Dec. 22, 1936. H. D. NEWTON 2,065,344

CONTROL MEANS FOR SIGNAL CONTROL TRANSMISSION SYSTEMS

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Fig. 1.

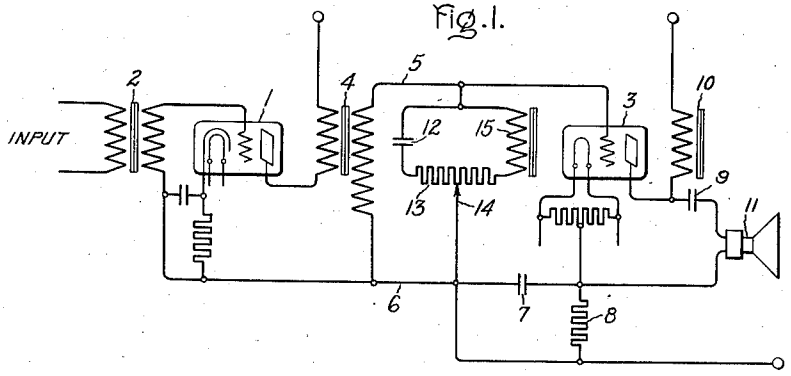


Fig. 2.

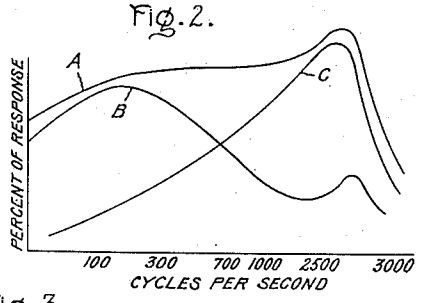


Fig. 3.

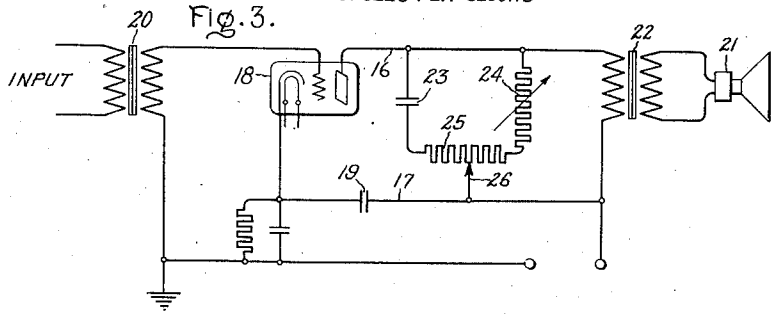
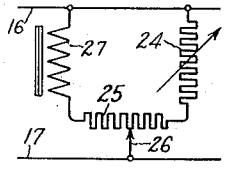


Fig. 4.



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CONTROL MEANS FOR SIGNAL CONTROL TRANSMISSION SYSTEMS

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8 Claims. (Cl. 179—1)

The present invention relates to means for varying the frequency response characteristic of an electric signal transmission system, whereby signals transmitted therethrough may be attenuated within desired and variable frequency ranges.

Means for varying the frequency response characteristic of signal transmission systems are well known and at present are applied generally to audio frequency amplifiers as tone control means adapted to accentuate the amplification in selected portions of the audio frequency response range of such amplifiers. For this reason the present invention will be herein described by way of example, more particularly in its application to audio frequency amplifiers, although it is not necessarily limited thereto.

In the usual audio frequency amplifying system, the tone control means include circuit networks and circuit elements therein for effecting within limits a desired change in, or adjustment of, the sound frequency transmission or audio frequency response characteristics of the system, whereby the electrical or sound output therefrom may be modified in accordance with a predetermined frequency response characteristic curve to produce a pleasing tone quality from a suitable output device.

In radio receiving apparatus, the tone control arrangement in connection with an audio frequency amplifier is such that the audio frequency signals from a sound producing device, such as a loud speaker, for example, are increased or decreased within certain portions of the audio frequency range, whereby the reproduced sound may be made pleasing to the ear under various conditions of reception.

Tone control systems heretofore employed in radio receiving apparatus and the like are characterized by the fact that only a limited range of operation is usually obtainable, or when arranged for a wide range of audio frequency tone compensation, require a plurality of control devices.

