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CARRIER AMPLITUDE CONTROL SYSTEM

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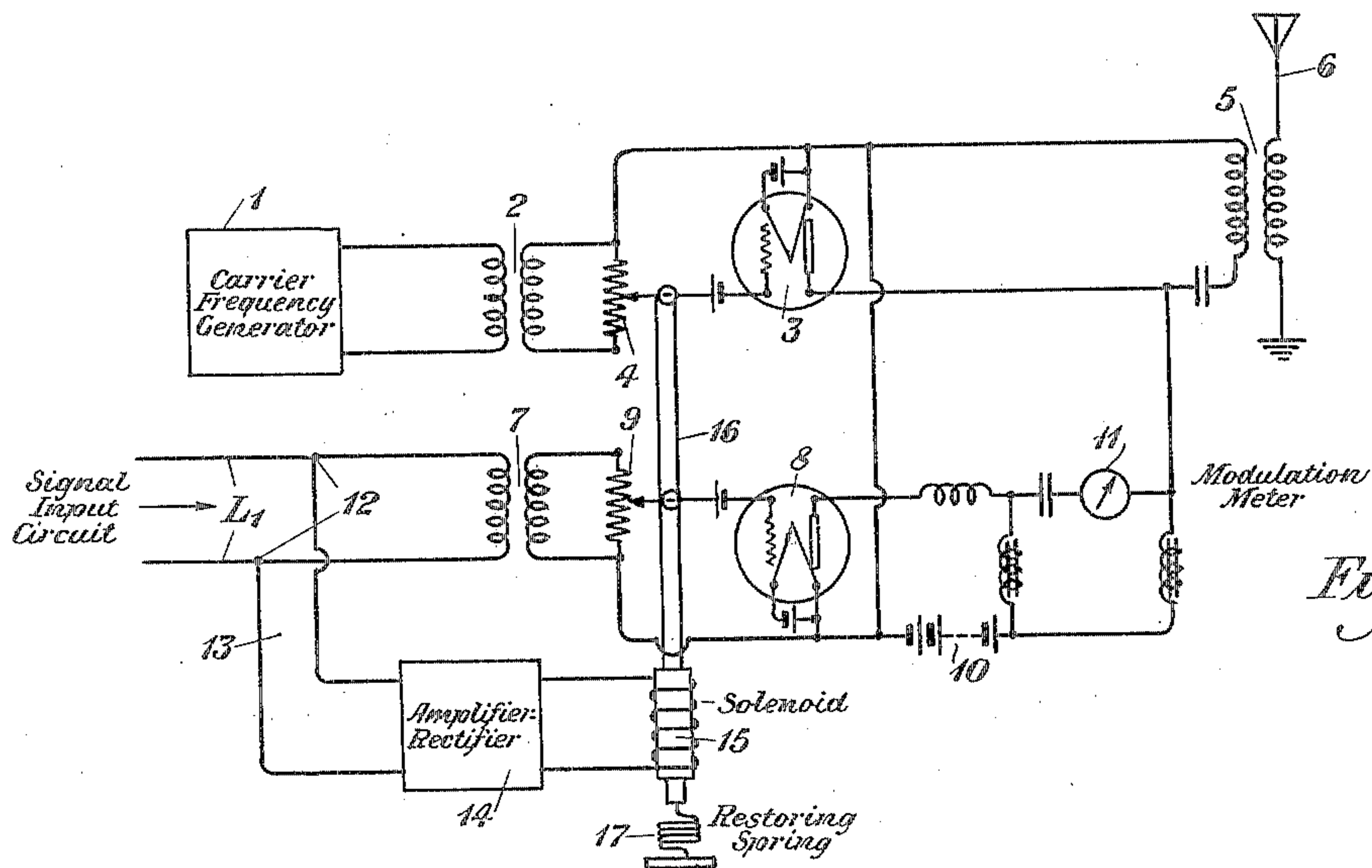


