

Feb. 9, 1937.

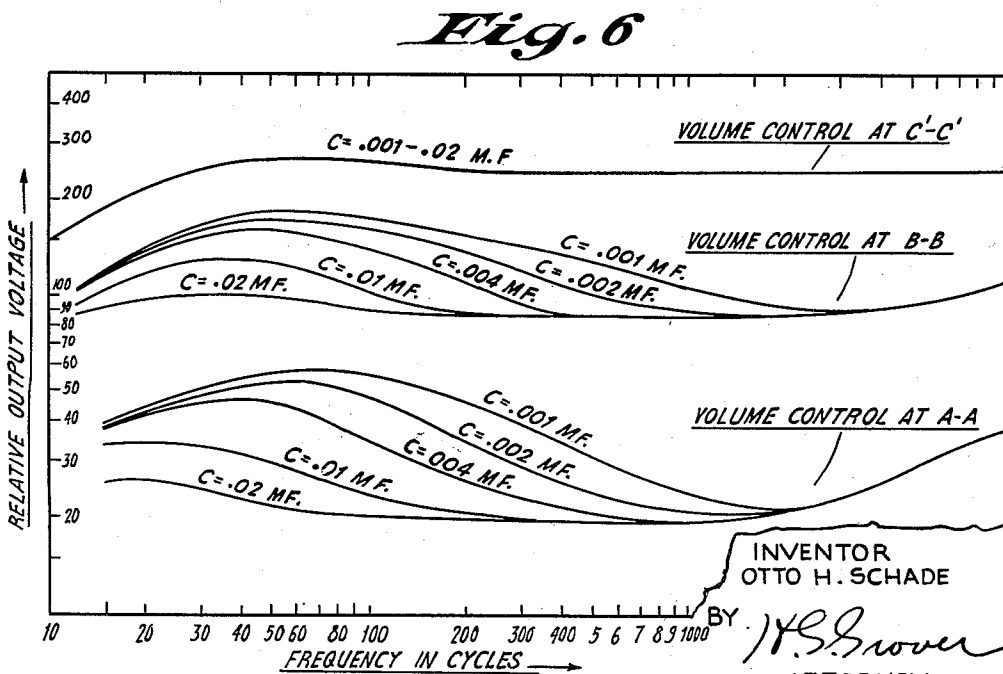
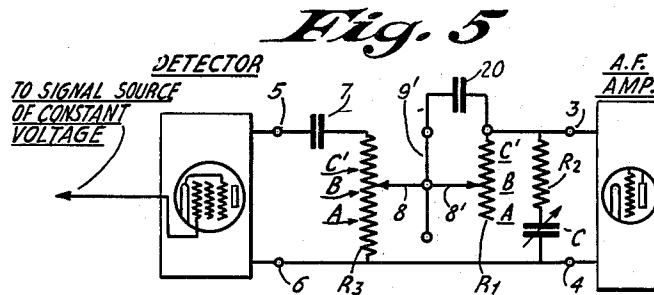
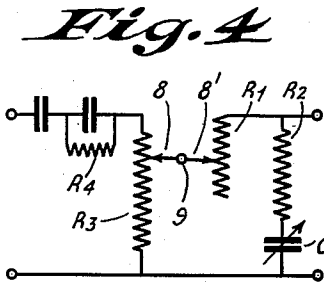
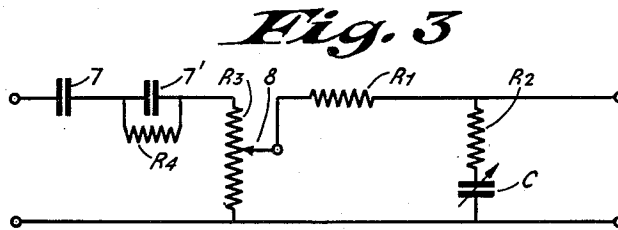
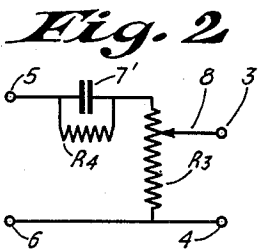
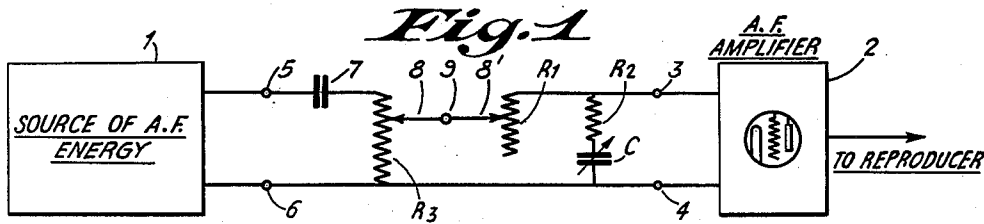
O. H. SCHADE

