Dec. 28, 1937. L. E. THOMPSON 2,103,878

SELECTIVE RADIO RECEIVING SYSTEM

Filed April 30, 1936 2 Sheets-Sheet 1

Fig. 1.

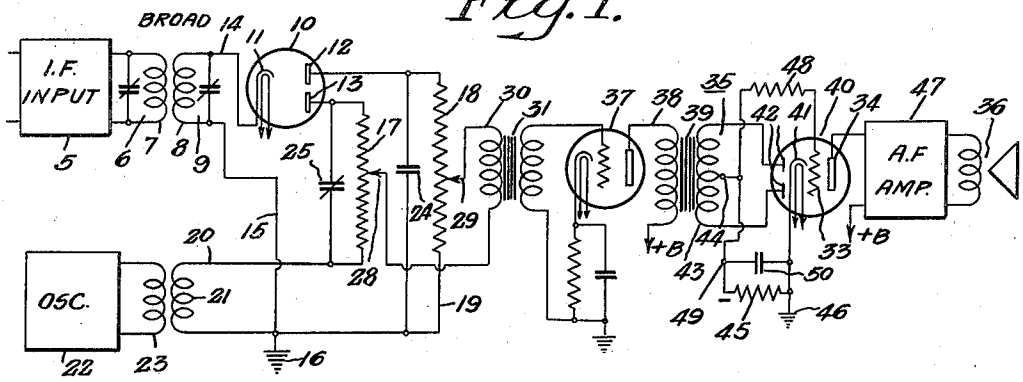


Fig. 2.

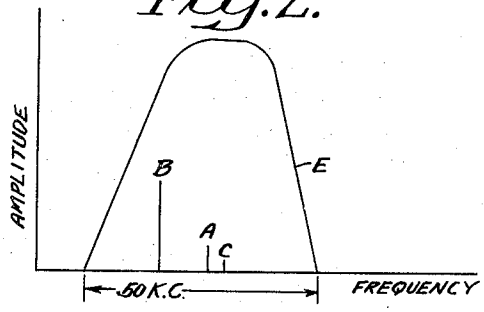
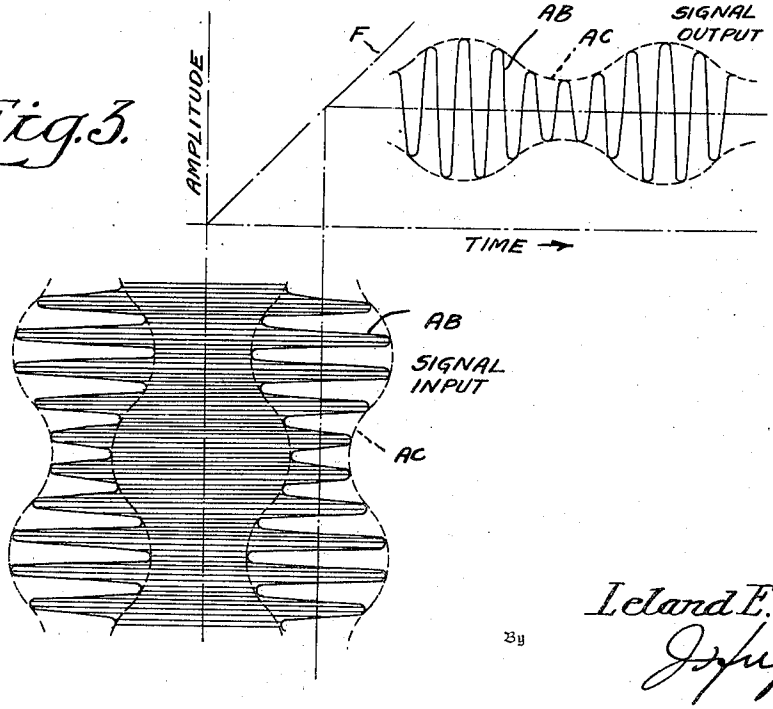


Fig. 3.



