Nov. 27, 1945. W. I. MATTHEWS 2,389,919

AUGMENTED AUTOMATIC GAIN CONTROL

Filed Dec. 16, 1942 3 Sheets-Sheet 1

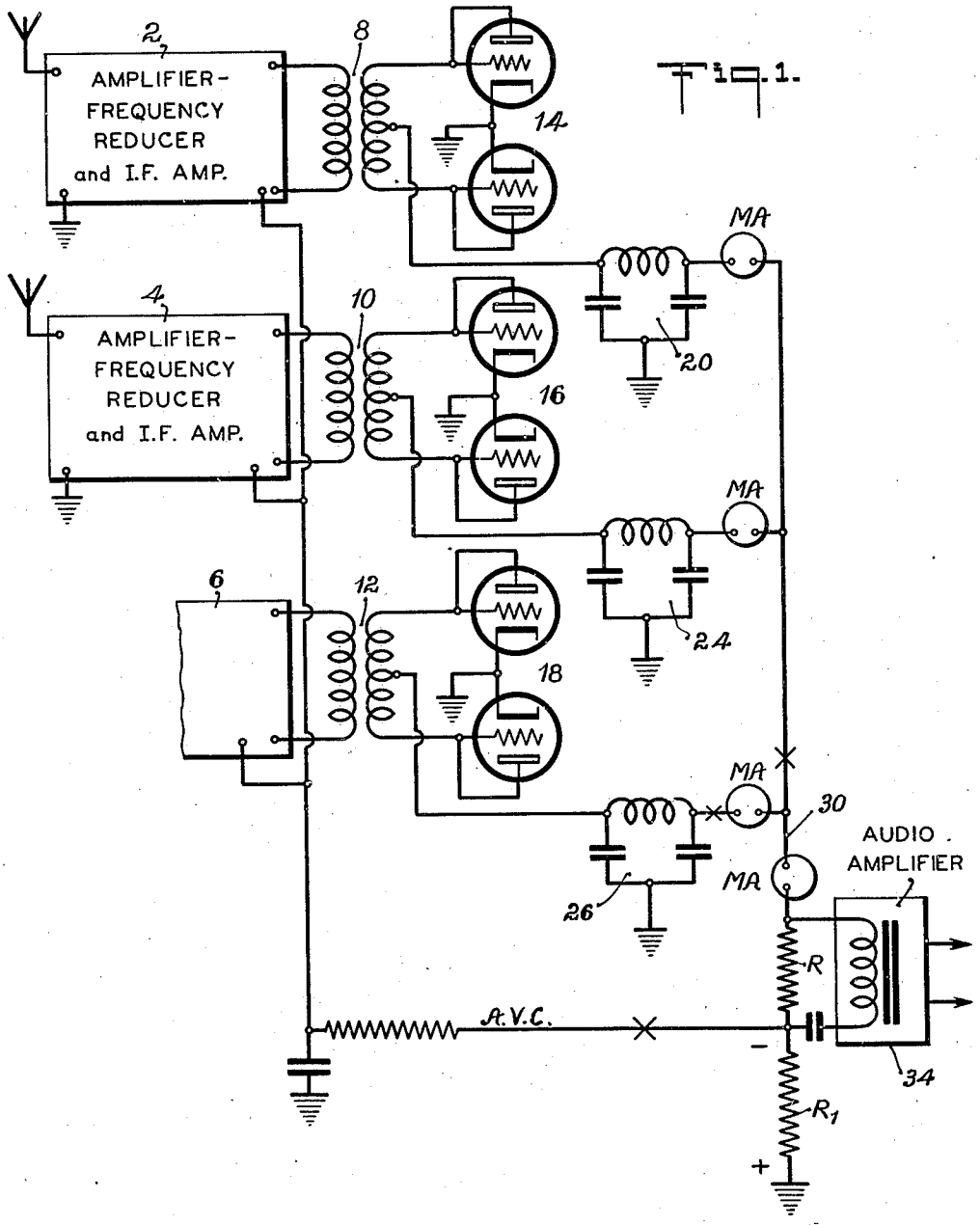


Fig. 1.

INVENTOR
W. I. MATTHEWS
BY H. S. Brown
ATTORNEY

AUGMENTED AUTOMATIC GAIN CONTROL

Filed Dec. 16, 1942 3 Sheets-Sheet 2

Fig. 2.

