

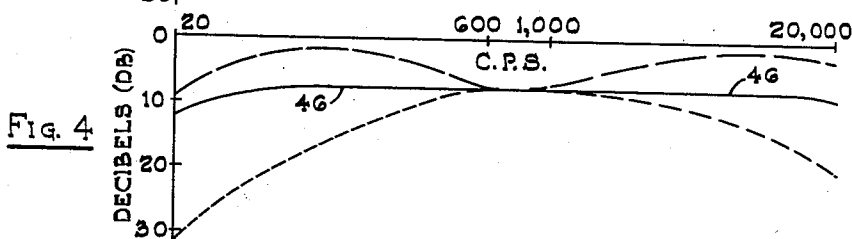
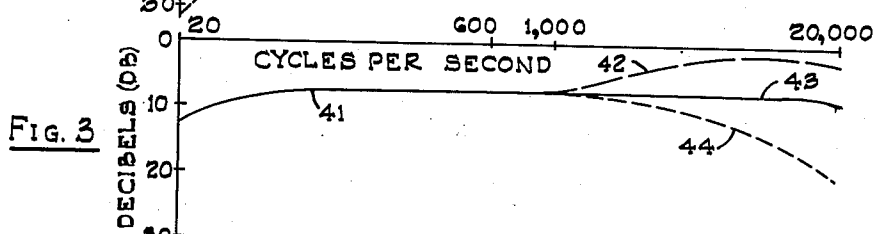
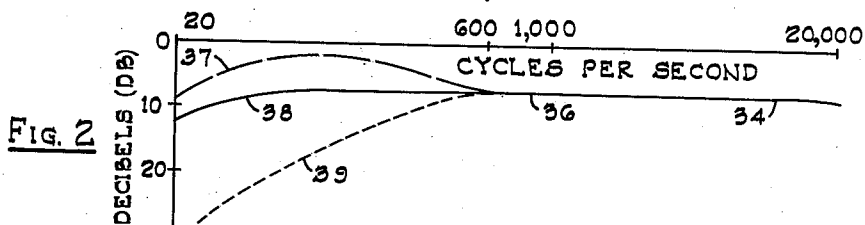
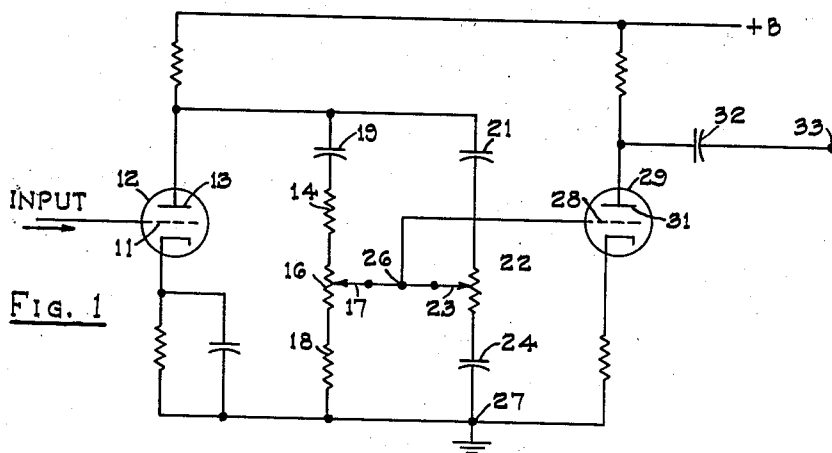
June 1, 1954

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2,680,231

TONE CONTROL

Filed Jan. 7, 1950



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2,680,231

TONE CONTROL

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Application January 7, 1950, Serial No. 137,397

10 Claims. (Cl. 333—28)

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This invention pertains to a tone control and more particularly to improvements in a selective frequency control.

Many classes of devices employ tone controls, including amplitude modulation and frequency modulation radio receivers, television receivers, phonographs, and special equipment of many kinds. In general, any device which has an electrical output with a range of frequencies in the audible region may employ a tone control. Also devices employing frequency bands above the audible range may be equipped with an analogous control to vary the output potential according to some desired function of the frequency. All such controls, whether employed in an audible frequency band or in an inaudible frequency band, are herein termed tone controls.