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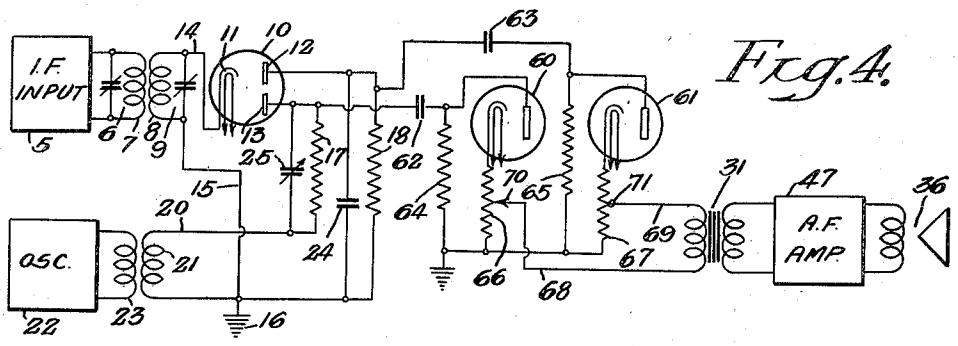


Fig. 4.

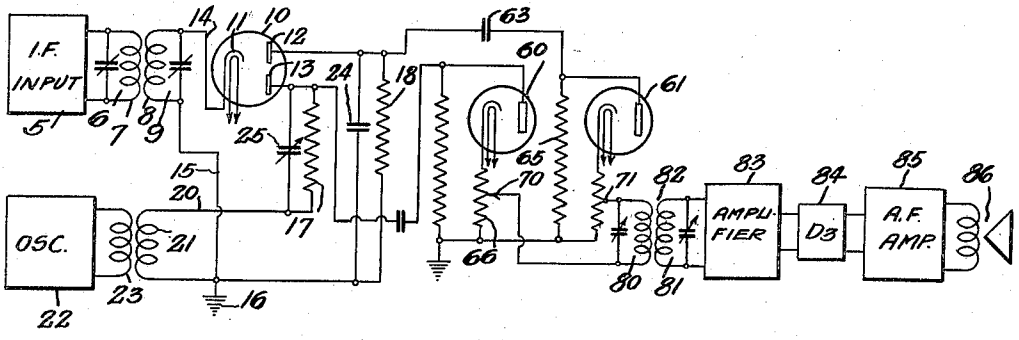
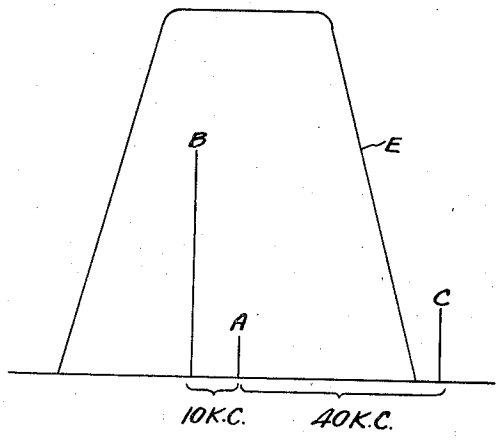


Fig. 5.

Fig. 6.



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2,103,878

SELECTIVE RADIO RECEIVING SYSTEM

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Application April 30, 1936, Serial No. 77,253

16 Claims. (Cl. 250—20)

The present invention relates to selective radio receiving systems and has for its object to provide a selective radio receiving system wherein the reduction of static and interference from undesired signals with a predetermined desired signal may be prevented or materially reduced for telegraph, continuous wave and telephone signal reception. This invention is an improvement on the radio telegraph and telephone receiving system shown and described in my U. S. Patent 1,929,086.

In the system disclosed in the patent referred to, a static limiter circuit comprising a balanced detector is arranged to make use of the principle of a heterodyne straight line detector wherein the output beat frequency between two input voltages of differing frequency has an amplitude dependent only upon the amplitude of the smaller of the input voltages and is independent of the larger voltage whereby the circuit operates as a limiter when the smaller voltage is supplied by a local oscillator and the larger voltage is provided by disturbing effects such as static or an interfering radio signal wave.

In the system referred to broadly responsive tuned circuits are provided in advance of the static limiter or balanced detector to obtain better static or noise reduction since the length of the oscillation trains in such circuits are materially reduced. Such a receiver, however, is not selective to radio signal waves and, accordingly, it is a further object of the present invention to provide a radio receiving system which imparts further selectivity to the system whereby signal waves in adjacent frequency channels may be selected without interference.

It is also a further object of the present invention to provide an improved interference limiting system which provides for the reduction of interference to a greater degree than that which is ordinarily provided by a static limiter circuit broadly tuned over a wide band, and a higher degree of selectivity than such systems provide.

