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W. L. CARLSON

2,258,599

FREQUENCY-MODULATION RECEIVING SYSTEM

Filed June 29, 1940

Fig. 1.

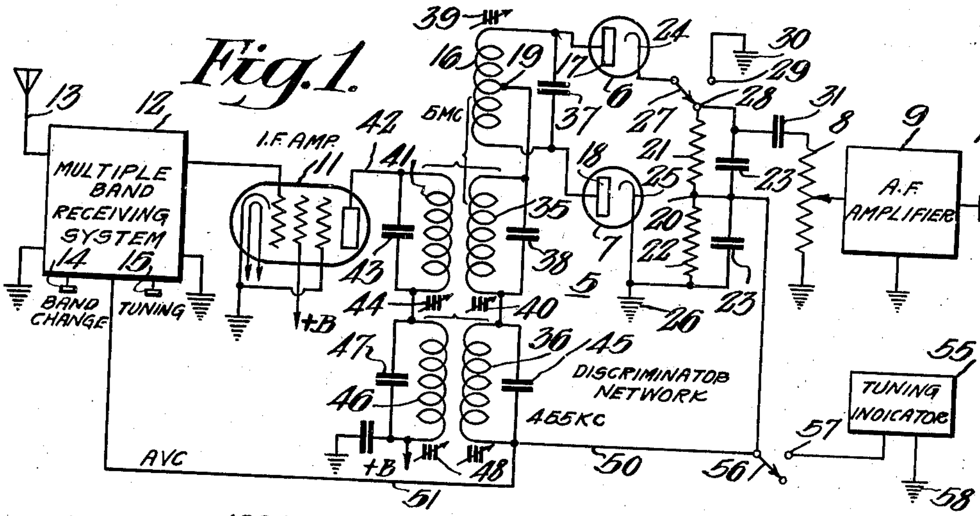


Fig. 2.

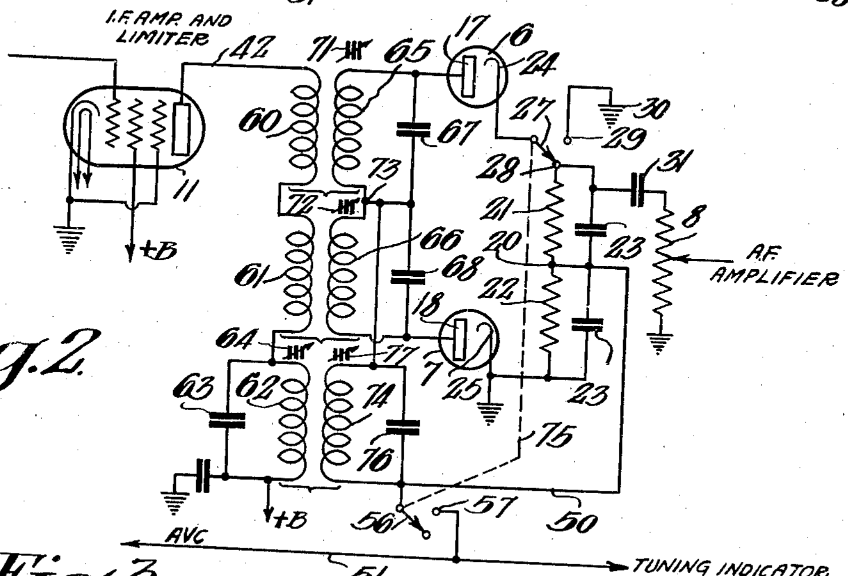
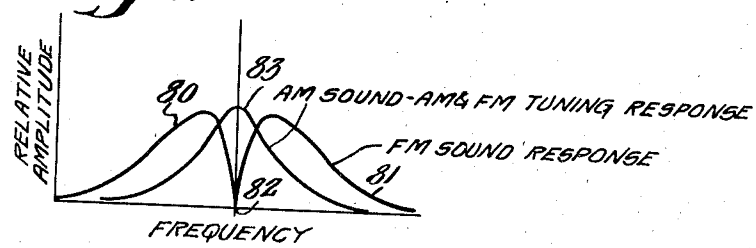


Fig. 3.



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FREQUENCY-MODULATION RECEIVING SYSTEM

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7 Claims. (Cl. 250—20)

This invention relates to frequency-modulation receiving systems, and has for its principal object to provide an improved frequency-modulation receiving system having a discriminator network adapted for multiple wave band reception. Frequency discriminator networks of the type referred to for the detection or conversion of frequency modulated signals are shown, for example, in the U. S. patents to Seeley 2,121,103 and Conrad 2,047,640.

