

June 10, 1969

D. HAFLER

3,449,681

AMPLIFIERS WITH TONE CONTROLS

Filed Dec. 18, 1964

Sheet / of 2

FIG. 1

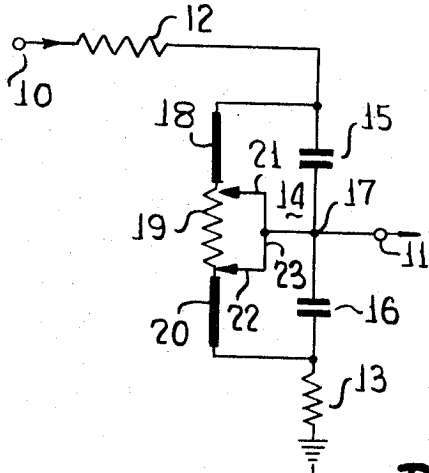


FIG. 2

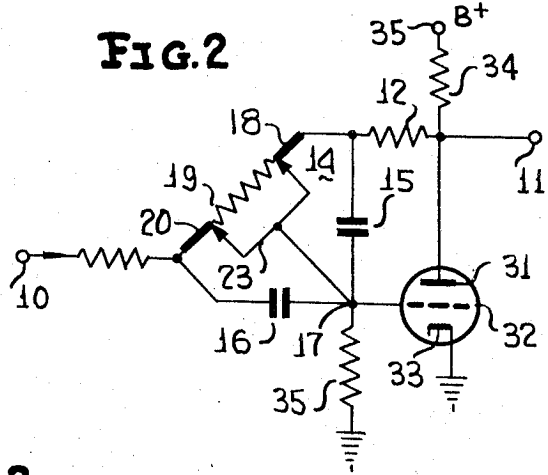


FIG. 3

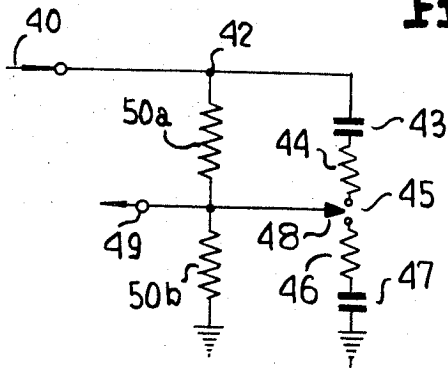


FIG. 5

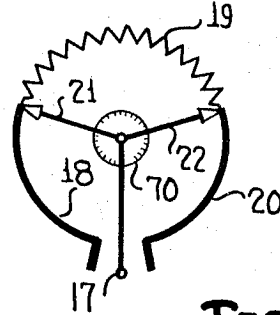


FIG. 4

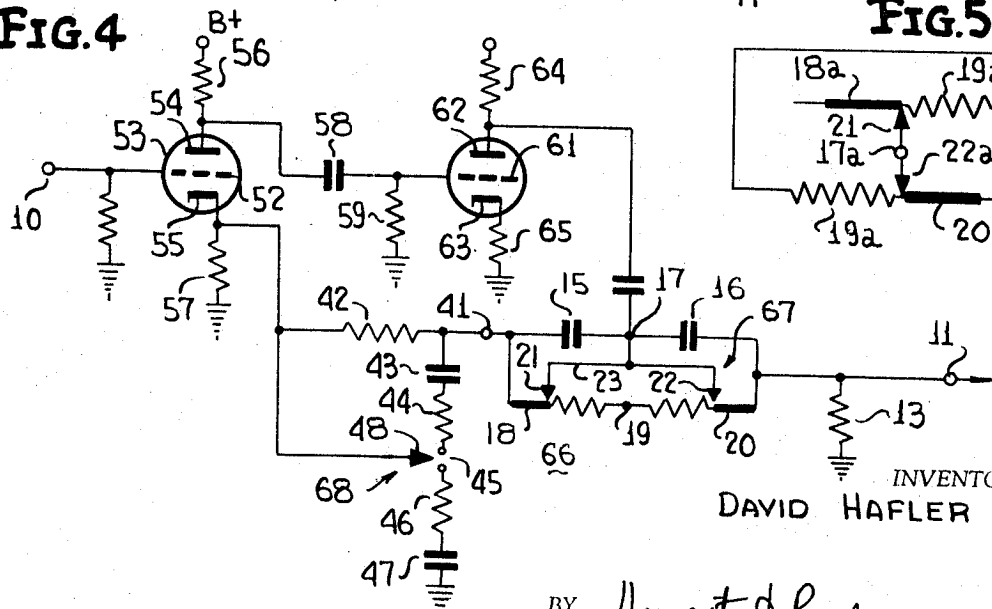
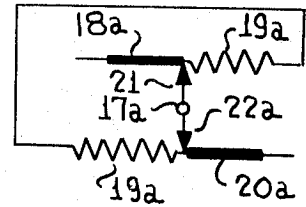


