Oct. 21, 1952 W. J. GRUEN 2,615,090

AUTOMATIC TONE CONTROL

Filed April 1, 1948

Fig. 1.

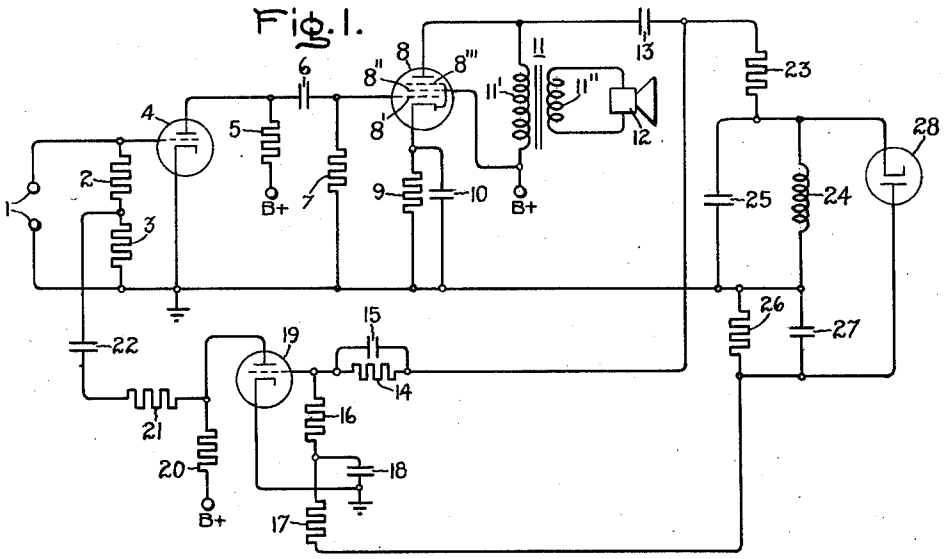
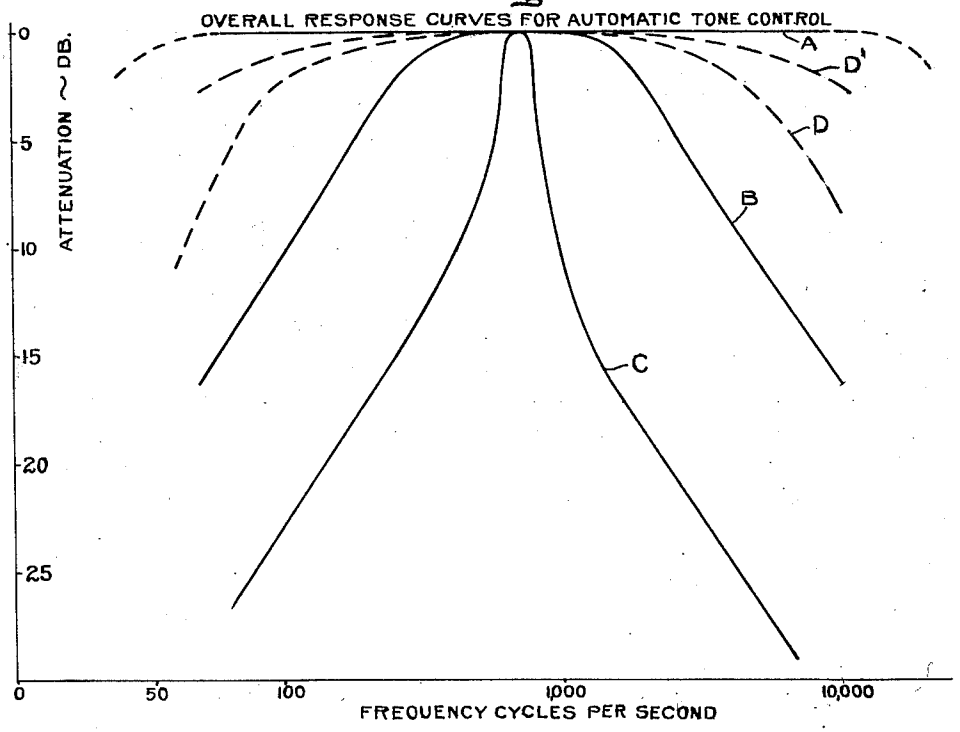


Fig. 2.



