April 21, 1942. N. P. CASE 2,280,187

CARRIER-SIGNAL RECEIVER

Filed July 10, 1940

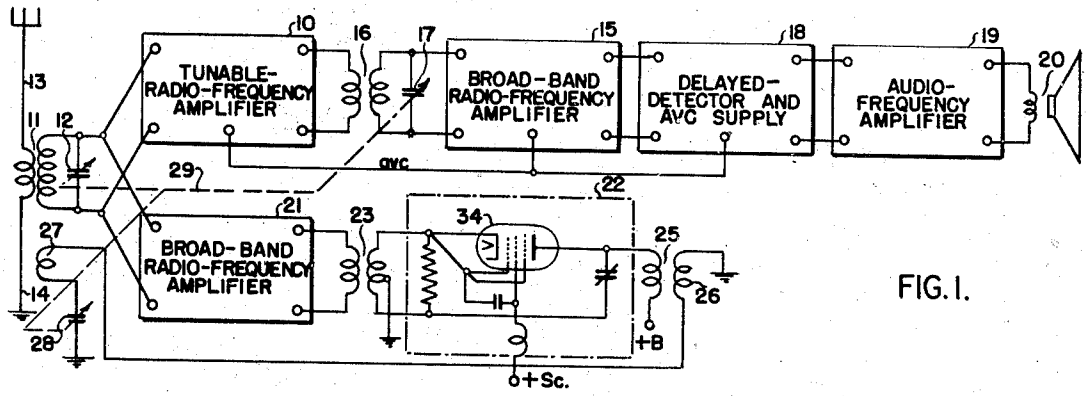

FIG. 1.

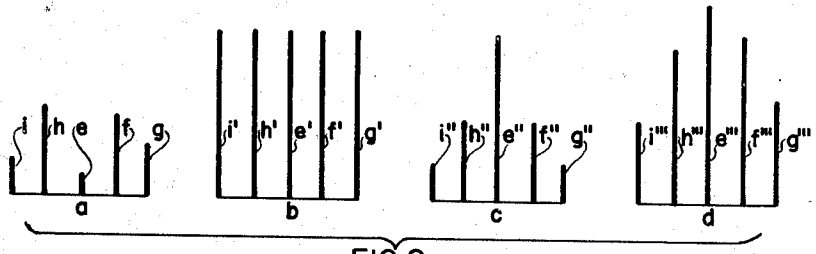

FIG. 2.

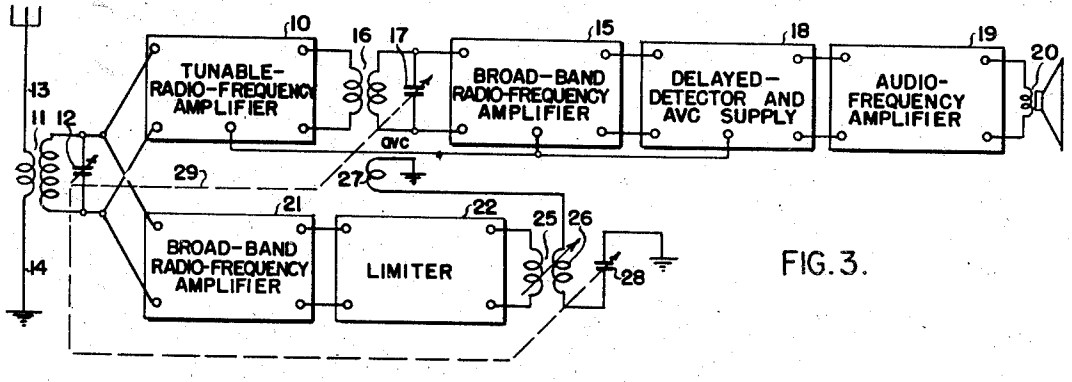

FIG. 3.

