Oct. 18, 1938. P. F. G. HOLST 2,133,816

TONE CONTROL SYSTEM

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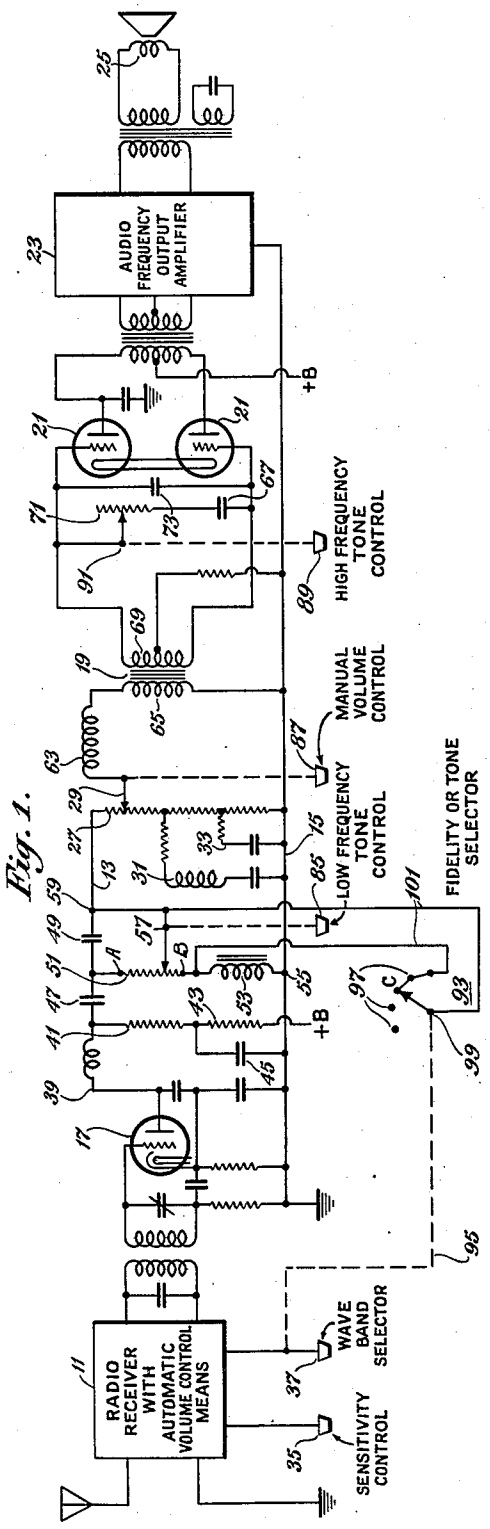


Fig. 1.

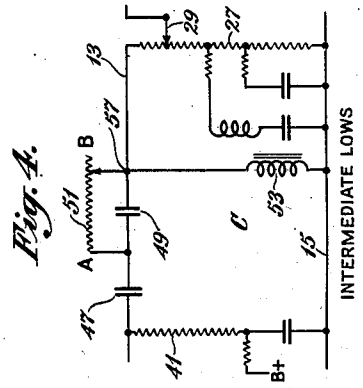


Fig. 4.

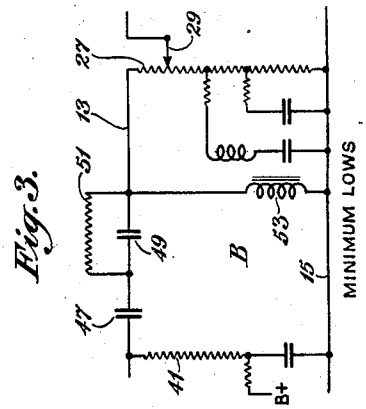


Fig. 3.

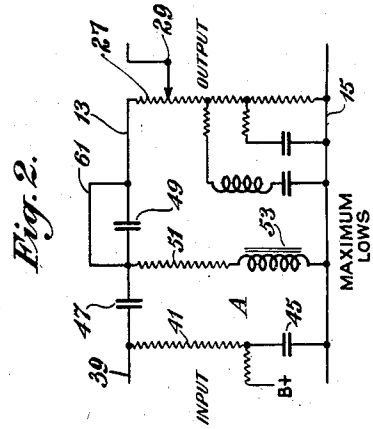


Fig. 2.

