

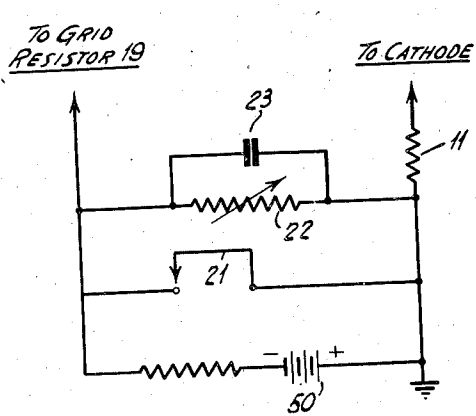
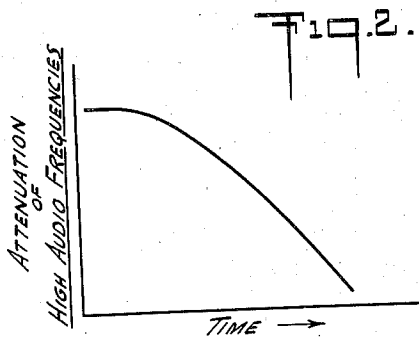
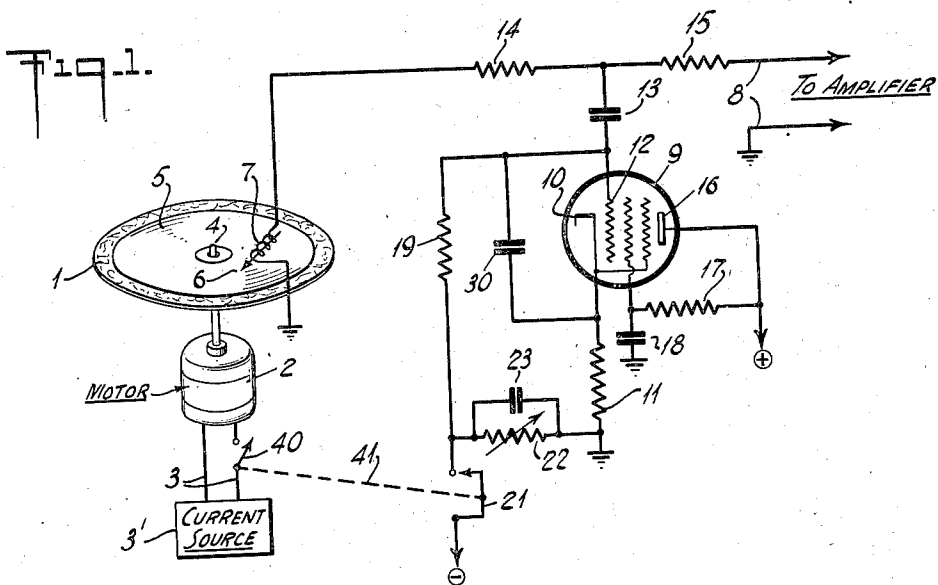
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AUDIO FREQUENCY COMPENSATOR CIRCUIT

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AUDIO-FREQUENCY COMPENSATOR
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My present invention relates generally to audio frequency compensation circuits, and more particularly to a novel method of automatically compensating for the frequency characteristics of a disc recording as a function of diameter.

It is well known that there occurs a relative loss of high audio frequencies where a sound recording of the disc type has a velocity which is relatively low. For example, such a loss of higher audio frequencies occurs toward the center of the record, but may be negligible toward the periphery. Such changes in frequency response also occur during the sound recording process, and the response characteristic, as a function of time, depends upon whether the cutter travels from the periphery toward the center of the record, or in the reverse direction.

Accordingly, it may be stated that it is one of the main objects of my present invention to provide a novel method of, and means for, automatically compensating for the frequency response characteristic of a record disc as a function of diameter, and the compensation being adapted for either the recording or play-back process to make up for the relative loss of high audio frequencies where the record velocity is low.