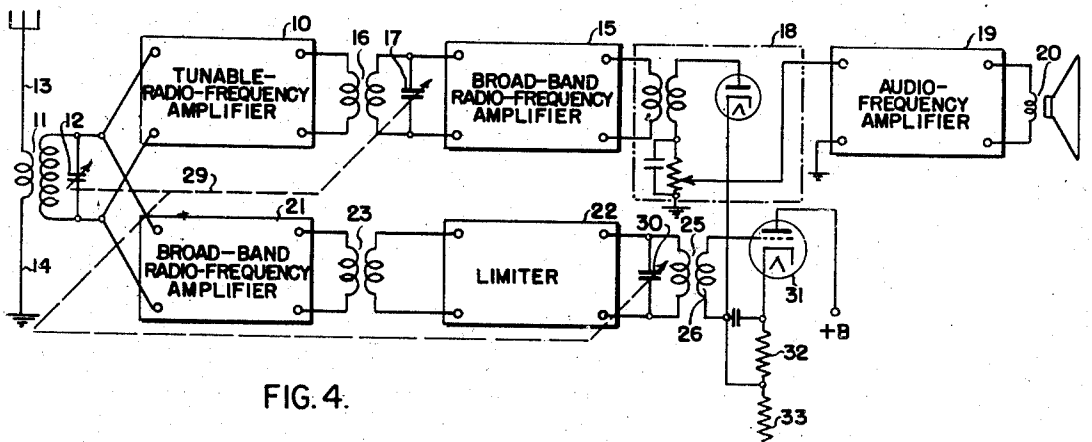

FIG. 4.

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Patented Apr. 21, 1942

2,280,187

UNITED STATES PATENT OFFICE

2,280,187

CARRIER-SIGNAL RECEIVER

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Application July 10, 1940, Serial No. 344,648

10 Claims. (Cl. 250—20)

The present invention relates to an improved carrier-signal receiver and more particularly to a carrier-signal receiver analogous to the homodyne type wherein the apparent selectivity of the receiver is substantially increased by adding to the desired received modulated-carrier signal locally-produced unmodulated carrier signals of relatively large amplitude and of a frequency equal to that of the received carrier signal.

One of the problems in carrier-signal communication has concerned the selectivity of the carrier-signal receiver; that is, the ability of the receiver to select a desired carrier signal to the exclusion of undesired carrier signals which may occupy adjacent channels in the frequency spectrum and may have a strength frequently very much greater than that of the desired signal. The superheterodyne type of carrier-signal receiver, which furnishes one solution to this problem, increases the apparent selectivity of the receiver by locally producing carrier signals individually-modulated in accordance with the modulation of the desired and undesired carrier signals. These new carrier signals are produced by combining the received carrier signals with locally-generated oscillations of a different frequency to produce intermediate-frequency carrier signals which may be subsequently amplified at intermediate frequency and applied to a suitable signal-translating device. However, the superheterodyne type of receiver has certain disadvantages, among which are the problems of image-frequency reception, the failure of the receiver to pass the desired carrier-signal frequency and its entire complement of modulation side-band components, and the difficulty in accomplishing adequate and proper tracking of the local oscillator with the radio-frequency selector circuits.

To avoid these inherent disadvantages of the superheterodyne type of carrier-signal receiver, the homodyne type of carrier-signal receiver was proposed as an additional solution of the selectivity problem. This receiver is capable of giving greater apparent selectivity than other known arrangements having a like number of tuned circuits. Like the superheterodyne type of receiver, the homodyne receiver employs locally-generated oscillations but, unlike the superheterodyne receiver, the frequency of the locally-generated oscillations is the same as that of the desired carrier signal. The homodyne receiver has the disadvantage, however, that the frequency of the locally-generated oscillations is critical and, if it differs only slightly from that of the desired carrier wave, audible beat-frequency components result, thereby producing intolerable distortion. Arrangements for synchronizing the local oscillator with the desired carrier signal have, in general, been relatively sensitive to variations in amplitude of the received signal so that reception is unsatisfactory under certain conditions of operation of the receiver. Furthermore, even though the frequency of the locally-generated oscillations is maintained exactly equal to that of the desired carrier signal, the homodyne receiver has the additional disadvantage that considerable distortion in the reproduction of the desired signal and considerable reduction in the volume of the reproduced signal occur when the locally-generated oscillations do not have the proper phase relationship with respect to the oscillations of the desired carrier signal. Arrangements for controlling the phase between the received and locally-generated oscillations have also generally been either quite complicated or responsive to the amplitude of the received signals and for that reason, in general, have not been commercially adopted. Even where the conditions of reception are such that the amplitude of the received carrier signal does not materially change, many of the phasing arrangements of the prior art have not satisfactorily maintained the correct phase relation necessary to produce optimum volume of distortionless reproduction of the received signal.

