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ELECTRONIC AMPLIFIER

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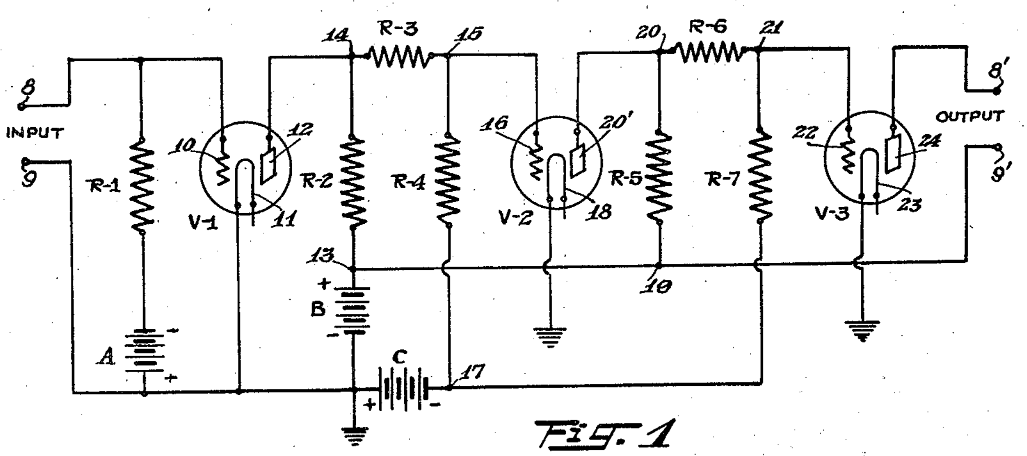

Fig. 1

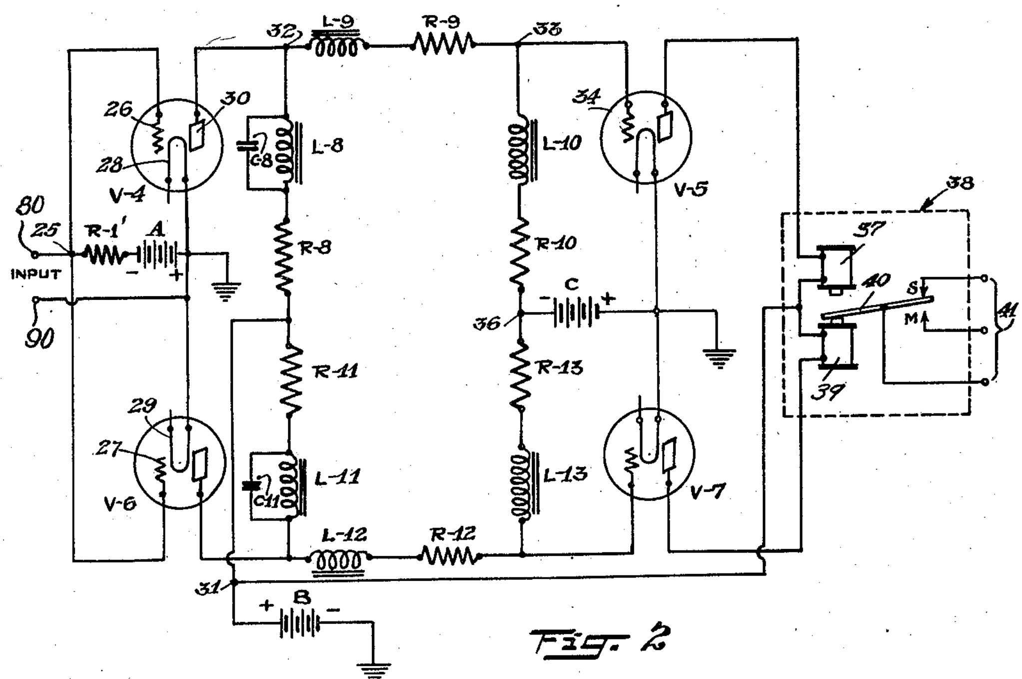

Fig. 2

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ELECTRONIC AMPLIFIER

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6 Claims. (Cl. 178—88)

This invention relates to electronic amplifiers, and more particularly relates to novel circuits for selectively amplifying electrical signals.

