Oct. 26, 1943. M. G. CROSBY 2,332,782

AUTOMATIC TONE CONTROL CIRCUIT

Filed Dec. 9, 1941

Fig. 1.

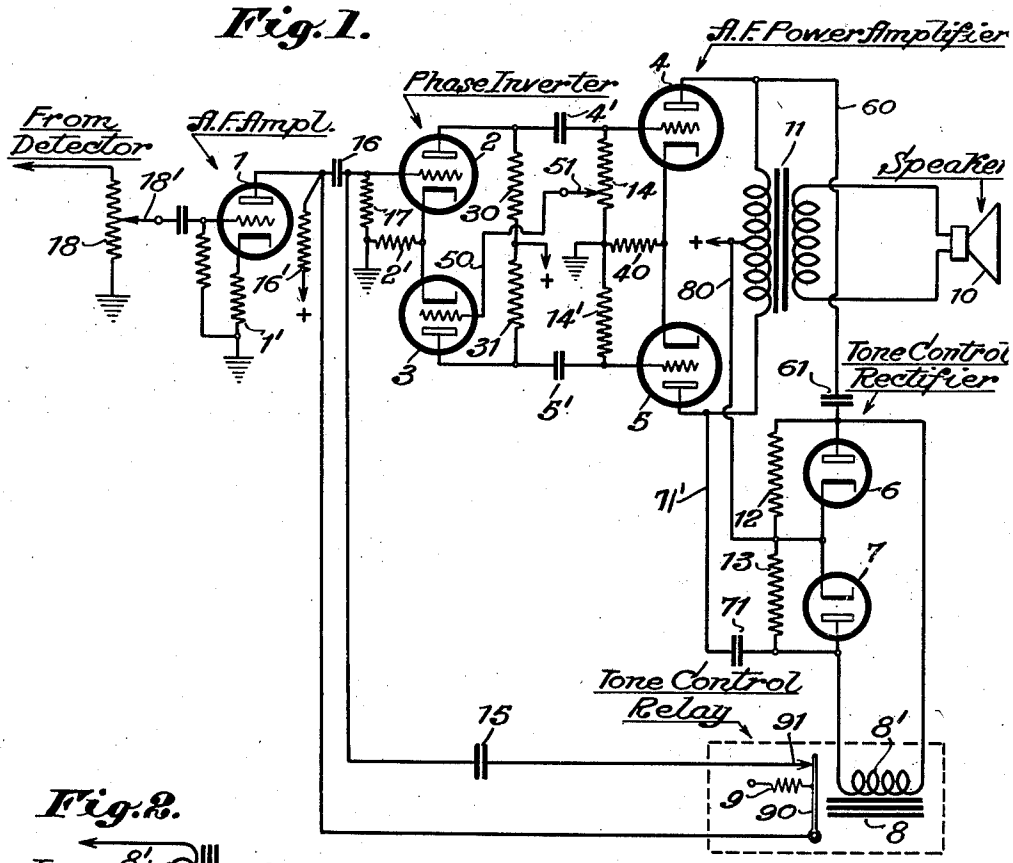


Fig. 2.

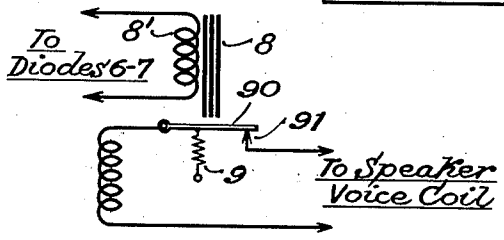


Fig. 3a.

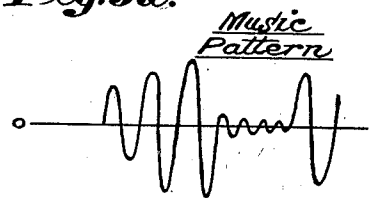
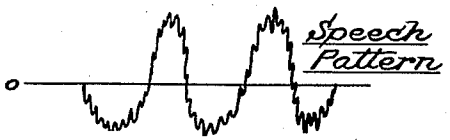


Fig. 3b.



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AUTOMATIC TONE CONTROL CIRCUIT

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13 Claims. (Cl. 179—1)

My present invention relates to automatic tone control circuits for audio systems, and more particularly to automatic tone control arrangements adapted automatically to switch an audio system from "music" to "speech" positions when the program applied to the audio system changes from music to speech.