A more specific object of my invention is to provide a tone compensation network in the output circuit of the electric pickup of a phonograph record play-back system, such tone compensation network comprising essentially an electronic impedance whose magnitude has a predetermined relation to the record speed.

Yet another object of my invention is to provide in an audio frequency transmission line an automatic tone compensation network consisting of an electron discharge device whose input impedance is related in a predetermined manner to the rate of disappearance of a negative bias developed in the input circuit of the discharge device.

Still other objects of my invention are to improve generally the efficiency and reliability of record reproducing circuits, and more especially to provide automatic tone compensation networks for sound record systems which are not only reliable in operation, but are economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth with 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 in-

dicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing:

Fig. 1 schematically shows a circuit diagram embodying the invention.

Fig. 2 graphically shows the functioning of the tone compensation network.

Fig. 3 shows a modification of the compensation circuit, adapted to be applied to a record play-back system wherein the pickup moves from the center of the record toward the periphery.

Referring, now, to the accompanying drawing, wherein like reference characters in the different figures designate similar circuit elements, there is shown in Fig. 1 in a purely schematic manner a turntable 1 adapted to be driven by a conventional motor 2 energized from current source 3' through conductors 3. The numeral 4 denotes the spindle of the turntable upon which is properly centered the record disc 5, which may be either a master disc upon which a sound recording is to be cut or a record which is to be played back. The numeral 6 denotes the stylus in the case of a play-back system, or it may be the cutter in the case of sound recording.

The numeral 7 designates the usual inductance coil which is associated with the stylus, there being generated across coil 7 the audio frequency currents corresponding to the modulation of the sound grooves of record 5. In the latter case, of course, we are dealing with a play-back system. The invention is not limited to the particular pickup shown. For the sake of simplicity let it be assumed that record 5 has grooves corresponding to a desired audio frequency selection, while 6-7 is the usual electric pickup which is employed to convert the mechanical vibrations of the stylus 6 into corresponding audio frequency currents. As is well known to those skilled in the art, the electric pickup is mounted at the free end of a tone arm.

The record may be played back in either of two ways. The stylus point may be positioned at the periphery of the record and travel toward the center of the record in a radial fashion, as is generally the case. On the other hand the play-back path may be radially from the center of the record toward the periphery. In either case the audio frequency current developed across coil 7 is transmitted over an audio frequency transmission line 8 to the input electrodes of an amplifier tube. The latter may be followed by one or more separate audio frequency amplifier stages terminated by a reproducer. These are networks

so well known to those skilled in the art that it is not necessary to illustrate them in the drawing. In Fig. 1 the low potential sides of the input and output terminals of the transmission line are shown at ground potential.

As is well known, there occurs a relative loss of high audio frequencies when the stylus 6 rides toward the center of record 5. This occurs because the relative record velocity at that point is low. The linear velocity of any rotating disc is greater at its periphery than close to its center. Hence, to the ear of the listener there occurs an apparent diminution of the higher audio frequencies. According to my invention, an automatic compensation is secured for this apparent loss of high audio frequency response. Compensation circuits elsewhere in the system, whether play-back or recording, provide sufficient high frequency accentuation to attain the desired response characteristic over the entire record.

The automatic tone compensation action is secured by providing across the transmission line an electronic impedance which normally permits a predetermined degree of attenuation of the higher audio frequencies. However, as the stylus 6 travels toward the center of the record the compensation network automatically increases its effective impedance to the higher audio frequency components of the audio currents thereby producing an equalizing, or compensation, effect to the listener's ear.

The electronic impedance device shunted across the audio transmission line comprises an electron discharge tube 9, which is preferably of the pentode type, having its cathode 10 connected to ground through an unbypassed resistor 11. The control grid 12 is connected by the direct current blocking condenser 13 to the junction of a pair of series-connected isolation resistors 14 and 15. Condenser 13 is sufficiently large to offer substantially zero impedance at the lowest reproducible frequency. The isolation resistors are arranged in the high potential side of the audio transmission line. These isolation resistors may be dispensed with, if desired. The plate 16 of tube 9 is connected to a point of positive potential of a direct current source (not shown). The screen grid of the tube is connected through a voltage reducing resistor 17 to the aforesaid positive potential point. The condenser 18 bypasses the screen grid to ground.

