Nov. 5, 1946. D. B. HOISINGTON 2,410,736

PULSE-MODULATED WAVE-SIGNAL RECEIVER

Filed Aug. 15, 1944 3 Sheets-Sheet 1

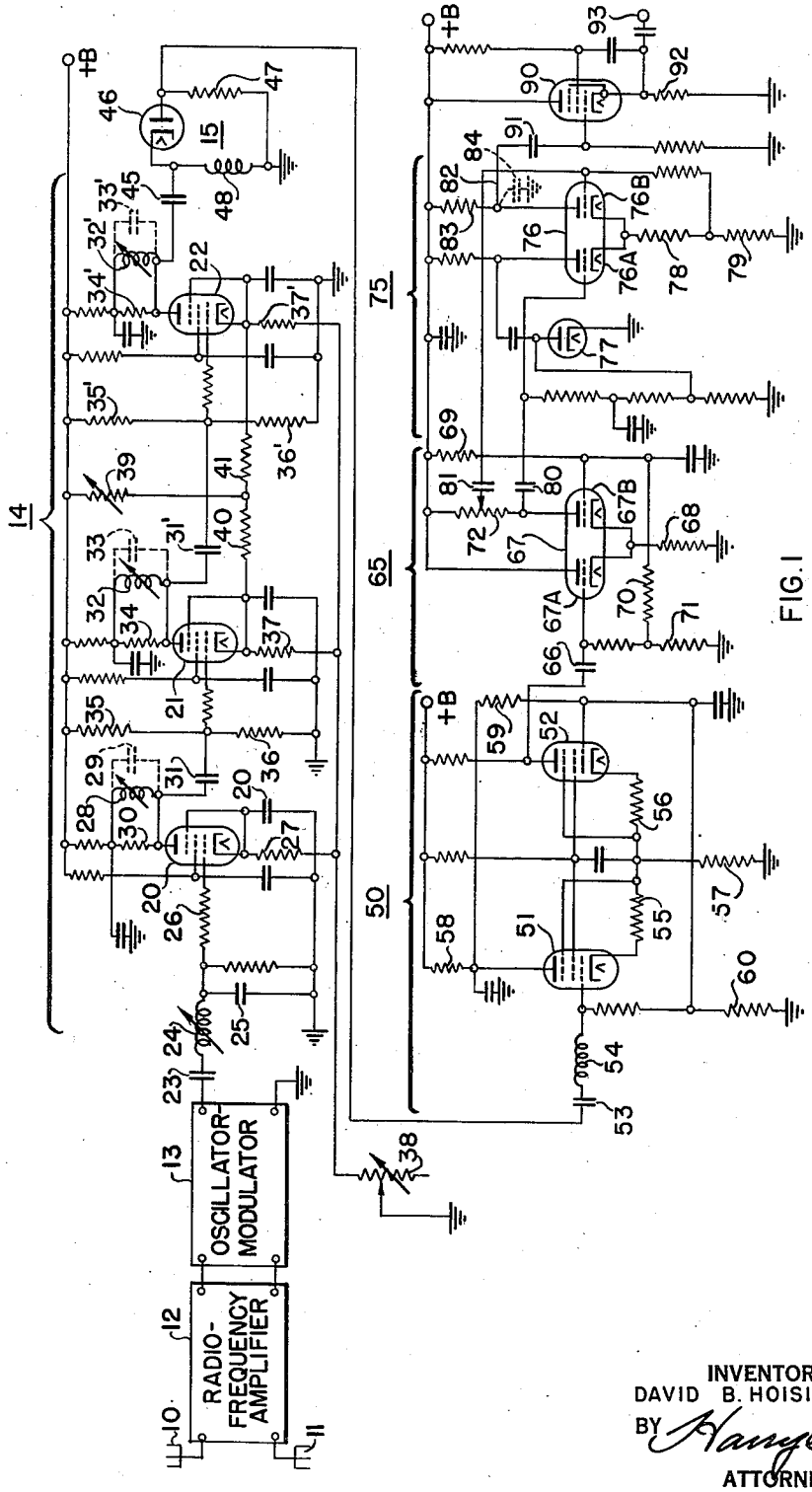


FIG. 1

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PULSE-MODULATED WAVE-SIGNAL RECEIVER

