Aug. 8, 1950 D. K. FROMAN 2,517,863

VOLTAGE SUPPLY CIRCUIT FOR VACUUM TUBES

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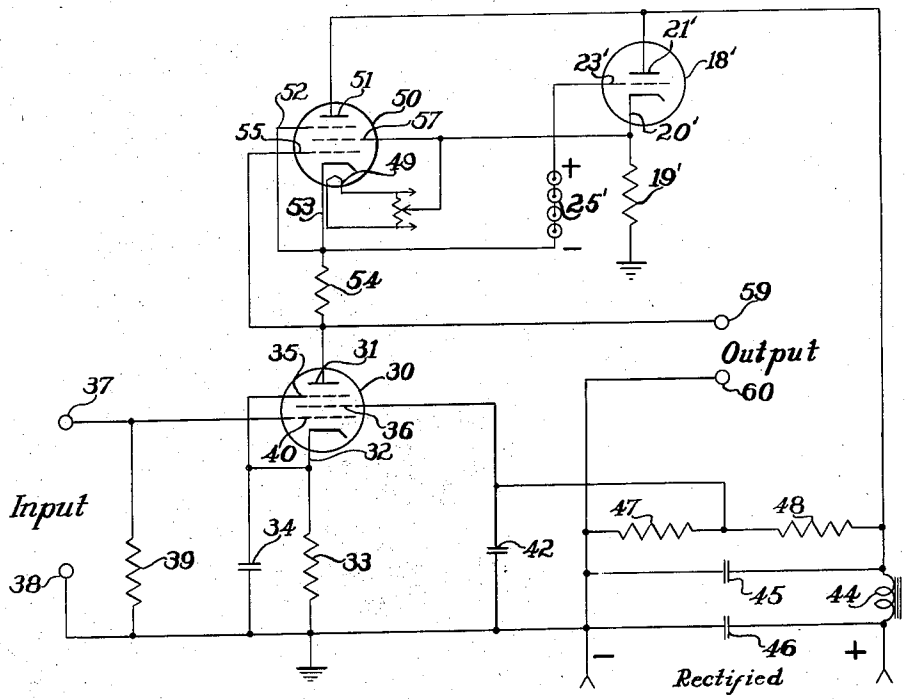


Fig. 2

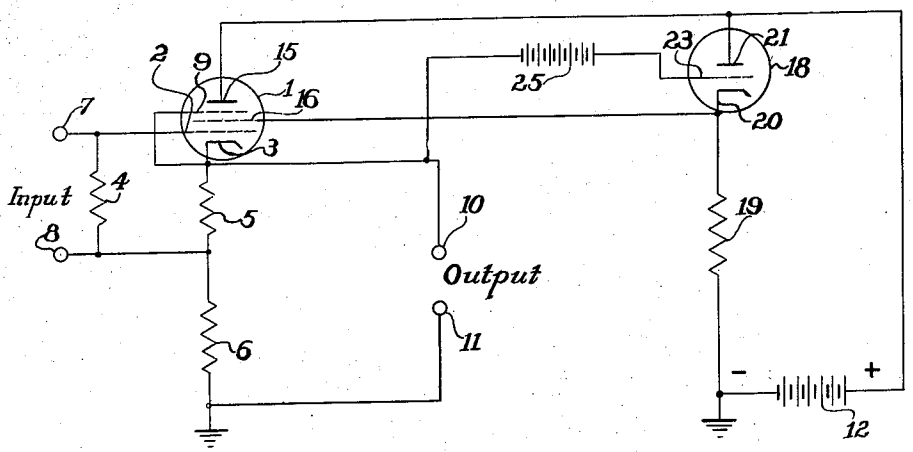


Fig. 1

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VOLTAGE SUPPLY CIRCUIT FOR VACUUM TUBES

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5 Claims. (Cl. 179—171)

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This invention relates to vacuum tube circuits and more particularly to circuit arrangements for supplying operating potentials to various electrodes of vacuum tubes under conditions which demand that certain of these potentials be maintained constant and that no undesired reactance be introduced by the source supplying these potentials.

In the electronic art circuit requirements often place a considerable burden on the designer, who in the attempt to meet certain specifications, is faced with the difficulty of placing component elements possessing inherently disturbing electrical constants in a judicious manner. These electrical constants are per se unalterable, such as the interelectrode capacities of vacuum tubes or the inductive or capacitive reactance that the physical configuration of the components must necessarily introduce.

A particular feature of this invention is that the conditions above-referred to are alleviated with respect to specific circuits wherein heretofore the source and the application of certain operating voltages has been a difficult problem.

