

Dec. 28, 1948.

G. G. ROBERTS
RELAY CONTROL SYSTEM

2,457,730

Filed Aug. 29, 1942

2 Sheets-Sheet 1

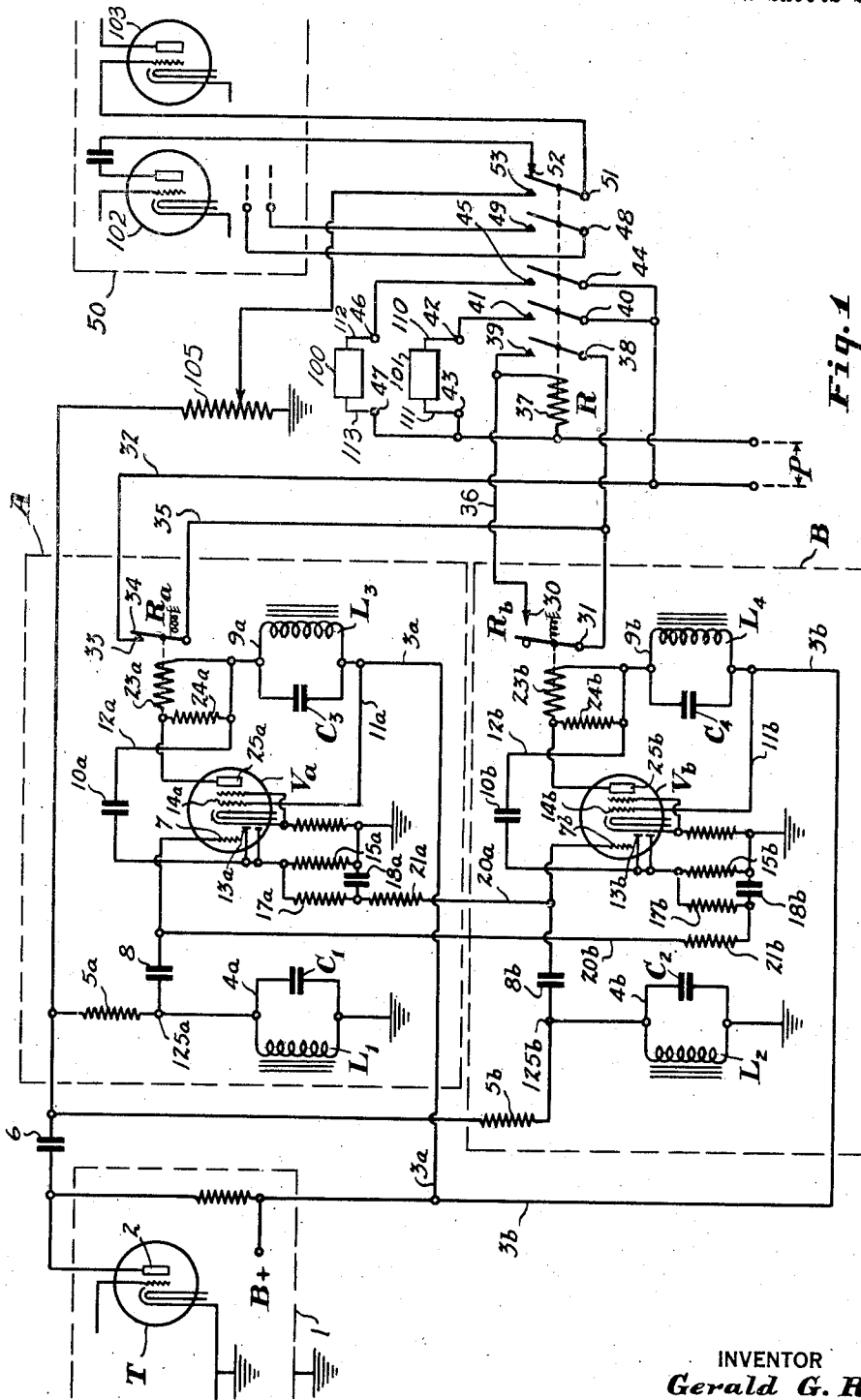


Fig. 1

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2 Sheets-Sheet 2

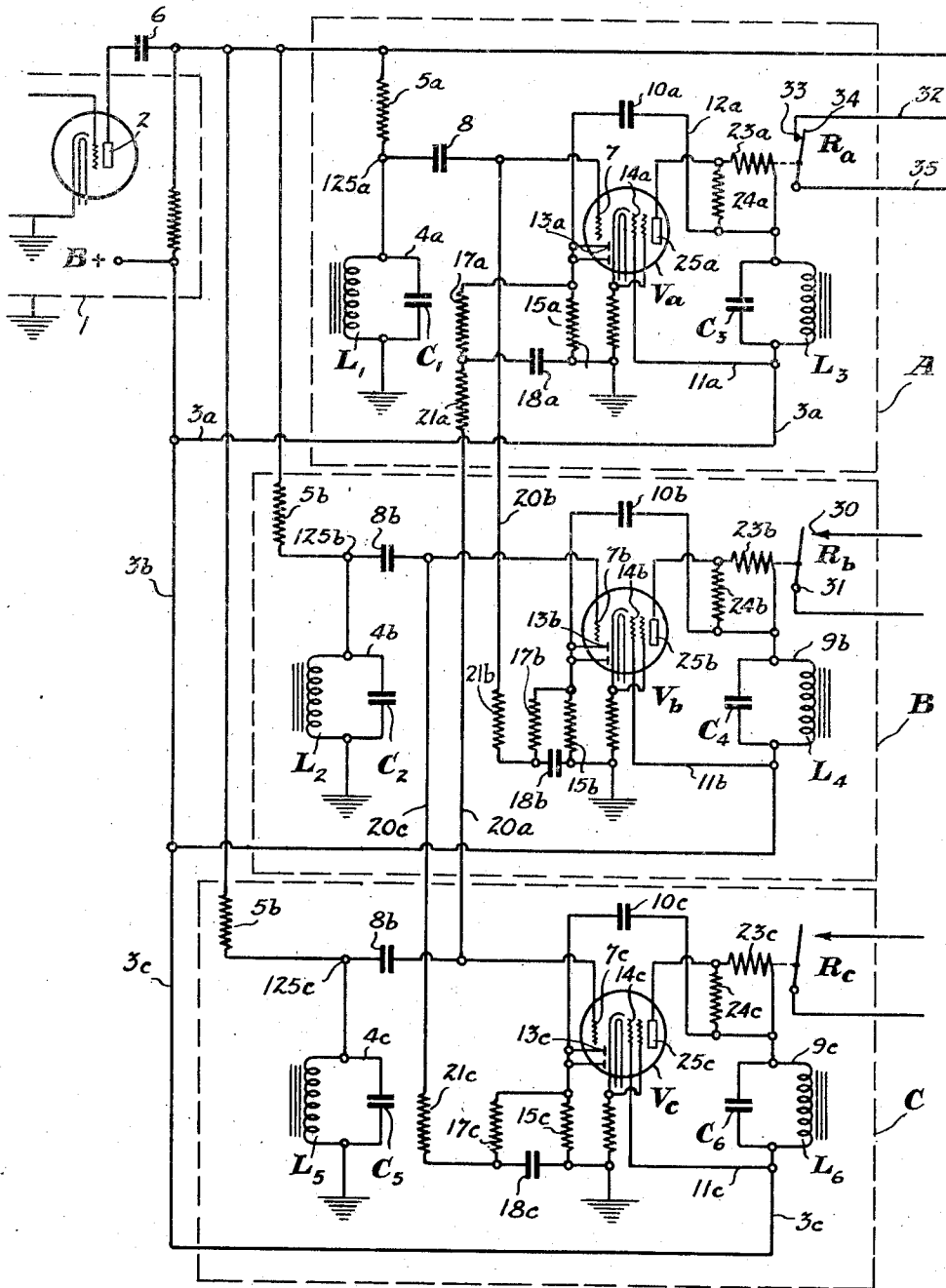


Fig 2

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RELAY CONTROL SYSTEM

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7 Claims. (Cl. 250-10)

1

This application is a continuation-in-part of my application Serial No. 415,398, filed October 17, 1941 Patent No. 2,330,241, granted September 28, 1943. The invention relates to a communication system and more particularly to a radio control device which may be remotely operated in response to transmitted radio frequencies to perform various functions or to insure the reception of special messages.