The circuits for amplifying electrical signals in ordinary use are essentially amplifier tubes cascaded by means of transformers, resistance-capacity coupling or inductance-capacity coupling. These systems inherently cause distortion due to reduced amplification of the lower audio frequencies as is well known, and moreover, do not amplify direct current signals. Direct current amplifiers generally are electronic circuits wherein amplifier stages are cascaded with direct connection between the plate of one tube and the grid of the next succeeding tube. However, the succeeding tubes in the direct current amplifiers heretofore generally used have the undesirable feature of requiring an independent ungrounded plate battery supply for each stage or a potential supply equal to the sum of the plate potentials necessary for each stage.

The operation of my present invention depends upon a novel amplifying circuit which may be used to amplify uni-directional currents of zero frequency up to signals of extremely high frequency with no discrimination in any frequency band. I also provide means wherein my circuit may be modified to amplify any desired frequency band and reject the other frequencies introduced to the input of the amplifier. The amplifier circuit, according to my invention, employs a common battery supply for all stages which are cascaded.

Accordingly, an object of my invention is to provide novel electrical signal amplifying circuits.

Another object of my invention is to provide a novel electronic circuit for selectively amplifying electrical signals ranging from zero frequency (uni-directional) to extremely high frequencies with substantially no phase shift or frequency discrimination.

Still another object of my invention is to provide a novel electronic amplifier circuit for selective telegraphic signal operation using a common grounded potential supply for all cascaded stages.

A further object of my invention is to provide a novel direct coupled electronic circuit for amplifying signals of predetermined frequency bands to the exclusion of all other signals.

Still a further object of my invention is to provide a novel amplifier circuit for operating a telegraph repeater relay using the amplifier principles outlined in my present invention.

These and other objects of my invention will become apparent in the description to follow in connection with the drawing, in which:

Figure 1 is a circuit diagram of three stages of an amplifier using the principle of my invention.

Figure 2 is a circuit diagram of the amplifier of my invention employing two predetermined frequency bands to selectively actuate a receiver relay.

The electrical signal to be amplified is introduced to the input terminals 8 and 9 of the amplifier shown in Figure 1. The terminals 8 and 9 conducts the signals to the grid 10 and cathode 11 respectively of the thermionic vacuum tube V—1. The cathode or heater 11 is preferably connected to ground potential. The input grid circuit biasing battery A maintains the grid 10 at its normal operating negative potential with respect to the cathode 11 and is connected thereto through the grid resistor R—1. The positive terminal 13 of the anode circuit potential supply B is connected to the anode 12 through the anode resistor R—2. A resistor R—3 is connected between the anode 12 of vacuum tube V—1 at point 14 and the grid 16 of vacuum tube V—2 at point 15. The negative terminal 17 of battery C is connected to a resistor R—4 which is in turn connected to the grid 16 at point 15 as shown in Figure 1. The positive terminal of potential supply C is connected to ground.

With no signal input to vacuum tube V—1, normal anode current will flow through resistor R—2 and cause a potential drop across resistor R—2, so that point 14 will have a lower voltage value than point 13. A circulating current will flow in the local circuit comprising battery B, resistor R—2, resistor R—3, resistor R—4, and battery C. The function of battery C is to make the potential of point 15 sufficiently negative to be equal to the normal or predetermined biasing potential for the grid 16 of the vacuum tube V—2 with respect to its cathode 18. Accordingly, the value of the voltage of battery C is of the order of the voltage of the B battery in this circuit according to my invention. The relative values of the resistors R—2, R—3, and R—4 depend upon the particular type of tube used and upon the voltages of the B and C batteries, and also depend on the other circuit parameters. I thus provide proper operating potentials for the anode of the tube V—1 and the grid of the tube V—2 by the resistor coupling circuit herein disclosed. A current flows through the resistance R—3 to cause a potential drop to reduce the normal positive plate voltage at point 14 to the proper negative biasing voltage for the succeeding grid 16 at point 15.

When a positive signal or impulse is applied to the grid 10 of the tube V—1, the space current in tube V—1 increases, as will the current flowing through the anode resistor R—2. The potential of point 14 will accordingly be lowered because of a correspondingly increased potential drop across resistor R—2. Accordingly, the potential drop across resistors R—3 and R—4 in series will become less because the potential source of battery C is at substantially constant potential and the potential of point 14 has decreased. The potential of point 15 will therefore be correspondingly lowered. A positive signal impulse introduced to the grid 10 of tube V—1, is accordingly repeated as an amplified but negative signal to the grid 16 of the next tube V—2. A phase reversal of 180° is produced upon the signal between these points.