FIG. 5A



INVENTOR
DAVID HAFLER

BY *Hurovitz & Rose*

ATTORNEYS

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FIG. 6

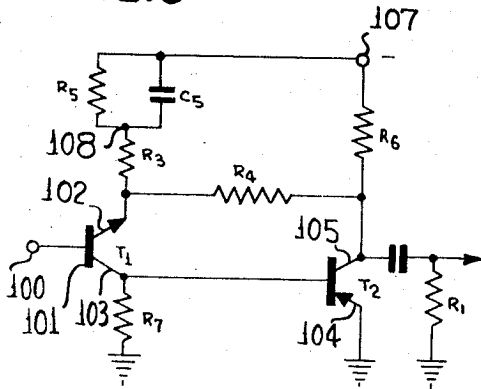


FIG. 7

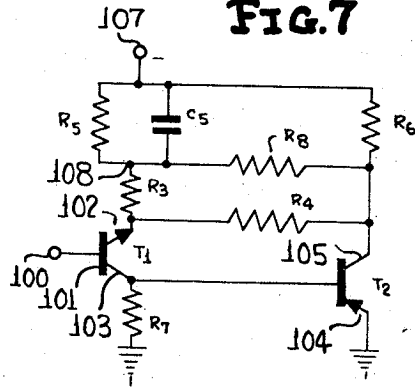


FIG. 8

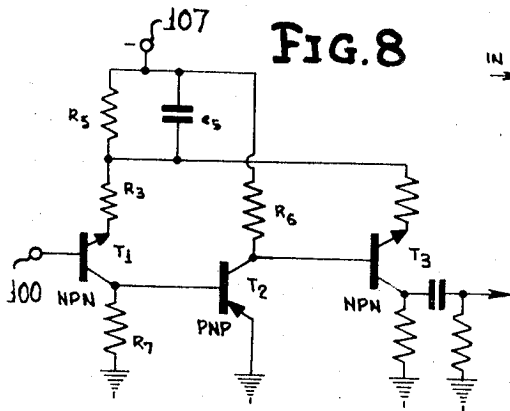


FIG. 9

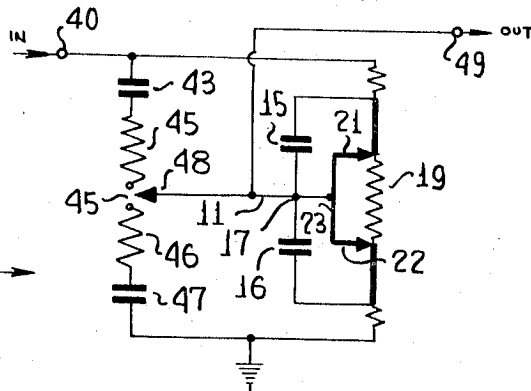
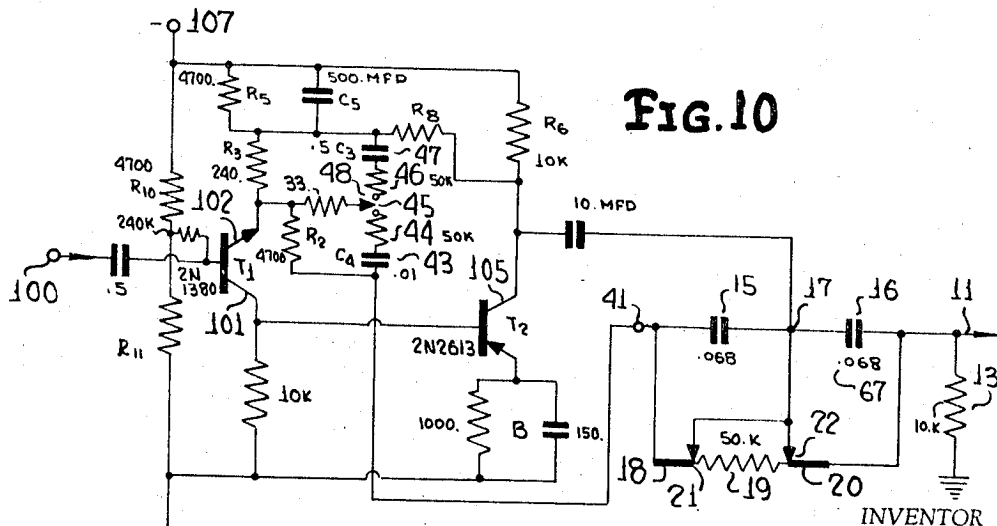


FIG. 10



INVENTOR
DAVID HAFLER

BY *Huntley & Rose*

ATTORNEYS

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3,449,681

AMPLIFIERS WITH TONE CONTROLS

David Hafler, Merion Station, Pa., assignor, by mesne assignments, to TLD, Inc., Philadelphia, Pa., a corporation of Pennsylvania