It is frequently desirable, especially in modern warfare, to have devices capable of being operated from a central control station. Thus in tanks which are deployed in the field of battle it is desirable to give a plurality of visual or audible signals from a central station to warn the operator or to cause the operator to change directions, etc. In order to have a control device capable of performing a large number of functions, it is almost necessary that the individual control elements which operate the separate functions be each responsive to a definite frequency or at least to a very limited band of frequencies. It is almost mandatory if the device to be controlled is subject to appreciable vibration that the control devices be free of mechanically tuned apparatus which might be affected by jars or mechanical vibrations of certain frequencies.

Remotely operative radio control devices have heretofore been proposed to operate switches and perform various functions. The control devices heretofore proposed, however, have been objectionable for the reason that they are responsive to too wide a band of frequencies and for the reason that they are adversely affected by vibration so that they cannot be used for controls of tanks or for giving signals where substantial vibration is experienced.

It is an object of the present invention to provide a radio control device which is responsive to definite modulations of radio frequencies to remotely operate mechanical elements or to insure reception of special messages and the like.

It is another object of the present invention to provide a radio control device responsive to definite modulations of radio waves and which is not affected by jarring, so that it may be used in tanks, aircraft and the like.

It is another object of the present invention to provide a radio control device having a plurality of control elements, each responsive to definite modulations or a small band of modulations in carrier frequency to accomplish a given result.

It is a further object of the present invention to provide a radio control device which when connected to the output of a suitable radio receiving

2

set will operate in response to a particular frequency or very small band of frequencies carried as modulations on the radio waves to which the radio receiver is tuned to operate a switch or given control mechanism, but which is not responsive to frequencies outside of said band.

It is a still further object of the present invention to provide a plurality of radio control devices which may be connected to the audio output of a radio receiver, each of which is only responsive to a definite narrow band of modulations in the radio wave to which said receiver is tuned to operate a given control device or to perform a given function.

Other objects will be apparent from the following description of the drawing, in which:

Figure 1 is a schematic diagram of a control device embodying the present invention and employing two circuit portions; and

Figure 2 is a schematic diagram of a control device employing a greater number of circuit portions to permit functional operations responsive to more than two control frequencies.

Control or signal devices embodying the present invention comprise essentially a plurality of circuit portions, each portion having connecting means for connection to a suitable power supply; a grid-controlled electronic tube connected to said connecting means and adapted to pass plate current from said power supply or to substantially prevent current flow, depending on the potential applied to said grid; a relay operatively controlled by a change in said plate current; separating means for separating an impedance potential due to signals of one of a plurality of control frequencies; a rectifier for said separating means for obtaining a rectified current due to said impedance potentials caused by said control frequencies; and means for impressing a potential drop due to said rectified current on the grid of an electronic tube in another of said circuit portions, so that when a control signal within one particular narrow band of frequencies is passed into said signal device a potential due to the signal is separated and a negative potential is applied to the grid of an electronic tube in one of said circuit portions, and when another control signal within another narrow wave-band is passed into said signal device a negative potential is applied to the grid of an electronic tube in the other of said circuit portions. The plate current in each of said circuit portions may therefore be controlled by transmission of separate control frequencies to said device.

Preferably, each circuit portion of the control device of the present invention also comprises an

amplifier for increasing the separated potential due to each control frequency, means connected into the plate circuit of said amplifier for separating the amplified potential due to said control frequency, means for impressing the amplified potential thus obtained on said rectifier and means for smoothing the wave-form or for delaying the rectified current.