The invention is particularly adaptable to vacuum tube circuits in which one or more multigrid tubes, such as a pentode or a tetrode is used in such manner that the zero signal potential reference point is at the anode electrode. In these circuits it is difficult to provide the operating potentials for associated control electrodes without disturbing the cathode impedance or interfering with coupling circuits designed to be energized therefrom.

Another important feature of this invention is that such disturbing effects are eliminated by providing a circuit arrangement in which the necessary operating potentials are supplied isolated from the cathode circuit with respect to signal voltages or currents.

An advantage of this invention is that the expedients chosen to obtain the features referred to are simple, and at the same time, exhibit other ancillary beneficial features. Among these, in particular a significant advantage is that in operation the voltage supply is automatically held substantially constant within wide limits as to potential variations of another electrode taken as a reference point.

Essentially, the invention provides a novel circuit arrangement for an electron discharge device having a plurality of control electrodes besides the principal anode and cathode. At least one of these control electrodes requires a substantially constant potential with reference to one of the principal electrodes. The circuit includes a source of operating potentials a portion of which is applied to the control electrode. A current controlling element in this circuit is in turn controlled by variations of potential of the principal electrode. In this manner the voltage applied to the control electrode is determined by the current controlling element and is maintained substantially constant.

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Other features and advantages will be apparent from the following description of the invention, defined in particular by the appended claims and taken in connection with the accompanying drawings in which:

Figure 1 shows a vacuum tube circuit utilizing a single pentode with the output impedance in the cathode circuit wherein, in accordance with the invention, the screen voltage is maintained substantially constant and the source does not interfere with the cathode impedance.

Figure 2 shows a modification of the invention applied to a vacuum tube amplifier wherein the anode coupling impedance of the amplifying tube comprises the dynamic anode resistance of a second vacuum tube. The screen voltage for the resistance tube is held constant and the effective shunt capacity of the heater circuit is substantially reduced.

Referring to the figures the electrical system shown in Figure 1 comprises the vacuum tube 1 connected as a resistance coupled amplifying stage in which the input circuit between grid electrode 2 and cathode 3 includes the resistor 4 connected to the junction point of the cathode resistors 5 and 6. The signal input is applied across the resistor 4 between terminals marked 7 and 8. The suppressor grid 9 returns in a conventional manner to the cathode 3. The output circuit is formed by the resistors 5 and 6 to which the output terminals 10 and 11 connect. The anode potential source is shown here by the battery 12. The latter represents by way of example, a source of direct current potential and may be replaced by any suitable type of direct current supply. The positive terminal of the battery 12

connects directly to the anode 15 of the vacuum tube 1.

In a circuit of this type a supply of screen grid potential for the screen grid electrode 16 has been a bothersome problem. For efficient operation of the amplifying stage it is necessary that this potential be held constant to a considerable degree with respect to fluctuations of potential of the cathode 3; moreover, if the amplifier operates with a high output impedance the customary series resistor voltage dropping method with the conventional by-pass condenser offers serious limitations. The by-pass condenser would be effectively in shunt with the output circuit and if the operation is in the high frequency ranges, the resultant change in output impedance would limit the usable range of amplification. In view of the fact that the potential of the screen grid electrode 16 is to be held constant and the cathode electrode is the reference point a battery as a source for this potential would have to be connected between the cathode 3 and the screen grid electrode 16. No matter how small this battery is in practice the physical size, despite its most judicious placement, introduces sufficient capacity to ground to limit the frequency range of operation. Electrical power supplies would necessarily introduce even a larger unwanted capacity.

A supply for the screen grid electrode 16 is obtained, in accordance with the invention, from a voltage divider in which one element of the dividing network is the anode-cathode current path of a vacuum tube 18. The other element is a high resistor 19. As will be seen, essentially the vacuum tube 18 performs the function of a cathode-follower circuit. The cathode 20 connects to the negative terminal of the battery 12 through the cathode resistor 19 whereas the anode 21 is connected to the positive terminal. The screen grid 16 is directly connected to the cathode 20. The cathode-follower is driven in accordance with potential variations of the cathode 3 of the vacuum tube 1. In view of the fact that the grid electrode 23 of the tube 18 connects to the cathode 3, a source of potential of approximately the value of the required screen grid potential is in series between the grid 23 of the tube 18 and the cathode 3 of the tube 1. This source is shown by the battery 25. It is to be noted that there is no current flow in the grid circuit of the tube 18 consequently, the battery 25 delivers only voltage and therefore can be made physically extremely small. It can also be replaced very advantageously by small primary cells as will be described later.

