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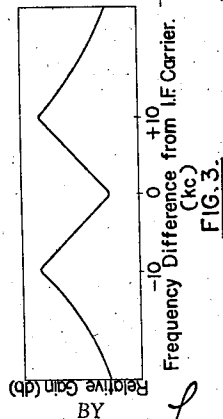
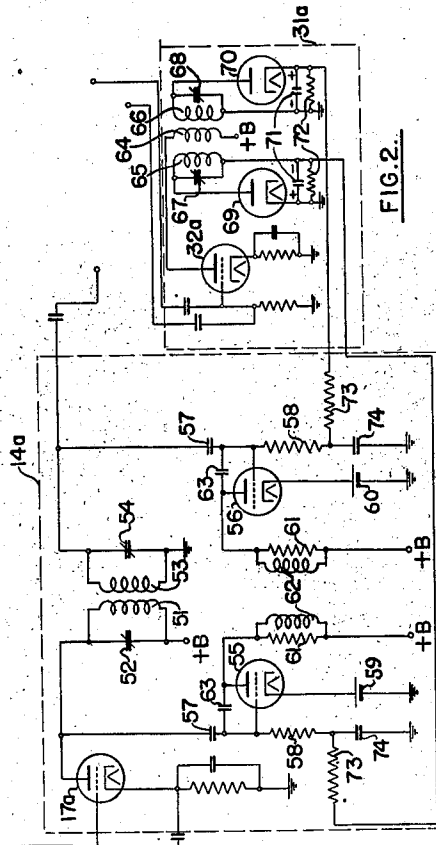
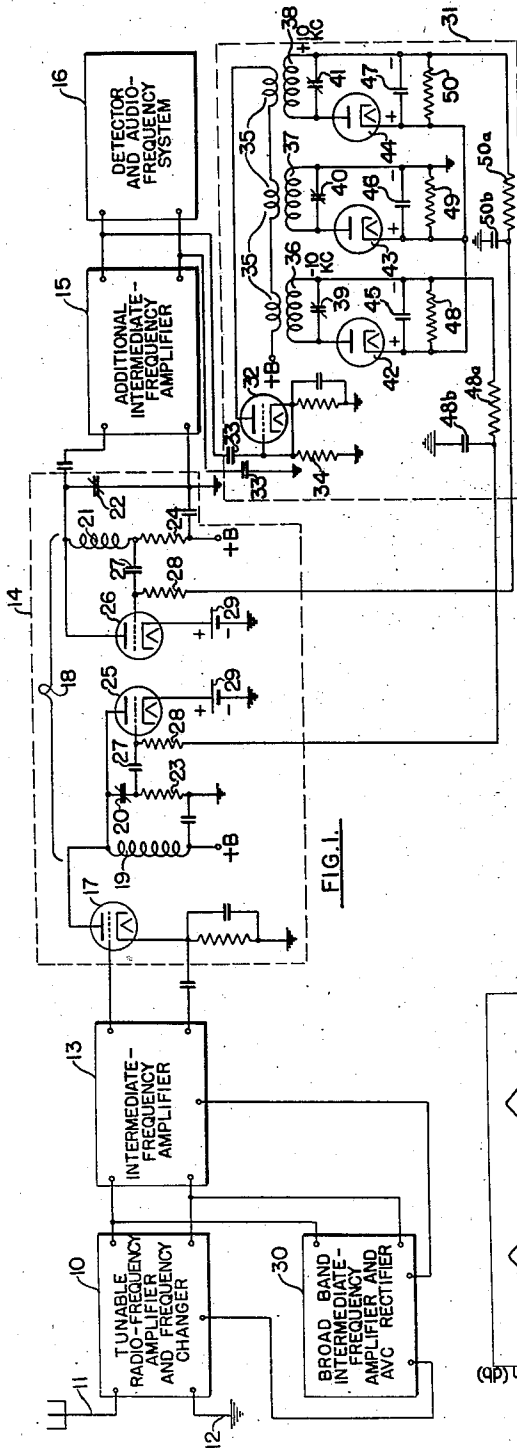
J. F. FARRINGTON

2,255,050

SELECTIVITY CONTROL

Filed June 12, 1936

2 Sheets-Sheet 1



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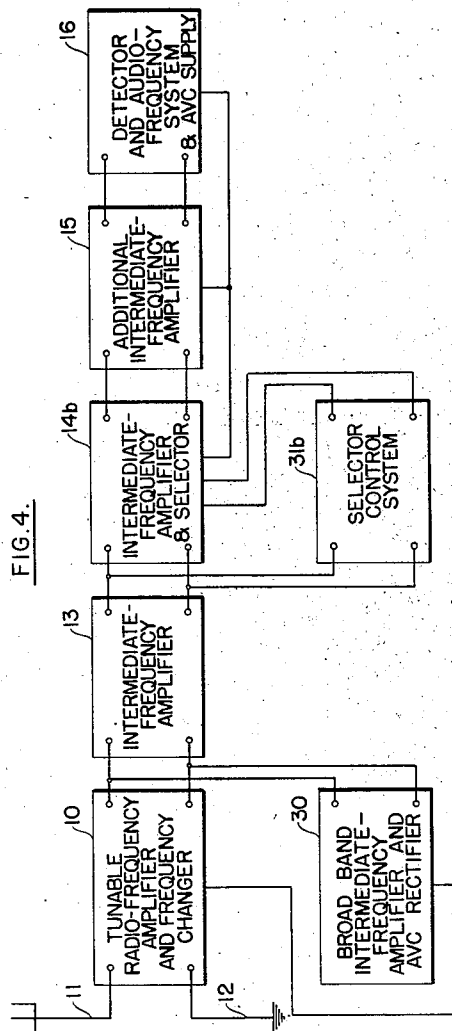
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SELECTIVITY CONTROL

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2 Sheets-Sheet 2



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SELECTIVITY CONTROL

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Application June 12, 1936, Serial No. 84,861

25 Claims. (Cl. 250-20)

This invention relates to modulated-carrier signal receivers and particularly to signal-selecting systems of such receivers and to methods of, and means for, controlling the selectivity and fidelity of reproduction of such systems to discriminate against undesired signals.

According to conventional radio broadcasting practice, a signal or program is ordinarily transmitted on a carrier frequency, having two sidebands of modulation which usually extend 6 or more kilocycles on either side thereof. Different carrier frequencies are utilized by the various broadcasting stations and these frequencies, according to present practice, are uniformly spaced throughout the broadcasting frequency range. The spacing of adjacent carriers is usually 10 kilocycles with the result that, in many instances, the sideband frequencies of one carrier overlap those of adjacent carriers received at the same location, or closely encroach thereon. Due to this condition, it is frequently difficult to tune a receiver to a desired signal without interference from undesired signals on carrier frequencies near the desired signal, particularly when the strength of the undesired signals is comparable to or exceeds that of the desired signal. So-called background noises, which are ordinarily present at the outer frequencies of the sidebands, may also interfere with the reception.

