Feb, 17, 1942. H. T. J. WIEGERINCK 2,273,680

AMPLIFIER CONTROL CIRCUIT

Filed March 6, 1940

Fig. 1

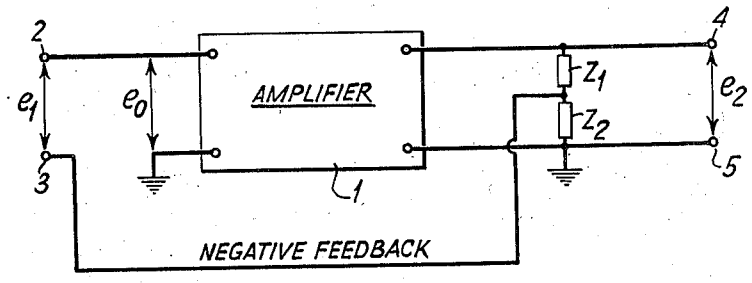


Fig. 2

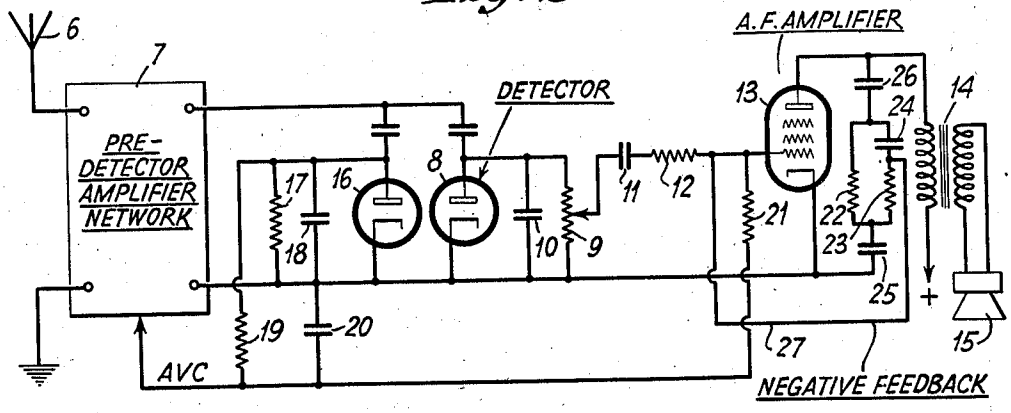
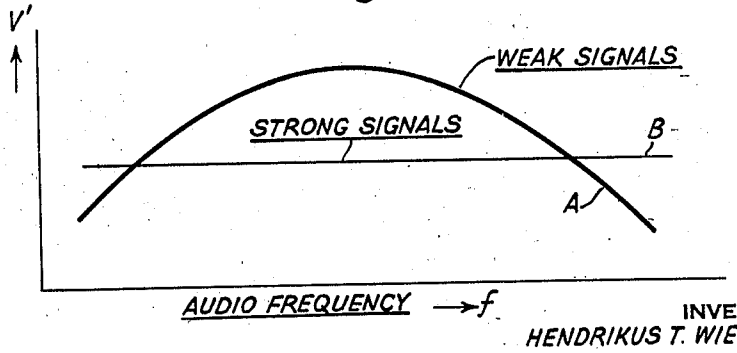


Fig. 3



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Patented Feb. 17, 1942 2,273,680

UNITED STATES PATENT OFFICE

2,273,680

AMPLIFIER CONTROL CIRCUIT

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Application March 6, 1940, Serial No. 322,460
In Germany April 26, 1939

6 Claims. (Cl. 250—20)

As is well known, in radio receiving apparatus comprising automatic volume control the phenomenon occurs that during reception of weak signals interfering noise is reproduced by the receiver.

