June 30, 1936. C. C. TAYLOR 2,045,735

RADIO RECEIVING CIRCUITS

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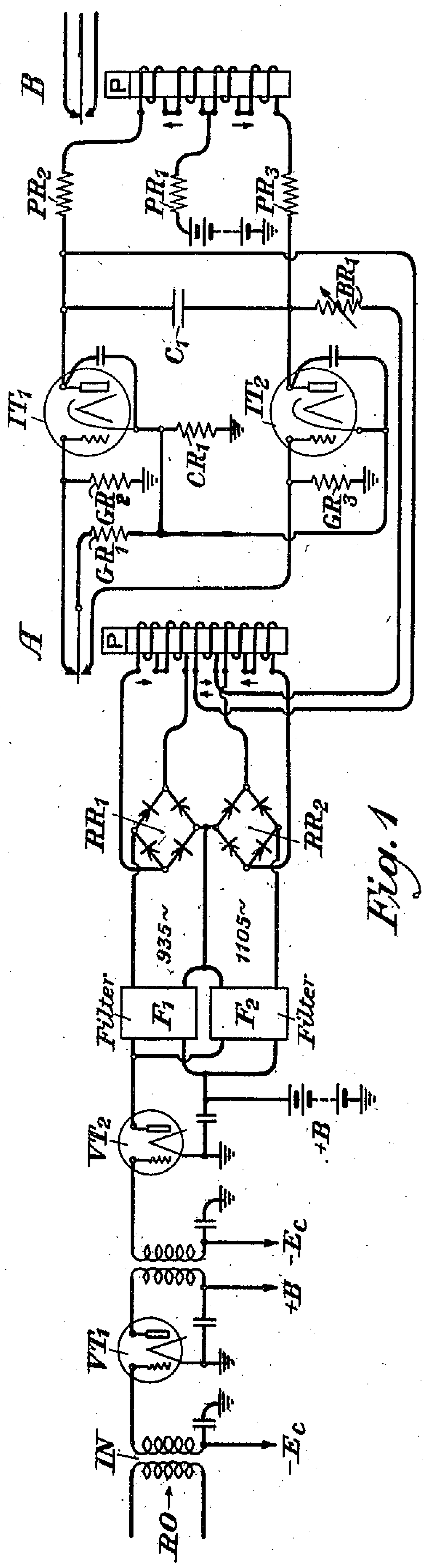

