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SUPERHETERODYNE RECEIVER

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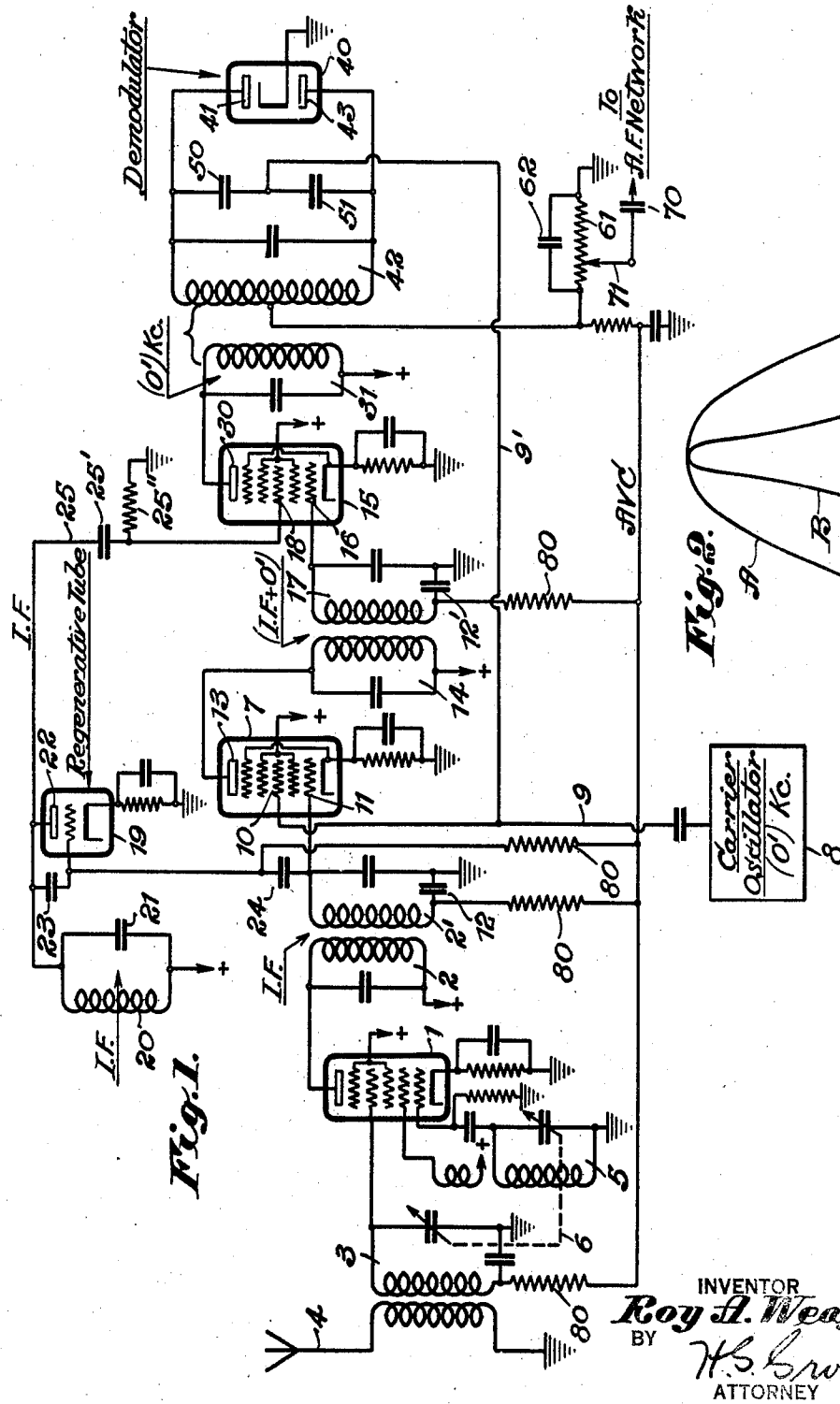


Fig. 1.

Fig. 2.

INVENTOR
Roy A. Weagant
BY
H. S. Bower
ATTORNEY

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SUPERHETERODYNE RECEIVER

Roy A. Weagant, Douglaston, Long Island, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

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10 Claims. (Cl. 250—20)

My present invention relates to modulated signal carrier receiving systems, and more particularly to receivers utilizing selective improvement in detector efficiency for desired signal carrier reception.