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Fig. 5.

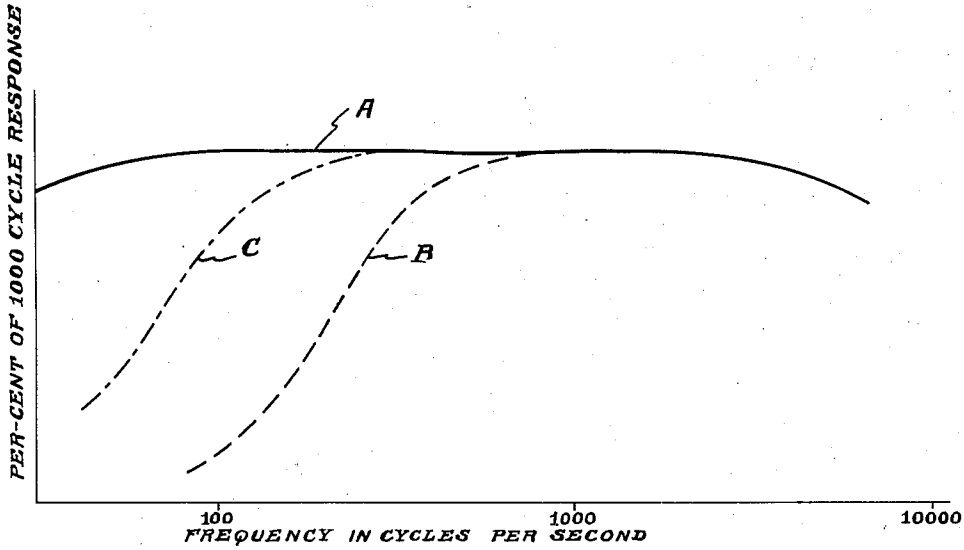
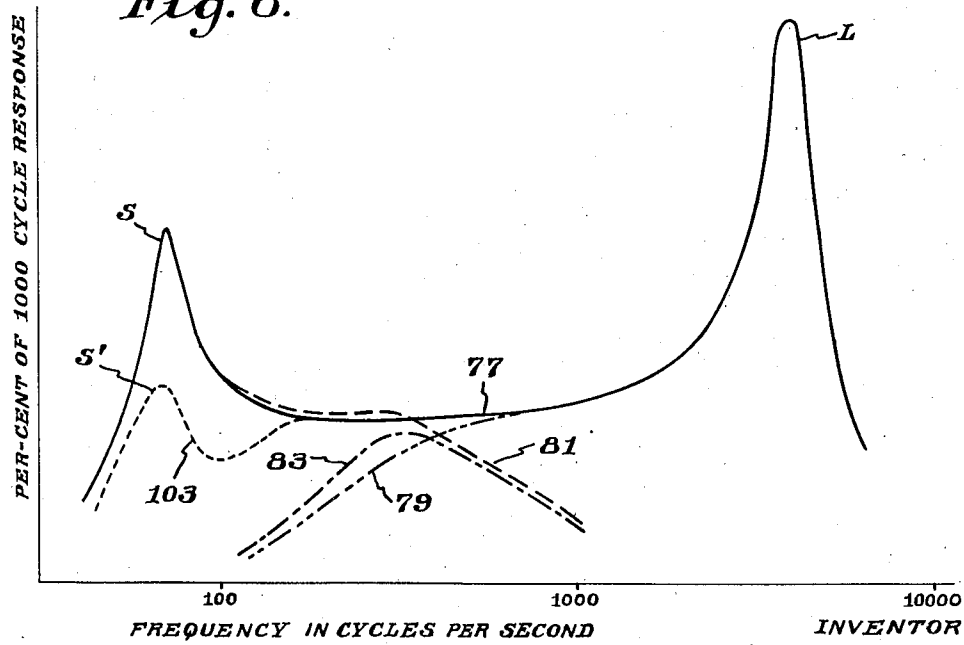


Fig. 6.