Fig. 1

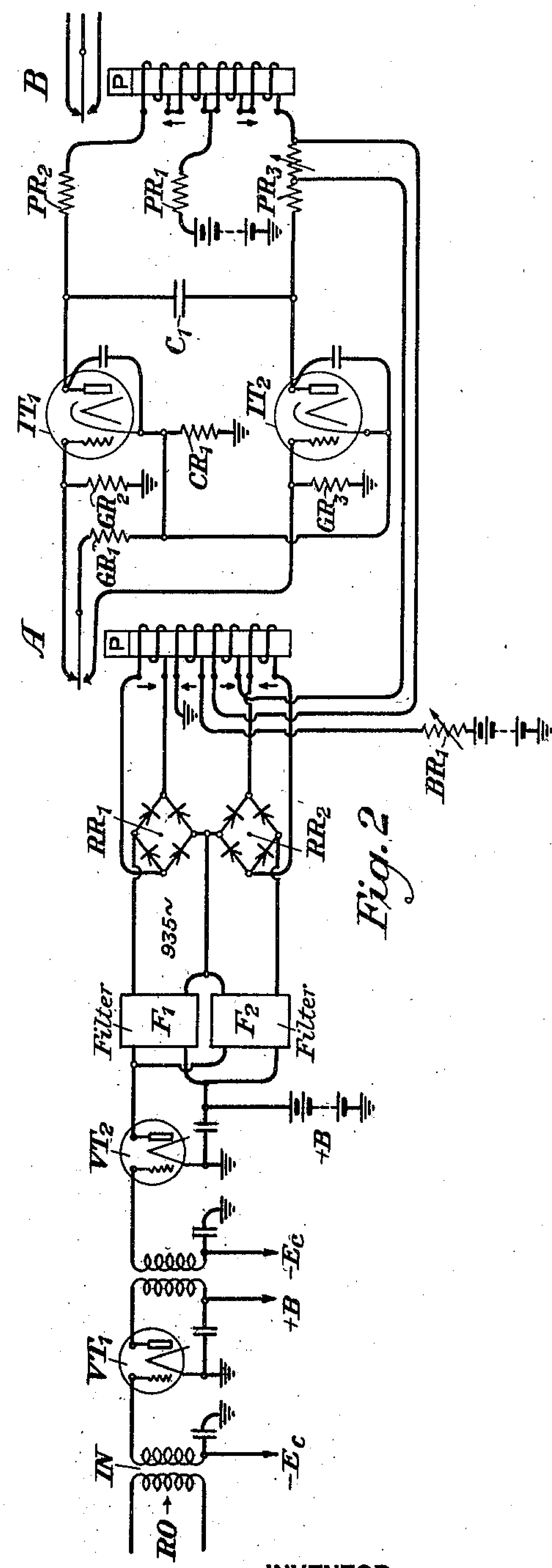

Fig. 2

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RADIO RECEIVING CIRCUITS

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16 Claims. (Cl. 178—66)

This invention relates to the transmission of signals over radio telephone systems or other channels for the transmission of intelligence and more particularly, to arrangements at the receiving end for receiving, through heavy static and fading conditions, signaling pulses for control currents, telegraph and teletypewriter transmission or other control or alarm functions.

As is well known, signal pulses may be sent over radio circuits by keying the carrier or by carrier on-off for control current usage. Likewise, use may be made of carrier shift with arrangements in the radio receiver to produce two voice frequency tones. Similarly, the carrier may be modulated with a single tone or with two tones, one for marking, the other for spacing signals. In accordance with this invention arrangements are provided whereby this two-tone or single-tone transmission, regardless of how transmitted, so long as voice frequency signals are emitted from the radio receiver, may be received with a minimum of interference from static crashes and fading.

The invention may be more fully understood from the following description when read in connection with the accompanying drawing, Figure 1 of which shows a circuit arrangement for reception of two-tone signals with static currents balanced out and with an ionic tube circuit to reverse biasing current so that the bias aids the tone being transmitted and locks the circuit up against fading of that tone and against any unbalance of static currents, and Fig. 2 of which shows a circuit arrangement for reception of single-tone signals with static currents balanced out and biasing arrangements which aid the single tone when it is present so that deeper fading of the tone may be tolerated than would otherwise be possible.

Referring to Fig. 1, RO designates the output of a radio receiver, the method of transmission being such that one or the other of two voice frequency tones is present in this output. For illustration I have taken 935 (F_1) and 1105 (F_2) cycles. The tone enters through the input transformer IN and passes through the two-stage amplifier. In the output circuit of the second vacuum tube VT_2 is a double band-pass filter arrangement F_1—F_2, which also is the plate battery feed for VT_2. This filter arrangement passes the frequency F_1 in one band and F_2 in the other, and feeds the full-wave rectifiers RR_1 and RR_2 of which the individual units may be copper-oxide or other well known types of rectifiers. The output currents from the rectifiers are applied to polar relay A so that they are opposing, the current from RR_1 causing A to operate and the current from RR_2 causing A to return to its normal or non-operated position. Noise currents entering through both bands of filter arrangement F_1—F_2 tend to balance out and therefore cause no operation of relay A. There is also a biasing winding on relay A so energized by the ionic tube circuit (to be described later) that the biasing current always aids the tone which has operated A, thereby making fading of the tone less bothersome due to this biasing lock-up which holds the relay during any fades occurring after A operates. A fade which occurs at the beginning of a signal before operation occurs may still, of course, prevent or delay this operation. Static currents in order to affect operation must be unbalanced sufficiently when either F_1 or F_2 is present to overcome the bias plus the tone output currents.