It is, therefore, a primary object of this invention to provide an improved frequency responsive tone control system having a relatively wide range of control. It is a further object of this invention to provide an improved audio frequency tone control system which embodies a simple circuit and a minimum number of circuit elements, and which may be applied to existing signal transmission systems at low cost.

It is a still further object of the present invention to provide an improved control circuit for a signal transmission system, whereby the frequency response characteristic of said system may be varied between wide limits and by a single control means.

It is a common characteristic of known frequency response control systems, that attenuation of or change in the frequency response characteristic of the system is accompanied by a change in the apparent overall output volume as registered by the listening ear. In certain other cases, there may be an actual change in the amplitude of the signals transmitted through the system to which the tone control means is applied, as the tone control means is varied. For example, certain known forms of tone control means having a tone control adjustment whereby the high frequency end of the audio frequency range is attenuated to a greater extent than the middle and lower frequency ranges, provided also a noticeable accompanying reduction in the apparent volume of the signal as reproduced by a suitable output device.

It has been found, however, that a frequency response control system embodying the invention, substantially entirely obviates the above described undesirable characteristics of tone control means heretofore employed, whereby the frequency response characteristic of the system to which it is applied may be varied without appreciably affecting the overall amplitude of signal waves transmitted through said system.

In accordance with the invention, a wide range of tone control is obtained by providing in connection with an audio frequency transmission circuit or channel, means providing shunt paths having impedance values so related to each other and to that of said transmission circuit or channel, that each is adapted to attenuate signals in a selected audio frequency range, with substantially equal individual shunting effect on the circuit, and by providing a control means having substantially no frequency response characteristic arranged to increase gradually the controlling effect of the one shunt path while decreasing the controlling effect of the other.

By properly relating the circuit impedance values of the controlling means, the transmission circuit and the attenuating means, it has been found that the control may be effected throughout the frequency range with substantially constant signal amplitude or constant volume of the sound output.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional

objects and advantages thereof, will best be understood from the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a circuit diagram showing a portion of the signal transmission circuit of an audio frequency amplifier provided with a tone control system embodying the invention; Fig. 2 shows curves illustrating certain operating characteristics of the amplifier shown in Fig. 1; Fig. 3 is a circuit diagram showing a modification of the tone control system of Fig. 1; and Fig. 4 shows a detail modification of the circuit shown in Fig. 3.

Referring to Fig. 1, an electron discharge amplifier device 1 is coupled to a suitable source of audio frequency currents represented by a suitable input transformer 2. The electron discharge device 1 is connected to a second electron discharge amplifier device 3 through a suitable signal transmission circuit, which in the present example includes an audio frequency interstage coupling transformer 4, having an output lead 5 which is connected to the grid of the electron discharge device 3, and a return lead 6 which is connected to the cathode of the electron discharge device 3 through a by-pass capacitor 7. The grid of the electron discharge device 3 is biased by a potential derived from a suitable source such as a resistor 8. An output choke coil 10 and a coupling capacitor 9 are arranged in the output or anode circuit of the device 3 to supply output signals to a suitable translating device such as a loudspeaker 11. Any suitable output circuit may however be employed to couple the tube 3 to the loudspeaker. The loudspeaker 11 represents any suitable sound producing device which may be connected in the output circuit of the discharge device 3 for receiving the signals and for converting them into audible sounds. In the present example, audio frequency signals supplied by the input device 2 are amplified by the electron discharge device 1 and are transmitted through the transformer 4 and the transmission circuit 5, 6 to the electron discharge device 3.

Connected in shunt with the signal transmission circuit 5—6 is a circuit network, or tone control system, including means for variably attenuating a portion of the frequency range of signals to be transmitted by said circuit. In the present example this includes an impedance device 12, the impedance of which varies with the frequency of the applied currents, and which may comprise a fixed capacitor having low capacity connected with the transmission circuit, preferably at the high potential side 5, and a series variable resistance provided by a potentiometer 13, the movable contact 14 of which is preferably connected with the low potential side 6 of the transmission circuit, all as indicated.

It will be seen that variation of the series resistance by operating the movable arm or contact 14 along the resistor element of the potentiometer 13 will cause the effectiveness of the impedance device or shunt capacity provided by the condenser 12, to be varied. When the movable contact 14 is moved to a position adjacent to or at one terminal to which the capacitor 12 is connected, it will be seen that the latter is most effective in providing a shunt path across the transmission circuit and serves to attenuate signals above a certain predetermined frequency depending upon its capacity value and its relative shunt impedance value in the circuit 5—6.