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TONE CONTROL SYSTEM

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Application December 21, 1934, Serial No. 758,602

7 Claims. (Cl. 250—20)

The present invention relates to tone control systems for radio receiving apparatus and the like, and has for its principal object to provide an improved tone control system having a relatively sharp variable low frequency cut-off characteristic.

It is a further object of the present invention to provide an improved tone control system providing high pass filter means for an audio frequency signal circuit having a variable low frequency cut-off characteristic.

It is also an object of the present invention to provide, in radio receiving apparatus, an audio frequency signal circuit having variable low frequency tone control means providing relatively sharp low frequency cut-off characteristic and means responsive to a change in an operating condition of the apparatus, such as wave band change, for changing the range of control of said tone control means.

It is a still further object of the present invention to provide, in an audio frequency signal transmission circuit, combined tone and volume control means providing variable low pass filter means and variable high pass filter means, whereby the frequency characteristic of said system may be varied between wide limits.

It is also a further object of the present invention to provide, in an audio frequency signal transmission circuit, low frequency tone control means comprising high pass filter elements, one of which is variable, and high frequency tone control means comprising low pass filter elements, one of which is variable, in conjunction with interstage coupling means and volume control means for said signal transmission circuit.

It is also an object of the present invention to provide, in an audio frequency signal transmission circuit, a filter network having a variable element providing low frequency tone control means, a second filter network having a variable element providing high frequency tone control means, and volume control means interposed in said circuit between said first and second named means whereby they are operable in the same circuit.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawings, and its scope will be pointed out in the appended claims. In the drawings,

Figure 1 is a schematic circuit diagram of a radio receiver showing an embodiment of the invention,

Figs. 2, 3, and 4 are fragmentary circuit diagrams of a portion of the circuit shown in Fig. 1, illustrating various connections for differing conditions of operation thereof, and

Figs. 5 and 6 are curve diagrams illustrating certain frequency-response characteristics of the circuits of Figs. 1 to 4, inclusive.

Referring to Fig. 1, 11 is a radio receiver or other source of signals having an audio frequency transmission channel or circuit, represented by leads 13 and 15 forming the output circuit in the present example, of a detector tube 17 and being coupled through suitable transformer coupling means 19 with a plurality of audio frequency amplifier tubes 21. The tubes 21, in turn, are coupled through a suitable amplifier indicated at 23 with an output device such as a loud speaker, indicated at 25.

The audio frequency transmission circuit 13—15 is provided with shunt volume control potentiometer means comprising a resistor 27 connected in shunt across the circuit and having a variable output tap 29. The volume control means is preferably compensated by suitable shunt circuits indicated at 31 and 33 for controlling the tone with volume, and for that reason the receiver 11 is preferably provided with automatic volume control means as indicated by the legend.

The receiver 11 also, is preferably provided with sensitivity control means indicated at 35, and in present receiver construction may also embody a wave band selector means indicated at 37 whereby the receiver is selectively adjustable for receiving signals over a plurality of differing wave bands.

The detector anode circuit, indicated at 39, is suitably coupled to the audio frequency transmission circuit 13—15 through an anode coupling resistor 41 and condenser 47. Anode potential is supplied through a filter comprising a series resistor 43 and a shunt by-pass condenser 45.

Interposed in the audio frequency transmission circuit, between the coupling condenser 47 and the volume control resistor or potentiometer 27, is a filter network comprising a series condenser 49 of relatively lower capacity than the coupling condenser 47 and two series connected impedance elements arranged in shunt across the circuit between the coupling condenser 47 and the series condenser 49 as indicated at 51 and 53. The element 51 is a resistor of relatively high value arranged to provide a potentiometer between a terminal indicated at A connected with the transmission circuit between

the two condensers and a terminal B connected with one end of the element 53. The latter element is an audio frequency choke coil having its opposite end connected as indicated at 55 with the lead 15 which is the low potential side of the transmission circuit. In the present example the coupling elements comprise the condenser 47 which may have a value of substantially .25 mfd. while the series condenser 49 may have a value of .025 mfd. The resistor 51 may have a resistance value of about 200,000 ohms and the choke coil 53 may have a value of approximately 13 henries and about 1500 ohms D. C. resistance.