2,069,853

TONE COMPENSATED VOLUME CONTROL CIRCUIT

Filed Nov. 17, 1933

2 Sheets-Sheet 1



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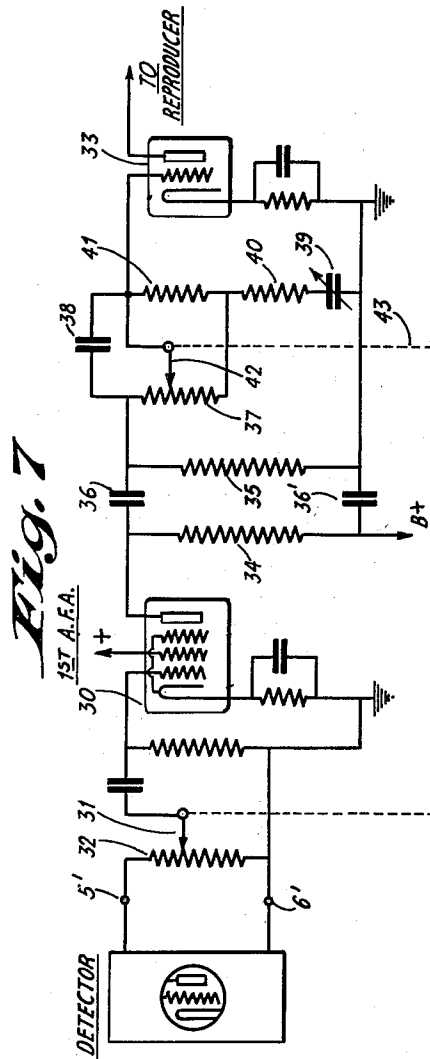
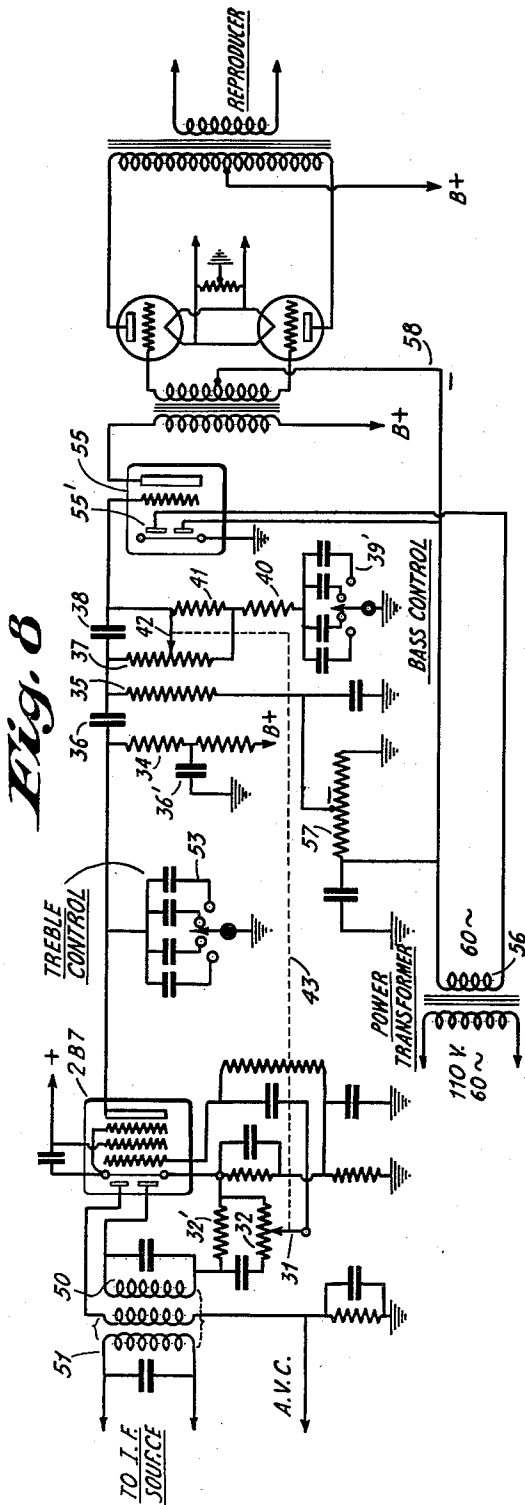
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2,069,853