Tone controls employed in any of the above diverse uses have heretofore been either as bass tone controls or treble controls, and "accentuation" or lift of one end of frequency band has required the attenuation of the frequencies at the other end of the band. When independent control of both the low and the high frequency ends of a frequency band has been desired it has been necessary to employ at the same time two separate and distinct circuits, one for each of the two purposes. Many circuits have been developed for each of these purposes, but in general they all comprise a passive linear network composed of resistance and reactance elements, one or more of which is adjustable for manual variation at will of the relative bass or treble amplitudes of the frequency band. Such a network attenuates all parts of the band, with the amount of attenuation at one end adjustable to a greater or lesser amount of attenuation than that undergone by the remainder of the band for the purpose of providing the desired "boost."

It is well-known that most sounds are complex waves containing several components having frequencies that are in harmonic relation to each other. The fundamental frequency of these harmonics, or overtones, is called the pitch. Changing the relative amplitude of the different component frequencies changes the quality without affecting the pitch. It is also well-known that various speech sounds differ in the way in which the energy is distributed with respect to the frequencies. There is a level for each frequency which appears normal to the human ear. If the amplitude of any given frequency is reduced below this norm, to the ear, this frequency substantially disappears.

It is conventional practice to take advantage

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of this phenomena in designing tone controls for audio circuits. It is usual to consider some frequency as the median point or norm with respect to which the bass and treble frequencies may be measured and controlled. It is usual to take as this median point a frequency of the order of 800 cycles per second. Then, in effecting tone control, it is usual to provide an attenuating network which attenuates the frequencies at the median point of the audio band by an amount equal to the maximum accentuation required at any frequency. "Boost" of the frequencies toward the bass end of the audio spectrum is accomplished by providing a control which reduces the attenuation of the network for this particular frequency range. Accordingly, to boost the high frequency end of the band it is conventional to provide a separate attenuating network with means for reducing the attenuation at these higher frequencies. It will be readily apparent that in order to get full range of tone control it would be necessary to connect these tone controls in series in the audio circuit with each separately causing attenuation of the midband frequencies.

Where it is desired to provide full range of control in the band, it has been known to couple the bass and treble tone controls in cascade but in order to prevent deleterious intercoupling effects these tone controls are usually coupled through an electronic amplifier, the latter serving to supply the attenuation losses and to provide the proper driving impedance for the second control circuit. Because of the resulting multiplied attenuation in the network fed by the amplifier the losses in these prior systems are excessive.

The present invention provides a tone control system covering the full audio range which utilizes only a single attenuating network for the midband attenuation which is comparable to either of the two separate attenuating networks necessary in the prior art systems. Accordingly, the present invention provides desirable full range tone control while reducing the decibel attenuation losses by a factor of two. Also with the present invention there is a minimum shift of the volume level of the midband frequency incidental to variation of the bass and treble controls. The single network of the instant invention, although having such reduced attenuation, has two adjustable elements, one for bass control and one for treble control. These two adjustments are independent, so that relative effective accentua-

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tion or attenuation of the bass and treble ranges can be made independently.

The single attenuating network of the present invention affords dual control of bass and treble frequencies and provides the important, and in some uses, critical advantage of having a voltage attenuation that is only the square root of the voltage attenuation accompanying the usual multiple attenuation network.

The primary object of the present invention is to provide a single electrical network capable of independent, adjustable attenuation of an electrical frequency band covering the full audio range with a minimum of midband attenuation.

A better understanding of the instant invention may be secured from the following detailed description and the accompanying drawings, in which:

Figure 1 depicts schematically the circuit of the invention.

Figures 2, 3 and 4 show graphically by curves the electrical characteristics of the apparatus of this invention.

In Fig. 1 an input signal is applied to the control grid 11 of an electronic tube 12. This signal is, for the purpose of illustration, an alternating current potential having a frequency which may vary from 20 to 20,000 cycles per second. An electrical potential representing voice or music would have frequency components in this range. However, the instant invention is also applicable when the input signal covers any other desired band of frequencies. The tube 12 with associated components constitutes an amplifier stage having an output signal potential relatively unaffected by variations in the impedance into which it works. In order to secure this characteristic it is preferred that the tube 12 be a medium mu triode.