It is also an object of the present invention to provide an improved frequency-modulation receiving system having a frequency-discriminator network adapted for the reception and demodulation of amplitude modulated signals.

A further object of the present invention is to provide an improved frequency-discriminator network for the reception and conversion or demodulation of ultra high-frequency amplitude and frequency-modulated signals selectively, and of relatively low frequency amplitude-modulated signals, with a minmium of circuit changes.

It is a further object of the present invention to provide an improved frequency-discriminator network for the reception of both amplitude and frequency-modulated signals and for tuning indication, with a minimum of circuit changes.

The invention will further be understood from the following description, when considered in connection with the accompanying drawing, and its scope is pointed out in the appended claims.

In the drawing,

Figure 1 is a schematic circuit diagram of a combined amplitude and frequency-modulation receiving system embodying the invention;

Figure 2 is a similar schematic circuit diagram of a modification of a portion of the circuit of Fig. 1; and

Figure 3 shows curves illustrating certain operating characteristics of the circuit of Fig. 1.

Referring to Fig. 1, the circuit 5 is a frequency discriminator network for the reception of frequency modulated signals, provided with a pair of balanced rectifiers 6 and 7 preferably of the diode type as shown, from which converted signals are applied through suitable volume control means 8 to an audio frequency amplifier system 9 and output device or loudspeaker 10.

The discriminator network is preceded by suitable intermediate frequency amplifier means represented by the amplifier stage comprising the tube 11 and the input portion of a multiple band receiving system indicated at 12, through which signals are selected from any suitable signal source such as an antenna circuit 13.

The receiving system is of the multiple wave band type for receiving signals in a plurality of differing wave bands, such as an ultra high frequency amplitude and frequency modulated signal band and the normal broadcast and short wave bands at present in use for entertainment programs. The wave band change means is indicated at 14, and variable tuning means for each band is indicated at 15. As such wave band tuning and selecting systems are known and as any suitable system may be provided at 12, further description is unnecessary.

The discriminator network 5 includes a tuned secondary inductance 16 having terminals connected with the diode rectifier anodes 17 and 18 and having an electrical center tap 19 connected to a similar center tap 20 on the balanced rectifier output impedance or resistor network 21—22, each half of which is provided with a suitable bypass capacitor 23. The diode cathodes 24—25 are connected with the terminals of the impedance 21—22, the cathode 25 preferably being grounded as indicated at 26. The cathode 24 is connected to a switch 27 having a contact 28 providing a connection with the ungrounded terminal of the output impedance and having a second contact 29 connected to the grounded or first named output impedance terminal preferably through a ground connection as indicated at 30.

The volume control device 8 is connected in shunt with the output impedance 21—22 through a coupling capacitor 31 and is preferably of relatively high resistance, thereby to provide a relatively light load on the rectifier circuit and output impedance.

In accordance with the invention the use of a choke coil between the secondary terminal 19 and the terminal 20 on the output impedance is obviated by interposing in the circuit ordinarily occupied by the choke coil one or more serially connected intermediate secondary windings such as a high frequency winding 35 and a low frequency winding 36, in series, the lower frequency winding being more adjacent to the terminal 20.

The main secondary 16 and the intermediate secondary 35 are each tuned to the same high intermediate frequency, such as 5 mc., for example, by suitable shunt capacitors 37 and 38, respectively, the exact tuning adjustment being effected preferably by means of movable ferromagnetic tuning cores indicated at 39 and 40.

The secondary winding 35 is coupled to a primary winding 41 which is connected in the output circuit 42 of the amplifier stage 11 and is tuned by a shunt capacitor 43 to the same intermediate frequency of 5 mc., the final tuning adjustment also being effected preferably by a suitable ferro-magnetic tuning core indicated at 44.

The tuned secondary 36, for low frequency broadcast and short wave signals, for example, is tuned to a low intermediate frequency such as 455 kc., by a suitable shunt capacitor indicated at 45 and is provided with a primary 46 coupled thereto as indicated and tuned by a similar shunt capacitor 47. Both primary and secondary are provided with suitable ferro-magnetic tuning cores indicated at 48 for the purpose of exact tuning to the desired intermediate frequency.