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U.S. Cl. 330—17

18 Claims

ABSTRACT OF THE DISCLOSURE

A transistorized audio preamplifier having bass and treble tone controls and temperature stabilization, employing novel potentiometers for bass control and for treble control. The treble control circuit consists of a first capacitor, a first potentiometer section, a second potentiometer section and a second capacitor, connected in the order recited. A break or infinite impedance is provided between the resistances, so that at mid-point adjustment the tone control circuit is entirely ineffective, and moving the slider to one side or the other brings one or the other potentiometer into play. In the bass control circuit, the potentiometer is used selectively to short one of two capacitors, except for a mid-point position, where both capacitors are shorted to provide a flat response.

The present invention relates generally to tone controls for amplifiers, and more particularly, to improved bass and treble boost and cut tone control circuits which may be incorporated in audio voltage amplifiers.

Tone controls are either of the continuously variable or of the stepped type. The latter type employs switches to select tone control settings and has the disadvantage of providing a limited number of control settings, but has the advantage of providing a precisely flat response at one setting. The switched types of volume control also have independence of boost and cut characteristics since there does not exist a forced relationship between boost and cut components.

Continuous control tone controls possess the advantage of smoothness of action and also are inherently economical, but attainment of flat response heretofore required compensating action, which cannot be assured for any predetermined setting. Also boost and cut are inter-related so that the designer cannot have boost at one frequency and cut at another, for example.

In the art of audio amplification, particularly in preamplifiers useful in audio recording and/or reproduction, it is desirable to provide continuous manual tone controls, capable of cutting and boosting, i.e. decreasing and increasing, the bass and treble responses of the amplifier. A system of this type is disclosed in U.S. Patent No. 3,059,190, issued to D. Hafler, on Oct. 16, 1962. The present invention is an improvement of the invention of the patent, providing continuous tone control action with independence of boost and cut action and a true flat setting regardless of component tolerances.

While the present system is disclosed, in one of its embodiments, as connected in the feedback path of an amplifier and controls gain in certain frequency ranges by varying the impedance of the feed-back path, the principles of the invention are applicable, as indicated in other embodiments, to amplifiers in which the tone control circuitry is inserted in cascade with an amplifier, i.e. the so-called passive type of tone control.

The systems of the invention are diverse as applied to bass and treble controls. For bass control in a feed-back tone control circuit, the invention uses a pair of capacitors connected in series and supplied with two outer terminals

and one mid-connected terminal. A potentiometer of novel type in the tone control art, or a dual potentiometer of special taper characteristics, is connected across the capacitors and has the function of always shorting at least one of the capacitors and for flat response shunting both. Signal input to the bass control circuitry is to the mid-terminal, one of the outer terminals provides output for a feed-back path and the other provides output to a load, usually a following amplifier stage. In another embodiment of this circuit, signal input is impressed across the two outer terminals; and output signal is taken from the mid-terminal.

The potentiometer resistance is used selectively to shunt one capacitor and short out the other, except for a mid-point position. The mid-point position effects a short circuit connection across both capacitors and is intended to provide flat response and does so by introducing fixed attenuation, not varying as a function of frequency, into the feed-back and load paths.

One of the capacitors provides cut and the other provides boost. When the slider of the potentiometer is moved in one direction, the cut circuitry is eliminated and when the slider moves in the other direction, the boost circuitry is eliminated.

In the Hafler patent, on the other hand, a balancing action is attempted, i.e. bass cut and boost are always simultaneously present and must be equal or mutually compensatory, for flat response. Such an arrangement represents a compromise, depending as it does on component tolerances to achieve true flat response.

Continuous control involving balancing action, as in the Hafler patent, has the further defect that at some frequencies signal swing or amplitude must be increased beyond the normal, thus increasing distortion and limiting possible signal output. For example, if low end cut is employed, which is compensated by low end boost, the circuit must work harder at the boost point to make up for signal lost in the cut circuit, so that if considerable cut or boost must be compensated there will or may exist frequencies for which such compensation involves overdrive.

A treble frequency control circuit is further provided, according to the invention, which consists of a first capacitor, a first potentiometer section, a second potentiometer section, a second capacitor, all in series in the order recited. A break or infinite impedance is provided between the resistances of the potentiometer, which employs a common single slider contact. Thereby, at mid-point, the tone control circuit is entirely disconnected, since the slider contact is at the break. Moving the slider to one side or the other brings one or the other potentiometer section into play, while eliminating the other.

In the Hafler patent, treble control is attained by balancing cut and boost, and flat response requires that these compensate for each other. It is the salient feature of the present invention, that for flat response the tone control circuits are eliminated or disabled, and that during cut the boost section of the tone control circuitry is inactive, while during boost the cut section of the tone control circuitry is inactive.