Fig. 1

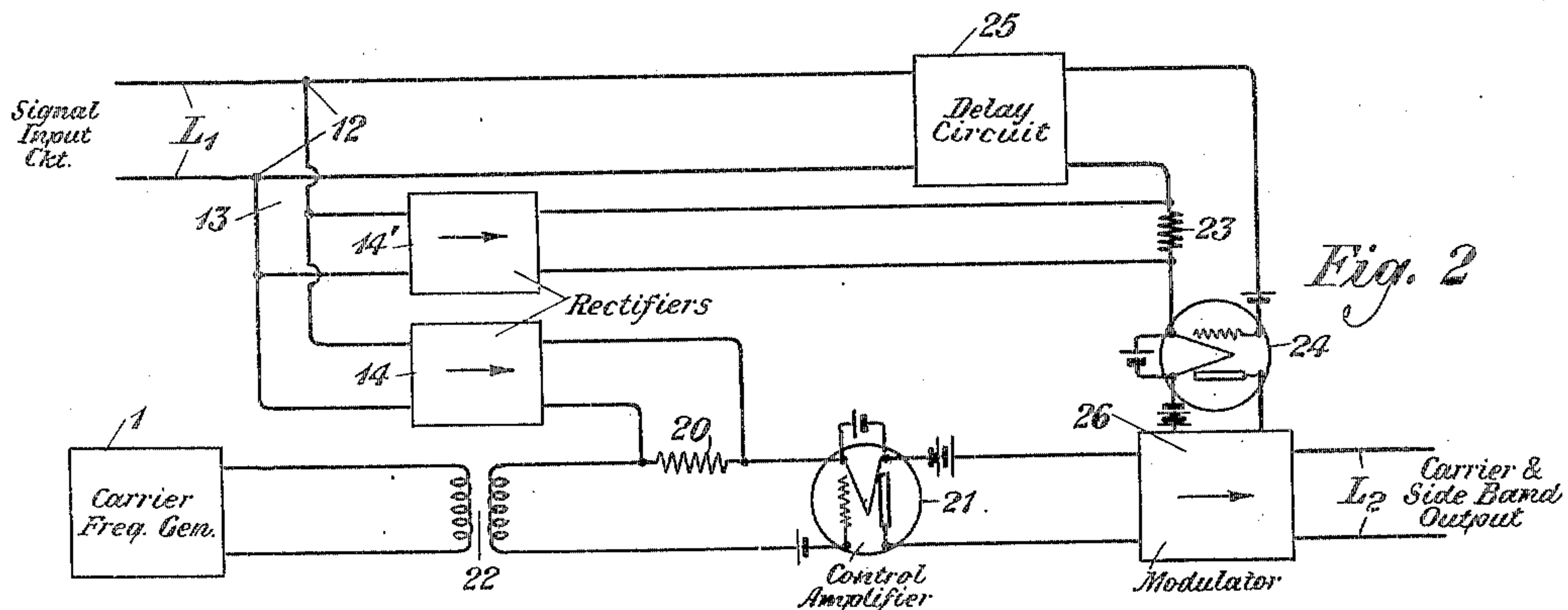


Fig. 2

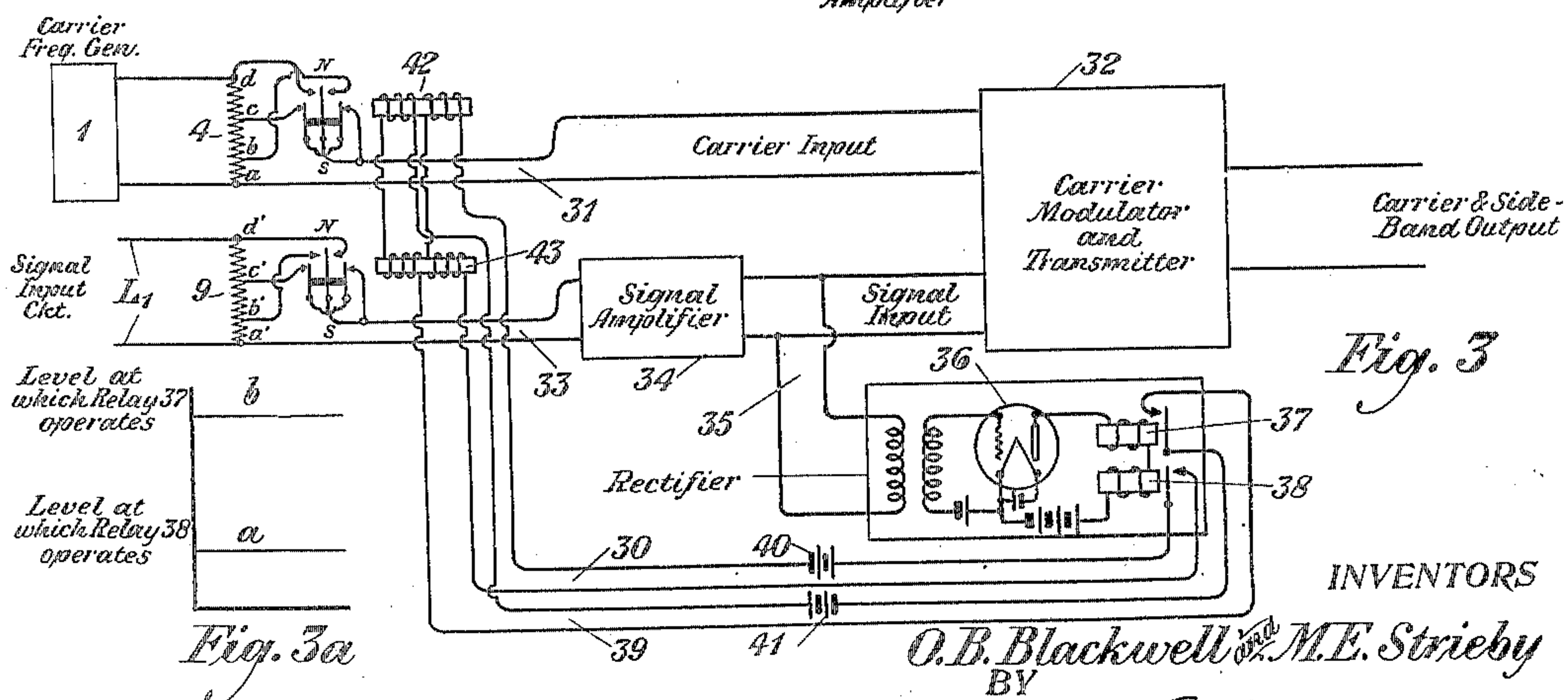


Fig. 3

Level at which Relay 37 operates
b

Level at which Relay 38 operates
a

Fig. 3a

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CARRIER-AMPLITUDE-CONTROL SYSTEM.

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This invention relates to a carrier system characterized by the simultaneous transmission of the carrier frequency and one of its side bands, and particularly to a method and means for controlling the amplitude of the carrier frequency in accordance with variations in amplitude of the side band corresponding to variations in the instantaneous values of the signal frequency load being transmitted over the carrier system.

In the method heretofore employed in radio transmission or broadcasting, and also in carrier systems in which the carrier frequency is simultaneously transmitted with one of the side bands resulting from modulation of the carrier by a frequency or band of frequencies representing the load to be transmitted by the carrier, the amplitude of the carrier frequency per se remains substantially constant, whereas the amplitude of the side band increases and decreases in accordance with the instantaneous values of the frequency or frequencies employed in modulating the carrier. For example, during the transmission of speech over a carrier system, there will be times when the side band will cease to exist, which times correspond to a cessation of sound, such as a pause in a speech being impressed upon the transmitter of the system. In such intervals, the carrier frequency continues to flow over the system to the detector at the receiving station. Any extraneous interference or noise which lies within the frequencies of the side band will be demodulated with this carrier by the detector at the receiving station. The objection to this situation is that during these pauses the receiving system is just as susceptible to noise conditions on the circuit as it is when the speech band is being received.

One of the objects of this invention is to overcome the objection set forth above by causing the sensitivity of the receiving system to be reduced during periods of light load, or no load, corresponding, for example, to pauses in a speech or musical program. This result is accomplished at the sending end by causing the amplitude of the carrier to be varied directly with variations in the load of the audio frequency input, and simultaneously subjecting the side bands to similar control, but in opposite fashion.

This invention will be clearly understood from the following description when read in

connection with the attached drawing, of which Figure 1 shows a system employing an electromagnetic device to control the signal and carrier input amplitudes; Fig. 2 shows the use of vacuum tubes to effect electrical control; Fig. 3 shows a system somewhat similar to Fig. 1, differing therefrom in that the variation in the carrier amplitude is made only when the variation of the signal strength exceeds certain limits; and Fig. 3^a serves to illustrate the principle underlying Fig. 3.