In order that a desired signal may be received and satisfactorily reproduced substantially free from undesired signal interference and background noises when these disturbances are present, it is necessary that a selecting system be employed at the receiver which is effective to pass a desired band of modulation frequencies sufficiently narrow greatly to reduce the undesired signals and noise. Since the outer frequencies of the sidebands, which in radio broadcasting correspond to the higher audio frequencies of modulation, are suppressed when the selected band is narrowed, the fidelity of reception of the desired signal is correspondingly impaired. It is, therefore, desirable that the width of the selected band of frequencies be automatically controlled in accordance with the conditions of reception; that is, that it be contracted when the desired signal is weak or when undesired signals or noise of sufficient amplitude appreciably to impair the reception are present, and that, in the absence of such undesired signals and when the strength of the desired signal permits, the band width be expanded sufficiently to admit and pass all of the useful sideband frequencies of the desired signal.

Since undesired or interfering signals are fre-

quently received at only one side of the desired signal carrier at any particular time, at such time it is only necessary to contract the frequency band passed by the selector, on the side of the selected carrier corresponding to that of the undesired signal in order to reduce the interference. For ideal reception, therefore, the band width should be automatically controlled in response to an undesired signal on one side of the desired signal carrier so that the width of only the sideband of frequencies passed by the selector on the side of the carrier corresponding to that of the undesired signal is contracted, and the other sideband is maintained at its maximum width, other conditions permitting. In other words, the expansion or contraction of the transmission band should be effected symmetrically with respect to the selected carrier frequency in accordance with the amplitude of the desired signal and unsymmetrically with respect to the selected carrier in response to an undesired signal at one side of the received desired carrier; that is, the band should be contracted only in a direction away from the undesired signal components and to an extent depending upon the interference values of such components. The term "interference value" is used herein to denote the disturbing characteristic of an undesired signal which is determined by both its amplitude and its frequency displacement from the desired signal carrier.

Various selector arrangements have heretofore been devised in order that the width of a selected band of frequencies might be automatically controlled in accordance with various of the above mentioned conditions of reception. In copending application of Harold A. Wheeler, Serial No. 46,081, filed October 22, 1935, there is described a system for automatically effecting symmetrical expansion and contraction of a selected band of frequencies in response to the amplitudes of the received desired signal as well as undesired signals on frequencies adjacent to the carrier of the desired signal. In copending application of Harold A. Wheeler, Serial No. 61,148, filed January 28, 1936, there is described a system for automatically effecting unsymmetrical expansion and contraction of a selected band of frequencies in accordance with the amplitude of an undesired signal adjacent the desired signal carrier; that is, individual adjustment of the width of each of the selected sidebands of frequencies is effected in accordance with the amplitude of an undesired signal on the same side of the desired signal carrier as such sideband.

It is an object of the present invention to pro-

vide an improved method of, and means for, controlling the selectivity and fidelity of reproduction of a modulated-carrier signal receiver.

It is a further object of the invention to provide an improved method of and means for controlling the selectivity and fidelity of reproduction of a modulated-carrier signal receiver automatically in accordance with the various conditions of reception, including the amplitude of the desired signal as well as the amplitudes of undesired signals near the carrier frequency of the desired signal, thereby to obtain maximum fidelity of reception consistent with such conditions.

It is a further object of the invention to provide a method of, and means for, controlling the selectivity and fidelity of reproduction of a receiver such as above described, in which the expansion and contraction of the entire band of frequencies passed by the system is effected symmetrically with respect to the selected carrier frequency directly in accordance with the amplitude of the desired signal and inversely in accordance with the amplitudes of the undesired signals and in which adjustment of the width of each of the sidebands of frequencies passed by the system is effected individually and independently of the other sideband and in accordance with the amplitude of a received undesired signal on a frequency near the desired signal carrier and on the same side thereof as the adjusted sideband.

It is a further object of the invention to provide a method of, and means for, automatically controlling the selectivity of a receiver, such as above described, in which electronic control circuits are utilized.

In accordance with the invention, a modulated-carrier signal receiver, including a band-pass selector for selecting a desired signal comprising a carrier and a band of modulation frequencies, includes a selectivity control system comprising means for adjusting the band-pass characteristics of the selector, means for developing a first control effect varying directly in accordance with the amplitude of the desired signal, and means for developing a second control effect varying inversely in accordance with the interference value of an undesired signal on a frequency near the carrier frequency of the desired signal and at one side thereof. The control system includes means for utilizing the first control effect for controlling the adjusting means to adjust the width of the band of frequencies passed by the selector and for utilizing the second control effect for controlling the adjusting means to shift the mean resonant frequency of the selector in a direction to avoid the undesired signal.

In one form of the invention, the selector comprises a plurality of resonant circuits, each normally tuned to the carrier frequency, and the selectivity control system comprises means for automatically adjusting the tuning of the resonant circuits simultaneously in opposite directions in accordance with the amplitude of the desired signal to expand the band of frequencies passed by the selector, and means for automatically individually adjusting the tuning of at least one of the circuits in accordance with the interference value of an undesired signal on a frequency adjacent the carrier frequency of the desired signal effectively to shift the mean resonant frequency of the selector in a direction away from the undesired signal.

In a preferred form of the invention, the selector of the receiver comprises two resonant cir-

cuits, each normally tuned to the carrier frequency of the desired signal, and the selectivity control system comprises means associated with one of the circuits for adjusting the apparent reactance of one type therein, and means associated with the other of the circuits for adjusting the apparent reactance of opposite type therein. The control system also includes means for controlling the two adjusting means simultaneously to effect adjustments of the apparent reactances in opposite senses directly in accordance with the amplitude of the desired signal, and means for controlling the two adjusting means independently and individually to effect the adjustments of the apparent reactances inversely in accordance with the interference values of undesired signals on opposite sides of the carrier frequency of the desired signal.

The term "effectively shift" is used herein to denote the effect of the contraction of one or both of the sidebands of the desired signal in response to interfering signals on frequencies at one or both sides, respectively, of the desired signal carrier, even though there is no actual adjustment of the mean resonant frequency of all of the selecting circuits of the receiver. In the case of an interfering signal on one side only of the desired carrier, the mean resonant frequency will be shifted in a direction away from such carrier and by an amount equal to one-half the amount of the contraction, while when interfering signals are present at both sides of the desired carrier at the same time the shift will be in a direction away from the interfering signal having the greater interference value and the amount of such shift will then be equal to one-half the difference between the amounts of contractions effected by the interfering signals.

