

Nov. 26, 1946.

S. BERKOFF

2,411,706

PHASE INVERTER CIRCUIT

Filed June 3, 1942

2 Sheets-Sheet 1

Fig. 1.

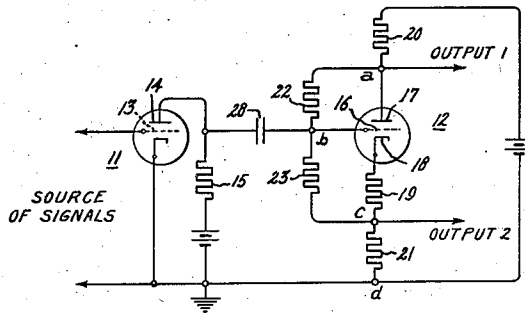
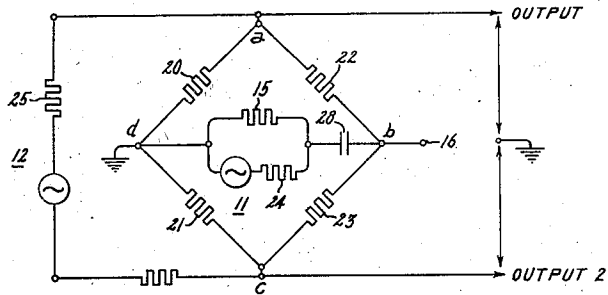


Fig. 2.



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Fig. 3.

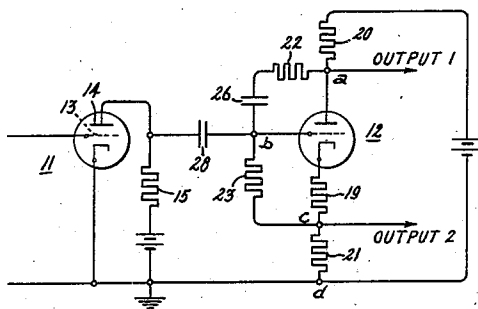


Fig. 4.

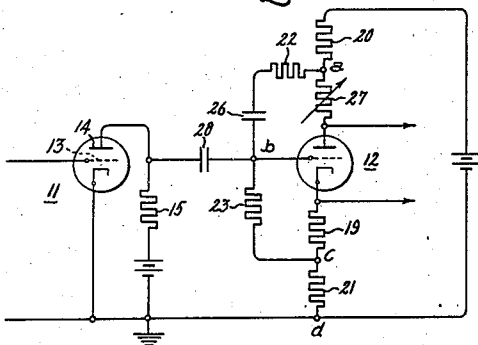
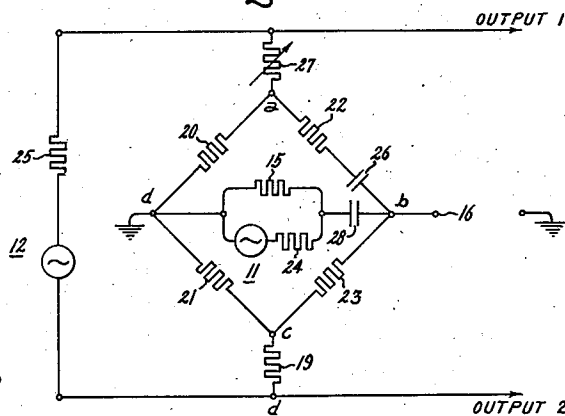


Fig. 5.



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PHASE INVERTER CIRCUIT

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10 Claims. (Cl. 179-171)

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My invention relates to phase inverter circuits and has for its object to improve the characteristics of such circuits.

A further object is to provide a phase inverter circuit in which the magnitudes of the output signals are proportional to the magnitude of the input signal, and in which the output signals are of the same time occurrence as the signals in the input circuit.

In radio apparatus used for signal purposes, for example, in which there is provided a single signal comprising a series of very short pulses at somewhat irregular intervals, the phase inverter used to convert this single signal into two signals for feeding, for example, two push pull amplifiers, should provide output signals which are equal, and opposite in phase. It is desirable both that there be no time delay between the input pulse and either of the output pulses and that there be no amplitude distortion in the phase inverter circuit. My invention proposes to eliminate both time delay and amplitude distortion in such a pulse amplifier by employing a balanced impedance bridge to reduce the effect of feedback on the control grid.