Control grid 12 is connected to a point of predetermined negative potential relative to ground through a path which comprises a grid return resistor 19 and a switch 21. The negative bias source is schematically represented. Any suitable source of negative bias may be used. The lower end of resistor 19 is connected to the grounded end of cathode resistor 11 through a resistor 22 which is shunted by condenser 23. Resistor 22 may be made adjustable for a reason which will be hereinafter set forth. The control grid 12 is also directly connected to cathode 10 by condenser 30.

In my U. S. Patent No. 2,323,598, granted July 6, 1943, I have disclosed and claimed an electronic impedance device of the type shown in Fig. 1. In that patent there has been described a network having an electron discharge device provided with at least a cathode, control grid and plate, the cathode including in circuit therewith an unbypassed resistor. An external impedance element is connected between the con-

trol grid and cathode. It has been shown in that patent that the effective impedance between the control grid of the tube and the low potential side of the cathode resistor is a function of the gain of the tube.

More specifically, it has been explained in my said patent that if the product of the impedance of condenser 30 and the transconductance of tube 9 is much greater than unity, then the effective impedance between control grid 12 and ground can be shown to be equal to $Z_{30}(1+gR_{11})$, where g is the transconductance of tube 9 and R_{11} is the resistance of cathode resistor 11. It will, therefore, be seen that the effective impedance between control grid 12 and ground is multiplied by the magnitude of the tube transconductance. Preferably, the impedance of condenser 30 should be greater than the resistance of resistor 11. In brief, the transconductance of tube 9 is used to reduce the effective impedance offered by an element connected across grid and cathode. Condenser 30 is the element whose impedance is controlled.

When the switch 21 is momentarily closed, the condenser 23 of the time constant circuit $R_{22}-C_{23}$ is charged up to a predetermined value. Preferably, the bias applied from the negative bias source has a magnitude such that when switch 21 is closed control grid 12 will be instantly biased to the plate current cut-off point. In other words, the effective impedance between control grid 12 and ground will be a minimum if the transconductance of tube 9 is a minimum. However, as the transconductance increases the effective impedance between control grid 12 and ground also increases. Since the effective impedance of control grid to ground of tube 9 is connected across the audio transmission line it will be seen that the attenuation of the higher audio frequency components depends upon the transconductance of tube 9. The constants of $R_{22}-C_{23}$ are chosen that the initial approximately cut-off bias applied to grid 12 gradually disappears as the stylus 6 rides in the sound grooves toward the center of the record. In other words, the higher audio frequencies are attenuated to a maximum extent when the stylus point is at the periphery of the record, while the attenuation is a minimum when the stylus has traveled toward the center of the record. Another way of explaining the action is to state that there is provided a form of equalizing action by initially "robbing" the pickup output of higher audio frequencies so that to the ear of the listener there will be an overall flatness of response for the higher audio notes throughout play-back.

In Fig. 2 there is graphically shown in a purely qualitative manner the relation between the attenuation of the higher audio frequencies and time. This representation is merely illustrative. It will be seen from this graph that the attenuation has a decreasing characteristic with time. Hence, the attenuation has a decreasing sense as the stylus travels toward the center of the record.

The motor switch 40 and the bias switch 21 may be conjointly actuated as suggested by the dotted line 41, although in many cases the motor should be separately controlled. In other words, switch 21 may be adjusted to be momentarily closed when the motor 2 is energized thereby to start the record play-back. Immediately a negative charge is given to condenser 23. Switch

21 must be released, however, before the compensation circuit will start coming into action. The charge is caused to be dissipated through resistor 22, and the time constant of $R_{22}-C_{23}$ is so chosen that complete, or nearly complete, discharge will have occurred during the length of time required for playing the record back.