In radio broadcast reception it is usually desirable to introduce over-emphasis in the bass response of the receiver in order to accentuate the rhythm of music, and give the music a rich sound which most people prefer. This is particularly true in the case of dance music in which the drums are accentuated for the emphasis of rhythm. However, when over-emphasis of the bass response is utilized, reproduction of speech modulation is given an annoying "boominess" which reduces intelligibility. Accordingly, most broadcast receivers are provided with a tone control device which is capable of being adjusted to one position marked "music" which gives an accentuated bass response in the audio network of the receiver, while a second position marked "speech" imparts a curtailed bass response to the audio network so that speech intelligibility is had.

The operator of the receiver would then switch the tone control device between these aforesaid modulation positions as the program changes. Usually the listener does not want to be bothered with the adjustments of the tone control devices. Hence, many listeners would rather tolerate the maladjustments of the response of the receiver than adjust the tone control device in the proper manner.

It may be stated, therefore, that it is one of the main objects of my present invention to provide an automatic device which operates to adjust the response of the audio network of a radio broadcast receiver as the program changes from music to speech reception, or vice versa, so that the proper response is had for a given program modulation on the received carrier wave.

Another important object is to provide a simplified automatic tone control mechanism which is capable of automatically switching the audio network response of the receiver from "music" to "speech" position when the program being received changes from "music" to "speech"; the voltage dissymmetry of speech audio waves being utilized to operate a relay device which changes the frequency response of the system.

It is well known that the alternating voltage obtained from a microphone being actuated by speech is unsymmetrical with respect to zero voltage. That is, the speech may produce a positive swing of 2 volts and a negative swing of one volt, or vice versa. On the other hand the voltage produced when music actuates the microphone is symmetrical with respect to the zero axis. Hence, by arranging a device which responds to dissymmetry of the audio voltage applied to the audio system the presence of speeeh modulation in the program may readily be indicated.

It is, therefore, an object of my present invention to provide a device which is capable of adjusting the frequency response of an audio network in accordance with the symmetry or dissymmetry of the audio waves applied to the audio network.

Still another object of my invention is to provide an automatic device, responsive to symmetry or dissymmetry of audio waves fed to a reproducer, for rendering the latter effective or ineffective to reproduce the waves.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a circuit diagram of an audio system embodying the invention,

Fig. 2 illustrates a modification of the control device,

Figs. 3*a* and 3*b* show illustrative patterns of music and speech audio waves.

Referring, now, to the accompanying drawing, there is shown in Fig. 1 an audio network utilizing the present invention, it being understood that the source of audio waves may be of any desired type. For example, the potentiometer 18—18' may be connected across the output circuit of the demodulator of a radio broadcast receiver so that there will be developed across potentiometer resistor 18 modulation voltage, say voltage in the audio frequency range. Of course, the audio input source can also be an electrical pick-up device which is used in connection with the phonograph unit of a public address system. In general, let it be assumed that the source of audio energy is one which has speech and music sequence programs.

Assume, however, for the sake of illustration,

that the system is employed in a radio receiver. It will be understood that, as is the practice at present in connection with radio broadcasting, the program material will be speech, such as announcements or narratives, while at other times there is employed music such as dance music. In the case of the latter there is sometimes an over-empha is of bass notes at the transmitter, because it is desired to accentuate the rhythm by means of drums and other bass instruments.

The audio network comprises an audio amplifier tube 1 whose control grid may be coupled to the adjustable tap 18' through the usual audio coupling condenser. The control grid secures bias from the usual cathode biasing resistor 1 which is unbypassed to provide a small amount of inverse feedback. The plate of audio amplifier tube 1 is coupled to the control grid of a phase inverter tube 2 through condenser 16 and resistor 17 which function to attenuate the low audio frequencies. In other words, condenser 16 in conjunction with resistor 17 acts as the de-emphasis element with regard to the bass response of the audio program to be reproduced. The plate of tube 1 may be connected to a source of positive direct current voltage through proper resistive impedance 16'. The phase inverter network comprises the two tubes 2 and 3 having a common cathode connection, the 'atter being connected to ground through an unbypassed common biasing resistor 2'. This provides an inverse feedback which improves the balance of the two tubes. The control grid of tube 2 is connected to the grounded end of resistor 2' by grid-return resistor 17.

The audio frequency power output amplifier comprises the tubes 4 and 5 arranged in push-pull relation. The control grid of tube 4 is connected to the plate of tube 2 through the audio coupling condenser 4', while the control grid of tube 5 is connected through audio coupling condenser 5' to the plate of tube 3. The plates of tubes 2 and 3 may be connected to a common source of positive potential through their individual load resistors 30 and 31.