It is known to decrease this noise by constructing the receiving apparatus in such a manner that the high frequencies of the frequency range to be reproduced are suppressed during reception of weak signals. This measure is based on recognition of the fact that the frequency spectrum of the interfering noise substantially comprises high audio frequencies, i. e., higher than 4000 to 5000 cycles. Due to the reproduction of these high audio frequencies being rendered impossible, undisturbed reception is obtained. Another known interfering phenomenon occurring in short wave reception is that hum having frequencies in the vicinity of 40 to 60 cycles occur due to the rapid fading phenomena in the short wave region and the action of the automatic volume control. To suppress this hum it is necessary during receptiton of weak signals that the low tones of the frequency range to be reproduced should be suppressed.

The present invention relates to a radio receiving apparatus in which measures are taken to suppress automatically the high and the low audio tones during reception of weak signals, whereas during reception of strong signals the whole frequency range to be reproduced is uniformly reproduced.

This is achieved according to the invention by controlling the amplification of the low frequency amplifier, which includes a negative feedback coupling path, in dependency on the amplitude of the received signals. This control acts in such manner, and the negative feedback coupling path is so designed that at a small amplitude of the received signals the amplification is substantially determined by the negative feedback coupling, whereas at a large amplitude of the received signals the amplification is smaller and substantially independent of the negative feedback coupling; impedances dependent on frequency being interposed in the negative feedback circuit in such a manner that the negative feedback coupling is greater for the low and the high frequencies than the negative feedback coupling for the intermediate frequencies of the frequency range to be amplified.

The invention will be more clearly understood by reference to the accompanying drawing wherein

Fig. 1 shows a feedback amplifier.

Fig. 2 shows an embodiment of the invention,

Fig. 3 graphically shows the operation of the invention.

Fig. 1 shows an amplifier 1 with input terminals 2 and 3 and output terminals 4 and 5. A potentiometer constituted by impedances Z_1 and Z_2 is connected between the output terminals. If the voltage between the output terminals is e_2 and the ratio is taken

$$\frac{Z_2}{Z_1+Z_2}\beta$$

a voltage βe_2 is produced across impedance Z_2 and this voltage is supplied to the input circuit of the amplifier in phase opposition with the voltage e_1 to be amplified which is produced between the input terminals. The total voltage e_0 produced in the input circuit of the amplifier consequently is $e_0=e_1-\beta e_2$.

If the amplification of the amplifier is V, the output voltage e_2 is consequently determined by $e_2=Ve_0=V(e_1-\beta e_2)$.

From this follows:

$$V'=\frac{e_2}{e_1}=V\frac{V}{1+V\beta}$$

in which V' is the amplification of the amplifier with negative feedback coupling.

If the amplification V and the value β of the negative fedback coupling are so chosen that $V\beta\gg 1$, V' becomes

$$\frac{1}{\beta}$$

which means that the amplification is almost exclusively determined by the negative feedback coupling. If, on the contrary, V and β are so chosen that $V\beta\ll 1$, V' becomes equal to V, or in other words the amplification of the amplifier with negative feedback coupling is substantially equal to the amplification without negative feedback coupling.

According to the invention, in a radio receiving apparatus the amplification of the low frequency amplifier, comprising a negative feedback coupling path, is so controlled in dependency on the amplitude of the received signals that during reception of a weak signal the amplification V is so great or during reception of a strong signal so small that the condition $V\beta\gg 1$ and $B\beta\ll 1$ respectively is fulfilled. Furthermore, the impedances Z_1 and Z_2 are made so dependent on frequency that the negative feedback coupling for the low and the high frequencies is greater than the negative feedback coupling for the intermediate frequencies. Since in this case during

reception of weak signals the amplification of the low frequency amplifier is determined by the negative feedback coupling and the latter is great for the low and the high frequencies, these frequencies are suppressed so that interferences due to rapid fading and noise are not reproduced, or at least reproduced with but small amplification. During reception of weak signals the amplification of the low frequency amplifier is substantially equal to the amplification without negative feedback coupling. The latter amplification may have any desired variation of frequency, for example in such manner that all frequencies are reproduced uniformly.

