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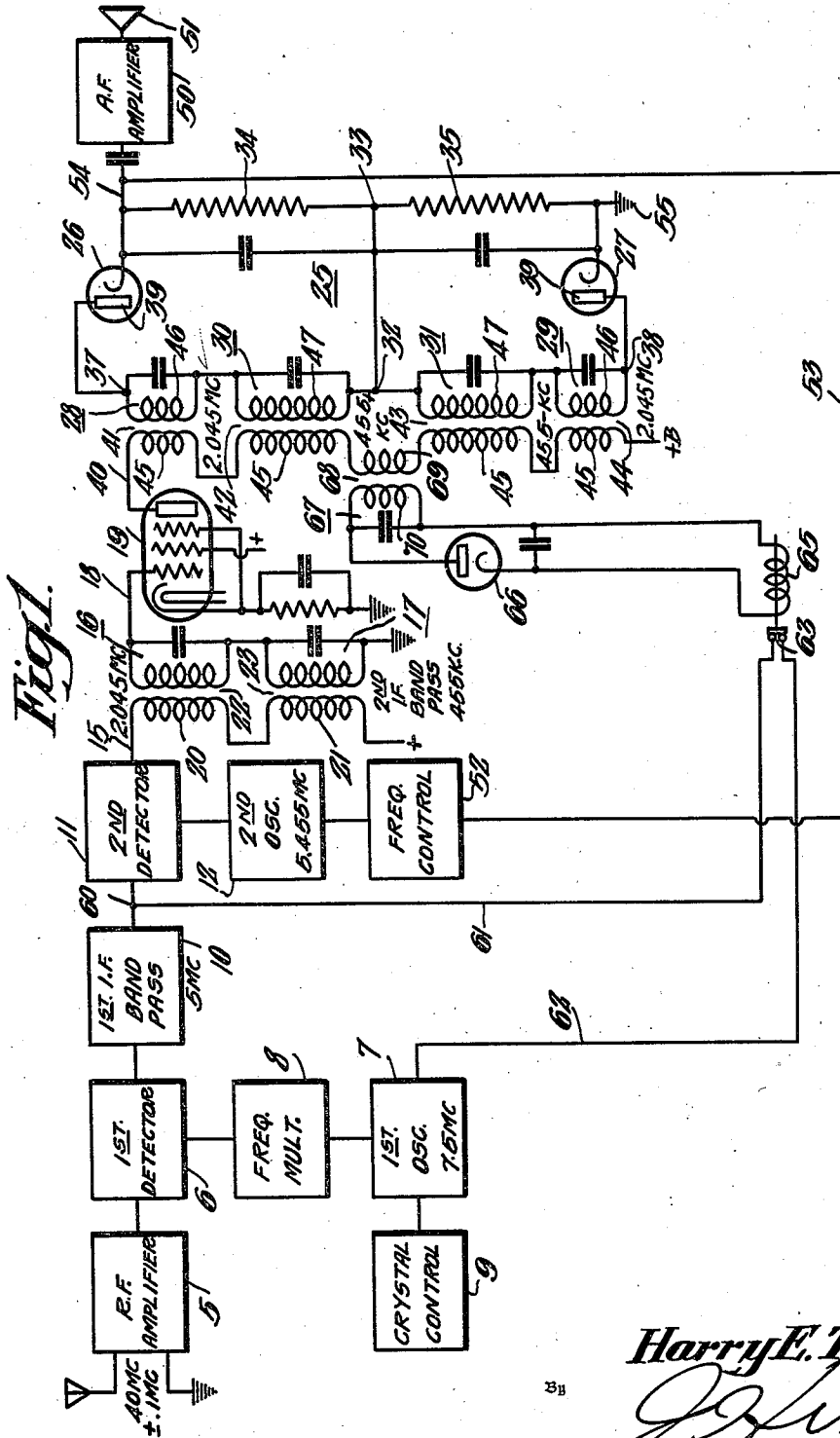
H. E. THOMAS