In Fig. 1 the carrier frequency generator 1 is coupled by means of the transformer 2 with the grid filament circuit of the modulating tube 3. A potentiometer 4 is bridged across the terminals of the secondary winding of the transformer 2, and its movable contactor is connected with the grid of the tube. The output circuit of this tube is connected by the transformer 5 with the transmitting antenna 6. The signal input circuit L_1 is connected by the transformer 7 with the grid filament circuit of the modulating tube 8. A potentiometer 9 is bridged across the secondary winding of the transformer 7 and has its contactor connected with the grid of the tube 8. The output circuit of this tube is effectively connected across the output of the tube 3 in such way as to effect modulation of the carrier frequency by variations in the plate current of the tube 3, which is supplied by the source 10. This output circuit comprises a meter 11, by means of which the degree of modulation may be determined. Bridged across the line L_1 at the points 12 is a branch circuit 13, which is connected with a rectifier 14, which preferably would be of the type shown in the copending application of Blackwell and Affel, Serial No. 90,638, filed February 25, 1926, which became Patent 1,681,972, August 28, 1928, which rectifier would preferably include a low pass filter in its output circuit to effect a smoothing out of the rectified current. This current flows through the winding of the solenoid 15, which controls the arm 16 connected with the contactors of the potentiometers 4 and 9. A restoring spring 17 is connected with the said arm in order to bring it back to such relative position when the solenoid is not energized, that the contactors will rest upon the uppermost points of the potentiometer winding, thus giving a maximum signal input and a minimum carrier input to the modulator.

In the system shown, carrier oscillations from the source 1 will be impressed upon the tube 3 and will be modulated by signal variations impressed by the line L_1 upon the tube 8, the said signal variations causing variations in the plate current supplied by the source 10 to the tube 3, thereby producing modulated carrier oscillations which will be transmitted by the antenna 6 together with unmodulated oscillations of the carrier frequency. The amplitude of the speech potential and of the carrier potential applied to the grids of the tubes 8 and 3, respectively, will depend upon the setting of the contactors of the potentiometers 9 and 4, respectively. A part of the energy, which may be relatively small, is diverted from the line L_1 by the branch circuit 13 and rectified by the device 14. The resultant current flows through the winding of the solenoid 15 and results in a downward movement of the arm 16, thereby tending to decrease the potential upon the grid of the tube 8, and increasing the potential of the carrier oscillations applied to the grid of the tube 3. As the level of the signal falls, the rectified current in the solenoid will decrease, and the restoring spring 17 connected with the arm 16 will tend to raise the arm, thereby increasing the potential applied to the grid of the tube 8, and decreasing the potential of carrier frequency applied to the grid of the tube 3. During the intervals of minimum voice input, the carrier output is made a minimum, and during the intervals of maximum voice input the carrier output is made a maximum. It will be seen, therefore, that the amplitude of the carrier transmitted by the antenna 6 is not constant, but is varied in such relation to the changes in the voice input. Inasmuch as the carrier is small at times when the signal is small, the noise resulting as a product of the carrier and noise at side band frequencies will be small. This is the object that it is desired to obtain, namely the minimization of noise at times when it would be most objectionable. Inasmuch as the volume of the voice signal at the receiving end is proportional to the product of the carrier and the side band, it can be easily shown that the amplitude changes in the carrier at the transmitting end should be half as great, expressed in transmission units, and in the opposite direction to the amplitude changes of the voice, in order to effect true reproduction of the original volume changes in the signal.

The arrangement shown in Fig. 2 differs from that shown in Fig. 1 in that the operations are carried out entirely by electrical devices. In the circuit, the signal input circuit L_1 has bridged across it at the points 12 a branch circuit 13 having two sub-branches, one of which is connected with the rectifier 14, and the other with the rectifier 14'. The output side of the rectifier 14 is connected

across the resistance 20 in the grid circuit of the control amplifier 21, to which grid circuit the carrier frequency generator 1 is connected by means of the transformer 22. The output side of the rectifier 14' is connected across the resistance 23 in the grid circuit of the amplifier 24, the said latter grid circuit including the delay circuit 25, connecting the line L_1 with the grid circuit of the tube 24. The output circuits of the tubes 21 and 24 are connected with the modulator 26, which may be of any well-known type. In the arrangement shown in Fig. 2, oscillations of the carrier frequency from the source 1 will be amplified by the tube 21 and impressed upon the modulator 26.