In my U. S. Patent 2,243,141, granted May 27, 1941, there is disclosed and claimed a modulated carrier detection system wherein selectivity is greatly increased by virtue of an electrical action termed "Selective improvement of detector efficiency"; the said action essentially comprising the injection into the detection system of substantially unmodulated carrier energy of the desired carrier frequency. The injected carrier energy is derived from the received modulated carrier waves, and is of such relatively great magnitude with respect to the signal energy at the detector input network that detection is caused to be highly efficient for the modulated carrier energy of the desired frequency, while detection is relatively inefficient for signal energy of an undesired interfering frequency.

More specifically the aforesaid detection system utilized a pair of diode rectifiers arranged for full wave rectification, there being employed means for impressing upon the common input circuit of the diodes combined modulated carrier energies of desired and undesired frequencies. There was utilized a network for deriving from the signal energies amplified oscillations of the desired carrier frequency, and the amplified oscillations were applied to the diodes in such a manner that the rectification of the modulated carrier energy of the desired frequency is relatively more efficient than the rectification of the signal energy of the undesired interfering frequency. Such a receiving system was found to have high selectivity, high fidelity of reproduction, and to be relatively free of adjacent channel interference.

A limitation which exists in the aforesaid receiving system is the fact that the exalted carrier energy which is injected into the final stage of detection is derived from the received modulated carrier waves. When the background noise level is of the same order of magnitude as the desired carrier itself, such a derivation of the exalted carrier energy is undesirable.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a system of receiving modulated carrier waves by selective improvement of detector efficiency, but wherein the exalted desired carrier energy is not derived from the received modulated carrier waves and is not affected by external disturbances or by tube noises; the present method involving the transmission to the final detector of modulated carrier waves, and the simultaneous transmission to the detector of carrier frequency energy derived from an auxiliary local oscillator whose frequency is independent of the frequency which the actual modulated carrier waves have in space.

Another important object of this invention is to provide a receiving system of the superheterodyne type wherein received modulated carrier waves are reduced to an intermediate frequency, an auxiliary oscillator of a predetermined carrier frequency being utilized to beat with the intermediate frequency energy to provide energy whose frequency is equal to the sum of the intermediate frequency and the auxiliary oscillator frequency, the intermediate frequency energy being subjected to the action of a highly selective network so as to produce unmodulated energy of substantially the intermediate frequency, and the aforesaid sum frequency being heterodyned with the unmodulated energy of intermediate frequency to produce oscillations of the auxiliary oscillator frequency which are modulated by the modulation frequency, and finally the latter energy is combined with energy of the auxiliary oscillation frequency to secure the selective improvement in detection efficiency.

Another object of the invention may be stated to provide a receiving system wherein in a first conversion stage the received signals are added to local oscillations to obtain a sum frequency which is modulated with the signal modulations, and in a second conversion stage there is subtracted from the sum frequency the original carrier frequency with the result that there is secured energy of the local oscillation frequency which is modulated with the signal modulations, and these last named modulated oscillations being supplied to the detector with oscillations from the local oscillator, the latter thus providing for the detector exalted carrier energy of high magnitude and constant strength and entirely free of any imperfections on the originally received signals.

Still other objects of the invention are to improve generally the efficiency, selectivity and fidelity of reproduction of radio broadcast receivers, and more especially to provide a receiver of the superheterodyne type employing selective improvement of detector efficiency which not only possesses the above desirable characteristics, but is constructed in an economical manner.

The novel features which I believe to be char-

acteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a receiving system embodying the invention,

Fig. 2 graphically illustrates the improvement secured by the invention.

Referring now to the accompanying drawing, there is shown in Fig. 1 a receiving system of the superheterodyne type which may be constructed for use in the standard broadcast band of 550 to 1700 kilocycles (kc.). Of course, the invention may also be used in the television and telegraph bands. The numeral 1 designates a converter stage which may be of the combined local oscillator-first detector type. For example, stage 1 can utilize, as is well known to those skilled in the art, a pentagrid converter tube of the 6A7 type which produces in its resonant output circuit 2 modulated carrier energy at intermediate frequency (I. F.). Such a network is too well known to describe in detail, and it is merely necessary to point out that the tunable signal input circuit 3 is coupled to any desired type of signal collector device 4. The latter may be the usual grounded antenna circuit, a loop antenna, a radio frequency distribution line, an automobile antenna device or any other well known type of signal collector.