In some applications it is desirable to be able to vary the relative magnitude of the two output voltages of a phase inverter to compensate for inequalities in the following stages, for example, two push pull amplifiers. Hence it is a further object of my invention to provide means for varying the relative magnitudes of the output voltages of a phase inverter circuit without introducing either amplitude distortion or time delay into said voltages.

One of the features of the present invention is the isolation of a single-ended source of signals from the output of a single tube phase inverter by means of an impedance bridge in which the single-ended source is connected across points remote from the two output points. Another feature is the proportioning of the values of the impedances comprising this bridge so that the magnitudes of the output signals will be exactly proportional to the magnitude of the input signal.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in which Fig. 1 is a diagram of a phase inverter circuit embodying my invention; Fig. 2 is a schematic diagram of the phase inverter circuit of Fig. 1 in which the impedance bridge is illustrated; Figs. 3 and 4 are phase inverter circuits showing modifications of the invention; and Fig. 5 is a schematic diagram of the circuit of Fig. 4 in which the impedance bridge is illustrated.

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In the circuit of Fig. 1 an electron discharge device 11, which may be an audio frequency amplifier of a radio receiver, furnishes a signal to a second electron discharge device 12 acting as a single tube phase inverter. The electron discharge device 11, having a control electrode 13 and an anode 14 coupled to resistor 15, comprises a single-ended source of signals supplying a series of pulses to control electrode 16 of electron discharge device 12. While the electron discharge device 12 has been shown as a triode having in addition to the above-mentioned control electrode an anode 17 and a cathode 18, any other type of suitable electron discharge device may be used. The resistor 19 in the cathode circuit of device 12 establishes a negative bias for the control electrode 16. The output conductors for this phase inverter circuit are shown as connected at point *a* to the anode of device 12 and at point *c* to the cathode circuit. The anode current flowing in device 12 establishes voltage drops in resistors 20 and 21, connected respectively in the anode and cathode circuits of the device. If resistances 20 and 21 have equal ohmic values, the voltages established across these two resistors by the anode current flowing in device 12 will be equal and opposite in phase and, if non-linearities arising in the circuit of device 11 are isolated from the output circuits of the phase inverter, the output voltages also will be equal and opposite in phase. To isolate the output circuits from non-linearities arising in the circuit of tube 11 due to operation of tube 12 and brought about by the fact that the grid resistance 23 is ungrounded, control electrode 16 in turn is coupled to the anode 17 by means of resistor 22 and to the junction between resistors 19 and 21 in the cathode circuit by means of resistor 23.

In Fig. 2 is shown a schematic diagram which illustrates the bridge relationship of the resistances in my improved phase inverter circuit. The anode resistances, i. e., the internal resistance between anode and cathode inherent in an electron discharge device, of devices 11 and 12 are shown respectively as resistances 24 and 25.

Since the anode resistance 24 is not a linear resistance, but varies, for a fixed grid potential, with anode potential, introduction of distortion into the grid circuit of device 12 is prevented by the use of resistor 22 to establish the bridge relationship illustrated in Fig. 2. If resistors 20 and 21 are equal, and resistors 22 and 23 are equal, the effect is that of a completely balanced bridge so that distortion cannot arise in electron discharge device 11 due to operation of tube 12 to appear in the output circuits of the phase inverter tube 12; i. e., there will be no feeding back of potentials arising in the output circuit of tube 12 into the circuit of tube 11. Therefore, the voltage appearing across the equal resistors 20 and

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21 are automatically equal and opposite and of the same time occurrence as the input signal supplied to the control electrode 16.

By the above-outlined circuit my invention provides a single tube phase inverter circuit which may be used in pulse circuits. When a signal is supplied to the preceding amplifier 11 and after amplification is supplied to the control electrode of tube 12, by means of the balanced bridge circuit, two pulses, one positive-going and the other negative-going, and of exactly the same time occurrence, are provided at the two output points. In this circuit, because of the balanced bridge relation, the phase inverter will have equal impedance with respect to both output 1 and output 2. Such a relationship between output impedances is desired, for example, where each of the two output signals is transmitted through an appreciable length of cable having a definite impedance characteristic before arriving at its destination and is attenuated during such transmission. If the effect of such a capacitive load across resistor 21 alone is considered, it will be seen that, because of attenuation, less degeneration occurs in the cathode circuit for higher frequencies. As a result the tube gain becomes larger for higher frequencies than for lower, that is, a greater higher frequency voltage appears across resistor 20 than appears across resistor 21. On the other hand, if the same capacitive load is shunted across resistor 20 alone, the higher frequency voltages across resistor 20 are less than those across resistor 21. Hence if equal capacitive loads are shunted across these two resistors, the upper frequencies across resistor 20 will be reduced in magnitude to practically the same value as those existing across resistor 21. The net effect of equal capacities across the anode and cathode circuits is therefore to keep the frequency response in the two circuits approximately the same, and the pulse shapes remain equal. Thus, with the equal output impedances of the phase inverter circuit provided by my balanced bridge arrangement, equal wave forms of the signal voltages at their destinations will be obtained.