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FIG. 4

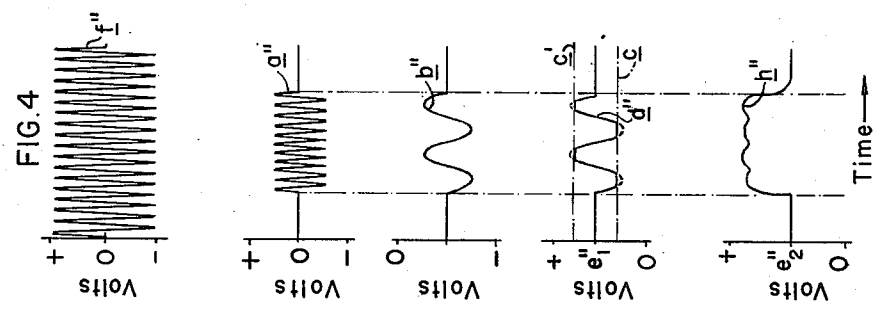


FIG. 3

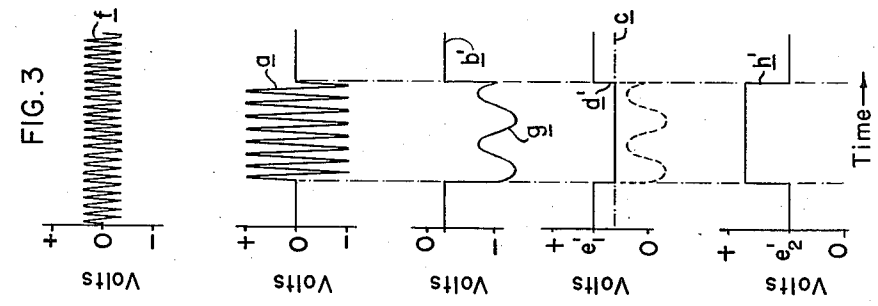
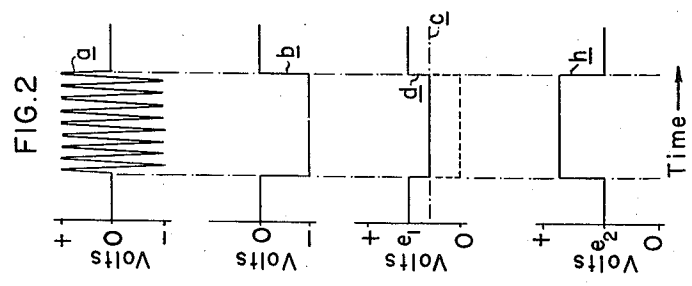


FIG. 2



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PULSE-MODULATED WAVE-SIGNAL RECEIVER

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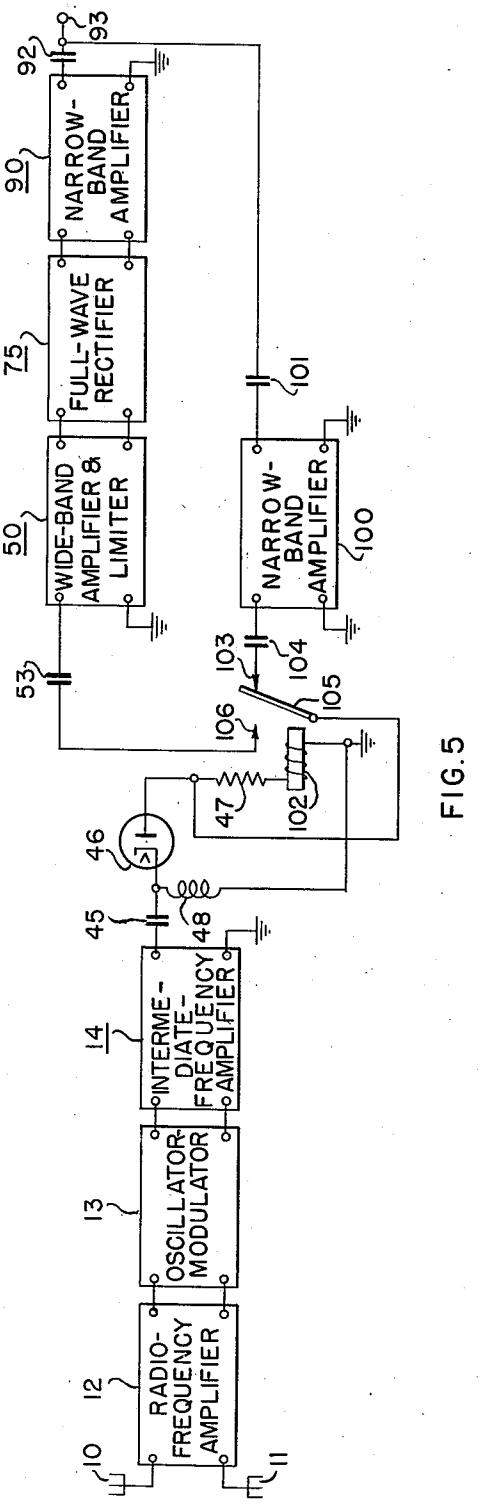


FIG. 5

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Patented Nov. 5, 1946

2,410,736

UNITED STATES PATENT OFFICE

2,410,736

PULSE-MODULATED WAVE-SIGNAL RECEIVER

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Application August 15, 1944, Serial No. 549,616

13 Claims. (Cl. 250—20)

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This invention relates, in general, to a receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal. It is particularly directed to such a receiver which is subject to receive an interfering continuous- wave signal concurrently with and having a different carrier frequency than the desired pulse-modulated signal. While the invention is subject to a variety of applications, it is especially suited for inclusion in the receiver portion of a radio-locator or direction-finder system and will be described in that connection.