According to one feature of the present invention, a progressive automatic selectivity and fidelity control arrangement is provided. In this arrangement, an adjustable selector is included in a given part of the system and is automatically controlled by means which is coupled to a point in the system preceding the selector and responsive to the signal conditions at such point. The progressive control may be effected either by novel selectivity control arrangements, such as described above, or by any other suitable means.

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

In the accompanying drawings, Fig. 1 is a circuit diagram of a complete superheterodyne radio receiver, partly schematic, embodying the principal features of the present invention; Fig. 2 is a circuit diagram of a modified form of the automatically adjustable band-pass selector, and control circuits therefor, of the receiver shown in Fig. 1; Fig. 3 is a graph representing certain operating characteristics of the receiver; and Fig. 4 is a schematic circuit diagram of a complete superheterodyne receiver embodying the progressive automatic selectivity control feature of the present invention.

Referring now particularly to Fig. 1, there is shown schematically a superheterodyne radio receiver embodying a preferred form of my invention. In general, the receiver includes a tunable radio-frequency amplifier and frequency changer having its input circuit connected with an an-

tenna 11 and ground 12, and its output circuit connected to an intermediate-frequency amplifier 13. The output circuit of the amplifier 13 is connected to additional intermediate-frequency amplifiers 14 and 15.

The adjustable band-pass selector system of the present invention is fully shown as embodied in the second intermediate-frequency amplifier 14 and is hereinafter described in detail. It will be understood, however, that such a selector system may be included additionally in either or both of the amplifiers 13 and 15. The output of the third intermediate-frequency amplifier 15 is connected to a detector and audio-frequency system 16.

It will be understood that the tunable radio-frequency amplifier and frequency changer 10, the intermediate-frequency amplifiers 13 and 15, and the detector and audio-frequency system 16 may be of conventional construction and operation, the details of which are well known in the art, rendering description thereof unnecessary herein.

Neglecting for the moment the particular operation of the band-pass selector system embodied in the amplifier 14 and the apparatus operating in connection therewith in accordance with the present invention, as hereinafter described, the system comprises a conventional superheterodyne receiver. Since the operation of such a receiver is well understood in the art, a detailed explanation thereof is unnecessary. In brief, however, signals intercepted by the antenna are selected, amplified and converted to intermediate frequencies, in the well-known manner, in the tunable radio-frequency amplifier and frequency changer 10 and intermediate frequencies are selectively amplified in the intermediate-frequency amplifiers 13, 14, and 15. The amplified intermediate-frequency signals are thereupon delivered to the detector and audio-frequency system 16 wherein the audio-frequency signals are derived, amplified and supplied, in the usual manner, to a loud speaker for reproduction.

While, in accordance with the broad aspect of the present invention, various different types of selectivity control circuits may be employed, particular features of the invention include the employment of a band-pass selector embodying a plurality of tuned circuits and the utilization of vacuum tubes to vary the reactances of these circuits thereby to adjust their tuning so as to control the selectivity of the selector. Such an arrangement is shown in Fig. 1, the adjustable band-pass selector being embodied in the second intermediate-frequency amplifier 14.

Referring in detail to this part of the receiver, the amplifier 14 includes a vacuum tube 17 having its input circuit coupled in conventional manner to the output circuit of the amplifier 13. The output circuit of the tube 17 is coupled to the input circuit of the intermediate-frequency amplifier 15 by a band-pass selector which includes an intermediate-frequency transformer comprising a primary winding 19 which is tuned to the intermediate frequency by a condenser 20, and a secondary winding 21 which is tuned to the intermediate frequency by a condenser 22. The band-pass selector thus comprises a pair of resonant circuits 19, 20 and 21, 22, each of which is individually tuned to the desired intermediate-carrier frequency. The windings 19 and 21 are loosely coupled as indicated at 18 in the drawings, so that, when the two resonant circuits are both tuned to the intermediate-carrier frequency, the

selector passes a relatively narrow band of frequencies.

In order properly to control the selectivity and fidelity of the receiver according to the prevailing conditions of reception, resistors 23 and 24 are connected in the capacitance arm and inductance arm, respectively, of the selector circuits 19, 20 and 21, 22. The impedances of these resistors are small at the intermediate frequency compared to those of the reactance elements of their associated resonant circuits. Vacuum tubes 25 and 26 are provided with their input circuits connected across the resistors 23 and 24, respectively, by way of suitable coupling condensers 27 and resistors 28. Suitable biasing batteries 29 are provided for the cathode circuits of the tubes 25 and 26 and serve normally to bias these tubes to cutoff.

The anode circuit of each of the tubes 25 and 26 is connected across its respective tuned circuit, the operating voltages being applied to the tubes, by way of the inductances of the respective circuits, from the direct voltage source, indicated at +B. The anode impedances of the tubes 25 and 26 are preferably high as compared with the tuned circuit impedances at resonance, so that the phase of the plate currents will be substantially unaffected thereby. While tubes 25 and 26 have been shown as triodes, pentodes may be preferable because of their higher plate impedance.

With this arrangement, since the input circuit of the tube 25 is connected across a resistor in the capacitance arm of its selector circuit, the intermediate-frequency voltages on the grid of this tube lead the voltages across the selector circuit 19, 20 by approximately 90°. On the other hand, since the input circuit of the tube 26 is connected across a resistor in the inductance arm of the selector circuit 21, 22, the intermediate-frequency voltages on the grid of the tube 26 lag the voltages across its tuned circuit by approximately 90°. Hence, the plate currents of the tubes 25 and 26 are substantially 90° ahead of, and 90° behind, the voltages across their respective tuned circuits, and the tubes, therefore, simulate a low power factor capacitance and a low power factor inductance, respectively, and thus may be used to vary the tuning of the selector circuits to which they are respectively connected depending upon the amplitudes of their plate currents which may be controlled by proper adjustments of the grid biasing potentials applied to the tubes, as will be hereinafter explained.

In accordance with the present invention, there is provided a broad band intermediate-frequency amplifier and automatic amplification control (A. V. C.) rectifier, indicated generally at 30, having its input circuit connected to the output circuit of the frequency changer 10. The auxiliary intermediate-frequency amplifier 30 is designed to pass a band of frequencies which is substantially wider than that of the radio-frequency amplifier; that is, it passes and amplifies not only the desired signal, but also all undesired signals which are passed by the radio-frequency amplifier and frequency changer and which have sufficient amplitude to be capable of overloading the frequency changer or causing interference.