In the phase inverter circuit of Fig. 1 resistor 22 is shown connected directly between the anode and control electrode of electron discharge device 12, a negative bias for the control electrode being maintained by the resistor 19. In certain applications it may be desired to block the control electrode from the anode potential. In Fig. 3 is shown a modification of my invention wherein the capacitor 26 is connected in the circuit between the control electrode and anode in series with the resistor 22. In order that the operation of my balanced bridge remain appreciably unaffected by the added impedances of capacitor 26, this capacitor should have a negligible impedance, at the lowest frequency to be amplified, as compared with the impedance of resistor 22. Since the value of resistor 22 is quite large and since the frequency of signals being amplified is usually very high, the requirement of negligible impedance for capacitor 26 is easily met.

In Fig. 4 is shown a modification of my phase inverter circuit which is applicable where it is desired to vary the relative magnitudes of the two output voltages. Such flexibility may be desired, for example, to compensate for inequalities in two push pull amplifiers following the phase inverter. In this arrangement the variable resistor 27 is connected in the anode circuit between the point of output 1 and the point of connection

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of resistor 22 with the anode circuit. Likewise output 2 is taken directly from the cathode 18. The schematic diagram of Fig. 5 illustrates the bridge arrangement of this circuit and the function of the variable resistor 27. Variation of this resistor varies the relative magnitudes of the output voltages, that of output 1 increasing linearly with the value of resistor 27, while that of output 2 is but slightly affected by such variation. Since resistor 20 equals resistor 21, the feed-back voltages supplied to the control electrode from the anode and cathode circuits are always equal, regardless of the setting of resistance 27. Consequently, the balance of the bridge circuit is undisturbed by variations of resistance 27 to adjust the relative magnitudes of the output voltages.

By means of the circuits described in the foregoing, two output signals which are opposite in phase and of precisely the same time occurrence as the input signal, are obtained from a single input signal. The relative magnitudes of the output signals may be made equal or may be adjusted to meet the requirements of following circuits.

By way of illustration only, and not in any sense by way of limitation, the following representative values are those which have been found suitable in a particular phase inverter circuit embodying my invention. In this receiver a type 6V6 triode tube was employed as the phase inverter tube in accordance with the modification shown in Fig. 5 of the drawings. The values of the circuit constants were as follows:

Resistor 15=2,000 ohms
 Resistor 20=1,000 ohms
 Resistor 21=1,000 ohms
 Resistor 22=.5 megohm
 Resistor 23=.5 megohm
 Resistor 19=500 ohms
 Resistor 27=1000 ohms potentiometer
 Capacitor 26=.1 microfarad
 Capacitor 28=.1 microfarad

Thus it will be noted that the resistance in the cathode circuit of Fig. 5 between output 2 and ground is 1500 ohms, while the resistance between anode and ground may be varied from 1000 to 2000 ohms without disturbing the balance of the bridge.

While I have described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without actually departing from the invention. I therefore desire by the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a system for isolating a single-ended source of signals which vary with respect to a point of fixed potential from the output of a single tube phase inverter comprising an electron discharge device having an anode, a cathode, and a control electrode, means for impressing signals from said source between said control electrode and said cathode, first and second output terminals connected to said anode and said cathode respectively, a series circuit connected between said terminals, said series circuit comprising a pair of resistances, means connecting said electrode to a point between said resistances in said series circuit, said last-named point being variable in potential with respect to said point of fixed potential, and resistance means connected

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between each of said output terminals and said point of fixed potential.