Direction-finder systems of the prior art having a receiver of the superheterodyne type and the effects thereon of an interfering continuous-wave signal will first be considered. It is to be noted at the outset that such a system is usually operated in the ultra-high portion of the frequency spectrum because of the present allocation of available radio-frequency channels and also to take advantage of improved directivity possible at ultra-high frequencies. Since allowance must be made for drifts in the operating frequency of the heterodyne oscillator and in the carrier frequency of the transmitted signal, at least the initial stages of such receivers are required to have a wide pass band to assure reception of the desired direction-finder signals. At the same time, this band-width characteristic renders the receiver subject to interfering signals of a correspondingly wide range. When the interfering signal has a high intensity, compared with that of a desired pulse-modulated direction-finder signal, it causes overloading or blocking in many of the prior art receivers to such an extent that the pulse-modulated signal is not translated. In other words, the desired direction-finder signal is lost under the stated condition. Obviously, this is an undesired limitation.

In certain other prior art receivers of the type under consideration the band width is materially reduced in stages following the second detector. The change in band width is desired to increase the signal-to-noise ratio of the receiver but impedes efficient operation in the presence of strong interference. Usually the band width of the stages following the second detector of such a receiver is selected to be only as wide as required to translate the desired modulation components of a received pulse-modulated direction-finder signal. Assume a strong interfering continuous-wave signal to be received concurrently with the pulse-modulated signal and also assume the design of the receiver to be such

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that both received signals are faithfully translated to the second detector. For this condition the aforementioned prior art receiver produces a heterodyne-component pulse-modulated signal in the output circuit of the second detector, containing the desired modulation components and having a carrier frequency equal to the difference between the carrier frequencies of the received pulse-modulated and continuous-wave signals. For the most part, at the operating frequencies of such a system, the carrier frequency of this heterodyne-component signal falls outside of the narrow pass band of the succeeding receiver stages and thus is effectively lost, even though this heterodyne-component signal includes a major portion of the energy content of the translated signals corresponding to the modulation components desired. Further, such prior art arrangements do not include means for deriving the desired modulation components of the heterodyne-component signal should its carrier frequency be such as to be translated by the narrow-band stages succeeding the second detector. It will be appreciated that this operating limitation may likewise be undesirable in many installations.

It is, therefore, an object of the invention to provide an improved receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal and which avoids one or more of the above-mentioned limitations of prior art arrangements.

It is another object of the invention to provide an improved receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal even in the presence of a strong interfering wave signal received concurrently therewith and having a carrier frequency different than that of the pulse-modulated signal.

In accordance with the invention, a receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of the pulse-modulated signal comprises a first signal-translating means including selector circuits for translating both of the received signals. The first signal-translating means also includes detecting means effective in the absence of the interfering wave signal to derive the desired modulation components of the pulse-modulated signal and effective in the presence of the interfering signal with high intensity to derive from

the received signals of a heterodyne-component pulse-modulated signal having modulation components corresponding to the desired components. The receiver is provided with a second signal-translating means coupled to the afore-mentioned detecting means and including selector circuits for translating both the desired modulation components and the heterodyne-component pulse-modulated signal. A rectifying means is included in the second signal-translating means effective to derive the desired modulation components from the heterodyne-component pulse-modulated signal. Additionally, the receiver is provided with means, coupled to the second signal-translating means, for supplying the desired modulation components to a utilizing device.

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

Referring to the drawings, Fig. 1 is a schematic representation of a pulse-modulated signal receiver in accordance with the invention; Figs. 2, 3 and 4 individually comprise a series of graphs utilized in explaining the operation of the Fig. 1 arrangement under several different operating conditions; and Fig. 5 is a schematic representation of a modified pulse-modulated signal receiver embodying the invention.

Referring now more particularly to Fig. 1 of the drawings, the arrangement there represented may be considered as constituting the receiver portion of a direction-finder system in which direction-finding information is translated by way of pulse-modulated carrier-frequency wave signals. Accordingly, the receiver is adapted to derive desired modulation components of a received pulse-modulated carrier-frequency wave signal for application to a utilizing device but is also subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of the received pulse-modulated signal. As illustrated, the receiver comprises an antenna system 10, 11 for intercepting pulse-modulated carrier-frequency wave signals and for applying such signals to a first signal-translating means coupled to the antenna system.

The first signal-translating means comprises a radio-frequency amplifier 12 of one or more stages to which are coupled, in cascade, an oscillator-modulator 13, an intermediate-frequency amplifier 14, described more particularly hereinafter, and a detecting means 15. Units 12 and 13, shown in block form, may be of any conventional construction and design. The heterodyning oscillator of unit 13 in the usual case will have a tendency to drift, that is, its operating frequency will tend to vary over a predetermined range of frequencies. Therefore, units 12 and 13 are preferably selected to have a correspondingly wide band-pass characteristic so as to allow for such instability or frequency shifts of the heterodyning oscillator as well as shifts of the carrier frequency of signals to be received.