In Fig. 3, relative gain in decibels is plotted against frequency difference from the intermediate-carrier frequency in kilocycles, for this amplifier. The curve of this figure clearly shows the

characteristic of the amplifier whereby the adjacent undesired signals are favored and, hence, will have relatively greater effect than the desired signal. The construction of an amplifier having a characteristic such as shown in Figure 3 is well understood by those skilled in the art and a detailed description thereof is deemed unnecessary. The A. V. C. rectifier is designed and operates in a conventional manner to develop a bias voltage proportional to the amplitude of the signal supplied thereto. The bias voltage thus developed is applied negatively to the control grids of one or more of the tubes of the radio-frequency amplifier and frequency changer 10 to vary the amplification therein proportionately to the input to the A. V. C. rectifier. A part of the rectified voltage developed by the A. V. C. rectifier 30 also may be applied to the control grids of one or more of the tubes of the intermediate-frequency amplifiers to effect progressive automatic amplification control, thereby to maintain the amplitude of the signal input to the signal detector within a relatively narrow range for a relative wide range of received signal amplitudes above a predetermined value.

There is provided a control system indicated generally at 31, preferably coupled to the output of one of the intermediate-frequency amplifiers, for controlling the action of the tuning control tubes 25, 26. This control system includes an amplifier tube 32 having its input circuit coupled to the output circuit of the amplifier 15 by way of suitable coupling condensers 33 and resistor 34. The output circuit of the tube 32 includes three inductances 35 connected in series, through which is supplied the anode operating voltage for the tube, indicated as $+B$, and constituting the primary windings of three separate transformers having secondary windings 36, 37 and 38. The winding 36 is tuned by a condenser 39 to a frequency 10 kilocycles below the intermediate-carrier frequency of the system; the winding 37 is tuned by a condenser 40 to the intermediate-carrier frequency; while the winding 38 is tuned by condenser 41 to a frequency 10 kilocycles above the intermediate-carrier frequency. There are connected across the respective tuned circuits 36, 39, 37, 40 and 38, 41, diode rectifiers 42, 43 and 44 which are provided with load circuits including condensers 45, 46 and 47 and resistors 48, 49 and 50, respectively.

The bias voltage developed across the resistor 49 of the diode 43 is applied positively to the control grids of the selector control tubes 25 and 26 by way of the resistor 48 and the filter including series resistor 48a and shunt condenser 48b and the resistor 50 and the filter including resistor 50a and shunt condenser 50b, respectively, and the high resistors 28. The voltage developed across the resistor 48, however, is applied negatively and in opposition to the positive voltage supplied from the rectifier 43 to the grid of the tube 25 only. In other words, the algebraic sum of these two bias voltages is applied to the grid of the tube 25. Similarly, the voltage developed across the resistor 50 is applied negatively and in opposition to the positive voltage supplied from the rectifier 43 to the grid of the tube 26 only.

In considering the operation of the selector 14 and control circuits 31, just described, it will be assumed that the selector circuits are initially adjusted to pass a band of minimum width for receiving a weak desired signal, the tubes 25 and 26 being biased to cutoff. When a relatively

strong desired signal is received, and in the absence of an interfering signal of an appreciable intensity, the amplitude of the desired intermediate-frequency signal delivered to the selective control circuits will increase. Since the selective control circuit 37, 40 is tuned to the intermediate-carrier frequency, under this condition an increased control bias voltage will be developed by the rectifier 43 across its resistor 48. This voltage, being applied positively to the control grids of the tubes 25 and 26, will serve to effect an increase in the apparent capacitance of the selector circuit 19, 20 and a decrease in the apparent inductance of the selector circuit 21, 22. Thus, the resonant frequency of the circuit 19, 20 will be shifted to a lower frequency and the resonant frequency of the circuit 21, 22 will be shifted to a higher frequency. In other words, the two selector circuits will be detuned to the same extent, but in opposite directions with respect to the mean intermediate-carrier frequency thereby to effect a symmetrical expansion of the band of frequencies passed by the selector with consequent increase in the fidelity of reproduction. Subsequent increase or decrease of the desired signal input to the selector 14 obviously results in corresponding symmetrical expansion and contraction, respectively, of the band passed by the selector system.

When an interfering signal is being received at one side of the desired signal carrier and is of appreciable amplitude, a resultant interfering intermediate-frequency signal is, of course, present on a corresponding side of the selected intermediate-frequency carrier. When such undesired intermediate-frequency-carrier signal is adjacent and below the selected intermediate-frequency carrier, the selective circuit 36, 39 favors this undesired signal, since this circuit is tuned to a frequency 10 kilocycles below the selected intermediate-frequency carrier. Hence, an increased bias voltage will thereupon be developed by the rectifier 42 across its resistor 48 and be applied, negatively and, therefore, in opposition to the voltage supplied by the rectifier 43, to the grid of the tube 25. That is, the resultant voltage of the positive and negative voltages supplied by the rectifiers 43 and 42, respectively, will be applied to the control grid of the tube 25. Since a decrease in the bias voltage applied to this tube tends to decrease the apparent capacitance of the selector circuit 19, 20, the resultant effect is a shifting of the resonant frequency of this circuit upward toward the intermediate-carrier frequency. In other words, the band passed by the selector is contracted in such a direction as to avoid the interfering components then present in the intermediate-frequency channel.

On the other hand, when there is being received an interfering signal which results in an intermediate-frequency adjacent and above the selected intermediate-carrier frequency, the selective circuit 38, 41 will favor this interfering frequency, since this selective circuit is tuned to a frequency 10 kilocycles above the desired intermediate-carrier frequency. In this instance, therefore, an adjustment of the selector circuit 21, 22 is effected similarly to that effected by the lower interfering frequency, excepting that, since the reduction of the bias voltage on the grid of the tube 26 effects an increase in the apparent inductance of the selector circuit 21, 22, the resonant frequency of this circuit will be shifted downward toward the intermediate-carrier frequency, and a shifting of the mean

resonant frequency of the band passed by the system in a direction away from the interference component then present will result.

Thus the diode rectifier 43, the tuned circuit 37, 40 and the load circuit 46, 49 comprise means for developing a first control effect varying directly in accordance with the amplitude of the desired signal, while the diode rectifiers 42, 44, the respective tuned circuits 36, 39 and 38, 41, and the respective load circuits 45, 48 and 47, 50 comprise means for developing a second control effect varying inversely in accordance with the interference value of a desired signal on a frequency near the carrier frequency of the desired signal and at one side thereof. Tubes 25, 26 comprise means for adjusting the tuning of the band-pass selector including the resonant circuits 19, 20 and 21, 22 to adjust the band-pass characteristic of the selector. The control circuits, comprising the filters 48a, 48b and 50a, 50b, comprise means for utilizing the first control effect for controlling the adjusting means to adjust the width of the band of frequencies passed by the selector and for utilizing the second control effect for controlling the adjusting means to shift the mean resonant frequency of the selector in a direction to avoid the undesired signal. That is, the control of the selector by the first control effect is such that the resonant circuits 19, 20 and 21, 22 of the selector are automatically individually adjusted directly and simultaneously in opposite directions in accordance with the amplitude of the desired signal to control the width of the band of frequencies, i. e., the width of both sidebands, passed by the selector. Also the control of the selector by the second control effect is such that the resonant circuits 19, 20 and 21, 22 are automatically individually adjusted simultaneously in the same direction inversely in accordance with the interference value of undesired signals on frequencies near the carrier frequency of the desired signal on either side thereof. Thus, the width of at least one side-band is controlled independently of the width of the other sideband, thereby effectively to shift the mean resonant frequency of the band in a direction to avoid an undesirable signal of the larger interference value.

