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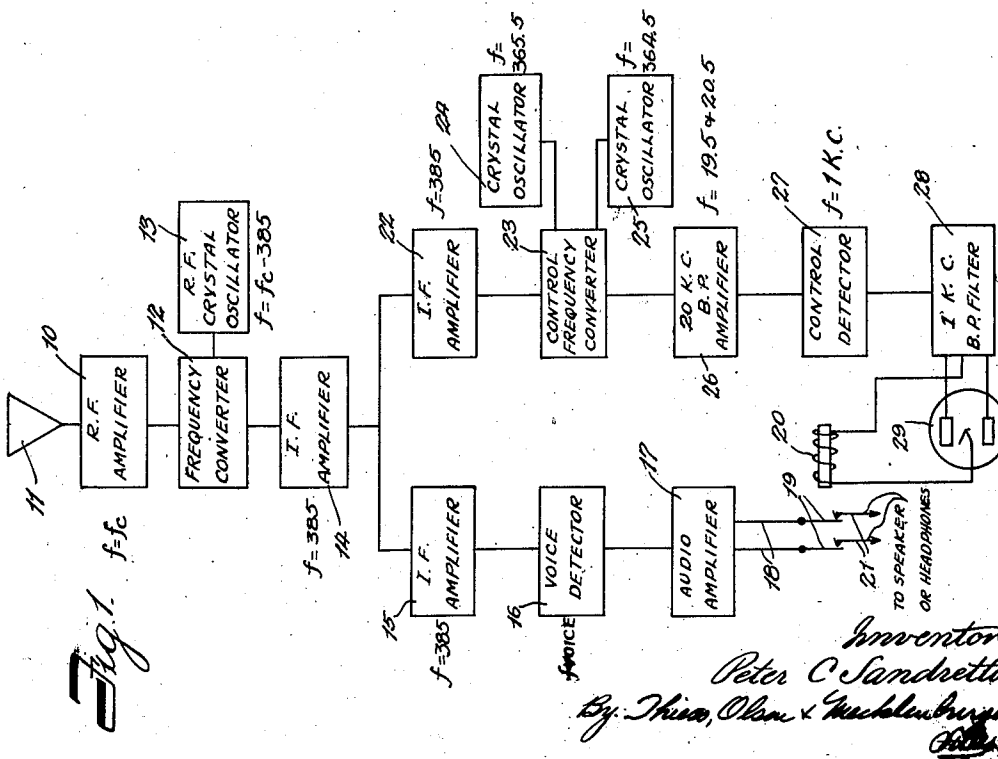
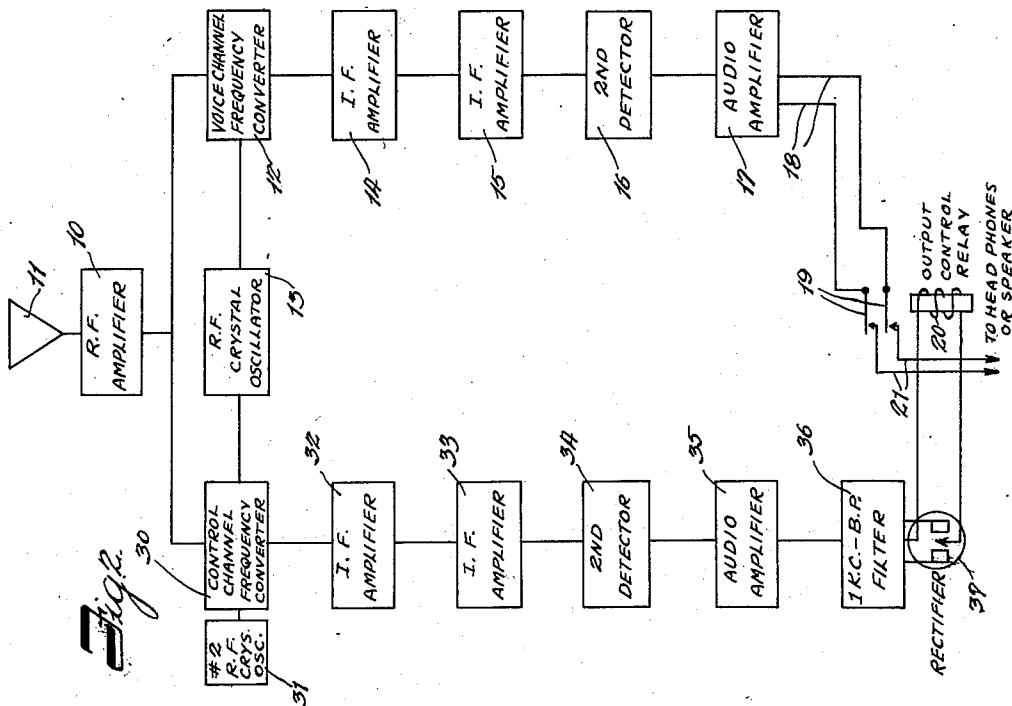
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2,362,958

RADIO RECEIVER SYSTEM

Filed June 22, 1942

3 Sheets-Sheet 1



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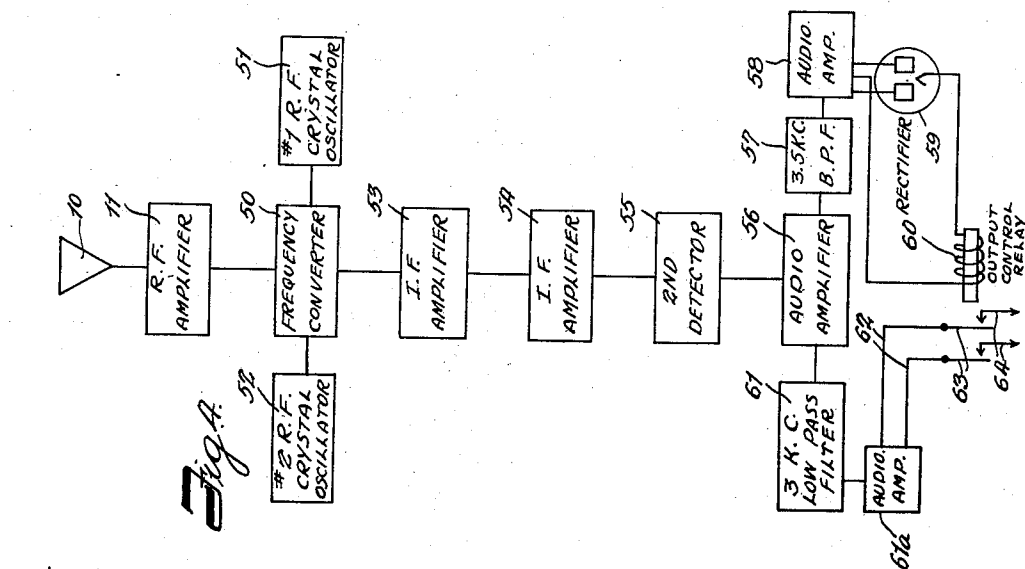


