June 21, 1938. K. W. JARVIS 2,121,150

TONE CONTROL SYSTEM

Filed June 22, 1934

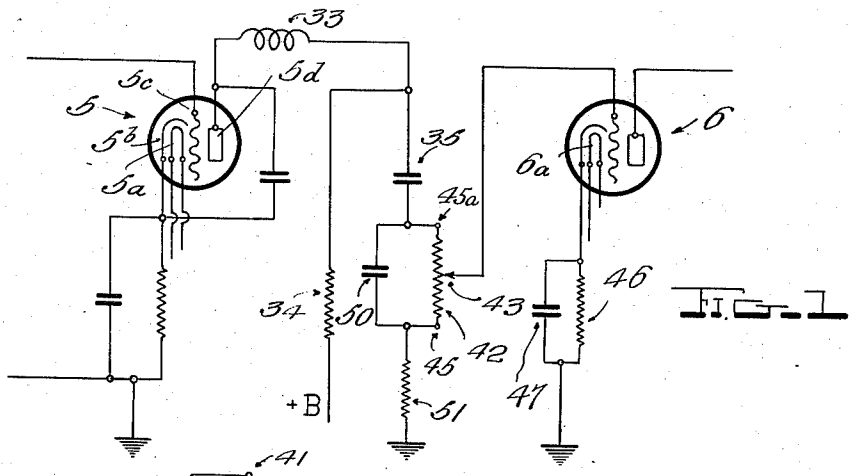


FIG. 1

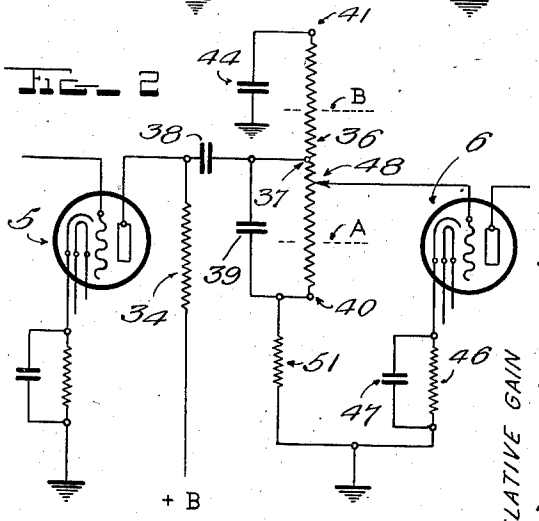
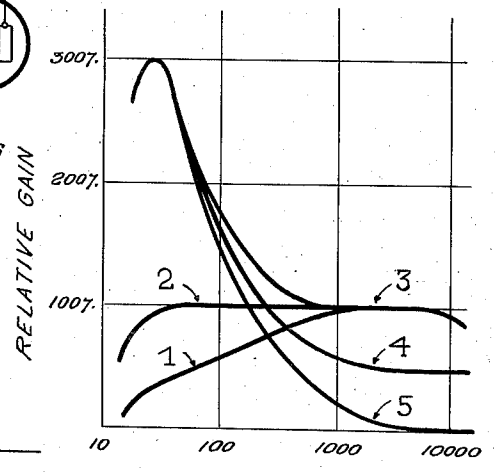


FIG. 2

FIG. 3



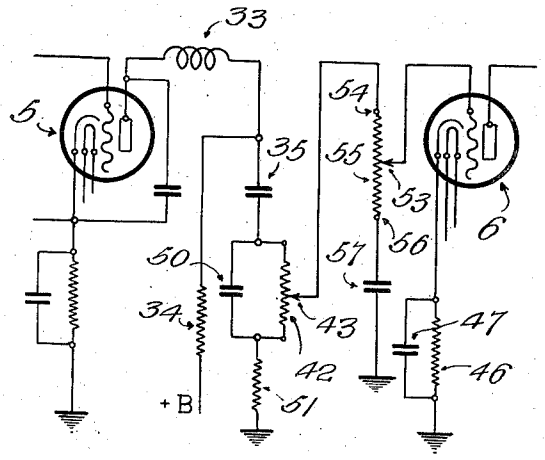


FIG. 4

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TONE CONTROL SYSTEM

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Application June 22, 1934, Serial No. 731,989

6 Claims. (Cl. 179—171)

My invention relates broadly to audio frequency amplification circuits and more particularly to a tone control system for audio frequency amplification circuits.

This application is a continuation-in-part of my application Serial No. 498,150, filed November 25, 1930, and now Patent Number 2,093,393, for Tone control system.

