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G. H. STEVENSON

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VOLUME CONTROL CIRCUITS

Filed July 1, 1926

Fig. 1

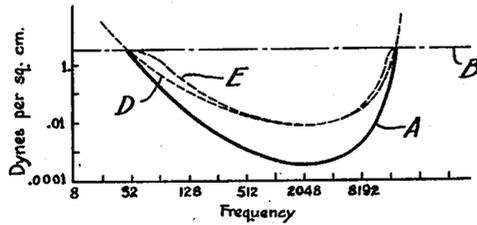


Fig. 2

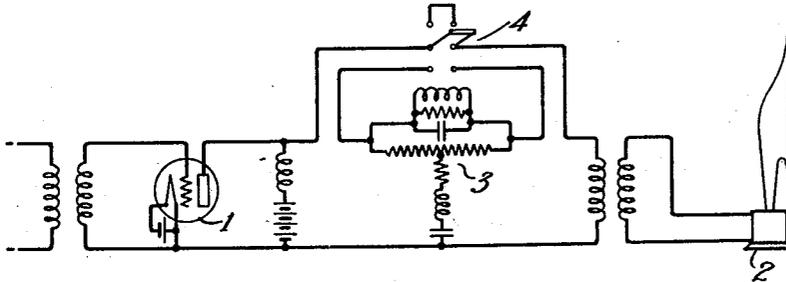


Fig. 3

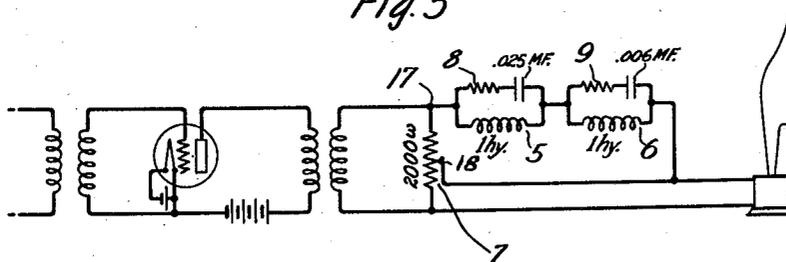
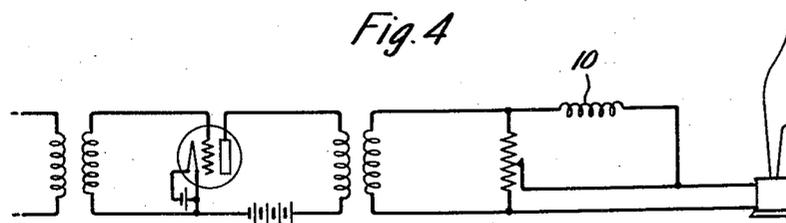


Fig. 4



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UNITED STATES PATENT OFFICE

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VOLUME-CONTROL CIRCUITS

Application filed July 1, 1926. Serial No. 119,932.

This invention relates to sound reproduction and particularly to electrical apparatus for controlling the volume of sounds produced.

5 It is an object of the present invention to improve the volume control of electrically operated sound reproducers.

In the volume control of sound reproducers it has been customary to employ a resistive artificial line or a potentiometer, either of which devices attenuates all frequencies uniformly. However, the ear is more sensitive to frequencies near the center of the audible range than to those near the limits of audibility. Therefore, when the volume of a reproduced sound is decreased by the use of a potentiometer, for example, the frequencies near the limits of the audible range will reach the minimum audible intensity first with the result that the quality of the sound may be impaired.

In accordance with the present invention it is proposed to control the volume and at the same time maintain the quality. As the volume is reduced the more weakly perceived high or low tones are retained at a level above the minimum audible intensity while the average volume of the reproduced sound is decreased to a desired level.

30 More specifically the present invention contemplates the use in connection with a radio receiver, or other electrical means for operating a sound reproducer, of combinations of impedances to reduce the more readily perceived frequencies to a greater degree than those which are less audible. According to one embodiment, the attenuation device comprises attenuating networks so adjusted as to have a combined attenuation-frequency characteristic more or less complementary in form to the curve of minimum audibility, and a switch is employed to include or exclude the attenuation device. According to another embodiment of the invention, the networks are associated with a potentiometer whereby they are made effective in a variable degree.

The features of the invention will be more clearly understood from a consideration of the following discussion which is illustrated

by the accompanying drawing. In the drawing, Fig. 1 shows a group of curves setting forth certain characteristics to be considered. Figs. 2, 3 and 4 show attenuating arrangements suitable for accomplishing the object of the invention.