2,282,834

DOUBLE HETERODYNE RECEIVING SYSTEM

Filed June 29, 1940

2 Sheets-Sheet 1



Inventor
Harry E. Thomas
[Signature]
 Attorney

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H. E. THOMAS

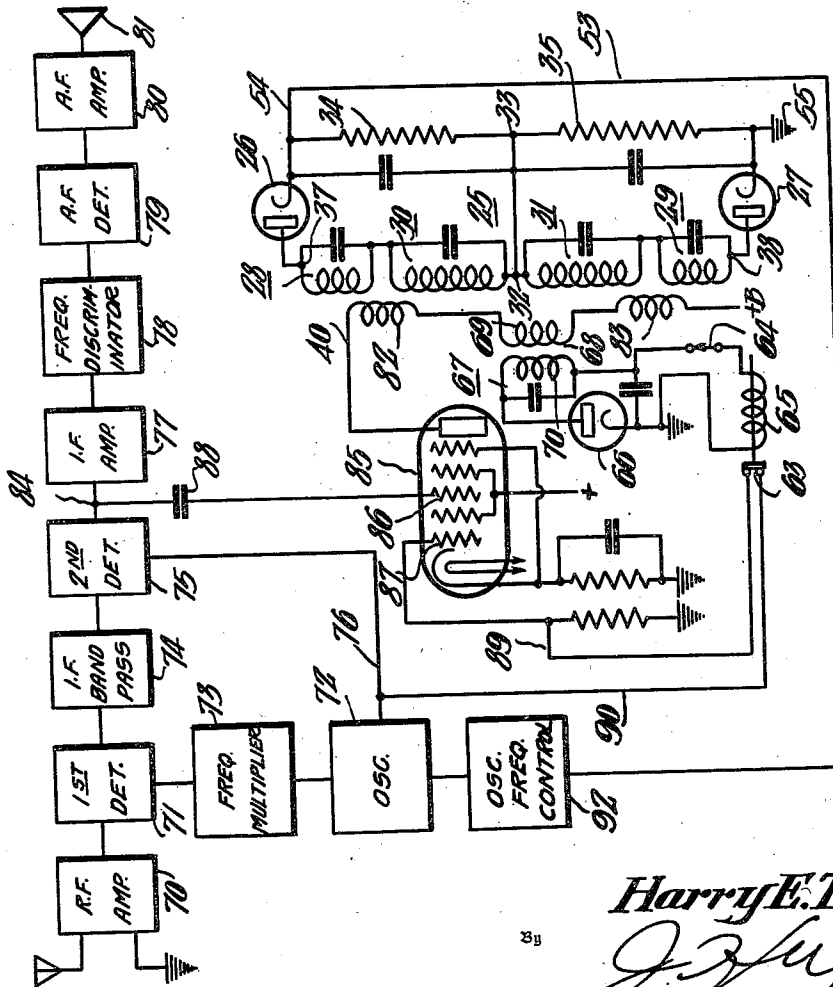
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Fig. 2.



Inventor

Harry E. Thomas

J. J. Huff
Attorney

UNITED STATES PATENT OFFICE

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DOUBLE HETERODYNE RECEIVING SYSTEM

Harry E. Thomas, Haddonfield, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

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9 Claims. (Cl. 250—20)

This invention relates to double heterodyne radio signal receiving systems, and has for its primary object to provide an improved oscillator control circuit in a double heterodyne signal receiving system for preventing oscillator frequency drift in the absence of received signals.

More particularly, this invention relates to frequency modulation signal receiving systems having a double heterodyne circuit including one or more heterodyne oscillators, and has for its further object to provide a dual signal channel terminating in a frequency discriminator network which is responsive to a difference of two oscillator frequencies and also the intermediate signal frequency to provide a differential feedback control potential for controlling the oscillator system whereby frequency drift in the presence or absence of signals is substantially prevented.

It is a further object of the present invention to provide an oscillator control circuit for a frequency modulated signal receiving system which operates to correct oscillator drift and in addition provides automatic frequency control of the oscillator means to establish mid-circuit or balanced tuning of the signal within the pass band of the signal conveying system, thereby to minimize the transmission of noise and undesired signal potentials.

As is known in frequency modulated signal receiving systems and similar wide band radio receiving systems of the heterodyne type, automatic frequency control or feedback of a direct current control potential to the oscillator may be provided to automatically vary the mean oscillator frequency in order to permit the full band pass width of the intermediate frequency circuits to be utilized for signals with normal modulation or full frequency swing, without overloading said circuits in response to full modulation or frequency swing when receiving frequency modulated signals, thereby eliminating undesired distortion and noise and interference signal transmission through the system.

