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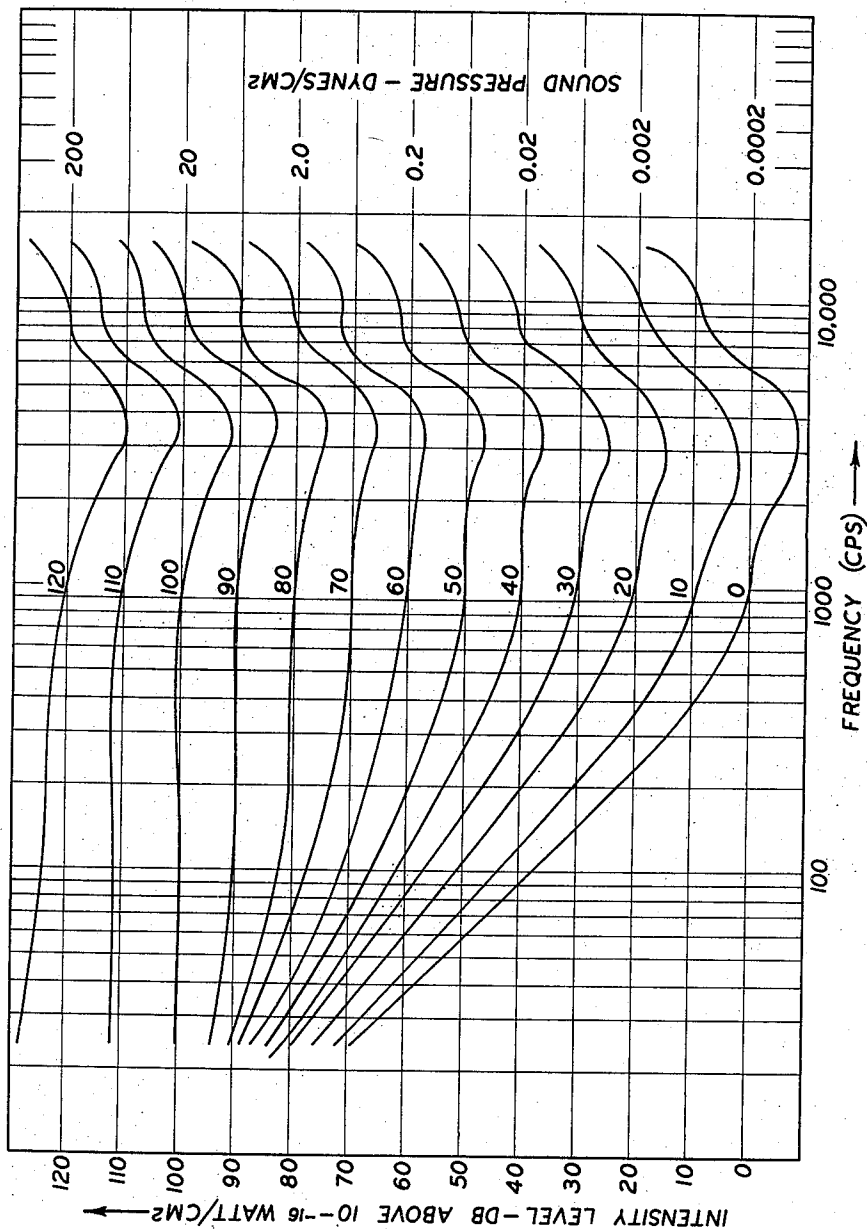
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tone compensated loudness control

