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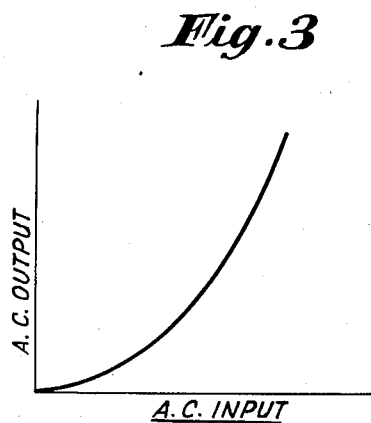
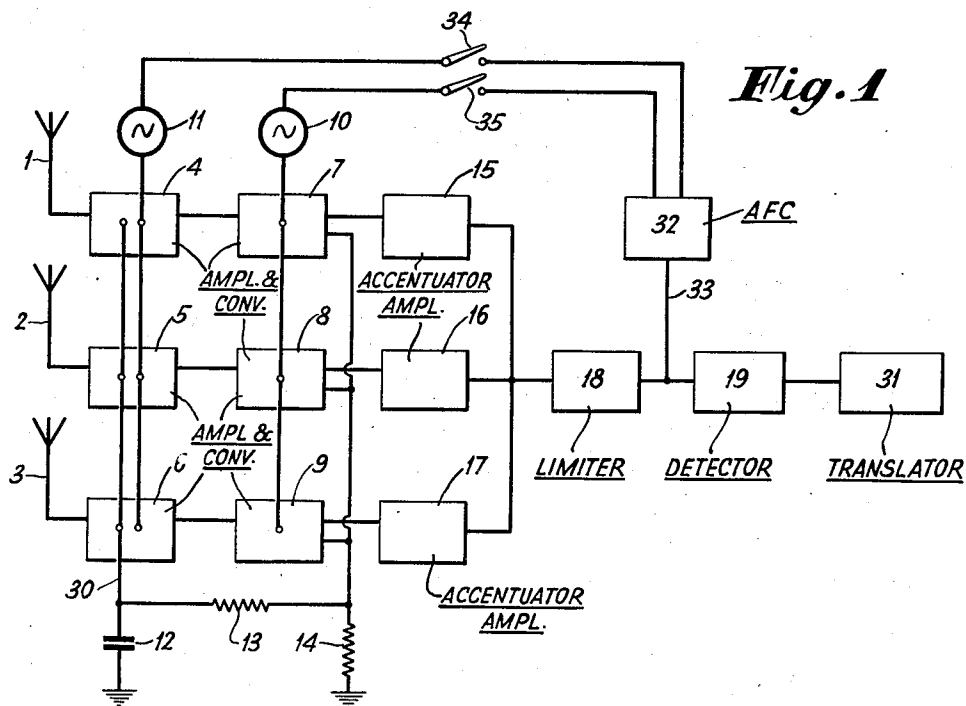
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2,302,951