Where the record play-back is from the center of the record toward the periphery, then the biasing arrangement shown in Fig. 3 is employed in the grid-cathode circuit of tube 9. In this case, the switch 21 functions to short out the negative bias from a suitable direct current source 50. In other words, the attenuation of the higher audio frequencies is a minimum at the beginning of record play-back, whereas the attenuation increases toward the periphery of the disc by virtue of the fact that the bias from negative voltage source 50 is built up as the stylus approaches the periphery of the disc. It is to be understood that the functions and operation described heretofore are equally applicable to the case wherein a cutter operates on the face of a master disc. In that case, the audio frequency currents will be derived from the right-hand side of the transmission line in Fig. 1. However, the circuit arrangement will otherwise be the same. It is to be understood, of course, that the $R-C$ value of network 23-22 may readily be adjusted for different types of record diameters by adjusting the relative magnitudes of resistor 22 and condenser 23 in a predetermined manner, the time constant of the circuit becoming longer as the product of the resistance and capacity is increased.

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 organizations 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 audio frequency currents, an audio frequency utilization circuit, an audio transmission line therebetween, an attenuation network for the higher audio frequency components of said currents, said network comprising an electron discharge tube circuit having its effective input impedance in shunt across said line, said circuit having its elements so chosen and arranged that the effective magnitude of said input impedance is proportional to the transconductance of the electron discharge tube, said input impedance normally providing a maximum attenuation of the higher audio frequency components of said currents, and means providing a transconductance-reducing bias for said tube which is a function of the passage of a predetermined period of time.

2. In combination with a record disc, a transducer device mechanically associated with said disc, an audio transmission line connected to said transducer, means for automatically controlling the transmission of higher audio frequency components through said line, said means comprising an electron discharge tube having its input impedance in shunt across said line thereby to provide normal attenuation of the higher audio frequency components of audio currents flowing through said line, a time constant network connected between the input electrodes of said tube, a source of negative potential connected to said time constant network, and means for controlling

the voltage charging of said time constant network by said negative voltage source.

3. In combination with an audio frequency transmission line having input and output terminals, an attenuation network comprising an electron discharge tube having at least an anode, a cathode and a control grid, an unbypassed resistive impedance arranged in the space current path of said tube between the cathode and ground, a condenser connected between the control grid and cathode, said condenser and resistive impedance being in series relation, a resistor and second condenser connected in shunt relation between the control grid and the grounded end of said resistive impedance, means adapted to apply a negative voltage of a predetermined magnitude across said second condenser, said shunt condenser and resistor providing a time constant network adapted to dissipate said charge after the passage of a predetermined period of time.

4. In combination with an audio frequency transmission line having input and output terminals, an attenuation network comprising an electron discharge tube having at least an anode, a cathode and a control grid, an unbypassed resistor arranged in the space current path of said tube between the cathode and ground, a condenser connected between the control grid and cathode, said condenser and resistor being in series relation, a second resistor and second condenser connected in shunt relation between the control grid and the grounded end of said resistive impedance, means adapted to apply a negative voltage of a predetermined magnitude across said last named condenser, said shunt condenser and resistor providing a time constant network adapted to dissipate said charge after the passage of a predetermined period of time.

5. In a system of the type employing a source of audio frequency currents, an audio current utilization circuit and an audio transmission line therebetween; the improvement comprising an attenuation network for the higher audio frequency components of said currents, said network comprising an electron discharge tube having its effective input impedance in shunt across said line, the effective magnitude of said input impedance being proportional to the transconductance of the electron discharge tube, said input impedance normally providing a maximum attenuation of the higher audio frequency components of said currents, and means for providing a transconductance-reducing bias for said tube which is a function of the passage of a predetermined period of time.

