Jan. 10, 1950 A. M. SEYBOLD 2,494,317

MULTIGRID TUBE AMPLIFIER CIRCUIT

Filed Aug. 28, 1947

Fig. 1

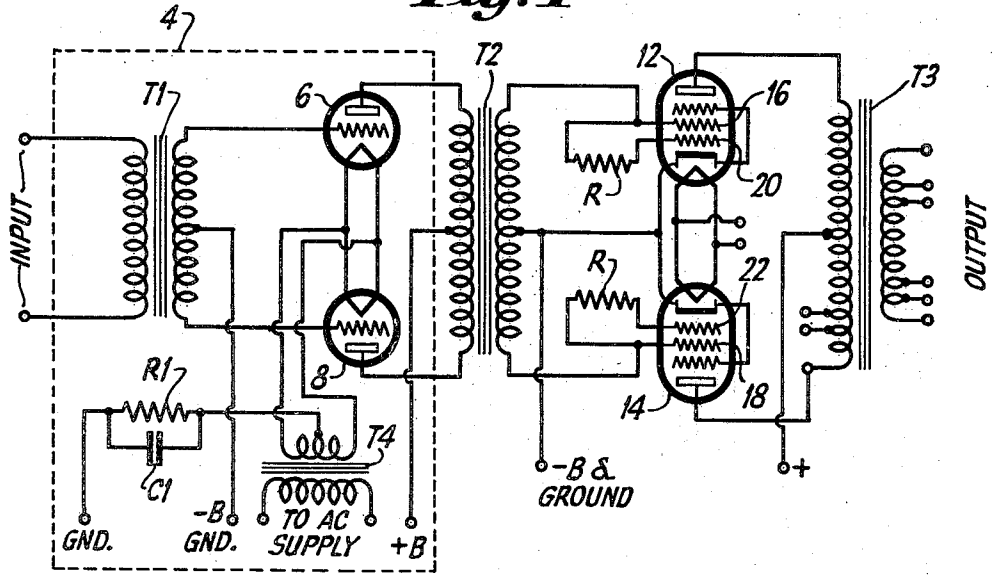


Fig. 2

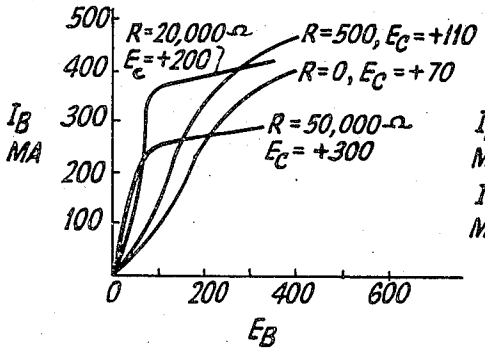


Fig. 3

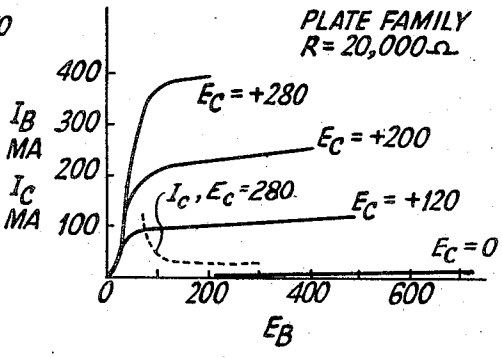
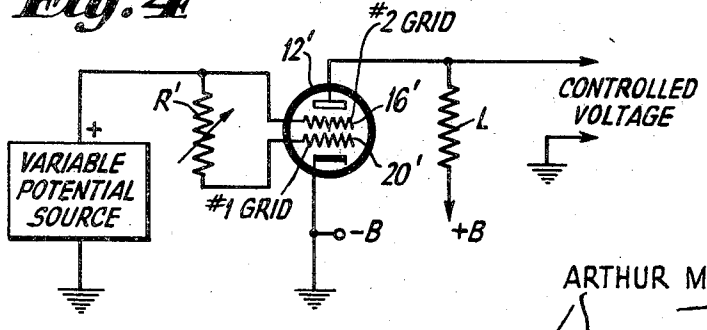


Fig. 4



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Patented Jan. 10, 1950

2,494,317

UNITED STATES PATENT OFFICE

2,494,317

MULTIGRID TUBE AMPLIFIER CIRCUIT

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Application August 28, 1947, Serial No. 771,088

6 Claims. (Cl. 179—171)

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In this application, I disclose an improved method of and means for operation of electron discharge tubes of the screen grid or beam pentode type. My invention is of wide use in the radio and allied arts, the uses thereof being too numerous to include in this application. I have, however, disclosed herein one important application of my invention. In this application, a tube is arranged and operated in accordance with my invention and is used as a power amplifier such as might be used to amplify speech for modulating a carrier. Of course, this application per se of my invention is of wide use in the electronic art since power amplifiers are widely used.