Fig. 3

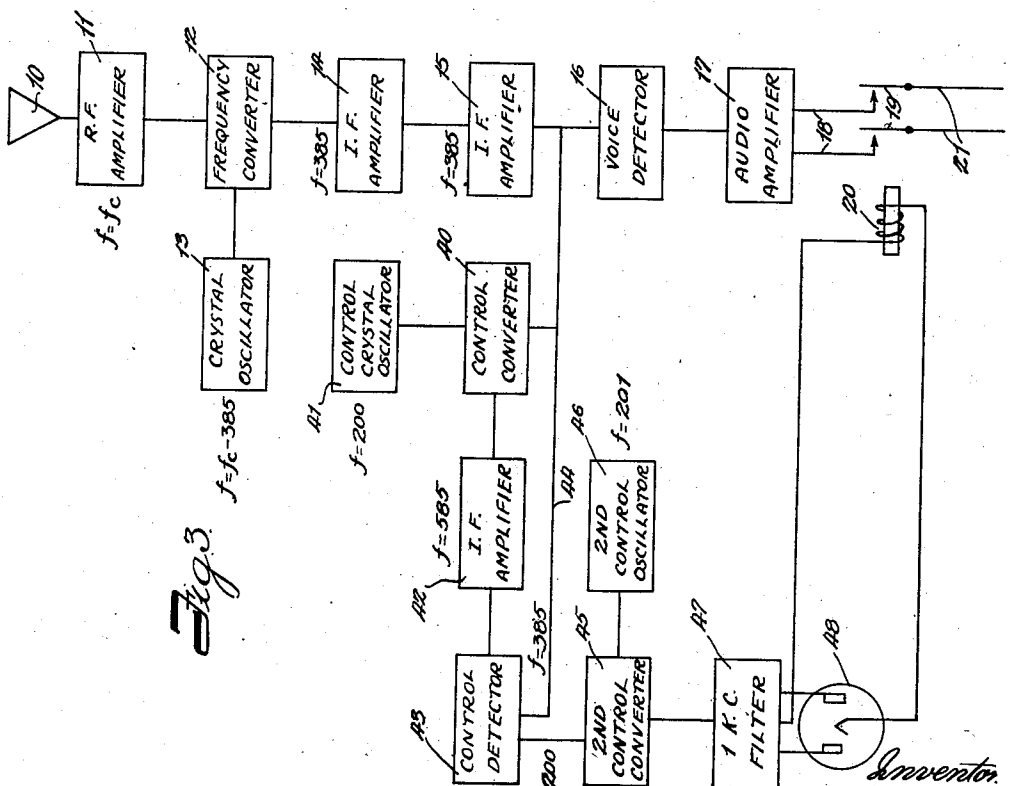


Fig. 4

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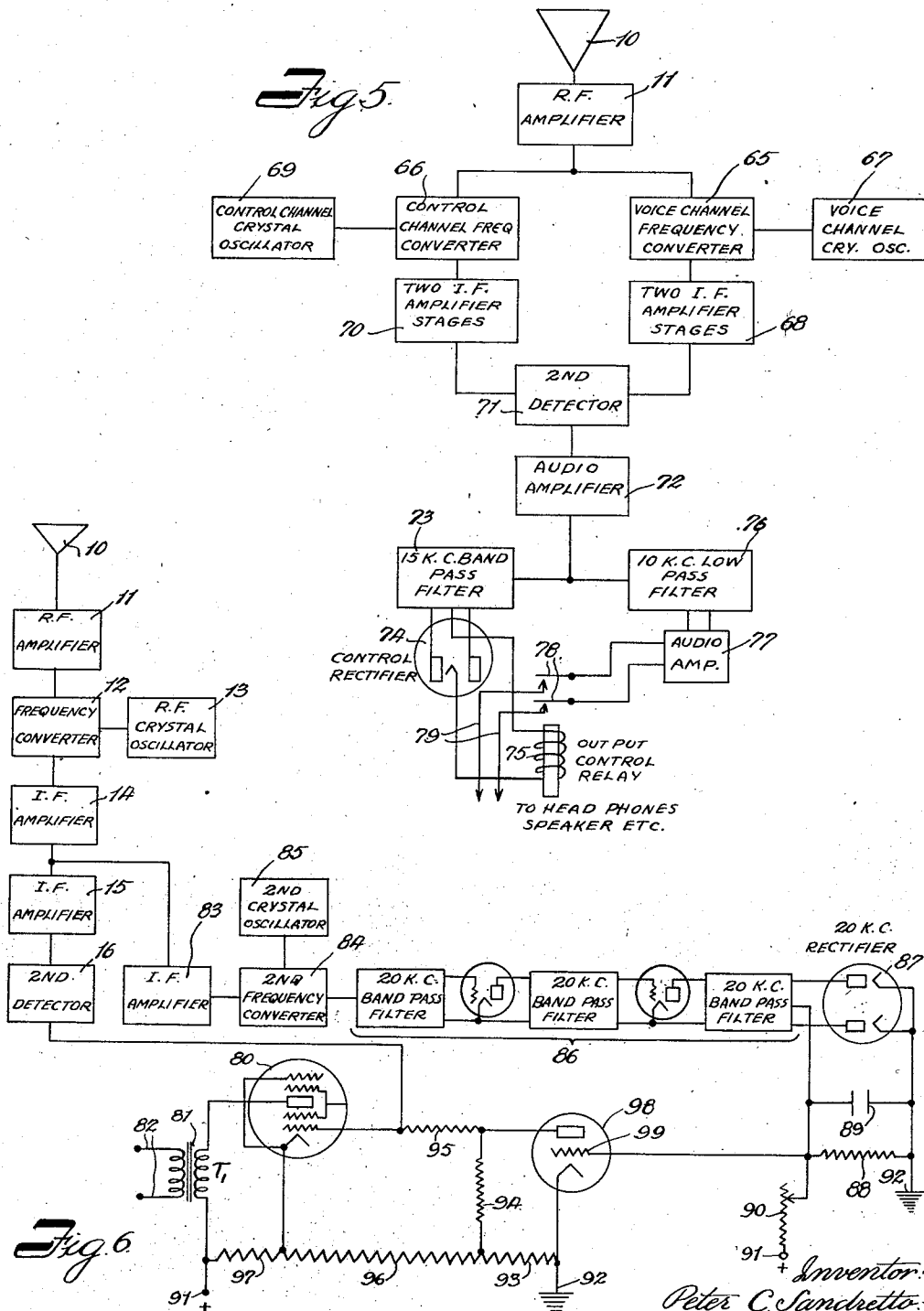
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RADIO RECEIVER SYSTEM