The ionic tube circuit includes two gas-filled tubes IT_1 and IT_2 each having a grid, a cathode and an anode, the cathode being of the uni-potential type which may be heated by a filament located in its immediate vicinity. The cathodes of the two tubes are connected to ground through the common resistance CR_1. The plates of the two tubes are connected to the plate battery through the upper and lower windings of the relay B and through the common resistance PR_1, there being resistances PR_2 and PR_3 provided in the individual plate connections. The armature of the relay A is arranged so that when it is on its upper contact the grid of the tube IT_2 will be at ground potential through the resistance GR_3, while the grid of the tube IT_1 will be connected to the potential of its cathode through the resistance GR_1. When the armature is on its lower contact the connections will be reversed, the grid of the tube IT_1 being at ground potential through resistance GR_2, and the grid of the tube IT_2 being connected to the cathode through resistance GR_1.

The characteristics of the tubes are such that when the grid is negative with respect to the cathode, the impedance of the cathode-plate circuit of the tube will be very high and no plate current will flow, as very few electrons will be emitted by the cathode due to the negative field in its vicinity produced by the grid. When, however, the grid is raised to substantially the cathode potential, electrons will be emitted freely from the cathode thereby ionizing the gas in the tube and causing the tube to break down, that is, causing the impedance between the plate and filament to be lowered with consequent reduction of the plate-cathode drop so that current will flow in the plate-cathode circuit.

The operation of the ionic tube circuit may now be understood. Assuming the frequency F_2 is being received, the armature of the relay A will be upon its upper contact so that the connection from the grid of the tube IT_2 to its cathode will be broken and the grid will be at ground potential. With a given potential of the plate source and with suitable values of the various resistances, the drop through the resistance CR_1 may be made about 10 volts so that the cathode of each tube will be 10 volts above ground. With the armature of the relay A upon its upper contact and the grid of the tube IT_2 at ground potential, the grid of the tube IT_2 will be about 10 volts negative with respect to the cathode, thereby substantially preventing electrons from passing from cathode to anode to ionize the tube and break down its impedance. No current will flow through the tube therefore, and the plate of the tube IT_2 will be about 100 volts above ground, or about 90 volts above the potential of its cathode. No current will flow through the lower winding of the relay B.

With the armature of the relay A upon its upper contact, the grid of the tube IT_1 will not be negative with respect to the cathode, but will be connected directly to the cathode through the resistance GR_1, and hence, will be at the cathode potential. Electrons will be emitted by the cathode and the gas in the tube will be ionized so that its impedance will be lowered. The plate cathode drop will then be about 20 volts so that the plate will be about 30 volts above ground (the drop through CR_1 being about 10 volts). Current will flow from the plate battery through the resistance PR_1, the upper windings of the relay B, through the resistance PR_2 from the plate to the filament of the tube IT_1, and through the resistance CR_1 to ground. The upper winding of the relay B will therefore be energized to hold its armature against its upper contact. Since the plate of the tube IT_1 is about 30 volts above ground, and the plate of the tube IT_2 is about 100 volts above ground, there will be about 70 volts difference of potential between the two plates which causes the condenser C_1 to be charged up and current to flow through the resistance BR_1 and the biasing winding of the relay A, in such a direction that said winding tends to aid the tone F_2 to hold the armature of the relay A against its upper contact.

When the frequency F_2 is replaced by the frequency F_1, the rectified current through the lower winding of the relay A ceases, and rectified current flows through the upper winding of said relay. This produces a force upon the armature of the relay opposite in direction to that exercised by the biasing winding, and of such strength as to shift the armature of the relay to its lower contact. The grid of the tube IT_1 is now isolated from its cathode and is at ground potential, while the grid of the tube IT_2 is connected over the armature of the relay A and through the resistance GR_1 to the cathode of the tube IT_2. The grid of the tube IT_2, being now substantially at its cathode potential, causes the tube to break down so that its plate-cathode potential will drop to about 20 volts and its plate will be about 30 volts above ground. The 70 volt charge built up in the condenser C_1 now leaks off, lowering for an instant the potential on the plate of the tube IT_1 by 70 volts. This makes the plate of IT_1 negative for a time sufficient to cause de-ionization, and with its grid now at ground potential through the resistance GR_2, the tube IT_1 remains de-ionized. Current now flows through the lower winding of relay B operating it to its opposite contact. With IT_2 ionized and IT_1 restored, the potentials at their plates are reversed, that of the plate of IT_1 being about 100 volts above ground and that of the plate IT_2 being about 30 volts above ground. This causes current to flow through the biasing winding of the relay A in the opposite direction to that previously described so that the bias winding now aids the pull of the upper winding of said relay due to the rectified tone F_1.

