

March 1, 1949.

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2,462,849

PUSH-PULL SYSTEM

Filed Aug. 4, 1945

Fig. 1.

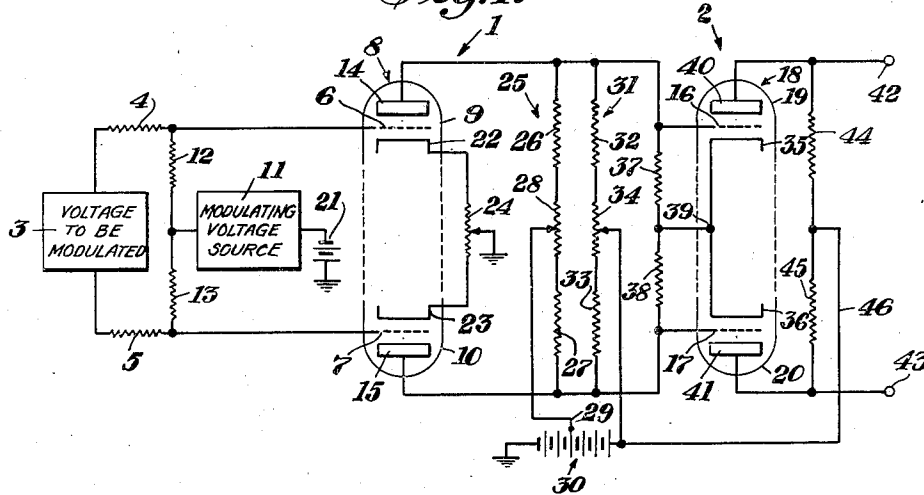
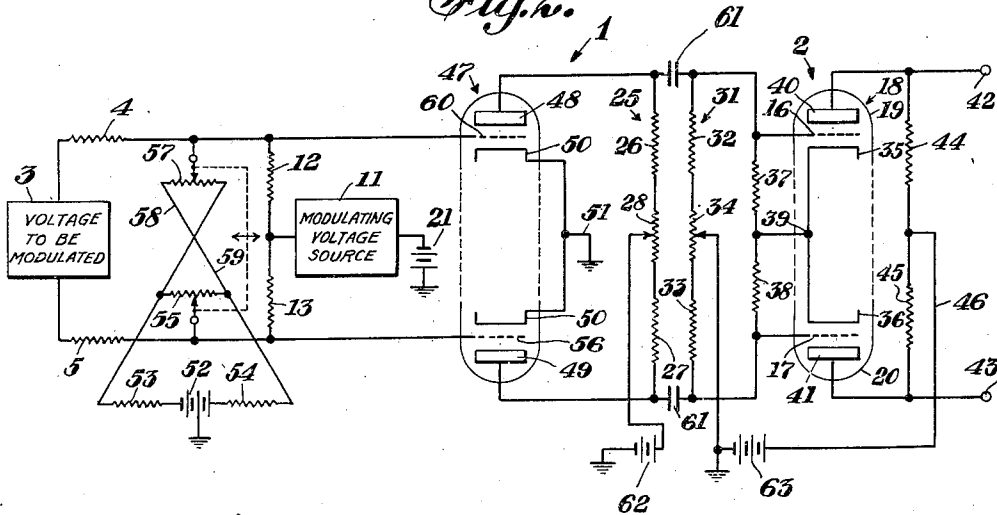


Fig. 2.



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2,462,849

PUSH-PULL SYSTEM

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Application August 4, 1945, Serial No. 608,948

4 Claims. (Cl. 179—171.5)

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The present invention relates to electron discharge tube circuits and more particularly to push-pull systems.

Generally in balanced modulators the voltages of the anodes are simultaneously varied in two ways. In one way the voltages on the anodes are inversely varied in relation to each other with respect to ground. In a second way the voltage of both anodes is varied in phase with respect to ground.

In certain systems, such modulators feed direct current push-pull amplifiers, the anodes of the modulator being directly coupled to the respective grids of the amplifier with the cathodes of the amplifier grounded. Such systems have frequently proven unsatisfactory. This appears to be due to the fact that the parallel shifting or cophasal variation of the modulators' anode potentials with respect to ground changes the bias of the amplifier tubes and shifts their operation so as to distort the push-pull signal.

An object of the present invention is the provision of an improved direct current amplifier.

Another object of the present invention is the provision of an improved amplifier in which the bias of the tubes therein is substantially independent of the parallel shifting with respect to ground of its input voltages.

Another object of the present invention is the provision of an improved modulator-amplifier system with the amplifier either D. C. or A. C. coupled to the modulator.

One of the difficulties encountered in balanced modulators is that due to the differences in the characteristics of the tubes used therein. Where these tubes have different characteristics, it is difficult to make them balance with respect to ground.

Still another object of the present invention is the provision of a balanced modulator in which two tubes having slightly different characteristics may be employed and in which the balance with respect to ground may be maintained despite these differences.