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RADIO RECEIVER SYSTEM

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14 Claims. (Cl. 250—20)

This invention relates to radio receiver systems; more particularly to means for controlling radio receivers for communication systems, and the invention has for an object the provision of improved control means of this character.

In modern radio receivers, particularly those utilizing automatic volume or gain control circuits, the gain of the receiver is vastly increased when the carrier of the transmitting station ceases. During periods when the transmitter is silent the thermal noise of the receiver, as well as any atmospheric noises picked up by it, are heard with high intensity. In communication systems it is the usual practice to keep the carrier of a transmitter on the air only during the time when transmission is actually being made in order that a large number of stations may utilize the same channel without interference. With such systems the radio operator must therefore listen to static between the periods when transmissions are actually being made. Under severe atmospheric conditions the operator is thus forced to undergo an extremely unpleasant experience, which is found in many cases to reduce the sensitivity of the operator's ears to the point where it is difficult, if not impossible, for him to read a transmission when a carrier is turned on.

As a proposed solution of the well recognized problem thus presented, it has been suggested that the gain of the receiver be reduced to the point where the noise heard by the operator is no longer annoying. This procedure, of course, has the disadvantage that the gain of the receiver is so greatly reduced as to render the receiver ineffective for the reception of relatively weak stations. It has also been proposed to control the audio output circuits of the receiver by means responsive to the carrier, which means are intended to silence the receiver until a carrier of a certain value is received. Difficulties arise in connection with such systems, however, because under severe static conditions the receiver may be turned on by the peaks of the noise. Consequently, when the system is most needed it fails to operate properly. Increasing the value of the carrier which is required to turn on the receiver may be effective to lessen the extent to which the control system is susceptible to static, but when this is done a weak carrier will no longer operate the receiver.

Something is yet to be desired, therefore, in control systems for communications receivers, and it is a further object of this invention to provide a control system such that any carrier

loud enough to make an impression on the receiver will be effective to render the receiver operative, while static conditions, regardless of the intensity thereof, will not effect operation of the control means for the receiver.

In carrying out the invention in one form, a standard radio receiver is provided with means for heterodyning selected components of the carrier of the incoming signal with selected locally generated frequencies to produce a predetermined audio frequency tone or beat note. This audio tone or beat note is filtered sharply to eliminate the static components therefrom, and the filtered tone is utilized to render the receiver operative. When no carrier is being received there will be no audio tone or beat note, and accordingly the receiver will be inoperative so that static noises will not reach the operator.

For a more complete understanding of the invention reference should now be had to the drawings, in which:

Fig. 1 is a block diagram illustrating what is now considered a preferred embodiment of the invention applied to a standard superheterodyne radio receiver; and

Figs. 2 to 6, inclusive, are similar diagrams illustrating further embodiments of the invention.

In the drawings block diagrams are employed to simplify the showing of the invention, and inasmuch as each of the elements represented by a properly identified and labeled block is a standard device well known in the art, it is not believed necessary to illustrate in detail the individual circuit connections thereof.

Referring now to Fig. 1 of the drawings, the invention is illustrated as applied to a conventional radio receiver having a radio frequency amplifier 10 suitably coupled to an antenna 11, the receiver also including a frequency converter 12 with which is coupled suitable means for locally generating the heterodyne frequency, the local generating means being illustrated as comprising a radio frequency crystal oscillator 13. Following the frequency converter are two stages of intermediate frequency amplification indicated in the drawings by the reference numerals 14 and 15, a voice detector 16, and the audio output circuit of the receiver which, in the embodiment shown, comprises an audio amplifier 17, the output conductors 18 of which are connected to the contacts 19 of a normally open relay, having an operating winding 20. The relay contacts are adapted to be connected

through suitable conductors 21 to utilization means such as a loud speaker or head-phones.

The above-identified elements, of course, constitute the signal channel of a conventional superheterodyne radio receiver, and in order to control the output circuit of the receiver so as to render the receiver operative or inoperative, in accordance with the presence or absence of a transmitted carrier in the receiver input, there is provided a control channel comprising an additional intermediate frequency amplifier 22, a frequency converter 23 having associated therewith a plurality of crystal oscillators 24 and 25 for locally generating predetermined frequencies, a suitable band pass filter and amplifier 26, a detector 27, and a sharply tuned band pass filter and amplifier 28, the output circuit of which is connected through a full wave rectifier 29 to the relay operating winding 20.

The control channel is connected to the signal channel by coupling the intermediate frequency amplifier 22 to the intermediate frequency stages of the signal channel at a point between the intermediate frequency amplifiers 14 and 15. The intermediate frequency amplifier 22 serves to isolate the frequency converter 23 from the signal channel of the receiver, and supplies to the frequency converter 23 signal energy having an intermediate frequency component equal to the heterodyne frequency generated in the signal channel. The two crystal oscillators 24 and 25 are so connected to the frequency converter 23 as to provide a double heterodyne action, and the frequency of these two oscillators is so related to the intermediate frequency as to provide sum and difference frequencies of the desired values. While any suitable type of frequency converter may be utilized, coupled to the two oscillators in any desired manner, it has been found satisfactory to employ a converter tube having a plurality of auxiliary control grids which are adapted to be energized from the respective crystal oscillators.