The local oscillator tank circuit is designated by numeral 5. The tunable signal and local oscillator circuits are varied in unison by the usual common tuning element designated by the dotted line 6. By virtue of the electronic coupling action within the converter tube there will be developed across the resonant output circuit 2 the intermediate frequency voltage. Circuit 2 may be resonated to any desired I. F. value chosen from a range of 75 to 465 kc. As is well known to those skilled in the art, the variable tuning condenser of tank circuit 5 will be adjustable through a range of local oscillation frequencies which constantly differ from the signal frequency range of circuit 3 by the I. F. value of output circuit 2.

The numeral 7 designates the converter stage which functions to heterodyne the modulated I. F. energy with oscillations from an auxiliary carrier oscillator 8. The carrier oscillator 8 may be tuned to a predetermined high frequency; for example, 1,000 kc. The carrier oscillator 8 is symbolically designated as producing oscillations of 0′ kc. The carrier oscillator may be of any conventional construction. It is schematically represented, since those skilled in the art are fully aware of the manner of constructing an oscillator which will produce fixed oscillations of the order of 1000 kc. The oscillatory output of carrier, or auxiliary, oscillator 8 is impressed through lead 9 upon the third grid 10 of the pentagrid converter tube 7. The modulated I. F. energy output of the first converter tube 1 is impressed upon the first grid 11 of tube 7, after passage of the I. F. energy through the coupled resonant circuits 2 and 2′.

The resonant input circuit 2′ is tuned to the operating I. F. value, and is magnetically coupled to output circuit 2. The grid 11 is connected to the high potential side of circuit 2′. The low potential end of the coil of circuit 2′ is connected to ground through a direct current blocking condenser 12. The cathode of tube 7 may be connected to ground through the usual self-biasing network, as in the case of the cathode of converter tube 1. The anode 13 of tube 7 is connected to a point of proper positive potential through the coil of resonant output circuit 14. The resonant circuit 14 is fixedly tuned to the sum frequency of the I. F. and 0′. Hence, the designation I. F.+0′ is placed adjacent the tuned circuit 14. Of course, this sum frequency will be modulated by the modulation frequencies existing on the carrier at the signal collector 4. It will, therefore, be seen that tube 7 functions as a converter stage for beating, or heterodyning, the I. F. energy with the carrier oscillations to produce a modulated sum frequency carrier.

The numeral 15 designates a further, or third, converter tube. This may, also, be of the 6A7 type, and is generally of the same construction as tube 7. The control grid 16 thereof is connected to the high potential side of the resonant input circuit 17. The latter is fixedly tuned to the sum frequency I. F.+0′. The low potential terminal of the input circuit 17 is grounded. The direct current blocking condenser 12′ is inserted between the grounded terminals of the coil and condenser of circuit 17. The third grid 18 of tube 15 has impressed upon it oscillations of the I. F. value. These oscillations are derived from the I. F. input circuit 2′ of converter tube 7. There is utilized for this purpose a tube 19 which has its plate connected to a direct current source of proper positive potential through the coil 20 of a resonant circuit tuned to the operating I. F. value. The coil 20 is shunted by condenser 21, and circuit 20—21 is fixedly tuned to the I. F. value.

Preferably, the circuit 20—21 is sharply tuned to the I. F. value. The plate 22 of tube 19 is regeneratively coupled to the grid thereof by the coupling condenser 23. The cathode of tube 19 is connected to ground through a self-biasing network. The grid of tube 19 is coupled to the high potential side of input circuit 2′ by condenser 24 which has a low impedance to the modulated I. F. currents. The grid 18 of converter tube 15 is connected by lead 25 to the plate 22. Grid condenser 25′ and grid leak resistor 25″ are in circuit with lead 25. The action of the regeneratively coupled I. F. amplifier 19 is to provide a highly selective network which substantially removes the modulation frequency components from the I. F. carrier.