Accordingly, the philosophy or underlying concept of the invention is the same for both bass and treble tone control, but the character of the potentiometers employed in instrumenting the concept are different, being arranged to suit the specific character of treble and bass tone control circuitry, of the type exemplified in the Hafler patent.

In accordance with the present invention, frequency discriminating elements are cut out of circuit at the mechanical potentiometer setting which is intended to provide flat response and thus provides true flat response for that setting regardless of component variation. At

the same time, for setting on either side of the flat setting, boost and cut are independently inserted.

Heretofore, then, if true flat response is required at a predetermined mechanical potentiometer setting, it has been necessary to use a switch rather than a potentiometer. Further, to achieve independence of bass and treble boost and cut action, a non-compensatory arrangement of switched tone control has been required. According to the present invention, the advantages of switched types of tone control are retained while retaining the advantages of continuous types. More specifically, use of the potentiometer arrangement of the present invention retains the simplicity and economy of potentiometer type tone controls, while retaining the precise mechanical reproduction of flat settings, and independence of cut and boost action.

One of the major problems in designing a transistorized amplifier circuit, is the problem of obtaining thermal stability. A low distortion circuit, when cold, may be when it becomes warm, subject to considerable distortion, because its operating point changes. I have found that use of DC feedback in a novel manner permits maintenance of the operating point of a transistor amplifier over a wide temperature range, and thus the elimination of distortion which can occur due to variation of operating point with temperature. It is recognized that, in a broad sense, the recited expedient is old. However, according to the present invention, the circuitry is so arranged that DC feedback far exceeds AC feedback. In such case, where the circuit involves two cascaded transistors, the operating point of each is independently selected for optimum operation, and optimum condition then is retained as a function of temperature. The system is operative when the transistor pair includes one NPN and one PNP transistor, but if three transistors are included those of similar character are tied together for DC, provided they occur in the sequence NPN, PNP, NPN or PNP, NPN, PNP.

While the tone control system of the present invention is disclosed as modifying the tone control circuitry of Hafer Patent No. 3,059,190, its principles are equally applicable to all tone control systems employing compensatory or simultaneous boost and cut. Similarly, the transistor temperature compensation circuit is of general application.

It is, accordingly, a broad object of the invention to provide novel tone control circuitry for amplifiers.

It is another object of the invention to provide a novel bass frequency tone control system.

It is still another object of the invention to provide a novel treble tone control system.

It is a more specific object of the invention to provide novel tone control circuitry which is disabled for one position of a tone control slider, and in which boost and cut controls are independently introduced, each without the other, as the slider is moved in one sense or the other.

It is a further object of the invention to provide temperature stabilization circuitry for transistor amplifiers, by employing relatively large DC feedback and relatively small AC feedback.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a circuit diagram of a passive bass tone control system, according to the invention;

FIGURE 2 is a circuit diagram of an active bass tone control system, employing a single stage of tone control feedback, according to the invention;

FIGURE 3 is a circuit diagram of passive treble tone control system, according to the invention;

FIGURE 4 is a circuit diagram of an active tone con-

trol system according to the invention, including both bass and treble feedback control;

FIGURE 5 is a view in plan, schematized, of a potentiometer of the type employed for bass control, in the circuitry of FIGURES 1, 2 and 4;

FIGURE 5a is a view in plan of a modification of the system of FIGURE 5;

FIGURE 6 is a schematic circuit diagram of a transistor amplifier employing a temperature stabilization circuit according to the present invention;

FIGURES 7 and 8 are schematic circuit diagrams of modifications of the system of FIGURE 6;

FIGURE 9 is a schematic circuit diagram of a passive bass and treble tone control combination; and

FIGURE 10 is a schematic circuit diagram of a transistorized amplifier including the tone control devices and temperature stabilization devices of the invention.

Referring now to the drawings, 10 is an audio signal input terminal and 11 an audio signal output terminal. Fixed current limiting resistances 12 and 13 are provided at the input and ground ends of the system, intermediate which lies a tone control network proper, identified as 14. Network 14 consists of two capacitors 15, 16 (which may be unequal but are shown as equal) (.0075) in series, and having a mid-tap 17 connected directly to output terminal 11. Across the capacitors 15, 16 is connected a novel potentiometer, consisting of a first zero resistance section 18, a following resistive section 19 and a further following zero resistance section 20 which may all be of the same physical lengths. A double slider is provided, comprising contacts 21, 22, electrically connected by lead 23, and spaced to straddle resistance 19, in its mid-position resting entirely on zero resistances 18, 20. The novel potentiometer of FIGURE 5 is electrically identical with the dual potentiometer of FIGURE 5a. FIGURE 5a shows the connection of two ganged controls, of opposite taper characteristics, with zero resistance on one half of each control. Both types of control (5 and 5a) provide equivalent action and are interchangeable in the circuits shown.