Fig. 2 of the drawing shows a radio receiving apparatus embodying the invention. The signals received in an aerial 6 are amplified in the high, and intermediate-frequency, portion of the receiving apparatus indicated by 7 and supplied to a diode 8. The network can be the usual pre-second detector circuits of a superheterodyne receiver. The low, or audio, frequency oscillations obtained by rectification, which are produced across a potentiometer resistor 9 shunted by a condenser 10, are supplied through a condenser 11 and a resistance 12 to the grid of a low frequency amplifying tube 13, in the output circuit of which is connected an output transformer 14 supplying the loudspeaker 15. For the purpose of obtaining a control voltage for automatic volume control of amplifiers 7 a diode 16 is provided, and the latter has intermediate frequency oscillations supplied to it. The control voltage is produced across a resistance 17, which is bridged by a condenser 18, and the control voltage is smoothed by means of a resistance 19 and a condenser 20 and controls in known manner the amplification of the high, and intermediate frequency, portion 7 of the receiver. The letters "AVC" denote the automatic volume control lead.

The control voltage is at the same time supplied, through a resistance 21, to the control grid of the low frequency amplifying tube 13, and controls the amplification of this tube in such a manner that during reception of weak signals the amplification is great and during reception of strong signals the amplification is small. In the output circuit of the amplifying tube 13 are connected impedances dependent on frequency which are constituted by resistances 22 and 23 and condensers 24 and 25. These frequency-dependent elements of the feedback path are purely passive; that is, the path includes no electron discharge device. To block the anode direct current a condenser 26 is provided. The resistance 23 is connected through a conductor 27 to the control grid of the tube with the result that a negative feedback coupling path is provided.

The condenser 25 is so chosen that it exhibits a high impedance for the low frequencies and a small impedance for the high frequencies and in the intermediate region of the frequency range to be produced. The condenser 24 only exhibits a small capacity, and consequently constitutes a high impedance for the low frequencies. The negative feedback coupling for the low frequencies is almost exclusively determined by the ratio between the condenser impedance and the resistance 22 and this ratio is made such that a strong negative feedback coupling is produced for the low frequencies. In the intermediate region of the frequency range to be reproduced the impedance of the condenser 25 is small and the impedance of the condenser 24 high so that the negative feedback coupling in this region is small. For high frequencies the impedance of the condenser 25 is very small so that for these frequencies the negative feedback coupling is determined by the ratio of the resistance 23 to the impedance of the condenser 24. This ratio is such that the negative feedback coupling is great for the high frequencies.

The resistances 22 and 23 and the condensers 24 and 25 may thus be adjusted in such manner that the factor β, which determines the negative feedback coupling for the low and the high frequencies exhibits the value

$$\frac{1}{10}$$

and for the frequencies in the intermediate region the value

$$\frac{1}{70}$$

Upon designing the impedance dependent on frequency in the negative feedback circuit, the impedances 9, 10, 11 and 12 etc., in the grid circuit of the amplifying tube 13 should be considered, which must also be given such values that the desired dependency on frequency of the negative feedback coupling is obtained. During reception of weak signals the amplification V of the amplifying tube is great and is, for example, 100. For the low and the high frequencies $V\beta=10$ in this case and for the intermediate region $V\beta=1.5$; consequently, the condition $V\beta \gg 1$ is satisfied so that during reception of weak signals the amplification is determined by the negative feedback coupling. Since the negative feedback coupling of the low and high frequencies is great, these frequencies are amplified to a smaller extent than the frequencies in the intermediate region. In this case the amplification V' varies as a function of the frequency f as shown by curve A in Fig. 3.

