

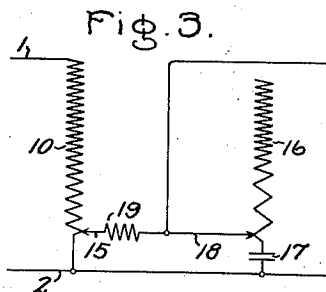
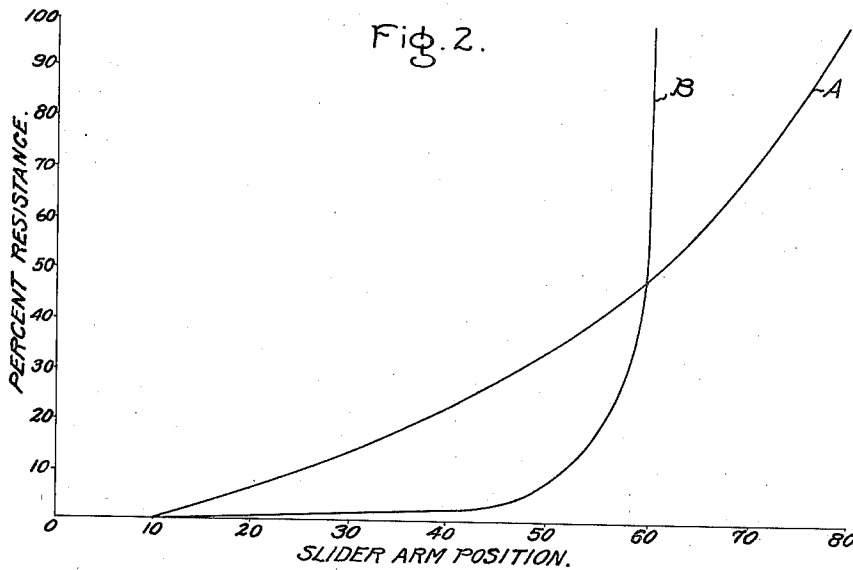
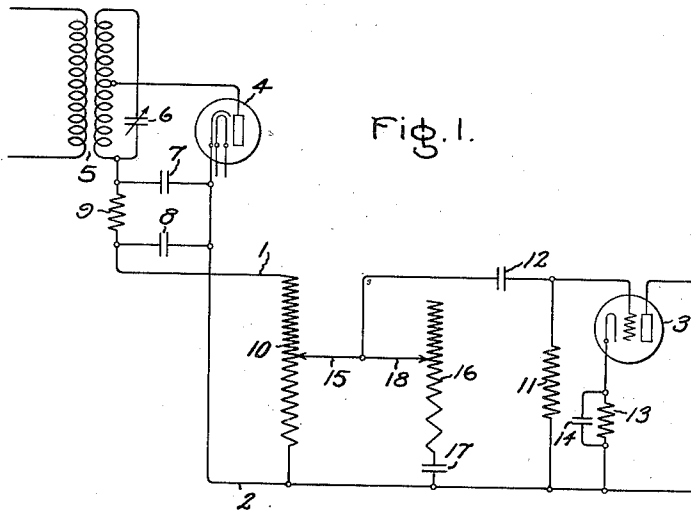
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COMBINED VOLUME AND BASS TONE COMPENSATION CONTROL DEVICE

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COMBINED VOLUME AND BASS TONE COMPENSATION CONTROL DEVICE

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9 Claims. (Cl. 250—20)

My invention relates to volume control circuits for audio frequency amplifiers and the like, and more particularly to such circuits in which means is provided for effecting bass tone compensation, i. e. means for varying the attenuation of currents in the high frequency portion of the audio range by amounts sufficient to compensate for the effects of variation in volume level upon the frequency sensitivity characteristic of the human ear.

In certain types of high frequency receiving systems it is desirable to employ, for example, a diode detector tube for feeding audio potential to an audio frequency amplifier. It is well known that such tubes function to give substantially distortionless detection when the impedance in the output circuit of the detector is substantially purely resistive and of a value high relative to the internal resistance of the diode detector tube in the conducting direction. It is also well known that on highly modulated signals cut-off distortion is introduced in the audio output from the detector if the output impedance is reactive, or different for alternating current from its value for direct current. It is highly desirable to effect volume control and bass tone compensation in that portion of the audio frequency circuit between the detector and the first audio frequency amplifier. It is, therefore, desirable to provide an arrangement whereby the necessary control operations may be performed in this part of the circuit without changing the value or characteristics of the impedance in the detector output circuit.

It is an object of my invention to provide in a high frequency receiving system a combined volume control and bass tone compensation network connected to the load resistance of an electron discharge detector, whereby the desired volume control and compensating functions may be effected without substantially changing the impedance characteristics of the detector load.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and the method of operation will best be understood by reference to the following specification taken in connection with the accompanying drawing, in which Fig. 1 shows a circuit having my invention embodied therein; Fig. 2 illustrates the resistance characteristics of certain of the elements of the circuit shown in Fig. 1, and Fig. 3 shows my invention in slightly modified form.

