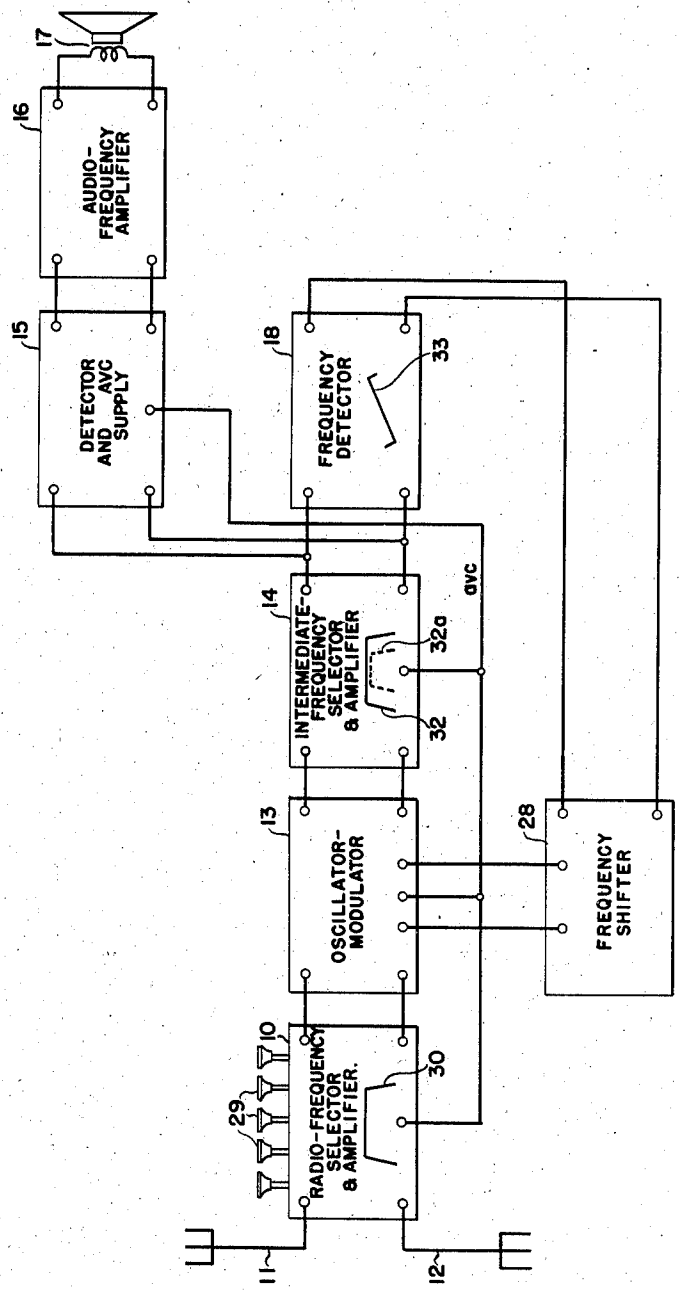
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CARRIER-SIGNAL RECEIVER

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CARRIER-SIGNAL RECEIVER

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The present invention relates to carrier-signal receivers and, particularly, to an automatic frequency control system for such receivers. While the invention is of general application, it is particularly adaptable to an ultra-high frequency carrier-signal receiver provided with an automatic frequency control system, the receiver having relatively little selectivity during the initial operation of tuning the receiver to a desired carrier signal but greatly increased selectivity after the receiver has been accurately tuned to such carrier signal.

Ultra-high-frequency carrier-signal receivers of the superheterodyne type are usually extremely selective and, therefore, difficult to tune accurately to a desired carrier signal. Furthermore, after such a receiver has initially been carefully tuned, the accuracy of tuning is quite likely to be impaired soon afterward by the frequency drift inherent in the conventional forms of local heterodyne oscillator. To facilitate accuracy in the initial tuning operation and to maintain a high degree of accuracy of tuning once established, it is desirable that the receiver be provided with some form of automatic frequency control system. The use of an automatic frequency control system, which generally takes the form of an automatic control of the heterodyne oscillator frequency, is particularly advantageous where tuning of the receiver is accomplished by mechanical or electrical tuning means initially preset to individual ones of a number of desired carrier signals, any one of which may be selected at will as by the manual operation of a selected tuning button.