2. In combination with a source of signals, a phase inverter for producing opposed signals at two points comprising an electron discharge device having an anode connected to one of said points, a cathode connected to the other of said points, and a control electrode coupled to said source of signals, impedances connected between said control electrode and each of said points, and impedances connected between each of said points and said source of signals, said impedances being of such magnitude as to form a balanced bridge circuit of which said points form two opposite corners and said source of signals is connected across the remaining corners, whereby said source is isolated from said two points to prevent feedback of distortion thereto.

3. In combination in an amplifier, a source of signals which vary with respect to a point of fixed potential, an electron discharge device having an anode, a cathode, and a control electrode, output means connected between said anode and said point of fixed potential, output means connected between said cathode and said point of fixed potential, means for impressing signals from said source on said electrode, and means for isolating said source of signals from said output means, said means comprising equal resistances connected between said control electrode and each of said output means, and equal resistances connected between each of said output means and said point of fixed potential.

4. In combination, a first electron discharge device having input means and output means for providing a signal which varies with respect to a point of fixed potential, a second electron discharge device having an anode, a cathode, and a control electrode, means for connecting said control electrode with said output means of said first electron discharge device, an output terminal connected to said anode, an output terminal connected to said cathode, and means for isolating said first electron discharge device from said terminals to prevent feedback of distortions thereto, said means comprising a pair of equal resistances connected between said terminals and said control electrode, and a second pair of equal resistances connected between said terminals and said point of fixed potential.

5. In combination with an electron discharge device having an anode, a cathode, and a control electrode, a bridge circuit comprising a pair of equal impedances connected between a point of fixed potential and said anode and said cathode respectively, and a second pair of equal impedances connected between said control electrode and said anode and said cathode respectively, and a source of signals connected between said control electrode and said point of fixed potential.

6. In an amplifier having a single-ended source of signals which vary with respect to a point of fixed potential, the combination of an electron discharge device having an anode, a cathode, and a control electrode, means for impressing signals from said source between said control electrode and said cathode, first and second output terminals connected to said anode and said cathode respectively, a variable resistance connected to said anode, a fixed resistor connected to said cathode, and means for isolating said single-ended source of signals from said output terminals, said means comprising equal resistances connected between said control electrode and said vari-

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able resistance and said fixed resistor respectively, and equal resistances connected between said point of fixed potential and said variable resistance and said fixed resistor respectively.

7. In combination, a first electron discharge device having input means and output means for providing a signal which varies with respect to a point of fixed potential, a second electron discharge device having an anode, a cathode, and a control electrode, means for connecting said control electrode with said output means, output terminals connected respectively to said anode and said cathode, a fixed resistor connected to said cathode, a variable resistor connected to said anode, and means for isolating said first electron discharge device from said terminals to prevent feedback of distortions thereto, said means comprising a pair of equal resistances connected respectively between said control electrode and said fixed and variable resistors, and a pair of equal resistances connected respectively between said point of fixed potential and said fixed and variable resistors.

8. In combination with an electron discharge device having an anode, a cathode, and a control electrode, a bridge circuit comprising a pair of impedances connected between a point of fixed potential and said anode and said cathode respectively, and a second pair of impedances connected between said control electrode and said anode and said cathode respectively, and a source of signals connected between said control electrode and said point of fixed potential, said second pair of impedances being proportioned with respect to each other and to the impedances of said first pair of impedances to prevent variations of the potential of said anode from being supplied to said electrode.

9. In an amplifier having a single ended source of signals which vary with respect to a point of fixed potential, the combination of, an electron discharge device having an anode, a cathode, and a control electrode, means for impressing signals from said source between said control electrode and said cathode, a first output circuit connected between said anode and said point, a second output circuit connected between said cathode and said point, one of said output circuits comprising a pair of serially connected resistances and the other of said output circuits comprising a fixed resistance and a variable resistance in series therewith, and means for isolating said single ended source of signals from said output circuits, said means comprising equal resistances connected respectively between said electrode and the common point of said pair of serially connected resistances and between said electrode and the common point of said fixed and variable resistances.

10. In combination, a source of signals, an electron discharge device having a control electrode coupled to said source, an anode, and a cathode, a first resistance connected between said anode and a point of fixed potential, a second resistance connected between said cathode and said point, and means for isolating said source from said output circuit comprising a third resistance connected between said electrode and said anode, a fourth resistance connected between said electrode and said cathode, the ratio of said first resistance to said third resistance being equal to the ratio of said second resistance to said fourth resistance.

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