One of the objects of my invention is to provide a circuit arrangement for a tone control system in an audio frequency amplification circuit by which correction can be made of the circuit characteristics according to the character of the musical variation or amplitude of the reproduced sound.

Another object of my invention is to provide an interstage coupling circuit arrangement for audio frequency amplifiers by which different portions of the coupling circuit may be rendered variably selective to the different frequencies which it is desired to transfer from one electron tube circuit to another for controlling the tone of the reproduced sound.

A further object of my invention is to provide a tone control circuit for coupling the output of one electron tube amplifier stage to the input of a succeeding electron tube amplifier stage including a plurality of impedance branches adapted to be selectively adjusted relative to each other for choosing the degree to which each branch adds for determining the characteristics of the energy transferred between the amplifier stages for selectively controlling the tone thereof.

A still further object of my invention is to provide a simplified construction of tone control circuit incorporated as part of the coupling means between the amplification stages of an audio frequency amplification system.

Another object of my invention is to provide an arrangement of resistors operating both as coupling elements between the stages of an audio frequency amplifier and adjustable for transferring varying amounts of electrical energy over a range of normal high frequencies with minimum bass, through a condition of normal bass and normal high frequencies, to a condition of more than normal bass and more than normal high frequencies, through a condition of more than normal bass and less than normal high frequencies, to a condition of normal bass with no high frequencies.

Other and further objects of my invention reside in the arrangement of frequency selection paths between the stages of an audio frequency amplifier adjustable within predetermined limits for controlling the tone of reproduced sound as more fully set forth in the specification hereinafter following by reference to the accompanying drawing, wherein:

Figure 1 diagrammatically illustrates one embodiment of the tone control system of my invention in which the tone control is incorporated as part of the coupling means between the amplification stages; Fig. 2 shows a modified form of tone control circuit for regulating the high and low response obtainable in sound reproducing apparatus employing the circuit of my invention; Fig. 3 shows the characteristic sound response curves obtainable by use of the control circuit of Fig. 2; and Fig. 4 shows a modified tone control circuit used in connection with a conductive coupling circuit in an audio frequency amplification system.

While I have shown my invention herein as applied particularly to radio broadcast receivers it is to be understood that the principles of my invention may also be applied to the circuits of electrical phonographs, public address systems, talking motion picture equipment and other sound reproducing apparatus. In radio receivers the problem of tone control is particularly difficult because of the existing background of static and other noises existent in the sound reproducer. No music can seem to be perfectly reproduced with a background of hiss and noise almost as great in amplitude as the signaling energy, resulting in noise practically as loud as the volume of the music. I have found that an effort to eliminate the high audio frequencies tends to improve the noise condition more rapidly than the quality of the music is depreciated with a net increase in enjoyment. However, there are many other considerations which tend to destroy tone effects, among which I may mention fading, phase shifting, lack of true binaural perception and the presence of harmonic frequencies. The failure of the amplifier circuits to follow a substantially flat characteristic introduces undesired differentiation of note from its normal characteristic. Even though the reproduction may be found faithful at one amplitude, when the amplification is raised it will be found that the tone is changed. In designing the tone control circuit of my invention, I have considered the response characteristics of the circuits under varying conditions and for the production of different sensations of hearing and the sense impressions produced thereby. The sense impressions, or quality of a complex sound wave, are due to the apparent loudness of each com-

ponent frequency. Either a change in loudness or frequency distribution of the sound components will change the sense impression or the apparent quality. This may be due to an actual change in the character of the music, as for example, a piano does not sound like a violin. It may be a change due to an increased energy level which produces, as noted above, a radical change in apparent quality. It is this change in quality which has been one of the most elusive factors in reproducing "perfect" quality.

I have found the tone control system of my invention extremely simple in its manufacture and production and highly efficient in operation. A minimum number of parts are required so that tone control may be effected at relatively slight expense. The network characteristics of the coupling system are modified for determining the sound energy response curve. I employ a construction of tone control which is built into the coupling elements of the audio frequency amplifier. That is to say, the tone control means has a portion thereof serving as a coupling means for the tubes of the audio frequency amplifier system.

Referring to the drawing in more detail, Fig. 1 shows one form of tone control circuit of my invention connected between the output circuit of detector tube **5** and the input circuit of the first stage of audio frequency amplification shown at **6**.