It is an object of the present invention, therefore, to provide a new and improved carrier-signal receiver of the homodyne type and one which avoids one or more of the above-mentioned disadvantages of the prior art receivers.

It is a further object of the invention to provide a homodyne type of carrier-signal receiver which derives the unmodulated oscillations necessary for homodyne reception from the received carrier signal itself, whereby the consequent omission of the local oscillator heretofore conventionally employed in such receivers eliminates the many limitations and faults formerly characteristic of this type of receiver which arose from the use of such local oscillator.

It is an additional object of the invention to provide a homodyne type of carrier-signal receiver wherein all received carrier signals of usable signal strength are amplified to a uniform predetermined amplitude level in order that the desired carrier signal may be selectively applied from this group of amplified signals to the signal-translating channel of the receiver,

selectively to reinforce therein the amplitude of the desired carrier signal.

In accordance with the invention, a carrier-signal receiver tunable over a range of frequencies comprises a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to the channel. An untunable broadly-responsive auxiliary signal-translating channel is coupled to the main channel and includes limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal. There is also provided signal-translating means selectively responsive to the desired carrier signal for deriving the desired carrier signal from the auxiliary channel and applying it to the main signal-translating channel to develop therein a desired carrier signal the amplitude of which is in excess of that of undesired carrier signals.

In accordance with a specific form of the invention, the carrier-signal receiver comprises a main signal-translating channel to which is coupled an auxiliary signal-translating channel including signal-amplifying means having a broad-band frequency-response characteristic for amplifying uniformly all received carrier signals in the vicinity of and including the desired carrier signal and there is coupled to the amplifying means, means for limiting to a uniform predetermined amplitude level the carrier signals translated by the amplifying means. The receiver also includes means for selectively applying to the signal channel the uniformly limited desired carrier signal to develop in the signal channel a desired carrier signal the amplitude of which is in excess of that of undesired carrier signals. The receiver also includes signal-demodulating means coupled to the main signal channel and means for rendering the demodulating means unresponsive to carrier signals having an amplitude substantially less than that of the reinforced desired carrier signals.

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.

Referring now to the drawing, Fig. 1 is a circuit diagram, partly schematic, of a complete carrier-signal receiver embodying the invention; Figs. 2*a*–2*d* are graphs representing the strengths of the carrier signals at various points in the receiver of Fig. 1 and are used in explaining the operation of the invention; while Figs. 3 and 4 are circuit diagrams, partly schematic, of receivers incorporating modified embodiments of the invention.

Referring now more particularly to Fig. 1, there is represented schematically a complete carrier-signal receiver embodying the present invention in a preferred form. In general, the receiver includes a main signal-translating channel having an input circuit tunable over a range of frequencies and adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to the channel. This channel comprises a tunable radio-frequency amplifier **10** having an input circuit comprising a radio-frequency transformer **11** which is connected to an antenna-ground system **13, 14** and tuned by a tuning condenser **12**. Connected to the output of radio-frequency amplifier **10** is a broad-band radio-frequency amplifier **15** having an input circuit comprising a radio-frequency transformer **16** and tuning condenser **17**. The radio-frequency amplifier **15** may include one or more stages of amplification and is designed to amplify uniformly signals within a relatively wide range of carrier frequencies applied to the input circuit **16, 17**. Connected in cascade with the output circuit of the radio-frequency amplifier **15**, in the order named, is signal-demodulating means, comprising a delayed detector and automatic amplification control or A. V. C. supply **18**, an audio-frequency amplifier **19**, and a sound reproducer **20**. The output of the automatic amplification control supply is applied to the input circuits of one or more of the tubes of the radio-frequency amplifiers **10** and **15** in conventional manner. There is coupled to the tunable input circuit **11, 12** of the main signal-translating channel an untunable broadly-responsive auxiliary signal-translating channel including signal-amplifying means having an untunable broad-band frequency-response characteristic for amplifying uniformly all received carrier signals in the vicinity of and including the desired carrier signal. The auxiliary channel also includes means coupled to the amplifying means for limiting to a uniform predetermined amplitude level all such received carrier signals. This auxiliary channel comprises an untunable broadly-responsive radio-frequency amplifier **21** which may comprise one or more stages of amplification constituting a signal-translating channel designed to translate uniformly signals within a wide range of carrier frequencies applied to the input circuit **11, 12**. Coupled to the output of the radio-frequency amplifier **21** is the input circuit of an amplitude limiter **22** comprising a radio-frequency transformer **23**.