The capacitor 12 may have a capacitance such that its impedance to higher audio frequency signals is relatively low with respect to that of the transmission circuit impedance within that range, and the potentiometer 13 or its equivalent resistance, may have a maximum impedance value such that when fully in circuit with the capacitor 12, the effectiveness of the latter as a circuit shunting means is substantially nil. The network or system whereby a desired change in the tone or frequency transmission characteristic of a circuit without appreciably changing the resistance load of the transmission circuit, or the volume or amplitude of the signals transmitted therethrough may be effected is completed by an impedance, in the present example, an inductor 15, connected in shunt across the signal transmission circuit 5—6, also through the potentiometer means 13, and, through said potentiometer means, in shunt also with the reactance device 12. The effect of this circuit arrangement is to provide a substantially constant shunt resistance load, but having an adjustable impedance, across the signal transmission circuit 5—6 at all times.

The tone control means or circuit thus provided operates to attenuate signals in the higher frequency range when the adjustable contact 14 of the potentiometer is moved toward the left in the direction of the capacitor 12, and operates to attenuate signals in the lower frequency range when the contact 14 is moved toward the right in the direction of the inductor 15; while in the intermediate positions substantially equal parallel paths are provided which attenuate only in some degree signals in both the high and low frequency ranges. The attenuation of the high or low frequency signals is due to the change in the effectiveness of the shunt impedance 15 and the capacitor 12 when the potentiometer arm 14 is shifted to the right or left of the intermediate position.

This tone control means or network may be connected across either of the windings of the transformer 4 by properly proportioning the component parts thereof in accordance with the circuit in which it is to be used. The tone control means now includes a circuit providing a high frequency path and a low frequency path connected together by an element having no frequency characteristic. The impedance values in each shunt path are preferably such that each path provides the same resistance load on the transmission circuit whereby the change from the one to the other by operation of the potentiometer device 13 produces no appreciable change in the overall apparent output volume of signals delivered from the system. The resistance of the potentiometer 13 is of a value which permits but a slight amplitude reduction in the normal frequency characteristic of the transformer or signal channel when the adjustable contact 15 is at the midpoint on the potentiometer 13.

Reference may now be made to Fig. 2 which shows a response curve in which per cent of response is plotted against frequency in cycles per second. Curve A illustrates the frequency characteristic of the amplifier shown in Fig. 1 as measured across the circuit 5—3 of the secondary winding of the transformer 4 without the tone control means. Curve B shows the attenuation of the treble or high frequency signals when the potentiometer arm 14 is at the left extremity of the potentiometer. Curve C illustrates the attenuation of the base or low frequency signals when

the potentiometer arm 14 is at the right extremity of the potentiometer.

Referring to Fig. 3 which illustrates a modification of my invention, 16 and 17 are circuit leads representing the high and low potential sides or leads respectively, of a signal transmission circuit, which in the present example is the audio requency output or anode circuit of an electric discharge amplifier device 18, the lead 16 being the high potential or anode lead, and the lead 17 being the audio frequency circuit cathode return lead. The lead 17 includes a suitable by-pass capacitor 19 whereby the signal current flowing therein may return to the device 18. Audio frequency signals are applied to device 18 through a suitable input or coupling device 20 and the output of transmission circuit 16—17 is connected with output translating device 21 through a suitable coupling device 22.

In the present example, audio frequency signals applied through the transformer 20 are amplified by the electron discharge device 18 and are transmitted to the translating device 21 through the transmission circuit 16—17 and the coupling device 22. Any suitable audio frequency response means may be connected to the transformer 22 such as a sound producing device 21 shown in connection with said transformer for receiving the signal output from the transmission circuit 16—17 and for converting the same into audible sounds. This device may be preceded by any desired degree of amplification, as is well understood. Further description of the amplifier circuit is believed to be unnecessary as it represents any suitable signal transmission circuit and is included in an audio frequency amplifier only by way of example as adapted also to this modification of the invention.