Automatic frequency control system generally have a frequency detector which is responsive to the frequency of a carrier signal passed by one or more carrier-signal selectors. It is possible to make the pass band of the frequency detector quite broad and yet to retain the required degree of detector sensitivity. This broadness would be desirable to facilitate the ease of the initial manual tuning operation or to extend the permissible limits of inaccuracy of tuning of the preset tuning means. This has not been possible heretofore, however, since the effectiveness of the frequency detector over a band of frequencies is limited by the pass band of the selector circuits which precede it and the latter necessarily is narrow to ensure adequate selectivity of the receiver against undesired carrier signals on transmission channels adjacent to that of the desired carrier signal.

It is an object of the invention, therefore, to provide a new and improved carrier-signal receiver having an automatic frequency control system which avoids one or more of the above-mentioned disadvantages and limitations of the prior art systems.

It is a further object of the invention to provide a carrier-signal receiver having an automatic frequency control system and having a band-pass selector which initially has a relatively wide pass band and in which the pass band is narrowed with the accurate tuning of the receiver to a desired signal.

In accordance with the invention, a carrier-signal receiver comprises a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of a carrier signal to be translated thereby. The relation between said mean frequencies is subject to deviations from the aforesaid predetermined relation, which deviations may be substantial as compared with the band width of the carrier signal. The selector initially has a pass band sufficiently wide to include the carrier signal and the aforesaid deviations. The receiver includes means responsive to the mean frequency of a carrier signal passed by the selector for reducing the deviations substantially to maintain the aforesaid normal predetermined relation and means for contracting the pass band of the selector in response to the translation of a carrier signal thereby.

In accordance with a preferred form of the invention, a carrier-signal receiver of the superheterodyne type comprises means for converting a received carrier signal to an intermediate-frequency carrier signal normally having a predetermined mean frequency but subject to undesired deviations therefrom which may be substantial as compared with the band width of the carrier signal. The receiver is provided with an intermediate-frequency carrier-signal translating channel including a band-pass selector of adjustable band width having an initial pass band sufficiently wide to include the carrier signal and the aforesaid undesired deviations. The receiver also includes means responsive to the mean frequency of an intermediate-frequency carrier signal passed by the selector for controlling the converting means to reduce the aforesaid undesired deviations and means for contracting the pass band of the selector in response to the translation of an intermediate-frequency carrier signal thereby.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the accompanying drawing, the single figure is a circuit diagram, partly schematic, of a complete carrier-signal receiver of the superheterodyne type embodying the present invention.

Referring now more particularly to the drawing, there is represented a complete carrier-signal receiver of the superheterodyne type embodying the present invention in a preferred form. In general, the receiver includes a radio-frequency selector and amplifier **10** having its input circuit connected to an antenna system **11**, **12**, and having its output circuit connected to an oscillator-modulator **13**. Connected in cascade with the oscillator-modulator **13**, in the order named, are an intermediate-frequency selector and amplifier **14** of one or more stages, a detector and A. V. C. supply **15**, an audio-frequency amplifier **16** of one or more stages, and a sound reproducer **17**. Also connected to the output of the intermediate-frequency amplifier **14** is a frequency detector **18**, the output of which is, in turn, coupled to the input circuit of a frequency shifter **28**. The latter includes a frequency-control circuit coupled with the oscillator-modulator **13**.

The receiver is provided with electrical or mechanical preset tuning means indicated schematically at **29**, comprising a plurality of tuning buttons by which the selector of unit **10** may be tuned to any desired one of a number of preselected carrier signals.

An automatic amplification control or A. V. C. circuit is connected between the output circuit of the A. V. C. supply of unit **15** and the input circuits of one or more of the tubes of the radio-frequency amplifier **10**, the oscillator-modulator **13**, and the intermediate-frequency amplifier **14**, in conventional manner.

It will be understood that the various units just described may, with one or two exceptions presently to be considered, be of a conventional construction and operation, the details of which are well known in the art, rendering detailed description thereof unnecessary. Considering briefly the operation of the receiver as a whole, a desired carrier signal is selected and amplified by the radio-frequency amplifier **10**, converted to an intermediate-frequency carrier signal in the oscillator-modulator **13**, amplified in the intermediate-frequency amplifier **14**, and detected by the detector **15**, thereby to derive the audio-frequency modulation components. The audio-frequency components are, in turn, amplified in the audio-frequency amplifier **16** and are reproduced by the sound reproducer **17** in a conventional manner.