In other words, there is transmitted over lead 25 to grid 18 energy of the I. F. value with substantially all the modulation side bands removed. Ideally, all the modulation components should be removed. Those skilled in the art are fully aware of the action of a regenerative circuit, and the fact that it can be constructed to be sufficiently sharp substantially to remove all the modulation side bands from a modulated carrier wave. Reference is made to my aforesaid U. S. Patent 2,243,141 for a disclosure of a regenerative amplifier wherein the degree of regeneration by the coupling condenser 23 can be established so that there is produced in the output of the regenerative tube I. F. carrier energy with substantially all modulation removed. The ideal removal of modulation components is limited by the best practical approximation.

Considering the action of the converter tube 15, its plate 30 is connected to a source of proper

positive potential through the coil of resonant output circuit 31. This circuit is fixedly tuned to the frequency of the carrier oscillator 8. It is pointed out in the circuit diagram that circuit 31 is tuned to a frequency of 0′ kc. In other words, the energy of I. F. value applied to grid 18 beats with the energy of I. F+0′ value. In the output circuit 31 the difference heterodyne frequency voltage is developed, and this voltage has a frequency of 0′ kc. Of course, the energy of 0′ kc. developed in circuit 31 is modulated by the modulation frequency components which exist on the sum frequency carrier at the input circuit 17. These modulation components are the same that exist on the original carrier at the signal collector 4. It will, therefore, be seen that there is now ready for transmission to the second detector, or demodulator, modulated carrier energy. However, the carrier frequency of the latter is of the value of the frequency of carrier oscillator 8.

The demodulator is of the same type disclosed in my aforesaid U. S. Patent 2,243,141. There may be utilized a double diode tube 40 of the 6H6 type, although it is to be understood that separate diode tubes may be employed if desired. The cathode of tube 40 may be established at ground potential. Anode 41 is connected to one side of the resonant input circuit 42, while anode 43 is connected to the opposite side thereof. The resonant input circuit 42 is magnetically coupled to the resonant output circuit 31 of the last converter tube 15. The circuit 42 is fixedly tuned to the 0′ frequency. Condensers 50 and 51 are arranged in series with each other, and the series condenser path is connected in shunt with the resonant input circuit 42. To the junction of condensers 50 and 51 is connected a lead 9′ which transmits the unmodulated carrier oscillations of 0′ kc. frequency to the demodulator.

The mid-point of the coil of circuit 42 is connected to ground through a path which includes load resistor 61. The condenser 62 shunts load resistor 61 in order to bypass the current of 0′ frequency. The modulation frequency voltage developed across load resistor 61 may be transmitted to an audio frequency amplifier network by means of the audio coupling condenser 70. The adjustable tap 71 controls the magnitude of the audio, or modulation, voltage picked off from load resistor 61. Direct current voltage developed across resistor 61 is utilized for automatic volume control (A. V. C.). The A. V. C. bias is applied through lead 70 to the signal input electrode of the first converter tube 1, to the signal input grid 11 of the second converter tube 7, to the signal input grid 16 of the third converter tube 15, and to the control grid of the regenerative tube 19. The lead 70 is shown connected to the control grids of each of the converter tubes through appropriate filter resistors 80. These resistors function to suppress any pulsation voltage components existing in the uni-directional voltage developed across load resistor 61. The lead to the regenerative tube grid also includes a filter resistor 80.

It will be understood that the circuit 42—50—51 is resonated to the 0′ frequency. The modulated carrier energy of 0′ value impressed on the circuit 42 is rectified in well known full wave rectification manner. There is developed across load resistor 61 both the direct current voltage component and the modulation voltage component as previously pointed out. Another reason for employing the A. V. C. circuit is to maintain the signal energy amplitude at the demodulator input circuit at a substantially uniformly low amplitude for the reasons stated in detail in my aforesaid U. S. Patent 2,243,141. The gain of the regenerative tube 19 is automatically controlled, and the magnitude of the injected, or exalted, I. F. carrier oscillations is maintained at a substantially constant magnitude at the grid 18.

In other words, the modulated carrier oscillations of 0′ value will be maintained at a substantially constant magnitude at the input circuit 42. The unmodulated carrier oscillations from oscillator 8 are impressed at the junction of condenser 50 and 51. These oscillations from source 8 are of necessity of a constant and uniform magnitude, since they do not depend on the received signal carrier. The unmodulated 0′ energy is injected into the demodulator network in phase quadrature with the modulated 0′ energy applied to the anodes. This phase relation is required by virtue of the unbalanced nature of the demodulator circuit. This is the optimum operating condition to secure the selective improvement in detector efficiency. It is not believed necessary for the purposes of the present application to explain again the last named selective improvement in detector efficiency, since that is fully explained in my aforesaid patent. It is to be understood that if a balanced type of demodulator were used, then the unmodulated carrier would be applied in like and unlike phases relative to the input signal.