With contacts 21, 22 in mid-position, a short circuit exists across the capacitors 15, 16, via the circuit 18, 21, 23, 22, 20, and point 17, connected to lead 23 directly, sees a voltage less than that at terminal 10, division being provided by resistances 12, 13. The circuit is entirely resistive and therefore the tone control setting is flat.

If sliders 21, 22 are moved up, (as viewed in FIGURE 1) capacitor 15 remains shorted, but resistor 19 and capacitor 16 is inserted in series with resistance 13, as seen from point 17. If sliders 21, 22 are moved down, capacitor 16 is shorted and capacitor 15 and resistance 19 are inserted in series with resistance 12, as seen from point 17. Accordingly, moving sliders 21, 22 up inserts impedance into the shunt path, with resultant boost, since this operation increases the impedance between point 17 and ground, while moving sliders 21, 22 down shorts capacitor 16 and introduces impedance into the direct signal path while leaving the shunt path unmodified, and result in cut.

In the system of FIGURE 2 is shown a triode 30, having anode 31, grid 32 and grounded cathode 33. An anode load 34 is connected between B+ terminal 35 and anode 31. Tone control circuit 14, precisely as in FIGURE 1 (except possibly in respect to circuit values) is connected between anode 31 and signal input terminal 10. The input signal to grid 32 is now controlled by capacitor 16 and resistance 19, while the feed-back circuit is controlled by capacitor 15 and resistance 19. With sliders 21, 22 moved to the right, in FIGURE 2, the entire feed-back signal is applied directly to the grid 32 through resistor 12, capacitor 15 being shorted. The feed-back signal appears across grid leak 35. Input resistance 36 in circuit with at least part of resistance 19 in shunt with capacitor 16 in proceeding to grid leak 35,

and signal at grid 32 is thus reduced, i.e. cut exists. On the other hand, if contacts 21, 22 are moved to the left, resistance 19 and capacitor 15 in shunt therewith are moved into the feedback path, while the direct signal path consists of resistances 36, 35, capacitor 16 being by-passed.

It follows that full feedback is available for all positions of contacts 21, 22 on one side of center, and a variable impedance is introduced between resistances 35, 36, or, for the other side, resistances 35, 36 are always directly in series with zero interposed impedance, while the feedback path is of variable impedance.

FIGURE 3 illustrates a passive treble tone control. Signal is supplied from input terminal 40. Connected between input terminal 40 and ground is a tone control network consisting of capacitor 43, resistance 44, gap 45, resistance 46, capacitor 47. Slider 48 connects to output terminal 49 and can move over the resistances 44, 46, gap 45 constituting its central position. Resistances 50a, 50b are connected from terminal 40 to output terminal 49 to ground, to provide a through circuit with fixed attenuation at all times.

When slider 48 is at gap 45 the shunt path, through the tone control capacitors is totally disabled and circuit response is flat. When slider 48 rides on resistance 44, resistance 46 and capacitor 47 are inactive and capacitor 43 provides boost by removing attenuation at high frequencies. When slider 48 is on resistance 46, resistance 44 and capacitor 43 are inactive, and capacitor 47 provides cut by increasing high frequency attenuation.

FIGURE 4 illustrates a multi-stage feed-back circuit, including both treble and bass tone control circuitry, in accordance with the present invention. The circuitry generally is that of U.S. patent to D. Hafler, No. 3,059,190, but introduces the specific tone control circuitry and potentiometers of FIGURES 1 to 5a, inclusive of this application.

In FIGURE 4, input signal is applied to terminal 10, which is connected directly to the control grid 52 of triode 53. The latter includes anode 54 and cathode 55, supplied, respectively, in conventional fashion with an anode load resistance 56 and an unbypassed cathode resistance 57. The anode 54 is RC coupled, via series capacitor 58 and grid leak resistance 59 to the grid 60 of a second triode 61. The latter includes an anode 62 and a cathode 63, supplied respectively, in conventional fashion with an anode load resistance 64 and an unbypassed cathode resistance 65.

The anode 62 is connected back to the cathode 55, via a tone control circuit 66, comprising a bass section 67 and a treble section 68, corresponding respectively to the circuits of FIGURES 1 and 3, but in a feedback arrangement. Accordingly, corresponding parts of FIGURES 1 and 3 on the one hand, and FIGURE 4 on the other hand, are identified by corresponding reference numerals; and the tone control circuitry, as in the Hafler patent, subsists in the feedback path of a two-stage amplifier.

Considering first the treble tone control circuitry, input thereto is essentially at point 41. With slider 48 at gap 45, tone control circuit 68 is disabled and feedback signal proceeds via resistances 42 and 57 to ground. Treble response is then flat.