With an increase in amplitude of the received signals the amplification decreases due to the control voltage supplied to the control grid of the tube 13; in this case the amplification V' is no longer determined exclusively by the negative feedback coupling. At a very great amplitude of the received signals the amplification V is still but small, and is, for example, 3 so that for the low and the high frequencies $V\beta=0.3$ and for the frequencies of the intermediate region

$$V\beta=\frac{3}{70}$$

Consequently, the condition $V\beta \ll 1$ is fulfilled and the amplification V' is substantially independent of the negative feedback coupling and equal to the amplification V of the amplifier without negative feedback coupling. If this amplification V is independent of frequency in the frequency range to be reproduced, the amplification V' in the case of large amplitudes of the received signals may be represented as a function of the frequency by the line B in Fig. 3.

In the arrangement of Fig. 2, the low frequency amplifier only comprises a single amplifier tube 13. The invention is also applicable, however, to low frequency amplifiers comprising a plurality of stages, and in which the negative feedback coupling takes place through two or more of these stages.

What is claimed is:

1. In a radio receiver of the type including a modulated carrier wave transmission network,

a demodulator, a modulation voltage transmission network and means for controlling the transmission efficiency through said carrier network in response to received carrier amplitude variation; the improvement which comprises purely passive means for degenerating transmission of modulation voltage through said modulation network at the low and high portions of the modulation frequency range, and means responsive to said control means for minimizing said degeneration at relatively high received carrier amplitude.

2. In an audio-modulated carrier wave receiver provided with an audio amplifier having input and output terminals, means for deriving from received modulated carrier waves a control voltage whose magnitude varies directly with carrier amplitude, a degenerative audio voltage feedback network between said output and input terminals, said network consisting of purely passive elements with constants chosen to provide a substantially dominating degenerative feedback at the low and high audio frequencies, and means for controlling said audio amplifier gain with said control voltage whereby said degenerative feedback is greatly reduced at high received carrier amplitude.

3. In an audio-modulated carrier wave receiver provided with an audio amplifier having input and output terminals, means for deriving from received modulated carrier waves a control voltage whose magnitude varies directly with carrier amplitude, a degenerative audio voltage feedback network between said output and input terminals, said network having its constants chosen to provide a substantially dominating degenerative feedback at the low and high audio frequencies, said network comprising a condenser arranged in series with a resistor between said output terminals, a second condenser in series with a second resistor arranged in shunt with the first resistor, and said feedback path being connected to said second resistor, and means for controlling said audio amplifier gain with said control voltage whereby said degenerative feedback is greatly reduced at high received carrier amplitude.

4. In an audio-modulated carrier wave receiver provided with an audio amplifier having input and output terminals, means for deriving from received modulated carrier waves a control voltage whose magnitude varies directly with carrier amplitude, a degenerative audio voltage feedback network between said output and input terminals, said network consisting of purely passive reactive elements with constants chosen to provide a substantially dominating degenerative feedback at the low and high audio frequencies, and means for controlling said audio amplifier gain with said control voltage whereby said degenerative feedback is greatly reduced at high received carrier amplitude and said audio amplifier gain is reduced for all audio frequencies.

5. In an amplifying system having at least one tube, said system having input and output terminals, means for applying signals of a wide frequency range to said input terminals, means for adjusting the gain of said tube over a wide range of values thereby to vary the transmission of said signals through said system, a negative signal feedback network connecting the said output and input terminals, said feedback network comprising frequency-dependent impedance elements whose constants are so chosen that feedback discriminates in favor of the low and high portion of said signal frequency range at high values of said tube gain, and said adjusting means being adapted substantially to eliminate feedback through said network at low values of said tube gain, said impedance elements comprising a first series condenser-resistor path across said output terminals, and a second series condenser-resistor path connected in shunt with the resistor of the first path.

6. In an amplifying system having at least one tube, said system having input and output terminals, means for applying signals of a wide frequency range to said input terminals, means for adjusting the gain of said tube over a wide range of values thereby to vary the transmission of said signals through said system, a negative signal feedback network connecting the said output and input terminals, said feedback network comprising solely passive frequency-dependent impedance elements whose constants are so chosen that feedback discriminates in favor of the high portion of said signal frequency range at high values of said tube gain, and said adjusting means being adapted substantially to eliminate feedback through said network at low values of said tube gain.

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