The signal transmission circuit 16—17 is provided with a tone control network or means including an impedance device 23, the impedance of which varies with the frequency of the applied currents and a second impedance member 24 having no frequency characteristic, all connected with one side of the transmission circuit 16, and a potentiometer 25 arranged therebetween and having a movable contact 26 connected to the other side of the transmission circuit 17. As the movable contact arm 26 is moved to the right to include resistance in circuit with the attenuating device 23, it causes resistance to be removed from circuit with the resistor 24 until finally the resistor 24 is connected in shunt with the transmission circuit 16—17 and the attenuating device 23 is rendered ineffective. Likewise, when the potentiometer arm is moved to the left to the opposite position at the other extreme end of the potentiometer element the resistor 24 is rendered substantially ineffective as a shunt means across the circuit while the device 23 is fully effective.

The resistor 24 is of such a value that it may provide across the circuit 16—17 substantially the same shunt impedance at all frequencies in the range to be transmitted, as does the device 23 in the range of frequencies to be attenuated

The effect of this circuit arrangement is to provide substantially a constant impedance in shunt across the signal transmission circuit for all positions of the adjustable tone control means, by reason of the fact that the variable resistor 24 is substituted at one end of the control range for the attenuating means 23 at the other end of the control range, while in intermediate positions substantially equal parallel paths are provided which obviously have a lower impedance than either of the paths singly, such paths being composed of the impedance devices 23 and 24 and portions in circuit therewith of the resistance element of the potentiometer element 24.

In order that the signal potential output through the transmission circuit 16—17 may be made substantially constant, or the apparent output volume may be substantially constant, as determined by listening to the output of the sound producing device 21, or be made to vary from such constant output in any desired way, or by way of correction of certain undesired response characteristics, the resistor 24 is made variable, whereby its impedance value may be changed or adjusted with respect to that of the device 23.

With a variable control means of this character, the tone of the output may be varied by adjustment of the contact 26, and the effect of such tone adjustment upon the volume or the apparent volume, as measured by listening to the sound producing device 21, may be adjusted by adjustment of the resistor 24. The resistor 24 may be fixed when once adjusted to a desired value, as determined by measuring the amplitude of the signal response in circuit 16—17 or by listening to or measuring the output of the sound producing device 21.

The resistor is adjusted to a value such that as an impedance device in the signal transmission circuit it is substantially equal to the reactance device in the frequency range for which the reactance device is effective as an attenuating means. The potentiometer is of such total resistance value that by its operation, sufficient resistance may be inserted in circuit with the resistor and the reactance device, whereby either one of said devices may be rendered substantially ineffective in the circuit alternatively.

It should be understood that the frequency response or tone control circuit of the present example is not necessarily limited to any particular range of frequencies, although it is preferably applicable to audio frequencies and in circuit with an audio frequency amplifier substantially as shown, and may be applied across any such audio frequency transmission circuit. Likewise, the tone control system shown may be followed by amplifying means other than the sound producing device 21.

In connection with the attenuation of signals at frequencies in other ranges, any suitable impedance means may be inserted in place of device 23 of Fig. 3. For example, referring to Fig. 4, a choke coil or impedance 27 may be substituted, with or without other change in the circuit. In the present example, no other change is made and the impedance device is connected in circuit with the potentiometer 25 in the same manner as the capacitor 23 in Fig. 3. In this case, however, as is obvious, the choke coil provides a relatively high impedance at the upper or high frequency end of the audio frequency range and a decreasingly lower impedance toward the lower end of the range. Accordingly, when connected by operation of the control contact 26, whereby it is most effective across the circuit 16—17, it serves to attenuate the lower frequency end of the audio frequency range.

From the foregoing description it will be seen that in accordance with the invention, and as a preferred embodiment thereof, a tone control system embodying the invention includes a reactance device or circuit impedance device having an impedance which varies with variations in the frequency of currents which are caused to pass

through it, and such device is connected with a signal transmission channel substantially in parallel with a second impedance device. The effective impedance values reduced to terms of load resistances are equal but in different frequency ranges whereby they are controllable by a common potentiometer means having no frequency characteristic, thereby maintaining substantially a constant load on the signal transmission circuit.

My invention provides a tone control for accentuating the amplification of any selected range of frequencies with substantially constant load and volume output therefore irrespective of the adjustment of the control.

While I have shown a particular embodiment of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications, both in the circuit arrangement and in the instrumentalities employed, may be made without departing from the spirit and scope of my invention as set forth in the appended claims.