The intermediate-frequency amplifier 14 is shown as a three-stage amplifier, although as many stages of amplification may be utilized as desired. In the illustrated arrangement, the stages include pentode-type amplifying tubes 20, 21 and 22. The first stage is coupled to oscillator-modulator 13 through a coupling condenser 23 and a series-tuned circuit provided by an adjustable inductor 24 and a condenser 25, the tuned circuit being coupled to the input electrodes of tube 20 by way of a resistor 26. An operating bias for tube 20 is supplied by a cathode-biasing resistor 27. A parallel-tuned circuit is coupled to the anode electrode of tube 20 and includes an adjustable inductor 28 which is tuned by a condenser 29, shown in broken-line construction since it may be comprised in whole or in part of the inherent capacitance of inductor 28 and associated stray capacitances. Tuned circuit 28, 29 is damped by a resistor 30.

The second intermediate-frequency amplifier stage is coupled to the output circuit of tube 20 through a coupling condenser 31. This stage is similar to the preceding one, having a damped tuned circuit coupled to the output circuit of its amplifying tube 21. The tuned circuit consists of an adjustable inductor 32, a condenser 33, and a resistor 34. A positive potential is applied to the input electrode of tube 21 through a bleeder network including resistors 35 and 36 coupled to a voltage source, indicated +B. The cathode-bias resistor 37 of this stage has a high value, for a purpose to be described hereinafter. The final stage of the intermediate-frequency amplifier, including tube 22, is substantially the same as the second stage and corresponding components are identified by like reference numerals primed.

Suitable operating potentials are applied to the several stages from the source indicated +B. A variable resistor 38 is included as a common element in the anode-cathode circuits of the amplifying stages of unit 14 to adjust the cathode bias of the several tubes, thereby to provide a gain control. Additional gain control is afforded by an adjustable resistor 39 coupled between source +B and the cathode electrodes of tubes 21 and 22 through resistors 40 and 41, respectively.

The described tuned circuits of the intermediate-frequency amplifier constitute selector circuits. The circuits are stagger-tuned in conventional manner and the damping provided is such that the circuits have a band-pass characteristic substantially as wide as that of units 12 and 13. That is, the selector circuits permit the received signals to be translated faithfully through the intermediate-frequency stages.

The detector 15 of the described signal-translating means comprises means effective in the absence of an interfering wave signal to derive desired modulation components of a received pulse-modulated wave signal and effective in the presence of an interfering wave signal of high intensity to derive from the received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to the desired components of the received pulse-modulated signal. This detector is coupled to the last stage of the intermediate-frequency amplifier through a coupling condenser 45 and includes a diode detector 46 having a load circuit comprising a resistor 47 and an intermediate-frequency choke 48.

The receiver of Fig. 1 includes a second signal-translating means, this second signal-translating means having an input circuit coupled to detector 15. This last-named means includes selector circuits having a band-pass characterestistic substantially as wide as that of the first signal-translating means for translating both the desired modulation components and the heter-

odyne-component pulse-modulated signal derived in the load circuit of detector 15 under various operating conditions. The second signal-translating means includes an amplifier 50 having a pair of cathode-coupled amplifying tubes 51 and 52. The output signal of detector 15 is applied to the input circuit of tube 51 through a coupling condenser 53 and an inductor 54. Inductor 54 resonates with the input capacitance of tube 51 to maintain high-frequency fidelity in the translating arrangement under consideration. Additionally, inductor 54 is self-resonant at the mid-frequency of intermediate-frequency amplifier 14 to isolate intermediate-frequency signals from the second signal-translating means under consideration. The cathode electrodes of tubes 51 and 52 are coupled through a T-type network including resistors 55, 56 and 57. With this circuit arrangement, tube 52 constitutes a cathode-driven amplifier. A source of space current, indicated +B, is connected with the anode electrodes of tubes 51 and 52, as shown, and a positive potential is applied to the control electrodes thereof through a bleeder network of resistors 58, 59 and 60. The components of the described T network are selected of such value that tubes 51 and 52 have the desired effective operating bias.

A limiter 65 is coupled in cascade with tube 52 through a condenser 66. The limiter 65 is similar to unit 50 in that it contains a pair of cathode-coupled electron-discharge repeater devices, illustrated as individual sections of a duo-triode 67 having a common cathode resistor 68. The anode electrodes of each section of tube 67 connect with a source of space current +B and a positive potential is applied to the control electrodes of each section through a network of resistors 69, 70 and 71. The resistor elements 68–71, inclusive, are proportioned to establish such operating biases on the control electrodes of the sections of tubes 67 that the first section 67A effects limiting of strong applied signal variations of negative polarity, while limiting of strong signal variations of positive polarity is accomplished in the remaning section 67B. This limiting action in each instance is obtained by the sections being driven to anode current cutoff by the signal variations limited in the particular section.

The second signal-translating means also includes a rectifying means 75 which effectively comprises a full-wave rectifier for deriving the desired modulation components from the heterodyne-component pulse-modulated signal obtained from detector 15 in the presence of a received pulse-modulated signal and a strong interfering continuous-wave signal of different frequency than the carrier frequency of the pulse-modulated signal. This rectifying means is substantially the same as the signal-translating system forming the subject matter of applicant's copending application, Serial No. 549,615, filed concurrently herewith and assigned to the same assignee as the present invention.