When slider 48 contacts resistance 44, a frequency sensitive shunt path exists around resistance 42, which increases feed-back and results in treble cut. When slider 48 contacts resistance 46, cathode resistance 57 is shunted by a frequency sensitive path, resulting in decreased feedback voltage at cathode 55, and hence treble boost.

Input to bass tone control circuit 67 is at terminal 17, mid-way of capacitors 15, 16. With slider 22 contacting zero resistance sections 20 and 18, capacitors 15 and 16 are shorted, and signal proceeds directly to load resistors 13 in one direction and through feedback resistor 42 in the other direction. Tone control action results from varia-

tion of resistance 19, shunting capacitor 15, in the feedback path of the amplifier, and hence provides variable boost, i.e. less feedback at low frequencies as more resistance is brought into circuit. With slider 22 moving over resistance 19, on the other hand, capacitor 15 is shorted and variable impedance introduced into series with load resistance 30, thus providing variable cut. In the case of both cut and boost, only one type of control subsists at any one time, and with sliders 21, 22 in central position, i.e. both on zero resistance sections of the potentiometer, both capacitors 15, 16 are shorted, and response is flat.

In FIGURE 5 is illustrated an exemplary physical embodiment of a bass tone control potentiometer according to the invention, wherein the sliders 21, 22 are mounted for simultaneous physical rotation of the same amounts, on rotation of knob 70. The physical length of resistive section 19 is at least as great as the lengths of zero (or near zero) resistance sections 18 and 20, and the central position of knob 70 finds both sliders 21 and 22 on sections 18 and 20. Knob 70 may thus move 120° clockwise, or 120° counterclockwise, from its mid position, in normal operation of the potentiometer.

In FIGURE 5a, which is an analog of FIGURE 5, sliders 21a, 22a are mounted for translation and the resistances 18a, 19a and 20a are physically linear, corresponding parts in FIGURE 5 and FIGURE 5a being differentiated by inclusion of subscript a in FIGURE 5a.

In the system of FIGURE 6, 100 is a signal input terminal, and is connected to the base 101 of an NPN transistor T₁, having an emitter 102 and a collector 103. The latter is connected to the ground through a load resistance R₇ and also directly to the base 104 of PNP transistor T₂ having an emitter 104 and a collector 105. The latter provides output signal to an output load R₁.

A negative supply terminal 107 is provided, which is connected via a collector load resistance R₆. The latter is connected back to emitter 102 via a resistance R₄, which provides a DC path, as well as an AC path. Connected between emitter 102 and terminal 107 is a pair of series resistances R₃, R₅, of which R₅ is by-passed for AC by capacitor C₅ and also is larger than R₃, which is not by-passed.

The resistances R₃, R₅ provide DC feedback, while, due to by-pass capacitor C₅, only resistance R₃ provides AC feedback. The recited circuitry provides large DC feedback and much smaller AC feedback and it has been found that as a result temperature stabilization holds from 0° to 100° with silicon transistors, and that substitution of transistors, even of different types, makes little difference. DC feedback, in the circuit of FIGURE 6, may be 100% or near that value. AC feedback can be any percentage which is found desirable for a given application, and the two can be independently adjusted or designed into the circuit. The system tends to hold the DC potential of emitter 102 at some fixed percentage of the potential of collector 105. This implies that transistor T₁ operates at a lower potential than does T₂, but this is desirable because T₁ operates at smaller AC levels.

The transistors T₁ and T₂ are direct coupled, in the forward direction, which implies that T₁ should operate at a lower DC level than T₂. The present system inherently drops the operating level of T₁ because the feedback circuit provides a steady drop across R₅. There occurs, accordingly, a double advantage, in that the same circuit which provides DC feedback enables setting of the DC levels of T₁ at optimum.

The system of FIGURE 7 is similar to that of FIGURE 6 except that a second feedback resistance R₈ is connected between collector 105 and the junction 108 of resistances R₃ and R₅. Resistance R₅ provides only DC feedback, since capacitor C₅ ground it for AC. Resistance R₈ accordingly supplements the DC feedback in any event available. Its inclusion introduces flexibility of design, i.e. selection of AC and DC feedback fractions. R₄, R₃, alone still determines AC feedback. But DC feedback via

R_6 is independent of R_3 , while DC feedback via R_4 is a function of R_3 .

The system of FIGURES 6 and 7 can be extended to a three transistor system, provided that the third transistor in cascade, T_3 , is complementary to T_2 , i.e. is NPN if T_2 is PNP. Feedback now occurs from emitter 111 of T_3 , T_2 having introduced the required phase reversal to provide correct phasing for rejective feedback.

It is evident that R_5 and C_5 can be replaced by a Zener diode or similar device which provides high DC and low AC impedance thus permitting different percentages of DC and AC feedback.