It will be seen that the series connected filter elements 51 and 53 are connected in shunt with the audio frequency signal transmission circuit across the input side of the series condenser 49, the resistor element being connected adjacent to the high potential side or lead 13 and the choke coil element 53 being connected adjacent to the low potential side or lead 15. The resistor 51 is provided with a movable contact indicated at 57, which is connected with the output side of the series condenser 49 and with the high potential side or lead 13 as indicated at 59.

With this arrangement, the contact 57 is movable between the terminals A and B to variably short circuit the condenser 49 as it is moved toward the terminal A and to place the choke coil 53 effectively across the output side of the condenser 49 when the contact is moved toward and to the terminal B.

The effect of this control means on the transmission circuit will be seen by reference to Figs. 2 and 3 along with Fig. 1, like parts in said figures bearing the same reference numerals as in Fig. 1.

Fig. 2 represents the condition of the circuit when the contact 57 is moved to the position A, short-circuiting the condenser 49, as indicated by the bridging lead 61 in Fig. 2, and placing the resistor 51 fully in series with the choke coil 53, thereby rendering the latter as well as the condenser substantially ineffective to control the frequency characteristic of the transmission circuit and giving maximum low frequency transmission efficiency. The transmission efficiency, furthermore, is indicated in Fig. 5 by the curve A plotted between the coordinates indicated and taken with a given input potential at the detector measured across the terminals of the volume control potentiometer 27.

When the contact 57 is moved to the position B, the circuit then assumes the connections indicated in Fig. 3 wherein the choke coil 53 is moved to the output side of the series condenser 49 directly in shunt across the signal transmission circuit, and the series condenser 49 is shunted by a relatively high resistance provided by the resistance element 51 which is substantially ineffective to change the effect of the condenser in the circuit. The result is such that the low frequency signals through the transmission circuit are not only attenuated by the series element 49, but are further attenuated by the shunt element 53 which in conjunction with the series condenser 49 provides a high pass filter, the frequency characteristic of which is indicated by the curve B in Fig. 5.

It will be noted that a large percentage of the low frequency response of the circuit is cut off and that the slope of the curve B is relatively sharp, as is desirable. This is for the reason that the circuit is then arranged substantially as a high pass filter in the audio frequency transmission circuit. The effect of the filter may be adjusted between the limits indicated by the curves A and B by adjustment of the contact 57 along the potentiometer resistor 51.

It should be noted that in the position B shown in Fig. 3, the series condenser 49 is the controlling series element since it is relatively lower in capacity than the coupling capacity 47, while in the position indicated in Fig. 2 the coupling condenser 47 is the controlling series element and its capacity determines the low frequency response of the system.

From the foregoing description it will be seen that the series circuit capacitor or condenser 49 is short-circuited and a sufficient resistance is put in series with the inductance 53 to render its load across the circuit negligible, with the contact 57 at the terminal A, and that when the arm 57 is placed in the position B, the resistance is placed across the condenser 49 and is sufficiently high to make the impedance of the parallel combination 51—49 almost completely capacitative, with the impedance of the choke coil 53 shunted across the volume control resistor 27 or across the audio frequency transmission circuit, thereby forming a high pass filter variable between relatively wide limits and having a relatively sharp low frequency cut-off characteristic in the minimum low frequency response position.

On the output side of the volume control means 27—29 a low pass filter arrangement is provided having a variable element providing high frequency tone control means. This is provided by a choke coil 63 in series with the primary 65 of the transformer 19 and a shunt condenser 67 connected across the secondary 69 of the transformer through a variable high resistance 71. Additional capacity may be provided by a shunt condenser indicated at 73. The arrangement is such that the coil is resonated at a high frequency peak and this may be reduced by decreasing the resistance of the resistor 71 to place the condenser 67 in shunt with the secondary.

The high frequency response peak is indicated at L in Fig. 6 on the curve 77, and is desirable in the audio frequency transmission characteristic of the system to compensate for the attenuation of the high frequency end of the range in the radio circuits. The low frequency peak caused by the loud speaker is also indicated at S on the curve 77.