The tone control of this invention is connected between the anode 13 of the tube 12 and ground for energization by the amplified signal output of the tube 12. The tone control consists of a condenser-resistance network of two branches connected in shunt. One branch consists of a resistance 14 in series with a voltage divider 16, for control of bass frequencies by manual or other adjustment of its slider 17, and a second resistor 18. The serially connected resistors 14, 18 and the voltage divider 16 through the blocking condenser 19 between the anode 13 of the tube 12 and ground; the sole purpose of the condenser 19 being to prevent anode supply potential from producing a direct current flow through this branch. The remaining branch of the tone control consists of a condenser 21 in series with a voltage divider 22 having a slider 23 for control of treble frequencies by manual or other adjustment, and in series with a second condenser 24. The two condensers 21, 24 and voltage divider 22 in series are connected at one end to ground and at the other to the anode 13 of the tube 12. The slider 17 and the slider 23 are mechanically separate so that each may be adjusted independently of the other. The output terminals of the tone control consist of a common terminal 26 of the two sliders 17 and 23 and a ground terminal 27.

The magnitudes of the components of the tone control circuit must bear certain relationships to each other in order to secure automatic and inherent shift of control at midband from one section of the circuit to the other in the desired frequency range. In bringing this about, the primary fact is that the midband attenuation is

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dependent upon the voltage division across the condensers 21 and 24, and a primary requirement is that this attenuation be relatively unaffected within the desired limits of accuracy by the settings of either the bass control slider or the treble control slider. The attenuation factor at midband is formulated:

$$\frac{E_{out}}{E_{in}} = \frac{C_{21}}{C_{21} + C_{24}} \quad (1)$$

in which E_{out} is the output potential of the tone control, E_{in} is the input potential at midband frequency, C_{21} is the capacitance of condenser 21, and C_{24} is the capacitance of condenser 24. In order for Equation 1 to be true it is obviously necessary that the impedance at midband of the branch containing the bass control be substantially higher than that of the branch containing the treble control, so that only negligible current flows in the former compared to the latter, or

$$Z_B \gg Z_T \quad (2)$$

in which Z_B stands for the sum of the impedances of the resistors 14 and 18 and of the voltage divider 16, and Z_T stands for the sum of the impedances of the condensers 21 and 24 and of the voltage divider 22 in series therewith. In order for the output potential to be unaffected at midband by any change in setting of the treble control slider 23, obviously it is necessary for the impedance of the voltage divider 22 for midband frequencies to be negligible in comparison with the sum of the impedances of the condensers 21 and 24, or

$$Z_{22} \ll Z_{21} + Z_{24} \quad (3)$$

in which Z_{22} is the impedance of the voltage divider 22. In order that the output potential at midband frequencies be unaffected by any changes in position of the slider 17, including changes to either end of its range of travel, the resistors 14 and 18 are small relative to the impedance of the bass control 16. Likewise, the value of the resistive impedance of the voltage divider 16 is very large as compared to the total capacitive impedance of condensers 21 and 24 at midband frequencies. This will be approximated when the value of each of the resistors 14 and 18 is at least two to five times the magnitude of the resistance of the voltage divider 22, or

$$\frac{Z_{14}}{Z_{22}} \geq 2 \text{ to } 5 \quad (4)$$

and

$$\frac{Z_{18}}{Z_{22}} \geq 2 \text{ to } 5 \quad (5)$$

in which Z_{14} is the impedance of the resistor 14, and Z_{18} is the impedance of the resistor 18.

If these midband conditions are secured, any change of position of the bass slider 17 will have no substantial effect upon frequencies at the high end of the band, and any change of position of the treble slider 23 will have substantially no effect upon frequencies at the low end of the band.

It is to be noted that the outputs of the two networks of the tone control are in parallel. In other words, the sliders 17 and 23 are directly connected to the output terminal 26 while the other sides of the respective circuits are connected to the other output terminal, or ground. This is an important feature as it fixes the output characteristic at the selected midband frequencies for which the networks are designed.

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The condenser 19 must be at least large enough to have a negligibly low impedance at the low frequency end of the band as compared with the resistors 14, 16 and 18.

When all of the stated conditions exist, there will be a middle setting of voltage divider slider 17 which produces an attenuation for all frequencies near the low frequency end of the band that is equal to the midband frequency attenuation. Settings of the slider 17 closer to the grounded end of the branch than this middle setting will produce greater attenuation for low frequencies and settings higher than this middle setting will produce less attenuation for low frequencies thereby effectively giving "boost" above the midband level. Since condensers 21 and 24 have very high impedance for low frequencies, the setting of the slider 23 has no substantial effect at that end of the band and the setting of said slider 17 controls the output voltage. At the high frequency end of the band the impedances of the two condensers 21 and 24 become very low compared to that of the voltage divider 22, and the output potential level is controlled only by the setting of the slider 23.