The system of FIGURE 6, specifically, is employed in the tone controlled amplifier of FIGURE 10, having both treble and bass tone control features. The same reference numerals are applied to corresponding parts of FIGURES 6 and 10. Additionally, the system of FIGURE 10 employs the tone control circuitry of FIGURE 4, and in respect to tone control circuitry FIGURES 4 and 10 employ the same reference numerals for corresponding parts.

In FIGURE 10, resistance R_{10} and R_{11} extend from negative voltage supply terminal to ground, and act on a voltage divider to set the bias for the base electrode 101 of transistor T_1 . Transistor T_2 is directly connected at its base electrode to collector 103 of T_1 so that the voltage at collector 103 becomes one aspect of the bias voltage of transistor T_2 . Since this value may be unsuitable, an RC/DC bias circuit B is provided at the emitter of T_2 , permitting the correct total DC bias to develop.

Feedback signal for the bass cut and boost is derived from collector 105 of T_2 and fed to junction 17, which parallels the situation in FIGURE 4. Terminal 41 of bass tone control circuit 67 then is connected via resistance R_2 to emitter 102 of T_1 . Capacitor 16 and resistance 13 control bass cut by increasing low frequency attenuation. Capacitor 15 and resistance R_2 control bass boost by decreasing low frequency feedback.

Resistance R_8 provides DC feedback alone since it connects the collector 105 of T_2 to an AC ground provided by capacitor C_5 . The terminal 41 supplies AC voltage to terminal 110, which supplies DC signal to treble control circuit 68, comprising capacitor 43, resistor 44, gap 45, resistor 46 and capacitor 47, all in series. The treble control circuit controls treble cut and boost generally as in FIGURE 4, wherefore further discussion is dispensed with, except for the comment that resistance R_3 and capacitor C_3 are involved in treble boost by removing high frequency feedback, while resistance R_2 and capacitor C_4 are involved in controlling treble cut by increasing high frequency feedback, as slider 48 is moved. With slider 48 on gap 45 the entire treble control circuit 68 is disabled and feedback signal proceeds from terminal 41 via resistances R_2 and R_3 to AC ground at capacitor C_5 . Treble response is then flat, and fixed non-discriminating feedback is set by relative values of R_2 , R_3 , which act as a voltage divider. With the treble control circuit active, the latter shunts resistance R_2 when contact 48 is moved down on resistance 44, thus increasing feedback and controlling cut, and by shunting R_3 when moved up on resistance 46 to by-pass feedback current, thus controlling boost.

The system of FIGURE 9 discloses a complete treble and bass passive tone control system, and includes essentially the passive treble control circuit of FIGURE 3, and the passive bass control circuit of FIGURE 1, connected in parallel, with common input terminal 40 and output terminal 49, and employing independent sliders 48, for treble control, and 21, 22 for bass control, electrically connected together and to output terminal 49. Corresponding parts in the several figures are identified by the same reference numerals, and since operation of the separate treble and bass tone control circuits have been fully described hereinbefore, the description is not repeated.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations

of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A bass tone control circuit, including a bass tone control capacitor, a second bass tone control capacitor, a lead extending from the junction of said capacitor, a potentiometer shunting said capacitors, said potentiometer including in the order stated a section of negligible resistance, a section of high resistance, and a section of negligible resistance, said sections of negligible resistance having physical lengths at least as great as the physical lengths of said section of high resistance, a pair of slider contacts, said pair of slider contacts having a fixed spacing as great as the physical length of said section of high resistance, means connecting said sliders directly together and to said lead, and means for moving said slider over the length of said potentiometer, whereby for one position of said sliders, both said capacitors are short circuited and for all other positions of said sliders only one of said capacitors at a time is short circuited.

2. The combination according to claim 1, wherein said lead is a signal input lead, one of the outer terminals of said potentiometer is a feedback lead, and the other outer terminal of said potentiometer is an output lead.

3. The combination according to claim 2 wherein is included an amplifier having a feedback path, a load circuit for said amplifier, said amplifier including a feedback path having an input terminal and an output terminal, means connecting said lead to said feedback path input terminal, means connecting one of said outer terminals to said load circuit and means connecting the other outer terminal to the output terminal of said feedback path.

4. The combination according to claim 1 wherein said lead is a signal output lead.

5. A treble tone control circuit, including a first terminal, a second terminal, a relatively high resistance connected between said terminals, and a shunt channel to ground extending from one of said terminals, said shunt channel to ground including in the order named, a first treble control capacitor, a first treble tone control resistor, a gap, a second treble tone control resistor, a second treble control capacitor, a slider selectively and at will movable over said resistors and locatable in said gap, and a connection from said slider to the other of said terminals.