DIVERSITY RECEIVING SYSTEM

Filed Aug. 27, 1940

2 Sheets-Sheet 1



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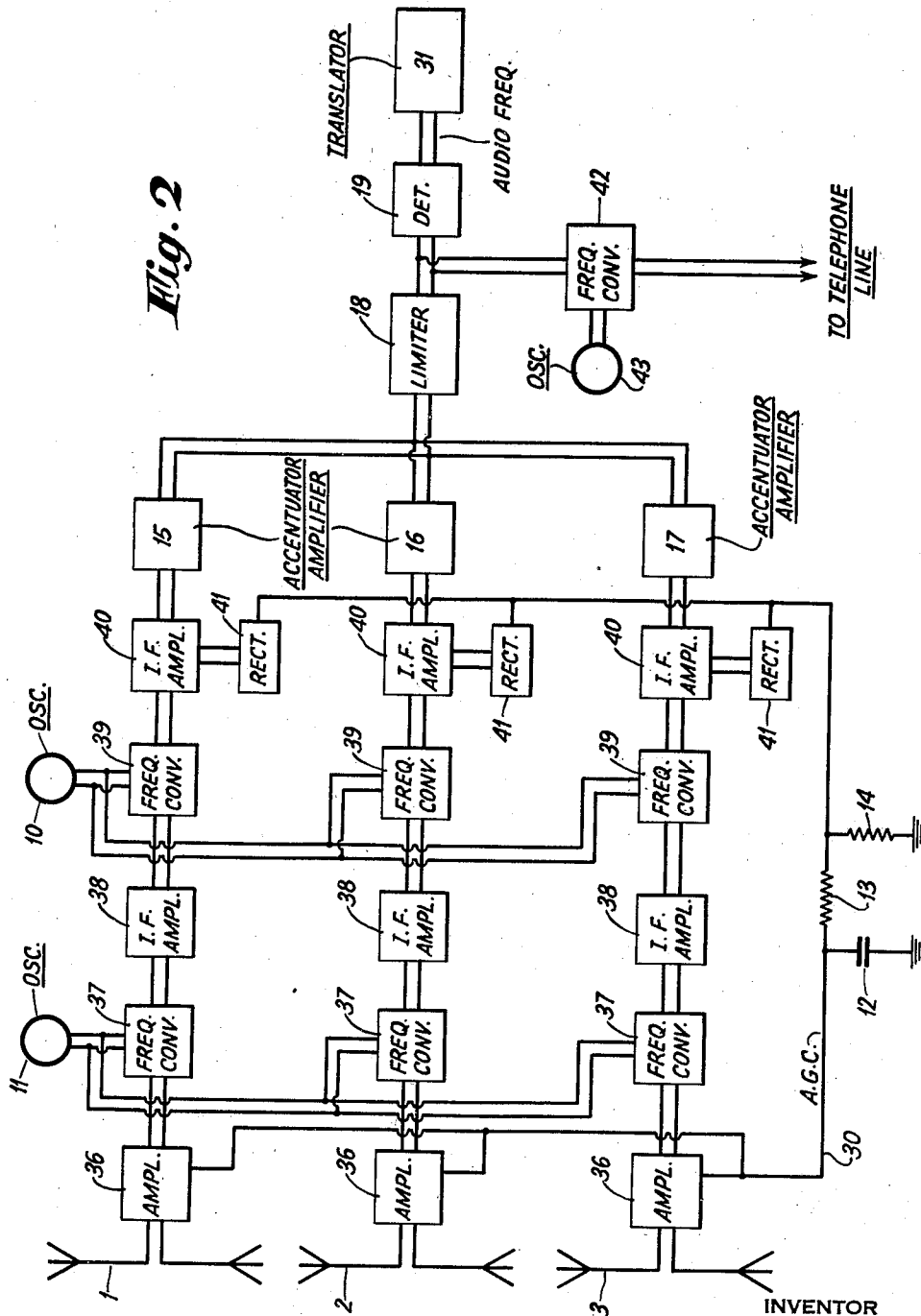
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Fig. 2



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DIVERSITY RECEIVING SYSTEM

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11 Claims. (Cl. 250—20)

This invention relates to a diversity receiving system for the reception of frequency or phase modulated signals.

It is known in radio reception that signals are subject to fading, the degree of which varies unpredictably. In the transmission of amplitude modulated signals, it has been proposed to eliminate or reduce the variations in intensity of the received signal by providing at the receiving station a plurality of geographically spaced antennae in the same or different planes of polarization and to feed the energies collected by these antennae to a single signal responsive circuit. The possibility of the signal fading out equally at all of the receiving stations at the same time is, therefore, reduced with increase in the number of receiving stations. Such known systems for overcoming fading are generally known as diversity receiving systems.

The present invention provides an improved diversity receiving system applicable particularly for the reception of frequency modulated or phase modulated signals.

A more detailed description of the invention follows in conjunction with the drawings, wherein:

Fig. 1 is a schematic view of a diversity receiving system arranged in accordance with the principles of the invention;

Fig. 2 is a more amplified block diagram of a receiving system similar to Fig. 1; and

Fig. 3 is a curve illustrating the operation of one of the circuit elements of the receiver of the invention.

Throughout these figures, the same elements are labeled with the same reference characters.

In Fig. 1, the incoming frequency or phase modulated signals are collected by antennae 1, 2 and 3 which are located at geographically spaced points where the signal does not fade similarly. Observations have shown that the receiving antennae need only be separated from one another by a distance of a few hundreds of feet and less in order to get this effect. These antennae may be polarized in the same plane or in different planes, and, if desired, be of the steerable directive type in order to insure optimum reception.

The radio frequency voltages from the antennae 1, 2 and 3 are fed to the inputs of high frequency units 4, 5 and 6. These high frequency units may incorporate radio frequency amplification for selectivity and a heterodyne converter for converting the incoming radio frequency to some intermediate frequency. The

