April 13, 1943. D. M. DAVIS 2,316,567

PHASE REVERSING MEANS

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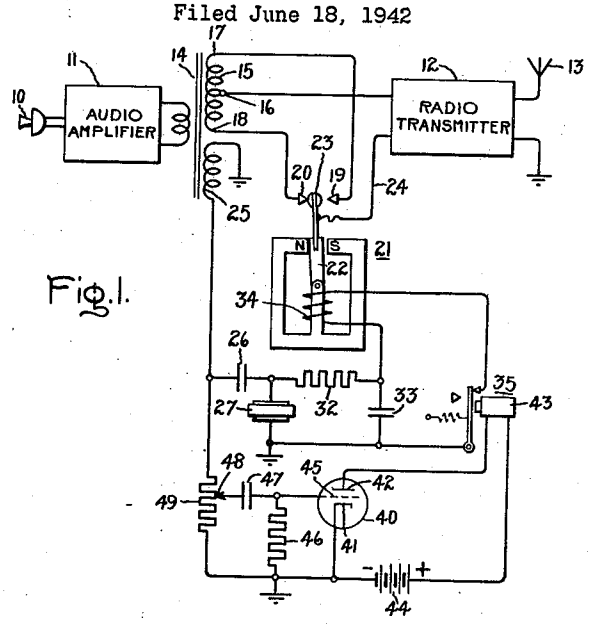


Fig. 1.

Fig. 2.

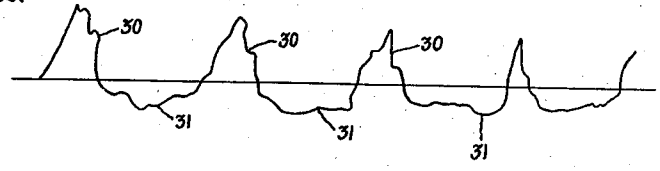
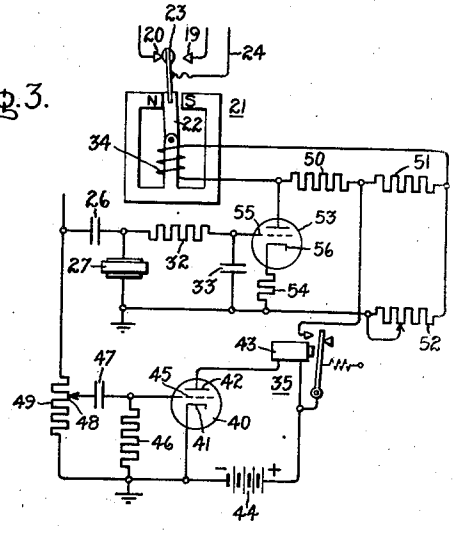


Fig. 3.



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PHASE REVERSING MEANS

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3 Claims. (Cl. 179—1)

This invention relates to phase reversing means and more particularly to means for reversing the phase of electromotive force having a wave form which is asymmetrical with respect to its average axis, i. e., that portion of the electromotive force which is of one polarity is more intense than that of the other polarity.

It has been found that signal electromotive force produced by certain types of signal equipment has peak intensities of one polarity greater than of the other. For example, certain types of microphones convert the human voice, particularly the male voice, into an electrical wave in which the peak intensity of one polarity may be two or more times as great as the peak intensity of the other polarity. Furthermore, the polarity of the signal peaks of greater intensity is reversed when the sound impinges on the opposite side of the microphone.

Signal transmission channels generally have an asymmetrical linear transmission characteristic. That is, they are capable of transmitting faithfully signals of which a particular polarity is more intense than the other. For example, an electron discharge amplifier device may be so arranged that a positive potential may be applied to its input of such value that its control electrode just begins to carry discharge current, which positive potential is less than the negative potential which must be applied to the input to cut off the flow of discharge current in the device. When so arranged the device is capable of amplifying a wave whose peaks of one polarity, corresponding to the negative potential, are larger than the peaks of opposite polarity.

Similarly, the carrier wave modulator and amplifier stages of a radio transmitter generally are capable of producing carrier wave power for short periods in amounts considerably greater than four times the power of the carrier wave when unmodulated, but the carrier wave intensity can never be reduced below zero intensity, with the consequence that the intensity of the carrier wave may be modulated between zero intensity and an intensity more than twice as great as the intensity of the unmodulated carrier wave.