When the tone F_1 ceases and is replaced by the tone F_2, the armature of the relay A is shifted to its upper contact by the pull due to the current through the lower winding of the relay thereby isolating the grid of the tube IT_2 from its cathode and putting it at ground potential, at the same time raising the potential of the grid of the tube IT_1 to its cathode potential causing the tube to break down. The plate potential of the tube IT_1 now drops from about 100 volts to about 30 volts and the condenser C_1, which has in the meantime been charged in the reverse direction to that previously described, now discharges to momentarily lower the potential of the plate of the tube IT_2 by 70 volts, causing the tube to become de-ionized. The resultant increase in the impedance of the tube raises its plate potential to about 100 volts above ground and reverses the current through the biasing winding so that the biasing winding now assists the rectified tone F_2 to hold the armature of the relay A upon its upper contact.

The values of resistances PR_2 and PR_3 and of the capacity C_1, may be so chosen that the speed of operation may be as fast as the relays can handle. The value of the biasing current may be adjusted from that which just holds the relay on its contact to somewhat larger values should static unbalances require. The lower value permits signaling with weaker fields or deeper fades where static conditions permit. Larger values may be required for heavy static crashes thereby requiring somewhat higher fields. Consequently, if the adjustment is such as to produce a biasing current suitable for heavy static conditions the permissible fading will not be as great.

It is obvious that the operation of the relay B is positive in one direction or the other. Any chattering which may occur on the armature of relay A is not transmitted to the relay B unless the armature of the relay A actually travels to its other contact when, of course, a complete and positive operation of the relay B would occur. The circuit acts therefore, to some extent, as a pulse corrector and provides satisfactory reception of two-tone signals through severe static and fading conditions.

Consider now Fig. 2 where RO represents the output of a radio receiver, the method of transmission being such that a tone is received for one signal impulse and no tone for the other. For example, 935 cycles (F_1) may be received for a marking pulse and no tone for the spacing pulse. Static currents are balanced out as in Fig. 1 by the output currents of rectifiers RR_1 and RR_2 being applied to polar relay A so that they are opposing. It will be understood, of course, that while the selective device F_2 does not receive a tone frequency the average static impulse will have frequencies corresponding to the bands of both selective devices. The two selected static components will be rectified and produce opposite effects upon the upper and lower windings of the relay A.

The upper winding of relay A is responsive to the tone at 935 cycles to shift the armature to its lower or marking contact. The armature is restored to its spacing contact when the marking tone ceases in response to a space signal, by means of the biasing current flowing from battery through the biasing resistance BR_1 and the biasing winding of the relay A which is the second winding from the top. When the marking frequency F_1 is received, rectified current from the rectifying arrangement RR_1 must overcome this bias to operate the relay A.

The operation of the ionic tube circuit IT_1 and IT_2 and relay B is as explained for Fig. 1. Frequency F_1 operates relay A causing IT_2 to ionize and IT_1 to become de-ionized. This causes relay B to operate. In addition advantage is taken of voltage drop through a part of resistance PR_3 in the plate supply of IT_2 to cause a biasing current to flow through one winding of relay A in such a direction as to aid frequency F_1. The value of this bias at its maximum adjustment must be sufficiently less than that bias which holds the relay non-operated so that relay A will be returned to its non-operated position when frequency F_1 is removed. The reason for putting a bias on to aid F_1 is that by so doing deeper fading of the tone, after it has operated A, may be tolerated than would otherwise be possible. This bias may be adjusted up to the maximum mentioned above for different conditions of radio field, static and fading. More satisfactory operation of relay B through all transmission conditions may be obtained than if relay A alone were depended upon for receiving the signals.