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

In the drawings, Figure 1 is a schematic circuit diagram of a radio signal receiving system embodying the invention;

Fig. 2 is a curve indicating the frequency characteristic of the receiving circuit and signal voltages provided in the system of Fig. 1 in the operation thereof;

Fig. 3 is a series of curves showing the modulation envelope resulting from the reception of an interfering wave in the system of Fig. 1;

Fig. 4 is a schematic circuit diagram of a radio receiving system embodying the invention being a modification of the circuit of Fig. 1;

Fig. 5 is also a schematic circuit diagram of a radio receiving system embodying the invention and being a modification of the circuit of Fig. 1 for the reception of telephone or modulated carrier wave signals, and

Fig. 6 is a curve showing the frequency response characteristic and operating voltages of the circuit of Fig. 5.

Referring to Fig. 1, a radio receiving system is shown wherein 5 is an intermediate frequency amplifier comprising a plurality of tuned circuits, one of which is shown at 6. This circuit includes the primary winding 7 of an intermediate frequency output transformer, the secondary 8 of which is also included in a tuned circuit 9 forming part of the input circuit for a balanced detector 10 of the diode rectifier type. This comprises a cathode 11 and two anode electrodes 12 and 13 associated therewith.

The rectifier circuit includes the tuned circuit 9, the high potential side 14 of which is connected with the cathode 11 and the low potential side of which is connected through a lead 15 to ground 16, and to each of the anodes 12 and 13 through a separate output resistor 17 and 18. The output resistor 18 is connected directly with the anode 12 and the ground 16 and the lead 15 through a circuit lead 19 and the resistor 17 is likewise connected with the anode 13 and the ground 16 and the lead 15 through a connection lead 20 and a coupling coil 21.

The coupling coil 21 provides a signal input connection for oscillations derived from an oscillator 22 provided with an output coupling coil 23 associated with the coil 21. Each of the output resistors 17 and 18 are provided with by-pass capacitors 24 and 25 one of which is preferably variable to balance the two anode circuits except for the oscillator coil 21 which is in the circuit with the resistor 17.

The capacitors 24 and 25 are adjustable relatively to produce in the balanced output resistors energy having the same wave form and the same phase relation between current and voltage, whereby zero output may be obtained by tapping at equi-potential points in the absence of oscillations.

An audio frequency output circuit is provided in connection with two variable tap connections

28 and 29 forming the terminals of the primary winding 30 of an audio frequency coupling transformer 31. The resistors 17 and 18 provide two balanced output circuits on which equi-potential points may be found whereby in response to received carrier waves the signal output applied to the output transformer winding 30 may be substantially zero. However, as described in the patent referred to the contacts 28 and 29 may be adjusted with respect to each other whereby the beat frequency between the oscillator and an incoming signal may be applied to the output transformer.

For example, a continuous wave signal will produce an audio frequency beat voltage with the oscillator voltage introduced at 21 which will appear across the resistor 17 but not across the resistor 18. It will then be present across the audio frequency transformer primary 30 and this voltage will at all times represent the difference between the potential at 28 and the potential at 29. The oscillator voltage introduced at 21 may have any voltage preferably not greater than the signal voltage or carrier voltage and in any case not greater than twice the peak voltage of the received carrier wave for 100% modulation if the carrier wave is modulated.

If the oscillator voltage is equal to or less than the incoming signal voltage the output beat frequency between the two input voltages will have an amplitude dependent only on the amplitude of the smaller of the input voltages which is the oscillator voltage, and this will be independent of the larger or signal voltage.

The signal receiving circuits preceding the balanced detector 10 are preferably broadly tuned and may be, in the present example, as broad as 50 kc., in which case an incoming interference wave of greater than signal intensity may operate to cut off the desired signal as will be seen by referring to Fig. 3 along with Fig. 1.

In Fig. 2 the vertical line A represents the frequency and amplitude of a signal impressed on the detector 10 of Fig. 1 and the vertical line C represents the frequency and amplitude of the local oscillator voltage impressed upon one-half of the balanced detector circuit. The vertical line B represents an interference voltage such as a continuous wave signal voltage impressed with the incoming signal on the detector 10. The curve E represents the over-all selectivity of the intermediate frequency amplifier or receiving circuit preceding the detector 10. It will be noted that it is relatively broad and may be of a value as indicated having a band width of 50 kc. or more.