The amplitude limiter **22** may be of any conventional type so long as the level of limiting is fixed by the constants of the limiting system and does not depend upon the intensity of carrier signals applied thereto. The limiting system here shown forms no part of the invention but is disclosed and claimed in the copending application of Jasper Okrent, Serial No. 337,653, filed May 28, 1940, now United States Letters Patent No. 2,271,203 dated January 27, 1942. It includes a pentode vacuum tube **24** having anode and cathode elements serially connected between the input transformer **23** and an ouput transformer **25**, the tube elements being so energized that limiting occurs on the negative half-cycles of the applied carrier signal by anode current cutoff and on the positive half-cycles by anode current saturation.

There is also included in the carrier-signal receiver signal-translating means selectively responsive to the desired carrier signal or, in other words, tunable to the frequency of the desired carrier signal, for deriving the desired carrier signal from the auxiliary channel and applying it to the main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of the undesired carrier signals. This means comprises a secondary winding **26** provided in the transformer **25** which is connected in a tunable link circuit comprising winding **26**, a winding **27** coupled to the input circuit **11, 12**, and a tuning condenser **28**. The

tuning condensers 12, 17, and 28 are mechanically connected for unicontrol operation as indicated by the broken line 29. The tuned circuits 11—12, 16—17, and 26—27—28 are sharply-resonant circuits tunable to a selected carrier signal in the tuning range of the receiver.

In considering the operation of the carrier-signal receiver just described, it will be assumed that the tuning condensers of the receiver are operated in unison to tune the receiver to a desired carrier signal applied to the input circuit 11, 12 from the antenna-ground system 13, 14. The desired carrier signal may have a relatively small amplitude as represented by the vertical line *e* of Fig. 2*a* while adjacent undesired carrier signals may appear in the input circuit 11, 12 with relatively larger amplitude as represented by the vertical lines *f*—*i*, inclusive, of Fig. 2*a*. This group of carrier signals appearing in the input circuit 11, 12 is amplified uniformly by the broad-band untunable amplifier 21 and is limited by the amplitude limiter 22 so that it appears in the output circuit thereof as a group of carrier signals without modulation and with uniform predetermined amplitude levels, as indicated by the vertical lines *e'*—*i'*, inclusive, of Fig. 2*b*, the repeating ratio of the amplifier 21 being sufficient to amplify the weakest useful carrier signal to this predetermined level.

The carrier signals of uniformly limited amplitude developed in the output of the limiter 22 are applied through transformer 25 to the tuned circuit 26, 27, and 28, which, being tuned by the condenser 28 to resonance with the desired carrier signal *e'*, is selectively responsive thereto and, therefore, couples through winding 27 into the input circuit 11, 12, the group of carrier signals *e''*–*i''*, inclusive, of Fig. 2*c* corresponding to the respective received carrier signals *e*–*i*, inclusive. The carrier signals *e''*–*i''*, inclusive, add with corresponding ones of the received carrier signals *e*–*i*, inclusive, to produce in the input circuit 11, 12 the reinforced carrier signals *e'''*–*i'''*, inclusive, of Fig. 2*d*, the resultant desired carrier signal thus being so reinforced that its amplitude is larger than that of any of the group of undesired carrier signals.

