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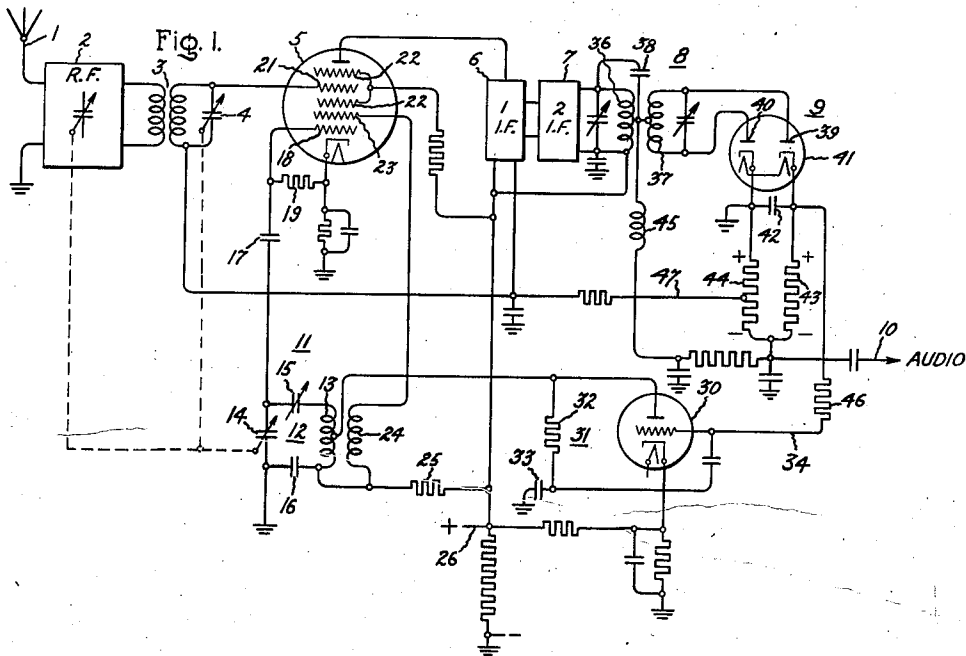
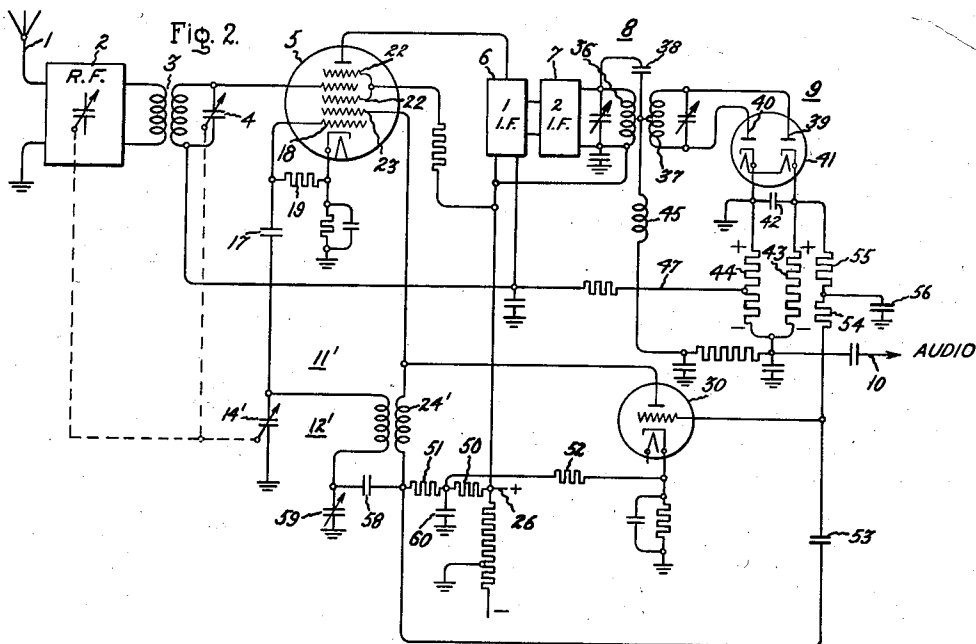
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2,210,781