It has long been known that there are frequencies of sound vibration so low and also so high that the human ear does not respond to them. It has also been found that for sound within the audible range there is a minimum intensity which the ear can just hear. A curve, showing the relation between the frequency of a sound and the minimum intensity of that sound which the ear can hear, is shown in Fig. 1, curve A. This curve represents what is known as the threshold of minimum audibility and is reproduced from an article by H. Fletcher and R. L. Wegel in the Physical Review, volume 19, No. 6, pages 553 to 565. The scales employed for both coordinates are logarithmic in character.

It is apparent from curve A that, particularly in the lower frequency range, a comparatively small change in the intensity of a sound will cause a marked alteration in the range of frequencies perceived. An illustration of this effect may be drawn from the noticeable "thinness" of music or other sounds heard at a distance. Music for instance loses its higher and lower tones to such an extent as to destroy the characteristic "tone" long before the sound as a whole becomes inaudible.

In the development of high quality loud speakers an effort has been made to bring about the reproduction of all frequencies of sound with equal intensity. The characteristic of such a loud speaker may then be represented by a horizontal line such as line B of Fig. 1. If this line represents the normal level of the energy of sound waves from the loud speaker all frequencies of importance will be heard. However, this audible intensity may be greater than is pleasant for all hearers. As pointed out above it is customary to control the volume of such a loud speaker by the use of a resistive artificial line or a potentiometer either of which devices atten-

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uate all frequencies uniformly. The effect of this may be seen from considering that the horizontal line B of Fig. 1 is moved downward on the curve A, with the result that the frequency range of the sounds that will then be heard by the normal ear is narrowed to a greater and greater extent with continued reduction in volume in this manner.

In accordance with the present invention it is proposed to control the volume and at the same time maintain the quality by introducing into the electric circuit operating the loud speaker an attenuating device which will reduce the level of the sound generally in accordance with one or the other of the curves D or E. In this way none of the tones is reduced below the threshold energy level and the quality is retained while the perceived loudness is reduced. The attenuation characteristic of such a control device will of course, be complementary in form to the curve D or E.

Fig. 2 shows an amplifier 1 and a loud speaker 2 together with a form of attenuating device 3. Switch 4 is provided for readily inserting or removing the attenuator from between the source of electrical oscillations or amplifier and the reproducer 2. This attenuator is of a constant resistance type and may be proportioned to give a wide range of frequency characteristics. It is substantially disclosed in my copending application, Serial No. 73,578, filed December 7, 1925, now Patent No. 1,606,817, granted November 16, 1926, and when used for the present purpose would have the resonant circuits tuned to frequencies around the middle of the audible range. A plurality of these attenuation devices may be used in tandem, which arrangement would permit of especially accurate control of the quality.

Fig. 3 represents the preferred embodiment of the invention. In this form precision is sacrificed to some extent, but adjustability is gained. The arrangement consists of a potentiometer 7 having a reactive network 5—6 bridged between the line terminal 17 of the resistance and the switch contact 18. The reactive network comprises a pair of anti-resonant circuits 5 and 6. Circuit 5 is anti-resonant at a frequency of about 1000 cycles and circuit 6 at about 2000 cycles. The potentiometer 7 is most effective at the frequencies of anti-resonance and it is less effective at higher or lower frequencies. Resistances 8 and 9 are inserted to reduce the sharpness of resonance and to maintain the impedance of the reactive network throughout the range between the anti-resonant frequencies. Suggested values for the elements of the networks are for network 5, an inductance of 1 henry and a capacity of .025 mf., and for network 6, an inductance of 1 henry and a capacity of .006 mf. These values are suitable for a circuit in which the receivers

and the wave source are of approximately 500 ohms impedance.

Where the loud speaker emphasizes a particular range of frequencies, one of the networks may be made anti-resonant at those frequencies to further improve the quality.

The above arrangement may be simplified to a form employing a single anti-resonant circuit or still further to one employing a single inductance such as inductance shown in Fig. 4. This last arrangement permits the reduction of the higher frequencies to a greater extent than the lower frequencies.