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FIG. 1



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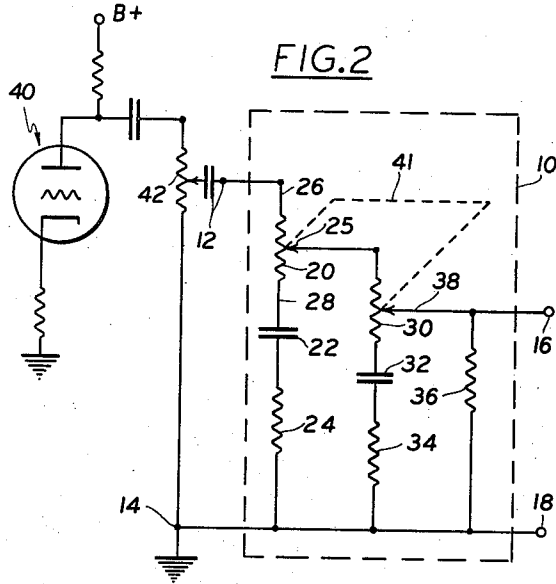
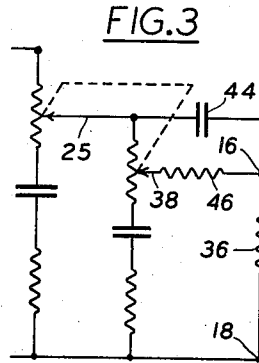
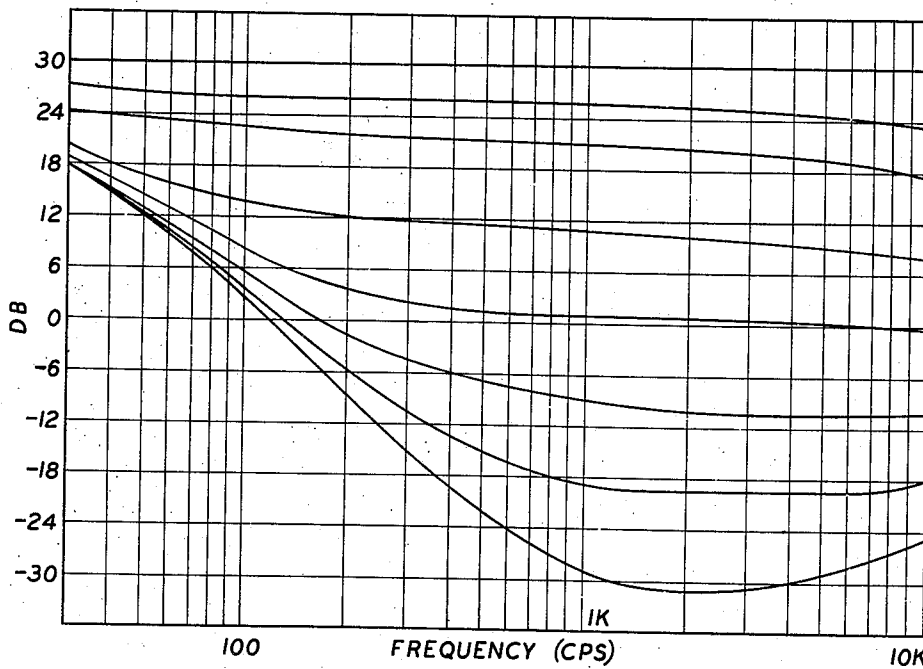
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TONE COMPENSATED LOUDNESS CONTROL

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2 Sheets-Sheet 2



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TONE COMPENSATED LOUDNESS CONTROL

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2 Claims. (Cl. 333—28)

The present invention relates to loudness controls for audio frequency amplifying systems, and more particularly to tone compensated loudness controls of the type which produce uniform hearing loudness over the audio frequency spectrum. It has now come to be recognized in the art of high fidelity audio systems that the human ears do not respond the same to different vibration signals lying in the audio frequency spectrum. The well-known Fletcher-Munson curves represent equal loudness sensitivity for normal ears over the entire audio spectrum. These curves graphically demonstrate that the ears are more sensitive to audio frequency signals lying in the range of from about 1,000 cycles to 5,000 cycles and drop off in sensitivity both above and below this range. The ears are rather insensitive to low frequency signals below 1,000 cycles.

From this it is seen that a flat frequency control in an audio system will not produce natural sound at sound-power levels which are below the originally produced loudness. Since it is rather unpleasant to listen to music, for example, in a small room at original concert hall production loudness, it becomes desirable to adapt the reproduced loudness for a room to that which is comfortable to the listener.

For reduced loudness, it becomes necessary to boost both bass and high frequency tones in accordance with the aforementioned Fletcher-Munson curves.

It is therefore an object of this invention to provide a frequency compensated loudness control which may adapt a sound system to the response characteristics of human ears at different sound-reproducing power levels.

It is another object of this invention to provide a tone-compensated loudness control which is simple in construction and does not require the use of critical circuit components.

It is yet another object of this invention to provide a loudness control which produces tone compensation at different hearing levels which closely resembles the Fletcher-Munson hearing curves.

Other objects will become apparent as the description proceeds.