In the operation of the circuit, assuming that no input signal is applied and static conditions prevail, the current flow through the cathode-follower tube 18 as determined by the applied grid bias voltage is of such magnitude that the IR drop of the resistor 19 applies to the screen grid 16 the required potential difference. When a signal is applied between input terminals 7 and 8, whether it is a uni-directional voltage or an alternating current, the change of potential of the cathode 3 controls the action of the vacuum tube 18. This in turn will change the current through the resistor 19 so that the effective potential of the screen grid electrode 16 is also altered in accordance with current fluctuations in the cathode circuit of the vacuum tube 1. In other words, as the voltage across the resistors 5 and 6 increases due to an increase of anode current of the tube 1, the bias on the grid 23 becomes also more positive and a corresponding

increase in current will increase the voltage drop across the resistor 19. Alternately, considering a reverse operation, when the voltage across the cathode resistors 5 and 6 decreases a similar decrease of current will be initiated in the voltage divider network; that is, in the cathode-follower the applied screen grid potential will then be reduced. With respect to the cathode 3 as a reference point, the regulating action is compensative in that the effective screen grid potential will be held substantially constant. It is to be noted that the potential of the screen grid 16 of tube 1 follows the fluctuations of the cathode 3 very rapidly, for the cathode-follower tube 18 acts as a generator with extremely low internal impedance. This low impedance also insures that the potential difference between the screen grid 16 and the cathode 3 is very nearly constant for wide fluctuations of screen grid current.

Referring to Figure 2, the invention is applied to a single stage high gain amplifier of the type wherein the output impedance is formed by the dynamic resistance of a vacuum tube. In other words, a vacuum tube replaces the conventional load resistance in the anode circuit of the amplifying tube. Amplifiers of this type are known in the art for example, the one disclosed in U. S. Patent 1,548,952 to Mills. It was found that very high gain per stage can be obtained approaching the amplification factor of the tube. The reason for this is that the second tube taking place of the anode resistance offers a comparatively low resistance for the static anode current and a much higher effective resistance for the signal component namely, the dynamic resistance of the tube.

The second vacuum tube which will be referred to as the "resistance" tube by virtue of its connection has its cathode at a high potential with respect to signal voltages. Consequently, operating potentials for other electrodes, for example, the screen grid electrode must be applied with reference to the cathode which, as stated before, changes in accordance with signal potentials. Separate batteries used heretofore to supply this voltage introduced a certain inherent capacity to ground which has a deleterious effect. The useful amplification, particularly in the higher frequency ranges, was therefore seriously limited.

The amplifying tube 30 is connected in the circuit in a conventional manner with respect to the various electrodes except the anode 31. The cathode 32 returns to the common or ground potential point of the system through a cathode resistor 33 which is by-passed by a condenser 34. The suppressor electrode 35 returns to the cathode 32. The input circuit of the amplifier between terminals 37 and 38 includes the grid resistor 39 connected to the grid 40 and ground. The output circuit is obtained between terminals 59 and 60 connected to the anode 31 and ground, respectively.

A portion of a conventional rectified, filtered alternating current power supply is shown for the operating voltage source. The rectifier portion is omitted for the sake of simplicity and only the filter choke 44 is shown in the positive side of the supply, by-passed by filter condensers 45 and 46. A voltage divider comprising resistors 47 and 48 in series between output terminals of the supply provides the required screen grid potential for the tube 30. The junction point of the resistors 47 and 48 connects to the screen grid electrode 36. This connection is by-passed by the condenser 42.

The amplifier shown in Figure 2 when energized from an alternating current supply would have the heater elements of the tubes connected to suitably proportioned transformer windings. The invention is not concerned with this portion of the circuit which follows conventional practice; therefore, the heater circuit of the tubes as well as their power supply are omitted. However, the heater circuit of one tube is indicated and the reason for this will be better understood when following the description of the invention.

The resistance tube **50** has its anode **51** connected directly to the high potential side of the power supply. The suppressor grid **52** returns to the cathode **53** which connects to the anode **31** of the tube **30** through a resistor **54**. The latter provides the required bias potential for the grid **55** which is connected to the terminal of the resistor **54** which is connected to anode **31** of tube **30**.

The operating potential for the screen grid **57** is obtained in the same manner as shown in connection with the description of Figure 1. Identical parts are marked with similar reference characters bearing primary indices. The vacuum tube **18'** is connected as a cathode-follower across the terminals of the anode voltage supply. The resistor **19'** between cathode **20'** returns to the negative terminal whereas the anode **21'** to the positive terminal of the supply.

