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TONE CONTROL CIRCUIT

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Fig. 1.

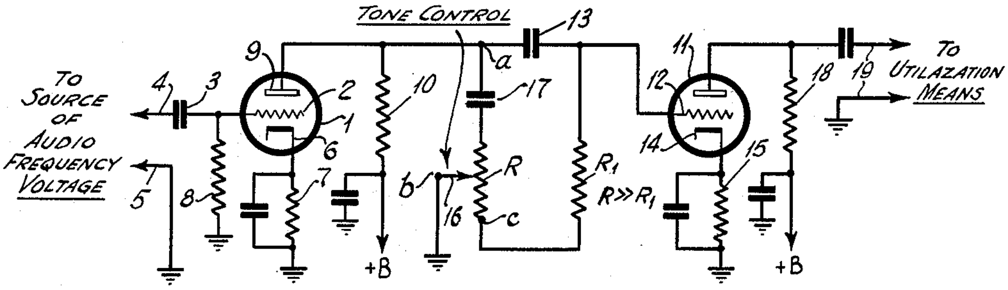


Fig. 2.

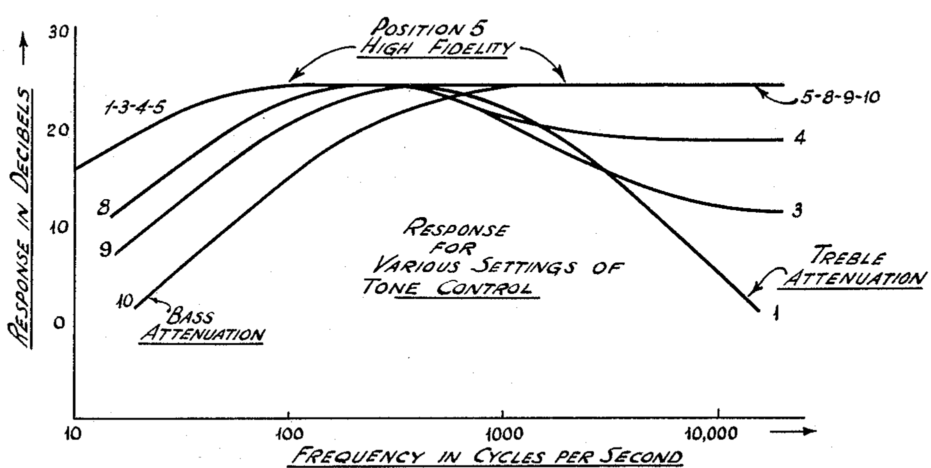
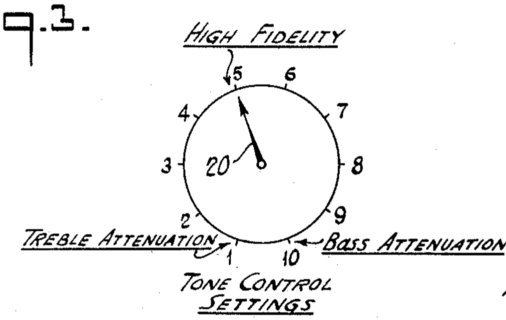


Fig. 3.



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slider or tap 16 along resistor R varies concurrently the magnitude of resistance in series with condenser 17 between the plate circuit of tube 1 and ground, and also the magnitude of resistance between the grid circuit of tube 11 and ground.

The plate circuit of tube 11 is completed in the usual manner. The signal voltage amplified by tube 11 is developed across load resistor 18. The amplified signal voltage transmitted to output leads 19 will have its frequency response characteristic dependent on the adjustment of slider 16. The utilization means may be a loudspeaker, amplifier or the like. By way of specific illustration, the following values of the above-recited elements have been used in a successful embodiment of the invention. My invention, however, is not limited to use of these particular values.

Resistor 10=33,000 ohms
R_1=100,000 ohms
R=1 megohm
Plate resistance of tube 1=8,000 ohms
Condenser 17=0.025 microfarad
Condenser 13=0.005 microfarad

Explaining, now, the functions of the elements of the tone control device, it is pointed out that the latter consists of a simple potentiometer having three terminals. Two of these terminals *a* and *b* are connected to provide a variable attenuation path for the higher audio frequency currents. The third terminal *c* is connected to the lower end of the grid return resistor R_1. The values of coupling condenser 13, grid return resistor R_1 and the overall resistance R of the potentiometer are so chosen that the time constant of the intertube coupling circuit is critically variable over half the range of the adjustable element 16.

The action of the tone control device will be analyzed in the light of the experimental curves of Fig. 2 and the illustrative control dial of Fig. 3. In Fig. 2 I have shown various frequency response curves experimentally secured for various settings of the tone control adjustable element 16. "Response in decibels" is plotted against "Frequency in cycles per second."