The problem of maintaining the oscillator at a predetermined normal frequency in the absence of signals in a system of the character referred to may, in accordance with the invention, be effected by simple means involving a dual frequency signal channel including a frequency discriminator network to which an intermediate frequency signal and oscillations may be applied to derive a differential control potential for automatic frequency control of a variable heterodyne oscillator.

In a preferred embodiment of the invention,

the output of a crystal-controlled or otherwise stabilized oscillator is utilized to control the frequency stability of a second oscillator in the absence of received signals.

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

In the drawings,

Figure 1 is a schematic circuit diagram of a frequency modulated signal receiving system of the double heterodyne type, embodying the invention, and

Figure 2 is a similar schematic circuit diagram of a frequency modulated signal receiving system of the single heterodyne type also embodying the invention.

Referring to Fig. 1, the double heterodyne frequency modulation signal receiving system shown comprises an R. F. amplifier indicated at 5, coupled to a first detector or converter 6 which receives oscillations from an oscillator 7 through a frequency multiplier 8. The oscillator is suitably stabilized in frequency, such as by crystal control means 9, and the resultant intermediate frequency signals from the converter 6 are applied through a band pass amplifier 10 to a second detector 11 which receives oscillations from a second oscillator 12.

From the second detector or converter 11, signals may be conveyed through two channels which operate at differing frequencies sufficiently spaced to prevent interaction. In the present example and as a preferred arrangement, the frequencies selected for the two channel amplifier is that of the difference frequency between the oscillator 7 and the oscillator 12, and the desired signal intermediate frequency which may be taken to be 2.045 mc. and 455 kc., respectively. The oscillator 7 is operable at a relatively low frequency with respect to the incoming signal to supply the 7.5 mc. signal directly and, therefore, the frequency multiplier 8 is utilized to provide a desired high frequency of 45 mc., for example, at the first detector for mixing with the incoming signal which may be at 40 mc., to provide a 5 mc. intermediate frequency signal for the band pass amplifier 10. In this case, the second detector 11 is supplied with oscillations from the second oscillator 12 at 5.455 mc. thereby providing a second intermediate frequency signal of 455 kc. in the output circuit 15 of the second detector.

The double channel amplifier and discriminator system following the second detector com-

prises two tuned circuits 16 and 17 operating respectively at the difference frequency of the stabilized and tunable oscillators and the signal intermediate frequency. In the present example, the circuit 16 is tuned to 2.045 mc. and the circuit 17 is tuned to 455 kc. These circuits are connected in series to the input grid circuit 18 of a second intermediate frequency amplifier 19 which serves to amplify signals at either or both frequencies. The circuits 16 and 17 are coupled to the second detector output circuit in any suitable manner, preferably as shown, by means of series connected primary windings 20 and 21 of intermediate frequency coupling transformers 22 and 23, respectively, the secondaries of which, as shown, are included in the tuned circuits 16 and 17, respectively.

The amplifier stage 19 is coupled to a frequency discriminator network 25 which includes a pair of balanced diode rectifiers 26 and 27, in the balanced input circuits of which are included two circuits 28 and 29 tuned to the one channel frequency and two circuits 30 and 31 tuned to the other channel frequency. The midpoint 32 of the balanced discriminator circuit is connected to a midpoint 33 between two output impedances 34 and 35 for the rectifiers 26 and 27, while the terminal ends 37 and 38 are connected with the anodes 39 of the rectifiers, thus providing a back-to-back discriminator connection for the rectifiers, of the type shown in Conrad U. S. Patent No. 2,057,640. In this system, however, two circuits 28 and 30 are tuned above their respective signal frequencies of 2.045 mc. and 455 kc., respectively, while two other circuits 29 and 31 are tuned slightly below 2.045 mc. and 455 kc., respectively. Thus the discriminator circuit is modified to provide termination for two channels at differing frequencies.

The circuits 28, 30, 31 and 29 are coupled to the output circuit 40 of the intermediate frequency amplifier stage 19 by means of coupling transformers 41, 42, 43 and 44, the primaries 45 of which are included serially in the output circuit 40 while the secondaries 46 and 47 are included in the tuned circuits 28-29, 30-31, respectively.

In the operation of the system thus far described, signals at a fixed intermediate frequency are received through the main signal channel at the second detector and pass through the tuned circuits 17 and 30-31 to the balanced rectifier output impedance 34-35 from which audio frequency signals are derived for the audio frequency amplifier 50 and loudspeaker output device 51.