I have illustrated in Figure 1, a further stage of amplification which is identical with that herein described. Resistor R—5 is the load resistance of tube V—2 and is connected between point 19 which connects to the positive terminal of the B battery and the point 20 connecting to the anode 21. A resistor R—6 is connected between point 20 and point 21. Resistor R—7 is connected between points 21 and the negative side 17 of battery C. Resistor R—5 corresponds to R—2, R—6 to R—3, and R—7 to R—4. A circulating current flows through the local circuit comprising the battery B, resistors R—5, R—6, and R—7 and battery C. The resistors R—5, R—6, and R—7 are so proportioned that the proper anode potential is applied to anode 20′ of the tube V—2 and the proper negative or predetermined biasing potential is applied to the grid 22 of the vacuum tube V—3 with respect to the cathode 23.

The amplified negative signal or impulse at grid 16 causes a decrease in the normal anode current which flows through resistor R—5 thereby decreasing the potential drop across this resistor R—5. Accordingly, the potential of point 20 is increased and the potential of point 21 is therefore correspondingly increased.

The original positive electrical signal input to the vacuum tube V—1 is amplified by tube V—1 and introduced to tube V—2, 180° out of phase with respect to the phase of the signal input, as will now be evident. Tube V—2 in turn further amplifies the amplified reversed phase signal and introduces it to the grid 22 of the third vacuum tube V—3, reversed 180° again. The original weak signal at the input terminals 8 and 9 of the amplifier of Figure 1 accordingly appears in substantially its original wave form and original phase relation but with greatly amplified magnitude at the input point 21 of the thermionic vacuum tube V—3. Further stages of amplification beyond tube V—3 are feasible in a similar manner. I have shown the anode 24 and the positive B battery terminal 13 connected to the output terminals 8′ and 9′ respectively. The amplified signals, however, may be connected to any suitable translating device or be transmitted by line wire or radio to a distant point, or be further amplified as desired.

The amplifier hereinabove described in connection with Figure 1 amplifies uni-directional signals (zero frequency) as well as extremely high frequencies with no frequency discrimination if proper design precautions are taken. This amplifier may for example be used in television receivers. Television signals ordinarily comprise a band width from 10 cycles or less to about 200,000 cycles. The amplifier of Figure 1 may readily be designed to amplify a range of frequencies from zero up to 200,000 cycles with negligible distortion and phase shift. The resistors used in such a circuit should be of the non-inductive type and the inter-electrode capacitances of the thermionic vacuum tubes should be as small as practicable. Although I have illustrated triodes, tetrodes or pentodes or any other type of vacuum tube may be substituted by anyone skilled in the art. The amplification of an extremely wide frequency signal band is accomplished by this amplifier with a linear amplification characteristic. The relative magnitudes of the respective frequencies of the signal are unchanged during amplification, and a negligible phase shift is imparted to them.

The outstanding advantages of the described direct current amplifier are that the succeeding cascaded stages are all connected to a common relatively low voltage battery supply, one end of which is at ground potential, and that the cathodes of all the amplifying tubes are at substantially the same potential. I have shown all cathodes as preferably connected to ground potential. The filament or heater supply for the vacuum tubes may accordingly be of any preferred type.

The selective telegraphic signal amplifier circuit of my present invention is illustrated in Figure 2. The electrical signals to be amplified are introduced at the input terminals 80 and 90 of the circuit of Figure 2. The input terminals are connected between ground and the point 25. The input circuits of the vacuum tubes V—4 and V—6 are connected in parallel so that grids 26 and 27 of vacuum tubes V—4 and V—6 respectively are both connected to the point 25. The negative terminal of the biasing battery A is connected to grid resistor R—1′ the other end of which is connected to the point 25. The grids 26 and 27 are properly biased with respect to their cathodes 28 and 29.