With this arrangement, the tuned primary or primaries in the discriminator network provide coupling between the intermediate frequency output circuit and the balanced or push pull secondary 16 and one or more additional secondary windings 35 and 36 which are connected through the secondary 16 of the diode rectifiers 6 and 7 in parallel, that is, serially between substantially the electrical centers of the main secondary 16 and of the rectifier output impedance 21—22.

In the present example, the connection between the lowest frequency intermediate secondary and the output resistor or impedance center tap is provided by a lead indicated at 50 from which A. V. C. potentials may be derived with respect to ground through a lead 51 for the input portion of the receiving system as indicated, in which case the I.-F. amplifier 11 is preferably operated without appreciable signal limiter characteristics.

With this arrangement, whether operating in response to amplitude or frequency-modulated signals, the A. V. C. potential is derived from the resistor section 22 of the rectifier output circuit between ground 26 and the center tap 20.

With the switch 27 closed to the contact 28, as shown, normal frequency-modulation reception is provided in which the rectifiers are connected with the main secondary 16 and the output impedance 21—22 in balanced or push-pull relation thereby to provide voltages in phase quadrature at resonance and to convert the frequency modulation on the carrier to audio signals in the usual manner.

In order to receive amplitude-modulated signals at either the high intermediate frequency of 5 mc., or the low intermediate frequency of 455 kc., switch 27 is moved to the contact 29 thereby placing the diode rectifiers in parallel with respect to either of the tuned secondaries 35 and 36 with the cathodes connected to ground. The impedance of the low inductance, high frequency secondary 16 in circuit with the secondaries 35 and 36 and the impedance of the relatively low inductance high frequency secondary 35 in circuit with the low freequency high inductance primary 36 is substantially negligible.

For tuning indication, either for amplitude-modulated or frequency-modulated signals, a tuning indicator device indicated at 55, may be connected with the lead 50 through a switch 56 having a contact 57 connected with the tuning device and thence to ground, as indicated at 58, whereby the tuning indicator is placed in parallel with the output resistor section 22.

For frequency-modulation reception, it is desirable to provide tuning indication during the tuning operation. In the present system this is provided by closing the switches 27 and 56 to the contacts 29 and 57, respectively, until the tuning is completed.

Where a circuit of the Conrad type is used, the discriminator network may be modified as shown in Fig. 2 to which attention is now directed, and in which like reference numerals refer to the same circuit elements as in Fig. 1.

Referring to Fig. 2, the intermediate frequency amplifier stage 11 is provided with an output circuit 42 including a pair of series connected primary windings 60 and 61 and a third primary winding 62 to the low intermediate frequency by a shunt capacitor 63 together with a ferro-magnetic tuning core 64.

The primaries 60 and 61 are coupled to secondaries 65 and 66, respectively, one being tuned above and the other being tuned below the mid-frequency or carrier, of the frequency modulated signal, by suitable shunt capacitors 67 and 68, respectively, together with ferro-magnetic tuning cores 71 and 72. The rectifiers 6 and 7 are connected with the mistuned input circuits and are differentially coupled to the output impedance 21—22 as in the preceding modification.

In the present circuit, however, the center tap for the input circuit is located between the secondaries 65 and 66, as indicated at 73, and the low frequency secondary 74 is included serially in circuit between the center tap 73 and the center tap 20 on the output impedance, through the lead 50. In the present example, the switch 56 connected with the lead 50 is arranged to connect the tuning indicator circuit and A. V. C. lead 51 simultaneously to the lead 50 through the contact 57 for amplitude modulation reception only, and tuning indication with amplitude modulation reception, the switch 27 being moved to the contact 29 to connect the rectifiers in parallel. Therefore, these switches may be arranged to be operated jointly as indicated by the dotted connection 75.

As in the preceding embodiment, the secondary 74 of the low intermediate frequency transformer is tuned by a capacitor 76 in conjunction with the variable tuning core indicated at 77.

The invention is applicable to any frequency discriminator network wherein the series secondary circuit may be connected with a balanced secondary circuit to provide push-pull or balanced operation of the rectifiers for frequency-modulation reception and parallel operation for amplitude-modulation reception. This circuit arrangement furthermore permits the use of a rectifier output impedance and simplified switching means for connecting the diode output electrodes to the terminals of the output impedance in balanced relation and to the same terminal of said impedance for parallel operation.

The operation of the tuning indicator system in response to frequency modulation and amplitude modulation signals will be readily understood by reference to the curves of Fig. 3, in which the curve 80—81 shows a resonance dip at 82 showing that the sound output for frequency modulation signals falls off at resonance, while the tuning indication or tuning response of the indicator rises at resonance as indicated by the curve 83. For this reason the use of the indicator is important in connection with the tuning of frequency modulation signals, since the sound output falls off, the indicator being connected in circuit by operation of the switches 27 and 56.