The second oscillator is variable in frequency about a mean or normal frequency under control of frequency control means 52 responsive to a variable control potential applied thereto through a control circuit 53 connected with the output circuit 54 of the discriminator network, the low potential side of the impedance 34-35 being grounded as indicated at 55.

As hereinbefore referred to, the first oscillator 7 is stabilized by suitable means such as a crystal control 9, and therefore provides a stabilized intermediate frequency for the second detector. The second oscillator is in effect provided with automatic frequency control means which serves to maintain the signal intermediate frequency of 455 kc. substantially constant thereby to utilize the full band width of the signal channel through the discriminator network with minimum noise transmission.

With a feedback voltage control system of this character for the variable frequency oscillator, in the absence of signals, the latter oscillator may tend to drift and in order to prevent such undesirable operation, signals from the first or stabilized oscillator are applied through the second channel and the discriminator following the second detector directly from the first oscillator.

The stabilizing signals from the first oscillator may be applied to the main signal channel at a point preceding the second detector and double channel input circuit which, in the present example, is the circuit 15. Therefore, in the present example, signals from the first oscillator are applied through the second detector to the circuit 15, the connection at 60 being provided for the oscillations which are conveyed from the first oscillator through a circuit 61-62 and a control switch 63 which is closed in the absence of received signals through the main channel. The circuit 16 of the amplifier 19 and the circuits 28 and 29 of the discriminator network being responsive to the difference between the first and second oscillator frequencies, the applied oscillations produce in the discriminator output a control potential which serves to hold the second oscillator at a fixed frequency substantially that at which it was maintained in the presence of signals through the main channel.

In order that the switch 63 may close to apply signals from the first oscillator through the second channel and discriminator for the control of the second oscillator in the absence of received signals, the switch 63 is provided by relay contacts, the operating coil 65 of which is connected through a rectifier 66 to a tuned circuit 67 which is responsive to signals at the signal intermediate frequency of 455 kc.

The circuit 67 is suitably coupled to the amplifier circuit 40 through a transformer 68, the primary 69 of which is included in the output circuit 40 while the secondary 70 is included in the tuned circuit 67.

Thus, in the presence of a received signal of 455 kc. the relay operates and disconnects the first oscillator, thus placing the second oscillator under control of the received signals, while in the absence of signals, the relay closes to again apply controlling oscillations from the stabilized first oscillator, thereby preventing oscillator drift in the controlled oscillator, while at the same time permitting mid-circuit or balanced tuning for minimum noise conditions in the presence of received signals.

In certain receiving systems, it is desirable to provide a single oscillator for double heterodyne operation, such a system being shown in Fig. 2, to which attention is now directed.

Referring to Fig. 2, an R. F. amplifier 70 is coupled to a first detector 71 which receives oscillations from a heterodyne oscillator 72 through a frequency multiplier 73 and the resultant intermediate frequency signals are conveyed through a band pass filter 74 to a second detector 75 which receives oscillations directly from the first oscillator 72 through a circuit 76.

The second intermediate frequency amplifier is indicated at 77 and is coupled through a frequency discriminator network 78 to the audio frequency detector 79, audio frequency amplifier 80 and output device 81, thus providing the main signal channel of the receiving system.

The same dual channel amplifier and discriminator network are provided as in the circuit of Fig. 1 and the same reference numerals are used

to designate like circuit elements and circuits therein as in Fig. 1.

This comprises the discriminator circuit 25 including rectifiers 26 and 27 coupled through the balanced mistuned circuits 28 and 29 operating above and below the oscillator frequency of 7.5 mc. and the similar circuits 30 and 31 operating above and below the second I. F. frequency of 455 rc., with the amplifier output circuit 40, which includes a common primary winding 82 for the circuits 28 and 30 and a common primary winding 83 for the circuits 31 and 29 whereby signals are applied to the discriminator network at the operating and oscillator frequencies from the circuit 40.

The amplifier stage connected with the circuit 40 in the present modification comprises a mixer tube 85 having two signal input grids 86 and 87, the former being coupled through suitable coupling means 88 to the main signal I. F. channel preferably at a point 84 following the second detector, and the grid 87 being connected through a circuit 89—90 with the output circuit 76 of the oscillator 72, this connection including the relay contact 63.

The relay operating winding 65 is connected through the rectifier 66 with the tuned circuit 67 coupled to the output circuit 40 through the winding 69. The relay is responsive to the mid-frequency of the main signal channel, in this case, to the second I. F. signals, whereby the relay contacts are opened in response to a received signal at the second I. F. frequency and are closed in the absence of such signal.