In Fig. 2, there is illustrated a modified form of the automatic adjustable band-pass selector and control circuit arrangement therefor shown in Fig. 1. In this selector, vacuum tubes are also employed for varying the impedance of the resonant circuits of the selector, to adjust the tuning thereof and thereby to effect the desired band width adjustments. The selector of Fig. 2 may be included in a receiver in substantially the same manner as the selector of Fig. 1. Thus, the selector of Fig. 2 is illustrated as embodied in an intermediate-frequency amplifier 14a which is similar to, and may be substituted in place of, the amplifier 14 of Fig. 1. A control circuit system 31a for the selector system embodied in the amplifier 14a may likewise be connected in the receiver in substantially the same manner as the corresponding control system of Fig. 1.

In this embodiment of the invention, the amplifier 14a includes an amplifier tube 17a having its input circuit adapted for connection to a preceding amplifier of the system in the same manner as the corresponding tube 17 of Fig. 1. The output circuit of the tube 17a may be coupled to the input circuit of a succeeding amplifier by the band-pass selector of this modified embodiment of the invention, which includes an intermediate-

frequency transformer comprising a primary winding 51 tuned to the intermediate frequency by a condenser 52 and a secondary winding 53, tuned to the intermediate frequency by a condenser 54. As in Fig. 1, therefore, the band-pass selector here comprises a pair of resonant circuits 51, 52 and 53, 54, each of which is individually tuned to the desired intermediate-carrier frequency. The windings of this transformer are also loosely coupled so that when the two resonant circuits are both tuned to the intermediate-carrier frequency, the selector passes a relatively narrow band of frequencies.

In this instance, control vacuum tubes 55 and 56 are provided with their input circuits connected across the selector circuits 51, 52 and 53, 54, respectively, by way of suitable coupling condensers 57 and the high value resistors 58. Suitable biasing batteries 59 and 60 are provided in the cathode circuits of the tubes 55, 56. In the anode circuit of each tube, an alternating current phasing impedance, including a resistor 61 and inductance 62, is provided in series with the direct voltage source, indicated as +B. A small condenser 63 is utilized to provide a feedback coupling between the anode and grid of each tube. The circuit constants are so proportioned that the phase of the current fed back from the plate circuit to the grid circuit of each tube through condensers 63 causes the input impedance thereof to simulate that of low power factor condensers. The input impedances of the tubes, which are effectively in parallel with the respective selector circuits, may be controlled within desired limits by adjustment of the bias voltages applied to the control grids of the tubes, thereby to adjust the tuning of the respective selector circuits in either direction. The tubes 55 and 56 are initially biased well above cutoff.

For controlling the action of the tubes 55 and 56, a control system 31a, corresponding to the arrangement 31 of Fig. 1, is adapted for connection to a subsequent intermediate-frequency amplifier of the system, as in the arrangement of Fig. 1. This connection may be made to the input circuit of amplifier tube 32a, the output circuit of which includes a winding 64 through which is supplied a source of anode voltage for the tube, indicated as +B. The winding 64 constitutes the primary winding of a transformer having two secondary windings 65 and 66. The winding 65 is tuned by condenser 67 to a frequency 10 kilocycles below the intermediate-carrier frequency of the system, and the winding 66 is tuned by condenser 68 to a frequency 10 kilocycles above the intermediate-carrier frequency. There are thus provided in this embodiment two tuned circuits which are both responsive, to a certain extent, to the intermediate-carrier frequency, but which are individually more responsive to adjacent frequencies below and above this carrier frequency.

There are connected across the respective tuned circuits 65, 67 and 66, 68 diode rectifiers 69 and 70, each of which is provided with a load circuit including a condenser 71 and a resistor 72. The bias voltages developed across the resistors 72 of the diodes 69 and 70 are applied negatively and positively, respectively, to the control grids of the selector control tubes 55 and 56 by way of filters, including series resistors 73 and shunt condensers 74, passing unidirectional voltages only.

In the operation of a receiver including this modified embodiment of the invention, when a relatively strong desired signal is received, in the

absence of an interfering signal of appreciable intensity, the amplitude of the desired intermediate-frequency signal delivered to the two selective circuits 65, 67 and 66, 68 increases. Since both of these selective circuits are responsive to a certain degree to the desired intermediate-frequency carrier, both of their associated rectifiers 69 and 70, under this condition, develop increased control bias voltages. The bias voltage developed by the rectifier 69, being applied negatively to the control grid of the tube 55, effects a decrease in the feedback of this tube and, hence, a decrease in the capacitance of the selector circuit 51, 52, causing an adjustment of the tuning of this selector circuit to a higher frequency. On the other hand, the bias voltage which is simultaneously developed by the rectifier 70, being applied positively to the control grid of the tube 56, effects an increase in the feedback of this tube and, hence, an increase in the capacitance of its respective selector circuit 53, 54, causing an adjustment of the tuning of this circuit to a lower frequency. These tuning adjustments of the respective selector circuits, in opposite directions with respect to the intermediate-frequency carrier, effect a symmetrical expansion of the band of frequencies passed by the selector to afford increased fidelity in accordance with the well-known principles. Subsequent increase or decrease of the desired signal input to the receiver obviously result in a corresponding symmetrical expansion or contraction, respectively, of the width of the band passed by the receiver.

When an adjacent interfering signal of appreciable amplitude is being received at a side of the desired signal carrier resulting in an interfering intermediate-frequency signal which is adjacent and below the selected intermediate-frequency carrier, the selective circuit 65, 67 favors this undesired signal. Hence, an adjustment in the tuning of selector circuit 51, 52 only is effected, causing a shift of the mean resonant frequency of the band passed by the selector toward a higher frequency to avoid the interference component then present. When, on the other hand, there is being received an interfering signal which results in an intermediate-frequency interfering signal adjacent and above the selected intermediate-frequency carrier, the selective circuit 66, 68 favors this interfering signal. In this instance, therefore, an adjustment in the tuning of the selector circuit 53, 54 is effected, causing a shift of the mean resonant frequency of the band passed by the selector toward a lower frequency to avoid the interference component then present.

When two interfering signals are present at the same time and at opposite sides of the desired carrier, the resultant shift in the mean resonant frequency of the band is in a direction to avoid the undesired signal having the greater interference value.