The grid **23'** of the tube **18'** connects to the cathode **53** through a bias supply source **25'** shown here by a number of primary cells connected in series. These cells are used in the art to supply potentials in circuits where practically no current is drawn. For this reason they are known as bias cells. Their small size and long life makes them particularly adaptable where a uniform and steady voltage source is required with a minimum of bulk so as not to introduce undesired capacities.

The screen grid **57** connects directly to the cathode **21'** and to the heater circuit indicated by a center tapped resistor connected across the conductors leading to the filament **49** of the tube **50**. The arrows terminating the heater circuit wires indicate that this is to be connected to a filament transformer, not shown here.

Referring to the operation of the circuit shown in Figure 2, the vacuum tube **30** connected as an amplifier has its anode potential supplied, as previously stated, through the anode to cathode space current path of the vacuum tube **50**. The latter, by virtue of the controlled screen grid potential will maintain a uniform load impedance. The voltage between cathode **53** and screen grid **57** is held substantially constant, in view of the fact that potential variations at signal voltage rate of the anode **31** will be applied to the grid **23'** of the tube **18'**. These variations control the current in the cathode resistance **19'** so that the voltage drop thereacross supplies to the screen grid **57** a control potential tending to maintain the effective voltage between the cathode **53** and the screen grid **57** constant. It is to be noted that the heater **49** being connected to the screen grid electrode **57** will also be held at a uniform potential. This connection eliminates the by-passing effect which would be produced if the heater **49** were held at ground potential. The effective frequency range of the amplifier is thereby considerably increased.

The cathode-follower voltage control presents an extremely high impedance in the circuit of the control grid **23'** connected to the cathode **53**; therefore, although this connection is at a high potential level with respect to signal voltages, the shunting effect will be negligible.

What is claimed is:

1. In an amplifying system wherein the anode coupling impedance of an amplifying vacuum tube comprises the dynamic anode resistance of a second vacuum tube, means for supplying said last mentioned tube with operating potentials including screen grid potential of substantially constant value with respect to the cathode of said second tube, said means including a source of potential, a vacuum tube connected as a cathode-follower between terminals of said source, circuit means for applying the potential drop across the coupling element of said cathode-follower to the screen grid electrode of said second tube and circuit means for controlling said cathode-follower in accordance with changes of potential of the cathode of said second tube.

2. In an amplifying system wherein the anode coupling impedance of an amplifying vacuum tube comprises the dynamic anode resistance of a second vacuum tube, means for supplying said last mentioned tube with operating potentials including screen grid potential of substantially constant value with respect to the cathode of said second tube, said means including a source of direct current potential, a vacuum tube having anode, cathode, and grid electrodes connected as a cathode-follower in series with a resistance between terminals of said source, circuit means for applying the potential drop of said cathode-follower to the screen grid of said second tube comprising a connection between the cathode of said cathode-follower and said screen grid electrode and circuit means for driving said cathode-follower in accordance with changes of potential of the cathode of said second tube comprising a connection between said last mentioned cathode and the grid electrode of said cathode-follower.

3. In an amplifying system wherein the anode coupling impedance of an amplifying vacuum tube comprises the dynamic anode resistance of a second vacuum tube, means for supplying said last mentioned tube with operating potentials including screen grid potential of substantially constant value with respect to the cathode of said second tube, said means including a source of direct current potential, a vacuum tube having anode, cathode, and grid electrodes connected as a cathode-follower in series with a resistance between terminals of said source, circuit means for applying the potential drop of said cathode-follower to the screen grid of said second tube comprising a connection between the cathode of said cathode-follower and said screen grid electrode and circuit means for driving said cathode-follower in accordance with changes of potential of the cathode of said second tube comprising a connection including a source of bias potential between said last mentioned cathode and the grid electrode of said cathode-follower.

4. In an amplifying system wherein the anode coupling impedance of an amplifying vacuum tube comprises the dynamic anode resistance of a second vacuum tube, whereby the cathode of said last mentioned tube is at signal potential, a heater for said cathode, a circuit for supplying screen grid potential for said second tube and means for reducing the deleterious effect of the inherent capacity of said heater including a circuit for applying said screen grid potential to said heater.

5. In an amplifying system wherein the anode coupling impedance of an amplifying vacuum tube

comprises the dynamic anode resistance of a second vacuum tube, whereby the cathode of said last mentioned tube is at signal potential, a heater for said cathode, a circuit for supplying screen grid potential for said second tube and means for reducing the deleterious effect of the inherent capacity of said heater including a circuit interconnecting said heater and the screen grid electrode of said tube.

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