TONE COMPENSATED VOLUME CONTROL CIRCUIT

Filed Nov. 17, 1933

2 Sheets-Sheet 2



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2,069,853

TONE COMPENSATED VOLUME CONTROL
CIRCUITOtto H. Schade, West Orange, N. J., assignor to
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Application November 17, 1933, Serial No. 698,407

11 Claims. (Cl. 179—1)

My present invention relates to audio frequency transmission control networks, and more particularly to tone compensated volume control circuits for radio receivers.

The threshold curve of the ear for normal hearing shows decreasing sensitivity for frequencies below and above 1000 cycles. This characteristic is taken care of in the original adjustment of sound intensities by the various instruments of an orchestra. Where orchestra music is reproduced with original loudness no correction is necessary in a reproducing system having a linear amplifier and a speaker with linear relation of sound output to power input. If, however, the reproduction loudness is reduced to lower levels of intensity, then the intensity of the bass and high frequency ranges have to be increased so as not to fall below the threshold of hearing.

As the loud speaker characteristic cannot be easily changed, the adjustment of the response characteristic has to be made on the amplifier. In order to compensate for eventual deficiencies of the transmitting end as well, it seems desirable to have separate adjustment for the bass range and the high frequency range. These adjustments should preferably not change the general impression of loudness of the reproduction and this is contrary to the normal commercial methods of tone control used on some radio receiving sets. This requirement calls for tone controls which permit the operator to raise or decrease the amplification at low and high audio frequencies with respect to the frequency range around 1000 cycles.

Accordingly, it may be stated that it is one of the main objects of this invention to provide tone control networks for radio receivers, the network embodying the present invention not only utilizing the audio frequency discrimination element, but also the audio frequency energy transmission adjustment devices.

It is another important object of the present invention to provide a tone compensated volume control network for the audio frequency amplifier section of a radio receiver, which network includes a device for simultaneously varying the attenuation of low or high audio frequencies and the transmission of the audio frequency energy to the amplifier in a desired relationship.

Another object of the invention is to provide a volume control instrumentality for an audio frequency amplifier wherein with decrease of volume level there simultaneously occurs relative increase in low frequency response.

Still another object of the invention is to pro-

vide a tone compensated volume control device for a radio receiver which comprises a common means for varying the audio energy transfer to the audio amplifier of the receiver and the degree of attenuation of the low and high audio frequencies with respect to a predetermined intermediate audio frequency.

Still other objects of the invention are to improve generally the simplicity and efficiency of tone control devices for radio receivers, and especially to provide a tone compensated volume control instrumentality for the audio frequency amplifier section of the receiver which is not only reliable in operation but economically assembled in the receiver.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, will best be understood by reference to the following description, taken in connection with the drawings, in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:—

Fig. 1 diagrammatically shows a tone compensated volume control device embodying one form of the invention,

Fig. 2 shows a tone control network for regulating the attenuation of the higher audio frequencies,

Fig. 3 shows a tone control network for regulating the attenuation of the lower and high audio frequencies,

Fig. 4 shows a tone compensated volume control network embodying the arrangement shown in Fig. 3,

Fig. 5 diagrammatically shows a receiver embodying a modified form of the present invention,

Fig. 6 shows a series of curves illustrating the operation of the embodiment of Fig. 5,

Fig. 7 shows a modification of the arrangement shown in Fig. 5, and

Fig. 8 shows the manner of embodying the tone compensated volume control arrangement of Fig. 7 in an actual radio receiver construction.

Referring now to the accompanying drawings, wherein like reference characters in the different figures correspond to similar circuit elements, there is shown in Fig. 1 a control network for regulating the transmission of audio frequencies between the source of audio frequency energy 1 and the audio frequency amplifier 2. The source

of audio frequency energy may comprise the usual demodulated signal output of a radio receiver, or it may consist of an audio frequency signal distribution line which feeds an audio amplifier and reproducer unit.