The curve 77 represents a condition of maximum high and low frequency response through the audio frequency transmission circuit, with the low frequency tone control means 57 adjusted in the position A and the resistance 71 wholly in circuit in series with the condenser 67. The effect of reducing the low frequency response by operation of the contact 57 to the position B is shown by the dash and double dot line curve 79 while the effect upon the overall response of reducing the resistance of the resistor 71 to zero is shown by the dash line curve 81.

The effect of reducing both the high and low frequency controls for minimum low and high frequency response is indicated by the dash and dot line curve 83. It will thus be seen that complete control of the audio frequency characteristic of the transmission system may be obtained by the two filter networks interposed in the circuit on opposite sides of the volume control means 27—29. Separate control means, as indicated by the control knobs 85, 87 and 89, are provided for varying tone controls and volume. The choke coil 63 in series with the primary of the coupling transformer 19, together with the variable resistor and series condenser 71—67 provided

across the secondary of the said transformer, provides a low pass filter with a variable high frequency cut-off characteristic on the output side of the volume control means for the audio frequency transmission circuit. Signals of substantially constant average amplitude are supplied to the detector from the receiver having automatic volume control means and the volume and frequency characteristic thereof may be adjusted by the low and high frequency tone control means and the interposed volume control means.

In connection with a multi-wave receiver, it has been found that it is desirable to limit the control range of the low frequency tone control means or filter network when receiving signals in certain of the higher frequency bands. It has further been found that the range of low frequency tone control may be reduced by maintaining the high pass filter in the circuit as a permanent part thereof and permitting only the series condenser element to be varied. This is provided in the circuit of the present example by providing suitable means such as a switch **93** for connecting the contact **57** with the terminal B of the series resistor **51** whereby the choke coil **53** is permanently connected across the audio frequency transmission circuit on the output side of the series condenser **49**. Adjustment of the contact **57** along the resistor **51** then serves to vary the relative series effect in the circuit of the series condenser **49** with respect to the coupling condenser **47**, the latter being effective to control the circuit when the resistor **51** is substantially out of circuit, the contact **57** being in the position A and the choke coil **53** remaining in shunt across the volume control resistor **27** or across the audio frequency transmission circuit on the output side of the series condenser **49**.

It will be noted that with the contact **57** in the position B and with the switch **93** closed, the same condition exists in Fig. 4 as exists in Fig. 3 for a minimum low frequency response, and the system is adjusted to operate in accordance with the curve B of Fig. 5, or the curve **79** of Fig. 6, measurements being taken at the loud speaker for the latter curve instead of at the volume control terminals. However, as the resistor **51** is short-circuited gradually across the condenser **49** the low frequency response is increased because of a reduction in the series impedance in the circuit presented by the condenser **49** and the response characteristic of the system reached that indicated by the curve C of Fig. 5 showing that the low frequency tone control has been reduced from the limits A—B to the limits C—B. In other words, the low frequency response of the system is reduced to a new and higher low frequency limit, and this has been found to be desirable to prevent howl, that is, acoustical feedback, and low frequency cabinet resonance in high frequency all-wave receivers. The acoustical feedback may result, as is well known, through vibration of the various parts of the receiver by sounds from the loud speaker. Other disturbances and beat notes at low frequencies are also reduced by this means.

The effect upon the overall response of the receiver of the adjustment C of Fig. 5 is shown in Fig. 6 by the curve **103**. It will be noted that while the loud speaker response peak is predominant, it is materially reduced to a relatively low level, as indicated at S', in comparison to the high frequency response peak L.

In order that the low audio frequency response range may be reduced with increase in the frequency response of the receiver, the wave band selector **37** may be connected by suitable means indicated by the dotted line **95**, with the switch **93** to be operable therewith or thereby.

In the present example, the switch is provided with five contacts **97** corresponding to five different wave bands, the wave bands over which compensation for the low frequency response is desired being connected in circuit by the arm **99** of the switch, with the choke coil and contact **57** through leads **101**. The switch **93** thus provides selector means for connecting the contact **57** with terminal B, thereby changing the low frequency cut-off point of the high pass filter and limiting the low frequency tone control range for certain of the received wave bands. By connecting the switch with the wave band selector, the low frequency tone control range is automatically adjusted with the wave band.