CONTROL CIRCUIT

Filed June 8, 1937

2 Sheets-Sheet 1



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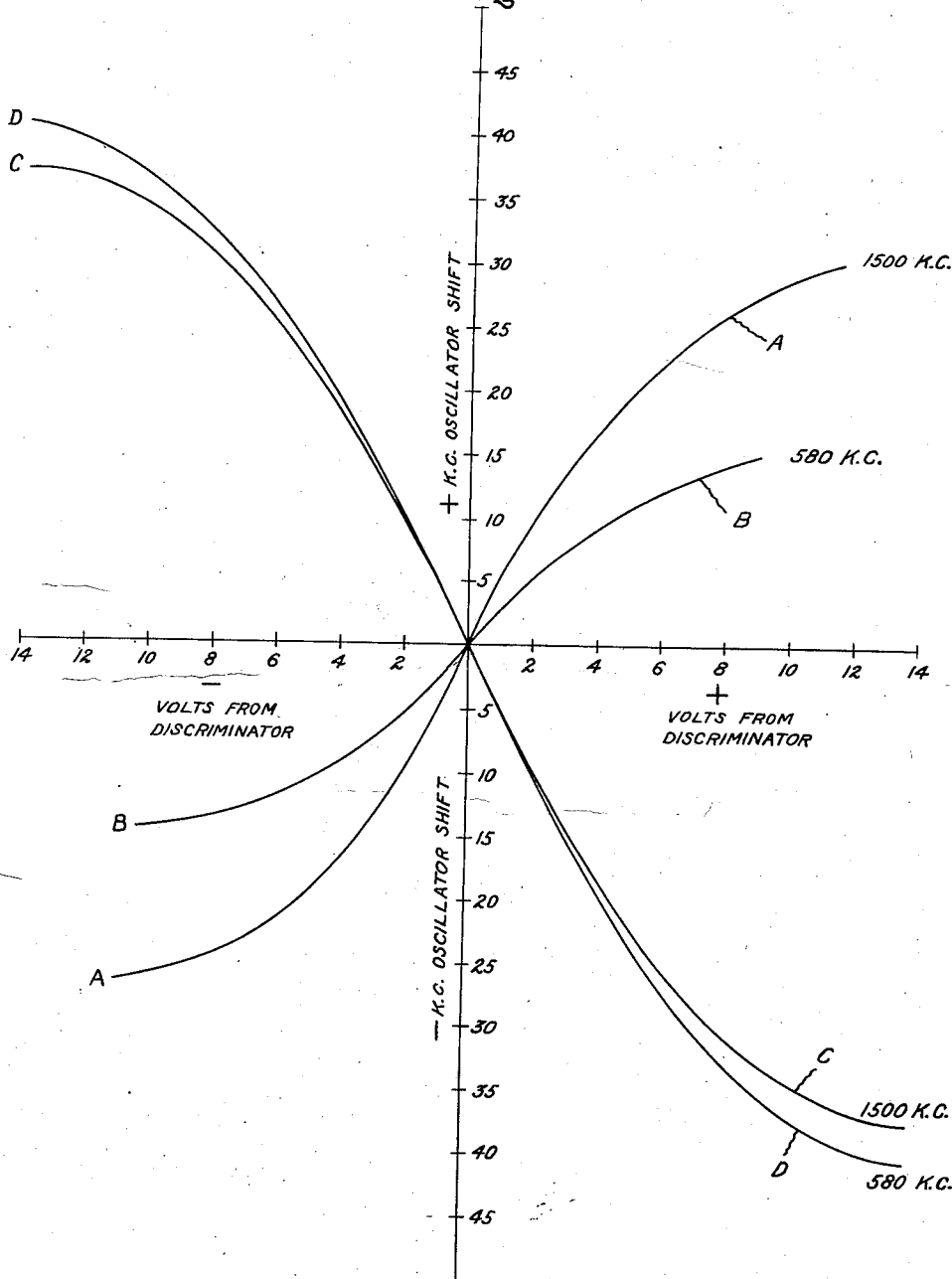
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Fig. 3.



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UNITED STATES PATENT OFFICE

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CONTROL CIRCUIT

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2 Claims. (Cl. 250—36)

My invention relates to reactance control circuits and particularly to such circuits which are employed in the control of frequency. More particularly my invention relates to signal seeking circuits employed in radio receivers, particularly those of the superheterodyne type, and it has for its object the provision of improved means for controlling the frequency of the local oscillator utilized in such circuits.