The signal frequency impressed upon the line L_1 will be transmitted through the delay circuit 25, and after being amplified by the device 24, will be impressed upon the modulator 26, thereby modulating the oscillations of the source 1. The carrier and the side bands will pass to the line L_2 , which may contain a filter to suppress one of the side bands. A portion of the energy from the line L_1 will pass to the branch circuit 13 and will there divide, part of it being rectified by 14, and part by 14'. The rectified current of 14 will produce a potential difference across the resistance 20 which will control the degree of amplification of the carrier frequency oscillations producible by the device 21. The portion of the signal frequency rectified by 14' will be impressed across the resistance 23, and will control the amplification of the speech variations producible by the amplifier 24. The connections between the output sides of the rectifiers and the grid circuits of the respective tubes shall be so arranged that the effects of the rectified current shall be produced in opposite senses upon the several tubes. That is to say, if the effect of the rectified current from the tube 14' is to increase the amplification of 24, the effect of the rectified current from the source 14 at the same instant shall reduce the amplification of the tube 21, and vice versa. The delay circuit 25, which may be similar to that shown in the copending application of Blackwell and Affel, supra, is intended to retard the impression of the voice variations upon the tube 24 until the rectifiers shall have operated and produce an effect upon the grid circuits of their respective tubes.

The arrangement shown in Fig. 3 is intended to effect a change of the carrier amplitude only when the signal amplitude rises above, or falls below predetermined limits. This differs from the case shown in Fig. 1, in which momentary variations of the signal level cause corresponding variations of the carrier level.

In Fig. 3 the carrier generator 1 is connected with the potentiometer 4 which has

a plurality of taps taken therefrom at the points designated *a*, *b*, *c* and *d*. The points *b*, *c* and *d* are connected with contact points of the relay 42 in a manner which will be more fully described later. Similarly, the signal input circuit *L*₁ is connected with the potentiometer 9 having a plurality of taps taken therefrom at the points designated *a'*, *b'*, *c'* and *d'*. The carrier source is connected through the contacts of the relay 42 and the circuit 31 with the modulator 32, which may be of any well known type. The signal circuit is connected through the contacts of the relay 43 and the circuit 33 with the said modulator, the connection preferably including an amplifier 34. Bridged across the output of the amplifier is a branch circuit 35 which is connected with a rectifier 36. This rectifier has two relays 37 and 38 connected with its output circuit which control the relays 42 and 43. The circuit 39, is connected with the armature and front contact of relay 37 so that the said circuit is closed when this relay operates. The circuit 30 is connected with the armature and the back contact of relay 38 so that this circuit is opened when relay 38 operates. The circuit 30 includes the source of potential 40 and the right-hand windings of the polar relays 42 and 43. Similarly, the circuit 39 includes the source of potential 41 and the left-hand windings of relays 42 and 43. The relays 42 and 43 which are preferably similar in design, are intended, when unoperated, to maintain the circuits 31 and 33, bridged across the points *a—c* and *a'—c'* of their respective potentiometers. This is rendered possible by the armature arrangement of the relays. Thus, for example, in relay 42, three armatures are fastened together so as to operate as a unitary structure. The outer armatures are electrically connected together so that when the relay is de-energized the point *c* is connected through the contact point of the left-hand armature with the contact point of the right-hand armature, and thence with the upper conductor of the circuit 31. The central armature is also connected with the same side of circuit 31. When the relay is operated the connection with the point *c* is opened and the upper conductor of circuit 31 is connected through the central armature either with the points *d* or *b*, depending upon the direction of the movement of the armatures. The arrangement of relay 43 is similar, except that the points *d'* and *b'* are connected with the right-hand and left-hand contact points of the central armature instead of with the left-hand and right-hand contact points of the central armature as in the case of relay 42. Relay 37 is designed to operate at a current level such as is represented by the line *a* of Fig. 3^a, and relay 38 at the level represented by the line *b*.

