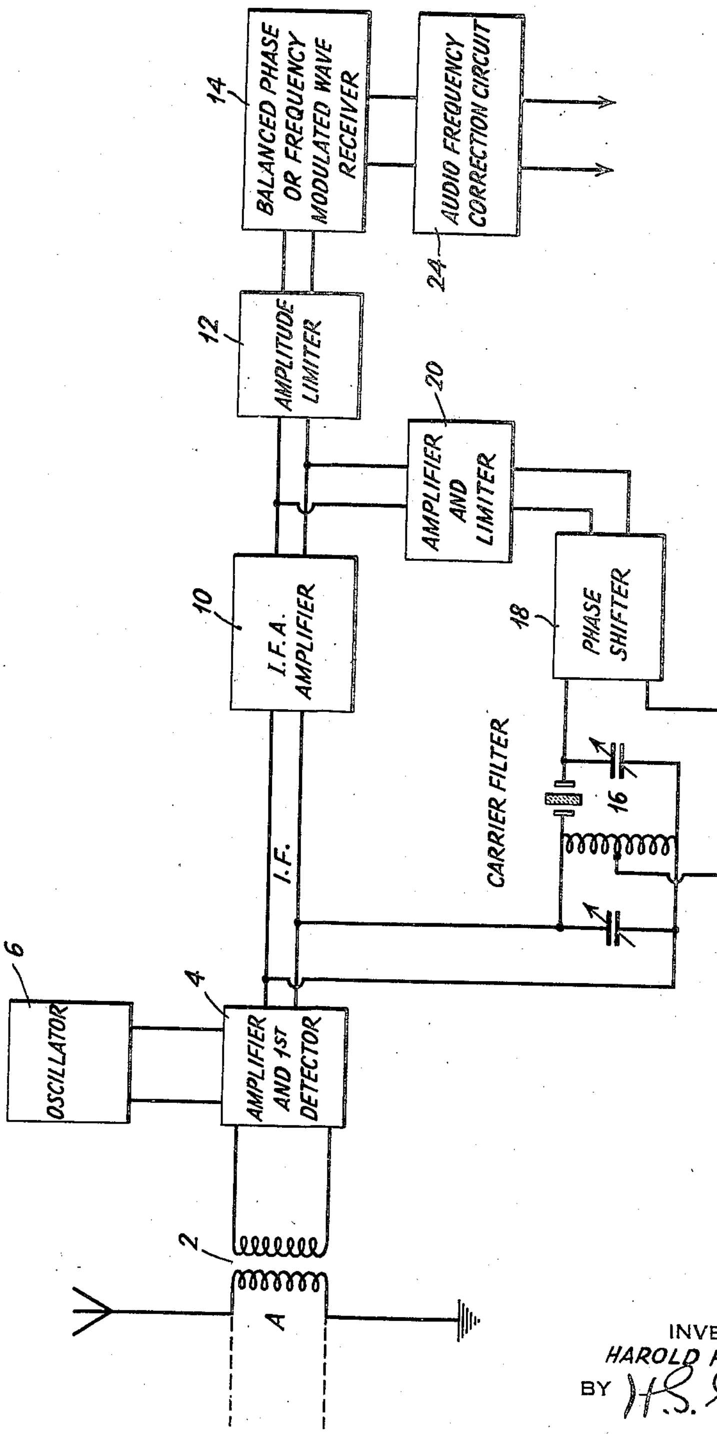
Sept. 19, 1939. H. H. BEVERAGE 2,173,156

AMPLITUDE MODULATION RECEPTION

Filed March 11, 1938



INVENTOR
HAROLD H. BEVERAGE
BY H. S. Grover
ATTORNEY

Patented Sept. 19, 1939

2,173,156

UNITED STATES PATENT OFFICE

2,173,156

AMPLITUDE MODULATION RECEPTION

Harold H. Beverage, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application March 11, 1938, Serial No. 195,269

10 Claims. (Cl. 250—20)

This application concerns a new and improved means for receiving and demodulating wave energy modulated in amplitude and for demodulating said wave energy in such a manner as to reduce the effect of fading thereon during transmission and to also balance out or remove from the demodulated energy output noise components set up therein in any manner during any stage of transmission and reception of the wave.