In signal seeking circuits employed in superheterodyne receivers means have been employed to control the frequency of the local oscillator in response to variations in the intermediate frequency of the receiver and in such a way as to compensate for such variations. Thus this compensating means has the effect of maintaining the intermediate frequency practically constant notwithstanding movement of the tuning control over a considerable range in proximity to a position where the receiver is tuned to a desired frequency. This control may be effected by the use of an electron discharge control device connected with the oscillator in such a manner that it serves to vary the oscillation frequency in the desired manner. Since the control device constitutes a load on the oscillation circuit the loading effect of the device has been kept at a low value by using a form of such device which has a high impedance. Such a device, however, is expensive and moreover has the disadvantage that since it has had a screen grid it required a source of screen grid voltage. In accordance with my invention I employ a low impedance control device with which a greater control is possible and which is of more simple construction and hence less expensive, and also I provide special means for reducing the loading effect of the device on the oscillation circuit.

My invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 is a circuit diagram illustrating one embodiment of my invention; Fig. 2 is a circuit diagram illustrating a modification, and Fig. 3 shows sensitivity curves illustrating the operation of my invention.

In the drawing I have shown conventionally a radio receiver having the antenna 1, one or more stages of radio frequency amplification 2, the coupling transformer 3 having the tuning capacitor 4 across its secondary, the pentagrid converter 5, the first and second stages of intermediate frequency amplification 6 and 7, the frequency discriminating circuit 8, the second detector 9, and

the audio output circuit 10. This receiver also comprises an electron discharge oscillation generator 11 having the oscillation circuit 12 which includes the inductance 13, and the tuning capacitor 14 which connect through the alignment capacitor 15 and the by-pass capacitor 16. One side of this oscillator circuit connects with ground and the opposite side connects through the coupling capacitor 17 with the grid 18 of the converter 5 and through the resistor 19 with the cathode 10 thereof.

The capacitor 14 of the oscillator is shown arranged for unicontrol with the tuning capacitor of the radio frequency amplifier and with the tuning capacitor 4 whereby the frequency of the oscillator is maintained different by a constant amount from the frequency to which the radio receiving circuits of the receiver is tuned. In this way a constant intermediate frequency is produced for all received signals.

The converter 5 of the receiver may be of any suitable type but is shown as being one in which the oscillations received from the antenna are supplied to the grid 21 which is separated from the anode and cathode of the converter by the screen grids 22. The converter 5 is also provided with the grid 23 which functions as an anode and connects with one end of the tickler coil 24 inductively associated with the inductance 13, the opposite end of which connects with the oscillation circuit 12 and through the resistor 25 with the source 26 of positive potential.

Variations in the oscillation frequency are produced by the use of the electron discharge control device 30 and the control circuit 31 comprising the resistor 32 and the capacitor 33 connected in series between the anode and cathode of the device 30. Inasmuch as the capacitor 33 connects between the grid and cathode of the device 30, the device functions as an equivalent inductance. As has already been pointed out, the control device 30 which I employ is a low impedance device represented as a triode whose impedance is of the order of 10,000 ohms. Were such a device to be connected across the oscillation circuit 12 for the purpose of variably supplying inductance across that circuit, it would load the oscillation circuit to an objectionable degree. To compensate for such an objectionable loading on the oscillation circuit I provide the inductance 13 of the oscillation circuit with an intermediate tap and connect the anode-cathode circuit of the control device 30 between said tap and one end of the inductance. By so doing I have found that the loading effect of the low im-

pedance device is reduced to a workable value without losing the advantage of the control effect of the device on the frequency of the oscillation circuit.

5 The control effect of the device 30 is governed by the D. C. potential supplied to the grid of the device through the conductor 34 from a discrim-
 10 inator of well known form comprising the discriminating circuit 8 and the rectifier 9. From this discriminator a potential is supplied to the grid of device 30 which varies from a predeter-
 15 mined value, as for example, ground potential, either positively or negatively depending upon the variations of the intermediate frequency from a desired fixed value. In this way the impedance
 20 between the anode and cathode of the discharge device 30 is varied whereby the device functions to supply a greater or less amount of equivalent inductance to the oscillation circuit 12 in such
 a way as to produce a change in the frequency of the oscillation generator tending to restore the intermediate frequency to its normal value.

The frequency discriminating circuit 8 com-
 25 prises the transformer having the primary wind- ing 36 and the secondary winding 37, both of which are tuned to the desired fixed intermediate frequency. The primary winding is connected between the intermediate-frequency ground and the midpoint of the secondary winding through
 30 the capacitor 38. The opposite terminals of the secondary winding 37 are connected to the respective anodes 39 and 40 of the double diode 41, the cathodes of which are connected together for
 35 alternating currents through the capacitor 42 and for direct currents through the resistors 43 and 44. One cathode of the double diode is grounded and the midpoint between the resistors 43 and 44 is connected to the midpoint on the
 40 secondary winding 37 through the choke coil 45. The conductor 34 connects the grid of the device 30 through the resistor 46 with the other cathode and with the resistor 43. Connected with a mid-
 45 point of the resistor 44 is the conductor 47 which supplies automatic volume control voltage to the first intermediate frequency amplifier 6, the converter and the radio frequency amplifier.