The tube described is an RCA 807. Other screen grid tubes may be used such as, for example, tubes of the 6L6 type. Tubes of this type have excellent class AB2 characteristics but have been used comparatively little in audio frequency modulator service. Perhaps this is because of the difficulties encountered in providing the required regulation of control grid bias and screen grid voltages. The possibility of using the 807 tube and others of the same type in class B audio service is intriguing. Its unipotential cathode, its low price, its small size and its ability to deliver a great deal of power at low plate voltage provided the impetus for a series of experiments, the primary purposes of which were to provide a circuit arrangement using this tube in a manner such as to bring out its good features enumerated in part and to suppress or eliminate its undesirable characteristics. A more specific purpose of my invention is to eliminate the use of screen grid and bias supplies necessary for AB2 operation of these tubes. In carrying out my invention, work was started with screen grid tubes of the 6L6 type but later tests were made with the type 807 tube and these tests show that the system can be used with other multi-grid tubes for numerous class B operations.

In describing my invention in detail, reference will be made to the attached drawings wherein

Fig. 1 is a schematic circuit diagram showing the essential features of my invention as used in a power amplifier.

Fig. 2 illustrates by a series of curves the progressive improvement of plate characteristics with addition of resistance in the #1 grid circuit.

Fig. 3 is a second family of curves illustrating the plate current voltage characteristics of tubes arranged and operated in accordance with my invention, while

Fig. 4 is a basic diagram of a tube arranged and operated in accordance with my invention, such

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as might be used to obtain the various characteristics illustrated by the curves in Figs. 2 and 3.

In Fig. 1, the voltage to be amplified is fed to the leads indicated Input and amplified in a preamplifier 4 of any approved type. A suitable amplifier for use here has been described in detail in a publication appearing in Ham Tips, May–June 1947, vol. VII, No. 2, entitled "New modulator circuit utilizes 807's in class B with zero bias." The amplified output is fed to the primary winding of a transformer T2.

My invention is included in the next stage comprising tubes 12 and 14 of the pentode type having screen grid electrodes 16 and 18 coupled differentially by the secondary winding of the transformer T2. The control grid 20 of tube 12 is connected to the screen grid 16 by a resistor R while the control grid 22 of the tube 14 is connected to its screen grid 18 by a resistor R. The electrical center of the secondary winding of transformer T2 is tied to the indirectly heated cathodes and to ground and to the negative terminal of the plate source. Tubes 12 and 14 are otherwise substantially conventional in their arrangement and connection and the anodes are connected with the primary winding of an output transformer T3.

In the development of this circuit, plate families were taken with various values of resistance R between the #2 and #1 grids of tubes 12 and 14. The series of curves shown in Fig. 2 illustrate the effect of the resistance in the #1 grid circuit upon the shape of the plate family. The driving voltage designated is that which is applied directly to the #2 grid. Low values of resistance give poor knees because the #1 grid is taking too much of the current. As the resistance is increased, the knee improves, until the optimum condition is reached at about 20,000 ohms. Higher values of resistance necessitate screen grid driving voltages that are higher than the type 807 tube ratings permit. In the curves of Figs. 2 and 3 E_C is voltage applied to the #2 grid. R is measured in ohms. E_B is plate potential in volts. I_B is plate current in milliamperes and I_C is current in milliamperes to the #1 and #2 grids.

The 20,000 ohm value for R is a good compromise, and it can be seen in Fig. 3 that when R=20,000 ohms, an adequate plate family is produced. The grid current curve is depicted by a dotted line. With a 750 volt supply, a plate-to-plate load of 6600 ohms, and a driving source giving 554 peak volts grid-to-grid, 120 watts of audio are available. The power to drive the grids is greater than that needed for class AB2, but the

sacrifice is an easy one to make because a push-pull triode driver will easily furnish the 5.3 watts needed for the class B 807 grids.

The only important technical difference between 807's and regular zero bias class B triodes is in their effective grid resistance. Whereas most of the high mu zero-bias triodes require low-voltage high-current driving signals, the 807's take excitation at high voltage but with low current.