In any case, it is to be understood that the amplifier 2 may include one or more stages of audio amplification, and that the subsequent reproducer may be of the loud speaker type or of the head telephone type. To clearly describe the nature of the present invention, it is pointed out that the frequency and amplitude range over which a normal ear receives audible sensations may be depicted by a dish-shaped curve. It can be demonstrated that the sensitivity of the ear depends upon the frequency and is a maximum in the range of 1000 to 3000 cycles. Hence, when the reproduction loudness of an audio amplifier is reduced to lower levels of intensity, the intensity of the bass and high frequency ranges has to be increased so as not to fall below the threshold of hearing. The adjustment of the fidelity response characteristic is most easily made by adjusting the characteristic of the transmission network between the source of audio energy and the audio amplifier.

Therefore, in Fig. 1 there is shown a path including a resistor R_2 and an adjustable condenser C , the path being connected in shunt across the input terminals 3, 4 of the audio amplifier. The path R_1 — R_2 — C functions as a bass control, and it will be noted that the resistors R_1 and R_2 and the condenser C are in series with each other. The output voltage is taken off between terminals 3 and 4 and is applied to the grid circuit of the first audio amplifier tube, and this means that the circuit is not loaded. For very low audio frequencies the reactance of condenser C approaches infinity, the output voltage consequently approaching the input voltage applied between terminal 6 and the slider 8.

For higher audio frequencies the reactance of condenser C approaches zero, and the output voltage approaches a value which is given by the relation

$$\frac{\text{input voltage}}{\text{output voltage}} = \frac{R_1 + R_2}{R_2}$$

The input voltage is taken between terminal 6 and slider 8, while the output voltage is taken between terminals 3 and 4. The aforesaid relation is only for the ideal case, R_3 being considered as very low compared to R_1 plus R_2 . The magnitude of R_1 and R_2 determines the magnitude of the change of the output voltage for variation of the frequency from zero to infinity. The magnitude of the condenser C determines the frequency range in which close approximation to the limit conditions is obtained. If the value of condenser C is varied from the values 0.1 mfd. to 0.001 mfd., the amplification of the range from 30 to 1000 cycles is gradually increased, where R_1 is 400,000 ohms or higher and R_2 is 100,000.

In alternating current operated amplifiers instability at very low frequencies occurs, as stabilization requires enormous time constants. It is, therefore, desirable to prevent amplification at very low frequencies. This is done by connecting a small condenser 7 in series with the input circuit. The value of the condenser 7 is about 0.01 mfd. for R_3 =250,000 ohms, and the effect of this condenser alone, that is with the shunt resistor R_3 connected directly to terminals 3 and 4, is to cut the lower audio frequencies.

The bass control may be interconnected with

the manual volume control device, and this is shown in Fig. 1. The volume control instrumentality comprises the shunt resistor R_3 which has a magnitude of about 250,000 ohms and the variable tap 8. A second adjustable tap 8' is employed to slide along the resistor R_1 , and a common knob 9 is used to simultaneously actuate taps 8 and 8'. At the maximum volume setting, that is with the knob 9 adjusted as shown in Fig. 1, the bass response is normal.

If the volume is decreased by moving the knob 9 downwards, the resistor R_1 increases in magnitude with a consequent relative increase of low audio frequency amplification with respect to the high audio frequencies. The resistors R_1 and R_2 may be tapered to obtain a desirable change in low frequency amplification at any particular setting of the double slider. In addition, the condenser C is made variable so that the amount of bass response can be regulated. The equivalent internal impedance of the driving source 1 should be of the order of 100,000 ohms or lower for the values of R_1 — R_2 — R_3 as given above. The tone compensated volume control arrangement shown in Fig. 1 where R_1 is variable has one marked advantage over the use of the bass control adjustment by itself or by the use of the bass control combined with a volume control by itself. This advantage resides in the fact that the voltage ratio input to output is close to unity at maximum volume, although the bass range cannot be boosted at maximum volume. This latter feature is to a certain extent desirable from the standpoint of power tube and loud speaker overload.

The high audio frequency amplification may be increased with respect to the middle audio frequencies by an arrangement as illustrated in Fig. 2. In that case the resistor R_3 has a magnitude of the order of 180,000 ohms, and the volume control tap 8 is connected between the resistor R_3 and the terminal 3. The condenser 7' is connected in series between terminal 5 and resistor R_3 and is given a magnitude of the order of 0.0001 mfd., the condenser being shunted by a resistor R_4 .

The ratio

$$\frac{R_1 + R_2}{R_1}$$

determines the maximum obtainable increase, and the condenser 7' determines the frequency limits within which the increase takes place. The amplification of the higher audio frequencies, that is from 1,000 to 10,000 cycles, depends upon the value of the resistor R_4 . For example, the relative higher audio frequency amplification will be substantially less for a value of 500,000 ohms than for a value of 1 megohm.