The operation of the above-described system is as follows: assuming that the tuning control
 50 of the radio receiver is adjusted for accurate resonance with the received carrier wave, the intermediate frequency has the desired value to which the primary and secondary windings 36 and 37 are tuned. The voltage across the sec-
 55 ondary winding of the transformer in accordance with the well known theory is displaced in phase from the voltage across the primary by 90°. With the connections shown the voltage of the primary is supplied in series to one-half of the
 60 voltage of the secondary through the anode 40 of the double diode 41 and the capacitor 42 and it is supplied in series with the other half of the voltage of the secondary through the anode 39
 65 and the capacitor 42. Because of the quadrature relation between the primary and secondary volt- ages the voltage on one-half of the secondary leads the voltage on the primary by 90°, whereas
 70 that on the other half of the secondary lags behind the voltage on the primary by 90°. Thus the voltage applied to anodes 39 and 40 when the intermediate frequency is at its desired value is equal, and accordingly, equal values of unidirec-
 75 tional currents flow from each of the diode anodes and hence through the resistors 43 and 44. It will be observed that these resistors are poled oppositely. That is, the voltages across the two

are opposite in polarity in the circuit between the conductor 34 and ground with the result that the conductor 34 is at ground potential when the intermediate frequency is at the desired value.

The quadrature relation between the primary 5 and the secondary voltages of the transformer exists, however, only when the oscillations sup- plied thereto have the desired intermediate fre- quency. If this frequency changes in either di-
 10 rection, the phase of the secondary voltage varies from its 90° relation with the primary voltage in one direction or the other depending upon whether the frequency increases or decreases. For example, if the frequency increases, the phase
 15 shift may be in such a direction that the voltage on the upper half of the secondary winding ap- proaches the aiding relation with the primary voltage, whereas that on the lower half of the secondary winding approaches the opposing rela-
 20 tion with the primary voltage. Thus the volt- age applied to the diode anode 39 increases and that applied to the diode anode 40 de- creases with the result that the unidirectional
 25 potential on resistor 43 increases, whereas that on the resistor 44 decreases and the con- ductor 34 thus becomes positive with respect to ground. On the other hand, if the intermediate frequency decreases, an opposite shift in phase
 30 of the secondary voltage occurs with the result that the larger alternating current voltage is sup- plied to the diode resistor 44 and the potential on the resistor 43 increases, whereas that on resistor 44 decreases and the conductor 34 is driven
 35 negative with respect to ground.

The discharge device 30 responds to these vari- 40 ations in potential of the conductor 34 to pro- duce corresponding variations in frequency of the oscillation generator 11, since as has already been pointed out above the device 30 in connection
 45 with the circuit 31 functions as an equivalent in- ductance connected between the intermediate tap on the inductance 13 and one end thereof. The resulting change in effective inductance across a portion of the inductance 13 thus causes
 50 a variation in the natural period of the oscillator to effect the desired frequency changes.

In the modified form of my invention illustrat- ed by Fig. 2 the anode of the electron discharge control device 30 is tied to the oscillator anode 23
 55 of the converter 5 and direct current voltage is supplied from the source 26 to the anode of device 30 and to the grid 23 which functions as an anode through the resistor 50, which, for example, may have a resistance of 7500 ohms and through the
 60 resistor 51, which, for example, may have a re- sistance of 4700 ohms. The cathode of the de- vice 30 is connected to the common point of said two resistors 50 and 51 through the resistor 52, which, for example, may have a resistance of
 65 47,000 ohms. The lower end of the tickler coil 24' connects through the capacitor 53 whose capacitance, for example, may be 250 mmf. with the grid of the device 30, which grid also con- nects with the automatic frequency control dis- criminator through the resistance 54 whose re-
 70 sistance, for example, may be 330 ohms and the resistor 55 whose resistance, for example, may be 47,000 ohms. The lower end of coil 24' also connects with ground through capacitors 58 and 59. A point intermediate the resistors 54 and 55 is grounded through the bypass capacitor 56 whose capacitance, for example, may be 0.05 mfd. Since the resistance 54 and the capacitor 53 comprise a quadrature voltage dividing net-
 75 work for the grid of the device 30, the voltage

supplied by this device to the tickler 24' will have a phase displacement relative to the normal voltage across that coil. Any change in the out of phase voltage supplied by the device 30, therefore, will change the oscillation frequency of the oscillation circuit 12' of the oscillation generator 11'. Hence when variations occur in the intermediate frequency the direct current voltage supplied from the discriminator to the grid of the device 30 will automatically modify the frequency of the oscillation circuit 12' just sufficient to restore the intermediate frequency to the desired value.