If now the beat frequency between A and C is 500 cycles and the beat frequency between A and B is 6000 cycles the 500 cycle frequency is the audio signal frequency which is desired. The voltages across the resistor 17 which is one branch of the balanced detector circuit are shown in Fig. 3 to which attention is now directed along with Figs. 1 and 2.

Referring to Fig. 3 the straight line detector characteristic of the detector 10 is indicated by the line F and the curve AB represents the undesired 6000 cycle voltage. This voltage is modulated at the desired audio frequency signal frequency of 500 cycles and it is evident that the desired audio frequency signal which is the difference between A and C of Fig. 2 will not be present in the output of the detector 10, for the reason that it is then the modulation envelope AC of the 6000 cycle wave AB.

In a receiving system of this character, the detector is said to be blocked under such conditions by the strong undesired signal B and this has been a decided disadvantage in the operation of balanced detector or limiter systems heretofore. In accordance with the invention, however, this voltage is passed through a further detector or rectifier circuit 35 wherein the frequency AB is filtered out and the desired signal may be amplified and used to operate a detector or loudspeaker 36.

In the present example, the audio frequency coupling transformer 31 provides the input coupling means for the audio frequency amplifier stage following the balanced detector. This comprises a single amplifier tube 37 of the electric discharge type having an output circuit 38 coupled through an audio frequency coupling transformer 39 with the circuit 35.

The detector circuit 35 may include a single or a "push-pull" or (full wave) detector and in the present example it is of the latter type and includes an electric discharge amplifier device 40 having a cathode 41 and two diode anodes 42 associated therewith and connected with the transformer secondary winding 43 at the terminals thereof. The center tap of the balanced input circuit, indicated at 44, is connected through a diode rectifier output resistor 45 with the cathode 41 and ground 46. In this manner a full wave rectifier circuit is provided in connection with the output resistor 45.

The output device 36 is coupled to the balanced detector circuit through an audio frequency amplifier 47, the initial stage of which is also provided in the device 40 through the medium of a control grid 33 and an output anode 34, the latter being connected with the amplifier 47, and the control grid being connected through a filter resistor 48 with the negative terminal 49 of the diode output resistor 45 whereby the grid receives biasing and signal potentials therefrom. The output resistor is provided with a suitable bypass capacitor 50.

It is desirable that the transformers 31 and 39 have a relatively broad frequency characteristic sufficient to carry through to the auxiliary detector circuit 35 both the modulation and the carrier wave represented by the signal AB and the modulation AC of Fig. 3 for the reason that unless this is provided the carrier wave will be cut off and distortion will result. As both of these frequencies are well within the audio frequency range, suitable transformers may be obtained having a flat characteristic at such frequencies. This is true even though the frequency AB be as great as the frequency band passed by the tuned input circuits although in general it is preferable to maintain this frequency within the audio frequency range as described.

From the nature of the balanced detector circuit it will be seen that if the interference voltage B of Fig. 2 varies, the effect upon the output will not change so long as the voltages A and C are lower and will have only the effect of shifting the envelopes AB and AC to the right with increased interference voltage in connection with the signal input envelope of Fig. 3 and in a vertical direction from the zero axis in the case of the signal output envelope of Fig. 3. It will be seen that the desired signal AC will not be recorded unless detected later to cut off the lower half of the envelope of the output wave shown in Fig. 3. By the use of an additional detector or recti-

fier connected with a balanced detector limiter the modulation or desired signal may be derived in the presence of an interference wave in the same manner that it is received in the absence of such wave.

Briefly, the receiving system shown and described provides for receiving signals and limiting disturbing effects therein in an amplifier having a relatively broad frequency characterstic preceding a detector. The detector includes two output circuits opposed to each other wherein the energy in each of the opposed circuits may be of the same wave form and have the same phase relation between current and voltage. This is most easily provided by the resistor output circuits provided with suitable by-pass capacitors one of which is adjustable. The received energy is transformed in one of the output circuits by combining with locally produced oscillations which are maintained appreciably smaller than the amplitude of the received energy. The resultant signal frequency is derived by further amplification and rectification of the output from the balanced detector circuit whereby in the presence of a disturbance such as a carrier wave of undesired frequency the modulation of the beat frequency between the undesired and desired signal waves may be derived as the desired signal and may be suitably amplified and reproduced.