In the foregoing description it will be seen that in an audio frequency transmission system a low frequency tone control filter may be provided by comparatively few changes in the circuit and that likewise the high frequency tone control filter may be added and that it is particularly adapted to a transmission circuit having therein a shunt volume control means, the one filter being connected on one side thereof and the other on the opposite side of said volume control means whereby all three controls are operable in the same circuit independently of each other.

In the present example a series coupling condenser of relatively large value is followed by a series condenser of relatively lower value in a variable high pass filter arrangement comprising a resistor and a choke coil in series across the transmission circuit on the input side of the condenser between the high potential and the low potential sides of the circuit. The contact on the resistor is connected with the output side of the series condenser, and the high frequency tone control means comprises a series choke coil in the primary of an audio frequency coupling transformer to reduce the high frequency response peak to a value within the desired audio frequency range and a shunt condenser provided with series variable control means across the transformer secondary.

While my invention has been illustrated and described in connection with an audio frequency signal circuit for a radio receiver, it is not limited thereto but may be applied to any audio frequency signal circuit requiring either or both, high and low frequency tone control, in conjunction with the loud speaker, and limitation of the low frequency tone control range for certain conditions of operation. To this end the control means **93** may be actuated manually or by any other suitable means.

I claim as my invention:

1. In a multi-wave radio receiver, the combination with an audio frequency signal transmission circuit, of a condenser in series and a choke coil in shunt with said circuit providing a high pass filter means therein, and variable control means connected with said condenser and choke coil for gradually rendering said condenser effective in said circuit as a series impedance element and said choke coil as a shunt impedance element on the signal output side of said condenser, means for limiting the range of control of said last named means, wave band selector means, and means providing a connection between said last

named means and said limiting means for simultaneous operation therewith.

2. The combination with a radio receiver, of signal wave band selector means, variable low frequency tone control means having a predetermined tone control range of variation for one wave band, and means simultaneously operable with and by said wave band selector means for limiting the effective frequency range of control provided by variation of said tone control means for another wave band.

3. In a radio receiver, the combination with signal wave band changing means, of manually variable electrical circuit means for varying the low frequency response characteristic of said receiver within a predetermined frequency range for one wave band, and means connected with and operable by said wave band changing means for limiting the effective frequency range of control provided by variation of said second named means for another wave band.

4. In a radio receiver, the combination with wave band changing means, of means for varying the low frequency response characteristic of said receiver, said means comprising an audio frequency transmission circuit, of a condenser in series and a choke coil connected in shunt with said circuit providing a high pass filter means therein, variable control means connected with said condenser and choke coil for gradually rendering said condenser effective in said circuit as a series impedance element and said choke coil as a shunt impedance element on the signal output side of said condenser, and means connected with and operable by said wave band changing means for limiting the range of variation of said second named means.

5. The combination with a receiver adjustable to receive signals over a plurality of frequency bands, of means for varying the low audio frequency tone characteristic of said receiver, and means for limiting the low frequency end of said variation range when said receiver is adjusted to respond to signals in certain of said frequency bands.

6. The combination with a receiver adjustable to receive signals over a plurality of frequency bands, of means for varying the low audio frequency tone characteristic of said receiver, means for limiting the low frequency end of said variation range when said receiver is adjusted to respond to certain of said frequency bands, separate means for manually controlling the volume of said receiver associated in circuit with said first named means, and separate means for controlling the high frequency tone characteristic of said receiver.

7. The combination with a receiver adjustable to receive signals over a plurality of frequency bands, of means for varying the low audio frequency tone characteristic of said receiver, and means for limiting the low frequency end of said variation range when said receiver is adjusted to respond to certain of said frequency bands, said first named means including an audio frequency circuit, an audio frequency choke coil connected in shunt relation to said circuit, a series capacitor in said circuit and a variable resistance device for jointly controlling the effect of said capacitor and choke coil in said circuit, and said last named means comprising a frequency band changing device and switch contacts connected therewith for connecting said audio frequency choke coil across said audio frequency circuit independently of the operation of said variable resistance device.

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