June 10, 1941. J. M. RIDDLE, JR 2,245,365

AUDIO-FREQUENCY AMPLIFIER

Filed Jan. 31, 1940

Fig. 1.

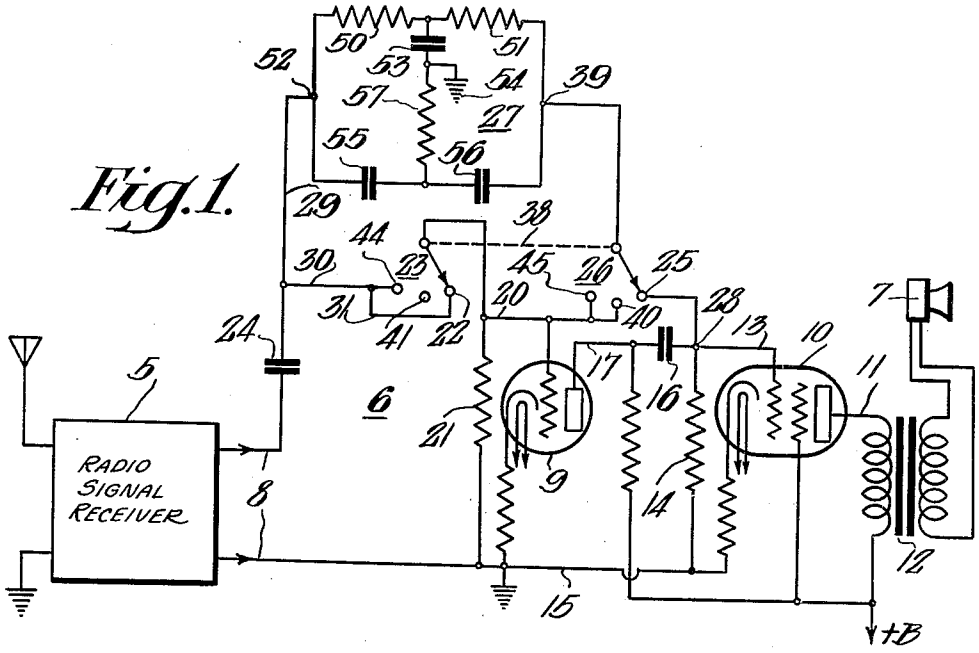


Fig. 2.

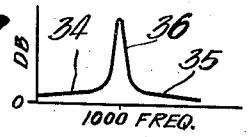


Fig. 3.

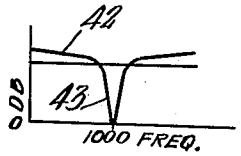
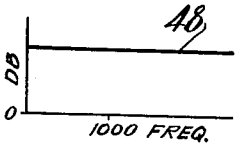


Fig. 4.



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UNITED STATES PATENT OFFICE

2,245,365

AUDIO-FREQUENCY AMPLIFIER

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Application January 31, 1940, Serial No. 316,616

6 Claims. (Cl. 250—20)

The present invention relates to audio frequency amplifiers, and has for its primary object to provide an improved audio frequency amplifier circuit wherein signals in the audio frequency range may be attenuated or accentuated in a relatively narrow band at a critical mean frequency.

It is a further object of the present invention to provide an improved audio frequency amplifier for aircraft receivers and the like for the selective reception of either range signals or voice signals, or both voice and range signals from transmitters which are simultaneously modulated by both range tone or beacon and voice signals.

It is also a further object of the present invention to provide an improved audio frequency amplifier of the inverse feedback type having a frequency-responsive network and means for including said network selectively either in the internal circuit of the feedback loop or main signal channel or in the external circuit of the feedback loop to provide selective accentuation or attenuation of signals in a relatively narrow band or at a critical frequency.

The invention is particularly adapted for use in aircraft receivers operating in connection with radio beams for accentuating the range tone of the beam or suppressing the range tone when utilizing the beam for telephone conversation. The range tone frequency is included in the audio frequency band and usually falls at approximately 1,000 cycles. Hence, it may be heard along with the voice modulation from a transmitter carrying both voice and range tone modulations. During flying time, ordinarily it is desirable to accentuate the range tone, particularly during periods of adverse atmosphere conditions affecting radio reception, while, for periods during which communication is necessary by voice, it is desirable to suppress the range tone.

It is, therefore, a still further object of the present invention to provide a simplified and improved audio frequency amplifier circuit for accentuating or suppressing the range tone of a radio beam without otherwise changing the normal response-characteristic of the amplifier.

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

In the drawing,

Figure 1 is a schematic circuit diagram of a radio receiving system provided with an amplifier embodying the invention, and

Figures 2, 3 and 4 are curves illustrating the response-characteristic of the system of Fig. 1 under various conditions of adjustment.