My novel method and means for demodulating amplitude modulated wave energy of the present invention is arranged to obtain advantages heretofore obtainable only in the reception of phase or frequency modulated waves. In this present system, amplitude modulated wave energy is changed to phase modulated wave energy by separating the carrier from the amplitude modulated wave energy or from intermediate frequency wave energy characteristic thereof and limiting the said separated carrier so that it has a constant amplitude and then shifting its phase by substantially 90° and re-introducing it with the signal carrying wave energy or wave energy of intermediate frequency characteristic thereof and passing the recombined energy through a limiter and a demodulator of the phase modulated wave energy type. An amplitude modulated wave with its carrier greatly increased in proportion to the sidebands and shifted 90° in phase is obtained and this wave energy is the equivalent of a phase modulated wave with relatively small phase deviation.

This method of demodulating amplitude modulated wave energy by converting the same to phase modulated wave energy with exalted carrier permits limiting thereof before demodulation to thereby reduce fading and the said produced phase modulated wave energy with the exalted carrier may be demodulated in a phase or frequency modulated wave demodulator of the balanced type so that the noise components thereon are balanced out.

In describing an embodiment of my invention reference will be made to the attached drawing wherein the single figure illustrates an amplitude modulated wave demodulation system arranged in accordance with the present invention.

In Figure 1, A is an aerial or line or any other radiant energy pick-up device or lines coupled by transformer **2** to wave amplifying and demodulating means **4** which may comprise a first detector connected with a local source of oscillations **6** to beat with the amplified wave energy. The first detector is connected at its output with an amplifier **10** which may include intermediate frequency selector circuits inter-connecting the desired number of tube amplifier stages. The output of the intermediate frequency amplifier is connected by way of an amplitude limiter **12** to a balanced detector such as is used for the demodulation of phase or frequency modulated wave energy. The output of the first detector in **4** is also coupled by way of a carrier filter circuit **16** to amplifiers and limiters **20**. This coupling also includes a phase shifting device **18**. The crystal filter **16** operates in a well known manner to pass carrier wave energy only and remove or strip from the carrier wave energy all signal components. The filter shown may be replaced by any other known filter having the desired characteristics as outlined above. The stripped carrier is shifted in phase in **18** by an amount such that it is displaced by 90° relative to its original phase in **4**. The phase shifted carrier is now amplified and limited to substantially constant amplitude in **20**. The output of **20** is impressed back on the output of the intermediate frequency amplifier **10** in substantially 90° phase displaced relation relative to its phase at the output of **4** and of proper amplitude and the re-combined energy is passed through the limiter **12** to the balanced detector **14**. The output energy from the balanced detector **14** may be impressed directly on any utilization circuit or may be passed through an audio frequency corrector network **24** to correct the audio frequency so that it is truly characteristic of the modulations on the received wave. Obviously the sequency of operations on the carrier wave described above need not be followed in the order described. The amplifying and limiting may precede the phase shifting and the filtering, etc.

The local oscillator **6** and amplifier and first detector **4** may be conventional and are so well known in the prior art that it is thought unnecessary to describe the same in detail here. The same remarks apply to the intermediate frequency amplifier in **10**. The amplitude limiters **12** and **18** may comprise one or more over-loaded electron discharge tube amplifier or relay stages and since these systems are well known in the prior art the limiter need not be described in detail here. The limiter may, of course, comprise amplifiers operated by automatic volume control means.

The phase shifter in **18** may comprise any network arranged in a well known manner, such as for example, the phase shifter network illustrated in Crosby United States Patent #2,065,565.

The balanced detector may be of any type wherein phase or frequency changes in the wave in accordance with signals produce corresponding amplitude changes in output energy and wherein amplitude changes, such as caused by noise, cancel and balance out. The balanced detector, for example, may take the form of the balanced detector shown in Usselman United States Patent #1,794,932; or in Crosby United States Patent #2,071,113 dated February 16, 1937; or in Crosby United States Patent #2,101,703 dated December 7, 1937; or in Crosby United States application #618,154 filed June 20, 1932; or in Crosby United States application #144,778 filed May 26, 1937.

Automatic frequency control means is preferably used to control the frequency of operation of 6 to keep the intermediate frequency supplied from **4** centered in the carrier filter **16**. Any known method of automatic frequency control may be used. In Crosby United States Patent #2,065,565 dated December 29, 1936, and United States Patent #2,112,881 dated April 5, 1938, are shown automatic frequency control circuits suitable for use here. The differential potentials may be obtained from **14** or a separate detector and supplied through control means to control the frequency of operation of **6**.