The common cathode connection of tubes 4 and 5 is connected to ground through the common cathode bias resistor 40. The grid leak resistor 14 connects the control grid of tube 4 to the grounded end of resistor 40. The grid leak resistor 14' connects the control grid of tube 5 to the grounded end of resistor 40. The control grid of tube 3 is connected by lead 50 to an adjustable tap 51 which is slidable along grid leak resistor 14. The function of the potentiometer 14—51 is to provide properly balanced inputs to the two phase inverter tubes 2 and 3. Adjustment of tap 51 to a proper point on potentiometer resistor 14 gives properly balanced inputs to the phase inverter tubes.

A push-pull output transformer 11 feeds the loudspeaker 10 with amplified audio frequency voltage. The output of the push-pull amplifier is also fed to a pair of diodes 6 and 7 which function as the tone control rectifier. Thus, the upper end of the primary winding of transformer 11 is connected by lead 60 and the audio coupling condenser 61 to the anode of diode 6. The lower end of the transformer winding is connected by lead 71' and audio coupling condenser 71 to the anode of diode 7. The load resistor 12 connects the anode and cathode of diode 6, while the load resistor 13 connects the anode and cathode of diode 7. The resistors 12 and 13 are arranged in series, and their junction is connected to the common cathode connection of diodes 6 and 7. The junction of resistors 12 and 13 is connected by lead 80 to the positive voltage supply lead. The latter is connected to the midtap of the primary winding of transformer 11.

The tone control relay which is responsive to the rectified voltage output of rectifiers 6 and 7 comprises the elements shown within the dotted rectangle designated as "tone control relay." These elements comprise an electromagnet 8 whose winding 8' has one end thereof connected to the anode of diode 7, while its opposite end is connected to the anode of diode 6. Hence, the rectified current output of diodes 6 and 7 flows through the winding 8' thereby energizing the core 8 of the electromagnet. The electromagnet is provided with a pivoted mobile element 90 which is normally spring-biased by spring 9 so as to make electrical connection with contact 91. In other words, the switch 90—91 is normally maintained in closed condition by spring 9. When the electromagnet 8 is energized by current flow through winding 8', the mobile element 90 is pulled towards the core 8 thereby opening the circuit through switch 90—91. As soon as the current flow through winding 8' ceases, the mobile element is released and the spring 9 pulls the mobile element 90 into electrical connection with contact point 91.

The function of the switch 90—91 is to connect the condenser 15 into parallel circuit with condenser 16, or to disconnect the condenser 15 from electrical circuit with condenser 16. The condenser 15 is given a magnitude such that when it is placed in parallel to condenser 16 the attenuation of the low audio frequencies by the network 16, 17 is eliminated. In other words, when the condenser 15 is in parallel with condenser 16, the low audio frequencies are transmitted to the loudspeaker 10.

As stated previously, the function of the rectifiers 6—7 is to provide current flow through winding 8' when speech is the program to be reproduced. In the case of speech audio waves the audio wave pattern is unsymmetrical with respect to the zero axis of the audio waves. This is pictured in Fig. 3b. In the case of alternating voltage obtained from a microphone actuated by music, the wave form is symmetrical with the zero voltage axis. This is depicted in Fig. 3a. My present invention takes advantage of this difference in the audio wave forms of speech and music. In other words, I have provided here a device which is capable of discriminating between different audio wave forms, and the discrimination is based upon the presence or absence of symmetry in the audio wave pattern with respect to a zero voltage axis.

It will now be seen that when a music program is being received the two diodes 6 and 7 rectify opposite halves of the audio voltage. Hence, the rectified voltages developed across resistors 12 and 13 will be equal. There will be no current flow through winding 8'. In such case the switch 90—91 is in closed position, and condenser 15 is effectively in parallel with condenser 16 thereby permitting the passage of the low audio frequencies to the reproducer. This is the proper connection for music reproduction, since the low audio frequencies are emphasized in a musical program. However, when speech is received, one of the resistors 12—13 has more direct current voltage developed thereacross than the other by

virtue of the fact that the audio wave form is unsymmetrical with respect to the zero voltage axis. Under this unsymmetrical condition current flows through winding 8', because resistors 12 and 13 are electrically connected so as to apply the differenece of their voltages to the winding 8'. Hence, the switch 90—91 is opened thereby removing condenser 15 from electrical parallelism with condenser 16.