In Fig. 3 there is shown a circuit which combines the network of Fig. 2 with the bass control adjustment heretofore described. In this figure the condenser 7 has a value of the order of 0.0025 mfd.; the condenser 7' has a value of 0.0001 mfd.; the resistor R_4 has a value of the order of 500,000 ohms; the resistor R_3 has a magnitude of the value of 250,000 ohms; the resistor R_1 has a value of the order of 400,000 ohms, and the resistor R_2 has a value of the order of 200,000 ohms. The condenser C may be varied over a range of values from 0.001 mfd. to 0.02 mfd., and the amplification of the lower audio frequencies will decrease as the magnitude of condenser C approaches the value 0.02 mfd.

In Fig. 4 there is shown a tone compensated

volume control network which embodies the arrangement shown in Fig. 1 and Fig. 2. The values of the various elements in this network are the same as in Fig. 3, the double slider of Fig. 1 being added. By suitable adjustment of the resistance and capacity values, a large number of shapes of the frequency characteristic may be obtained.

In Fig. 5 there is shown a tone compensated volume control network which differs from the arrangement shown in Fig. 1 and Fig. 4 in that relatively few elements are employed. In this figure the volume control is a double unit, the resistor R_3 being retained and having a total resistance value of the order of 250,000 ohms. The condenser 7 is retained and has a value of the order of 0.02 mfd. As a specific example, the input terminals 5 and 6 are shown connected to the output circuit of a detector of the pentode type. The bass control path embodies the resistor R_2 having a value of the order of 200,000 ohms and the adjustable condenser C which has a range of 0.001 to 0.02 mfd. The resistor R_1 is retained, and is given a total resistance value of the order of 500,000 ohms, a condenser 20, having a magnitude of the order of 0.0001 mfd., being connected between the junction of taps 8 and 8' and the grid side of resistor R_1 .

The mechanically coupled variable resistor R_1 , together with the fixed resistor R_2 and the condenser C, form the bass control section of the network. As resistor R_1 is varied together with resistor R_2 , the low frequency characteristic depends on the volume setting. Thus, at maximum volume setting, that is at C'—C', the low frequency range cannot be raised, with C varied from 0.001 to 0.02 mfd., thus preventing overload of the power tubes and loud speaker. This is clearly shown in Fig. 6 by the uppermost curve. If the volume level is decreased the resistor R_1 is gradually increased, causing a simultaneous increase in low frequency response. The magnitude of this increase is determined by the values of R_1 and R_2 as described before, the upper frequency limit of the rise being determined by the magnitude of condenser C and the lower limit being determined by the value of condenser 7. The condenser C being variable provides a separate bass adjustment.

In Fig. 6 there are shown two sets of additional curves to show the characteristics obtained with the volume control at point B—B and with the volume control at points A—A. The effect of varying the value of condenser C is also shown in this figure, and it will be noted that the variation of the condenser results in control over the intensity of the lower audio frequencies with respect to the middle and higher audio frequencies.

The high audio frequency range is also gradually relatively increased when the volume level is lowered, as can be clearly seen by the group of curves obtained with the volume control at points A—A. This has been explained heretofore as being desirable. The value of the condenser 20 determines the frequency beyond which the high audio frequency response begins to rise, and it is pointed out that the resistor R_1 , together with condenser 20 and resistor R_2 , form a section similar to that shown in Fig. 2, the reactance of condenser C being negligible at high audio frequencies.

Of course, a separate high frequency control may be connected at some other point of the amplifier to permit independent adjustment (lowering) of the high audio frequency range. In order to obtain an input impedance across terminals

5 and 6 of the order of 100,000 ohms, there is utilized a pentode tube as a detector and audio frequency amplifier loaded with a 100,000 ohms resistor, (the r_p of such tube itself being very high). The signal voltage impressed upon the control grid of the pentode tube is substantially constant, and to accomplish this any well known type of automatic volume control mechanism may be utilized in conjunction with the radio frequency amplifiers preceding the detector. This is so well known to those skilled in the art that it need not be described in any further detail, reference being made to illustrate such a system merely by way of example to U. S. Patent #1,913,959 of June 13, 1933, in the name of W. van B. Roberts. For sources of different impedance or plate load, the resistance and reactance values of the circuit should be changed proportionately to obtain equal performance.