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

1. In combination, a signal transmission circuit, means to transmit through said circuit audio currents extending over a wide range including high audio tones and low audio tones, a tone control network effective over said wide range and predominately effective in the ranges of said high and low tones, said network comprising a resistance, one point of said resistance being connected to one side of said circuit through an impedance which is high to low tones and low to high tones, and another point on said resistance being connected to the same side of said circuit through an impedance which is low to low tones and high to high tones, and a connection from the other side of said circuit to a point on said resistance variable between said first points whereby as said connection is varied along said resistance opposite effects are produced upon said high and low tones.

2. In combination, a signal transmission circuit, means to transmit through said circuit audio currents extending over a wide range including high audio tones and low audio tones, a tone control network effective over said wide range and predominately effective in the ranges of said high and low tones, said network comprising a resistance, one point of said resistance being connected to one side of said circuit through a capacitance having high impedance to said low tones and low impedance to said high tones and another point on said resistance being connected to the same side of said circuit through an inductance having low impedance to said low tones and high impedance to said high tones, both said inductance and capacitance having values of impedance varying oppositely with respect to frequency in said frequency range between said high and low tones, and a connection from the other side of said circuit to a point on said resistance variable between said first points whereby as said connection is varied along said resistance the frequency attenuation characteristic of said circuit is correspondingly varied, said variation occurring throughout said range and in opposite senses with respect to frequency.

3. The combination with an audio frequency transmission circuit, of a tone control network connected thereto, said network including a resistor potentiometer having a movable contact, a frequency responsive impedance device connected between one end of said potentiometer and one side of said circuit, a second impedance connected between the other end of said potentiometer and the same side of said circuit, and means connecting said movable contact of said potentiometer and said impedances to the opposite side of said circuit, said impedances being of such character that said potentiometer operates as a variable control means for said tone control network while maintaining the effective ohmic load of said network substantially constant.

4. An audio frequency signal transmission circuit including input and output circuits, a tone control circuit connected across one of said circuits for by-passing selected audio frequency energy including an inductive reactance in one path, a capacitive reactance in another path, and a potentiometer having a single movable contact arranged for selectively proportioning the effectiveness of said paths in accordance with the position of the single movable contact of said potentiometer thereby operates selectively to attenuate the signals in different frequency ranges dependent upon the position of said single movable contact while maintaining a constant ohmic load upon said transmission circuit.

5. The combination with an audio frequency current transmission circuit of a tone control network connected in shunt thereto, said network including a resistor potentiometer having a movable contact connected to one side of said circuit, a frequency responsive impedance device connected to one end of said potentiometer, a second impedance device having a resistance value equal to said first impedance and being connected to the other end of said potentiometer, both of said impedances being connected to the other side of said circuit, said impedance devices having different impedance frequency characteristics and cooperating with said potentiometer to maintain the total apparent volume of audio frequency current transmitted substantially constant for all of positions of said potentiometer contact.

6. The combination with an audio frequency transmission circuit having a sound producing device, of a tone control network connected thereto, said network including a resistor potentiometer having a movable contact, a frequency responsive impedance device connected between one end of said potentiometer and one side of said circuit, a second impedance having substantially the same ohmic resistance as said first impedance device and being connected between the other end of said potentiometer and said one side of said circuit, and means connecting said movable contact of the potentiometer to the other side of said circuit whereby the potentiometer operates as a variable control means for said tone control network and said impedances cooperate to maintain the apparent volume of said sound reproducing device substantially constant for all adjustments of said potentiometer contact.

7. The combination, in a circuit for transmission of currents representing music, of a tone control network comprising a plurality of impedances including a resistor and a pair of impedances having different frequency characteristics, one terminal of each of said impedances being connected to one side of said circuit and the opposite terminals of said impedances being connected respectively to opposite ends of said resistor, and a connection from a variable point on said resistor to the opposite side of said cir-

cuit, said impedances being of such character that as said variable point is moved along said resistor the tones efficiently transmitted through said circuit are varied while the total volume of reproduced currents is maintained substantially constant.

8. The combination, in a circuit for transmission of currents representing music, of a tone control network comprising a plurality of impedances including a resistor, and a pair of impedances having different frequency characteristics, one terminal of each of said impedances being connected to one side of said circuit and the opposite terminals of said impedances being connected to opposite ends of said resistor, a connection from a variable point on said resistor to the opposite side of said circuit, said impedances being of such character that as said variable point is moved along said resistor the tones efficiently transmitted through said circuit are varied while the total volume of reproduced currents is maintained substantially constant, and means to vary one of said pair of impedances having different frequency characteristics to control the total volume of reproduced currents.

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