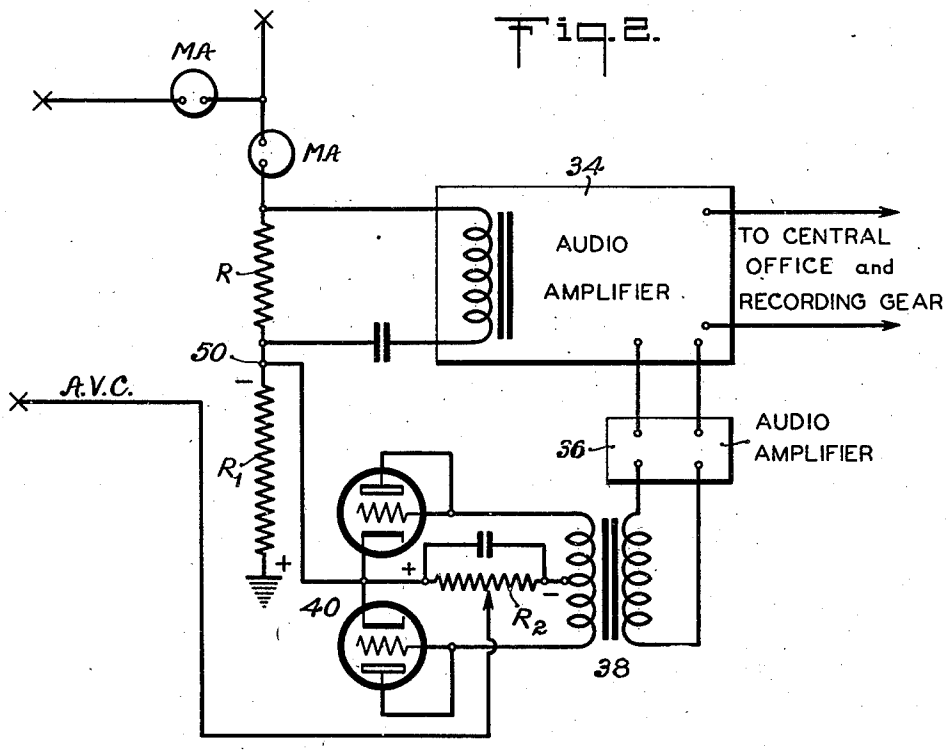
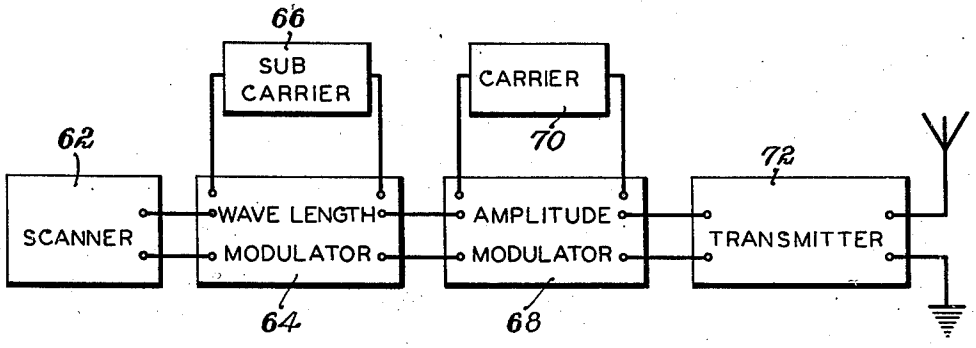


Fig. 4.