From the frequency converter 23 there is supplied to the band pass filter and amplifier 26 a plurality of sum and difference frequencies, and this filter amplifier is designed with a sufficiently wide band pass so that when tuned to a frequency having a mean value, as compared to the difference frequencies generated in the converter 23, the two difference frequencies will be passed without discrimination. In the detector 27 these two difference frequencies beat together to provide a beat note having a frequency which is determined by the frequency separation of the crystal oscillators 24 and 25, and which is independent of the intermediate frequency derived from the signal channel. Preferably the crystal oscillator frequencies are so selected as to have a very small separation in the audio range, and thus there is produced in the detector 27 an audio beat note of a comparatively low audio frequency. This beat note is then filtered in the band pass filter 28 which is sharply tuned so as to eliminate all other signal components which may be present, including the static side bands.

In the usual receiver the amount of static present in the audio stage is a function of the static side bands that the receiver will accept, and of course the width of the band of acceptance must be sufficient in the conventional receiver to permit acceptance of the audio spectrum, as otherwise the signals will not be understood. In the control channel provided in the above described embodiment of this invention, however, it is unnecessary to pass audio frequencies other than

the predetermined beat note frequency, and consequently there is no limitation imposed on the permissible sharpness of the tuning of the band pass filter 28. The filtered beat note, as previously indicated, is rectified in the rectifier 29, and the rectified current serves to energize the operating winding 20 of the relay.

For purposes of a specific example it will be assumed that the crystal oscillator 13 in the signal channel is arranged to generate a frequency which is less than, and is separated from, the carrier frequency by 385 kilocycles. Consequently there will be produced in the frequency converter 12 heterodyne signals equal to the sum and difference of the carrier frequency and the locally generated frequency, the difference frequency being equal to 385 kilocycles, and the sum frequency being equal to twice the carrier frequency minus 385 kilocycles. The intermediate frequency amplifiers 14, 15, and 22 are so constructed as to pass and amplify this 385 kilocycle intermediate frequency and reject the heterodyne sum frequency. Therefore, a frequency of 385 kilocycles is supplied to the control converter 23 in the control channel.

In order to produce the desired audio beat note for controlling the receiver, the crystal oscillators 24 and 25 are arranged to generate frequencies of 365.5 kilocycles and 364.5 kilocycles, respectively. Although any desired frequencies may be selected, it is desirable to provide a low frequency difference between each of the crystal oscillators and the intermediate frequency in order that relatively low difference frequencies may be generated in the converter 23. While there will also be generated in the converter 23 sum frequencies equal to the sum of the intermediate frequency and the respective oscillator frequencies, only the difference frequencies which are respectively equal to 19.5 and 20.5 kilocycles will be passed by the band pass filter and amplifier 26, which constitutes a 20 kilocycle band pass amplifier so designed as to provide a sufficiently wide band pass that when tuned to 20 kilocycles it will not discriminate against a 19.5 or a 20.5 kilocycle frequency. In the control detector 27 the 19.5 and 20.5 kilocycle frequencies beat together to form a 1-kilocycle note which then passes through the sharply tuned 1-kilocycle filter 28, which filter, as heretofore indicated, is effective to remove the static side bands.

It will now be apparent that whenever a carrier of sufficient intensity to make an impression on the receiver is present in the signal channel thereof, there will be produced in the control channel a 1-kilocycle beat note which, when rectified, serves to energize the winding 20 and operate to their closed positions the contacts 19 in the audio output circuit of the receiver. In the absence of such a carrier, however, the relay will be deenergized since the control channel will not be effective to produce an audio note capable of passing the 1-kilocycle filter 28. The locally generated energy produced by the oscillator 13 cannot pass the intermediate frequency amplifiers 14 and 22, and consequently there is no intermediate frequency input to the control converter 23. The locally generated energy produced by the crystal oscillators 24 and 25 will then not produce a heterodyne frequency which can be passed by the 20-kilocycle band pass filter in amplifier 26, and consequently the relay will remain deenergized. The presence of static conditions, regardless of the intensity thereof, is wholly ineffective to ener-

gize the relay 20 and is thus ineffective to render the signal channel of the receiver operative.

In Fig. 2 there is represented another embodiment of the invention as applied to a conventional superheterodyne receiver, the signal channel of which comprises the same elements 10 to 21, inclusive, as were previously described in connection with the embodiment of Fig. 1. In this case, however, the control channel is connected to the signal channel at a point in the radio frequency stage so that radio frequency energy rather than intermediate frequency energy is supplied to the control channel. In order to produce in the control channel the same 1-kilocycle beat note, for example, which was produced in the embodiment of Fig. 1, the control channel in Fig. 2 is shown as comprising a frequency converter 30 to which radio frequency energy is supplied, and which is coupled to the radio frequency crystal oscillator 13 as well as to a second radio frequency crystal oscillator 31.

The second crystal oscillator 31 is adapted to generate a local frequency different from the frequency of the oscillator 13 by a fixed value, which would be 1 kilocycle, when it is desired to produce a 1-kilocycle beat note. Thus there will be produced in the converter 30 two intermediate frequencies separated from each other by 1 kilocycle. These two intermediate frequencies, since they are separated by only 1 kilocycle, may readily be passed by the intermediate frequency amplifiers 32 and 33 in the control channel, which amplifiers may be of the conventional type capable of passing such frequencies without appreciably discriminating therebetween. In the detector 34 these intermediate frequencies beat together to form a 1-kilocycle beat note which is amplified in the audio amplifier 35, filtered in the sharply tuned 1-kilocycle band pass filter 36, and supplied through the full wave rectifier 37 to the operating winding 20 of the relay which controls the output circuit of the signal channel.

It will be obvious that in this embodiment of the invention, as well as in the previously described embodiment, the frequency of the beat note produced in the control channel is independent of the carrier frequency of the signal picked up by the receiver. Consequently frequency swings will not affect the value of the beat note, and extremely sharp tuning may be provided at the band pass filters 28 and 36.

When no carrier is present the oscillators 13 and 31 may heterodyne with each other in the converter 30 to produce a 1-kilocycle note, but this note will not be passed and amplified by the intermediate frequency amplifiers 32 and 33. Consequently the operating winding 20 of the relay will not be energized and the signal channel of the receiver will not be rendered operative to supply signal energy to the utilization means to which the conductors 21 are connected.