The curve 83 also indicates the sound output and the tuning response for amplitude modulation signals, providing maximum tuning indication and maximum sound output simultaneously.

From the foregoing description it will be seen that the tuning indicator may be used for frequency modulation tuning indication providing silent tuning at the resonance point which is a desirable feature of the tuning indication system shown and described.

It is obvious that the switching control for the tuning indicator and detector may be incorporated with the tuning system in any suitable manner other than that shown and described herein by way of example.

I claim as my invention:

1. A radio signal receiving system comprising in combination, tunable signal receiving and selecting means, a frequency discriminator network for multiple wave band reception coupled to said first-named means, rectifier means in said network including a pair of rectifier elements, means for connecting said elements in balanced relation to each other for frequency-modulation reception in one wave band, and means for connecting said elements in parallel relation to each other through said last named means for amplitude-modulation reception in another wave band, and tuning indication means connected to said rectifiers in said parallel relation for tuning said system to frequency-modulated signals.

2. A radio signal receiving system comprising in combination, tunable signal receiving and selecting means, a frequency discriminator network for multiple wave band reception coupled to said first-named means, rectifier means in said network including a pair of rectifier elements, means for selectively connecting said elements in balanced relation to each other for frequency-modulation reception in one wave band and in parallel relation to each other for amplitude-modulation reception in another wave band, and means for producing a peak signal indication for tuning to resonance with a frequency modulated signal with substantially zero output.

3. A radio signal receiving system comprising in combination, amplifying means for selected signals having an output circuit, a frequency discriminator network including a plurality of primary windings connected with said last-named circuit, a plurality of secondary windings coupled to said primary windings, rectifier means connected in balanced relation to one of said secondary windings, means providing a circuit through said one winding and others of said secondary windings in series for operating said rectifier means in parallel, an output circuit for said network including output impedance means, and means for connecting said rectifier means selectively in balanced relation and in parallel relation to each other through said output impedance means.

4. A radio signal receiving system comprising in combination, amplifying means for selected signals having an output circuit, a frequency discriminator network including a plurality of primary windings connected with said last-named circuit, a plurality of secondary windings coupled to said primary windings, rectifier means connected in balanced relation to one of said secondary windings, means providing a circuit through said one winding and others of said secondary windings in series for operating said rectifier means in parallel, an output circuit for said network including output impedance means, means for connecting said rectifier means selectively in balanced relation and in parallel relation to each other through said output impedance means, and means for deriving a tuning indication from said output circuit when said rectifier means are connected in said parallel relation to each other.

5. In a multiple waveband signal receiving system, the combination of a frequency discriminatory network comprising a plurality of primary windings, a plurality of secondary windings coupled to said primary windings, and tuned one to a relatively high intermediate frequency and another to a relatively low intermediate frequency, rectifier means connected in balanced relation to one of said secondary windings, a circuit through said one winding and others of said secondary windings in series for operating said rectifier means in parallel, an output circuit for said network including output impedance means, means for connecting said rectifier means selectively in balanced relation and in parallel relation to each other through said output impedance means, and means coupled to said output impedance for deriving a converted signal therefrom.

6. In a frequency-modulation receiving system, a frequency discriminator network comprising a plurality of tuned inductances, rectifier means comprising a pair of rectifier elements, a rectifier output circuit including an output impedance, a circuit connecting said rectifier elements in balanced relation between said inductances and said output impedance, said circuit including at least two of said inductances in series, means for tuning one of said series-connected inductances to signals one at a relatively low frequency and another at a relatively high frequency, and selective switching means for connecting said rectifier elements in parallel relation with each other to said output impedance for response to signals at one of said frequencies.

7. In a frequency-modulation receiving system, a frequency discriminator network comprising a plurality of tuned inductances, rectifier means comprising a pair of rectifier elements, a rectifier output circuit including an output impedance, a circuit connecting said rectifier elements in balanced relation between said inductances and said output impedance, said circuit including at least two of said inductances in series, means for tuning one of said series-connected inductances to signals one at a relatively low frequency and another at a differing frequency, selective switching means for connecting said rectifier elements in parallel relation with each other to said output impedance for response to signals at one of said frequencies, and means for deriving a tuning indication from said output impedance in response to parallel operation of said rectifier elements.

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