INVENTOR
W. I. MATTHEWS
BY H. B. Brower
ATTORNEY

Nov. 27, 1945. W. I. MATTHEWS 2,389,919

AUGMENTED AUTOMATIC GAIN CONTROL

Filed Dec. 16, 1942 3 Sheets-Sheet 3

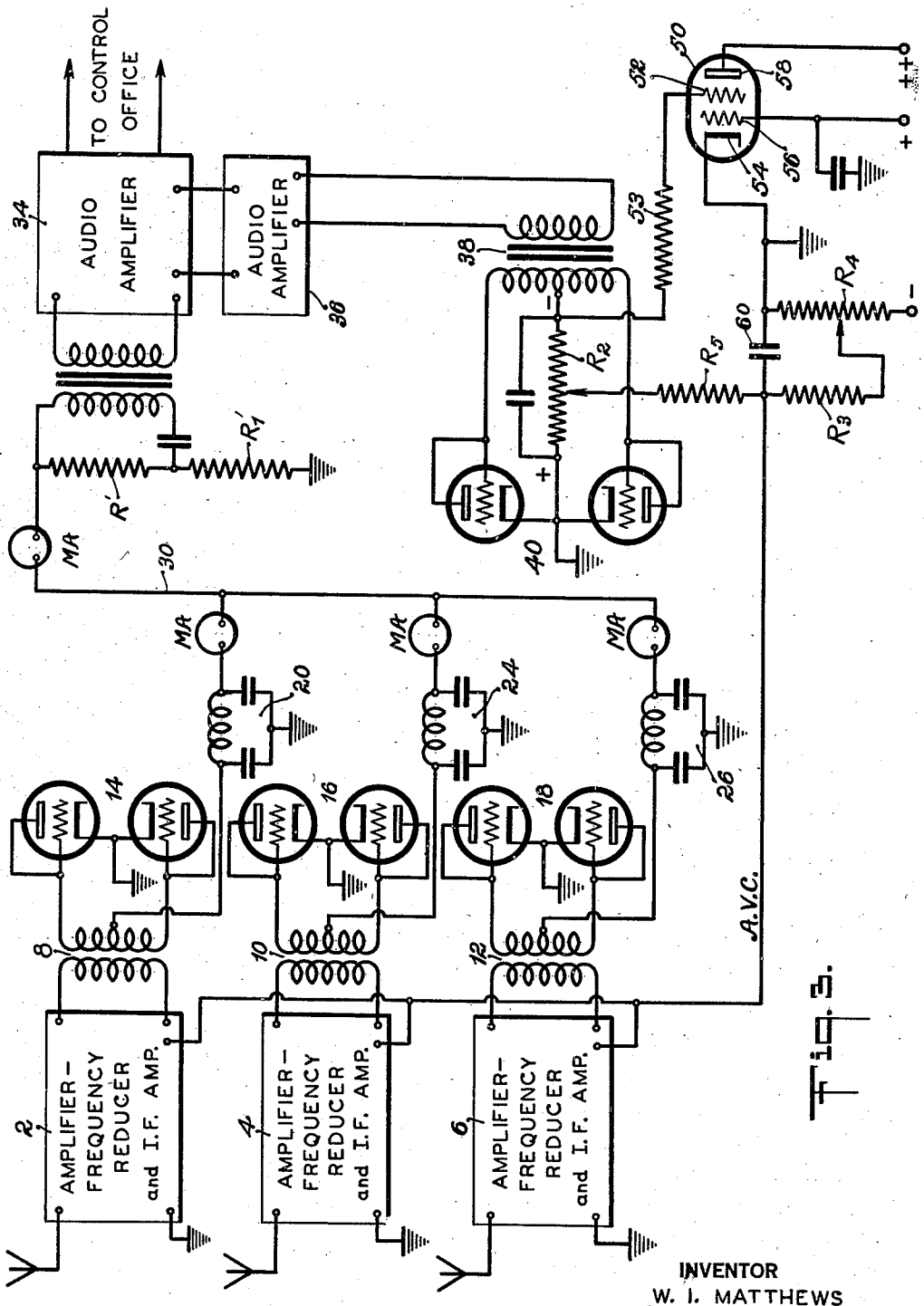


Fig. 5.

INVENTOR
W. I. MATTHEWS
BY H. B. Brower
ATTORNEY

Patented Nov. 27, 1945 2,389,919

UNITED STATES PATENT OFFICE

2,389,919

AUGMENTED AUTOMATIC GAIN CONTROL

Walter I. Matthews, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application December 16, 1942, Serial No. 469,246

5 Claims. (Cl. 250—20)

In the transmission of sub-carrier frequency modulated facsimile the modulation consists of continuous tones of constant amplitude and varying frequency. The tones, now in use by RCA Communications, Inc., in certain applications vary from 1600 to 2000 cycles. These frequencies are radiated at a constant level of modulation. This type of modulation is unique inasmuch as there is always modulation on the carrier during the transmission of facsimile material, as opposed to voice modulation, where there are intervals between words, etc. To insure good results at the recording end of the circuit, the tones must be presented to the facsimile recording gear at a constant level.