The reinforced group of carrier signals is applied to the radio-frequency amplifier 10, amplified therein, and applied through the tuned circuit 16, 17 to the radio-frequency amplifier 15, the circuit 16, 17 further discriminating in favor of the desired carrier signal. The group of carrier signals is amplified in the broad-band untunable radio-frequency amplifier 15 and applied to the detector 18. The detector 18 preferably has a delayed response characteristic such that it responds only to carrier signals having an amplitude greater than that of the strongest undesired carrier signal of the group. The detector 18 thus is responsive only to the desired carrier signal, which it demodulates to derive the modulation components. The modulation components are ampified by the audio-frequency amplifier 19 and are resproduced by the sound reproducer 20 in a conventional manner. The detector 18 is preferably a peak detector having the well-known property of discriminating in favor of the strongest carrier signal applied thereto. This characteristic aids in improving the apparent selectivity of the carrier-signal receiver. The automatic amplification control or A. V. C. supply of unit 18 derives from the desired carrier signal an automatic control or A. V. C. bias. This bias is effective to control the amplification of one or both of the units 10 and 15 to maintain the signal input to the detector 18 within a relatively narrow range for a wide range of received signal intensities.

In this operation, it may be noted that reinforcement of the desired carrier signal by the carrier signal of uniformly limited amplitude, which is fed back to the input circuit 11, 12 from the limiter 22, may cause oscillation in the receiving system in the absence of a strong desired signal, although the amount of energy fed back from the limiter 22 to the input circuit 11, 12 cannot exceed a predetermined value due to the inherent action of the limiter.

The modification of the invention represented in Fig. 3 is essentially similar to that of Fig. 1, similar circuit elements being designated by similar reference characters, except that the winding 27 of the tuned link circuit 26, 27, 28 is coupled to the input circuit 16, 17 of the radio-frequency amplifier 15 which, it will be seen, is at a point in the main signal-translating channel succeeding the point therein to which the input circuit of the auxiliary signal-translating channel is coupled, this latter point comprising, of course, the tuned circuit 11, 12. The radio-frequency amplifier 10 thus constitutes an isolating amplifier to prevent direct feedback of energy from the output circuit of the limiter 22 to the input circuit 11, 12. The possibility of self-oscillation of the receiving system is accordingly greatly reduced. In this arrangement, the radio-frequency amplifier 10 preferably has little amplification for strong desired signals applied to antenna-ground system 13, 14, in order that the amplified desired carrier fed to the input circuit 16, 17 of radio-frequency amplifier 15 should not be large compared to the desired carrier component fed to this circuit from the limiter 22 by way of the link circuit 26, 27, 28. The operation of this modification is essentially similar to that of Fig. 1 and will, for that reason, not be repeated.

The modification of the invention represented in Fig. 4 is likewise similar to that of Fig. 1, and similar circuit elements are designated by similar reference characters. In this modification, the output of the limiter 22 is tuned to the desired carrier signal by a condenser 30 which is mechanically connected for unicontrol with the tuning condensers 12 and 17. The output of the limiter 22 is applied through the radio-frequency transformer 25 to the input circuit of a radio-frequency amplifier 31, the cathode circuit of which includes serially arranged resistors 32 and 33. The resistor 32 provides a normal operating bias for the control electrode of the amplifier 31 for linear amplification while the resistor 33 provides a sensitivity control or delay bias for the detector 18, the purpose of which is to render the detector 18 unresponsive to carrier signals having an amplitude slightly less than that of the desired carrier-signal output of the limiter 22. The output circuit 25, 30 is tuned to the desired carrier signal and, therefore, selectively applies the desired carrier signal of limited amplitude from the output circuit of the limiter 22 to the radio-frequency amplifier 31. Since the resistor 33 is included in the output circuit of the amplifier 31, there is also developed across this resistor, in addition to the delay bias, a group of carrier signals having the relative amplitudes represented generally by the vertical lines *e''*—*i''*, inclusive, of Fig. 2*c*. This group of carrier signals is thus coupled by the

resistor 33 into the output circuit of the main signal-translating channel, specifically into the detector 18 where the desired carrier signal from the radio-frequency amplifier 15 is reinforced and the reinforced desired carrier signal is demodulated substantially to the exclusion of the undesired carrier signals. The operation of the Fig. 4 embodiment is otherwise similar to that of the Fig. 1 embodiment. From the above description of the Fig. 4 arrangement, it will be seen that the resistor 33 and amplifier 31 comprise means for rendering the demodulating means or detector 18 unresponsive to carrier signals having an amplitude substantially less than the amplitude of the desired carrier signals developed in the circuit of the detector. Further, it will be evident that the tuned circuit comprising circuit elements 25, 30 and the amplifier 31 comprise signal-translating means selectively responsive to the desired carrier signal for deriving the desired carrier signal from the auxiliary signal-translating channel and applying it to the demodulating means or detector 18 to develop therein a desired carrier signal the amplitude of which is in excess of that of the undesired carrier signals.