It follows from the foregoing that since the ratio of the capacities of the condensers 21 and 24 alone determines the output level at the midband frequencies, the output at these frequencies is essentially unchanged by the movement of either of the sliders 17 or 23 of the tone control throughout the full range of movement of the sliders.

The output impedance between terminals 26 and 27 is very high and therefore this must be matched by a high input impedance of the following amplifier. To this end, the terminal 26 is connected to the control grid 28 of an output amplifier discharge tube 29. An amplified output potential is taken from the anode 31 of the discharge tube 29 through a coupling condenser 32 and is available at an output terminal 33. A potential load having proper impedance matching may be attached to this output terminal, as for instance, a power output amplifier stage and a loudspeaker (not shown).

As an example of circuit impedances suitable for use in carrying out the purposes of this invention there is taken the case of a circuit having $8\frac{1}{2}$ db attenuation at midband for use over a frequency band extending from 20 C. P. S. to 20,000 C. P. S., and providing for an attenuation varied between 2 db and 18 db of potential at 100 C. P. S. and 10,000 C. P. S. by two independent adjustments. In such a circuit the resistor 14, Fig. 1, has a resistance of 120,000 ohms, the resistor 18 has a resistance of 56,000 ohms, the voltage divider 16 has a resistance of one megohm, the voltage divider 22 has a resistance of 25,000 ohms, the condenser 21 has a capacitance of .003 mfd., and the condenser 24 has a capacitance of .0056 mfd.

The performance curves of Figs. 2, 3 and 4 illustrate the independence of the bass and treble controls of each other and at the same time illustrate the fact that the compound tone control of this invention has inherently for both bass and treble control only the attenuation or loss of either a bass control or treble control alone of the prior art.

Fig. 2 illustrates the bass attenuation attained in the specific circuit described supra. With the treble adjustment slider 23 at its neutral point near the middle of its range of motion, the right end 34 of the curve of Fig. 2 indicates the result-

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ing treble attenuation which is a continuation at the treble end of the midrange attenuation represented by the midportion 36 of the curve. Adjustment of the bass slider 17 to the end of its range of motion nearer ground moves the bass end of the curve to the position of the dotted line 39, representing low output potential and high attenuation. Adjustment of the slider 17 to a neutral point near the middle of its range of motion produces the solid prolongation 38 of the midrange attenuation 36, and adjustment to the end of the voltage divider 16 nearer the anode 13 produces the decreased bass attenuation represented by the dashed curve 37.

The bass adjustment represented by the curve 38 is reproduced in the left end 41 of the curve of Fig. 3, in the right end of which the dotted curve 44 represents the increased treble attenuation produced when the slider 23 is moved to the end of its voltage divider 22 that is nearer ground. Adjustment of the slider 23 to a midpoint produces the neutral degree of attenuation represented by the curve 43, and adjustment to the high potential end of the voltage divider 22 results in the degree of attenuation represented by the dashed curve 42.

Fig. 4 represents the combination of the characteristics of Figs. 2 and 3 and illustrates the low attenuation of this circuit. This is illustrated by comparing the neutral line of relatively equal attenuation of all frequencies marked 45-46 in Fig. 4 with the similar lines 34-36-38 and 41-43 of Figs. 2 and 3. These level lines all have the same attenuation, the level line 45 representing a midband attenuation of $8\frac{1}{2}$ db, as do the lines 34-36-38 and 41-43. In fact all three lines are actually the same line. This is in sharp distinction to all previously existing circuits, in which the decibel attenuation of the composite characteristic is the sum of the decibel attenuations of the individual bass and treble attenuations.

It is obvious that although the circuit selected as example is represented to have the attenuation shown in Fig. 4, the basic design shown in Fig. 1 permits greater or less attenuations to be attained by merely changing the sizes of the resistive and capacitive components, while keeping the relative proportions of the impedances as described above.

What is claimed is:

1. A dual tone control for the high and low frequency components of an input signal having a spectrum of frequencies comprising, a first input terminal and an input-output terminal adapted to have an input signal impressed therebetween, a second output terminal, a dual control network including a first branch comprising a first resistor, a first voltage divider, and a second resistor connected in series in the order named across said input terminals, a second branch comprising a first capacitor, a second voltage divider, and a second capacitor connected in series in the order named in parallel with said first branch, said first input terminal being electrically connected to said first resistor and to said first capacitor, an electrical connection common to said second resistor, said second capacitor and said input-output terminal, and an electrical connection common to the slider of said first voltage divider, the slider of said second voltage divider, and said output terminal, whereby control of low frequencies is exercised by movement of said slider of the first voltage divider and control of high frequencies is exercised by move-

ment of said slider of the second voltage divider.