Although the carrier radiated from a distant radio transmitter is modulated at a constant level, nevertheless the modulation as received at the distant receiving station varies widely in level. This change in the character of the level is due to fading which is found in radio transmission and reception including short wave transmission and reception. The present practice is to put the received signal through a limiter at the central office before presenting the signal to the recording gear. Results using this method are quite good. However, if some of the modulation variations could be relieved at the receiving station, the signal fed to the central office would be of a more constant value, thereby relieving the central office limiter somewhat of its heavy responsibility.

In accordance with this invention the variation in the audio output level can be materially reduced at the receiving station. The drawings and general description of my invention show its application to one of the Radio Corporation of America's diversity receiver systems, but the scheme may also be used on other types of receiving equipment.

In describing my invention reference will be made to the attached drawings wherein:

Figure 1 illustrates a receiver of the type heretofore used in facsimile reception with automatic gain control connections;

Figure 2 illustrates my improved augmented automatic gain control system to be used in receivers of various types, such as, for example, the receiver shown more completely in Figure 1;

Figure 3 illustrates a modification of the arrangement of Figure 2; and

Figure 4 illustrates by block diagram a system adapted to the generation and transmission of frequency modulated sub-carrier energy on a main transmitting carrier as amplitude modulation.

Although for purposes of description, I have illustrated in Figure 1 a diversity receiver system, it will be understood that the invention is equally applicable to a system using a single receiver. Moreover, although I have illustrated the receivers as being of a type adapted to the reception of modulated wave energy comprising a radiated carrier, the amplitude of which is modulated in accordance with a sub-carrier, in turn frequency modulated in accordance with the output of a scanner, it will be understood that my system applies equally well to other types of transmitted energy including voice modulated energy, television signals, etc. My improvement is particularly applicable to receiver systems of the nature disclosed in Whitaker United States Patent No. 2,289,157, dated July 7, 1942.

In Figure 1, three receivers 2, 4 and 6 are shown. These receivers may include, if desired, amplifiers, frequency reducers, intermediate frequency amplifiers, and, where the received signal is frequency modulated a discriminator circuit, such as, a circuit having a sloping filter characteristic or crossed sloping filter characteristic for converting the frequency modulation to corresponding amplitude variations. The converted energy is supplied to couplings 8, 10 and 12 and thence to diode rectifier systems 14, 16 and 18 wherein the amplitude variations are demodulated and supplied through filtering circuits 20, 24 and 26 to a common output lead 30 which runs through resistances R and R1 to ground. The resistance R supplies the potential drop thereacross by way of a transformer to an audio amplifier 34 and thence to any utilization circuit.

The potential at the grounded end of resistance R1 is positive since the cathodes of the diode systems 14, 16 and 18 are grounded, and a point which is negative on the series resistances supplies the automatic gain control potentials to the receivers.

The gain control circuit supplies bias in a well-known manner to the grids of the radio-frequency amplifier tubes in the receivers 2, 4 and 6. The voltage for this gain control is taken from a portion of the combined output load resistors R and R1. Different values of current through the load resistor R and R1 supply different values of negative voltage to the radio frequency amplifier tubes. The effect of this control is to set the gain of the radio frequency amplifiers an amount depending upon the strength of the incoming carrier frequency signal at the particular instant.

The results of fading and phase displacement are such that the audio output level is not always in agreement with the value of diode current running through the load resistors R and Rf. To assist these automatic gain control connections in improving the stability of the audio level, I have provided the new and improved means of Figure 2.

In my improved system audio voltage is derived from the audio amplifier **34** and amplified in an additional amplifier stage in **36** and fed by transformer **38** to a push-pull diode rectifier system **40**, the cathodes of which are connected to the point **50** intermediate the resistors R and Rf. The cathodes of the system **40** are also connected by a potentiometer resistor R2 to a point on the secondary winding on transformer **38**, while the movable point on the potentiometer R2 is connected to control electrodes in the receivers for gain control purposes.

The improved gain control system of Figure 2 is used with a receiver of the type shown in Figure 1 by breaking the connections in said receiver at the points marked with X's and connecting to said points the connections at the points marked with X's in Figure 2.

In Figure 2 a portion of the audio output is fed into the stage **36** for audio amplification and thence by way of transformer **38** to the push-pull rectifier **40**. The output of this rectifier **40** is placed in series with the existing automatic gain control resistor Rf in such polarity that the audio rectifier voltage adds to the normal automatic gain control voltage in Rf.