It is desirable to modulate the intensity of such a carrier wave in accordance with a signal, of which the peaks of one polarity are more intense than the peaks of the other polarity, so that the carrier wave intensity is increased in response to the more intense signal peaks, and decreased in response to the less intense signal peaks of the opposite polarity. It is an object of my invention to provide an improved and simplified arrangement for transmitting signals of which peaks of one polarity are more intense than peaks of the other polarity through a signal transmission channel in such phase that the channel is capable of most efficiently transmitting such signals.

An arrangement of this general nature is disclosed in Patents 2,158,820 and 2,158,821—Hathaway, issued on May 16, 1939, in which the dissymmetry of signals is detected by electronic means. It is an object of my invention to provide in such an arrangement improved and simplified means for detecting such dissymmetry of a signal. It is a further object of my invention to provide in connection with such detecting means improved highly sensitive means for reversing the phase of such signals as desired.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Figs. 1 and 3 illustrate two embodiments of my invention; and Fig. 2 indicates certain characteristics of the arrangement of Fig. 1.

In Fig. 1 a microphone 10, which may be excited by sound, produces audio signals which are amplified through an audio amplifier 11, and which modulate the intensity of a carrier wave in a radio transmitter 12, which carrier wave is radiated from an antenna 13. As explained previously, it is desired that the signals amplified through amplifier 11 be transmitted to the radio transmitter 12 with such polarity that the signal peaks of greater intensity shall increase the intensity of the carrier wave, while the oppositely poled peaks of less intensity shall decrease the intensity of the carrier wave. To this end audio signals from the amplifier 11 are impressed on the primary of a transformer 14 which has a secondary 15, of which a center tap 16 is connected to the radio transmitter 12, while the two terminals 17 and 18 are connected respectively to fixed contacts 19 and 20 of a polarized relay 21.

The relay 21 is arranged, with apparatus to be described hereinafter, so that its armature 22 moves to the left in response to signals from the amplifier 11 of which the peaks of one polarity are most intense, and moves to the right in response to signals from amplifier 11 of which peaks of the other polarity are most intense. The armature 22 carries a movable contact 23, which is connected through a conductor 24 to the radio transmitter 12. When the armature 22 is in the left-hand position signals from the amplifier 11 are impressed on the radio transmitter 12 through a circuit extending from the transmitter 12 through center tap 16, the lower half of secondary 15 of transformer 14, terminal 18, fixed contact 20, movable contact 23, and conductor 24. When the armature 22 is in the right-hand posi-

tion, signals from the amplifier 11 are impressed in opposite phase on the transmitter 12 through a circuit extending from the transmitter 12 through center tap 16, the upper half of secondary 15 of transformer 14, terminal 17, fixed contact 19, movable contact 23, and conductor 24.

Apparatus is provided to produce a continuous potential whose polarity depends on the polarity of the most intense signal peaks from the amplifier 11, and whose intensity depends on the amount of dissymmetry of signals from the amplifier 11. This apparatus includes a tertiary winding 25 of the transformer 14, one terminal of which is grounded, and the other terminal of which is connected through a coupling condenser 26 to one terminal of a nonlinear resistance 27, the other terminal of which is grounded. Audio signals from the amplifier 11 consequently appear across the non-linear resistance 27 in predetermined phase.

The non-linear resistance 27 is preferably of the type described in United States Patent No. 1,822,742, issued Sept. 8, 1931, to K. B. McEachron, and assigned to the same assignee as the present application, but may be composed of any material having a non-linear resistance-current relation.

The action of the non-linear resistance 27 in producing a continuous potential compoent when an asymmetrical signal from the amplifier 11 is impressed thereacross may be better understood by reference to Fig. 2, in which a signal wave having pronounced dissymmetry is illustrated. The peaks 30 of one polarity in Fig. 2 are illustrated as substantially more intense than the peaks 31 of opposite polarity. When the particular material described in the above-mentioned McEachron patent is utilized as the resistance 27, its resistance decreases as current flow therethrough increases. That is, a small increase in voltage results in a large increase in current through the resistance. Consequently, the more intense peaks 30 produce a current through the resistance 27 which is proportionately greater than the current produced through the resistance 27 by the less intense peaks 31. Therefore, during the more intense peaks 30, a greater reactive voltage drop across condenser 26 exists than would be the case if the resistance 27 had linear characteristics, with the result that the peaks 31 of the signal wave are more effective in producing a voltage across the resistance 27 than are the peaks 30.