In Fig. 3 there is shown an illustrative dial that may be used in conjunction with the adjustable element 16. Let it be assumed that potentiometer slider 16 is rotated in an arc in sliding contact with the resistor R. In such case the indicator or pointer 20 would be mechanically coupled to element 16 for motion therewith. At position 1 of slider 16 (extreme counterclockwise position) the slider will be located at the upper end of resistor R. At position 10 in Fig. 3 (extreme clockwise position) the slider is located at the terminal *c* of resistor R. Position 5 of the indicator 20 corresponds approximately to the midway position of slider 16 on resistor R. It will be noted that position 1 is the "Treble attenuation" point; position 5 is the "High fidelity" setting; setting 10 is the "Bass attenuation" adjustment. Fig. 2 relates these three settings on the frequency response curves. Further, the response curves of Fig. 2 are numbered to correspond to the tone control settings of Fig. 3.

It will be observed that when the slider 16 in Fig. 1 is adjusted to the upper end of resistor R, there will occur maximum bypassing of higher audio frequency currents. In this position of the slider the condenser 17 connects the plate circuit of tube 1 directly to ground, and no portion of resistor R is included in circuit with the condenser. When the slider is adjusted in the counterclockwise path of the potentiometer range, higher audio frequencies are attenuated to a greater or lesser degree depending on the amount of resistance to ground that is placed in series with condenser 17. For the higher audio frequencies the impedance of condenser 17 plus the resistance in series therewith becomes low enough sufficiently to lower the plate load resistance 10. The impedance of condenser 17 at higher than any chosen cut-off frequency should be nearly as small as, or smaller than, the impedance of the load resistor 10. That is, of course, true for counterclockwise positions of slider 16. This reduces the gain of tube 1 for the higher audio frequencies.

The value of resistor R is chosen so that when the slider 16 reaches the midpoint on R, the resistance in series with condenser 17 is sufficiently high in comparison to the load resistance 10 that its shunting effect even at higher audio frequencies becomes negligible. This midpoint on position 5 of indicator 20 is the "high fidelity" region, where the tone control has no effect at either the high or low frequency end. This is best illustrated in Fig. 2 wherein the frequency response curve corresponding to position 5 of indicator 20 possesses substantially uniform transmission of audio frequency currents above 100 cycles with minimum attenuation of currents below 100 cycles.

If the slider 16 is moved closer to the lower end *c* of the resistor R, that is clockwise, the resistance from grid 12 to ground becomes less. For the midpoint position of slider 16, the resistance of R_1 plus half of the resistance of R is the factor which controls the value of condenser 13. The capacity of condenser 13 is chosen so that the time constant (i. e. the RC product) is great enough to pass low audio frequencies down to the lowest audio frequency required for high fidelity. As the maximum clockwise position is reached the time constant becomes less thereby causing the low frequency range to be curtailed. At the extreme clockwise position of slider 16, that is position 10 of indicator 20 in Fig. 3, the bass character is determined by the magnitude of coupling condenser 13 and resistor R_1. The magnitude of resistor R_1 is thus chosen to give the maximum frequency range reduction required. It is preferred to choose the magnitude of R_1 so that it is comparatively large with relation to the load resistance 10. The reason for this relation is that the tone control device will have a minimum effect on the general volume level. This can best be accomplished by choosing the resistance of load 10 as low as the amplification requirements will allow. The impedance of condenser 13 at low audio frequencies should be as great, or greater than, that of R_1. Hence, at such frequencies there will be a definite amount of voltage division at the grid terminal.

From the experimental curves of Fig. 2, it will be seen that when slider 16 is adjusted to position 1 in Fig. 3 there will be maximum attenuation of the higher audio frequencies, with no effect on the lower audio frequencies. Adjustment to position 2 of Fig. 3 results in substantially the same frequency response curve. Successive adjustments to positions 3 and 4 result in successive decrease of attenuation in higher audio frequencies. At the midpoint 5, as stated before, there occurs optimum transmission over the entire signal frequency range. Further adjustment of the slider to positions 8, 9 and 10 in succession results in increased attenuation of the lower audio frequencies, but with substantially no effect on the higher audio frequencies. It will, therefore, be seen that the tone control device of my present invention provides a median setting for high fidelity signal transmission with increasing attenuation of higher audio frequencies upon movement of the tone control in one direction from the median setting, and with increasing attenuation of lower audio frequencies upon movement of the tone control device in the opposite direction from the median setting.

While I have indicated and described a system 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.

What I claim is:

1. In combination with a signal transmission network having a pair of input terminals and a pair of output terminals and a coupling capacitor connected between one input terminal and one output terminal and the other input and output terminals being connected to a common point; a frequency control network which includes a compensating capacitor connected between said one input terminal and one end of a potentiometer having an adjustable contact arm, and a fixed resistor connected between said one output terminal and the other end of said potentiometer, said contact arm being connected to said common point.