It is merely necessary to point out for the purposes of this application that the magnitude of the oscillations derived from the carrier oscillator 8 is very much greater than the magnitude of the modulated carrier energy at input circuit 42. When the unmodulated 0′ carrier energy is applied, and when this unmodulated voltage is from 10 to 100,000 times as strong as the modulated carrier voltage applied at input circuit 42, the latter will be detected on the efficient part of the diode detector characteristic. Detection is extremely inefficient at the bottom of such characteristic, while at the upper portion of the characteristic it is efficient. Without injection of the unmodulated 0′ oscillations detection occurs near the lower portion of the characteristic, and is inefficient. Hence, a great increase in desired signal output is secured without increase in interference when the unmodulated 0′ energy is applied to the demodulator in the proper magnitude.

This highly selective improvement in detection efficiency occurs when the ratio of the signal input magnitude to the demodulator to the magnitude of the injected unmodulated 0′ oscillations is very low. The great increase in selectivity obtained is due to the action of the injected 0′ oscillations in greatly increasing the efficiency of signal detection without at the same time increasing the efficiency of the detection of the undesired interfering energy.

While there has been disclosed a regenerative amplifier circuit for providing the substantially unmodulated I. F. oscillations for grid 18, it is pointed out that other forms of highly selective circuits may be utilized. For example, there may be employed one or more stages of crystal-controlled amplification. The exalted carrier for the demodulator is applied by the auxiliary carrier oscillator 8, and the modulated and unmodulated energies supplied to the demodulator are of identical frequency. Yet no problem of synchronization exists in this system.

The present arrangement improves the reduction of static disturbances. The static results in the production of a band of frequencies in a receiving instrument, the band width being determined by the tuning of the receiver and each frequency is modulated. If the static disturbance is man-made, the modulation will be the same for all frequencies in the band. If it is natural static, it will have different modulation on the different frequencies. In order that static may be heard, it is necessary that demodulation take place. In the arrangement described herein, one frequency, namely the signal carrier frequency, will be demodulated with a high order of efficiency, while all other frequencies will be demodulated with a low efficiency. This is the result of the action which has been termed "Selective improvement in detector efficiency." Were the regenerative circuit only one frequency wide, then only this frequency of static would be demodulated, and the resultant improvement in operating would be enormous. Actually the regenerative circuit, or its equivalent selective network, has a band width. Hence, other frequencies will be admitted and will appear in the detector circuit as the same frequency as the signal, but with amplitude reduced in accordance with the resonance curve of the highly selective regenerative circuit.

With ordinary methods of reception the demodulation of any frequency admitted by the tuning takes place with the same degree of efficiency. The audio output is then definitely proportional to the resonance curve of the receiver. In the present receiver, this statement is true only of those frequencies which are admitted by the highly selective regenerative circuit. The amount of static reduction to be expected, therefore, will be shown by the relation between the resonance curve of the receiver without the regenerative circuit, and the resonance curve of the regenerative circuit plus whatever tuning action exists ahead of the first converter tube. In Fig. 2 this has been qualitatively illustrated. The curve A depicts the receiver resonance curve taken at the demodulator input circuit without the use of the regenerative tube circuit. In other words, the regenerative circuit is assumed to be replaced by a hypothetical I. F. oscillator. Curve B shows the resonance curve taken at resonant circuit 20—21 when the regenerative circuit is used. This resonance curve takes into account the tuning action ahead of the converter.

The static admitted to the loudspeaker will be proportional to the ordinates of curve B, instead of to the ordinates of curve A as would be the case for an ordinary receiver with same overall resonance curve. The action may be summed up in the following statement: The arrangement described will result in a discrimination against static equal to that of the most highly selective tuned circuit, while at the same time admitting a modulated signal having any desired band width. This represents any desired reduction, particularly if one resorts to all the known methods of obtaining extreme selectivity for signal input into converter tube 15.