The circuit of Fig. 7 shows an electrical separation of the slider arms 8 and 8' of Fig. 5 by an audio frequency amplifier tube. This arrangement was made in order to reduce hum pick-up on the tone control section by placing it after the first audio stage. The volume control is located ahead of the first audio frequency tube in order to prevent grid current on this tube which might occur due to imperfect AVC control of the preceding radio frequency amplifier if the volume control was located between the first and second audio frequency amplifiers in an arrangement similar to that of Fig. 5. Specifically, there is shown in Fig. 7 an audio pentode amplifier tube 30 having its signal grid coupled through a blocking condenser to the tap 31 of one section of the manual volume control device. The resistor 32 is connected between the terminals 5' and 6', and the latter are connected to the output circuit of the detector. The energizing potential circuits associated with the audio amplifier tube 30 are purely conventional, and will be clearly understood from their diagrammatic representation. The plate circuit of tube 30 is coupled to the input electrodes of the power tube 33 through a network which will now be described.

This coupling network includes a resistor 34 having a magnitude of about 100,000 ohms, and the resistor 34 is connected in parallel with the second resistor 35 having a magnitude of the order of 500,000 ohms. A pair of coupling condensers 36 and 36' having magnitudes respectively of 0.01 mfd. and 0.25 mfd. couple the resistors 34 and 35. The second section of the manual volume control device comprises the resistor 37, the high potential side of resistor 37 being connected to the grid of tube 33 through a condenser 38 having a magnitude of the order of 0.0001 mfd. The resistor 37 itself has a magnitude of the order of 1 megohm, and there is connected in series with this resistor a variable condenser 39 and a resistor 40.

The resistor 40 has a magnitude of the order of 50,000 ohms, and the condenser 39 has a capacity variation range of the same order as that of condenser C in Fig. 5, for example. The resistor 41, having a magnitude of the order of 200,000 ohms, is connected in shunt between the low potential side of resistor 37 and the adjustable tap 42. The taps 31 and 42 are arranged for mechanical uni-control in any desired manner, and this uni-control device is represented in Fig. 7 by the dotted line 43. In actual operation the tone compensated volume control arrangement of Fig. 7 gave satisfactory results, and it was

found that the low frequency range between 40 and 100 cycles rises approximately 9 times with respect to the frequency range around 1500 cycles when the volume control is set to a position corresponding to soft volume. The high frequency response from 5,000 to 10,000 cycles is likewise raised with respect to the range around 1500 cycles approximately $2\frac{1}{2}$ times for the soft volume setting. At maximum volume the frequency characteristic is substantially linear over the entire frequency range. Intermediate settings give smaller values of increase of the bass and high frequency ranges. The resistor 41 contributes to obtain the correct amount of rise in low frequency and high frequency response in addition to the taper of the controls for various settings. The maximum amount of low frequency rise may be adjusted as described previously by varying the size of the condenser 39.

In Fig. 8 there is shown the manner in which the tone compensated volume control arrangement of Fig. 7 is embodied in an actual receiver construction. It is to be clearly understood that only those parts of the circuit arrangement in Fig. 8 which are essential to an understanding of the present invention are described in detail, the remaining circuit elements being well known to those skilled in the art and their functions obvious from their diagrammatic representations.

The section 31-32 of the manual volume control is disposed between the signal grid circuit of the pentode section of tube 2B7 and the diode detector section of the same tube. The multi-function tube 2B7 is well known to those skilled in the art, and is known as a duplex diode-pentode tube, and its physical construction and circuit use have been described by T. M. Shrader in application Serial No. 622,140, filed July 12th, 1932. The resistor 32 is connected across the diode load resistor 32', and the tap 31 is connected through an audio frequency coupling condenser to the signal control grid of the pentode section of the multiple duty tube.

The tuned circuit 50 connected in the diode detector circuit is fixedly tuned to the operating intermediate frequency, and is coupled to a tuned circuit 51 which may be arranged in the output of the usual intermediate frequency amplifier of a conventional superheterodyne receiver. Automatic volume control action is secured by coupling the remaining diode anode to the tuned circuit 51, and the automatic volume control network has been designated "AVC". The manner of connecting this network to the preceding high frequency amplifiers is too well known to be described in any further detail.