Referring now to Fig. 4, the circuit of Fig. 1 is shown in part, and for the same circuit elements the same reference numerals are used as in Fig. 1. In this system, the auxiliary detector or rectifier, following the signal detector **10**, is placed between the audio frequency output transformer **31** and the detector **10**, and in this circuit comprises a pair of diode rectifiers **60** and **61**, connected through coupling capacitors **62** and **63**, respectively, with the balanced output resistors **17** and **18**. The rectifiers **60** and **61** are also provided with input coupling impedances provided by resistors **64** and **65**, and with output resistors **66** and **67**, preferably of equal resistance value, to which output resistors leads **68** and **69** for the transformer **31** are connected at suitable tap points **70** and **71**, one of which is preferably variable.

This system has the advantage that the transformer **31**, following the balanced detector **60**, **61**, may have a sharp audio frequency band pass characteristic, thereby lending selectivity to the system, and otherwise operating in a similar manner to the system shown in Fig. 1. By connecting the impedance coupling connections, through the coupling capacitors **62** and **63**, with equal impedances **17** and **18**, only the modulated AC is transmitted to the balanced detector **60**, **61**, and in the case of an interference signal producing the wave AB, the operation is substantially as shown in Figs. 2 and 3, and as described in connection with Fig. 1.

A desirable feature of Fig. 4 is that a greater frequency band-pass input to the balanced detector may be used (say 50 kc.) and it will not be necessary to have an audio transformer that will pass this high frequency. (That is, if AB was 50 kc. it would be impractical to design a transformer that would pass this frequency efficiently to the detector **35** in Fig. 1.)

Referring now to Fig. 5, the receiving system of Fig. 4 is shown as adapted for receiving a modulated carrier wave signal, and like parts throughout bear the same reference numerals as in Fig. 4.

The desired modulated signal is received in the balanced detector **10**, and the resultant signal, after combining with oscillations from the oscillator **22**, are rectified in the balanced detector circuit **60**, **61** and applied to a tuned output circuit for the last named detector, provided by two tuned coupling circuits **80** and **81** in connection with a high frequency coupling transformer **82**. The output signals are then amplified in a suitable amplifier **83**, and the desired modulation is derived in an audio frequency detector **84**. The detector signals are amplified in a suitable audio frequency amplifier **85**, and applied to an output device or loudspeaker **86**. This system differs from the system of Fig. 4 in operation, in the use of a tuned coupling circuit in connection with the output of the rectifier following the balanced detector, and in the use of a third or audio frequency detector following the coupled tuned circuits.

The operation of this system may be better understood by referring to Fig. 6, along with Fig. 5. In Fig. 6 the oscillator frequency may be such that it lies outside of the overall response characteristic or selectivity E of the receiving system, preceding the detector **10**, while A and B represent the incoming modulated signal and the interference voltages, respectively. AC is shown at 40 kilocycles merely by way of example, and the amplitude of the incoming signal A is preferably maintained somewhat below one-half that of the local oscillator, in order that when the signal A is modulated the peaks do not rise above the value of C; otherwise distortion may result. The frequency of the oscillator C should be sufficiently far removed from the selectivity curve E that direct audio frequency beat notes between the signal and the oscillator are not obtained

The input signal to the auxiliary detector or rectifier **60**, **61** will contain two signal frequencies—that is, AB, equal to 10 kilocycles, and BC, equal to 50 kilocycles. The output circuit of the rectifier **60**, **61**, as applied to the transformer **82**, will include, in addition, a third signal frequency, which is the difference between BC and AB, or 40 kilocycles, together with a fourth signal frequency which is the sum of BC and AB, or 60 kilocycles.

The tuned coupling circuits **80** and **81**, following the second detector or rectifier, may be designed to pass the 40-kilocycle signal and to reject the other signals.

With the system described, this may be done readily, for the reason that the amplitudes of all of the signals are in the order of the amplitude of the oscillator voltage C, regardless of the amplitude of the interference B. This is for the reason that variations in the amplitude of B serve merely to move the modulation envelope of AB, as provided by AC, to a greater distance from the zero axis as explained in connection with Fig. 3.

However, since the signal A is modulated, this modulation will appear on the 40-kilocycle signal and the band-pass characteristic of the tuned coupling circuits **80** and **81** should be sufficiently broad to carry this modulation. Therefore, a 40-kilocycle modulated signal is obtained through the transformer **82**, whether interference B is present or not.

The 40-kilocycle modulation signal is then amplified in the amplifier **83**, if desired, and is finally detected in the detector **84** to derive the desired modulation or audio frequency signal.