Referring to the drawings, in which like parts are indicated by like numerals of reference throughout the several views, and more particularly to Figure 1, the control or signal device embodying the present invention may be suitably connected to the audio output of a suitable radio receiver 1, such for example as a three-tube receiver having a mixer tube, one stage of I. F. diode-detector and a high mu, high impedance audio tube. The output or audio tube of said receiver may for example be designated as T with a plate 2. The negative terminal of the power supply as well as of the cathode of the tube T may be grounded. The positive terminal of the power supply is designated as B+.

The control or signal device of the present invention is responsive to at least two control frequencies to cause at least two functional operations. The two circuit portions are designated generally as A and B; each circuit portion has suitable connecting means, such as wires 3a and 3b, respectively, to power supply B+. Suitable grid-controlled electronic tubes V_a and V_b of the respective portions A and B are suitably connected through said connecting means to said power supply and are adapted to pass plate current from said power supply or to substantially prevent plate current, depending upon the potential applied to grid 7 thereof. The relays R_a and R_b are operatively controlled by the electronic tube of the respective circuit portion or by the plate current thereof.

For each circuit a separating means such as a tuned circuit or network 4a and 4b is provided to obtain a potential drop due to one of said control frequencies. The circuit constants as determined by the inductances and capacitors L₁ and C₁ of the circuit 4a and L₂ and C₂ of the circuit 4b are different so that the networks 4a and 4b are tuned to resonance for different control frequencies F₁ and F₂, which may be transmitted as modulations of the radio frequency to which the receiver 1 is tuned. The networks 4a and 4b are connected through respective isolating resistors 5a and 5b to a coupling condenser 6 which makes connection to the plate 2 of the tube T, or to other suitable supply or line over which control signals are to be sent, and permits passage of only alternating current or the variable portion of the output or plate current of the receiver 1. An amplifier, to amplify any potential drop across the network due to the presence of a control current of frequency corresponding substantially to that to which the particular circuit 4a or 4b, etc. is tuned, especially when used with an additional filtering or tuned circuit to separate amplified potential, markedly increases the sensitivity or selectivity of the device. In the circuit shown, the tubes V_a and V_b are of the remote cut-off pentode and duodiode type; such tubes are desirable in that they may perform the functions of the grid-controlled electronic tube, as well as those of the amplifier and rectifier. Thus, when the grid potential is sufficiently positive to permit passage of plate current, the tubes V_a and V_b may serve as amplifiers to amplify the voltage drop across the respective networks 4a and 4b, respectively,

due to a control frequency to which the particular network 4a or 4b is tuned. Means such as a coupling condenser 8 or 8b and suitable connector are therefore provided for suitably connecting a positive portion of the respective network 4a or 4b to the grid 7 of the appropriate tube V_a or V_b.

A second tuned network 9a and 9b, having respective inductances L₃ and L₄ and respective capacitors C₃ and C₄ in the circuit portions A and B, so selected that its closed circuit is tuned to the same control frequency F as the network 4a or 4b of the same circuit portion, is connected into the plate circuit of the tube V_a or V_b of each of the circuit portions A or B, respectively. The network 9a or 9b together with the condenser 10a or 10b serves as a means for separating the D. C. plate current of the tubes V_a or V_b from the amplified potential drop due to amplified current of the control frequencies F₁ or F₂ to which the circuit 4a or 4b of the respective circuit portion is tuned. Connecting means, including the wires 12a and 12b, which are respectively connected to the more negative terminal of the respective tuned circuits 9a and 9b, are provided for applying the voltage drop across the circuit 9a or 9b to the respective terminals 13a and 13b of the diode rectifier in the appropriate tube V_a or V_b. The more positive side of the networks 9a and 9b are preferably connected to the respective accelerating grids 14a and 14b. The diode rectifier serves as means for rectifying the current due to the control frequency.