The arrangement of unit 75 is described in the copending application as a signal-translating system for translating a signal which may include bidirectional amplitude variations with respect to a reference amplitude level. Briefly, the system comprises a first repeater device including section 76A of a duo-triode 76. This section is biased substantially to anode current cutoff by virtue of a stabilizing circuit including a diode 77, so that it is responsive substantially only to amplitude variations of an applied signal in a given direction from its reference level. That is, repeated device 76A is effective to repeat only signal variations of positive polarity. The system also includes a second repeater device, section 76B of tube 76, biased so as to be responsive to bidirectional amplitude variations, or variations of positive and negative polarity, of the applied signal from its reference level. Input and output circuits are provided for the repeater devices, including an impedance which is common to the output circuit of the first device and to the input circuit of the second device. This impedance is shown as series-connected cathode resistors 78 and 79 and is such that signal variations in the first device 76A tend to effect opposing signal variations in the second device 76B. The system has means, comprising a coupling condenser 80, for applying the signal output of limiter section 67B with a given phase and given intensity to the input circuit of first device 76A. The system likewise has means, comprising a coupling condenser 81 connected to a tap on the anode resistor 72 of limiter section 67B, for applying the signal output of section 67B with the same phase but with substantially less than the aforesaid given intensity to the input circuit of second device 76B. Preferably, the tap of resistor 72 is so adjusted that the signal is applied to repeater device 76B with less than one-half the intensity of the signal as applied to repeater device 67A. Finally, the system includes means, comprising a connection 82, coupled to the output circuit of the second repeater device for deriving an output signal from the system having amplitude variations which are determined by the variations of the applied signal but which are unidirectional with respect to a reference amplitude level corresponding to the reference level of the applied signal. A detailed description of unit 75 is contained in the above-mentioned copending application.

The receiver of Fig. 1 further includes means coupled to the signal-translating means comprising units 50, 65 and 75 for supplying the desired modulation components to a utilizing device. This means is provided by a cathode follower including a pentode-type tube 90. The cathode follower is coupled to the output circuit of second repeater device 76B through connection 82 and a coupling condenser 91. A source of space current, indicated +B, is connected with anode electrode of tube 90. The desired modulation components of the received pulse-modulated signal are derived across a cathode impedance 92 and supplied to an output terminal 93 to which a suitable utilizing device (not shown) may be connected. The anode resistor 83 of repeater 76B and the inherent capacitance of its anode circuit, represented by broken-line condenser 84, effectively constitute a low-pass filter in the input circuit of cathode follower 90 so that substantially only the desired modulation components are translated therethrough to output terminal 93. In other words, while the selector circuits of the several stages of the described receiver from the antenna system 10, 11 to cathode follower 90 have wide band-pass characteristics, the final stage 90 has a narrow pass band, being only as wide as required to translate the desired modulation components. This reduction in band width at the final stage of the receiver enhances the signal-to-noise ratio.

In considering the operation of the described arrangement, reference is made to the series of graphs of Fig. 2. These graphs illustrate the

operation for the condition in which the desired pulse-modulated direction-finder signal alone is intercepted by antenna system 10, 11. A single pulse of the received signal is represented by curve *a*. The received signal is translated through units 12 to 15, inclusive, in accordance with conventional heterodyne operation, and the detected modulation components thereof appear in the output circuit of detector 15 with the wave form of curve *b*. The derived output signal, after amplification in unit 50, is translated through limiter 65 where the first section 67A limits the signal at the limiting level represented by horizontal line *c* of Fig. 2. The output signal of the limiter, full-line curve *d*, is a unidirectional signal having only amplitude variations of negative polarity from a reference amplitude level, indicated e_1. This output signal of limiter 65 is applied through condenser 80 to the input circuit of first repeater device 76A of unit 75 with a given phase and full intensity. The same signal is applied with the like phase but with less than half intensity through condenser 81 to the input circuit of second repeater device 76B. The applied signal, having only amplitude variations of negative polarity, is not translated by first repeater device 76A. However, the second repeater, functioning in a manner analogous to a conventional triode amplifier, translates the signal of less than half intensity to the output circuit of detector 75 where it appears with the wave form of curve *h*. This signal has unidirectional amplitude variations determined by the amplitude variations of the applied signal, curve *d*, but of positive polarity with respect to a reference amplitude level e_2 corresponding to the reference level e_1 of the applied signal. The desired modulation components of this output signal of unit 75 are selected in the input circuit of cathode follower 90 and supplied to output terminal 93 for utilization. By stating that the reference level e_2 of the output signal of unit 75 corresponds to the reference level e_1 of the signal applied thereto is meant that the amplitude level of the output signal has the value e_2 when the applied signal has its reference amplitude value e_1.

From the foregoing description it will be apparent that when the pulse-modulated signal alone is received, the arrangement of Fig. 1 functions as a conventional superheterodyne receiver, deriving the desired modulation components in the second detector 15 and translating these components after suitable amplification in the succeeding signal stages 50, 65 and 75 to output terminal 93.