An inductance L—8 in series with a resistance R—8 is connected to the anode 30 of tube V—4 to form the load impedance thereof. The positive terminal 31 of the B battery provides the anode potential supply. Point 32 is at the anode 30 potential and is lower in value than the voltage at terminal 31 by the normal direct current potential drop across R—8 and L—8 with no signal input. Inductance L—9 and resistor R—9 are connected in series between points 32 and 33 corresponding to a metallic or conductive coupling between the anode 30 of tube V—4 and grid 34 of tube V—5. Inductance L—10 and resistor R—10 are connected between the negative terminal of battery C and point 33. The positive terminal of battery C is preferably connected to ground as shown.

A direct current corresponding to a circulating current flows in the local series circuit comprising the B battery, inductances and resistances L—8 and R—8, L—9 and R—9, L—10 and R—10, and battery C. Resistor R—8 and the potential of the B battery are proportioned to produce a normal operating anode 30 potential for tube V—4 at point 32. The voltage of the C battery is of the same order of magnitude as that of the B battery and serves to make the potential of the grid 34 at point 33 of proper negative biasing value. A direct current potential drop occurs between points 32 and 33 equal to the difference between the normal operating potential of anode 30, and the normal biasing potential of grid 34 at zero signal impulse. The inductances permit the use of smaller voltage sources for producing required electrode operating voltages as is well known in the art.

The inductors may be air-cored, iron-cored or have metal cores of high permeability. The inductances of the coupling circuit herein described between tubes V—4 and V—5 may be considered as components of three arms of a pi-type filter and suitable condensers may be connected across them to form a band pass filter for a predetermined frequency band. I have illustrated condenser C—8 connected in parallel with inductance L—8. This parallel circuit may be made to be resonant at, for example, 800 cycles. The impedances between points 32 and 31 will be relatively very high at the resonant frequency of 800 cycles and correspondingly much lower for frequencies of resonance as is well known in the communications art. The amplificaton of the input signal by tube V—4 will correspondingly be a maximum for only the predetermined frequency, and will tend to suppress all other frequencies, particularly those remote from the resonant frequency. The predetermined frequency signal which corresponds to the resonant frequency of the parallel resonant circuit L—8, C—8 is introduced to the succeeding vacuum tube V—5 through the arm L—9 and R—9 of the coupling circuit. The predetermined frequency signal is further amplified by vacuum tube V—5, the output of which is connected to the alternating current relay 37 of the repeater relay 38.

Another selective amplifier circuit is connected in parallel with the selective circuit hereinbefore described. This second circuit is similar to the one hereinafter described but is tuned to another predetermined frequency, for example, 1200 cycles. The second selective circuit comprises the vacuum amplifier tubes V—6 and V—7. The grid 27 of the triode V—6 is connected to the common input terminals of the circuit at point 25. The anode arm includes inductance L—11 and resistance R—11, the coupling arm, inductance L—12 and resistance R—12; and the grid arm, inductance L—13 and resistance R—13. The common B and C battery are used. A condenser C—11 is connected across the inductance L—11 and tuned to the second predetermined frequency, for example, 1200 cycles. The 1200 cycle component of the input signal is accordingly selected by the amplifier section comprising tubes V—6 and V—7, and is amplified and introduced to the alternating current relay 39 of the repeater relay 38.

The circuit of Figure 2 is used to segregate and amplify two predetermined frequency signals and introduce them to the corresponding coacting alternating current relays 37 and 39 of repeater relay 38. The 800 cycle signal may be made to correspond to a spacing impulse, and the 1200 cycle signal to a marking impulse for suitable local translating apparatus such as for printing telegraphy and the like. The 800 and 1200 cycle signal impulses may be transmitted over a land line to the input terminals of the circuit of Figure 2; or may be made to modulate a radio frequency carrier wave for radio transmission to the distant receiver which detects the original modulating signals and introduces them to the input of my selective amplifying circuit. Telegraphic communication using two-tone electrical signals for positive actuation at the translating apparatus with corresponding marking and spacing impulses may readily be carried out with the circuit of my present invention. A marking impulse may be used to correspond to the 800 cycle frequency; the spacing impulse, to the 1200 cycle frequency. When a marking impulse of 800 cycles occurs, it is selectively amplified by section V—4, V—5 and introduced to the relay 37 which attracts the pivoted armature 40 to energize a local marking M circuit as is well known in the communications art. When a spacing impulse corresponding to a 1200 cycle signal occurs, it is selectively amplified by section V—6, V—7 and introduced to the relay 39 which attracts the pivoted arm 40 to actuate the spacing S contacts of the local circuit. Terminals 41 connect the translating relay 38 to the local circuit.