Referring to Fig. 1, the radio receiving system, schematically represented, includes a signal-receiving and detecting portion 5, an audio frequency amplifier 6, and a sound output or loudspeaker device 7. The receiving system may be of any suitable type having an audio frequency output circuit 8 and, in the present example, may be considered to be an aircraft receiver for the reception of a radio beam carrying range tone modulation and voice signals for the purpose of communication, the range tone being assumed to fall at approximately 1,000 cycles, or in a narrow band of which 1,000 cycles is the mean frequency.

The audio frequency amplifier 6 is interposed between the audio frequency output circuit 8 of the receiving system and the sound-producing device 7, and is of the two-stage impedance-coupled type comprising a feedback amplifier stage 9 and a second amplifier stage 10, the latter having an output circuit 11 coupled to additional amplifier means as required or directly to a loudspeaker 7, as shown, through an output coupling transformer or other suitable coupling device 12.

The output stage 10 is provided with an input grid circuit 13 including a grid resistor 14 connected to the common or ground side 15 of the audio frequency signal channel and coupled at the grid or high potential side through a coupling capacitor 16 with the output anode circuit 17 of the feedback amplifier stage 9.

The feedback or first stage 9 is provided with a signal input grid circuit 20 including a grid resistor 21 connected to the low potential side of the signal channel. The input circuit is further connected through a contact 22 of a switch 23 and a coupling capacitor 24 to the high signal potential side of the audio frequency output circuit 8 of the receiving system. This connection permits signals to be received from the circuit 8 and applied to the input circuit 20 of the first stage 9, amplified therein and applied through the coupling capacitor 16 to the input circuit 13 of the second stage 10 with further amplification in the second stage and the application of the amplified signals to further amplifying means or to the loudspeaker 7 directly.

With the switch 23 in the position shown for connection with the contact 22, a feedback con-

nection is simultaneously provided through the contact 25 of a second switch 26 and a filter network 27 from the output circuit 17 back to the input circuit 20, the feedback circuit being traceable from a tap connection 28 on the input circuit 13, which is coupled to the output circuit 17 through the capacitor 16, thence through the switch contact 25 and the switch 26 to the filter network 27 and from the latter through a series of circuit connections 29, 30 and 31 to the switch contact 22 and through the switch 23 to the input circuit 20.

With the inverse feedback connection, the over-all gain of the amplifier is reduced in accordance with the degree of feedback provided and, in the present example, and as indicated by the curved portions 34 and 35 in Fig. 2, the gain is maintained at a relatively low level by the feedback.

The filter network, however, is so constituted that it imparts a frequency-responsive characteristic to the feedback circuit, and, in the present example, is arranged to provide attenuation at a critical frequency which is the range tone of 1,000 cycles. This prevents any appreciable degenerative feedback at the critical frequency and, therefore, prevents attenuation of signals at that frequency through the inverse feedback circuit. By means of this connection, the range tone may be given maximum amplification as indicated by the peak 36 in the curve of Fig. 2, while the voice or other portions of the audio frequency range, that is, signals outside of the range tone, are suppressed.

The filter network 27 may be designed to provide any desired response characteristic in the feedback circuit for preventing feedback in any frequency range or at any frequency at which it is desired to provide full amplification with simultaneous suppression of other portions of the audio frequency range.

By including the network in the main amplifier channel instead of in the external portion of the feedback loop, attenuation of signals in the exact frequency range or at the exact frequency selected may be obtained without the use of additional circuit elements, and, in the case of aircraft communications or beacon receivers, the range tone may be suppressed while receiving voice modulation during periods of phone communication.

In the present example, this is further provided by additional contacts on the switches 23 and 26. The latter are connected for conjoint operation as indicated by the dotted connection 38, the switch 26 being movable from the position shown to connect one terminal 39 of the filter with a contact 40 and the input grid circuit 20, while the switch 23 is moved to an open contact 41, permitting the transfer of signals from the input circuit 8 through the coupling capacitor 24 and the lead connection 29 to the filter network 27, and thence through the switch 26 and contact 40 to the input grid circuit 20.

The signal attenuation provided by the network 27 formerly in the inverse feedback circuit now provides the same attenuation in the main amplifier channel and a suppression of the signals in the exact frequency range or at the same frequency as in the former case.

This results in a suppression of the range tone as indicated by the curve 42 in Fig. 3, having the attenuation peak 43 at substantially 1,000 cycles.