To the accomplishment of the above and related objects, my invention may be embodied in the forms illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that specific change may be made in the specific constructions illustrated and described, so long as the scope of the appended claims is not violated.

In the drawings:

Fig. 1 is an illustration of the Fletcher-Munson equal loudness curves for normal ears;

Fig. 2 is a circuit diagram of one embodiment of this invention;

Fig. 3 is a circuit diagram of another embodiment of this invention; and

Fig. 4 is an illustration of sound curves which may be achieved by use of this invention.

With reference to the drawings, and more particularly

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to Fig. 1, the respective curves presented therein represent equal hearing loudness over the audio spectrum at various sound-power levels. The upper and lower extremes of these curves are the sense of feel at and above 100 decibels and the threshold of hearing at zero decibels, respectively. For example, the 40 db curve represents the sound power necessary at the different frequencies which are required to produce hearing loudness of uniform intensity. From this it is seen that a flat frequency control will not produce uniform hearing loudness below the level of loudness originally produced. For values of hearing loudness lower than 100 db, it is necessary to boost both the low and high frequency signals, or conversely to attenuate the intermediate frequency signals to the level of the low and high frequency signals.

These boosting or attenuating conditions are satisfactorily matched by the embodiments of this invention as shown in Figs. 2 and 3. The tone-compensated control of Fig. 2 is enclosed in the dashed line block 10 having input terminals 12 and 14 and output terminals 16 and 18. A first network of components comprising a potentiometer 20, a condenser 22 and a fixed resistor 24 are series-connected as shown between the input terminals 12 and 14. A tap or contact arm 25 of the potentiometer 20 is movable between the upper and lower ends 26 and 28, respectively.

A similar network comprising a potentiometer 30, a condenser 32 and a resistor 34 connected in series is coupled between the tap 25 and a line leading from input terminal 14. A suitable load resistor 36 is connected between the tap 38 on the potentiometer 30 and the terminal line 14. The output terminals 16 and 18 are coupled across this resistor 36.

The two potentiometers 20 and 30 are preferably ganged together as shown by the dashed connecting lines 41. The purpose of this ganged connection will be explained more fully in the following.

A suitable amplifier is generally indicated by the reference numeral 40 and is terminated in the usual potentiometer volume control 42 having a variable tap coupled to the input terminal 12. Different settings of this potentiometer 42 will thereby couple correspondingly different amounts of power into the circuit 10.

In considering the design of this control circuit 10, it is convenient to consider a single network 20, 22 and 24 alone. It may be stated at this point that the two networks 20, 22, 24 and 30, 32, 34 are preferably of identical design. By connecting these two networks in cascade as shown, the variations in the Fletcher-Munson curves may be more closely approached.

Considering the network 20, 22, 24 only, the values of the resistor 20 and the condenser 22 are so selected that the resistance of the potentiometer 20 will be substantially equal to the reactance of the condenser 22 at bass frequencies, for example, 20 cycles per second. If the value of resistance of potentiometer 20 is one megohm, the condenser 22 should have an impedance of one megohm also.

Brief reference to the Fletcher-Munson curves discloses that attenuation in the vicinity of 1,500 cycles per second is desired, whereupon the reactance of the condenser 22 at this frequency of 1,500 cycles per second is calculated and the value of the resistor 24 is chosen to be equal thereto. From practical experience and empirical formulation, it may be determined that the resistor 24 should have a value of approximately 25,000 ohms.

Practical values for these components are found to be one megohm for potentiometer 20, 0.0022 microfarad for the condenser 22, and 22,000 to 25,000 ohms for resistor 24. It will now appear obvious that the network constitutes a voltage dividing circuit. With the tap 25 of the potentiometer 20 positioned adjacent end 26, max-

imum loudness with no attenuation will appear between this tap 25 and ground line 14. With the tap 25 moved to the opposite end 28 of potentiometer 20, the high frequency signals appearing between this tap and ground line 14 will be greatly attenuated whereas the bass frequencies will receive very little attenuation. This is true since the condenser 22 produces only a small reactance at the high frequencies and tends to shunt them toward the ground line 14. Thus, a signal taken from the upper end 28 of the condenser 22 will possess high frequencies of lower amplitude. Movement of the tap 25 from the potentiometer end 26 toward the lower end 28 thereby serves to progressively attenuate the high frequency signals appearing across the tap 25 and terminal line 14, which in effect is considered to boost the bass signals.