The object of this present switching circuit is to change the response characteristic of the amplifier between two positions. The first position is what might be called the "normal" condition in which the bass response of the reproducing system is not curtailed, but is allowed to give the over-emphasis of bass that the "normal" tone position of most receivers are adjusted for. This over-emphasis is assumed to be in some circuit which is external to the network which is switched. It may be brougth about by means of cabinet resonance, or speaker resonance, or electrical emphasis following the detector. The second position of the switch adjusts the network so that the bass response is curtailed, and the normal "boominess" is removed. For this position, the network actually attenuates, but in the "normal" position the network passes all frequencies of the range with the same amplitude.

The network composed of condenser 16 and resistor 17 is of the type described on page 63 of "Radiotron Designer's Handbook," third edition. By properly choosing the size of the grid coupling condenser, the low frequencies may be curtailed in the manner of the curves of Fig. 8 on that page. For instance, with the relay contacts closed so as to give the "normal" connection, the coupling condenser composed of 15 and 16 in parallel might have a value of 0.05 microfarad for the case of a resistor 17 having a value of 1.0 megohm. This would give a negligible attenuation to the lower frequencies. With the contacts open so that the coupling condenser consisted of capacity 16 alone, the attenuation curve corresponding to a value of 0.0005 microfarad might be desired. Hence, for this example condenser 16 would have a value of 0.0005 microfarad, and condenser 15 would have a value of about 0.05 microfarad.

The manner in which this network attenuates the lower audio frequencies is somewhat as follows: The voltage from tube 1 is applied to the series combination of 16 and 17, and the output of the network is taken as the drop across resistor 17. The current flowing through resistor 17 is dependent upon the impedance of 16 and the resistance of 17. The impedance of condenser 16 rises as the frequency is made lower, so that the current flowing through resistor 17 will be reduced and the drop across 17 correspondingly reduced. As the frequency is increased, the impedance of 16 becomes so low in comparison with the resistance f 17 that the current is determined by 17 alone. For these higher frequencies, there is no attenuation. The result is an attenuation curve like the above-mentioned Fig. 8 of said handbook.

It is to be clearly understood that the relay 90—91 may be placed in the loudspeaker circuit to open, or close, the circuit feeding the voice coil of the loudspeaker 10. Such a modification is shown in Fig. 2. In that case elements 16, 17 and 15 could be dispensed with. In other words, a normal audio coupling network would be used between tube 1 and tube 2. As long as music was being transmitted, the switch 90—91 would be closed in the circuit feeding the voice coil. A change over to speech, as during an announcing sequence, would result in an opening of the switch with consequent automatic interruption of reproduction. This would enable listeners to listen solely to musical sequencies, and avoid announcing sequencies if they deemed such type of listening desirable.

It will be apparent that this switching arrangement may be used with the opposite switching sequence, if desired. That is, it may be desired to listen to the voice part of a program to the exclusion of music. Such a case might arise in the instances that desired news or scores are broadcast between intervals of music. To reverse the switching sequence, contact 91 would be placed on the other side of arm 90 so that when the unsymmetrical wave form of speech arrives, the contacts would be closed so as to turn on the loudspeaker. It will be apparent that the amplifier which operates the switching mechanism need not be that same amplifier which operates the loudspeaker. For instance, a separate amplifier might be used to obtain the energy for the switching mechanism which switches elements in a second amplifier which feeds the loudspeaker. With such an arrangement, the energy fed to the switching mechanism does not go through the attenuating network. Such a condition might be desirable for the case of a particular type of attenuation which tended to remove the unsymmetrical nature of the voice wave.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination with a source of modulation voltage waves and a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, said source providing waves which are symmetrical in form with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical in form with respect to said axis for another type of modulation, full wave rectification means, responsive to said unsymmetrical waves, for producing a control voltage which is the differential output thereof, and means responsive to said control voltage for controlling the transmission of modulation to said reproducer.

2. In combination with a source of modulation voltage waves and a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, said source providing waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation, opposed rectifiers responsive to said unsymmetrical waves, for producing a differential control voltage, and means responsive to said control voltage for controlling the transmission of modulation to said reproducer, said control voltage responsive means including a device for regulating the frequency response of said transmission network.

3. In combination with a source of modulation voltage waves and a reproducer therefor, a modulation voltage transmission network coupling the

source and reproducer, said source providing waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation, full wave rectification means, responsive to said unsymmetrical waves, for producing a differential control voltage, and means responsive to said control voltage for controlling the transmission of modulation to said reproducer, said control voltage responsive means including a device arranged to control the operation of said reproducer in a sense to prevent reproduction of the modulation voltage in the presence of said unsymmetrical waves.