When the normal output of the amplifier is desired without suppression or accentuation of the range tone as, for example, when simultaneous reception of range tone and voice modulation is desired, the switches 23 and 26 are operated to close contacts 44 and 45, respectively, which provides a direct connection from the input circuit 8 through the coupling capacitor 24 to the lead connection 30, thence through the switch contact 44 to the input circuit 20, while the filter network is short-circuited by the connection provided by the contact 45 of the switch 26. With this arrangement, the over-all gain of the amplifier through the operating frequency range is indicated by the curve 48 of Fig. 4.

While the filter network 27 may be of any suitable type dependent upon the frequency or frequency range of signals to be attenuated and accentuated by the selective switching arrangement, it is preferably as shown, in the form of two parallel-connected T-pads, one of which is inverted. As will be seen from the drawing, one T-pad comprises two series-connected impedance or resistor elements 50 and 51 connected between an input terminal 52 and the output terminal 39 of the filter network and having a shunt capacitively reactive arm 53 connected to the low potential side of the audio frequency channel, as indicated at 54.

The second T-pad of the filter network comprises two series-connected capacitively reactive elements 55 and 56 between the terminals 52 and 39 and a shunt resistance element 57 also connected to the low potential side 54 of the transmission circuit.

Assuming the resistance at 50 and at 51 each to equal a resistance R, which is equal to twice the resistance at 57, and the capacitive reactances 55 and 56 to be provided by equal capacitors, each having a capacity C and equal to one-half of the capacity of the shunt element 53 also provided by a capacitor, then the critical frequency is

$$f=\frac{1}{2\pi RC}$$

From the foregoing description, it will be seen that a filter network having a desired frequency characteristic may be connected in the external connection of a feedback loop of an inverse feedback amplifier to provide gain through the amplifier at only a critical frequency or in a predetermined frequency band, or the network may be connected in series with the feedback loop in the amplifier channel, to provide attenuation at the same critical frequency or frequency band, thereby to alter the response characteristic of the amplifier for the reception of carrier waves carrying modulation at the range tone, as well as speech modulation.

I claim as my invention:

1. In an audio frequency amplifier, the combination of means providing a main amplifier channel, means providing an external inverse feedback circuit for said channel, a filter network having a predetermined frequency characteristic, and means for selectively connecting said network in the main amplifier channel and in the external inverse feedback circuit, thereby to provide signal attenuation and signal accentuation selectively through the amplifier within the response range of the filter network.

2. In an audio frequency amplifier, the combination of an audio frequency signal-conveying circuit, means providing an inverse feedback connection with said circuit, a filter network in said

last-named connection having a predetermined frequency characteristic permitting a predetermined signal output in a frequency range determined by said characteristic, and means for transferring said filter network to said signal conveying circuit to the exclusion of the feedback connection, thereby to attenuate the signals in the frequency range as determined by said frequency characteristic.

3. In an aircraft radio signal receiving system, the combination with radio signal-receiving means and sound-producing means, of an audio frequency amplifier interposed therebetween and including means providing an audio frequency signal amplifying channel, an inverse feedback circuit for said channel, means providing a filter network in said inverse feedback circuit for accentuating the signal response of said amplifier in a predetermined frequency range, and means for selectively including said network in the signal amplifying channel to the exclusion of the feedback circuit, thereby to provide signal attenuation in said amplifier in the same frequency range.

4. In an aircraft radio signal receiving system, the combination with radio signal-receiving means and sound-producing means, of an audio frequency amplifier interposed therebetween and including means providing an audio frequency signal amplifying channel, an inverse feedback circuit for said channel, means providing a filter network in said inverse feedback circuit for accentuating the signal response of said amplifier in a predetermined frequency range, and means for selectively including said network in the signal amplifying channel to the exclusion of the feedback circuit, thereby to provide signal attenuation in said amplifier in the same frequency range, said filter network including two T-pads, connected in parallel with one of said pads inverted.

5. The combination with a signal supply circuit, of an audio frequency amplifier comprising an inverse feedback circuit and an amplifier stage having a signal input circuit, a filter having a relatively high impedance in a predetermined frequency band, and means for applying signals to said input circuit through said filter network selectively from said inverse feedback circuit or said first named supply circuit, thereby to provide signal attenuation or accentuation in said predetermined frequency band.

6. In a communications receiver, the combination with signal selecting and receiving means, of an audio frequency amplifier comprising an inverse feedback circuit and an amplifier stage having a signal input circuit, a filter having a relatively high impedance at a critical frequency corresponding to the range tone of a radio beacon wave, a sound-producing device coupled to the said amplifier stage, and means for applying signals to said input circuit through said filter network selectively from said inverse feedback circuit or said first named means, thereby to provide signal attenuation or accentuation at said critical frequency.

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