conversion is accomplished by the combination of the incoming frequency with the frequency of the high frequency oscillator 11. The intermediate frequency outputs of the high frequency units 4, 5 and 6 are transmitted to intermediate frequency units 7, 8 and 9, which provide more selectivity and another heterodyne converter using an oscillator 10 to convert the first intermediate frequency to a second intermediate frequency. Units 7, 8 and 9 provide more selectivity and gain and are followed by diode rectifiers which feed rectified signal to a common load circuit 14 producing a resultant direct current voltage which operates through a time constant circuit composed of condenser 12 and resistance 13 to supply automatic gain control to some of the earlier stages of each receiver over lead 30. Intermediate frequency outputs are obtained from intermediate frequency units 7, 8 and 9, and these are fed to accentuator units 15, 16 and 17. These accentuator units have a characteristic, as shown in Fig. 3, such that the output of a given unit is more than proportional to the input. The effect of this characteristic is to accentuate the predominance of the output from the receiver associated with that antenna having momentarily the greatest received voltage. By thus predominantly amplifying the energy from that antenna at which the received signal is the strongest, there is occasioned little or no conflict due to relative phase fluctuations at the different antennae; and this predominantly amplified signal is effectively utilized for automatically controlling the gain of the preceding stages. The outputs of units 15, 16 and 17 are combined in a limiter unit 18. The effect of the limiter unit 18 is to yield a constant amplitude output regardless of amplitude variations in the voltage fed into this limiter. In the process of limiting in unit 18, there is also a tendency to make the strongest input voltage predominate.

The output from the amplitude limiter 18 is passed on to an analyzing detector 19 which converts the frequency modulated signals to amplitude modulated signals of an audio frequency character to which the translator 31 is responsive. These amplitude modulated signals are a true reproduction of the original frequency modulation. Detector 19 may be of the balanced type shown in Seeley Patent No. 2,121,103, granted June 21, 1938, and in Usselman Patent No. 1,794,932, granted March 3, 1931, or an unbalanced detector operating on one side of the operating range of frequencies, as is shown in

Fig. 3 of Hansell Patent No. 1,803,504, granted May 5, 1931. Translator 31 may be a loud-speaker, headphones, or a suitable recording device.

In order to stabilize the frequency of either one of the heterodyne oscillators 10 and 11 or both simultaneously, there is provided an automatic frequency control (AFC) circuit 32 which is fed by intermediate frequency energy over lead 33 from the output of limiter 18. This AFC circuit may comprise a pair of rectifier tubes, each having a tuned circuit, both tuned circuits having resonance curves intersecting at the mean or assigned frequency corresponding to the middle of the pass band with maxima lying either side of the assigned frequency. Such an AFC circuit is known in the art and is described in Usselman patent, supra, or, alternatively, the AFC circuit 32 may be of the type described in Seeley Patent No. 2,121,103, supra. Switches 34 and 35 are used to disconnect the AFC control from either oscillator 11 or 10, respectively.

Fig. 2 illustrates in greater detail a diversity receiving system similar to Fig. 1. The individual stages are shown conventionally in box form and appropriately labeled.

The frequency modulated or phase modulated energy radiated from a transmitter, not shown, is collected by the antennae 1, 2 and 3, each of which is provided with a receiver. Inasmuch as the apparatus for the receivers associated with antennae 1, 2 and 3 are similar and have corresponding elements, only one receiver associated with one particular antenna will be described. The receiver preferably includes a radio frequency amplifier 26 and a frequency converter 37 in which the received energy is heterodyned with energy from a local oscillator 11 to produce an intermediate frequency signal. This intermediate frequency signal is selectively amplified in an intermediate frequency amplifier 38 from which the signal energy is passed on to another frequency converter 39 which by the aid of another local oscillator 10 reduces the energy still further to a lower intermediate frequency signal. This last intermediate signal is selectively amplified in intermediate frequency amplifier 40 from which a portion of the output is passed on to a rectifier 41, the latter feeding rectified signal to an automatic gain or volume control circuit 12, 13 having suitable time constants. It is preferred that each rectifier unit 41 include in its output a screen grid vacuum tube whose anode is connected to the single lead extending to the load resistor 14. The resultant direct current voltage from all rectifier units 41 for automatic gain control purposes passes over lead 30 to the control electrode of a preceding stage, here shown by way of example, as radio frequency amplifier 36.

Intermediate frequency energy from amplifier 40 is also passed on to accentuator electron discharge device amplifier 15, 16 or 17. This accentuator amplifier is so biased as to give approximately the characteristic shown in Fig. 3, so that the gain for a weak signal input is less than for a strong signal input, the effect being to accentuate the predominance of the output from that receiver associated with the particular antenna having momentarily the greatest received voltage. Circuits having such a characteristic are well known in the art. The output from the accentuator amplifier is impressed upon the limiter 18 which provides a constant amplitude of alternating current output. The frequency or phase modulated output energy from the limiter

18 is then detected in 19 which produces an amplitude modulated audio frequency signal which is a true reproduction of the original frequency modulation. If desired, the output from the limiter 18 can be converted to a lower frequency suitable for transmission over a telephone line by means of a frequency converter 42 and a local heterodyne oscillator 43.