What is claimed is:

1. A system for reproducing speech or music comprising means for transmitting frequency components in the middle portion of the speech and music range less efficiently than in the lower portion by an amount substantially corresponding to the greater sensitivity of the ear in the middle portion of the range than in the lower portion of the range, and means in combination therewith for increasing the volume of the reproduced sound by increasing the transmission efficiency for the middle portion of the range more than for the lower portion in substantial correspondence with the greater sensitivity of the ear at said middle portion than at said lower portion.
2. A system for reproducing speech or music comprising means for transmitting frequency components in the middle portion of the speech and music range less efficiently than in the other portions in substantial correspondence with the differences in sensitivity of the ear at these portions of the range, and means in combination therewith for increasing the volume of the reproduced sound by increasing the transmission efficiency for the middle portion of the range more than for the other portions in substantial correspondence with the differences in sensitivity of the ear at these portions of the range.
3. In combination with a sound reproducer having a substantially flat characteristic, a volume control device connected thereto capable of different settings and including a selective attenuating network through which waves supplied to said reproducer are conducted, said network attenuating to different extents at the different settings the more readily perceived tones, each by an amount depending on the sensitivity of the normal ear for the respective tones, while retaining at an audible level the tones to which the ear is less sensitive.
4. In a sound reproducing system, a sound reproducer and means for transmitting to said reproducer electrical waves representing sounds at different volume levels while retaining the quality of the sound reproduction at the different levels, said means comprising an adjustable attenuating net-

work in the path of the electrical waves, having for each volume level adjustment a characteristic substantially complementary in form to the minimum audibility curve of the ear.

5. In combination with a sound reproducing system having a substantially flat characteristic throughout the speech and music range, a volume control device including a variably attenuating network which is anti-resonant at the middle portion of the audible range and introduces greater loss at the middle portion than at the higher and lower audible frequencies whereby the more readily perceived frequencies are attenuated while retaining at an audible level the higher and lower frequencies to which the ear is less sensitive.

6. In combination with a sound reproducing system having a substantially flat characteristic throughout the speech and music range, a variable volume control device including a plurality of attenuating networks each anti-resonant at a particular frequency near the middle of the audible range whereby the more readily perceived frequencies are attenuated while retaining at an audible level the frequencies to which the ear is less sensitive, and a variable resistance for controlling the average level of the reproduced sounds.

7. In combination with a sound reproducer having a substantially flat characteristic, a variable volume control device including a pair of attenuating networks which are anti-resonant at a frequency of approximately 1000 cycles and 2000 cycles respectively whereby the more readily perceived frequencies are attenuated while retaining at an audible level the frequencies to which the ear is less sensitive, and a variable resistance associated therewith for changing the average energy level of the transmitted waves.

8. The combination with an electrical transmission line and a sound reproducer associated therewith having a substantially flat characteristic throughout the speech and music range, of means for attenuating differently pitched tones progressively in substantial correspondence with the sensitivity of the ear at the different pitches, said means comprising an adjustable attenuating network having a transmission characteristic substantially complementary to the minimum audibility curve of the ear.

9. The combination with a transmission circuit for waves of a range of frequency components representing speech or music, of a variable volume control means comprising an adjustable attenuating network located in the path of said waves and having for each adjustment a characteristic substantially complementary in form to the curve of minimum audibility of the ear.

10. The combination with an electrical

transmitting and sound reproducing system for waves having a range of frequency components representing speech or music, of an attenuating network associated with said system and through which said waves are conducted, said network being adjustable for changing the volume of the transmitted waves to different desired levels and having its constants proportioned with reference to the normal sensitivity of the ear at the different portions of the transmitted frequency range such that at each volume level substantially the same width of frequency band is transmitted and the various components are differently attenuated to an extent necessary to enable them to be perceived by the ear with substantially the same quality.

11. An electrical transmission and sound reproducing system including a line and an attenuating network associated with said line, said network being adjustable to produce different average volume levels in the reproduced sounds, said network having for each such volume level a different attenuation for the different frequency components such that substantially the same frequency range is transmitted at each volume level and all the frequency components in the range are maintained above the minimum audibility intensity level.

12. The combination with a system for translating electrical waves into sound and comprising a transmission line, of an attenuating network including an anti-resonant circuit in shunt to a variable portion of a resistance in series in the line, the remainder of the resistance being in shunt of the line, said anti-resonant circuit being tuned to the middle portion of the essential speech frequency band, whereby upper and lower frequencies in the band are more effectively transmitted than the middle frequencies at the various adjustments of said resistance.

In witness whereof, I hereunto subscribe my name this 30th day of June, A. D. 1926.

GEORGE H. STEVENSON.

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