From the foregoing description, it will be seen that a selective receiving circuit in accordance

with the invention comprises relatively broadly tuned receiving and amplifying circuits, preceding a balanced diode rectifier detector having a balanced output circuit in one branch of which is connected a source of oscillations to provide a beat frequency. The rectifier is connected with the output circuit of the balanced detector, and arranged to rectify or detect the beat frequency alone or after the modulation envelope on an interfering signal wave, whereby the presence of interference is prevented from interrupting the reception of a signal wave.

It will be seen that the rectifier following the balanced detector may be placed in advance of or following the audio frequency coupling transformer, and that for modulated carrier wave signals the detector following the balanced rectifier or first detector is connected with an audio frequency detector through a selective tuned signal circuit responsive to the beat frequency between the oscillator and the desired received carrier wave.

The diode type of detector or rectifier is preferred, as shown herein, for the reason that it insures straight line rectification in both the limiter and the demodulator or output rectifier stages, which type of rectification is substantially necessary or highly desirable for most effective operation of the limiter system.

From the foregoing description, further, it will be seen that broadly tuned circuits are provided in connection with a balanced detector limiter which operates in conjunction with an oscillator for heterodyne limiting and that a balanced output connection is provided with which is connected a suitable demodulator for preventing interruption in signal reception by the presence of a strong undesired carrier wave. Furthermore, there may be provided tuned circuits following the rectifier for transmitting a new intermediate frequency and a third rectifier or demodulator for providing the audio frequency signal.

From the foregoing description, it will be also seen that the method of obtaining selectivity in a radio receiver for the purpose of eliminating interference may comprise the use of broadly tuned signal receiving circuits preceding a limiter device and then demodulating the modulating effects of the limiter and also further using selective circuits following the demodulator to remove the local signal. If highly selective circuits are used before the limiter, it has been found that the interference is not properly reduced.

I claim as my invention:

1. A selective radio receiving system comprising, in combination, a broadly tuned signal receiving circuit, a balanced detector limiter circuit connected therewith, said circuit including a balanced output impedance network, means for introducing oscillations into one leg only of said output network, means for deriving an output signal from said network comprising a beat frequency signal resulting from mixing an incoming carrier wave and said oscillations in one leg of said network, and means for rectifying the beat frequency output signal derived from said network.

2. A selective radio receiving system in accordance with claim 1, further characterized by the fact that the detector and the rectifying means include diode rectifiers whereby a high degree of straight line rectification is provided.

3. In a radio signal receiving system, means for imparting selectivity thereto while eliminating undesired signal voltages therefrom, which comprises a balanced limiter rectifier device, means for applying oscillations thereto to provide a beat frequency signal output, means for rectifying said beat frequency output, a tuned selective circuit for receiving the signal output from said last named rectifier means, and means for detecting a desired signal component of said output wave connected with said last named tuned output circuit.

4. A radio signal receiving system in accordance with claim 3, further characterized by the fact that the last named detector is an audio frequency detector, and that an audio frequency amplifier and signal output device is connected therewith for reproduction of a desired signal envelope.

5. The method of obtaining selectivity in a heterodyne beat limiter system, which comprises deriving a signal wave by broadly selecting the same, applying local oscillations of a predetermined amplitude to the selected signal wave to limit the amplitude of the received signal wave and interference by means of a heterodyne beat, and subsequently demodulating the interference modulating effects of the limiting process.

6. The method of obtaining selectivity in a heterodyne beat limiter system, which comprises deriving a signal wave by broadly selecting the same, applying local oscillations of a predetermined amplitude to the selected signal wave to limit the amplitude of the received signal wave and interference by means of a heterodyne beat, subsequently demodulating the interference modulating effects of the limiting process, and subsequently further selecting a portion of the output from the demodulating process in a narrow frequency band.

7. In a radio receiver for eliminating disturbing effects, the combination of a broadly tunable receiver circuit, two opposed detector circuits, an oscillator arranged to superimpose a voltage on only one of said opposed detector circuits, means for adjusting the detector circuits for producing rectified energy having the same wave form and the same phase relation between current and voltage, an output circuit connected with equipotential points on said detector circuits, and a rectifier device and a second signal rectifier circuit connected with said output circuit.