Other and further objects of the present invention will become apparent and the invention will be best understood from the following description of embodiments thereof, reference being had to the drawings, in which:

Fig. 1 is a schematic diagram of a modulator-amplifier system embodying my invention; and

Fig. 2 is a schematic diagram of another modulator-amplifier system of the push-pull type embodying my invention.

Referring now to Fig. 1, the modulator- ampli-

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fier system of the push-pull type there illustrated includes a balanced modulator 1 and a push-pull D. C. amplifier 2. A source 3 of voltages to be modulated is connected in push-pull through resistors 4 and 5 to the grids 6 and 7 respectively of a double triode tube 8, consisting of two tube sections 9 and 10 respectively. Voltages from a source of modulating voltages 11 are applied through resistors 12 and 13 cophasally to grids 6 and 7 respectively. Anodes 14 and 15 are connected respectively to the grids 16 and 17 of a double triode 18 consisting of two sections 19 and 20 in the push-pull amplifier 2.

In accordance with our invention, provision is made for discrepancies between the two sections 9 and 10 of the double triode 8 which tend to unbalance the circuit. Maintenance of balance in the circuit is particularly difficult when the modulating voltages produce wide variations in grid swing or bias as for example, a shift in the bias of the two sections between zero and cut-off. We have found that by adjusting both the normal bias of the sections and the value of the load resistors of each section, suitable balance can be obtained over the entire range of operation of the system. Accordingly means for making both of such adjustments are included in the balanced modulator of Fig. 1.

A fixed source of biasing potential 21 may be arranged between the modulating voltage source and ground. The cathodes 22 and 23 of sections 9 and 10 respectively are connected to the opposite ends of the resistor of a potentiometer 24, the arm of which is connected to ground. By varying the position of the arm of potentiometer 24, the relative bias on both sections can be varied, said resistor serving as the cathode resistor for both cathodes. If said resistor is large enough the biasing source 21 may be dispensed with.

Anode 14 and anode 15 are connected to the opposite ends of a load resistance generally designated by the numeral 25 which consists of two resistors 26 and 27, preferably of equal value, between which is arranged the resistor of a potentiometer 28 whose arm is connected to an intermediate point 29 of a source of D. C. potential 30 whose negative side is connected to ground. A voltage divider 31 is arranged in parallel with load resistance 25, voltage divider 31 being comprised of resistors 32 and 33 between which is arranged the resistor of a potentiometer 34, the arm of said potentiometer being connected to the positive side of the D. C. source 30.

Voltage divider 31 has a resistance many times that of load resistance 25, so that the effective

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load resistances of tube sections 9 and 10 are determined by 25. By varying the position of the arm of potentiometer 28, the value of the load resistors of sections 9 and 10 are inversely varied with relation to each other.

In practice, the balanced modulator is adjusted in the absence of voltages from source 3, but with voltages, usually sinusoidally varying, from source 11. The arms of potentiometers 24 and 28 are simultaneously adjusted until the trans-conductances of sections 9 and 10 track each other over the entire range of voltages from source 11. Usually after this operation, the voltages of anodes 14 and 15 are somewhat different, thus applying different biases to grids 16 and 17 of the amplifier tube sections 19 and 20. To correct this, the arm of potentiometer 34 is then adjusted. The positive side of D. C. source 30 is several times as high in potential as point 29 while the voltage divider 31 has a relatively large resistance. Therefore a small current is bled through divider 31 into the load resistance 25 and by adjustment of the arm, of potentiometer 34, this current is proportioned to vary the voltages of anodes 14 and 15 inversely and equalize them.

In the D. C. balanced amplifier 2, the cathodes 35 and 36 of sections 19 and 20 respectively are connected together, but in accordance with our invention, instead of being tied to ground while the grids vary cophasally with respect to ground, the cathodes float with the grids in respect to ground. For this purpose grid 16 is connected through a resistor 37, and grid 17 is connected through a resistor 38, to the common connection point 39 of cathodes 35 and 36. By the foregoing arrangement the cathodes 35 and 36 are not tied to ground but instead vary with relation to ground as do the grids 16 and 17 and the anodes 14 and 15, the cathode potential with respect to ground being equal to the average of the potentials of grids 16 and 17 each with respect to ground. Resistors 37 and 38 are of such a value as to provide the bias required for the sections 19 and 20 respectively. The anodes 40 and 41 of sections 19 and 20 respectively are connected to output terminals 42 and 43 and are connected by means of load resistors 44 and 45 and line 46 to the positive side of the source 30.