In Fig. 3 there is shown still another embodiment of the invention comprising a control channel for producing a suitable 1-kilocycle beat note, for example, for the purpose of rendering operative or inoperative the signal channel of a conventional superheterodyne receiver. The receiver of Fig. 3 embodies the same elements 10 to 21, inclusive, as in Figs. 1 and 2, but in this case the control channel is somewhat differently arranged. As shown, the control channel comprises a converter 40, the input side of which is connected to the intermediate frequency stage of the signal channel at a point between the

second intermediate frequency amplifier 15 and the detector 16, and there is also associated with the converter 40 a crystal oscillator 41 for the purpose of heterodyning the locally generated frequency thereof with the intermediate frequency of the signal channel.

Assuming that the signal channel oscillator 13 is designed as in Fig. 1 to produce an intermediate frequency of 385 kilocycles, the control crystal oscillator 41 may be designed to produce a frequency of 200 kilocycles. Thus heterodyne frequencies will be produced equal to the sum and difference of 200 and 385, and the output circuit of the control converter 40 is coupled to an intermediate frequency amplifier 42, which is adapted to pass only the sum frequency of 585 kilocycles. The amplified 585 kilocycle frequency is then supplied from the amplifier 42 to a control detector 43, and by way of a suitable connection, represented in Fig. 3 by the conductor 44, there is also supplied to the control detector 43 the intermediate frequency derived from the signal channel. Thus the 385 kilocycle intermediate frequency beats with the 585 kilocycle frequency supplied to the detector 43 to produce a difference frequency of 200 kilocycles. As shown, the 200 kilocycle output of the control detector 43 is coupled to a second control converter 45 with which there is also associated a second control oscillator 46 adjusted to generate a local frequency of 201 kilocycles. Thus a frequency of 1 kilocycle is generated in the second control converter 45, and after passing through a sharply tuned 1-kilocycle band pass filter 47, the 1-kilocycle beat note is rectified in a full wave rectifier 48 and serves to energize the operating winding 20.

It will be observed that the 200 kilocycle frequency generated in the detector 43 is equal to the frequency of the first control crystal oscillator 41 and is independent of the frequency of the carrier or the intermediate frequency in the signal channel of the receiver. This is due to the fact that variations in the signal channel intermediate frequency will cancel out in the portion of the control channel comprising the elements 40, 41, 42, 43 and the intermediate frequency connection 44. Thus, whenever a carrier is being supplied to the signal channel of the receiver there will be produced in the control channel a 1-kilocycle beat note which will energize the winding 20 and operate the relay in the signal channel output circuit so as to render the receiver operative. In the absence of a carrier the locally generated frequency supplied by the oscillator 13 will be suppressed in the intermediate frequency amplifiers 14 and 15. The local frequency generated in the control oscillator 41 will be suppressed in the intermediate frequency amplifier 42 and the locally generated frequency of the control oscillator 46 will be rejected by the 1-kilocycle band pass filter 47. Consequently the winding 20 will not be energized and the receiver will remain inoperative regardless of the static conditions which may exist.

Referring now to the embodiment of the invention shown in Fig. 4, the signal channel and the control channel are combined throughout a portion of their extent. In this modification, the conventional antenna 10 is connected through the usual radio frequency amplifier 11 to a suitable frequency converter 50, to which a plurality of radio frequency crystal oscillators 51 and 52 are also connected. One of the crystal oscillators

is so designed as to generate a radio frequency differing from the carrier frequency of the receiving signal by an amount equal to the intermediate frequency for which the receiver is designed. The second one of the two oscillators is designed to generate a frequency which differs from the first oscillator frequency by a relatively low audio frequency. For example, the frequency difference between the oscillators may be on the order of $3\frac{1}{2}$ kilocycles.

The carrier wave, after being amplified in the radio frequency amplifier 11, heterodynes with the locally generated frequencies of the two oscillators to provide two sum frequencies and two difference frequencies separated by the frequency difference of the oscillators. Thus, regardless of any variation in the carrier frequency, the two sets of generated intermediate frequencies will have a constant frequency difference. The two sum frequencies will be suppressed in the intermediate frequency stages of the receiver which comprise two intermediate frequency amplifiers 53 and 54 so constructed as to embody band pass characteristics which will permit both of the intermediate difference frequencies to pass with substantially no discrimination.

These two intermediate frequencies are of course amplified in the intermediate frequency amplifiers and are thereafter demodulated in a suitable detector 55 wherein the intermediate frequencies beat together to form a $3\frac{1}{2}$ -kilocycle beat note. Thus the audio output of the detector 55 includes in addition to the voice frequencies a constant frequency $3\frac{1}{2}$ -kilocycle beat note. These audio components are then amplified in a suitable audio amplifier 56 having a plurality of output circuits, which respectively constitute the control channel and the signal channel of the receiver. The control channel comprises a $3\frac{1}{2}$ -kilocycle band pass filter 57 which is sharply tuned so as to reject all of the audio components except the $3\frac{1}{2}$ -kilocycle note and also to reject the static side bands which may be present in the output of the audio amplifier. The output from the $3\frac{1}{2}$ -kilocycle filter 57 is then amplified by a suitable audio amplifier 58, and, after being rectified in a full wave rectifier 59, is impressed on the operating winding 60 of a suitable control relay. There is of course no limit on the sharpness of the filter 57 because it is unnecessary for any of the other audio components to pass through this filter.

The signal channel connected to the output of the audio amplifier 56 comprises a 3-kilocycle low pass filter 61, which is effective to reject the $3\frac{1}{2}$ -kilocycle beat note, but which passes all of the lower frequency audio components. The output of this low pass filter of course constitutes the output circuit of the receiver and is connected through an audio amplifier 61a and suitable output conductors 62 to the movable contacts 63 of the output control relay for selectively connecting the signal channel output circuit to suitable utilizing means such as a loud speaker or headphones through suitable conductors 64.

When the operating winding 60 is energized by the rectified $3\frac{1}{2}$ -kilocycle note, the contacts 63 will be closed to render the signal channel of the receiver operative, but in the absence of the $3\frac{1}{2}$ -kilocycle note the relay will remain open to render the receiver inoperative. Of course, in the absence of a carrier the oscillators 51 and 52 will beat together to generate a $3\frac{1}{2}$ -cycle note which will be suppressed by the intermediate fre-

quency amplifiers 53 and 54, and, as in the other embodiments of the invention, static pulses or side bands cannot actuate the control relay because they are filtered out by the sharply tuned band pass filter 57.