This practical example given produces a difference in attenuation between 20 cycles per second and 1,500 cycles per second of 25.4 db. While this tends to conform to the Fletcher-Munson curves, it is noted immediately that a greater difference is needed to more nearly conform to the Fletcher-Munson curves. By cascading the second network 30, 32, 34 across the tap 25 and line terminal 14, the attenuation difference appearing across the output terminals 16 and 18 becomes 50.8 db for the frequencies given. Comparison of this cascaded attenuation with the Fletcher-Munson curves shows an ideal similarity. The response curves of Fig. 4 of the loudness control circuit 10 graphically reveal this close similarity. When the potentiometers 20 and 30 are moved to the upper extremities, the frequency response is substantially flat at 30 db.

Briefly restating the theory of operation, the condenser 22 and resistor 24 together determine the maximum high frequency attenuation. At infinite frequency at which the reactance of the condenser 22 would be zero, the resistor 24 would be the sole determinant of this high frequency attenuation. From this it can be seen that the levelling off or cross-over point of the response characteristic is determined by the reactance of the condenser and the resistance of resistor 24. Increasing the value of the resistor 24 results in less high frequency attenuation. Reducing the value of resistor 24 increases high frequency attenuation. Thus, a designer by suitably selecting the values of the various components of the network can achieve different preferred response curves.

The output resistor 36 which is connected across the tap 38 and the terminal line 14 is sufficiently high in value to prevent a shunting effect across the network 30, 32 and 34.

Reference to the Fletcher-Munson curves of Fig. 1 reveals that some boosting of high frequencies is desired. This is accomplished by the circuit of Fig. 3 wherein a condenser 44 is coupled between the potentiometer tap 25 and the output terminal 16 and a fixed resistor 46 between the potentiometer tap 38 and this same terminal 16. From this, it will be noted that the degree of high frequency boost may be controlled by a suitable selection of values for these two components 44 and 46. It is important that the value of the resistor 46 is not too large as compared to the value of resistor 36 in order to prevent an insertion loss since the total frequency spectrum is developed across both of the resistors 46 and 36 and the signal output is taken across the resistor 36 alone.

While it will be understood that the circuit specifications of this tone-compensated loudness control may vary

according to design desiderata, the following circuit specifications are included by way of example only as generally suitable for an amplifier system which is manufactured in mass production quantities and is generally accepted by the average customer:

Tube of amplifier 40	12AX7.
Potentiometer 42	500,000 ohms.
Potentiometer 20	1 megohm.
Condenser 22	0.0022 mfd.
Resistor 24	22,000 ohms.
Potentiometer 30	1 megohm.
Condenser 32	0.0022 mfd.
Resistor 34	22,000 ohms.
Resistor 36	1 megohm.
Condenser 44	47 mmfd.
Resistor 46	10,000 ohms.

What is claimed is:

1. A tone-compensated loudness control comprising first and second networks connected in cascade, each of said networks comprising two resistors and a condenser connected in series with said condenser being between said resistors, one resistor of each network having an adjustable tap, the tap in the first network being coupled to the outer end of the second network resistor having the tap, an input circuit coupled across said first network and an output circuit coupled between the tap of the second network and the outer end of the other resistor of the second network, and a connection between the outer ends of said untapped resistors, the taps of both networks being ganged together for simultaneous adjustment on the respective resistors to control each network separately but substantially identically, the values of the resistors and condenser of each network being such as to provide a set of characteristic curves which resemble the Fletcher-Munson hearing curves, both networks acting conjointly to more nearly conform to said Fletcher-Munson curves than a single network acting alone.

2. A tone compensated loudness control comprising a pair of input terminals and a pair of output terminals, and a common connection between one of said input terminals and one of said output terminals, first and second networks connected in cascade between said pair of input terminals and said pair of output terminals, each of said networks comprising two resistors and a condenser connected in series, and said condenser being between said resistors, one resistor of each network having an adjustable tap, the tap in the first network being coupled to the outer end of the second network resistor having the tap, an input circuit coupled across said first network at said input terminals and an output circuit coupled across said second network at said output terminals by way of said adjustable tap of said second network resistor having an adjustable tap, the values of the resistors and condenser of each network being such as to provide a set of characteristic curves which resemble the Fletcher-Munson hearing curves, both networks acting conjointly to more nearly conform to said Fletcher-Munson curves than a single network acting alone.

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