4. In combination with a source of audio waves which may represent music or speech sequences, and said waves being symmetrical with respect to a zero voltage axis for music and unsymmetrical with respect to said axis for speech, an audio reproducer, an audio transmission network coupling said source and reproducer, means in said audio transmission network constructed and arranged to emphasize the bass response of the waves, and opposed rectifiers, responsive to said unsymmetrical audio waves, providing a differential output voltage for altering the response of said audio transmission network in a sense to diminish said base response.

5. In combination with a source of audio waves which may represent music or speech sequences, and said waves being symmetrical with respect to a zero voltage axis for music and unsymmetrical with respect to said axis for speech, an audio reproducer, an audio transmission network coupling said source and reproducer, means in said audio transmission network constructed and arranged to emphasize the bass response of the waves, means responsive to said unsymmetrical audio waves, representative of speech sequences, for altering the response of said audio transmission network in a sense to diminish said bass response, said responsive means comprising a pair of opposed rectifiers coupled to said audio transmission network, and means responsive to the differential output of the opposed rectifiers for providing said response alteration.

6. In combination with a source of audio waves and a reproducer therefor, an audio voltage transmission network coupling the source and reproducer, said source providing audio waves which are symmetrical with respect to a zero voltage axis for music modulation and other waves which are unsymmetrical with respect to said axis for speech modulation, opposed rectifiers responsive to said unsymmetrical waves for producing a differential control voltage, and relay means responsive to said control voltage for controlling transmission to said reproducer.

7. In combination with a source of modulation voltage waves and a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, said source providing waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation, full wave rectifier means responsive to said unsymmetrical waves for producing a differential control voltage, and relay means responsive to said control voltage for controlling the transmission of modulation to said reproducer, said control voltage responsive means including a device for regulating the tone of said transmission network.

8. In combination with a source of modulation voltage waves and a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, said source providing waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation, opposed rectifiers responsive to said unsymmetrical waves for producing a differential control voltage, and an electromagnetic relay means responsive to said control voltage for controlling the transmission of modulation to said reproducer.

9. In combination with a source of audio waves which may represent music or speech sequences, and said waves being symmetrical with respect to a zero voltage axis for music and unsymmetrical with respect to said axis for speech, an audio reproducer, an audio transmission network coupling said source and reproducer, means in said audio transmission network constructed and arranged to permit emphasis of the bass response of the waves, and means, responsive to said unsymmetrical audio waves, for altering the response of said audio transmission network in a sense to diminish said bass response.

10. In combination with a source of audio waves which may represent music or speech sequences, and said waves being symmetrical with respect to a zero voltage axis for music and unsymmetrical with respect to said axis for speech, an audio reproducer, an audio transmission network coupling said source and reproducer, means in said audio transmission network constructed and arranged to emphasize the bass response of the waves, and means responsive to said unsymmetrical audio waves for altering the response of said audio transmission network in a sense to diminish said bass response, said responsive means comprising a pair of opposed rectifiers coupled to said audio transmission network, and an electromagnetic relay means responsive to the differential output of the opposed rectifiers for providing said response alteration.

11. In a system having a source of modulation voltage waves, a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, and said source providing waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation; the method comprising translating modulation waves transmitted along said network into a pair of voltages whose relative magnitudes are dependent upon the degree of symmetry of the waves relative to said axis, combining said voltages to provide a differential control voltage, and controlling the transmission of modulation to said reproducer with said control voltage.

12. In a system of the type including a source of modulation voltage waves, a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, and said source providing waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation; the method which includes rectifying said unsymmetrical waves for producing a pair of unequal voltages, differentially combining said voltages to provide a control voltage, controlling with said control voltage the transmission of modulation to said reproducer.

13. In a system of the type comprising a source of modulation voltage waves, a reproducer therefor, a modulation voltage transmission network coupling the source and reproducer, and wherein said source provides waves which are symmetrical with respect to a zero voltage axis for one type of modulation and other waves which are unsymmetrical with respect to said axis for another type of modulation, rectifying said unsymmetrical waves to provide a pair of unequal voltages, means combining said unequal voltages differentially for producing a control voltage, and controlling in response to said control voltage the operation of said reproducer in a sense to prevent reproduction of the modulation voltage in the presence of said unsymmetrical waves.

MURRAY G. CROSBY.