Although the signal wave shown in Fig. 2 is asymmetrical in nature, having peaks 30 which are of greater intensity than its oppositely poled peaks 31, the total area under the peaks 30 is exactly equal to the total area under the peaks 31 of opposite polarity. However, due to the non-linear resistance current characteristics of the resistance 27, the peaks 30 and the peaks 31 are so distorted in the signal as it appears across the resistance 27 that this is no longer the case. In the voltage wave across the resistance 27, the peaks corresponding to the peaks 31 of the signal voltage wave across resistance 27 enclose a larger area than the peaks of the signal wave across resistance 27. Consequently, there is a unidirectional component of voltage in the resultant wave across the non-linear resistance 27.

A resistance 32 and condenser 33 are connected in series between the terminals of the resistance 27. It is preferred that the condenser 33 be sufficiently large to store enough energy to operate the relay 21 after a short time interval, and that the combination of resistance 32 and condenser 33 have a time constant such that the voltage across condenser 33 changes quite slowly. Such changes may be made of the order of the syllabic rate of the signals from the microphone 10.

The operating coil 34 of relay 21 is connected in shunt to the condenser 33 through the normally open contacts of a relay 35. The relay 21 must be sufficiently sensitive to operate in response to the voltage which is developed across condenser 33 by action of the non-linear resistance 27. As more powerful signals from the amplifier 11 are impressed upon the non-linear resistance 27, it is capable of developing a larger voltage across the condenser 33, so that the relay 21 need be less sensitive. Whenever the normally open contacts of relay 35 are closed, and voltage exists across the condenser 33, the relay 21 produces the proper connection between audio amplifier 11 through transformer 14 and radio transmitter 12, so that the carrier wave intensity is reduced in response to peaks of the signal wave of less intensity, and the carrier wave intensity is increased in response to peaks of the signal wave of greater intensity. This proper connection may be determined by trial, and if it be found that the connection as first made is wrong, the polarity of the signal impressed across resistance 27 may be changed, the polarity of the voltage impressed on operating coil 34 of relay 21 from condenser 33 may be changed, or the polarity of the connections to the secondary 15 of transformer 14 may be changed.

It is desirable that the phase reversing arrangement operate only in the absence of signals from the amplifier 11. Accordingly, a discharge device 40 is provided which is so arranged as to close the normally open contacts of relay 35 in the absence of signals, and to maintain those contacts open in the presence of signals. That is, whenever signals are absent, device 40 energizes relay 35 so that its contacts close and energy stored in the condenser 33 acts to operate the relay 21 to its proper position.

The discharge device 40 may be connected in any suitable manner to perform its function, and as illustrated is connected as a triode detector. Its cathode 41 is grounded and its anode 42 is connected through the operating coil 43 of relay 35 to the positive terminal of a source 44 of potential, the negative terminal of the source 44 being grounded. The control electrode 45 of device 40 is connected through a grid leak resistance 46 to ground and is connected through a coupling condenser 47 to the movable contact 48 of a variable resistance 49, of which one terminal is grounded. The ungrounded terminal of resistance 49 is connected to the ungrounded terminal of the tertiary winding 25 of transformer 14, so that audio signals are impressed through condenser 47 upon the control electrode 45 of device 40 in intensity determined by the adjustment of contact 48.

The operating time of the detector, that is, the time required after the cessation of signals from the amplifier 11 before relay 35 operates, is determined by the size of condenser 47 and resistance 46. The larger this condenser 47 and resistance 46, the longer the time required for the relay 35 to operate after signals cease. It is desirable to make this time reasonably long, to prevent too frequent operation of relay 35. The time, however, must be sufficiently short to close the contacts of relay 35 before the charge disappears from condenser 33. Condenser 33 has two functions, one being to separate the continuous

potential developed across resistance 27 from the signal potential thereacross, and the other to store such potential until relay 35 operates.