2. A tone control as claimed in claim 1 in which the total value of the fixed resistances of said first branch is very large as compared to the resistance of said second voltage divider and the resistance of said second voltage divider is very low as compared to the total capacitive reactance of said second branch at the midpoint of the audio spectrum.

3. A dual tone control in accordance with claim 1 in which the ratio of the capacitance of said second capacitor to the sum of the capacitances of said first and second capacitors is in accordance with midband frequency attenuation, the ratio of the sum of the impedances of said first and second resistors and said first voltage divider to the sum of the impedances of said first and second capacitors at low frequencies is less than unity while at midband frequencies said ratio is more than unity, the ratio of the impedance of said second voltage divider to the sum of the impedances of said first and second capacitors for midband frequencies is less than unity while for high frequencies said ratio is more than unity, the ratio of the value of said first resistor to the value of said second voltage divider is greater than unity, and the ratio of said second resistor magnitude to said second voltage divider magnitude is greater than unity.

4. A dual tone control in accordance with claim 1 in which the ratio of the sum of the resistances of said first and second resistors and said first voltage divider to the sum of the impedances of said first and second capacitors at low frequencies is less than one-third while at midband frequencies said ratio is several times unity, the ratio of the resistance of said second voltage divider to the sum of the impedances of said first and second capacitor for midband frequencies is less than one-third while at high frequencies said ratio is several times unity, the ratio of the resistance of said first resistor to the resistance of said second voltage divider is more than one and a half but less than five, and the ratio of the resistance of said second resistor to the resistance of said second voltage divider is more than one and a half but less than five.

5. A tone control comprising two impedance networks connected in parallel to a pair of input terminals, a pair of output terminals, one of which is common to one side of each of said networks, and the other of which is common to points on the respective networks where the impedance drop between said second output terminal and either of said input terminals is a substantial portion of the impedance drop across said input terminals, the first of said networks having predominantly resistive impedance which is high as compared to the impedance of the second of said networks at a preselected frequency, said second network including two capacitive impedances electrically separated by a resistive impedance, and means for selectively connecting points on the respective networks with the second of said output terminals.

6. The combination as set forth in claim 5 in which the resistive impedance of said first network at the selected frequency is higher than the total impedance of said second network and the resistive impedance of said second branch is small compared to its capacitive impedance at said selected frequency.

7. A tone control comprising two impedance networks connected in parallel to a pair of input terminals, a pair of output terminals one of which is common to one side of the respective networks and the other of which is electrically common to points on the electrically medial portions of said networks, said first network having predominantly resistive impedance which is higher at the audio midband than the total impedance of said second branch, said second branch having a predominantly capacitive impedance at said midband which is lower than the resistive impedance of said first network and a resistive impedance which is small compared to the capacitive impedance at the midband but which latter resistive impedance is very high as compared to the capacitive impedance at the high frequencies and means for selectively connecting points on the electrically medial portions of the resistive impedances of the respective branches with said second output terminal.

8. A tone control comprising two impedance networks connected in parallel to a pair of input terminals, a pair of output terminals one of which is common to one side of each of said networks, the first of said networks having predominantly resistive impedance, the second of said networks comprising two capacitive impedances electrically separated by a resistive impedance, the total value of said capacitive impedances of said second network being low as compared to the resistive impedance of first said network at the midband frequencies, means for selectively associating points on the electrically medial portion of said first network with points on said resistive impedance of said second network and with said second output terminal, the resistive impedance on either side of said medial portion on said first network being at least two to five times the value of the resistive impedance of said network.

9. A tone control network for selectively boosting or cutting either the lower or higher portion of the audio frequency spectrum comprising two branch circuits connected across a pair of input terminals, a pair of output terminals, one of which is common to one of said input terminals, the first of said circuits including a first reactance, a resistor, and a second reactance serially connected across said input terminals, the second of said circuits having an impedance which is predominantly resistive and higher than the impedance of said first circuit for all frequencies within the operating range, and means for connecting the second of said output terminals to an adjustable medial point of said first circuit and to an adjustable medial point of said second circuit.

10. A tone control as set forth in claim 9 in which said reactances are capacitive.

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