While the embodiment shown in Fig. 4 is similar to the previously described embodiments in that the audio beat note generated for control purposes is independent of the carrier frequency and may be sharply filtered to remove all static components, this particular embodiment is subject to certain limitations because of the necessity of providing intermediate band pass filter amplifiers capable of passing both intermediate frequencies, which detracts from the selectivity of the receiver. With this system it is also necessary to limit the audio response of the receiver since only audio components below 3.5 kilocycles, for example, are passed to the output circuit of the signal channel.

In the embodiment of Fig. 5 the above referred to limitation in the modification of Fig. 4 is overcome, while at the same time retaining a portion of the common signal and control channel. In this embodiment the antenna 10 and the radio frequency amplifier 11 are similar to the previously described corresponding elements, but the output of the radio frequency amplifier is connected, as shown, to two frequency converters 65 and 66. The frequency converter 65 forms a part of the signal channel of the receiver and is provided with a local oscillator 67 which is adapted to heterodyne with the carrier of the signal energy to provide an intermediate frequency which then passes through two identical intermediate frequency amplifier stages indicated in the drawings by the reference numeral 68. Similarly, the converter 66 forms a part of the control channel and is associated with a crystal oscillator 69 having a frequency which differs from the frequency of the oscillator 67 by some suitable audio frequency such, for example, as 15 kilocycles. The intermediate heterodyne frequency produced in the converter 66 passes through two intermediate frequency amplifier stages represented in the drawings by the reference numeral 70, and as illustrated in the drawings the outputs of the intermediate frequency amplifiers 68 and 70 are connected to a common detector 71. In this detector the voice frequencies are demodulated and the two intermediate frequencies supplied from the signal channel and the control channel beat together to generate a 15-kilocycle audio beat note. The voice frequencies and this beat note are then amplified in a suitable audio amplifier 72, the output of which is again divided to provide separate control and signal channels. The control channel comprises a 15-kilocycle band pass filter 73 which serves to reject the various audio components in the output except for the 15-kilocycle beat note. The filtered beat note is rectified in a suitable rectifier 74 and the rectified beat note is impressed on the operating winding 75 of the output control relay. In the signal channel of the receiver there is provided a 10-kilocycle low pass filter 76, which rejects the 15-kilocycle tone, but passes all of the audio components below 10 kilocycles. The voice currents passed by the filter 76 are next amplified in a suitable output amplifier 77 which is connected to the movable contacts 78 of the control relay, the co-operating contacts of which are connected through suitable conductors 79 to headphones or loud-speakers, as previously described.

In this embodiment the intermediate frequency amplifier stages 68 and 70 in the signal and control channels may be tuned to the intermediate heterodyne frequencies produced in the respective channels, and since there is no necessity for the broad pass characteristic employed in the embodiment of Fig. 4, the selectivity of the set is not reduced. As in the previously described embodiment, however, the frequency of the audio beat note produced is independent of the carrier frequency and consequently very sharp tuning of the band pass filter 73 may be employed. Furthermore, in this embodiment the audio response of the receiver is not so limited as in the embodiment of Fig. 4, since all audio frequency components up to 10 kilocycles will be present in the audio output circuit of the signal channel.

It will of course be understood that means other than the various output control relays heretofore described may be utilized for rendering the receiver circuit operative and inoperative in accordance with the presence or absence of a suitably generated audio beat note, and in Fig. 6 there is shown an embodiment of the invention which not only employs a somewhat different type of control means, but also utilizes a somewhat different control channel for producing the audio beat note.

In the embodiment of Fig. 6 a conventional heterodyne receiver similar to the receiver of Fig. 1 is employed, consisting of the same conventional elements 10 to 16, inclusive, as were described in connection with Fig. 1. In this embodiment, however, the audio amplifier is illustrated as comprising an amplifying tube 80, the output circuit of which is connected through a suitable transformer 81 and conductors 82 to utilization means such as headphones or loud-speakers (not shown). The control channel comprises an intermediate frequency amplifier 83 which is connected to the intermediate frequency stage of the signal channel between the amplifiers 14 and 15, and a suitable frequency converter 84 to which is connected an oscillator 85. The oscillator 85 generates a frequency which differs from the intermediate frequency of the signal channel by an audio frequency which, for example, may be 20 kilocycles. Thus there are produced in the frequency converter 84 frequencies which represent the sum and difference of the intermediate and the oscillator frequencies.

Following the frequency converter 84 there are disposed in the control channel a plurality of 20-kilocycle band pass filters and amplifiers 86 which are designed to pass only the difference frequencies and reject the sum frequencies generated in the converter 84. As previously indicated, the amount of static which appears in the audio output of an ordinary receiver is a function of the static side bands that the receiver will accept and the width of this band of acceptance is a function of two factors, one being that a width sufficient to allow acceptance of the audio spectrum must be employed in order that the signals may be understood. This factor, of course, is not present in the control channel of the embodiment shown in Fig. 6, because there is no necessity for passing audio frequencies other than the 20-kilocycle note. The second factor which affects the amount of static lies in the inherent sharpness that can be secured with intermediate frequency amplifiers, this sharpness being on a percentage basis. For example, if the Q of an intermediate frequency transformer is 200, a frequency 10% from the acceptance frequency will

be attenuated 32.5 decibels. Thus if an intermediate frequency of 350 kilocycles is employed, a total band width of 70 kilocycles will be passed when the suppression is 32.5 decibels. If, however, a transformer with a similar Q is used in a 20-kilocycle band pass filter, a suppression of 32.5 decibels will prevail with a total band width of only 4 kilocycles. With a series of sharply tuned filters such as are shown in Fig. 6, it is possible to secure a band width of only 2 kilocycles with an attenuation of 80 decibels. Consequently substantially all of the static components will be rejected. As shown in Fig. 6, the filtered 20-kilocycle note is rectified in a full wave rectifier 87, and the output voltage of the rectifier is impressed across a suitable resistor 88, a condenser 89 being provided to remove any trace of the 20-kilocycle note or other frequency from the output of the rectifier.