The fact that indirect heater type tubes have been illustrated in the drawing is not intended to limit the application of my invention to audio frequency amplifier circuits including the indirect heater type of tube for it will be understood that any desired type of tube may be employed including the three electrode direct heater type of tube. The heater for tube **5** has been shown at *5a*. The heater for tube **6** is shown at *6a*. The cathode for tube **5** is indicated at *5b* connected to one side of the input circuit. The other side of the input circuit connects to control grid *5c*. Anode *5d* is connected in the output circuit of tube **5** through radio frequency choke coil **33** and coupling resistor **34**. A connection is taken through condenser **35** to one side of the tone control circuit comprising potentiometer **42** and condenser **50**. The opposite side of the tone control circuit connects through coupling resistor **51**, as shown.

The tone control potentiometer shown at **42** also serves as a coupling element between the output circuit of detector tube **5** and the input circuit of amplifier tube **6**. With the tone control tap **43** set at the end **45** of potentiometer **42**, the condenser **50** forms a series reactance having high values at low frequencies and decreasing the low frequency response. When the tap **43** is set on the end *45a* of potentiometer **42**, condenser **50** forms a shunt reactance having high values at low frequencies thereby raising the effective bass response. The apparent volume is maintained approximately constant by the action of the coupling resistance **51**, which in the arrangement shown in Fig. 1, has a value of 5000 ohms. If the condenser **50** in Fig. 1 is replaced by a selected inductance which is opposite in impedance characteristics to the condenser **50**, the connections to the ends **45** and *45a*, as shown, must be reversed, although the principle of operation remains the same. As the inductance is shifted, so far as the tone arm pick-up is concerned, from a series reactance to a shunt reactance, the bass response decreases.

The auxiliary decreasing of high frequencies may be accomplished in a circuit arrangement similar to Fig. 1 by using a special type of potentiometer in lieu of potentiometer **42** having four terminals thereby providing a double unit, as shown more particularly in Fig. 2.

The special type of potentiometer is indicated by reference character **36** with a center tap **37** thereon which connects to the output circuit of the detector tube **5** through coupling condenser **38**. One half of the special potentiometer **36** is shunted by means of condenser **39** which connects between mid-point **37** and end terminal **40** of the special potentiometer **36**. The opposite end **41** of the special potentiometer **36** connects through condenser **44** to ground. The end **40** of the potentiometer **36** connects through coupling resistor **51** to ground and one side of the input circuit of tube **6** through self-biasing resistor **46** shunted by condenser **47**, as shown. Adjustable tap **48** is moved along the special potentiometer **36** for effecting the desired tone control.

Fig. 3 is a chart showing the sound response curves which are obtained for different settings of the adjustable tap **48**. Curve **1** shows the sound response curve when tap **48** is moved to the lowest point on the potentiometer **36** near terminal **40** whereby normal high frequencies are reproduced but with minimum or no bass response.

For a position of tap **48** approximately one-quarter of the way up the potentiometer **36**, as represented for example at A, characteristic curve **2** is obtained showing normal bass response and normal high frequency response. Curve 3 shows the response characteristic when tap **48** is moved to mid-way position of potentiometer **36** substantially corresponding to mid-connection **37** and in which more than normal bass and normal high frequency response is obtained. Curve **4** shows the characteristic obtainable when moving tap **48** three quarters of the distance up potentiometer **36**, such as at position B, by which more than normal bass and less than normal high frequencies are reproduced. Curve **5** shows the response obtained by moving tap **48** all the way up potentiometer **36** to a position adjacent terminal **41** whereby more than normal bass and substantially no high frequencies are reproduced. It will, therefore, be seen that a wide variation in tone response is obtained by adjustment of movable tap **48**.

Fig. 4 shows a form of tone control circuit in which two separate controls are provided at **43** and **53** whereby the tone becomes conformable to every operating requirement. In this arrangement, the potentiometer **42** is connected in the same manner illustrated in Fig. 1 except that the adjustable tap **43** connects to the end **54** of the second potentiometer **55**, the opposite end of which is shown at **56** connected through condenser **57** to ground. Both controls **43** and **53** are independently adjustable for effecting the required tone control.

In the system of my invention, the bass response is varied in relation to that at other frequencies. The low audio frequencies are independently controlled with respect to the other frequencies. Control may be so arranged that as the volume is decreased, the percentage of bass response increases, and as the volume is increased, the percentage of bass response decreases. The characteristics of the coupling networks have definite relations to each other, being

determined from the characteristics of the threshold of audibility curve so that the amplitude above the threshold value of all frequencies shall be in approximately a constant ratio regardless of the initial amplitude chosen for any reference frequency. As clearly shown by curves 1 and 3, the average amplitude of the high frequencies is greater than the minimum bass as secured by adjustment of tap 48 of Fig. 2 to a position near point 40 and is also less than the maximum bass as secured by adjustment of the tap to a position near terminal 37. In other words the proportion of the bass response to the treble response in a reproduced sound may be easily controlled by the operator by a simple adjustment of tap 48.