The present system is of aid in overcoming the effect of fading of the carrier relative to the sidebands. This is commonly called "selective fading." The present method of injecting exalted carrier, not derived from the signal energy, into the demodulator network will overcome any degree of carrier fading so long as the sidebands are present.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. A method of reception which includes the steps of changing received side-band modulated carrier energy to a different carrier frequency, producing unmodulated carrier energy whose frequency is other than said different carrier frequency, combining said unmodulated carrier energy and said modulated different carrier frequency energy to produce side-band modulated carrier energy whose frequency is the heterodyne of said combined carrier frequencies, removing the modulation side bands from modulated different carrier frequency thereby to provide substantially unmodulated carrier energy of said different frequency, combining said modulated heterodyne carrier frequency energy with said substantially unmodulated carrier energy of said different frequency to produce side-band modulated carrier energy whose frequency is that of said unmodulated other carrier frequency, and combining said last named modulated carrier energy with said unmodulated other carrier frequency energy during demodulation.

2. A method of reception which includes the steps of reducing received side band modulated carrier energy to a lower carrier frequency, producing unmodulated carrier energy whose frequency is different from said reduced carrier frequency, combining said unmodulated carrier energy and said modulated reduced carrier frequency energy to produce side-band modulated carrier energy whose frequency is the sum of said combined carrier frequencies, deriving from said modulated reduced carrier frequency energy substantially unmodulated carrier energy of said reduced frequency, combining said modulated sum carrier frequency energy with said substantially unmodulated carrier energy of said reduced frequency to produce side-band modulated carrier energy whose frequency is that of said unmodulated different carrier frequency, and combining said last named modulated carrier energy with said unmodulated different carrier frequency energy during demodulation.

3. A method of reception which includes the steps of reducing received side-band modulated carrier energy to a lower carrier frequency, producing unmodulated carrier energy whose frequency is different from said reduced carrier frequency, combining said unmodulated carrier energy and said modulated reduced carrier frequency energy to produce side-band modulated carrier energy whose frequency is the sum of said combined carrier frequencies, deriving substantially unmodulated carrier energy of said reduced frequency from said modulated carrier energy of reduced frequency, combining said modulated sum carrier frequency energy with said substantially unmodulated carrier energy of said reduced frequency to produce side-band modulated carrier energy whose frequency is that of said unmodulated different carrier frequency, combining said last named modulated carrier energy with said unmodulated different carrier fre-

quency energy during demodulation, and maintaining the magnitude of said unmodulated different carrier frequency energy at a high value relative to the magnitude of said modulated energy of the same carrier frequency throughout said demodulation.

4. In a receiver of the superheterodyne type, means for converting received modulated carrier waves to an intermediate frequency, an oscillator operating at a fixed frequency different from the intermediate frequency, a second converting means for mixing modulated energy of said intermediate frequency and oscillations from said oscillator to produce energy whose frequency is the sum of the intermediate and fixed frequencies and which is modulated in the same manner as the received carrier waves, means for deriving from the modulated intermediate frequency energy substantially unmodulated carrier energy whose frequency is that of the intermediate frequency, a third converting means for mixing said modulated sum frequency energy and said substantially unmodulated intermediate frequency energy to produce energy of said fixed frequency modulated in the same manner as the received carrier waves, a demodulator, means applying said last named modulated fixed frequency energy to the demodulator, and means for applying oscillations from said oscillator to said demodulator.

5. In a receiver of the superheterodyne type, means for converting received modulated carrier waves to an intermediate frequency, an oscillator operating at a fixed frequency different from the intermediate frequency, a second converting means for mixing modulated energy of said intermediate frequency and oscillations from said oscillator to produce energy whose frequency is the sum of the intermediate and fixed frequencies and which is modulated in the same manner as the received carrier waves, means for deriving from the modulated intermediate frequency energy substantially unmodulated carrier energy whose frequency is that of the intermediate frequency, a third converting means for mixing said modulated sum frequency energy and said substantially unmodulated intermediate frequency energy to produce energy of said fixed frequency modulated in the same manner as the received carrier waves, a demodulator, means applying said last named modulated fixed frequency energy to the demodulator, means for applying oscillations from said oscilator to said demodulator at a relatively higher amplitude, and said deriving means comprising a highly selective regenerative circuit having an input connection to the first converting means.