The plate of the 2B7 tube is connected to ground through a treble control 53, and this control may have a capacity range of 0.00005 to 0.01 mfd. The plate of the multi-function tube is also connected to the grid of the succeeding tube 55 through the condensers 36 and 38, as shown in Fig. 7. The remaining elements of the tone compensated volume control arrangement are the same as in the case of Fig. 7, and similar numerals are utilized to show the same circuit elements.

Instead of employing a continuously variable condenser 39 to control the bass, there is employed a variable capacity control 39', which includes a plurality of fixed condensers, having a range of from 0.0005 to 0.01 mfd. The dotted line 43 again designates the mechanical uni-control between taps 42 and 31, and variation of these two taps results in a variation of the audio fre-

quency energy transmission to the audio amplifiers of tube 2B7 and tube 55.

In Fig. 8 there is also shown a method of securing the negative bias for the grid of the tube 55 and the grids of the push-pull power amplifier stage. Briefly, the diode anode 55' of the tube 55, the construction of which tube has been disclosed in the aforesaid Shrader application, cooperates with the cathode of the tube to provide a diode rectifier circuit for rectifying the 60 cycle current obtained from the conventional power supply transformer of the set, the 60 cycle current being fed to the diode anode 55' through a special winding 56 on the power transformer. The negative bias for the grid of the triode section of tube 55 is obtained through a path which includes resistor 35 and the tapped resistor 57, one end of which resistor 57 is grounded, and the other end connected to the diode anode 55' through the winding 56.

The grids of the push-pull power amplifier tubes are connected through a lead 58 to the negative side of resistor 57, and in this way the diode rectifier circuit which includes the anode 55' furnishes the negative bias for the push-pull stage. The heating filament circuits of the tube 55 and the push-pull tubes are so constructed that when the tube 55 is removed from its socket then automatically the filament circuits of the push-pull tubes are opened.

In order to have a high quality audio amplifier unit in the receiver shown in Fig. 8, the push-pull tubes can be of the 2A5 type, and in that case the diode power rectifier element of tube 55 would be constructed to furnish a normal negative bias on the grids of the push-pull tubes of the order of -45 volts, the plates and the screens having positive potentials of the order of 380 volts. In such a case the push-pull tubes would be operating as over-biased class B pentodes. The advantage of using such over-biased class B pentodes in a push-pull stage resides in the fact that it is only necessary to supply voltage to the grid circuits of the tubes, and obtain very high efficiency and high power amplitude, comparable to other class B amplifiers which draw grid current.

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 an audio frequency transmission system including a source of audio frequency voltage and an audio frequency utilizing load, a network for regulating the audio frequency transmission between said source and load, said network comprising a resistor connected across said load, an adjustable tap connected to said resistor, a bass control path comprising a resistor and condenser in series, said path being connected in shunt with said load, a variable resistor connected in series with said path, a common means for mechanically operating said adjustable tap and the adjustable element of said variable resistor, and a condenser connected in series between said path and the said adjustable tap.

2. In an audio frequency transmission system including a source of audio frequency voltage and an audio frequency utilizing load, a network for regulating the audio frequency transmission be-

tween said source and load, said network comprising a resistor connected across said load, an adjustable tap connected to said resistor, a bass control path comprising a resistor and condenser in series, said path being connected in shunt with said load, a variable resistor connected in series with said path, a common means for mechanically operating said adjustable tap and the adjustable element of said variable resistor, and a second condenser connected in series between said path and the said adjustable tap, the first condenser in said series path being adjustable to vary the low audio frequency end of the response characteristic of the transmission system at any setting of the said common means.

3. In an audio frequency transmission system including a source of audio frequency voltage and an audio frequency utilizing load, a network for regulating the audio frequency transmission between said source and load, said network comprising a resistor connected across said load, an adjustable tap connected to said resistor, a bass control path comprising a resistor and condenser in series, said path being connected in shunt with said load, a variable resistor connected in series with said path, a common means for mechanically operating said adjustable tap and the adjustable element of said variable resistor, and a second condenser connected in series between said path and the said adjustable tap, the first condenser in said path being adjustable to vary the bass portion of the audio response characteristic of said transmission system, and a fixed condenser connected in series between said first mentioned resistor and said source.

4. In an audio frequency transmission system including a source of audio frequency voltage and an audio frequency utilizing load, a network for regulating the audio frequency transmission between said source and load, said network comprising a resistor connected across said load, an adjustable tap connected to said resistor, a bass control path comprising a resistor and condenser in series, said path being connected in shunt with said load, a variable resistor connected in series with said path, a common means for mechanically operating said adjustable tap and the adjustable element of said variable resistor, and a second condenser connected in series between said path and the said adjustable tap, the first value of the condenser in said path being so proportioned with respect to the values of said resistors that the bass response of said transmission system is increased relatively as the common volume control means is adjusted to decrease the transmission of audio frequency energy from said source.