Because of the large number of stages which are included in the control channel, thermal effects in the various tubes may produce a rectified current which appears in the resistor 88. In order to balance out this current, a suitable adjustable resistor 90 is provided connected through the resistor 88 across a suitable source of high voltage, represented by the terminal 91 and the ground connection 92. Associated with the resistors 88 and 90, and with the audio amplifier tube 80 for the purposes of controlling the output of the receiver, are a plurality of isolating and balancing resistors 93, 94, 95, 96 and 97, and a suitable three-element electric-discharge device or tube 98. With the resistors 93, 96 and 97 connected across the source of high voltage, as indicated in the drawings, and with the grid or control element 99 of the tube 98 connected to the common terminal of the resistors 88 and 90, the resistor 90 may be adjusted until the current flowing through the resistors 90 and 88 exactly balances the normal current flowing through the resistor 88 due to the thermal effect of the tubes hereinbefore referred to. Thus, substantially zero bias is normally applied to the grid 99 of the tube 98, which has a high plate current, and consequently a high current flows through the resistor 94. As shown, this resistor 94 is connected through the isolating resistor 95 to the grid circuit of the amplifier tube 80 and consequently there will be applied to the amplifier 80 a bias sufficiently high to cut off the plate current therein and block the production of audio energy therein. Thus the signal channel of the receiver is rendered inoperative.

When a carrier is received by the receiver and heterodyned in the signal and control channels so as to provide a 20-kilocycle note at the input terminals of the rectifier 87, a voltage is produced across the resistor 88 which effects a substantial reduction in the plate current of the tube 98 and thus decreases the current flow through the resistor 94. Thus normal bias is restored to the grid circuit of the amplifier 80, and the audio components received thereby from the detector 16 will be amplified and transmitted through the transformer 81 and the conductors 82 to the utilization means with which the receiver is associated.

In this embodiment of the invention, the vacuum tube relay operates substantially in the same manner as the various relays illustrated in Figs. 1 to 5 to render the receiver inoperative in the absence of an audio beat note in the control channel, and to render the signal channel of the receiver operative whenever a carrier is re-

ceived which will enable the production of the desired beat note in the control channel. As in the previously described embodiments, the intermediate amplifiers 14 and 83, in the absence of a suitable carrier, reject the locally generated frequencies produced by the oscillator 13, and the 20-kilocycle band pass filters 86 in the control channel will, in the absence of a carrier, reject the locally generated frequency produced by the oscillator 85. This embodiment of the invention, however, differs from the previously described embodiments in that the beat note produced is not independent of the carrier frequency received, and consequently the sharpness of the tuning which may be utilized in the 20-kilocycle band pass filters is limited by the accuracy and the constancy of the carrier frequencies to be received.

While particular embodiments of the invention have been shown, it will be understood, of course, that it is not desired that the invention be limited thereto since many modifications may be made, and it is, therefore, contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In a radio receiver having a signal channel including an audio stage; the combination of means for rendering said receiver operative whenever, and only when, signal energy from a transmitter station is being received and regardless of existing static conditions, comprising; a control channel coupled to said signal channel for energization therefrom; means for heterodyning selected components of the signal energy in said control channel to produce heterodyne signals including a predetermined beat note in the audio frequency range; means in said control channel independent of said signal channel audio stage for sharply filtering said heterodyne signals to pass said audio beat note and substantially eliminate all other components including the static side bands thereof; and means for controlling the output circuit of said receiver to render said output circuit operative or inoperative in response to the presence or absence of said audio beat note at the output side of said filter means.

2. In a radio receiver; the combination of means for rendering said receiver operative whenever, and only when, signal energy from a transmitter station is being received and regardless of existing static conditions, comprising; means for locally generating at least two signal frequencies differing from each other by a predetermined audio frequency; means for heterodyning said locally generated signal frequencies with selected components of the received signal energy to produce a constant frequency audio beat note regardless of variations in the frequency of the carrier component of the received signal energy; means for sharply filtering the heterodyne signals to pass said audio beat note and reject substantially all other components of said heterodyne signals including the static side bands thereof; and means responsive to the presence or absence of said audio beat note at the output side of said filter means for controlling the output of said receiver.

3. In a radio receiver having a signal channel including an audio stage; the combination of

means for rendering said receiver operative whenever, and only when, signal energy from a transmitter station is being received and regardless of existing static conditions, comprising; a control channel coupled to said signal channel for energization therefrom; means for heterodyning selected components of the signal energy in said control channel to produce heterodyne signals including a predetermined beat note in the audio frequency range; means in said control channel independent of said signal channel audio stage for sharply filtering said heterodyne signals to pass said audio beat note and substantially eliminate all other components including the static side bands thereof; means for rectifying said audio beat note; and means operable by said rectified beat note for selectively rendering the output circuit of said receiver operative.

4. In a superheterodyne receiver having a signal channel including an audio stage and means for heterodyning the incoming signal energy with locally generated signals to produce intermediate frequency components, the combination of a control channel coupled to said signal channel for energization by said intermediate frequency components, means in said control channel for heterodyning additional locally generated signals with said intermediate frequency components of said signal energy to produce an audio beat note of predetermined frequency, band-pass filter means in said control channel independent of said signal channel audio stage for passing said audio beat note and for rejecting other components of said signal energy including the static side bands thereof, and means responsive to the audio beat note passed by said filter means for rendering said receiver operative only when the input to said receiver includes signal energy components from which said audio beat note may be heterodyned.

5. In a radio receiver having a signal channel terminating in an output circuit, the combination of means for locally generating a plurality of signals having a predetermined frequency difference in the audio range, means for heterodyning said locally generated signals with components of the received signal energy to produce an audio beat note having a frequency equal to said frequency difference regardless of the frequency of the carrier component of said signal energy, band-pass filter means for passing only said audio beat note and rejecting substantially all other components of said signal energy including the static side bands thereof, and means responsive to said audio beat note passed by said filter means for rendering said signal channel operative to energize said output circuit only when said signal channel includes signal energy components from which said beat note may be heterodyned.

6. In a superheterodyne receiver having a signal channel including an audio stage and means for heterodyning the incoming signal energy with locally generated signals to produce intermediate frequency components, the combination of a control channel coupled to said signal channel for energization by said intermediate frequency components, means in said control channel for heterodyning additional locally generated signals with said intermediate frequency components of said incoming signal energy to produce an audio beat note of predetermined frequency, band-pass filter means in said control channel independent of said signal channel audio stage for passing said audio beat note and for rejecting other

components of said signal energy including the static side bands thereof, means for rectifying said audio beat note, and means responsive to said rectified audio beat note for rendering said receiver operative only when the input to said receiver includes signal energy components from which said audio beat note may be heterodyned.