Referring to Fig. 1 of the drawing I have shown

an audio frequency transmission channel, or circuit, as comprising the circuit conductors 1 and 2, which circuit is included in the connections between an audio frequency amplifier 3 and a diode detector 4 forming a part of a radio receiving system. The input circuit of the diode detector 4 includes the secondary of a coupling transformer 5 which may be energized through its primary from a source of audio modulated high frequency currents, as for example the output from a radio frequency, or intermediate frequency, amplifier. The tunable input circuit of the tube 4 is provided with a variable condenser 6 for tuning the circuit to resonate with a selected incoming carrier. A resistance-capacity filter circuit comprising the condensers 7 and 8, and the resistance 9 is connected in the output circuit of the detector 4 and functions to filter the radio or intermediate frequency component from the rectified carrier which is passed through the detector 4.

The audio potential across the conductors 1 and 2 is impressed on a load comprising a volume control resistance potentiometer element 10 connected between the two conductors. A coupling network consisting of the resistor 11 and the condenser 12 is provided for coupling the volume control potentiometer element 10 to the audio frequency amplifier tube 3. Other forms of coupling may be used if desired although in the particular circuit shown the resistance-capacity coupling is preferable. A resistance 13 shunted by a condenser 14 is connected in the cathode-anode circuit of the tube 3 for biasing the grid of the tube negative with respect to the cathode thereof. A slider arm 15 is provided for varying the portion of the resistance element 10 which is shunted by the coupling network to the amplifier tube 3.

With the above-described arrangement the operation is as follows:—The modulated high frequency currents impressed on the primary of the transformer 5 are rectified in the diode detector 4 and the audio and direct current output is impressed on the volume control resistance 10. A variable portion of the audio potential existing across the impedance 10 is impressed on the coupling network in the input circuit of the amplifier tube 3 through the slider arm 15. In order to vary the value of the audio potential existing across the coupling network to the amplifier 3, the setting of the slider arm 15 on the resistance 10 may be varied.

In order to obtain the desired bass tone compensation simultaneously with changes in the

setting of the volume control slider arm 15, a shunt path for high audio frequency current is provided, comprising a resistance 16 and an audio frequency by-pass condenser 17, the latter having a low impedance to currents in the high audio frequency range. The shunt path thus formed is connected at one end to the audio frequency transmission circuit conductor 2 and is arranged variably to shunt the lower portion of the volume control resistance 10 included between the arm 15 and the circuit lead 2. A second slider arm 18 cooperates with the resistance 16 to vary the impedance of the path 16, 17 to high audio frequency currents; this arm being arranged simultaneously to move with the slider arm 15 under the influence of a single manually operable control member (not shown). The series-connected resistor 16 is of such a value that with the slider arm 18 just engaging the open end thereof, the impedance of the path formed by the series-connected elements is exceedingly high for currents having a frequency in the audio range.

With the above circuit arrangement adjusted for maximum input to amplifier 3, the slider arm 18 is disengaged from the upper or high potential end of the resistance 16 and the total audio potential existing across the resistance 10 is impressed on the amplifier input circuit. If now it be desired to lower the volume level, the slider arm 15 is manually operated to decrease the portion of the resistance 10 which is shunted by the amplifier coupling network thereby to decrease the audio potential impressed on the amplifier input circuit. Since the slider arm 18 is arranged to move with the arm 15, it approaches, during such movement, the free end of the resistance element 16 and, after a predetermined movement, engages the open end of the element 16 and connects the series-connected impedance elements 16 and 17 in parallel with the amplifier input circuit and also in parallel with the lower portion of the resistance 10. Further movement of the slider arms 15 and 18 results simultaneously in a decrease in the portion of the resistance element 10 paralleling the amplifier coupling network, and in a decrease in the impedance value of the high audio frequency impedance path consisting of the resistance 16 and the condenser 17.

With all of the resistance 16 included in the circuit a very small portion of the high audio frequency current flows through this branch. However, as the slider arms 15 and 18 are moved in a direction to decrease the volume, the value of the resistance 16 included in the circuit is decreased, thereby resulting in increased attenuation of high frequency audio currents produced by the path 16, 17. This progressive decrease in the impedance of this shunt path as the lower portion of the resistance element 10 is decreased produces the desired bass tone compensation as the volume is decreased.