Filtering or delaying means, comprising suitably arranged resistors 15a or 15b and 17a or 17b together with a condenser 18a or 18b, is preferably connected to the diode rectifier. The filtering means serve to smooth out the wave-form of the rectified current due to amplified potential drop caused by the control frequencies and to provide the desired delay, so that the control device is not responsive to control signals unless they are transmitted for a reasonable period of time. Means such as a wire 20a or 20b and a resistor 21a or 21b are provided for connecting the rectifier or said filtering means to the grid of an electronic tube in a cooperating circuit portion. Thus, when only two circuit portions are used, a wire 20a and a resistor 21a make connection between the grid 7 of the tube V_b of circuit portion B and the ungrounded side of the condenser 18a in the circuit portion A, whereas the resistor 21b and the wire 20b serve as means for connecting the ungrounded side of the condenser 18b to the grid of the electronic tube in the circuit portion A.

The respective coils 23a and 23b of the relays R_a and R_b, preferably with a by-pass resistor 24a or 24b, may be connected in series with the plate 25a or 25b of the electronic tube of the respective circuit portion, so that plate current from said tube passes through the coils 23a or 23b to operate the respective relay.

In the operation of the devices of the present invention, signals or modulations transmitted by the station to which the radio receiver 1 is tuned pass from the output thereof through the coupling condenser 6 through the isolating resistors 5a and 5b to the networks 4a and 4b. If the frequency of the signal received corresponds substantially to frequency F₁, to which the circuit 4a is tuned, circuit 4a operates as a high impedance and a substantial potential drop is produced between terminal 125a and the ground. If the frequency of the signal received differs substantially from the frequency F₁, the circuit 4a allows

it to pass to ground without appreciable potential drop.

The potential due to the frequency F_1 is applied through the condenser 8 to the grid 7 of the tube V_a . It appears in amplified form across the network 9a, also tuned to frequency F_1 and connected in the plate circuit of the tube V_a . The potential drop across the network 9a is applied through the coupling condenser 10a to the diode rectifier 13a.

The negative direct current voltage developed at the diode is delayed and its wave-form smoothed by the resistances 15a and 17a, together with the condenser 18a. It is applied to the grid of the tube V_b in the cooperating circuit portion B. This negative voltage causes the normal plate current of the tube V_b to cease, de-energizing the relay coil 23b and causing operation or movement of the relay R_b so that contact is made between contacts 30 and 31. Closure of the contacts 30 and 31 permits current to flow from the power supply P along wires 32 between contacts 33 and 34 of the relay R_a along wires 35 and 36 through a coil 37 of the relay R, causing it to close and cause one of the functional operations of the control device. The relay R may, for example, operate a plurality of switches and preferably has holding means, such as contacts 38 and 39 which are connected in parallel with the contacts 30 and 31 of the relay R_b for maintaining closure, so that upon closure of the relay R it is held closed regardless of the position of the contacts 30 and 31.

It is seen that except for the short interval of time required to cause initial operation of relay R_b , transmission of the control frequency F_1 , to which network 4a is tuned, may be discontinued or it may be transmitted at suitable periodic intervals to cause periodic operation of relay R_b without interfering with the connections initially established. Thus F_1 is available and may be used for sending of code messages or with the aid of the flapper of the relay R_b and a suitably attached ratchet switch to accomplish additional functional operations.

If a signal is received of frequency corresponding to frequency F_2 , to which the network 4b is tuned, a substantial potential drop is obtained between the terminal 125b and the ground. This potential drop is amplified, rectified and delayed similarly to the potential drop due to the frequency F_1 , and after passing through the delay network, comprising the resistors 15b and 17b and the condenser 18b, is applied as a negative voltage to the grid 7 of the tube V_a , causing cessation of plate current therein and de-energization of the coil 23a of the relay R_a , breaking contact between contacts 33 and 34, and causing de-energization of the coil 37 of the relay R and causing opening of the circuits closed by the previous operation of the relay R.

