battery 105 and a source of alternating heating current 106 supplied through power transformer 107. In series with the filament supply is a resistance 109 and in series with the two filaments themselves is a resistance 110. The filament circuit therefore for the tubes is traceable from a terminal of the secondary of the power transformer 107 through the resistance 109, the filaments of the tubes in parallel, complementary portions of the resistance 110 in parallel, and then to the secondary of the power transformer 107. The grid circuit for the tube 101 is traceable from the grid of the tube, through the upper one-half of the secondary winding of the transformer 100, the grid battery 104, and to the filament of the tube, while the grid circuit for the tube 102 is from the grid of the tube, through the lower one-half of the secondary winding of transformer 100, the grid battery 104, the resistance 110, and to the filament of the tube. The connection 111 from the power transformer 107 to the filaments is shown variable in order to compensate for any variation in filament energy requirements for the two tubes or variations in the static characteristics of the two tubes.

Although these amplifiers have been shown as audio frequency amplifiers, it is to be understood that this method of neutralizing undesired hum components introduced through the filament heating circuit is applicable to radio frequency amplifiers as well, the invention being adaptable to radio receivers and the like.

What is claimed is:

1. In a tandem stage amplifier, each stage including a space discharge tube having a cathode, an anode and a grid or the equivalent, means for energizing the cathodes by alternating current, a common source of space

current for said stages, separate means in the respective stages for deriving from the cathode energizing means and applying to the respective cathode-anode circuits alternating voltages sufficient to compensate the effect on the anode current of the alternating cathode-energizing current, and means in each cathode-anode circuit permitting space current voltage to be supplied to the several stages from said common source but preventing the alternating current that is applied to one cathode-anode circuit from affecting other stages.

2. An amplifier circuit according to claim 1 in which the means in each cathode-anode circuit permitting space current to be supplied to the several stages from said common source but preventing the alternating current that is applied to one cathode-anode circuit from affecting other stages comprises a filter in each cathode-anode circuit each including a capacity through which said alternating voltages are applied to the cathode-anode circuit, said filters including an element in the space current supply path of high impedance to alternating currents.

3. In a tandem stage amplifier, each stage including a space discharge tube having a cathode, an anode and a grid or impedance control element, separate alternating current cathode-energizing circuits for energizing certain stages, said circuits supplying different voltages to the cathodes of different ones of said certain stages, each stage having its grid return to one side of its respective cathode-energizing circuit, a resistance included in the opposite side of each cathode-energizing circuit, a tap point on each resistance, said tap points being directly connected together, a source of plate voltage having its negative pole connected to said tap points in common, individual connections from the anodes of said stages to points of positive potential in said source, whereby the cathode-anode circuit of each stage is supplied with direct voltage and also with alternating voltage such as to compensate the effect on the cathode-anode current of the cathode-energizing current applied to the respective stage, and means in each cathode-anode circuit preventing the alternating current that is applied to one cathode-anode circuit from affecting other stages.

4. In an electrical circuit, a plurality of vacuum tubes having grids, cathodes and anodes, a connection from said grids to a common point on one of said cathodes, a source of heating current having an alternating current component therein, a resistance connected to one terminal of said source and to said cathodes in parallel, a connection from said anodes to a movable contact along said resistance, a second resistance in series with said cathodes themselves, and a connection

from the other terminal of said source to a movable contact on said second resistance.

In witness whereof, I hereunto subscribe my name this 2 day of March, 1928.

VAN METER COUSINS.