In order to obtain the correct relation between decrease in audio current intensity and attenuation of high frequency currents produced by resistance 16 and capacitance 17, the two resistance elements 10 and 16 are graded, or tapered, as indicated in Fig. 2 wherein the per cent of the total resistance of each element included in parallel with the amplifier input circuit is plotted against position of the slider arms 15 and 18. The resistance of element 10 between the lower terminal and the slider is indicated by curve A and that of element 16 by curve B. It will be observed that with all of the resistance element 10 paralleling the amplifier input circuit, the

slider arm 18 is disengaged from the end of the resistance element 16 and the high audio frequency current shunt impedance path is excluded from the circuit. When the slider arms 15 and 18 have been moved sufficiently to decrease the percentage of the resistance element 10 shunting the amplifier input by approximately 50 per cent, the slider arm 18 engages the open end of the resistance 16 to connect the series-connected resistance 16 and condenser 17 in parallel with the amplifier input circuit. Further movement of the slider arms 15 and 18 in the same direction results in a rapid decrease in the per cent of the resistance 16 included in the shunt circuit and a more gradual decrease in the per cent of the resistance element 10 paralleling the amplifier input. This relation obtains until the lower portion of the resistance 10 has been reduced to approximately 25 per cent of the total impedance thereof, when the value of the resistance 16 included in the shunt path is reduced to a negligible value such that the condenser 17 is practically shunted across the amplifier input circuit.

It will be observed that as the slider arm 15 approaches the low resistance end of the resistance 10, the condenser 17 approaches a direct shunt on the lower portion of the resistance 10. In order to decrease the capacitive effect of the condenser 17 on the detector load resistance 10 in this region of the adjusting range, the arrangement shown in Fig. 3 may be used wherein a resistance 19 is inserted in the connection between the slider arm 18 and the circuit lead to the amplifier coupling impedance.

By using the slider arms 15 and 18 cooperating respectively with the resistance 10 and the resistance 16, in the manner described, the value of the load resistance on tube 4 remains substantially the same for both alternating current and direct current irrespective of movement of the slider arms to effect the desired volume control and bass tone compensation. Obviously, during the initial movement of the arm 15 to decrease the volume, the shunt impedance 16, 17 has no effect on the detector load impedance since it is excluded from the circuit. When the arm 18 has been moved so that it engages the free end of the resistance 16, approximately 50 per cent of the impedance 10 has been transferred from the lower portion of the potentiometer to the portion between the arm 15 and the circuit lead 1, and the value of the series impedance 16, 17 shunting the lower portion of the element 10 is of such a high order that the over-all impedance between the conductors 1 and 2 is substantially unaffected. This condition is maintained throughout movement of the slider arms since a decrease in the value of the resistance 16 included in the circuit is accompanied by a simultaneous increase in the upper portion of the element 10 included between the conductor 1 and the arm 15. In this manner the value of the impedance between the conductors 1 and 2 is maintained substantially purely resistive irrespective of the control operations, and distortion in the detector tube 4 is avoided.

The operation of the series impedance 16, 17 to give the desired bass tone compensation may be easily understood by considering the shunt impedance to be an element of a resistance-capacity filter circuit. Thus, as the contacts 15 and 18 are moved simultaneously downward the upper portion of resistance 10 and the condenser 17 operating together become increasingly effective as an element of a resistance-capacity

filter such as that indicated at 9, 8 for example, except that it is designed to attenuate high audio frequency currents, whereas the elements 9, 8 attenuate radio frequencies, and except for the further fact, that that portion of resistance 16 which is in the circuit, is in the capacity arm of the filter. This type of filter has the desired characteristic of substantially equally attenuating all frequencies above a fairly definite predetermined frequency. By proper choice of the resistances 10 and 16 as indicated by the curves of Fig. 2, and proper choice of condenser, 17, the characteristic of this filter may be made such as to effect the desired compensation for the effect of volume upon the frequency sensitivity characteristic of the human ear.

One bass tone compensation expedient of the prior art comprises a series combination of resistance and capacity connected permanently across a portion of the detector load resistance, which load resistance is employed as a volume control potentiometer. My invention possesses definite advantages over such an arrangement, however, in that in the region of volume levels where high frequency attenuation is not required the capacity is entirely out of the circuit. This permits the use of the entire load resistance for volume control purposes. That is, no additional series load, to overcome the effect of the capacity is necessary, and the loss of audio energy on such additional load is avoided.

My invention possesses the further advantage over such an arrangement in that the variation of tone with change in position of the control element is satisfactorily smooth and gradual throughout the entire range, there being no undesirably abrupt changes in output tone. When member 18, in its downward movement first engages resistance 16, its resistance in the circuit is so high that no undesirable click is heard. The change in resistance effected upon further movement is then sufficiently gradual to give the desired smooth control operation.