While there have been described what are at present considered to be the preferred embodiments 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 tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said channel, an untunable broadly-responsive auxiliary signal-translating channel coupled to said main channel and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, and signal-translating means selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and applying it to said main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

2. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said channel, an untunable broadly-responsive auxiliary signal-translating channel coupled to said main channel at a predetermined point therein and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signals, and signal-translating means selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and applying it to said main channel at a point succeeding said predetermined point to develop in said main channel a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

3. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto desired carrier signals of a predetermined frequency and undesired carrier signals of different frequency, an untunable broadly-responsive auxiliary signal-translating channel coupled to said main channel and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, and signal-translating means tunable to said predetermined frequency for deriving said desired carrier signal from said auxiliary channel and selectively applying it to said main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

4. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel having an input circuit and adapted to have applied thereto desired carrier signals of a predetermined frequency and undesired carrier signals of different frequency, an untunable broadly-responsive auxiliary signal-translating channel coupled to said input circuit and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, and signal-translating means tunable to said predetermined frequency for deriving said desired carrier signal from said auxiliary channel and for selectively applying it to said main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

5. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel having an input circuit tunable over said range of frequencies and adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said input circuit, an untunable broadly-responsive auxiliary signal-translating channel coupled to said main channel and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, and signal-translating means tunable with said input circuit to be selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and for selectively applying it to said main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

6. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said channel, an auxiliary signal-translating channel coupled to said main channel and including signal-amplifying means having an untunable broad-band frequency-response characteristic for amplifying uniformly all received carrier signals in the vicinity of and including the desired carrier signal and means coupled to said amplifying means for limiting to a uniform predetermined amplitude

level the carrier signals amplified by said amplifying means, and signal-translating means selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and for applying it to said main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

7. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel including a carrier-signal amplifier having an output circuit and having an input circuit adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said amplifier, an untunable broadly-responsive auxiliary signal-translating channel coupled to said input circuit and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, and signal-translating means selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and for applying it to the output circuit of said signal amplifier to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

8. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said channel, an untunable broadly-responsive auxiliary signal-translating channel coupled to said main channel and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, signal-translating means selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and applying it to said main channel to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals, signal-demodulating means coupled to said main channel, and means for rendering said demodulating means unresponsive to carrier signals having an amplitude substantially less than the amplitude of said desired carrier signal developed in said channel.

9. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said channel, an untunable broadly-responsive auxiliary signal-translating channel coupled to said main channel and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, signal-demodulating means coupled to said main channel, and signal-translating means selectively responsive to said desired carrier signal for deriving said desired carrier signal from said auxiliary channel and applying it to said demodulating means to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals.

10. A carrier-signal receiver tunable over a range of frequencies comprising, a main signal-translating channel adapted to have applied thereto received carrier signals the amplitude of a desired one of which may be less than that of adjacent undesired carrier signals applied to said channel, an auxiliary signal-translating channel coupled to said main channel and including limiting means for limiting to a uniform predetermined amplitude level all received carrier signals in the vicinity of and including the desired carrier signal, signal-demodulating means coupled to said main translating channel, a vacuum tube amplifier having a cathode resistor and having an input circuit coupled to said auxiliary channel and selectively responsive to desired carrier signals for developing across said cathode resistor said desired carrier signal, said amplifying means also developing across said cathode resistor a unidirectional bias, means for applying said desired carrier signal developed across said cathode resistor to said demodulating means to develop therein a desired carrier signal the amplitude of which is in excess of that of said undesired carrier signals, and means responsive to said unidirectional potential bias for rendering said demodulating means unresponsive to carrier signals having an amplitude substantially less than that of said desired carrier signal developed in said demodulating means.

NELSON P. CASE.