6. In a phonograph system of the type employing a record disc, a transducer device mechanically associated with said disc and an audio transmission line connected to said transducer; the improvement comprising means for automatically controlling the transmission of higher audio frequency components over said line, said means comprising an electron discharge tube having its input impedance connected to said line to provide normal attenuation of the higher audio frequency components of audio currents flowing over said line, a time constant network connected between the input electrodes of said tube, and means for controlling the voltage charging of said time constant network.

7. In combination with a phonograph record electrical pickup, an audio frequency current utilization circuit, and an audio frequency transmission line therebetween; an attenuation network

for the higher audio frequency components of said currents, said network comprising an electron discharge tube circuit having its effective input impedance connected to said line, said circuit having its constants so chosen that the effective magnitude of said input impedance is proportional to the transconductance of the electron discharge tube, said input impedance normally providing a maximum attenuation of the higher audio frequency components of said currents, and means for controlling the transconductance of said tube as a function of the passage of a predetermined period of time.

8. In combination with a transducer device mechanically associated with a record, an audio transmission line connected to said transducer, means for automatically controlling the transmission of higher audio frequency components over said line, said means comprising an electron discharge tube having its input impedance in shunt across said line thereby to provide normal attenuation of the higher audio frequency components of audio currents flowing over said line, a time constant network connected between the input electrodes of said tube, a source of negative potential connected to said time constant network, and means for controlling the voltage charging of said time constant network by said negative voltage source.

9. In combination, a source of audio frequency currents, an audio frequency utilization circuit, an audio frequency transmission line therebetween, and an improved attenuation network for the higher audio frequency components of said currents comprising an electron discharge tube circuit having its effective input impedance in shunt across said line, said circuit having its elements so chosen and arranged that the effective magnitude of said input impedance is proportional to the transconductance of the electron discharge tube, said input impedance being condensive and normally providing attenuation of the higher audio frequency components of said currents, a switch-controlled current source providing a transconductance-reducing bias for said tube, and an RC time constant circuit connected to said source and said tube for causing said bias to be a function of the passage of a predetermined period of time.

10. In combination, a record disc, a transducer device mechanically associated with said disc, an audio transmission line connected to said transducer, and improved means for automatically controlling the transmission of higher audio frequency components through said line which comprises an electron discharge tube having an input

capacitance in shunt across said line thereby to provide attenuation of the higher audio frequency components of audio currents flowing through said line, an RC time constant network connected between the input electrodes of said tube, a source of negative potential connected in shunt to said time constant network, and switch means in shunt with said potential source for controlling the voltage charging of said time constant network by said negative potential source.

11. A method of reproducing a phonograph disc of the rotatable type, which includes translating the sound tracks into audio frequency currents, transmitting the currents, providing attenuation of the higher audio components during the initial translation period, providing an electronic control over said attenuation which has a decreasing effect with the passage of time, and progressively decreasing the attenuation of said higher audio components in response to said decreasing effect of said electronic control as a function of the time during which complete translation takes place.

12. In a system of the type employing a source of audio frequency currents, an audio current utilization circuit and an audio transmission line therebetween; the improvement comprising an attenuation network for predetermined audio frequency components of said currents, said network comprising a reactive impedance in shunt across said line, a tube for controlling the effect of said reactive impedance, the effective magnitude of said impedance being proportional to the transconductance of the tube, and means for providing a transconductance-reducing bias for said tube which is a function of the passage of a predetermined period of time.

13. In a system of the type employing a record disc, a motor-actuated turntable supporting said disc, a transducer device mechanically associated with said disc, and an audio transmission line connected to said transducer; the improvement comprising means for automatically controlling the transmission of higher audio frequency components over said line, said means comprising an electron discharge tube having its input impedance connected to said line to provide normal attenuation of the higher audio frequency components of audio currents flowing over said line, a time constant network connected between the input electrodes of said tube, and means responsive to energization of said turntable motor for controlling the voltage charging of said time constant network.

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