As stated above, any approved amplifier may be used as the preamplifier 4. In Fig. 1, I have shown in rectangle 4 an amplifier I found satisfactory in operation. The voltage to be amplified is impressed on the primary winding of a transformer T1, a secondary winding of which is coupled in push-pull relation to the control grids of a pair of amplifier tubes 6 and 8. In the embodiment illustrated, these preamplifier tubes were of the 2A3 type with their cathodes heated by alternating current from a transformer T4, the secondary winding of which is connected to ground by a biasing resistor R1 shunted by a large condenser C1. The potential drop therein is applied to the center point of the secondary winding of transformer T1 and operates the grids as desired. The anodes of the tubes 6 and 8 are coupled in push-pull relation by the primary winding of the transformer T2 and direct current potential for the anodes of the preamplifier stage is supplied to a point at the electrical center of this primary winding.

The 807 grids present a fairly constant load, applied continuously. A pair of 2A3's, which will give ten watts with a plate-to-plate load of 5,000 ohms, can be coupled to the 807's by a transformer T2 matching the 5,000 ohms of 2A3 plate load to the 7,100 ohms or equivalent grid resistance of the 807 class B stage.

The final item in the modulator is the output transformer T3. Any audio transformer designed to handle the required output will do, providing it will match the plate-to-plate impedance of the tubes 12 and 14 to the load which, in the case under discussion, might be the plate circuit of an RF amplifier operating class C.

As stated above, my invention was made during work on power amplifiers. The principle involved, however, is much broader being the use of a resistor between the control grid and screen grid of a multigrid tube. The selection of the resistor will determine the operating characteristic of the tube and such selection is made with the use to which the tube is put in mind. For example, with a tube as arranged in Fig. 4, adjustment of the resistor R' may be made to obtain various characteristics such as illustrated in Fig. 2. The range of resistor R values and magnitude of E_c of Fig. 2 are such as may be used with a type 807 tube. Different type tubes will require other values of resistance to obtain the optimum operating conditions for the job at hand. The variable potentials may represent control potentials of any type such as for tuning purposes or keying purposes and the like. The conductance of tube 12' and its current output changes with changes in the magnitude of the supplied screen grid potential in accordance with the tube characteristic as established by selection of R'. The resistor L may represent the load and the current therethrough is controlled. For example, a relay winding may replace L and then the relay may be controlled by the variable potential on the #2 grid. Controlled voltage appears across L and may be used as desired.

What is claimed is:

1. In a voltage or current amplifier, an electron discharge tube having an anode, a cathode, a control grid and a screen grid, an alternating current input circuit, on which said voltages or currents to be amplified are impressed, coupled directly between said screen grid and said cathode, an alternating current output circuit coupled to said anode, and direct current circuits for the electrodes of said tube including a series resistor of appreciable value connecting said screen grid to said control grid and a source of direct current potential for maintaining said anode electro-positive relative to said cathode.

2. In a voltage or current amplifier, a pair of electron discharge tubes each having an anode, a cathode, a control grid and a screen grid, an alternating current circuit excited by voltages or current to be amplified coupled directly to the screen grids of said devices in push-pull relation, said push-pull coupling including a connection to the cathodes of the tubes, an alternating current output circuit coupled to the anodes of said tubes, and direct current circuits for the electrodes of said tubes including a series resistor of appreciable value connecting the screen grid of each tube to its control grid, there being a separate resistor for each tube, and a source of direct current potential for maintaining said anodes electro-positive relative to said cathodes.

3. An amplifier as recited in claim 2 wherein said resistors are of substantially equal value.

4. An electron discharge tube circuit, comprising an electron discharge tube having an anode, a cathode, a control grid, and a screen grid; a source of controlling voltage; means connecting said source directly to said screen grid; means connecting said control grid to said source and to said screen grid only through a resistor of appreciable value; and a utilization circuit connected between said anode and said cathode.

5. In an electrical energy repeater making use of an electron discharge tube which has an anode, a cathode, a control grid, and a screen grid; a circuit terminal for each tube electrode; means connecting the control grid terminal to the screen grid terminal only through a resistor of appreciable value; connections for applying a controlling voltage directly to the screen grid terminal; and means for connecting a utilization circuit between the anode and cathode terminals.

6. In connections for operating an electron discharge tube which has an anode, a cathode, a control grid, and a screen grid; a circuit terminal for each tube electrode; means connecting the control grid terminal to the screen grid terminal only through a resistor of appreciable value; connections for applying a variable controlling voltage directly to the screen grid terminal; and a utilization circuit connected between the anode and cathode terminals.

ARTHUR MACK SEYBOLD.

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