What is claimed is:

1. In a signalling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related that the received signals vary differently at the several receivers with variations in transmission conditions, a common utilization circuit, separate paths extending from each of said receivers to said utilization circuit, a high frequency, and means in each path for amplifying to a greater extent the stronger intelligence carrying signal than the weak intelligence carrying signal, whereby the strongest signal in said paths predominates at said utilization circuit.
2. In a signalling system subject to variable transmission conditions, a plurality of receivers each receiving the same signal and so related that the received signals vary differently at the several receivers with variations in transmission conditions, each of said receivers having means for converting the received signal to an intermediate frequency signal and for amplifying said intermediate frequency signal, an electron discharge device circuit coupled to each receiver and characterized by an output which increases more than proportionally to its input over an operating range, an amplitude limiter, means for combining the outputs from said electron discharge device circuits and for impressing the combined output upon said limiter, and a detector coupled to the output of said limiter.
3. A diversity receiving system comprising a plurality of spaced antennae, an amplifier coupled to each antenna, a frequency converter for changing the output of each amplifier to an intermediate frequency, an intermediate frequency amplifier in the output of each of said converters, a rectifier coupled to each intermediate frequency amplifier, a common load resistor for the outputs of said rectifiers, an automatic gain control lead extending from said resistor to corresponding electrodes of said amplifiers associated with different antennae, an electron discharge device circuit coupled to each receiver and characterized by an output which increases more than proportionally to its input over an operating range, an amplitude limiter, means for combining the outputs from said electron discharge device circuits and for impressing the combined output upon said limiter, and a detector coupled to the output of said limiter.
4. A diversity receiving system comprising a plurality of spaced antennae, an amplifier coupled to each antenna, a frequency converter for changing the output of each amplifier to an intermediate frequency, an intermediate frequency amplifier in the output of each of said converters, a rectifier coupled to each intermediate frequency amplifier, a common load resistor for the outputs of said rectifiers, an automatic gain control lead extending from the same point on said resistor to corresponding electrodes of said amplifiers associated with different antennae, an amplitude limiter, means for combining the outputs from said intermediate frequency amplifiers and for impressing the combined output upon said limiter, and a detector circuit coupled to said limiter.

5. The method of diversity reception which includes making a plurality of energy collections at spaced points, amplifying and converting the collected energies in separate paths to energies of an intermediate frequency, separately amplifying the intermediate frequency energies, rectifying a portion of each of said amplified intermediate frequency energies, controlling the gain in one of the steps of amplification in dependence upon the amplitude of the combined rectified energies, separately further amplifying the intermediate frequency energies such that the stronger incoming signal in each path is amplified to a greater extent than the weaker incoming signal in the same path, combining the last separately amplified energies and limiting the amplitude of the same, and detecting and translating the amplitude limited energy.

6. The method of diversity reception which includes making a plurality of energy collections of the same radio frequency signal at spaced points, amplifying the stronger radio frequency signals received at any point to a greater extent than the weaker radio frequency signals received at said same point, and combining the amplified signal energies from all of said points.

7. The method of diversity reception which includes making a plurality of energy collections of the same radio frequency signal at spaced points, changing the frequency of each of the collected energies to a lower frequency, amplifying at the lower frequency the stronger intelligence carrying signals received at any point to a greater extent than the weaker intelligence carrying signals received at said same point, and combining the amplified signal energies from all of said points.

8. In a diversity receiving system, the method of radio reception which includes collecting the same signal at a plurality of points, and amplifying to a greater extent the stronger radio frequency intelligence carrying signals than the

weaker radio frequency intelligence carrying signals received at each of said points, and combining the resultant amplified energies.

9. In a signalling system, a radio receiver having a plurality of vacuum tube stages, a rectifier for a portion of the output of one of said stages, a load resistor in the output of said rectifier, an automatic gain control lead extending from said resistor to an electrode of one of the stages preceding said stage to which said rectifier is connected, a utilization circuit, and a radio frequency accentuator unit having its input coupled to said receiver and its output coupled to said utilization circuit and so biased that the gain for all portions of a weak radio frequency input signal is less than the gain for all portions of a strong radio frequency input signal.

10. In a frequency or phase modulation signalling system, a radio receiver having a plurality of vacuum tube stages, a rectifier for a portion of the output of one of said stages, a load resistor in the output of said rectifier, an automatic gain control lead extending from said resistor to an electrode of one of the stages preceding said stage to which said rectifier is connected, a utilization circuit, and a radio frequency accentuator circuit whose radio frequency output voltage is nonlinearly proportional to its radio frequency input voltage coupling said receiver to said utilization circuit.

11. In a diversity receiving system, the method of radio reception which includes collecting the same signal at a plurality of points, and amplifying to a greater extent the stronger radio frequency intelligence carrying signals than the weaker radio frequency intelligence carrying signals received at each of said points, combining the resultant amplified energies, limiting the combined energy, and translating the limited combined energy.

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