What is claimed is:

1. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, each circuit including a translating device, means to produce a potential difference between said translating devices under the control of said armature, and means to impress said potential difference upon a winding of said relay in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

2. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode and an anode in each of said circuits, means governed by the armature of said relay to control the relative flow of current in said tubes and thereby produce a difference in potential at the anodes of said tubes, and means to impress said difference in potential upon a winding of said relay in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

3. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode, an anode and a control electrode associated with each of said circuits, means to change the potential of said control electrodes under the control of the armature of said relay so that with the armature on one contact current will flow in the cathode-anode circuit of one tube and substantially no current will flow in the cathode-anode circuit of the other tube, and with the armature upon the other contact the conditions will be reversed, and a winding of said relay having its terminals so associated with the anodes of said tubes that the difference in potential of said anodes will cause current to flow in said winding in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

4. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, a gas-filled ionizing tube including a cathode, an anode and a control electrode associated with each of said circuits, said tubes having such characteristics that when the control electrode is negative with respect to the cathode substantially no ionization occurs and hence substantially no current flows in the cathode-anode circuit, and when the control electrode is raised to substantially the cathode potential ionization takes place so that current flows in the cathode-anode circuit, means whereby when the armature of said relay is on one contact the control electrode of one tube is at such potential that ionization occurs and the control electrode of the other tube is at such potential that ionization does not occur, and when the armature is on the other contact the conditions of the tubes are reversed, means associated with the anodes of the tubes to de-ionize the tube previously ionized as the armature shifts from one contact to the other, and a winding of said relay having its terminals so associated with the anodes of said tubes that the difference in potential of said anodes will cause current to flow in said winding in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

5. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, each circuit including a translating device, means to produce a potential difference between said translating devices under the control of said armature, a second relay having windings differentially connected to said translating devices, and a winding of said first relay having its terminals connected on the output sides of said translating devices whereby the said first relay tends to hold its armature on at least one of its contacts.

6. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode and an anode in each of said circuits, means governed by the armature of said relay to control the relative flow of current in said tubes and thereby produce a difference in potential at the anodes of said tubes, a second relay having windings differentially connected to the cathode-anode circuits of said tubes, and a winding of said first relay having its terminals connected on the output sides of said translating device whereby the said first relay tends to hold its armature on at least one of its contacts.

7. In a receiver, a relay responsive to received signals, circuits controlled over atlernate contacts of the armature of said relay, a translating tube including a cathode, an anode and a control electrode associated with each of said circuits, means to change the potential of said control electrodes under the control of the armature of said relay so that with the armature on one contact current will flow in the cathode-anode circuit of one tube and substantially no current will flow in the cathode-anode circuit of the other tube, and with the armature on the other contact the conditions will be reversed, a second relay

having windings differentially connected to the cathode-anode circuits of said tubes, and a winding of said first relay having its terminals connected on the output sides of said translating devices whereby the said first relay tends to hold its armature on at least one of its contacts.

8. In a receiver, a relay responsive to received signals, circuits controlled over alternate contacts of the armature of said relay, a gas-filled ionizing tube including a cathode, an anode and a control electrode associated with each of said circuits, said tubes having such characteristics that when the control electrode is negative with respect to the cathode substantially no ionization occurs and hence substantially no current flows in the cathode-anode circuit, and when the control electrode is raised to substantially the cathode potential ionization takes place so that current flows in the cathode-anode circuit, means whereby when the armature of said relay is on one contact the control electrode of one tube is at such potential that ionization occurs and the control electrode of the other tube is at such potential that ionization does not occur, and when the armature is on the other contact the conditions of the tubes are reversed, means associated with the anodes of the tubes to de-ionize the tube previously ionized as the armature shifts from one contact to the other, a second relay having windings differentially connected to the cathode-anode circuits of said tubes, and a winding of said first relay having its terminals connected on the output sides of said translating devices whereby the said first relay tends to hold its armature on at least one of its contacts.

9. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, each circuit including a translating device, means to produce a potential difference between said translating devices under the control of said armature, and means to impress said potential difference upon a winding of said relay in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

10. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode and an anode in each of said circuits, means governed by the armature of said relay to control the relative flow of current in said tubes and thereby produce a difference in potential at the anodes of said tubes, and means to impress said difference in potential upon a winding of said relay in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

11. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode, an anode and a control electrode associated with each of said circuits, means to change the potential of said control electrodes under the control of the armature of said relay so that with the armature on one contact current will flow in the cathode-anode circuit of one tube and substantially no current will flow in the cathode-anode circuit of the other tube, and with the armature on the other contact the conditions will be reversed, and a winding of said relay having its terminals so associated with the anodes of said tubes that the difference in potential of said anodes will cause current to flow in said winding in such direction as to tend to hold the armature of said relay on the contact upon which it is resting.

12. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, a gas-filled ionizing tube including a cathode, an anode and a control electrode associated with each of said circuits, said tubes having such characteristics that when the control electrode is negative with respect to the cathode substantially no ionization occurs and hence substantially no current flows in the cathode-anode circuit, and when the control electrode is raised to substantially the cathode potential ionization takes place so that current flows in the cathode-anode circuit, means whereby when the armature of said relay is on one contact the control electrode of one tube is at such potential that ionization occurs and the control electrode of the other tube is at such potential that ionization does not occur, and when the armature is on the other contact the conditions of the tube are reversed, means associated with the anodes of the tubes to de-ionize the tube previously ionized as the armature shifts from one contact to the other, and a winding of said relay having its terminals so associated with the anodes of said tubes that the difference in potential of said anodes will cause current to flow in said winding in such direction as to tend to hold the armature of said relay upon the contact upon which it is resting.

13. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, each circuit including a translating device, means to produce a potential difference between said translating devices under the control of said armature, a second relay having windings differentially connected to said translating devices, and a winding of said first relay having its terminals connected on the output sides of said translating devices

whereby the said first relay tends to hold its armature on at least one of its contacts.

14. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode and an anode in each of said circuits, means governed by the armature of said relay to control the relative flow of current in said tubes and thereby produce a difference in potential at the anodes of said tubes, a second relay having windings differentially connected to the cathode-anode circuits of said tubes, and a winding of said first relay having its terminals connected on the output sides of said translating devices whereby the said first relay tends to holds its armature on at least one of its contacts.

15. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, a translating tube including a cathode, an anode and a control electrode associated with each of said circuits, means to change the potential of said control electrodes under the control of the armature of said relay so that with the armature on one contact current will flow in the cathode-anode circuit of one tube and substantially no current will flow in the cathode-anode circuit of the other tube, and with the armature on the other contact the conditions will be reversed, a second relay having windings differentially connected to the cathode-anode circuits of said tubes, and a winding of said first relay having its terminals connected on the output sides of said translating device whereby the said first relay tends to hold its armature on at least one of its contacts.

16. In a receiver, a selecting device for passing two frequency ranges at least one of which corresponds to a signal into two different circuits, rectifiers in each circuit, a relay differentially connected to said circuits so that interfering disturbances extending over a frequency range wide enough to cover both of said passed ranges will tend to oppose each other in said relay, circuits controlled over alternate contacts of the armature of said relay, a gas-filled ionizing tube including a cathode, an anode and a control electrode associated with each of said circuits, said tubes having such characteristics that when the control electrode is negative with respect to the cathode substantially no ionization occurs and hence substantially no current flows in the cathode-anode circuit, and when the control electrode is raised to substantially the cathode potential ionization takes place so that current flows in the cathode-anode circuit, means whereby when the armature of said relay is on one contact the control electrode of one tube is at such potential that ionization occurs and the control electrode of the other tube is at such potential that ionization does not occur, and when the armature is on the other contact the conditions of the tubes are reversed, means associated with the anodes of the tubes to de-ionize the tube previously ionized as the armature shifts from one contact to the other, a second relay having windings differentially connected to the cathode-anode circuits of said tubes, and a winding of said first relay having its terminals connected on the output sides of said translating devices whereby the said first relay tends to hold its armature on at least one of its contacts.

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