From the intermediate-frequency carrier signals applied to the input of the frequency detector **18**, there is derived in the output circuit of the frequency detector a control potential which is applied to the frequency shifter **28** to control the frequency of oscillations generated by the oscillator of unit **13**, thereby to maintain the frequency of the intermediate-frequency carrier signal substantially constant at a predetermined value in a conventional manner.

The automatic amplification control or A. V. C. bias derived from the A. V. C. supply of unit **15** is effective to control the amplification of one or more of the units **10**, **13**, and **14** to maintain the signal input to the detector of unit **15** within a relatively narrow range for a wide range of received signal intensities.

Referring now more particularly to the portions of the system embodying the present invention, the selector circuit of radio-frequency amplifier **10** has a wide band-pass characteristic, as indicated by curve **30**, which is wider than desirable for freedom from interference from undesired carrier signals adjacent to the desired carrier signal and from excessive noise components. The intermediate-frequency amplifier **14** comprises a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of the intermediate-frequency carrier signal to be translated thereby. The relation between these mean frequencies is subject to deviations from the aforesaid predetermined relation which may be substantial as compared with the band width of the carrier signal. The band-pass selector of amplifier **14** may be of any suitable type wherein the pass band thereof is contracted in accordance with the value of a control bias applied thereto, for example, of the type disclosed in United States Letters Patent No. 2,152,618 issued to Harold A. Wheeler on March 28, 1939. The band-pass selector of that patent includes input and output resonant circuits coupled by a forward coupling tube and a backward coupling tube, the contraction of the pass band of the selector being accomplished by applying to at least one of the tubes a negative control bias to reduce the transconductance thereof with increasing amplitude of signal output and control bias. The band-pass selector of the present invention is designed to have initially a pass band sufficiently wide to include both the carrier signal to be translated by the selector and also the deviations to which reference has previously been made, as indicated by curve **32**.

The A. V. C. bias derived from unit **15** varies with the mean amplitude of the carrier-signal output from unit **14** and is applied to one or more of the tubes of the band-pass selector system of the amplifier **14** in such sense as to adjust the pass band of the selector inversely in accordance with the mean amplitude of the carrier signal. If the circuit of the above-mentioned Patent 2,152,618 is employed, it is preferable that this bias be applied to the backward tube or tubes, to secure the most complete reduction of the pass band on moderately weak signals. A signal of sufficient strength operates to reduce the pass band of the selector substantially to the minimum permissible value for reducing interfering disturbances. The contracted pass band of the selector is much less than the initial pass band and is preferably only sufficiently wide to pass the modulation band of the desired carrier signal, the reduced pass band being indicated by the broken-line curve **32***a* of the drawing.

The constants of the control-bias circuit of the band-pass selector, to which the control bias from unit **15** is applied, may be proportioned to have a time constant such that the contraction of the pass band of the selector is relatively slow as compared with the frequency compensation effected by unit **28**.

The pass band of the frequency detector **18** is preferably at least as wide as the initial pass band of the band-pass selector of the interme-

diate-frequency amplifier 14, as indicated by the curve 33 which is the frequency-response curve of the frequency detector 18.

In considering the operation of the invention, it will be assumed that the receiver is not tuned to any carrier signal and it is desired manually to tune the receiver to a particular carrier signal. The receiver is tuned into such proximity with the desired carrier signal that the latter is within the wide band-pass characteristics of the radio-frequency amplifier 10, whereupon a corresponding intermediate-frequency carrier signal appears within the wide band-pass characteristic 32 of the band-pass selector of intermediate frequency amplifier 14. A bias-control voltage is thereupon derived in the output of the frequency detector 18 and is applied to the frequency shifter 28 which operates so to change the frequency of oscillations generated by the oscillator of unit 13 that the frequency of the intermediate-frequency carrier signal is adjusted to a value approximately equal to the mean resonant frequency of the band-pass selector of amplifier 14. The time constant of this automatic frequency control is preferably very short, unless the carrier signal is of the frequency-modulation type, in which case this time constant is greater than the periods of the low frequencies of modulation. Under the assumed conditions, a control bias is also developed by the A. V. C. supply of unit 15, but the action of this bias in controlling the band-pass selector of amplifier 14 to contract the pass band is delayed by the relatively long time constant of this circuit so that the pass band of the selector does not become fully contracted until after the automatic frequency control system comprising detector 18 and the frequency shifter 28 has shifted the frequency of the intermediate-frequency carrier signal substantially to the mean resonant frequency of the band-pass selector of unit 14. It is desirable that the contraction of the pass band of the selector be not only delayed with respect to the frequency correction of the intermediate-frequency carrier signal, but also that the pass band contraction occur substantially instantaneously.