Although I have described my invention with particular reference to a diode detector, it will be understood that it is equally applicable in connection with triode detectors, or in fact, with other sources of audio frequency current where it is desired to maintain a substantially pure resistance load upon the source.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications in the circuits may be made, and I contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a volume control and bass tone compensation network for audio frequency circuits comprising a source of audio currents requiring a substantially pure resistance load, and an output device responsive to audio frequency electromotive force from said source, the combination of a resistance potentiometer comprising said load, said output device being connected between a fixed point on said resistance potentiometer and a variable point thereon, a second resistance and capacity connected in series between said points, and means whereby upon movement of said variable point along said potentiometer to change the volume of output to said output device said second resistance is simultaneously varied to vary the attenuating effect of said capacity at differ-

ent volume levels while maintaining the load on said source substantially purely resistive.

2. In combination, an electron discharge detector having an output circuit including a load of substantially pure resistance, an audio frequency amplifier including an input circuit, said input circuit being arranged to be variably coupled to said output circuit, a path including a condenser arranged in shunt to said input circuit, said path having a variable impedance to currents in the high audio frequency range, and means for simultaneously varying the coupling between said input and said output circuits and the impedance value of said high frequency current shunt path while maintaining the load on said detector substantially purely resistive.

3. In combination, a diode detector including an output circuit having a load resistance connected therein, an audio frequency amplifier including an input circuit arranged in shunt to a variable portion of said resistance, an impedance path arranged to shunt said input circuit, said path having a variable impedance to currents in the high audio frequency range, movable means for varying the connections of said input circuit to said load resistance thereby to vary the portion of said resistance shunted by said input circuit, and means simultaneously movable with said last-named means for connecting said high audio frequency current path in parallel with said input circuit after a predetermined movement of said last-named means to decrease the value of said resistance shunted by said input circuit.

4. In combination, an electron discharge device, an audio output circuit therefor including a load resistance, a load device connected in shunt to a variable portion of said load resistance, a series combination of resistance and capacitance connected across the same portion of said load resistance thereby to attenuate high frequency audio currents, and means to vary said last resistance while maintaining the load on said electron discharge device substantially purely resistive.

5. In combination, an electron discharge device, an audio output circuit therefor including a load resistance, a load device connected in shunt to a variable portion of said load resistance, a series combination of a second resistance and capacitance connected across the same portion of said load resistance thereby to attenuate high frequency audio currents, and means simultaneously to vary said portion of said load resistance to control the current intensity supplied to said load device, and the value of said second resistance to vary the attenuation of said high frequency currents, the relative rates of said variations of said portion and said second resistance being such as to maintain a substantially constant load on said discharge device.

6. The combination, in a coupling network between a detector requiring a pure resistance load and an output device, of a pair of tapered resistance potentiometers, said potentiometers having their terminals at the low resistance ends thereof connected together through a condenser, and having their movable members mechanically coupled together for simultaneous movement to and from said terminals, said detector being connected across the terminals of one of said potentiometers, and said load device being connected between the terminal at the low resistance end of said one potentiometer and said movable members whereby the other potentiometer

- and condenser constitute an audio frequency shunt to said load device, said shunt being variable upon movement of said movable members, the taper of said potentiometers being such that
- 5 in the positions of said movable members where output currents of large value are supplied to said load device said condenser has substantially no attenuating effect at high frequency and upon movement of said members to reduce said volume
- 10 said condenser and said one potentiometer rapidly become effective as a resistance capacity filter to attenuate currents of high audio frequency.
7. In combination, a resistance adapted to have electromotive force impressed thereon representing music, a contact variable along said
- 15 resistance, a load device connected between one terminal of said resistance and said variable contact, a second resistance having one end connected to said terminal through a condenser, and
- 20 a contact variable along said second resistance, said variable contacts being mechanically connected for simultaneous movement along said resistances.
8. In combination, a resistance adapted to
- 25 have electromotive force impressed thereon representing music, a contact variable along said resistance, a load device connected between one terminal of said resistance and said variable contact, a second resistance having one end connected to said terminal through a condenser, and
- 30 a contact variable along said second resistance,

said variable contacts being mechanically connected for simultaneous movement along said resistances, said resistances having values per unit of length which increase from the ends nearest said one terminal to the other, said variable contacts being arranged for simultaneous movement from said ends nearest said one terminal toward the other.

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9. In combination, a source of currents having frequencies extending over the audio range, a resistance connected across said source, a load device connected between one terminal of said resistor and a variable point thereon, said load device including an audible output device, a shunt path including a capacitance and a variable resistance connected between said variable point and said resistance, and means whereby the load on said source is substantially purely resistive at all positions of said variable point along said first mentioned resistance notwithstanding said

10 first capacitance, said means including means to increase said second resistance as said variable point is moved away from said terminal, said capacitance and resistances being of such value and so proportioned that the attenuation of

15 higher audio frequency currents increases as said point is moved toward said terminal to an extent to compensate for greater sensitivity of the ear at low volume and high frequencies.

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