It will be apparent that in this modified embodiment of the invention, in so far as the operation of the selective circuits and their rectifiers and control circuits, per se, is concerned, the occurrence of strong interfering signals on opposite sides of the carrier at the same time would result in adjustments of the tuning of the selector circuits in opposite directions, thus increasing the band width in the same manner as by a strong desired signal in absence of undesired signals. However, this condition is compensated by the action of the broad-band intermediate-frequency

amplifier and A. V. C. rectifier unit 30 of Fig. 1. Since this amplifier is designed to favor undesired signals on carriers adjacent the desired signal carrier, the reception of undesired signals of appreciable intensities on the opposite sides of the desired carrier at the same time will effect a substantial increase in the A. V. C. bias voltage developed by this rectifier and applied to the tubes in the first stages of the receiver, as hereinabove described. Hence, the amplitudes of both the desired and undesired signals delivered to the succeeding stages of the receiver are reduced. Such reduction of the desired signal effects a contraction of the band passed by the selector in the manner described above. When a strong undesired signal is present on only one side of the by the broad-band intermediate-frequency desired carrier, a similar control action is effected amplifier and A. V. C. rectifier, in accordance with the interference value of such undesired signal.

Referring now to Fig. 4, there is shown schematically a superheterodyne receiver embodying the progressive automatic selectivity control feature of the present invention. The receiver of Fig. 4 is similar in many respects to the receiver shown in Fig. 1 and corresponding portions are indicated by similar reference numerals in the two figures. These corresponding portions may be the same in both construction and operation, excepting as hereinafter pointed out, so that further detailed description thereof is unnecessary.

The receiver of Fig. 4 includes an intermediate-frequency amplifier 14b, comprising an adjustable selector, and a control system 31b, which selector and system may be similar to either the amplifier 14 and control system 31 or the amplifier 14a and control system 31a, respectively, of Figs. 1 and 2, or may comprise any other selectivity control arrangement wherein the control system is responsive to variations in the signal conditions at the input thereof for adjusting the selectivity in accordance with such conditions. Here, however, as distinguished from the previously described embodiments of the invention, the input of the control system 31b is coupled to the output of amplifier 13, so that the selectivity control of succeeding amplifier 14b is effected progressively. The control effected by the arrangements of Figs. 1 and 2 may be said to be regressive, since the circuits which are controlled in these arrangements precede the point in the system to which the control system is coupled. In this respect, the arrangements of Fig. 1 and 2 are conventional. However, various advantages are achieved by the progressive arrangement of Fig. 4. For example, where the control system, per se, is responsive to the undesired signals, as in the arrangement of Fig. 1, with progressive control the selector of the amplifier 14b may be so adjusted as to discriminate against these undesired signals sufficiently to reduce them to negligible amplitudes, thus reducing or substantially eliminating their effects on the succeeding stages of the receiver. Obviously, in regressive systems such as Fig. 1, such undesired signals must be present and of appreciable amplitude in the output of the controlled amplifier to effect the selectivity control and they will, therefore, be transmitted to succeeding stages of the receiver.

Since the selectivity adjustments in this em-

bodiment of the invention may vary the amplitude of the desired signal transmitted through the selector, with this arrangement an additional automatic amplification control, or A. V. C., is employed for the purpose of compensating for such variations. As shown in Fig. 4, an A. V. C. supply, which may be of conventional design, is provided in connection with the detector 16. The unidirectional bias voltage developed by this A. V. C. supply is applied to the control grids of the tubes in either or both the amplifier 14b and amplifier 15 and serves to control the gain thereof so as to maintain the amplitude of the signal output of the amplifier 15 within relatively narrow limits for a wide range of variations in the signal amplitude at the output of the selector in the amplifier 14b.

While there has been described what are at present considered the preferred embodiments of the 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, therefore, it is 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. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and a band of modulation frequencies, said selector comprising a plurality of resonant circuits, each normally tuned to the carrier frequency of said desired signal, a selectivity control system comprising means for adjusting the tuning of one of said circuits, means responsive to the interference value of an undesired signal on a carrier frequency near the carrier frequency of the desired signal and on one side thereof for developing a control effect, and means for utilizing said control effect to control said adjusting means to adjust the width of the portion of said band the pass band of said selector on the side of the carrier frequency of said desired signal corresponding to said undesired signal.

2. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and modulation sidebands, said selector comprising a plurality of resonant circuits each normally tuned to said carrier frequency, a selectivity control system comprising means for automatically adjusting the tuning of said circuits simultaneously in opposite directions in accordance with the amplitude of said desired signal to expand the band of frequencies passed by said selector, and means for automatically individually adjusting the tuning of at least one of said circuits in accordance with the interference value of an undesired signal on a frequency adjacent the carrier frequency of said desired signal effectively to shift the mean resonant frequency of said selector in a direction away from said undesired signal.

3. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and modulation sidebands, said selector comprising a plurality of resonant circuits each normally tuned to said carrier frequency, a selectivity control system comprising means for automatically and simultaneously adjusting the tuning of said circuits relative to each other directly in accordance with the amplitude of said desired signal to control the width of the band of frequencies passed by

said selector, and means for automatically individually adjusting the tuning of the respective circuits inversely in accordance with the interference value of undesired signals on frequencies near the carrier frequency of said desired signal at either side thereof effectively to shift the mean resonant frequency of said band in a direction to avoid the undesired signal of the larger interference value.

4. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and two modulation sidebands, a selectivity control system comprising means for controlling the width of the band of frequencies passed by said selector including means for adjusting simultaneously the width of both sidebands passed by said selector directly in accordance with the amplitude of said desired signal, and means including a selective circuit most responsive at a frequency at the outer edge of one of the sidebands for automatically controlling the adjustment of said selector to control the width of at least said sideband independently of the width of the other sideband and inversely in accordance with the amplitude of an undesired signal on a frequency at said edge.

5. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and two modulation sidebands, a selectivity control system comprising means for automatically adjusting said selector to control the width of the band of frequencies passed thereby directly in accordance with the amplitude of said desired signal, means including a pair of selective circuits individually most responsive at frequencies at the outer edges of the sidebands of frequencies passed by said selector, and means controlled by said selective circuits for effecting the adjustment of the width of either of said sidebands independently and inversely in accordance with the amplitude of undesired signals on frequencies at the outer edge of its respective sideband.

6. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and modulation sidebands, said selector comprising two resonant circuits each normally tuned to the carrier frequency of said desired signal, a selectivity control system comprising means associated with one of said circuits for adjusting the apparent reactance of one type therein, means associated with the other of said circuits for adjusting the apparent reactance of opposite type therein, means for controlling said two adjusting means simultaneously to effect adjustments of said apparent reactances in opposite senses directly in accordance with the amplitude of said desired signal, and means for controlling said two adjusting means independently and individually to effect adjustments of said apparent reactances inversely in accordance with the interference values of undesired signals on opposite sides of the carrier frequency of said desired signal.

7. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and two modulation sidebands, a selectivity control system comprising means for adjusting said selector to control the width of the band of frequencies passed thereby including a plurality of circuits, a first of said circuits being most responsive to the mean frequency of the band passed by said selector and other of said circuits being individually most responsive at frequencies at the outer edges of

said modulation sidebands, and means controlled by said first selective circuit for effecting adjustments of the width of said band directly in accordance with the amplitude of said desired signal, said last-mentioned means also being controlled by said other circuits for independently effecting adjustments of the width of either of said modulation sidebands inversely in accordance with the amplitude of undesired signals on carrier frequencies near the outer edges of the respective sidebands.

8. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier frequency and a band of modulation frequencies, said selector comprising two resonant circuits each normally tuned to said carrier frequency, a selectivity control system comprising means associated with a first of said circuits for adjusting the apparent capacitance therein, means associated with a second of said circuits for adjusting the apparent inductance therein, and a plurality of control circuits, a first of said control circuits being selectively responsive to said desired signal, means coupling said first control circuit to both said adjusting means for simultaneously effecting said adjustments of both said apparent capacitance and said apparent inductance in the same sense to lower the resonant frequency of said first selector circuit and raise the resonant frequency of the second said selector circuit, a second of said control circuits being selectively responsive to an undesired signal near and below the carrier frequency of said desired signal, means coupling said second control circuit to said first named adjusting means for effecting an adjustment of said apparent capacitance of its associated selector circuit to raise the resonant frequency thereof, a third of said control circuits being selectively responsive to an undesired signal near and above the carrier frequency of said desired signal, and means coupling said third control circuit to said second-named adjusting means for effecting an adjustment of said apparent inductance of its associated selector circuit to lower the resonant frequency thereof.

9. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and two modulation sidebands, a selectivity control system comprising a plurality of selective circuits, means for controlling the amplitude of the input to said circuits inversely in accordance with the amplitudes of the desired signal and undesired signals on frequencies adjacent the carrier frequency of said desired signal and at either side thereof, said selective circuits including a first circuit selectively responsive to the mean frequency of the desired signal input and two other circuits selectively responsive individually to signals on frequencies at the outer edges of the sideband frequencies passed by said selector, rectifying means coupled to each of said selective circuits for deriving unidirectional voltages variable in accordance with the responses of the respective selective circuits, and means for utilizing the unidirectional voltage derived by the rectifying means coupled to the first said circuit to adjust said selector to control the width of both of the sidebands of frequencies passed by said selector simultaneously and directly in accordance with the amplitude of said desired signal and for utilizing the unidirectional voltages derived by the rectifying means coupled to said two other selective circuits indi-

vidually to control the width of either of said sidebands independently and inversely in accordance with the interference values of undesired signals on frequencies at the respective outer edges of said sidebands to which said selective circuits are selectively responsive.

10. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and two modulation sidebands, a selectivity control system comprising means for controlling the amplitude of the input to said selector inversely in accordance with the amplitudes of the desired signal and undesired signals on frequencies adjacent the carrier frequency of said desired signal and at either side thereof, a pair of selective circuits responsive to the desired signal input to such selector and individually more responsive to signals on frequencies at the outer edges of the sideband frequencies passed by said selector, rectifying means coupled to each of said selective circuits for deriving unidirectional voltages variable in accordance with the responses of the respective selective circuits, means for utilizing certain of said unidirectional voltages to adjust said selector to control the width of both of the sidebands of frequencies passed by said selector simultaneously directly in accordance with the amplitude of said desired signal and inversely in accordance with the amplitude of said undesired signals, said last-mentioned means also utilizing certain of said unidirectional voltages for adjusting said selector individually to control the width of either of said sidebands independently and inversely in accordance with the interference values of the undesired signals on frequencies at the respective outer edges of said sidebands.

11. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and modulation sidebands, said selector comprising two resonant circuits each normally tuned to the carrier frequency of said desired signal, a selectivity control system means associated with each of said circuits for adjusting the effective reactance of one type therein, means for controlling said adjusting means simultaneously to effect adjustments of said reactances in opposite senses symmetrically directly in accordance with the amplitude of said desired signal and inversely in accordance with the interference values of undesired signals on carrier frequencies adjacent the carrier frequency of said desired signal, and means for controlling said adjusting means individually to effect adjustments of said reactances in accordance with the interference values of said undesired signals on the opposite sides of the carrier frequency of said desired signal unsymmetrically to adjust the width of the band passed by the selector.

12. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier frequency and a band of modulation frequencies, said selector comprising two resonant circuits each normally tuned to said carrier frequency, a selectivity control system means associated with each of said circuits for adjusting the effective reactance of one type therein, a pair of control circuits, one of said control circuits being responsive to said desired signal but more responsive to an undesired signal on a carrier frequency near and above the carrier frequency of said desired signal, means coupling said one of said control circuits

to said adjusting means of one of said resonant circuits to adjust the reactance of said resonant circuit to lower the resonant frequency thereof, the other of said control circuits being responsive to said desired signal but more responsive to an undesired signal near and below the carrier frequency of said desired signal, and means coupling said other control circuit to said adjusting means of the other of said resonant circuits to adjust the reactance of said other resonant circuit to raise the resonant frequency thereof.

13. In a modulated-carrier signal receiver including a band-pass selector having means controlled by a bias voltage for adjusting the width of the portion of the band of frequencies passed by the selector on one side of the desired carrier frequency, a selectivity control system comprising means connected to a point in the receiver preceding said selector for deriving a bias voltage varying in accordance with the amplitude of an undesired signal on a carrier frequency at said one side of the desired signal carrier frequency, and means for applying said voltage to said first-named means to adjust at least the width of the portion of the band of frequencies passed by said selector on the same side of said desired signal carrier frequency as said undesired signal inversely in accordance with the amplitude of said undesired signal.

14. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and a band of modulation frequencies, a selectivity control system comprising means responsive to an undesired signal on a carrier frequency at one side of the desired signal-carrier frequency at a point in said receiver preceding said selector for deriving a control effect, and means for utilizing said control effect for automatically adjusting said selector to shift the mean resonant frequency thereof in a direction to avoid said undesired signal.

15. The method of controlling the selectivity of a band-pass selector in the signal-selecting system of a modulated-carrier signal receiver, which comprises selecting the desired signal including its carrier and at least one band of modulation frequencies, adjusting the width of said band directly in accordance with the amplitude of said desired signal and inversely in accordance with the interference value of an undesired signal on a frequency adjacent the carrier frequency of said desired signal, and effectively shifting the mean resonant frequency of said selector in a direction to avoid said undesired signal.