Consider now the operation of the receiver when an interfering continuous-wave signal of relatively low intensity is received concurrently with the pulse-modulated direction-finder signal. The response of the receiver for this condition is represented by the graphs of Fig. 3. The curve *a* represents the pulse-modulated signal and curve *f* represents an interfering continuous-wave signal having a carrier frequency different from that of the pulse-modulated signal but included within the pass band of units 10—14, inclusive. For this condition, both signals are translated to detector 15 in view of the wide band-pass characteristics of the preceding stages. The output signal of the detector, as shown by curve *b'*, contains a low-intensity direct current component, the detected modulation components of the received pulse-modulated signal and a superposed ripple component *g*. The ripple component represents a heterodyne-component signal resulting

from intermodulation of the pulse-modulated and interfering signals. It has a frequency corresponding to the difference in the carrier frequencies of these received signals but has a relatively low intensity compared with the detected pulse-modulated signal. The ripple component is effectively removed through the limiting action of section 67A of unit 65 so that the signal applied to unit 75, as represented by curve *d'*, is substantially the same as that obtained in the presence of the pulse-modulated signal alone. Consequently, the output signal of detector 75, curve *h'*, and that delivered to terminal 93 correspond to those obtained for the first-mentioned operating condition.

Before considering the over-all response of the receiver to a pulse-modulated signal and a strong interfering continuous-wave signal received concurrently therewith, mention should be made of the function of the biasing circuits of the second and third intermediate-frequency amplifier stages described above. While a positive potential is applied to the control electrodes of tubes 21 and 22, the cathode resistors 37 and 37' of these stages are selected of such value that the effective grid bias operates the tubes close to anode current cutoff. Due to the curvature of the characteristic curves of tubes 21 and 22 at the selected operating point, any signal voltage on the input electrodes tends to increase the average space current since positive half cycles of the applied signal increase the space current more than negative half cycles decrease it. Due to the positive voltage on the control electrodes and due to the large cathode resistors, a small change in the space current produces a relatively large change in the operating bias. High-intensity continuous-wave signals move the operating point beyond anode current cutoff so that such high-intensity signals may be accommodated without overloading the intermediate-frequency stages on the positive signal peaks. For this reason, high-intensity interfering signals do not produce such over-loading as would cause the desired pulse-modulated signal received concurrently therewith to be effectively lost.

The graphs of Fig. 4 indicate the over-all receiver response when the interfering continuous-wave signal is of high intensity as compared with that of the pulse-modulated signal. These graphs correspond with those of Fig. 3 and are identified by similar reference characters double primed.

It will be seen that for such operating conditions, the output signal of the detector 15, curve *b''*, comprises a substantial direct current component and a heterodyne-component pulse-modulated signal having modulation components corresponding to the desired components of the received pulse-modulation signal and having a carrier-frequency equal to the difference between the carrier frequencies of the received signals. In other words, the detected modulation components derived directly through detection of the received pulse-modulated signal are overwhelmed by the heterodyne-component signal resulting from the intermodulation of the received pulse-modulated and continuous-wave signals. Since capacitive coupling is utilized between the second detector 15 and amplifier 50, the direct current component of the detector output signal is lost and the signal of curve *b''* is applied to unit 50 as a pure alternating current signal. Both the positive and negative amplitude variations of this signal are limited in unit 65, as indicated by limit-

ing levels c and c' of Fig. 4. The resulting signal output of the limiter is represented by full-line curve d''. It has bidirectional amplitude variations from a reference level e_1'' corresponding to the alternating current axis of the heterodyne-component pulse-modulated signal. The limited signal is translated by detector **75**, appearing in the output circuit thereof with the wave form of curve h''. The translated signal has amplitude variations which are determined by the bidirectional amplitude variations of the limited signal of curve d'' but which are unidirectional with respect to a reference amplitude level e_2'' corresponding to the reference level e_1'' of the limited signal. From a comparison of curves d'' and h'' it will be evident that the unit **75** functions as a full-wave rectifier. The specific operation of unit **75** in this respect is completely described in the above-mentioned copending application.

While the output signal of curve h'' includes the desired modulation components of the received pulse-modulated signal, it also contains a component having twice the frequency of the heterodyne-component pulse-modulated signal obtained from detector **15**. This high-frequency component, as well as others not desired to be utilized, are effectively eliminated by the filter **83, 84** in the input circuit of cathode follower **90**. Therefore, the signal delivered to output terminal **93** for application to the utilizing device again contains substantially only the desired modulation components of the received pulse-modulated direction-finder signal.

In order to simplify the description, the response of the receiver has been considered only for the condition in which a given interfering signal of high intensity is received concurrently with the desired pulse-modulated signal. However, it will be clear that an interfering signal having a carrier frequency within a range of frequencies corresponding to the pass band of the receiver may be translated simultaneously with a desired pulse-modulated signal. For this reason, the resulting heterodyne-component pulse-modulated signal derived in detector **15** may likewise have a carrier component within a corresponding frequency range. Since the pass band of the second signal-translating means comprised of units **50, 65** and **75** is as wide as that of the preceding stages, any such heterodyne-component signal is translated thereby to derive the desired modulation components in the described manner.