I claim:

1. In a system for demodulating wave energy modulated in amplitude at signal frequency and for reducing the effect of fading thereon, the combination of means for separating the carrier from said amplitude modulated wave energy, means for relatively shifting the phases of said modulated wave energy and separated carrier substantially 90°, means for amplifying said carrier and re-combining it with said modulated wave energy, and phase modulated wave detector means connected with said amplifying means.

2. In a system for demodulating wave energy modulated in amplitude at signal frequency and for reducing the noise components of said wave energy, the combination of means for separating the carrier amplitude modulated wave from said wave energy, means for relatively shifting the phases of said modulated wave energy and separated carrier substantially 90° and re-combining the phase differentiated carrier and modulated wave energy, a phase modulation detector of the balanced type, and means for impressing said re-combined energy on said detector.

3. In a system for demodulating wave energy modulated in amplitude at signal frequency and for reducing the effect of fading thereon, the combination of means for separating the carrier from said wave energy, means for shifting the phase of said separated carrier substantially 90°, amplifying it and re-combining it with said modulated wave energy, amplitude limiting means on which said re-combined energy is impressed and phase modulated wave detector means connected with said amplitude limiting means.

4. In a system for demodulating wave energy modulated in amplitude at signal frequency and for reducing the noise components of said wave energy, the combination of means for separating the carrier wave from said wave energy, means for shifting the phase of said separated carrier substantially 90° and re-impressing it on said modulated wave energy, amplitude limiting means on which said re-combined energy is impressed, a balanced phase modulation detector connected with said amplitude limiting means, and a correction circuit coupled with the output of said detector.

5. In a system for demodulating wave energy modulated in amplitude at signal frequency and for reducing the effect of fading thereon, the combination of means for heterodyning said wave energy to a lower frequency, means for separating the carrier from said wave energy of lower frequency, means for relatively shifting the phases of said separated carrier and said energy of lower frequency substantially 90°, and amplifying the carrier and re-combining it with said wave energy of lower frequencies, amplitude limiting means on which said re-combined energy is impressed and phase modulated wave detector means connected with said amplitude limiting means.

6. In a system for demodulating wave energy modulated in amplitude at signal frequency and for reducing the noise components of said wave energy, the combination of means for heterodyning said wave energy to a lower frequency, means for separating the carrier wave from said wave energy of lower frequency, means for shifting the phase of said separated carrier substantially 90°, amplifying the carrier of shifted phase, limiting the amplified carrier and impressing it on said wave energy of lower frequency, amplitude limiting means on which said re-combined energy is impressed, a phase modulation detector connected with said amplitude limiting means, and a correction circuit coupled with the output of said detector.

7. The method of demodulating amplitude modulated wave energy and of reducing the effect of fading or attenuation of said wave energy during transmission or reception which includes the steps of, separating the carrier energy from said wave energy, relatively shifting the phases of the separated carrier and the wave energy substantially 90°, amplifying the phase shifted carrier and limiting its amplitude to a substantially constant value, reintroducing said limited carrier with said modulated wave energy to produce wave energy comprising amplitude modulated sidebands and a carrier shifted substantially 90°, and demodulating the resultant energy to derive the signal.

8. The method of demodulating amplitude modulated wave energy and suppressing noise components thereon which includes the steps of, converting said amplitude modulated wave energy into characteristic wave energy in which the carrier is shifted substantially 90° so that the converted wave energy has the characteristics of phase or frequency modulated wave energy, and demodulating said wave energy having characteristics of phase or frequency modulated wave energy and simultaneously opposing the noise components on said wave energies during said demodulation process.

9. The method of demodulating transmitted amplitude modulated wave energy comprising a carrier and side bands, and reducing the effects of fading on said wave energy during transmission which includes the steps of, separating said carrier from said side band components, exalting said separated carrier relative to said side band components and producing a substantially 90 degrees phase displacement between the carrier and side band components, combining the exalted carrier with the side band components in said substantially 90 degrees phase displaced relation, and limiting the amplitude of the combined energy to obtain wave energy modulated in phase in accordance with the amplitude modulations on said transmitted wave energy for demodulation purposes.

10. The method of demodulating amplitude modulated wave energy comprising carrier and side band energy and reducing noise components

on said energy which includes the steps of, separating the carrier from the side band component, producing a relative phase displacement of substantially 90 degrees between said carrier and side band component, combining the said carrier and side band component so phase differentiated to produce a resultant having relatively small phase deviations characteristic of the amplitude modulations on the original wave energy, limiting the resultant energy to remove therefrom amplitude variations and demodulating the phase modulated resultant to derive the signal.

HAROLD H. BEVERAGE.