I have found the tone control system of my invention highly efficient in its operation and practical in its construction. While I have described preferred embodiments of my invention, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

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

1. A tone control circuit for signal receiving systems comprising a multiple stage amplifier, each stage including an electron tube having grid, cathode, and plate electrodes, the output circuit connecting the plate and cathode of the electron tube constituting one of said amplifier stages including a resistor and a potential source, a potentiometer, a connection to a tap on said potentiometer intermediate the opposite ends thereof, said connection including a condenser electrically connected with the aforesaid output circuit, a condenser connected between the aforesaid tap and one end of said potentiometer, a connection between the last mentioned end of said potentiometer and the cathode of the electron tube in the succeeding amplifier stage, a second condenser having one side thereof directly connected to ground and its other side connected to the other end of said potentiometer, and an adjustable tap on said potentiometer, said adjustable tap being connected with the grid of an electron tube in the succeeding amplifier stage.

2. A tone control circuit for signal receiving systems comprising a multiple stage amplifier, each stage including an electron tube having grid, cathode and plate electrodes, a potentiometer system interconnecting the plate of one amplifier stage with the grid of a succeeding amplifier stage, said potentiometer system including a resistance having a capacitative connection between a point intermediate the opposite ends thereof with the plate of one amplifier stage, a condenser having high impedance for currents of low audio frequencies connected between the intermediate point and one end of said resistance, an adjustable tap on said potentiometer connected with the grid electrode of the electron tube in the succeeding amplifier stage, and connections exclusive of and in addition to said potentiometer and said condenser between the opposite ends of said resistance and the cathode of the electron tube in the succeeding amplifier stage.

3. A tone control circuit for signal receiving systems comprising a multiple stage amplifier, each stage including an electron tube having grid, cathode and plate electrodes, input circuits interconnecting said grid and cathode electrodes, an output circuit interconnecting the plate and cathode of the first stage, and a potentiometer system interconnecting the output circuit of said first amplifier stage with the input circuit of the succeeding amplifier stage, said potentiometer system including a resistance having a capacitative connection between a point intermediate the opposite ends thereof with the output circuit of said first amplifier stage, a condenser connected between said intermediate point and one end of said resistance, an adjustable tap on said potentiometer connected with the grid electrode of the electron tube in the succeeding amplifier stage, and connections between the opposite ends of said resistance and the cathode of the electron tube in the succeeding amplifier stage, said connections being exclusive of and additional to said resistance and said condenser, one of said connections including a second condenser and the other of said connections including a resistor, and a resistor shunted by a condenser common to both of said connections.

4. A tone control circuit for signal receiving systems comprising a multiple stage amplifier, each stage including an electron tube having grid, cathode and plate electrodes, input and output circuits interconnecting said cathode and grid and said cathode and plate electrodes respectively, and a potentiometer system interconnecting the output circuit of one amplifier stage with the input circuit of a succeeding amplifier stage, said potentiometer system including a resistance having a capacitative connection between a point intermediate the opposite ends thereof with the output circuit of one amplifier stage, an adjustable tap on said potentiometer connected with the grid electrode of the electron tube in the succeeding amplifier stage, a capacitative connection between one end of said resistance and the cathode of the electron tube in the succeeding amplifier stage and a conductive connection between the other end of said resistance and the cathode of the electron tube in the succeeding amplifier stage, and a condenser connected between the intermediate point on said resistance and the end of said resistance which is conductively connected with the cathode of the electron tube in the succeeding amplifier stage.

5. A tone control device comprising the combination of a resistor, means for impressing audio frequency potentials covering a band of frequencies on an intermediate point of said resistor, a vacuum tube amplifier having a cathode, grid and plate, an output circuit connected to said plate, a connection between said cathode and ground, a tap adjustable along said resistor and connected to said grid, a second resistor connected between the lower end of said first named resistor and ground and a condenser having one side directly connected to the upper end of said resistor and its other side directly connected to ground.

6. A tone control device according to claim 5 in which said condenser has a low impedance to audio frequency currents in the upper portion of the band of frequencies.

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