7. In a radio receiver having a signal channel terminating in an audio stage coupled to an output circuit, the combination of a control channel coupled to said signal channel for energization therefrom by a component of the signal energy in said signal channel, means for locally generating signals differing in frequency from said signal energy component, means in said control channel for heterodyning said locally generated signals with said signal energy component in said control channel to produce heterodyne signals including an audio beat note, band-pass filter means in said control channel independent of said signal channel audio stage for passing said audio beat note and rejecting static side bands contained in said heterodyne signals, and means responsive to said audio beat note for rendering said signal channel operative to energize said output circuit only when said signal channel supplies to said control channel signal energy components from which said beat note may be heterodyned.

8. In a superheterodyne receiver having a signal channel including an audio stage and means for heterodyning the incoming signal energy with locally generated signals to produce intermediate frequency components, the combination of a control channel coupled to an intermediate frequency stage of said signal channel for energization therefrom, means for locally generating additional signals differing in frequency from said intermediate frequency components, means in said control channel for heterodyning said additional locally generated signals with said intermediate frequency components to produce an audio beat note component, band-pass filter means in said control channel independent of said signal channel audio stage for passing said audio beat note component and rejecting other components present in said control channel including the static side band components thereof, and means responsive to said audio beat note component for rendering said receiver operative only when the input to said receiver includes signal energy components from which said audio beat note may be produced in said control channel.

9. In a superheterodyne receiver having a signal channel including means for heterodyning the incoming signal energy to produce intermediate frequency components, the combination of a control channel coupled to an intermediate frequency stage of said signal channel for energization therefrom, means for locally generating a first frequency which differs by an audio frequency from the intermediate frequency component in said control channel, means for locally generating a second frequency which differs by another audio frequency from said intermediate frequency component, means for heterodyning said locally generated frequencies with said intermediate frequency component to produce sum and difference frequencies, audio frequency band-pass filter means in said control channel for passing without substantial discrimination said audio difference frequencies of said heterodyning means, means for heterodyning said audio difference frequencies to produce sum and dif-

ference frequencies therefrom, said last-mentioned difference frequency being an audio beat note equal to the frequency difference between said locally generated frequencies, sharp tuned filter means for passing said audio beat note and rejecting substantially all other frequency components in said control channel including the static side bands thereof, and means responsive to said audio beat note for rendering said receiver operative only when the input to said receiver includes signal components from which said beat note may be heterodyned.

10. In a superheterodyne receiver having a signal channel including means for heterodyning the incoming signal energy to produce an intermediate frequency component, the combination of a control channel coupled to an intermediate frequency stage of said signal channel for energization therefrom, means for locally generating a first frequency, means for heterodyning said first frequency with the intermediate frequency component in said control channel to produce sum and difference heterodyne frequencies, means for amplifying one only of said sum and difference frequencies, means for heterodyning said amplified frequency with said intermediate frequency component to produce sum and difference heterodyne frequencies one of which is equal to said first locally generated frequency, means for locally generating a second frequency differing from said first frequency by a predetermined audio frequency, means for heterodyning said second locally generated frequency with said last-mentioned sum and difference heterodyne frequencies to produce other heterodyne frequencies one of which is equal to said audio frequency difference, sharp filter means for passing said audio heterodyne frequency and rejecting substantially all other components of said heterodyne frequencies including the static side bands thereof, and means responsive to said audio frequency for rendering said receiver operative only when the input to said receiver includes signal components from which said audio frequency may be heterodyned.

11. In a radio receiver, the combination of means for locally generating a pair of radio frequencies having a predetermined audio frequency difference, means for heterodyning said locally generated frequencies with the radio frequency component of the incoming signal energy to produce two sets of sum and difference heterodyne frequencies, intermediate frequency amplifier means for amplifying only the difference frequencies of said two sets of heterodyne frequencies, means for combining and demodulating said amplified intermediate frequencies to produce audio frequency components including a beat note equal to said audio frequency difference, band-pass filter means for passing said audio beat note and rejecting substantially all others of said audio components including the static components therein, low pass filter means for passing audio components of frequencies below said audio beat note, audio output means connected to said low pass filter means, and means coupled to the output of said band-pass filter means responsive to said audio beat note for rendering said audio output means operative only when the input to said receiver includes a carrier component from which said audio beat note may be heterodyned.

12. In a radio receiver, the combination of means for locally generating a pair of radio frequencies having a predetermined audio frequency

difference, means for dividing the input signal energy of said receiver into a signal channel and a control channel, means for heterodyning one of said locally generated frequencies with the carrier component of said signal energy in said control channel to produce sum and difference heterodyne frequencies, intermediate frequency amplifier means in said control channel for amplifying only said difference frequency, means for heterodyning the other of said locally generated frequencies with the carrier component of said signal energy in said signal channel to produce other sum and difference heterodyne frequencies, intermediate frequency amplifier means in said signal channel for amplifying only said other difference frequency, means common to said two channels for combining and demodulating said difference frequencies to produce audio frequency components including a constant frequency audio beat note equal to said predetermined audio frequency difference, band-pass filter means connected to the output of said common means for passing said audio beat note and rejecting from said control channel substantially all others of said audio components including the static components therein, low pass filter means connected to the output of said common means for passing to said signal channel audio components of frequencies below said audio beat note, audio output means for said signal channel, and means in said control channel responsive to said audio beat note for rendering said audio output means operative only when the input to said receiver includes a carrier component

from which said audio beat note may be produced.

13. The method of controlling the audio output stage of a radio receiver to render said receiver operative only when the carrier of a transmitted signal is being received, which method comprises heterodyning selected components of said carrier with locally generated frequencies to produce heterodyne signals including an audio frequency beat note current, sharply filtering said heterodyne signals independently of said audio stage of said receiver to eliminate the static components from said signals, and rendering said audio output stage operative or inoperative in accordance with the presence or absence of said beat note current in the output of the filter circuit.

14. The method of controlling a radio receiver to render said receiver operative only when the carrier of a transmitted signal is being received, which method comprises heterodyning selected components of said carrier with a plurality of selected locally generated frequencies to produce heterodyne signals including an audio beat note current independent of the frequency of said carrier and differing in frequency from said locally generated frequencies, suppressing heterodyne frequencies generated in the absence of said carrier, filtering said heterodyne signals to eliminate static components therefrom, and rendering said receiver operative or inoperative in accordance with the presence or absence of said beat note current.

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