Since distortion of the desired carrier signal or interference therewith may be caused by undesired frequency deviations between the mean resonant frequency of the intermediate-frequency selector of unit 14 and the mean frequency of the intermediate-frequency carrier signal, it may, in general, be said that the receiver as a whole is accurately tuned to the desired carrier signal when such deviations are reduced to a minimum even though the units 10 and 13 may be somewhat detuned from the received carrier signal. When this condition is established, or shortly subsequent thereto, the pass band of the selector of amplifier 14 automatically becomes fully contracted, whereupon the receiver operates with a high selectivity against interference by undesired carrier signals adjacent to that of the desired carrier signal and against excessive noise components. It may be noted that, once the automatic frequency control system comprising detector 18 and frequency shifter 28 has accurately tuned the receiver to a desired carrier signal, the accuracy of such tuning is thereafter maintained, even though the receiver is highly selective by virtue of the contracted pass band of the band-pass selector, since any change of frequency of the received carrier signal or frequency drift of the local oscillator is immediately corrected by the action of the automatic frequency control system.

On detuning the receiver from a received carrier signal, the A. V. C. control bias from unit 15 disappears, the pass band of the band-pass selector of unit 14 thereupon expands to its initial width, and the receiver thereafter has an over-all wide pass band characteristic and is conditioned to be tuned with facility to any desired carrier signal.

The frequency detector 18 and the frequency shifter 28 thus comprise means responsive to the mean frequency of a carrier signal passed by the band-pass selector of unit 14 for reducing the deviations from a predetermined desired relation between the mean frequency of the intermediate-frequency carrier signal and the mean resonant frequency of the selector of unit 14, thereby substantially to maintain the desired normal predetermined relation therebetween. That is, it is desired that the intermediate-frequency carrier signal have a mean frequency substantially equal to the mean resonant frequency of the band-pass selector of unit 14 and that the automatic frequency control system comprising the frequency detector 18 and the frequency shifter 28 so control oscillator-modulator 13 as to maintain the mean frequency of the intermediate-frequency carrier signal substantially at this desired value.

The foregoing description of the operation of the invention applies equally well whether the receiver is manually tuned to a desired carrier signal, or is tuned by the manual operation of a selected push-button of the preset tuning means 29. A carrier-signal receiver embodying the invention has the advantage that the most selective part of the receiver automatically is accurately tuned to a desired carrier signal, even though the less selective radio-frequency amplifier 10 and oscillator-modulator 13 are tuned only approximately to the desired carrier signal by the operation of the preset tuning means 29. This is especially important in the higher frequency bands where it is relatively difficult initially to preset the tuning means 29 with sufficient precision to selected carrier signals and where, even though the tuning means 29 has initially been accurately preset, it is difficult to maintain such accuracy of tuning over any appreciable period of time.

A carrier-signal receiver embodying the invention has the additional advantage that the initial over-all broad pass-band characteristic of the receiver greatly facilitates the ease by which the receiver may be tuned to a desired carrier signal. That is, the initial broad pass-band characteristic of the receiver permits the automatic frequency control system to operate over a pass band materially wider than that heretofore possible where the receiver has necessarily had a relatively narrow pass-band characteristic to avoid undue interference from undesired carrier signals in proximity to a desired received carrier signal.

While the above description of the invention and its operation has, in general, been treated as though the invention were embodied in an amplitude-modulated carrier-signal receiver, the invention is equally suitable for use in a frequency-modulated carrier-signal receiver or in a carrier-signal receiver adapted to receive a desired carrier signal and a single modulation sideband thereof.

Where the carrier-signal receiver is of the frequency-modulated type, the unit **15** comprises a frequency-modulation detector and may include an amplitude-limiting system of conventional form. Alternately, in this form of receiver either one of the units **15** or **18** may be omitted and the input of the audio-frequency amplifier **16** is then connected to the output of the unit retained. In the latter event, the A. V. C. supply is included in the retained unit and is arranged to be responsive to the amplitude of the intermediate-frequency carrier signal in conventional manner.