As shown in the drawing, the operation of the relay R may be utilized to provide any desired number of functions; thus, closure of contacts 40 and 41 permits power to be obtained between terminals 42 and 43, which may be respectively connected by wires 110 and 111 to any desired apparatus 101. Closure of contacts 44 and 45 permits power to be obtained between terminals 46 and 47, which may be respectively connected by wires 112 and 113 to any desired apparatus 100. Contacts 48 and 49 are a power switch in parallel with that of a standard receiver, such as that schematically designated by numeral 50 and having two tubes 102 and 103, as shown.

A contact 51 may be connected to the input or grid of a suitable audio stage of the receiver 50, a contact 52 may be connected to the output of an intermediate tube of the standard receiver, and a contact 53 may be suitably connected to the output of the auxiliary or midget receiver 1, so that upon energization of the coil of the relay R connection is broken between the contacts 51 and 52, disconnecting the radio frequency stages from the audio of the receiver, and made between contacts 51 and 53 connecting the output of the midget receiver to the audio stages of the standard receiver 50. It is thus seen that in response to a signal of a frequency F_2 with the arrangement shown, the broadcast to which the midget receiver may be fixedly tuned will be immediately heard through the standard receiver 50, even though the latter is tuned to a station other than that to which the midget receiver is fixedly tuned. In response to a signal of frequency F_2 , the standard receiver is again connected to its normal radio frequency stage.

The modification shown in Fig. 2 illustrates the method of connecting additional circuit portions, such as circuit portion C, so that the relay of each portion is operatively controlled by a given control frequency or by transmission of modulations of a given control frequency in a radio carrier wave to which the radio receiver 1 is tuned. The connections to the contacts of relays R_a , R_b and R_c of the respective circuit portions A, B and C may be arranged in any desired manner, depending on the functional operation desired. It will be seen that a more negative portion of the rectifiers in each of the circuit portions is connected to the control grid of only one electronic tube in another circuit portion. Thus, the rectifier 13a of the circuit portion A is connected in series through the delay network comprising the condenser 18a and resistors 15a and 17a, the resistor 21a and the wire 20a to the grid 7c of electronic tube V_c ; the rectifier 13b of the circuit portion B is connected in series through the delay network comprising the condenser 18b and the resistors 15b and 17b, the resistor 21b and the wire 20b to the grid 7 or the tube V_c ; and the rectifier 13c of circuit portion C is connected in series through the delay network comprising the condenser 18c and the resistors 15c and 17c, the resistor 21c and the wire 20c to grid 7 of the electronic tube V_a . Thus the relay R_a is responsive to frequency F_2 ; relay R_b is responsive to frequency F_3 to which circuit 4c is tuned; and relay R_c is responsive to frequency F_1 .

While I have shown control devices having only two and three circuit portions in the drawings, it is obvious that the number of circuit portions may be increased as desired to accomplish any number of functional operations. A single circuit portion in a single cut-off frequency may be used to stop current flow in all desired circuit portions.

Control devices of the present invention may have exceedingly high sensitivity and very high selectivity. With the use of an amplifier and two networks tuned to the same frequency in each circuit portion, as shown in the drawing, it is found that the controls to accomplish a given function are sensitive to signals in a wave-band having a width much less than 10 per cent of the signal frequency and insensitive to signals outside this band. With the sharp cut-off obtainable by the present invention, a large number of signals to accomplish different functions may be grouped relatively close together.

It is to be understood that variations and modifications of the specific devices herein shown and described for purposes of illustration may be made without departing from the spirit of the invention.

What I claim is:

1. A control or signal device adapted to be connected to an audio output portion of a radio receiver and responsive to a plurality of control frequencies to cause a plurality of functional operations, comprising a plurality of circuit portions, each portion having connecting means for connection to a suitable power supply, a grid-controlled electronic tube connected to said connecting means and adapted to pass plate current from said power supply or to substantially prevent current flow, depending on the potential applied to the grid thereof, a relay operatively controlled by a change in said plate current, a filter means for selectively obtaining a higher potential at one of said control frequencies than for others, an amplifier connected to said filter means for increasing the potential at said control frequency, second filter means connected to the output circuit of said amplifier for separating the amplified potential at said control frequency, a rectifier connected to said second filter means for obtaining a rectified potential due to said amplified potential, means for delaying said rectified potential and means for impressing said rectified potential on the grid of an electronic tube in one of the other of said circuit portions, so that when said amplified potential in one of said circuit portions is of substantial magnitude a negative potential due to said rectified current is applied to said grid in another of said circuit portions, said filter means in one of said circuit portions being adapted to selectively obtain a potential at one of said control frequencies and the filter means in other of said circuit portions being adapted to selectively obtain a potential at another of said control frequencies, so that in response to one control frequency flow of plate current in one of said circuit portions is substantially prevented and in response to another control frequency the flow of plate current in the other of said circuit portions is substantially prevented, whereby said relays in said circuit portions are selectively operated in response to said control frequencies.

2. A control or signal device adapted to be connected to an audio output portion of a radio receiver and responsive to a plurality of control frequencies to cause a plurality of functional operations, comprising a plurality of circuit portions, each portion having connecting means for connection to a suitable power supply, a grid-controlled electronic tube connected to said connecting means and adapted to pass plate current from said power supply or to substantially prevent current flow, depending on the potential applied to the grid thereof, a relay operatively controlled by a change in said plate current, a circuit tuned to one of said control frequencies and connected through a resistance to an output portion of said receiver to obtain a potential drop at one of said control frequencies, an amplifier tube to amplify said potential drop, means for suitably connecting said tuned circuit to the grid of said amplifier tube, a second circuit tuned to substantially the same control frequency connected in series with the plate supply and the plate of said amplifier tube to obtain an amplified potential drop due to said amplified control frequency, a rectifier to obtain a rectified current

due to said amplified potential drop, means for suitably connecting said second tuned circuit to said rectifier, means for smoothing out the waveform of said rectified current, and means for impressing a negative potential due to said rectified current on a control grid of said electronic tube in another of said circuit portions, said tuned circuits in different circuit portions being tuned to different control frequencies, so that in response to one control frequency flow of plate current in one of said circuit portions is substantially prevented and in response to another control frequency the flow of plate current in the other of said circuit portions is substantially prevented, whereby said relays in said circuit portions are selectively operated in response to said control frequencies.

3. In a control or signal device responsive to at least two control frequencies to cause at least two functional operations, two circuit portions, each portion having a source of power supply, a grid-controlled electronic tube adapted to pass plate current from said power supply or to substantially prevent current flow, depending on the potential applied to the grid thereof, a relay operatively controlled by said current, filter means for obtaining a potential drop at one of said control frequencies, an amplifier tube connected to said filter means for amplifying said potential, a rectifier connected to the output of said amplifier tube for obtaining a rectified potential corresponding to said amplified potential, means connected to said rectifier for filtering and delaying said rectified potential, and means for impressing a more negative portion of said rectified potential on a control grid of said electronic tube in another of said circuit portions, the filter means in each of said circuit portions being adapted to separate potential due to a different control frequency, so that in response to one control frequency flow of the plate current in one of said circuit portions is substantially prevented and in response to another control frequency the flow of plate current in the other of said circuit portions is substantially prevented, whereby the relay of one of said circuit portions is operated in response to one of said control frequencies and the relay of said other circuit portion is operated in response to the other of said control frequencies.

4. In a control or signal device responsive to at least two control frequencies to cause at least two functional operations, two circuit portions, each portion having a source of power supply, a grid-controlled electronic tube adapted to pass plate current from said power supply or to substantially prevent current flow, depending on the potential applied to a control grid thereof, a relay operatively controlled by said current, filter means for separating a potential drop at one of said control frequencies, a separate amplifier tube connected to said filter means for amplifying said separated potential, second filter means connected to said amplifier for obtaining said amplified potential from the amplifier output current, a rectifier connected to said amplifier for obtaining a rectified potential due to said amplified potential, means for filtering and delaying said rectified potential, and means for impressing a negative portion of said delayed rectified potential on the grid of said electronic tube in another of said circuit portions, the filter means in each of said circuit portions being adapted to separate potential at a different control frequency, so that in response to one control frequency

quency flow of the plate current in one of said circuit portions is substantially prevented and in response to another control frequency the flow of plate current in the other of said circuit portions is substantially prevented, whereby the relay of one of said circuit portions is operated in response to one of said control frequencies and the relay of said other circuit portion is operated in response to the other of said control frequencies.