The oscillator is controlled through the circuit connection 53 and oscillator frequency control means indicated at 92 suitably coupled to the oscillator 72. In the presence of signals, the oscillator frequency is under control of the discriminator network which receives I. F. signals through the coupling 88 and the input grid 86, thence through the tuned circuits 30 and 31 and the differential output impedance 34—35. The oscillator frequency is varied automatically in response to signal frequency variations to maintain mid-tuning for the pass band of the circuits 30 and 31.

In the absence of signals, the relay 65 closes to apply signals directly from the oscillator 72 to the second input grid 87 of the amplifier 85 and the amplified oscillations are applied to the discriminator circuits 28 and 29 which are inherently more stable under temperature and humidity variations than the oscillator, and provide a stabilizing control potential for the oscillator feedback through the common output circuit 53. Thus, any tendency of the oscillator to drift in the absence of signals is stabilized to the amplifier and discriminator circuits.

Simultaneous action of the two stabilizing frequencies may be effected by keeping the relay contacts 63 closed as by opening a switch 64 in the circuit 89—90 to cut off the relay coil 65. In this case, both oscillator and I. F. frequencies are simultaneously passed through the amplifier and discriminator dual channel and the differential potentials derived are combined in the output circuit 53 to give broad discrimination for signal restoration in the high frequency oscillator frequency channel and vernier action through the discrimination in the more selective low frequency signal or second I. F. channel.

It should be noted that in each of the circuits shown and described, the automatic frequency control of the oscillator by feedback is through

a circuit which derives a controlling potential from a portion of the signal channel which is relatively broadly tuned so that wide variations in frequency may be effective to control the AFC action.

Furthermore, a double frequency control circuit is provided which utilizes but one additional amplifier tube and one group of windings to establish a stabilized oscillator control system which functions to provide mid-circuit tuning. Such a circuit also provides for automatically following transmitter frequency drift to maintain the receiving system in tune with a received signal.

Although the invention may be applied to any wide band signal receiver, it is particularly adaptable to frequency modulation signal receiving systems which normally are provided with some form of automatic frequency control for the oscillator system to insure constant tuning to the mid-point of the intermediate frequency pass band. Thus the control may be applied to the second oscillator of a double heterodyne frequency modulation receiving system to prevent oscillator drift in the absence of signals while providing the desired frequency control in the presence of signals for following the signal drift. The first oscillator may then be stabilized as shown, so that in the absence of signals a differential potential may be derived from the discriminator network thereby preventing drift of the second oscillator into another channel.

Switching to accomplish this is actuated by a section of the main signal amplifier sensitive only to the signal I. F. frequency.

However, while the invention has been shown and described in connection with the specific receiving system and circuits, it will be appreciated that it may be applied in connection with any wide band signal receiving system having feedback control of the heterodyne oscillator or oscillators.

I claim as my invention:

1. In a radio signal receiving system, the combination of a variable frequency oscillator, an automatic frequency control circuit therefor, an amplifier responsive to the oscillator frequency and to a signal frequency in non-adjacent frequency bands, means providing a frequency discriminator network coupled to said amplifier, means for deriving a differential control potential for the automatic frequency control circuit from said network in response to signals and oscillations from said oscillator, and means responsive to the signal frequency for applying said oscillations to said signal channel in the absence of received signals thereby to provide a stabilizing control potential for said oscillator through said discriminator network.

2. In a radio signal receiving system of the double heterodyne type, the combination of a first oscillator, means for stabilizing the operation of said oscillator, a second oscillator, automatic frequency control means therefor including a control circuit, a frequency discriminator network responsive to signals and to differential oscillations from said first and second oscillators in non-adjacent frequency bands, and means connected with said network for deriving a differential control potential for said automatic frequency control means in response to differential oscillations from said oscillators and signals applied to said system.

3. In a radio signal receiving system of the double heterodyne type, the combination of a

first oscillator, means for stabilizing the operation of said oscillator, a second oscillator, automatic frequency control means therefor including a control circuit, a frequency discriminator network responsive to signals and to differential oscillations from said first and second oscillators in non-adjacent frequency bands, means connected with said network for deriving a differential control potential for said automatic frequency control means in response to differential oscillations from said oscillators and signals applied to said system, and means for applying said differential oscillations to said network through a portion of said signal receiving system including said discriminator network in the absence of received signals.