In the event that the carrier-signal receiver is of the single sideband type, that is, adapted to receive a carrier signal and a single modulation sideband thereof, the intermediate-frequency carrier signal has a frequency near one edge of the pass-band characteristic **32***a* of the selector of unit **14** and the automatic frequency control system, comprising the frequency detector **18** and the frequency shifter **28**, so controls the operation of the oscillator-modulator **13** that the frequency of the intermediate-frequency carrier signal is adjusted to and maintained at this particular relationship with respect to the pass-band characteristic of the selector of unit **14**.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A carrier-signal receiver comprising, a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of a carrier signal to be translated thereby, the relation between said mean frequencies being subject to deviations from said predetermined relation which may be substantial as compared with the band width of said signal, said selector initially having a pass band sufficiently wide to include said signal and said deviations, means responsive to the mean frequency of a carrier signal passed by said selector for reducing said deviations substantially to maintain said normal predetermined relation, and means for contracting the pass band of said selector in response to the translation of a carrier signal thereby.

2. A carrier-signal receiver comprising, a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally equal to the mean frequency of a carrier signal to be translated thereby, the difference between said mean frequencies being subject to deviations from zero which may be substantial as compared with the band width of said signal, said selector initially having a pass band sufficiently wide to include said signal and said deviations, means responsive to the mean frequency of a carrier signal passed by said selector for reducing said deviations, and means for contracting the pass band of said selector in response to the translation of a carrier signal thereby.

3. A carrier-signal receiver comprising, a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of a carrier signal to be translated thereby, the relation between said mean frequencies being subject to deviations from said predetermined relation which may be substantial as compared with the band width of said carrier signal, said selector initially having a pass band sufficiently wide to include said signal and said deviations, means responsive to the mean frequency of a carrier signal passed by said selector for reducing said deviations substantially to maintain said normal predetermined relation, and means having a time constant at least as long as that of said reducing means for contracting the pass band of said selector in response to the translation of a carrier signal thereby.

4. A carrier-signal receiver comprising, a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of a carrier signal to be translated thereby, the relation between said mean frequencies being subject to deviations from said predetermined relation which may be substantial as compared with the band width of said carrier signal, said selector initially having a pass band sufficiently wide to include said signal and said deviations, means having a relatively short time constant responsive to the mean frequency of a carrier signal passed by said selector for reducing said deviations substantially to maintain said normal predetermined relation, and means having a relatively long time constant for contracting the pass band of said selector in response to the translation of a carrier signal thereby.

5. A carrier-signal receiver comprising, a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of a carrier signal to be translated thereby, the relation between said mean frequencies being subject to deviations from said predetermined relation which may be substantial as compared with the band width of said carrier signal, said selector initially having a pass band sufficiently wide to include said signal and said deviations, means responsive to the mean frequency of a carrier signal passed by said selector for reducing said deviations substantially to maintain said normal predetermined relation, and means responsive to the translation of a carrier signal by said selector for contracting the band width of said selector to that corresponding to the band width of said carrier signal.

6. A carrier-signal receiver comprising, a carrier-signal translating channel including a band-pass selector of adjustable band width having a mean resonant frequency normally bearing a predetermined relation to the mean frequency of a carrier signal to be translated thereby, the relation between said mean frequencies being subject to deviations from said predetermined relation which may be substantial as compared with the band width of said carrier signal, said selector initially having a pass band sufficiently wide to include said signal and said deviations, means responsive to the mean frequency of a carrier signal passed by said selector for reducing said deviations substantially to maintain said normal predetermined relation, and means responsive to the translation of a carrier signal by said selector for adjusting the band-pass of said selector inversely in accordance with the mean amplitude of said carrier signal.

7. A superheterodyne carrier-signal receiver comprising, means for converting a received carrier signal to an intermediate-frequency carrier signal normally having a predetermined mean frequency but subject to undesired deviations therefrom which may be substantial as compared with the band width of said carrier signal, an intermediate-frequency carrier signal translating channel including a band-pass selector of adjustable band width having an initial pass band sufficiently wide to include said intermediate-frequency carrier signal and said undesired deviations, means responsive to the mean frequency of an intermediate-frequency carrier signal passed by said selector for controlling said converting means to reduce said undesired deviations, and means for contracting the pass band of said selector in response to the translation of an intermediate-frequency carrier signal thereby.

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