16. The method of controlling the selectivity of a band-pass selector in the signal-selecting system of a modulated-carrier signal receiver including a plurality of resonant circuits each normally tuned to the carrier frequency of said desired signal, which comprises adjusting the tuning of said circuits simultaneously and in opposite senses with respect to said carrier frequency directly in accordance with the amplitude of said desired signal and inversely in accordance with the interference values of undesired signals on carrier frequencies adjacent the carrier frequency of said desired signal to adjust the width of the band of frequencies passed by said selector, and individually adjusting the tuning of one of said circuits in accordance with the interference value of one of said undesired signals and in a direction to avoid said undesired signal.

17. The method of controlling the selectivity of a band-pass selector in the signal-selecting sys-

tem of a modulated-carrier signal receiver including a plurality of resonant circuits each normally tuned to the carrier frequency of the desired signal, which comprises simultaneously adjusting the tuning of said circuits in opposite senses in accordance with the amplitude of the desired signal and individually adjusting the tuning of one of said circuits in accordance with the interference value of an undesired signal on a frequency adjacent the carrier frequency of the desired signal at one side thereof and in a direction to avoid said undesired signal.

18. The method of controlling the selectivity of a band-pass selector in the signal-selecting system of a modulated-carrier signal receiver including a plurality of resonant circuits each normally tuned to the carrier frequency of a desired signal, which comprises simultaneously adjusting the tuning of said circuits in opposite senses in accordance with the amplitude of the desired signal and individually adjusting the tuning of each of said circuits in accordance with the interference values of undesired signals on frequencies near the carrier frequency of the desired signal and at either side thereof and in directions to avoid the respective undesired signals.

19. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and a band of modulation frequencies, a selectivity control system comprising means for adjusting the band-pass characteristics of said selector, means for developing a first control effect varying directly in accordance with the amplitude of said desired signal, means for developing a second control effect varying inversely in accordance with the interference value of an undesired signal on a frequency near the carrier frequency of said desired signal and at one side thereof, and means for utilizing said first control effect for controlling said adjusting means to adjust the width of the band of frequencies passed by said selector and for utilizing said second control effect for controlling said adjusting means to shift the mean resonant frequency of said selector in a direction to avoid said undesired signal.

20. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and modulation sidebands, a selectivity control system comprising means for adjusting the band-pass characteristics of said selector, means for developing a first control effect varying directly in accordance with the amplitude of said desired signal, means for developing other control effects varying inversely in accordance with the interference values of undesired signals on frequencies near the carrier frequency of said desired signal and at either side thereof, and means for utilizing said first control effect for controlling said adjusting means simultaneously to adjust the widths of both sidebands of frequencies passed by said selector in accordance with the amplitude of said desired signal and for utilizing said other control effects for controlling said adjusting means independently to adjust the widths of either of said sidebands passed by said selector inversely in accordance with the interference value of undesired signals on carrier frequencies near the carrier frequencies of said desired signal and on the same side thereof corresponding to the respective sidebands.

21. In a modulated-carrier signal receiver including a band-pass selector for selecting a de-

sired signal comprising a carrier and a band of modulation frequencies, a selectivity control system comprising means for adjusting the band-pass characteristics of said selector, means for developing a control effect varying in accordance with the amplitude of the desired signal, means for developing a second control effect varying in accordance with the interference values of said undesired signals on carrier frequencies near the carrier frequency of the desired signal and at either side thereof, and means for utilizing said first control effect for controlling said adjusting means to expand the band of frequencies passed by said selector in accordance with the amplitude of said desired signal and to contract the band of frequencies passed by said selector in accordance with the interference value of said undesired signal, said means also utilizing said second control effect for controlling said adjusting means effectively to shift the mean resonant frequency of said selector by an amount substantially equal to one-half the difference of the contractions of the widths effected by said undesired signals and in a direction to avoid the undesired signal having the greatest interference value.

22. In a modulated-carrier signal receiver including a band-pass carrier for selecting a desired signal comprising a carrier and modulated sidebands, said selector comprising a plurality of resonant circuits each normally tuned to said carrier frequencies, a selectivity control system comprising means for tuning the said circuits to adjust the band-pass characteristics of said selector, means for developing a first control effect varying in accordance with the amplitude of said desired signal, means for developing a second control effect varying in accordance with an undesired signal on a carrier frequency near the carrier frequency of said desired signal, and means for utilizing said first control effect for controlling said adjusting means to detune said circuits relative to each other to adjust the width of the band of frequencies passed by said selector directly in accordance with the amplitude of said desired signal and for utilizing said second control effect for controlling said adjusting means to detune said circuits relative to each other to adjust the width of the band of frequencies passed by said selector inversely in accordance with the amplitude of said undesired signal.

23. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and a band of

modulation frequencies, a selectivity control system comprising means for adjusting the band-pass characteristics of said selector, means responsive to signal conditions at a point in said receiver preceding said selector for developing a control effect varying in accordance with the amplitude of said desired signal and in accordance with the amplitude of the interference value of an undesired signal on a frequency near the carrier frequency of said desired signal and at one side thereof, and means for utilizing said control effect for controlling said adjusting means to control the width of the band of frequencies passed by said selector directly in accordance with said desired signal amplitude and inversely in accordance with said undesired signal interference value, said means also utilizing said control effect for controlling said adjusting means simultaneously effectively to shift the mean resonant frequency of said selector in a direction to avoid said undesired signal.

24. In a modulated-carrier signal receiver including a band-pass selector for selecting a desired signal comprising a carrier and a band of modulation frequencies, a selectivity control system comprising means for adjusting the band-pass characteristics of said selector, means for developing a first control effect varying directly in accordance with the amplitude of said desired signal, means for developing a second control effect varying in accordance with the interference value of an undesired signal on a frequency near the carrier frequency of said desired signal and at one side thereof, and means for utilizing said first control effect for controlling said adjusting means to adjust the width of the band of frequencies passed by said selector directly in accordance with the amplitude of said desired signal and for utilizing said second control effect for controlling said adjusting means simultaneously effectively to shift the mean resonant frequency of said selector in accordance with said interference value and in a direction to avoid said undesired signal.

25. In combination, a pair of coupled oscillatory circuits, a plurality of electron discharge devices having their input circuits connected to said oscillatory circuits and their output circuits connected through a resistor to a source of high voltage, means, including means for varying the input capacitance of said electron discharge devices, for symmetrically detuning said oscillatory circuits.

JOHN F. FARRINGTON.

CERTIFICATE OF CORRECTION.

Patent No. 2,255,050.

September 9, 1941.

JOHN F. FARRINGTON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, second column, line 17, strike out "by the broad-band intermediate-frequency" and insert the same after "effected" in line 18; page 7, first column, line 42, claim 1, strike out "said band"; page 8, second column, lines 44 and 67, claims 11 and 12 respectively, before "means" insert "--comprising--"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 3rd day of March, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.