6. A tone control system for amplifier comprising a frequency selective circuit for introducing boost, a frequency selective circuit for introducing cut, a single potentiometer having a manual positionable control, said potentiometer including means operative in one position of said control for disabling both said frequency selective circuits, and means operative in alternate positions of said positional control with respect to said one position for disabling alternate ones of said frequency selective circuits and enabling the other, and means for applying signal to and deriving tone controlled signal from said frequency selective circuit.

7. The combination according to claim 6 wherein said frequency selective circuits are bass tone control circuits.

8. The combination according to claim 6 wherein said frequency selective circuits are treble tone control circuits.

9. A transistor amplifier comprising, a first transistor having a first base, emitter and collector, a second transistor of type complementary to said first transistor having a second base, emitter and collector, a first resistive AC loading extending from said first collector to a point of reference potential, a DC path of negligible resistance extending from said first collector to said second base, means connecting said second emitter to said point of reference potential, a load resistance connected in series with said second collector, a feedback path extending from said second collector to said first emitter, and power supply terminal, and a circuit in series between said power sup-

ply terminal and said first emitter, said circuit including a relatively small AC unbypassed resistance and a relatively large AC bypassed resistance in series.

10. The combination according to claim 9 wherein is further provided a resistive path extending between said second collector and the junction of said last mentioned resistances.

11. A transistor amplifier comprising, a first transistor having a first base, emitter and collector, a second transistor of complementary characteristics having a second base, emitter and collector, a first resistive AC load extending from said first collector to a point of reference potential, a DC path of negligible resistance extending from said first collector to said second base, means connecting said second emitter to said point of reference potential, a load resistance connected in series with said second collector, a feedback path extending from said second collector to said first emitter, and power supply terminal, and a circuit in series between said power supply terminal and said first emitter, said circuit including two sections in series one of which has equal DC and AC impedance, the other having high DC and low AC impedance.

12. A transistor amplifier, comprising a first transistor having first base, emitter and collector electrodes, a second transistor having second base, emitter and collector electrodes, said first and second transistors being complementary types, a voltage supply terminal, a load resistance connected between said first collector electrode and ground, a lead connecting said first collector electrode and said second base electrode, a purely resistive path connecting said second collector electrode and said first emitter electrode, and an AC by-pass capacitor and a relatively large shunt resistance connecting a point of said path to said voltage supply terminal, said shunt resistance having a sufficiently high value to provide large DC feedback, and an AC feedback path extending from said second collector electrode to said first emitter electrode, wherein a path from said first emitter electrode to said voltage supply terminal includes a relatively low unbypassed AC feedback resistance and said by-pass capacitor and shunt resistance in a series circuit.

13. The combination according to claim 12 wherein is provided an output load coupled to said second collector electrode, and a selective base attenuation circuit connected between said second collector electrode and said output load, and wherein is further provided a further selective bass augmentation circuit connected in said AC feedback path.

14. The combination according to claim 12 wherein is further provided a treble tone control circuit in said AC feedback path, said treble tone control circuit including means for selectively shunting said AC feedback resistance for treble frequencies, and for selectively introducing treble attenuation in series with said AC feedback path.

15. The combination according to claim 14 wherein said treble tone control circuit is a potentiometer tone control circuit including a disabling position for eliminating said treble tone control circuit from said amplifier.

16. An attenuation circuit, comprising a first resistance, a second resistance in series with said first resistance, a potentiometer including physically and electrically in series a first section, a gap, a second section and a single slider movable over said sections and said gap, means connecting said slider to the junction of said resistances, means connecting said slider and one of said sections in series across one of said resistances, and means connecting said slider and other of said sections across the other of said resistances, whereby for the position of said slider at said gap said resistances are unshunted, and for all other positions of said slider only one of said resistances is shunted by only one of said sections.

17. A transistor amplifier comprising a drive transistor, an output transistor, means providing a DC drive path coupling said transistors in cascade, a DC feedback path coupling said transistors for DC, said DC feedback path including in series an AC by-passed resistance arranged and adapted to develop more than 50% DC feedback signal at said drive transistor and an AC feedback path for said amplifier arranged to provide a relatively small AC feedback signal at said drive transistor, wherein said AC feedback path includes a treble and a bass tone control circuit.

18. A treble tone control circuit, including a control potentiometer circuit, said tone control circuit including a tone signal input terminal, a tone signal output terminal, and circuit means connecting said tone signal input terminal to said tone signal output terminal, means connecting said control potentiometer circuit between said circuit means and a reference point, wherein said potentiometer circuit includes a first tone control capacitor, a first tone control resistance, a gap, a second tone control resistance and a second tone control capacitor, a slider movable selectively over said resistances individually and into said gap, and means connecting said slider to said circuit, whereby when said slider is in said gap said tone control potentiometer circuit is disabled.

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ROY LAKE, *Primary Examiner.*

SIEGFRIED H. GRIMM, *Assistant Examiner.*

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