4. In a radio signal receiving system, the combination with a first detector and a second detector, of oscillator means for applying controlled oscillations to said detectors, means responsive to a variable controlling potential for varying the frequency of the oscillations applied to the second detector, means providing a signal conveying channel including a frequency discriminator network having circuits responsive to a predetermined intermediate frequency and to oscillations from said oscillator means in non-adjacent frequency bands, means for deriving a differential controlling potential from said frequency discriminator network, and means responsive to variations in said potential for controlling the frequency of oscillations applied to the second detector, thereby to stabilize said oscillator means in the absence of signals and to provide substantially constant intermediate frequency signals through the pass band of said system with drift in the frequency of a received carrier wave.

5. In a double heterodyne frequency modulated signal receiving system, the combination of a first detector, a stabilized first oscillator, frequency multiplier means coupling said oscillator and first detector, a second detector, an intermediate frequency band pass system connecting said first and second detectors, a second oscillator, frequency control means for varying the frequency of said second oscillator responsive to a variable controlling potential, an amplifier coupled to said second detector comprising tuned circuits responsive to a second intermediate frequency and to differential oscillations from said oscillators in two non-adjacent frequency bands, a frequency discriminator network coupled to said last named amplifier and comprising circuits tuned to said second intermediate and differential oscillator frequencies, rectifier means for said discriminator network having an output circuit coupled to said frequency control means for the second oscillator, and means responsive to received signals for applying oscillations from the first oscillator to the signal channel preceding the input to said amplifier.

6. In a double heterodyne frequency modulated signal receiving system, the combination of a first detector, a stabilized first oscillator, a second detector, a second oscillator, frequency control means for varying the frequency of said second oscillator responsive to a variable controlling potential, an amplifier responsive to two non-adjacent frequency bands coupled to said second detector, a frequency discriminator network coupled to said last named amplifier and

comprising circuits tuned to said second intermediate and oscillator differential frequencies in said frequency bands, rectifier means for said discriminator network having an output circuit coupled to said frequency control means for the second oscillator, a circuit for applying oscillations from the first oscillator to the signal channel preceding the input to said amplifier, and means responsive to received signals for opening said last named circuit.

7. In a double heterodyne frequency modulated signal receiving system, the combination of a first detector, a stabilized first oscillator, a second detector, a second oscillator, frequency control means for varying the frequency of said second oscillator responsive to a variable controlling potential, an amplifier responsive to the second intermediate and differential of the oscillator frequencies in two non-adjacent frequency bands and coupled to said second detector, a frequency discriminator network coupled to said last named amplifier and comprising circuits tuned to said second intermediate and oscillator differential frequencies in said frequency bands, rectifier means for said discriminator network having an output circuit coupled to said frequency control means for the second oscillator, a circuit for applying oscillations from the first oscillator to the signal channel preceding the input to said dual channel amplifier, a tuned circuit responsive to the second intermediate frequency coupled to said amplifier, a relay device connected in circuit between said first oscillator and said signal channel to control the flow of oscillations to said signal channel from said first oscillator, an operating winding for causing said relay to open, and a rectifier connected in circuit between said winding and said last named tuned circuit whereby, in the presence of received signals, the oscillations from the first oscillator are cut off from the signal channel.

8. In a radio signal receiving system, the combination of a variable frequency oscillator, an automatic frequency control circuit therefor, a fixed frequency oscillator, an amplifier responsive to the oscillator difference frequency and to a signal frequency in non-adjacent frequency bands, means providing a frequency discriminator network responsive to said frequency bands and coupled to said amplifier, and means for deriving a differential control potential for the automatic frequency control circuit from said network in response to signals and differential oscillations from said oscillators.

9. In a radio signal receiving system, the combination of a variable frequency oscillator, an automatic frequency control circuit therefor, a stabilized oscillator, an amplifier responsive to the oscillator difference frequency and to a signal frequency in non-adjacent frequency bands, means providing a frequency discriminator network responsive to said frequency bands and coupled to said amplifier, means for deriving a differential control potential for the automatic frequency control circuit from said network in response to signals and said differential oscillations from said oscillators, and means responsive to the signal frequency for applying said differential oscillations to said signal channel in the absence of received signals, thereby to provide a stabilizing control potential for said first named oscillator through said discriminator network.

HARRY E. THOMAS.