In order that the voltage supplied by the discriminator may exercise full control the alternating voltage on the grid of the device 30 must be maintained at a constant value notwithstanding changes in frequency in the oscillator circuit. To render the alternating voltage which is applied to the grid of device 30 constant under all tuning conditions, I provide the capacitor 58 in the connection between the oscillation circuit 12' and the tickler coil 24'. This capacitor may have a capacitance, for example, of 750 mmf. Without this capacitor the voltage supplied across capacitor 59 from the oscillation circuit to the capacitor 53 and the resistor 54 would increase as the frequency of oscillations in the oscillation circuit decreased since the impedance and hence the voltage drop across the padder capacitor 59, which for example may have a capacitance of 200 mmf. obviously increases with a decrease in frequency. Since, however, the impedance of the capacitors 58 and 53 in like manner increase with a decrease in frequency, the resultant alternating voltage applied to the grid of device 30 is maintained practically (within 5%) constant notwithstanding changes in the oscillation frequency. A further advantage of the capacitor 58 is that it blocks the high voltage of the source 26 from reaching the grid circuit of the converter 5, this advantage being particularly important in installations where this grid circuit is in an exposed position. The intermediate point of resistors 50 and 51 is grounded through the filter capacitor 60 which, for example, may have a capacitance of 4 m. f. This capacitor in conjunction with the resistor 50 forms a resistance-capacity filter to prevent voltage fluctuations of the direct current supply circuit from reaching the anodes of the discharge devices 5 and 30 and causing an overall "flutter".

In Fig. 3 I have shown control tube sensitivity curves plotted between volts supplied by the discriminator and the resulting kilocycles change in the frequency of the oscillation generator. Curves A and B show this relation for carrier frequencies of 1500 k. c. and 580 k. c. respectively obtained with that form of my invention illustrated by Fig. 1. Likewise curves C and D show the relation for carrier frequencies of 1500 k. c. and 580 k. c. obtained with the form of my invention illustrated by Fig. 2. From the above curves it will be seen that a more uniform sensitivity is

obtainable with the apparatus illustrated by Fig. 2 than with that illustrated by Fig. 1, since the curves C and D show that substantially equal changes occur in the oscillator frequency per discriminator volt at any point in the frequency band between 1500 k. c. and 580 k. c.

I have chosen the particular embodiments described above as illustrative of my invention and it will be apparent that various various other modifications may be made without departing from the spirit and scope of my invention, which modifications I aim to cover by the appended claims.

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

1. In combination, an oscillator having a frequency determining circuit, means for varying the frequency determined by said circuit, an electron discharge device having an anode, a cathode, and a control grid, a resistance connected between said cathode and grid, means for supplying to said grid a voltage having the same frequency as that of said oscillator and substantially in quadrature therewith, means for supplying to said control grid a direct current control voltage, means for coupling the anode-cathode circuit of said device with said oscillator and means comprising a capacitor for maintaining the alternating voltage applied to said grid constant and independent of frequency changes of the oscillator, said capacitor being connected in series with said resistance across a portion of said frequency determining circuit, the variations of the impedance of said capacitor inversely with said frequency being sufficient to maintain said voltage constant and independent of the frequency.

2. In a superheterodyne receiver, an electron discharge oscillation generator having a frequency determining circuit and a tickler coil inductively coupled therewith, said coil having a normal voltage therein due to said coupling, means for applying to said coil a variable voltage substantially in quadrature with the normal voltage thereof for varying the frequency of said generator, said means comprising a grid-controlled electron discharge device having its output circuit coupled with said coil, means including a quadrature voltage dividing network including a resistor for applying to said grid a phase displaced voltage having the same frequency as that of said generator, means for applying a direct current control voltage to said control grid responsive to variations in the intermediate frequency of said receiver and means comprising a capacitor for maintaining the alternating voltage applied to said grid constant notwithstanding frequency changes of the generator, said capacitor being connected in series with said resistance across a portion of said frequency determining circuit, the variations of the impedance of said capacitor inversely with said frequency being sufficient to maintain said voltage constant and independent of the frequency.

NORTON F. SHOFSTALL.