In sub-carrier frequency modulation facsimile work this audio voltage will be a continuous one as there is modulation present at all times. Resistance R2 is adjusted according to the fading conditions. It should, however, be so adjusted to a value that it will hold down the radio frequency gain a reasonable amount. This allows the radio frequency gain to increase during periods of weak modulation, thereby raising the audio level. This control is particularly effective when the carrier in the receivers goes into a selective fade, leaving the sidebands to beat against themselves, producing a second harmonic of the transmitted tone of exceedingly high audio level.

At these times the audio rectifier augments the normal radio frequency bias and reduces the gain of the radio frequency amplifier, thereby limiting the gain of the radio frequency amplifier, in turn limiting the audio level. It also limits the noise from the radio frequency amplifier stages which results from a sharp reduction of the normal automatic gain control voltage when the carrier goes into a sharp fade.

In some cases it may be desirable to avoid using in this system both rectified diode (carrier) output and rectified audio output for gain control purposes. Control solely by the rectified audio output is then attained by grounding the cathode of the rectifiers **40** of Figure 2. This provides the radio frequency amplifiers with bias using only the audio rectified output, and this works very well. The major objection to its use in this fashion is that the radio frequency amplifiers are left without any bias at all during periods between pictures, i. e., periods when modulation is not present.

In the modification which Figure 3 illustrates it is only the audio rectified current that furnishes the radio frequency amplifier gain control bias. But means are provided for preventing the radio frequency gain from rising to excessive levels during periods of no modulation.

Referring to Figure 3, the radio frequency amplifiers in **2**, **4** and **6** are supplied with negative bias potential from the rectified audio output, substantially as in Figure 2. In addition to this, a threshold bias control circuit is provided and this threshold bias circuit takes its input from the rectified audio output. The tube **50** has a grid **52** connected by resistance **53** to the negative end of resistance R2 and its cathode **54** grounded and connected by resistance R4 to the negative terminal of a source positive points on which are connected to the grid **56** and anode **58**. A point on R4 is connected by resistance R3 to the AVC circuit for the radio frequency stages. The connection from R2 through R5 extends through R3 to a point on R4, while the junction point of R5 and R3 is connected to ground by a condenser **60**, which with the resistances forms the time constant elements of the gain control circuit.

Audio signals are fed through rectifiers **40** as in the prior modifications and supply a negative potential to the radio frequency amplifiers the value of which varies as the audio signal waxes and wanes.

During idle periods, i. e., when there is no modulation, the control grid **52** of tube **50** will be substantially at ground potential, because there will be little or no drop in potential across resistor R2. This period of no modulation occurs, or is liable to occur, at the end of a transmission of a picture, for example, the interval required to readjust the transmitting facsimile gear between one picture transmission and another. At the end of a transmission of a picture, the transmission operator generally removes all modulation from the carrier and it is during this idle period that the tube **50** takes control. During modulation the negative potential developed in resistance R2 by the action of the rectifiers biases tube **50** so that little or no current flows in resistance R4 to act on the automatic gain control circuit.

However, if the modulation is removed, there will be no drop of potential across resistance R2 and the control grid **52** of tube **50** is at ground potential and plate current flows through tube **58** and resistor R4. A portion of the drop across resistance R4 is fed through resistor R3 to the junction point between resistors R4 and R3. The voltage appearing on the arm R4 is negative and, therefore, the grids of the radio frequency stages **2**, **4** and **6** are furnished with a negative potential, the value of which depends upon the setting of the arm on R4. The instant modulation appears, the grid **52** of tube **50** becomes negative and cuts the plate current through tube **58** to substantially zero. The resistance R4 no longer develops a potential as described above and the modulation rectifier **40** takes hold through the drop of potential developed in resistor R2 and fed to the AVC circuit by resistor R5.

The receiving operator generally monitors the incoming signal on the speaker and obviously if nothing was provided to hold the radio frequency gain down during the idle periods described above, severe noise would result due to the fact that the radio frequency amplifier tubes have little or no bias during these idle periods, the only bias being that provided by the noise voltage. The gain of the radio frequency amplifiers would go up thereby increasing the noise if my means including the tube **50** were not provided. If the modulation was continuous with no intervals

between pictures, the control tube would be unnecessary.