5. In an audio frequency transmission system including a source of audio frequency voltage and an audio frequency utilizing load, a network for regulating the audio frequency transmission between said source and load, said network comprising a resistor connected across said load, an adjustable tap connected to said resistor, a bass control path comprising a resistor and condenser in series, said path being connected in shunt with said load, a variable resistor connected in series with said path, a common means for mechanically operating said adjustable tap and the adjustable element of said variable resistor, and a second condenser connected in series between said path and the said adjustable tap, and the magnitude of the second condenser in series between said adjustable tap and said path being such that the higher audio frequency response

of said transmission system increases relatively as the common volume control means is adjusted to decrease the transmission of audio frequency energy between said source and said load.

6. In a tone compensated volume control device for an audio frequency amplifier, the improvement which comprises a bass control path including a resistor and variable condenser in series, the path being connected across the input of said amplifier, a double volume control means connected in shunt with said bass control path, and a fixed condenser connected in series between the adjustable element of said volume control and the bass control path, said volume control means including a resistor in series with the said bass control path, said last named condenser having a magnitude such that the high audio frequency response of the amplifier increases as the volume control element is adjusted to decrease the volume of the amplifier.

7. In combination, an audio frequency amplifier having a manual volume control device connected between its input electrodes, a source of audio frequency signal energy connected to said manual volume control device, said volume control device comprising a resistive element and an adjustable tap, a second audio frequency amplifier having its input electrodes arranged to be coupled to the output electrodes of said first amplifier, a second manual volume control device arranged between said two amplifiers and including a resistive element and an adjustable tap, a bass control path including the resistive element of said second manual volume control device, a fixed resistor and a variable condenser all arranged in series relation between the output electrodes of the said first amplifier, and means for simultaneously varying the adjustable taps of both said volume control devices.

8. In combination, an audio frequency amplifier having a manual volume control device connected between its input electrodes, a source of audio frequency signal energy connected to said manual volume control device, said volume control device comprising a resistive element and an adjustable tap, a second audio frequency amplifier having its input electrodes arranged to be coupled to the output electrodes of said first amplifier, a second manual volume control device arranged between said two amplifiers and including a resistive element and an adjustable tap, a bass control path including the resistive element of said second manual volume control device, a fixed resistor and a variable condenser all arranged in series relation between the output electrodes of the said first amplifier, means for simultaneously varying the adjustable taps of both said volume control devices, and a fixed condenser connected between the grid of the second amplifier and the high potential side of the resistive element of said second manual volume control device.

9. In a tone compensated volume control device for an audio frequency amplifier, an improvement which comprises a bass control path including a fixed resistor, a variable resistor and a variable condenser in series, said variable condenser and fixed resistor being in series across the input of said amplifier, a double volume control means including an adjustable resistor and said variable resistor, said adjustable resistor and said bass control path being arranged in parallel, and a common means for simultaneously operating the adjustable elements of said adjustable and variable resistors whereby the bass

response of the amplifier characteristic increases as the energy input to the amplifier is decreased.

10. In a tone compensated volume control device for an audio frequency amplifier, an improvement which comprises a bass control path including a fixed resistor, a variable resistor and a variable capacity means in series, said variable condenser and fixed resistor being in series across the input of said amplifier, a double volume control means including an adjustable resistor and said variable resistor, said adjustable resistor and said bass control path being arranged in parallel, and a common means for simultaneously operating the adjustable elements of said adjustable and variable resistors whereby the bass response of the amplifier characteristic increases as the energy input to the amplifier is decreased.

11. In a tone compensated volume control

device for an audio frequency amplifier, an improvement which comprises a bass control path including a fixed resistor, a variable resistor and a variable capacity means in series, said variable condenser and fixed resistor being in series across the input of said amplifier, a double volume control means including an adjustable resistor and said variable resistor, said adjustable resistor and said bass control path being arranged in parallel, and a common means for simultaneously operating the adjustable elements of said adjustable and variable resistors whereby the bass response of the amplifier characteristic increases as the energy input to the amplifier is decreased, said variable capacity means being adjustable to change the bass response of the amplifier characteristic at any given adjustment of said common means.

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