2. In combination with an audio frequency signal amplifier tube provided with an output load, a second amplifier tube provided with at least a cathode, a control grid and an output electrode, a first condenser of low impedance to high audio frequency currents coupling the plate end of said output load to said control grid, a potentiometer having an adjustable contact connected to ground, a second condenser of relatively low impedance to higher audio frequencies connected from the plate end of said output load to one end of said potentiometer, and a resistor of fixed magnitude connected from said control grid to the other end of said potentiometer whereby said control grid is returned to ground through said fixed magnitude resistor and a portion of said potentiometer.

3. In combination with an audio frequency signal amplifier tube provided with an output load, a second amplifier tube provided with at least a cathode, a control grid and an output electrode, a first condenser of low impedance to high audio frequency currents coupling the plate end of said output load to said control grid, a potentiometer having an adjustable contact connected to ground, a second condenser of relatively low impedance to higher audio frequencies connected in series from the plate end of said output load to one end of said potentiometer and through said contact to ground, a resistor of fixed magnitude connected from said control grid to the other end of said potentiometer whereby said control grid is returned to ground through said fixed magnitude resistor and a portion of said potentiometer, the overall resistance value of said potentiometer between the ends thereof being very high compared to that of the fixed resistor whereby the lower audio frequencies are not attenuated until after a substantial portion of the resistance of said potentiometer is included in series with the second condenser to ground.

4. In combination with an audio frequency signal amplifier tube provided with an output load resistance, a second amplifier tube provided with at least a cathode, a control grid and an output electrode, a first condenser of low impedance to high audio frequency currents coupling the plate end of said output load resistance to said control grid, a potentiometer having an adjustable contact connected to ground, a second condenser of relatively low impedance to higher audio frequencies connected in series from the plate end of said output load to one end of said potentiometer and through said contact to ground, a resistor of fixed magnitude connected from said control grid to the other end of said potentiometer whereby said control grid is returned to ground through said fixed magnitude resistor and a portion of said potentiometer, said fixed magnitude resistor being comparatively large relative to said output load resistance so that variation of said potentiometer will have a minimum effect on the volume level at the output of the second amplifier tube.

5. In a system as defined in claim 2, said first condenser having an impedance at low audio frequencies which is at least as great as the impedance of said resistor of fixed magnitude.

6. In a system as defined in claim 2, said second condenser having an impedance which, at higher than any chosen cut-off frequency, is at least as small as the impedance of said output load resistance.

7. In combination with an audio frequency signal transmission network provided with a pair of input terminals and a pair of output terminals and a coupling condenser connected between one of said input and one of said output terminals, an adjustable attenuation network connected in shunt across the transmission network, said attenuation network consisting of a compensating condenser having a relatively low impedance at the upper end of the audio frequency range connected between said one input terminal and one end of an adjustable potentiometer resistor having a movable contact connected to the other input and output terminals, a second attenuation circuit including said coupling condenser, said coupling condenser having a relatively low impedance to said high frequency end of the signal frequency range, and a connection between said one output terminal and the other end of said potentiometer, the magnitude of the resistance included in said second attenuation circuit being directly dependent upon adjustment of said movable contact, and the impedance of said coupling condenser at low audio frequencies being chosen to be nearly as great as, or greater than that of the resistance included in said second attenuation circuit at any position of said movable contact.

8. In combination with an audio frequency signal amplifier tube provided with an output resistor, a second amplifier tube provided with at least a cathode, a control grid and an output electrode, a first condenser of low impedance to high audio frequency currents coupling the plate end of said output resistor to said control grid, a second condenser of relatively low impedance to higher audio frequencies connected in series with a first variable portion of a potentiometer resistor from the plate end of said output resistor to ground, a resistor of fixed magnitude connected from said control grid to said poten-

tiometer resistor whereby said control grid is returned to ground through said resistor of fixed magnitude and a second variable portion of said potentiometer resistor, the overall resistance of said potentiometer resistor being chosen very high compared to that of the fixed magnitude resistor whereby the lower audio frequencies are not attenuated until after a substantial portion of the resistance of said potentiometer resistor is included in series with the second condenser to ground, said fixed magnitude resistor also being large compared to said output resistor.

9. The combination set forth in claim 1 in which said compensating capacitor has a relatively low impedance at the high frequency end of the signal frequency range and in which the overall resistance value of said potentiometer is such that when said contact arm is centered on said potentiometer the resistance in series with said compensating capacitor is sufficiently high that the loading effect of said compensating capacitor on said network is neligible.

10. The combination set forth in claim 9 in which the time constant of the resistance of said fixed resistor plus one-half the resistance of said potentiometer with the capacitance of said coupling capacitor is so related to the lowest frequency of the signal frequency range that said lowest frequency is passed through said network substantially without attenuation.

11. The combinaiton set forth in claim 1 in which the time constant of the resistance of said fixed resistor plus one-half the resistance of said potentiometer with the capacitance of said coupling capacitor is so related to the lowest frequency of the signal frequency range that said lower frequency is passed through said network substantially without attenuation.

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