In one embodiment of the invention found to have practical utility, the receiver had the following characteristics:

Pass band of units **12–15**, inclusive	megacycles__ 4
Pass band of units **50, 65** and **75**	____do____ 4
Pass band of cathode follower **90**	kilocycles__ 200
Mid-frequency of radio-frequency stages	megacycles__ 172
Mid-intermediate frequency	____do____ 11
Pulse-repetition frequency	____cycles__ 400

The receiver arrangement of Fig. 5 is generally similar to that of Fig. 1 and corresponding components thereof are identified by the same reference numerals, with exceptions as noted hereinafter. In the Fig. 5 modification the second signal-translating means coupled to detector **15** effectively comprises a pair of parallel-connected signal-translating channels. One such channel comprises a narrow-band amplifier **100** which may be of conventional construction. This channel is characterized by a band-pass characteristic such as to translate substantially only the desired modulation components of the received pulse-modulated direction-finder signal. The other channel is generally similar to the described second signal-translating means of the Fig. 1 arrangement, having a relatively wide band-pass characteristic. In particular, this channel comprises a unit **50** which here designates both the wide-band amplifier **50** and limiter **65** of the Fig. 1 arrangement. This channel also includes the full-wave rectifier **75** and its band-pass characteristic is such that the channel is effective to translate any heterodyne-component pulse-modulated signal derived in detector **15** in the presence of both a pulse-modulated signal and a strong interfering continuous-wave signal, as described above. Preferably, the pass band of this second channel comprising units **50** and **75** is such as to translate substantially only such heterodyne-component pulse-modulated signals of detector **15**. The desired modulation components derived from the heterodyne-component signal in rectifier **75** are supplied to the narrow-band amplifier **90** which may comprise a cathode follower arranged to translate substantially only the desired modulation components, as in the Fig. 1 arrangement.

The modified receiver also includes means coupled to the described pair of parallel-connected channels for supplying the desired modulation components to the utilizing device. This means is provided by an output terminal **93** to which the first channel is coupled through a condenser **101**, while the second channel is coupled thereto through amplifier **90** and a condenser **92**.

In general, the two channels coupled to detector **15** will not be used simultaneously and, therefore, the arrangement is provided with an amplitude-selective means responsive to an interfering wave signal of high intensity for disabling the first-described channel. This means, as represented, includes a relay **102** of well-known construction connected in the output circuit of detector **15**. An armature **105** normally connects the first channel, including narrow-band amplifier **100**, to the output circuit of detector **15** through a condenser **104** and normally closed contact **103**. In its alternate position the armature disables the first channel and connects the second channel to the output circuit of detector **15** through condenser **53** and the remaining relay contact **106**.

The operation of the Fig. 5 arrangement will be apparent from the preceding discussion. Briefly, when a pulse-modulated direction-finder signal alone is received, the desired modulation components are derived in detector **15** and applied through normally closed contact **103** and narrow-band amplifier **100** to output terminal **93**. However, when a strong interfering continuous-wave signal is simultaneously received, the average current in the output circuit of detector **15** has such value that relay **102** is energized and connects the output circuit of the detector with the alternate parallel-connected signal-translating channel. For this condition, the desired modulation components are derived in full-wave rectifier **75** and applied through narrow-band amplifier **90** and condenser **92** to output terminal **93**.

It is well known that a pulse-modulated signal of the type represented by the curves of Figs. 2, 3 and 4 contains, at least theoretically, an infinite series of frequency components. These

components require an unusually wide band-pass characteristic if the signal is to be translated with no distortion. Such fidelity, however, is seldom required and in the usual installation only a selected portion of those components are utilized in the receiver. The expression "desired modulation components," as used throughout this specification, is intended to include such a selection of the frequency components of a received pulse-modulated signal.

While the invention has been particularly described in connection with a receiver of the superheterodyne type, it will be understood that this is not a necessary limitation. It will be obvious to those skilled in the art that the invention may likewise be applied to other receivers, for example, the tuned radio-frequency type.

In discussing the receiver response in the presence of an interfering continuous-wave signal of high intensity with reference to, and of a carrier frequency different than, the received pulse-modulated signal, it was shown that a heterodyne-component pulse-modulated signal is produced which includes the desired modulation components. This same general operation prevails whether the interfering signal is a continuous-wave signal in a strict sense of the term or is a keyed continuous-wave signal having a long duty cycle with reference to the pulse duration of the received direction-finder signal. Also, substantially the same result is obtained when the continuous-wave signal has a sinusoidal or other modulation at a frequency which is low with reference to the period of the received pulses.

The rectifier 75, utilized in deriving the desired modulation components from the heterodyne-component pulse-modulated signal, is disclosed as a full-wave rectifier. This represents the preferred embodiment of the invention, increasing the energy level of the desired modulation components to a value comparable to that obtained when the pulse-modulated signal is received with no interference. It will be understood that a half-wave rectifier may be employed, if desired.

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

What is claimed is:

1. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, rectifying means included in said second signal-translating means effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying said desired modulation components to a utilizing device.

2. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components and having a carrier frequency equal to the difference between the carrier frequencies of said received wave signals, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, rectifying means included in said second signal-translating means effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying said desired modulation components to a utilizing device.

3. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, full-wave rectifying means included in said second signal-translating means effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying said desired modulation components to a utilizing device.

4. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal comprising, a first signal-translating means including selector circuits for translating said pulse-modulated signal and

having a band-pass characteristic effective to translate a predetermined range of frequencies such that said receiver is subject to receive concurrently with said pulse-modulated signal interfering wave signals having carrier frequencies within a band of frequencies substantially as wide as said predetermined range, detecting means included in said first signal-translating means effective in the absence of an interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of an interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components and having a carrier frequency within a band of frequencies substantially of the width of said predetermined range, a second signal-translating means coupled to said detecting means and including selector circuits having a band-pass characteristic substantially as wide as that of said first signal-translating means for translating said desired modulation components and heterodyne-component pulse-modulated signals derived in said detecting means in the presence of said pulse-modulated signal and an interfering signal of high intensity, rectifying means included in said second signal-translating means effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying said desired modulation components to a utilizing device.

5. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, rectifying means included in said second signal-translating means effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying substantially only said desired modulation components to a utilizing device.

6. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive

said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, rectifying means included in said second signal-translating means effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means including a low-pass filter for supplying substantially only said desired modulation components to a utilizing device.

7. A receiver for deriving desided modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signal a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, means included in said second signal-translating means for limiting the maximum amplitudes of said desired modulation components and said heterodyne-component pulse-modulated signal to a predetermined value, rectifying means coupled to said limiting means for deriving said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying said desired modulation components to a utilizing device.

8. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and including selector circuits for translating said desired modulation components and said heterodyne-component pulse-modulated signal, means included in said second signal-translating means compris-

ing a pair of cathode-coupled electron-discharge repeater devices for limiting the maximum amplitude of said desired modulation components and said heterodyne-component pulse-modulated signal to a predetermined value, rectifying means coupled to said limiting means for deriving said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said second signal-translating means for supplying said desired modulation components to a utilizing device.

9. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and effectively comprising a pair of parallel-connected signal-translating channels, one of said channels having a band-pass characteristic effective to translate substantially only said desired modulation components and the other of said channels having a band-pass characteristic effective to translate said heterodyne-component pulse-modulated signal, rectifying means included in said other channel effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said pair of channels for supplying said desired modulation components to a utilizing device.

10. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal comprising, a first signal-translating means including selector circuits for translating said pulse-modulated signal and having a band-pass characteristic effective to translate a predetermined range of frequencies such that said receiver is subject to receive concurrently with said pulse-modulated signal interfering wave signals having carrier frequencies within a band of frequencies substantially as wide as said predetermined range, detecting means included in said first signal-translating means effective in the absence of an interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of an interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components and having a carrier frequency within a band of frequencies substantially of the width of said predetermined range, a second signal-translating means coupled to said detecting means and effectively comprising a pair of parallel-connected signal-translating channels, one of said channels having a band-pass characteristic effective to translate substantially only said desired signal components and the other of said channels having a band-pass characteristic substantially of the width of that of said first signal-translating means to translate substantially only heterodyne-component pulse-modulated signals derived in said detecting means in the presence of said pulse-modulated signal and an interfering signal of high intensity, rectifying means included in said other channel effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, and means coupled to said pair of channels for supplying said desired modulation components to a utilizing device.

11. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and effectively comprising a pair of parallel-connected signal-translating channels, one of said channels having a band-pass characteristic effective to translate substantially only said desired signal components and the other of said channels having a band-pass characteristic effective to translate said heterodyne-component pulse-modulated signal, rectifying means included in said other channel effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, means coupled to said pair of channels for supplying said desired modulation components to a utilizing device, and means for selectively disabling one of said pair of channels.

12. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and effectively comprising a pair of parallel-connected signal-translating channels, one of said channels having a band-pass characteristic effective to translate substantially only said desired signal components and the other of said channels having a band-pass characteristic effective to translate said heterodyne-component pulse-modulated signal, rectifying means included in said other channel effective to derive said desired modulation components from said heterodyne-component pulse-modu-

lated signal, means coupled to said pair of channels for supplying said desired modulation components to a utilizing device, and means responsive to said interfering wave signal for disabling said one of said channels.

13. A receiver for deriving desired modulation components of a received pulse-modulated carrier-frequency wave signal but subject to receive concurrently therewith an interfering wave signal of different frequency than the carrier frequency of said pulse-modulated signal comprising, a first signal-translating means including selector circuits for translating both of said received signals, detecting means included in said first signal-translating means effective in the absence of said interfering wave signal to derive said desired modulation components of said pulse-modulated signal and effective in the presence of said interfering signal with high intensity to derive from said received signals a heterodyne-component pulse-

modulated signal having modulation components corresponding to said desired components, a second signal-translating means coupled to said detecting means and effectively comprising a pair of parallel-connected signal-translating channels, one of said channels having a band-pass characteristic effective to translate substantially only said desired signal components and the other of said channels having a band-pass characteristic effective to translate said heterodyne-component pulse-modulated signal, rectifying means included in said other channel effective to derive said desired modulation components from said heterodyne-component pulse-modulated signal, means coupled to said pair of channels for supplying said desired modulation components to a utilizing device, and amplitude-selective means responsive to said interfering wave signal of high intensity for disabling said one of said channels.

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