In Figure 4 I have shown a means for producing a carrier modulated in accordance with a sub-carrier, in turn modulated in accordance with picture elements derived by scanning means. In a particular application the carrier is modulated in amplitude by a sub-carrier modulated in accordance with the signals. Other types of modulation may be used as desired. In the particular application, we have present at all times, during signalling, the sub-carrier frequency modulation use of which is made as described above to augment the gain control action.

In Figure 4, 62 represents a scanner, 64 a wave length modulator, which is also connected with a sub-carrier source 66. The wave length modulated carrier is fed through an amplifier and modulator in 68 wherein it modulates carrier energy from 70. The output of 68 is amplified in an amplifier and transmitter system in 72 and radiated.

As stated above, my system is also to be used on phone work. By phone work is meant voice and music modulation. This material is, of course, variable in amplitude and frequency. Potentiometer R2 is then adjusted to a position where the peak modulation provides a small amount of "series voltage." The peak level is the so-called zero level output of the audio amplifier. Severe second harmonic distortion during periods of selective fading is materially reduced. Increasing the value of potentiometer R2 to give a "series voltage" on modulation below peak values would compress the amplitude of the modulation.

What is claimed is:

1. In a receiver of carrier wave energy normally modulated by variable potentials during signalling, an amplifier of variable gain, a rectifier for deriving a negative potential the value of which varies in direct ratio to the degree of modulation of said carrier wave by said variable potentials, means including circuit components for controlling the gain of said amplifier by said derived potential, means including additional circuit components operable only in the presence of a substantially unmodulated carrier for deriving therefrom a negative gain control potential and means for applying said gain control potential to said variable gain amplifier to hold down the gain therein during the reception of said unmodulated carrier.

2. In a receiver of carrier wave energy modulated by variable potentials during signalling, an amplifier of variable gain, a rectifier for deriving a negative potential the value of which depends on the degree of modulation of said carrier wave by said variable potentials, means including circuit components for controlling the gain of said amplifier by said derived potential, a tube having an anode, a cathode, and a control grid, an impedance connected between the anode and cathode of said tube, connections between the grid of said tube and said rectifier for applying the derived negative potential to said control grid and a connection between said impedance and said amplifier for taking a negative potential and supplying the same to said variable gain amplifier to hold down the gain thereof during the time when said carrier wave energy is not modulated by said variable potentials.

3. In a receiver of wave energy including a carrier wave normally modulated by waves of lesser frequency, an amplifier of variable gain responsive to said carrier so modulated, a rectifier coupled to said amplifier and having output electrodes connected in an output circuit wherein a rectified current of an intensity substantially proportional to the carrier strength appears, a first impedance in said output circuit, means including connections from said first impedance to said amplifier of variable gain for controlling the gain of the amplifier, a second rectifier excited by voltages derived from said waves of lesser frequency, a second impedance interconnecting the electrodes of said second rectifier, a connection from the output electrodes of said second rectifier to the first said impedance such that the potential drops in the two said impedances are in aiding relation, said second rectifier and said second impedance constituting means jointly effective to additionally control the gain in said amplifier in accordance with the strength of said voltages of lesser frequency.

4. In a receiver of continuously modulated wave energy, an amplifier of variable gain responsive to said wave energy, a wave modulation detector coupled to said amplifier, said detector having output electrodes in a circuit including an impedance wherein rectified current flows, a gain control circuit coupling said impedance to said amplifier to control the gain thereof, a modulation potential selecting circuit coupled to said impedance, a rectifier coupled to said selecting circuit, said rectifier having in its output an impedance wherein a direct current derivative of said wave energy flows, and connections including said last named impedance in series with said first named impedance in said gain control circuit.

5. In a receiver of wave energy including a carrier wave normally modulated by voltages of lesser frequency, an amplifier of variable gain responsive to said carrier so modulated, a rectifier coupled to said amplifier and having output electrodes connected in an output circuit wherein a rectified current of an intensity substantially proportional to the carrier strength appears, an impedance in said output circuit, means including connections from said impedance to said amplifier of variable gain for reducing the gain of the amplifier in direct ratio to said carrier strength, a second rectifier excited by said voltages of lesser frequency, an output circuit including an impedance connected across the electrodes of said second rectifier, and means responsive only to the reception of an unmodulated carrier wave and including circuit components connected between the last said impedance and said amplifier of variable gain for reducing the gain of said amplifier whenever the received carrier wave is unmodulated.

WALTER I. MATTHEWS.