8. A selective radio receiving system for eliminating disturbing effects, comprising, in combination, signal receiving means including a receiving circuit broadly responsive to a predetermined frequency band of signals, diode rectifier means having a pair of output anodes, said rectifier means being connected with said receiving circuit and having a balanced output circuit comprising two impedance elements connected in balanced relation to each other with said anodes, means for producing rectified energy in said impedance elements having the same wave form and the same phase relation between current and voltage, an oscillator for superimposing an oscillator voltage lower than a received signal voltage in one branch of said output circuit, and means for detecting resultant modulated interference and signal beat voltages to derive an original signal and oscillator beat voltage, said last named means being coupled to said balanced output circuit at substantially equi-potential points thereon.

9. A selective radio receiving system in accordance with claim 8, further characterized by the fact that the last named detecting means is provided with an output circuit including selective

coupling means responsive to signals in a predetermined narrow band of frequencies.

10. A selective radio receiving system in accordance with claim 8, further characterized by the fact that a desired super-audible signal is produced in connection with the second detecting means having sound modulation thereon and that additional means are provided for demodulating said signal.

11. A selective radio receiving system for eliminating disturbing effects, comprising, in combination, a balanced detector limiter circuit, limited means for applying an oscillator voltage thereto not greater than an incoming signal voltage whereby the output beat frequency between the two input voltages will have an amplitude dependent only upon the amplitude of the oscillator voltage, means providing a signal rectifier following said limiter circuit for detecting a resultant modulated interference and signal beat frequency to derive the desired signal therefrom, and said balanced detector limiter circuit including diode rectifier means having a pair of output anode electrodes connected in balanced relation to said last named signal rectifier means.

12. A selective radio receiving system for eliminating disturbing effects, comprising, in combination, a balanced detector limiter circuit, limited means for appplying an oscillator voltage thereto not greater than an incoming signal voltage whereby the output beat frequency between the two input voltages will have an amplitude dependent only upon the amplitude of the oscillator voltage, means providing a signal rectifier following said limiter circuit for detecting a resultant modulated interference and signal beat frequency to derive the desired signal therefrom, and a selective signal coupling means connected in circuit following the last named signal rectifier means.

13. A selective radio receiving system for eliminating disturbing effects, comprising, in combination, a balanced detector limiter circuit, means for applying an oscillator voltage thereto not greater than an incoming signal voltage whereby the output beat frequency between the two input voltages will have an amplitude dependent only upon the amplitude of the oscillator voltage, and means providing a signal rectifier following said limiter circuit for detecting a resultant modulated interference and signal beat frequency to derive a high frequency modulated signal therefrom, a selective tuned circuit following said rectifier, and a demodulator connected with said last named circuit.

14. A selective radio receiving system including, in combination, a heterodyne signal limiter including a source of oscillations for limiting an incoming signal, means broadly responsive to an incoming signal for applying said signal to said limiter, said limiter including diode rectifier means providing two output anodes, a signal detector impedance-coupled to said rectifier, means whereby the coupling is responsive to a relatively wide band of signal frequencies, and said detector including a second diode rectifier means including two anodes, means providing a balanced output circuit with said last named anodes, and means providing equi-potential connections with said output circuit.

15. In a radio receiving system, means for eliminating disturbing effects, comprising a limiter circuit including diode rectifier means having two anodes, a signal rectifier coupled to said limiter circuit, means for introducing oscillations in circuit with one anode of said diode rectifier means relative to the other anode, and said detector being coupled to substantially equal potential points on said limiter circuit, and means for rectifying the signal output from said limiter circuit thereby to demodulate a signal wave resulting from a received interference wave, and said output circuit being broadly tuned to the beat frequency between said interference wave and a desired carrier wave in addition to the beat frequency between local oscillations and an interference wave.

16. In a selective radio receiving system for eliminating disturbing effects, the combination of a high frequency amplifier broadly responsive to a predetermined frequency band, a diode detector means having a pair of output anodes, said detector being connected with said amplifier to receive the signal output therefrom, means providing a balanced output circuit for said detector in connection with said anodes, means for introducing oscillations in circuit with one anode relative to the other anode to limit incoming signals, a second output circuit connected with substantially equal potential points on said balanced diode output circuit, means for detecting the resultant modulated interference and signal beat voltages connected with said last named output circuit, and coupling means between said last named detector means and the limiter circuit substantially uniformly responsive within a predetermined wide frequency range, which includes the said interference and signal beat voltages and a signal and oscillator beat voltage.

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