6. In a receiver, means for converting received modulated carrier waves to an intermediate frequency, means to produce oscillations of a fixed frequency different from the intermediate frequency, a second converting means for mixing modulated energy of said intermediate frequency and said oscillations to produce modulated energy whose frequency is the sum of the intermediate and fixed frequencies, means for deriving from the modulated intermediate frequency energy substantially unmodulated carrier energy whose frequency is that of the intermediate frequency, a third converting means for mixing said modulated sum frequency energy and said substantially unmodulated intermediate frequency energy to produce modulated energy of said fixed frequency, a demodulator, means applying said last named modulated fixed frequency energy to the demodulator, and means for applying said oscillations to said demodulator at a relatively high amplitude.

7. In a receiver of the type wherein received modulated carrier waves are converted to an intermediate frequency, an oscillator operating at a fixed frequency different from the intermediate frequency, a converting means for mixing modulated energy of said intermediate frequency and oscillations from said oscillator to produce energy whose frequency is the sum of the intermediate and fixed frequencies and which is modulated in the same manner as the received carrier waves, means for deriving from the intermediate frequency energy substantially unmodulated carrier energy whose frequency is that of the intermediate frequency, an additional converting means for mixing said modulated sum frequency energy and said substantially unmodulated intermediate frequency energy to produce energy of said fixed frequency modulated in the same manner as the received carrier waves, a demodulator, means applying said last named modulated fixed frequency energy to the demodulator, means for applying oscillations from said oscillator to said demodulator at a relatively higher amplitude, and means, responsive to variations in received carrier amplitude, for controlling the gain of the receiver in a sense to maintain the modulated fixed frequency energy at the demodulator substantially uniform.

8. A method of reception which includes the steps of reducing received modulated carrier energy to a lower carrier frequency, locally producing unmodulated carrier energy whose frequency is substantially different from said reduced carrier frequency, combining said unmodulated carrier energy and said modulated reduced carrier frequency energy to produce modulated carrier energy whose frequency is the sum of said combined carrier frequencies, deriving substantially unmodulated carrier energy of said reduced frequency from said modulated carrier energy of reduced frequency, combining said modulated sum carrier frequency energy with said substantially unmodulated carrier energy of said reduced frequency to produce modulated carrier energy whose frequency is that of said unmodulated different carrier frequency, demodulating said last named modulated carrier energy while combining with said unmodulated different carrier frequency energy, and controlling the magnitude of the last named modulated carrier energy in response to received carrier energy variation.

9. In a receiver of the superheterodyne type, means for converting received modulated carrier waves to an intermediate frequency, an oscillator operating at a fixed frequency different from the intermediate frequency, a second converting means for mixing modulated energy of said intermediate frequency and oscillations from said oscillator to produce energy whose frequency is the sum of the intermediate and fixed frequencies and which is modulated in the same manner as the received carrier waves, means for deriving from the intermediate frequency energy substantially unmodulated carrier energy whose frequency is that of the intermediate frequency, a third converting means for mixing said modulated sum frequency energy and said substantially unmodulated intermediate frequency energy to produce energy of said fixed frequency modulated in the same manner as the received carrier

waves, a full wave rectifier, means applying said last named modulated fixed frequency energy to the rectifier, and means for applying oscillations from said oscillator to said rectifier at a relatively higher amplitude and in phase quadrature with said modulated fixed frequency energy.

10. In a receiver of the superheterodyne type, means for converting received modulated carrier waves to an intermediate frequency, a local oscillator operating at a fixed frequency different from the intermediate frequency, a second converting means for mixing modulated energy of said intermediate frequency and oscillations from said oscillator to produce energy whose frequency is the sum of the intermediate and fixed frequencies and which is modulated in the same manner as the received carrier waves, means for deriving from the intermediate frequency energy substantially unmodulated carrier energy whose frequency is that of the intermediate frequency, a third converting means for mixing said modulated sum frequency energy and said substantially unmodulated intermediate frequency energy to produce energy of said fixed frequency modulated in the same manner as the received carrier waves, a demodulator of the full wave rectifier type, means applying said last named modulated fixed frequency energy to the demodulator, means for applying oscillations from said oscillator to said demodulator at a relatively higher amplitude, and said deriving means comprising a highly selective regenerative circuit having an input connection to the first converting means.

ROY A. WEAGANT.