In certain double triodes, a single cathode is used instead of two separate cathodes for each section. In such cases when tubes of such type are used in the modulator, cathode resistors as shown in a balanced modulator 1 of Fig. 1 cannot be employed but other means must be used for varying the bias on the two sections. A balanced modulator utilizing such tubes is illustrated in Fig. 2 in which the double triode 47 consists of two sections 48 and 49 having a single cathode 50. In balancing each of the said sections 48 and 49, the cathode 50 is connected to ground by a conductor 51. The source of potential 21 may provide a fixed bias but for the purposes of obtaining a variable bias, a source 52 of biasing voltages, which is balanced with respect to ground, is utilized. The opposite sides of the source 52 are connected through resistors 53 and 54 to the opposite ends of the resistor of a potentiometer 55, whose arm is connected to the grid 56 of section 49. A similar potentiometer 57 has its resistor cross-connected by crossed conductors 58 and 59 to the opposite ends of the resistor of potentiometer 55, the arm of potentiometer 57 being connected to grid 60 of section 48. The arms of potentiometers 55 and 57 are ganged together. It will be seen that when these arms are moved

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in the same direction, the bias applied to grids 56 and 60 will be inversely varied, that is, the bias on one of said grids will be increased in a negative direction while the bias on the other of said grids will be increased in an opposite direction. This is accomplished without injecting the biasing voltages into the modulating source 11, which injection is usually undesirable. Thus our invention may be employed in adjusting the balance of two sections of a double triode in which only a single cathode is used for both sections. The rest of the system of Fig. 2 is similar to the system described with reference to Fig. 1, except that the case of A. C. coupling between modulator and amplifier is shown. A pair of condensers 61 are used to couple the modulator to the amplifier. The arm of potentiometer 28 is connected to the positive side of a source of D. C. voltages 62 whose negative side is connected to ground. The arm of potentiometer 34 is connected to ground and to the negative side of a source of D. C. potential 63 whose positive side is connected between resistors 44 and 46.

While we have described above the principles of our invention in connection with specific apparatus, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of our invention as defined in the accompanying claims.

We claim:

1. A balanced modulator and direct current amplifier system comprising a balanced modulator for modulating energy from a first source with energy from a second source including a first pair of electron discharge devices each having an anode, cathode and grid, means coupling said first source to the grids in push-pull, means coupling said second source to the grids in parallel, means for inversely varying the bias of one of the grids with respect to its cathode relative to the bias of the other of the grids with respect to its cathode, a balanced amplifier including a second pair of electron discharge devices each having an anode, cathode and grid with the grids coupled to the anodes of said first pair of electron discharge devices and the cathodes connected with each other, resistance means interconnecting the grids of said second pair of electron discharge devices and having an intermediate point thereon connected with the cathodes of said second pair of electron discharge devices a first and second load resistance means for coupling said modulator and said amplifier, a capacitive means, said first and second load resistance means connected in parallel by said capacitive means and interconnecting the plates of said modulator and the grids of said amplifier, respectively, adjusting means for inversely varying the value of the load resistance of one of said devices with respect to the value of the load resistance of the other of said devices.

2. A system according to claim 1 wherein in said balanced modulator said bias-varying means includes a common cathode resistor connected at opposite ends thereof to each of the cathodes of the first mentioned electron discharge devices, and means coupling a selected one of a number of intermediate points on said resistor to the negative side of the source of anode potential.

3. A system according to claim 1 wherein in said balanced modulator the first-mentioned pair of electron discharge devices are included within a single envelope and include a single cathode common to both of said devices, and said biasing

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means includes a source of biasing potentials balanced to ground, a pair of potentiometers having their arms connected to the grids of said devices in said balanced modulator and their resistances connected at opposite ends to said balanced source of biasing voltages, said cathode being connected to ground, and means for moving the arms of said potentiometer so as to inversely vary the effective bias applied to the grid of one of said electron discharge devices in said balanced modulator with respect to the grid of the other of said electron discharge devices in said modulator.

4. A balanced modulator and direct current amplifier system comprising a balanced modulator for modulating energy from a first source with energy from a second source including a first pair of electron discharge devices each having an anode, cathode and grid, means coupling said first source to the grids in push-pull, means coupling said second source to the grids in parallel, means for inversely varying the bias of one of the grids with respect to its cathode relative to the bias of the other of the grids with respect to its cathode, a balanced direct current amplifier including a second pair of electron discharge devices each having an anode, cathode and grid with the grids connected separately to the anodes of said first pair of electron discharge devices and the cathodes connected with each other, resistance means interconnecting the grids of said second pair of electron discharge devices and having an intermediate point thereon connected with the cathodes of said second pair of

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electron discharge devices, a first and second load resistance means connected in parallel and interconnecting the plates of said modulator for coupling said modulator to said amplifier, adjustment means on each of said load resistance means for inversely varying the value of the load resistance of one of the said devices with respect to the value of the load resistance of one other of said devices, a direct current source, first connecting means for connecting said adjustment means of said first load resistance means to a point on said direct current source, second connecting means for connecting said adjustment means of said second resistance means to a point of higher potential on said direct current source than said first connecting means, a third resistance means for interconnecting the plates of said amplifier, an intermediate point on said third resistance means connected to said second connecting means.

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