The manner in which this circuit functions to control the relative amplitudes of the carrier and the signal is as follows: Signal currents, such as voice currents transmitted over the line *L*₁ will be impressed upon the potentiometer 9, and assuming that the relay 43 is in its normal unoperated position, the voltage impressed across the points *a'—c'* will in turn be impressed upon the circuit 33 and the amplifier 34. This amplified signal current will then be impressed upon the modulator 32. At the same time the carrier oscillations will be impressed upon the potentiometer 4, and assuming that the relay 42 is in its normal de-energized position, that portion of the voltage set up between *a* and *c* will be impressed by the circuit 31 upon the modulator 32, and will be modulated by the signal currents impressed thereon by the line *L*₁. A portion of the amplified signal energy will be diverted by the circuit 35 and impressed upon the rectifier 36. If the level of the rectified current is above the value represented by the line *a* of Fig. 3^a, but below the values represented by line *b*, relay 38 will be operated but relay 37 will not be. Accordingly, the contacts of both relays will be opened and the polar relays 42 and 43 will not be energized. If the level of the signal falls to such level that the portion of the voltage across the points *a'—c'* when amplified by 34 and rectified by 36 will be below the value represented by the line *a* of Fig. 3^a, relay 38 will be deenergized and its contact will be closed. This results in the closing of the circuit 30 whereupon current from the source 40 will flow through the right-hand windings of relays 42 and 43. These windings are so poled with respect to the source 40 that the armatures will be drawn toward the right, thereby connecting the circuit 33 across the points *a'* and *d'* and the circuit 31 across the points *a* and *b*. It will accordingly be seen that this increases the amplitude of the signal voltage applied to the modulator 32 and simultaneously decreases proportionately the amplitude of the carrier applied to the said modulator. If on the other hand the level of the signal currents has increased instead of decreased so that its value would be above that represented by the line *b* of Fig. 3^a, not only will relay 38 remain operated but also relay 37 would be energized. This results in the closing of the circuit 39 thereby connecting the source 41 with the left-hand windings of relays 42 and 43. The armatures of the latter relays would be moved to the left, thus connecting the circuit 33 across the points *a'* and *b'*, and the circuit 31 across the points *a* and *d*. The effect of this is to reduce the amplitude of the signal voltage applied to the modulator 32 and to simultaneously increase the amplitude of the carrier applied to the said modulator. It will accordingly be seen that the changes in the signal level controls

the setting of the potentiometers, causing an increase in the amplitude of the side band, and a decrease in the amplitude of the carrier or vice versa. Since these changes are in an opposite sense, the resultant signal at the receiving end of the system, which is a product of the amplitude of the side band and of the carrier, has the variations in volume of the original signal. If the energy level of the speech circuit L_1 rises to such a point that the rectified current exceeds the limit represented by b , relay 38 will be operated, thereby opening the circuit 30 and causing the restoring spring to move the potentiometer to reduce the grid voltage of the signal input circuit, and to increase the corresponding voltage of the carrier input circuit.

The arrangement for effecting the relative control of the signal and the carrier side bands is purely schematic and other ways may be devised for attaining the same result which will readily occur to those skilled in the art. Thus, for example, the control of the relays 42 and 43 may be effected directly by variations of the space current of the rectifier 36 without the employment of the relays 37 and 38. Furthermore, an arrangement such as that shown in Fig. 1 may be used for varying the relative potentiometer settings of the speech and carrier sources.

It will be seen that by means of the method and of the principle underlying the systems disclosed hereinbefore, the amplitude of the carrier is reduced, and the amplitude of the side band is increased during the interval when the level of the signal, namely, the speech, is relatively low. By this reduction in the carrier amplitude, the interference effect produced by static or other interfering voltages is correspondingly lessened as compared with ordinary systems of modulation.

It is furthermore desirable to point out that the systems herein described and shown disclose a modulator in which the volume control of the voice input is so manipulated as to result in a constant voice input to the modulator. In order to produce true volume reproduction at the receiving end, the carrier input to such a modulator should be varied in a manner inversely proportional to one-half the change in the voice input. This results in a transmission system which may be termed a "constant voice-variable carrier system" as contrasted with the well-known "constant carrier-variable voice system". In the arrangements shown herein, if a volume indicator is placed in the circuit between the voice volume control and the modulator input, it is an easy matter to maintain the voice level constant by so varying the volume control potentiometer that the reading of the volume indicator will be substantially constant.