In Fig. 3 there is illustrated an arrangement whereby the relay 21 may be less sensitive. In this figure many of the elements are similar to those illustrated in Fig. 1, and are given like reference characters. The operating coil 34 in Fig. 3, instead of being connected in shunt to the condenser 33, is connected across one diagonal of a bridge circuit, of which the resistance of one arm is influenced by the voltage across condenser 33.

This bridge circuit includes four arms, respectively formed by resistance 50, resistance 51, adjustable resistance 52, and the anode to cathode discharge path of an electron discharge device 53 and resistance 54. A point between resistances 52 and 54 is connected to ground, which is thus at one corner of the bridge, and the opposite corner, between resistances 50 and 51, is connected through the contacts of relay 35 to the positive terminal of source 44. Condenser 33 is connected between the control electrode 55 of device 53 and ground.

The bridge should be adjusted for balance when there are no signals from microphone 10. Under such conditions there is no voltage across the condenser 33, and the contacts of relay 35 are held closed by current flowing through device 40. Resistance 54 produces a bias potential between control electrode 55 and cathode 56 of device 53 by reason of the discharge current of device 53 flowing therethrough. This bias potential developed across resistance 54 should be of such a value that the potential of control electrode 55 may be changed a substantial amount in either direction without cutting off the discharge current of device 53, and without causing the control electrode 55 to become positive with respect to cathode 56.

With the bias resistance 54 so adjusted, and with no signal from microphone 10, the resistance 52 is adjusted so that substantially no potential exists across the operating coil 34.

Under such conditions of adjustment, when a potential appears across condenser 33, so as to make the control electrode 55 less negative with respect to ground, device 53 tends to transmit more current and appears as a smaller resistance, thereby unbalancing the bridge. When the bridge is so unbalanced the upper terminal of operating coil 34 is made positive in potential and the relay 21 operates accordingly.

When the opposite potential appears across condenser 33 and makes the control electrode 55 more negative with respect to ground, the device 53 appears as a larger resistance and makes the lower terminal of operating coil 34 positive so as to cause the relay 21 to operate oppositely.

The relay 35 operates as described previously to prevent operation of the relay 21 except in the absence of signals. That is, whenever signals are present, current through the device 40 is reduced, so that relay 35 is deenergized, thereby disconnecting the source 44 from the bridge and consequently preventing operation of the relay 21. When signals disappear, the device 40, after a time determined by the size of the condenser 47 and resistance 48, begins to pass current and energizes relay 35, so that its normally open contacts close and supply energy to the bridge, so that, if the bridge is unbalanced, relay 21 is operated accordingly.

The arrangement may be used for transmitting any type of signals, such as audio signals, which are asymmetrical, through any channel which has an asymmetrical linear transmission characteristic.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, in a system for transmitting an asymmetrical alternating potential through a channel having an asymmetrical linear transmission characteristic, a non-linear resistance, means for impressing said alternating potential across said resistance to develop a continuous potential whose polarity corresponds to the asymmetry of said alternating potential, and means responsive to the polarity of said continuous potential for supplying said alternating potential to said channel in such phase that the asymmetry of said alternating potential corresponds to the asymmetry of the linear transmission characteristic of said channel.

2. In combination, in a system for transmitting an asymmetrical alternating potential through an asymmetrical transmission channel, a non-linear resistance, means including said resistance for developing a continuous potential component in accordance with the asymmetry of said alternating potential, means for producing a continuous potential from said component and for storing such potential, means responsive to said stored potential for supplying said asymmetrical alternating potential to said channel in such phase that the asymmetry of said alternating potential corresponds to the asymmetry of said channel, and means for preventing the operation of said last means during the presence of said alternating potential.

3. In combination, in a system for transmitting an asymmetrical alternating potential through an asymmetrical transmission channel, a non-linear resistance, means for impressing said potential across said resistance to develop a continuous potential in accordance with the asymmetry of said alternating potential, a bridge having an arm including the discharge path of an electron discharge device having a control electrode, said bridge being balanced when no potential is impressed on said control electrode, a source of operating potential for said device connected across one diagonal of said bridge, means for supplying said asymmetrical potential to said channel in polarity dependent on the polarity of voltage across the other diagonal of said bridge, and means for impressing said continuous potential on said control electrode in such polarity that the resulting unbalance of said bridge causes said alternating potential to be supplied to said channel in that polarity in which the asymmetry of said alternating potential corresponds to the asymmetry of said channel.

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