Although I have described a preferred embodiment of my present invention, modifications may be made which fall within the broader spirit and scope thereof and accordingly I do not intend to be limited, for example, by any particular type of vacuum tube employed, by the type of coupling impedances used, by the frequency ranges or bands for the amplifiers or to their applications except as set forth in the following claims.

I claim:

1. In a signalling system, a pair of thermionic tubes, each having an input circuit connected in parallel; anode electrodes for each of said tubes; a second pair of thermionic tubes having cathode, anode and control electrodes; metallic connections from each of the anode electrodes of the first pair of thermionic tubes to the control electrodes of their associated thermionic tube of said second pair and impedance means including circuit connections to said metallic connections for by-passing all frequencies except predetermined bands individual to each of said metallic paths.

2. In a signalling system, a pair of thermionic tubes, each having an input circuit connected in parallel; anode electrodes for each of said tubes; a second pair of thermionic tubes having cathode, anode and control electrodes; metallic connections from each of the anode electrodes of the first pair of thermionic tubes to the control electrodes of their associated thermionic tube of said second pair; impedance means including circuit connections to said metallic connections for by-passing all frequencies except predetermined bands individual to each of said metallic paths and a common source of anode potential for all of said thermionic tubes.

3. In a signalling system, a pair of thermionic tubes, each having an input circuit connected in parallel; anode electrodes for each of said tubes; a second pair of thermionic tubes having cathode, anode and control electrodes; metallic connections from each of the anode electrodes of the first pair of thermionic tubes to the control electrode of the associated thermionic tube of said second pair; impedance means including circuit connections to said metallic connections for by-passing all frequencies except predetermined bands individual to each of said metallic paths and a common source of anode potential for all of said thermionic tubes.

4. In a signalling circuit, a cathode and an anode forming an electronic stream path therebetween; a second set of electrodes comprising a cathode, anode and a control electrode forming a second electronic stream path; a metallic connection including a first resistance and first reactance from the anode of said first stream

path to said control electrode; a common anode potential source for said paths; a second common potential source; impedance means including a second resistance and second reactance connecting said first mentioned anode to said common anode potential source; further impedance means including a third resistance and third reactance connecting said control electrode and said second potential source; said first, second and third resistances and potential sources forming a series circuit for producing a potential drop in said first resistance to obtain a predetermined bias on said control electrode; said first, second and third reactances forming a selected frequency network for by-passing all frequencies except a predetermined band from said first mentioned anode and said control electrode.

5. In a signalling circuit, a cathode and an anode forming an electronic stream path therebetween; a second set of electrodes comprising a cathode, anode and a control electrode forming a second electronic stream path; a metallic connection including a first resistance and first reactance from the anode of said first stream path to said control electrode; a common anode potential source for said paths; a second common potential source connected to said first source; impedance means including a second resistance and second reactance connecting said first mentioned anode to said common anode potential source; further impedance means including a third resistance and third reactance connecting said control electrode and said second potential source; said first, second and third resistances and potential sources forming a series circuit for producing a potential drop in said first resistance to obtain a predetermined bias on said control electrode; said cathode electrodes being maintained at substantially the same potential, and the interconnection of said sources being also connected to said cathodes; said first, second and third resistances forming a selective frequency network for by-passing all frequencies except a predetermined band from said first mentioned anode and said control electrode.

6. In an amplifying circuit, a plurality of pairs of amplifying electron stream paths, each path including a cathode, anode and control electrode; a common anode potential source for all of said paths; a second potential source common to a plurality of said paths and connected to said anode source; a metallic connection including a first resistance and first reactance extending from the anode of each path of the first pair of said electron paths to the control electrode of the next succeeding electron path; a connection extending from the cathode of each path to the interconnection between said sources; circuit connections including a second resistance and second reactance extending from a plurality of said anodes to a terminal of said anode source; further circuit connections including a third resistance and third reactance extending from the control electrodes of a plurality of said paths to a terminal of said second source, all of said circuit connections controlling the application of the anode potential to their respective anodes and maintaining a predetermined bias potential on their respective control electrodes; said first, second and third reactances forming a selective frequency network for by-passing all frequencies except a predetermined band from the anode of each of said electron paths to the control electrode of the next succeeding path.

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