While this invention has been disclosed as embodied in particular forms, it is obviously

capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the combination with a source of carrier frequency of a source of signal frequency, a modulator having its input connected with both sources, a potentiometer interposed between the said source of carrier frequency and the said modulator, a second potentiometer interposed between the said source of signal frequency and the said modulator, and a control circuit connected with the said source of signal frequency comprising a rectifier and an electromagnetic device connected with the output of the rectifier, the said device being so connected with the said potentiometers, as to vary them simultaneously in opposite directions.

2. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the combination with a modulator as a source of carrier frequency, a source of signal frequency, both connected with the input of the said modulator, a potentiometer individual to each source and connected between the source and the modulator, and a control device connected with the source of signal frequency and responsive to variations of the signal level to simultaneously operate the said potentiometers in opposite directions.

3. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the combination with a modulator of a source of carrier frequency, a source of signal frequency, both sources being effectively connected with said modulator, and means individual to each source and controlled by the energy level of the said source of signal frequency to reduce the amplification of the carrier frequency and to increase the amplification of the side band during periods of low signal volume, and to increase the carrier amplitude and decrease the side band amplitude during high volume periods.

4. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the combination with a modulator of a source of carrier frequency, a source of signal frequency, both sources being effectively connected with the said modulator, of amplitude controlling means connected between each source and the said modulator, a rectifier connected with the source of signal frequency, and means responsive to variations in the rectified current to affect in opposite ways the amplitude controlling means connected with each of the said sources.

5. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the method of reducing the effect of interference and at the same time to main-

tain constant the volume of the received signal which consists in decreasing the amplitude of the carrier and increasing that of the signal prior to modulating said carrier by said signal whenever the level of the signal falls below a predetermined value, and increasing the amplitude of the carrier and decreasing that of the signal prior to modulation whenever the level of signal rises above a predetermined value.

6. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the method of reducing the effect of interference and at the same time to maintain constant the volume of the received signal, which consists in amplifying the signal current, rectifying a portion of the said signal current as amplified, simultaneously varying in opposite senses the voltage of the carrier and of the signal prior to modulation whenever the level of the signal exceeds a fixed limit and simultaneously varying in opposite senses the voltage of the carrier and of the signal prior to modulation whenever the level of the signal falls below a fixed limit.

7. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the method of reducing the effect of interference and at the same time to maintain constant the volume of the received signal, which consists in amplifying the signal current, rectifying a portion of the said signal current, simultaneously increasing by a fixed amount the voltage of the carrier and decreasing by a fixed amount the voltage of the signal prior to modulating the carrier by the signal whenever the level of the signal exceeds a fixed value, and simultaneously decreasing by a fixed amount the voltage of the carrier and increasing by a fixed amount the voltage of the signal prior to modulating the carrier by the signal whenever the level of the signal falls below a fixed value.

8. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the combination with a modulator of a source of carrier frequency, a source of signal frequency, both sources being effectively connected with the said modulator, a potentiometer connected across said source of carrier frequency between said source and said modulator, electromagnetic switching,

means to connect the carrier input circuit of said modulator across a portion of the carrier potentiometer, another potentiometer similarly connected across the source of signal frequency, and electromagnetic switching means to effectively connect the signal input circuit of said modulator across a portion of the signal potentiometer, a rectifier connected across the said signal input circuit, relays connected with the output circuit of said rectifier and controlled by the current therein and circuits having sources of potential therein connecting said relays and the windings of the said electromagnetic switching means, the said circuits being so arranged as to vary the potentiometer adjustments whenever the level of the signal exceeds fixed upper and lower limits.

9. In a carrier signaling system in which a carrier frequency is modulated by a signal frequency, the combination with a modulator of a source of carrier frequency, a source of signal frequency, both sources being effectively connected with the said modulator a potentiometer connected across said source of carrier frequency between said source and said modulator, electromagnetic switching means to connect the carrier input circuit of said modulator across a portion of the carrier potentiometer, another potentiometer similarly connected across the source of signal frequency, and electromagnetic switching means to effectively connect the signal input circuit of said modulator across a portion of the signal potentiometer, and a control circuit to vary simultaneously and in opposite senses the amplitude of the carrier and signal applied to said modulator, the said control circuit including a rectifier, a plurality of relays connected with the output of said rectifier, and circuits having sources of potential therein connecting said relays and the windings of said switching means to vary the potentiometer settings whenever the level of the signal exceeds fixed upper and lower limits.

In testimony whereof, we have signed our names to this specification this 30th day of December, 1925.

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