5. A control or signal device adapted to be connected to an audio output portion of a radio receiver and responsive to a plurality of control frequencies to cause a plurality of functional operations, comprising a plurality of circuit portions, each portion having connecting means for connection to a suitable power supply, a grid-controlled electronic tube connected to said connecting means and adapted to pass plate current from said power supply or to substantially prevent current flow, depending on the potential applied to a control grid thereof, a relay operatively controlled by a change in said plate current, a circuit tuned to one of said control frequencies and connected through a resistance to an output portion of said receiver to obtain a potential drop at one of said control frequencies, an amplifier tube to amplify said potential drop, means for suitably connecting said tuned circuit to the grid of said amplifier, a second circuit tuned to substantially the same control frequency connected in series with the plate supply and the plate of said amplifier tube to obtain an amplified potential drop due to said amplified control frequency, a rectifier to obtain a rectified current due to said amplified potential drop, means for suitably connecting said second tuned circuit to said rectifier, and means for applying a negative potential due to said rectified current to said control grid of said electronic tube in another of said circuit portions, said tuned circuit in different circuit portions being tuned to different control frequencies, so that in response to one control frequency flow of plate current in one of said circuit portions is substantially prevented and in response to another control frequency the flow of plate current in the other of said circuit portions is substantially prevented, whereby said relays in said circuit portions are selectively operated in response to said control frequencies.

6. In a control or signal device responsive to a control frequency with which a carrier is modulated to cause a functional operation, a receiver tuned to said carrier, a network connected to the output of said receiver and tuned substantially to said control frequency for separating a higher potential drop at said control frequency than at other frequencies an amplifier tube suitably connected to said network for amplifying said separated potential drop, a second network also tuned to substantially said control frequency and connected to the output of said amplifier for separating an amplified potential drop at said control frequency, a rectifying means for obtaining a rectified current from said amplified and sepa-

rated potential, means connected to said rectifying means for filtering and delaying build-up of potential from said rectified current, means for applying a portion of the delayed and rectified potential to a grid of an electronic tube which is connected to a suitable power supply to modify the plate current thereof, from said power supply, and a relay connected to the plate of said electronic tube to be controlled by said modification of said plate current, whereby the relay in said plate circuit is operated in response to said control frequency.

7. In a control or signal device responsive to a plurality of relatively low control frequencies with which a relatively high frequency carrier wave is modulated to accomplish a plurality of functional operations, a receiver tuned to said carrier, a circuit portion for each of said control frequencies connected into the output of said receiver, each portion comprising a connection to a source of power supply, a grid-controlled electronic tube adapted to normally pass plate current from said power supply but being adapted to prevent said plate current when said grid is made sufficiently negative, a network tuned substantially to one of said control frequencies for presenting a much higher potential drop at said control frequencies than at other frequencies, means for amplifying said potential drop due to one of said control frequencies and separated by said network, a second network disposed in the output of said amplifying means and tuned to substantially the same frequency as said first-mentioned network for obtaining potential drop due to the amplified control frequency to which said networks are tuned, means for obtaining a rectified current from said amplified potential drop, means for suitably filtering said rectified current and means for delaying the build-up of a negative potential therefrom, means for applying said negative potential to said grid of said electronic tube in another of said circuit portions, which other circuit portion contains a network tuned substantially to another of said control frequencies, so that in response to one control frequency a negative charge is applied to the grid of said electronic tube in said other of said circuit portions to cause a decrease in plate current flow there-through, and a relay suitably connected to the plate circuit of said last-mentioned electronic tube to operate by cessation of said plate current in response to one of said control frequencies.

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