Inventor:
Wolf J. Gruen,
by Merton D. Moore
His Attorney.

Patented Oct. 21, 1952 2,615,090

UNITED STATES PATENT OFFICE

2,615,090

AUTOMATIC TONE CONTROL

Wolf J. Gruen, Syracuse, N. Y., assignor to General Electric Company, a corporation of New York

Application April 1, 1948, Serial No. 18,339

4 Claims. (Cl. 178—44)

1

This invention relates to automatic tone control circuits, and more particularly to such circuits useful for controlling the frequency response of audio frequency amplifiers, audio reproducing systems, and the like.

It is an object of this invention to provide an automatic tone control circuit which may be utilized for controlling the frequency response of an audio frequency amplifier, and the like, the tone control circuit acting to broaden or narrow the frequency response of the amplifier and being actuated by a control potential which is in turn dependent upon the energy content of signals amplified by the amplifier and lying solely within a predetermined frequency range.

In the attainment of the foregoing objects there is provided an audio amplifier having a variable frequency response, this response being controlled by the proposed tone control circuit. Frequency selective filter means and rectifying means are included in the control circuit, and from these means a control potential is derived, the value of the control potential being dependent upon signals amplified by the amplifier, lying, for example, within the frequency range of 300–1500 C. P. S. As a major portion of the energy content of musical programs lies within this frequency range, the frequency response of the amplifier is increased during such programs, and high quality translation is thereby obtained. However, during the intervals between the musical passages, the tone control causes the frequency response of the amplifier to decrease so that the limits thereof are substantially 300–1500 C. P. S., and disturbing scratch, rumble and other interference, being outside this frequency range and normally masked by the music, are effectively attenuated.

It is proposed, for example, to utilize the above-described system in record reproducing devices, as the disturbing noise frequencies from the record generally fall outside the above-mentioned predetermined frequency range. These noises are therefore suppressed during the silent passages due to the tone control circuit, limiting the band-pass characteristic of the amplifier, but during the presence of musical passages when the frequency response of the amplifier is increased by the tone control circuit, these disturbances are masked by the music.

The features of this invention which are believed to be new are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof may best be understood by reference to the accompanying drawing in which Fig. 1 is the circuit diagram of an audio amplifier incorporating the proposed automatic tone control circuit, and Fig. 2 shows various response curves of the system.

2

Referring now to Fig. 1, audio signals from any appropriate source are applied to terminals 1, these terminals being connected across series connected grid-leak resistors 2 and 3 which are in turn connected between the control electrode of discharge device 4 and ground. The cathode of device 4 is connected directly to ground, and the anode of this device is connected to a unidirectional potential source B+ through load resistor 5. Output from device 4 is derived across resistor 5 and applied to control electrode 8' of discharge device 8 through capacitor 6. The control electrode 8' is connected to ground through resistor 7, and the cathode of device 8 is biased by means of resistor 9 bypassed for audio frequencies by capacitor 10. Suppressor electrode 8''' is connected to the cathode of device 8, and screen 8'' is connected directly to the unidirectional potential source B+. The anode of device 8 is connected to unidirectional potential source B+ through the primary winding 11' of audio output transformer 11, the secondary winding 11'' of this transformer being connected to a signal translating device 12.

The output potential across the primary winding 11' of audio output transformer 11, or a portion thereof, is applied to the control electrode of discharge device 19 through a capacitor 13, and shunt connected capacitor 15 and resistor 14, discharge device 19 being of the variable mu type. The control electrode of device 19 is connected to ground through series connected resistor 16 and capacitor 18. The cathode of device 19 is directly connected to ground, and the anode of this device is connected to the unidirectional potential source B+ through resistor 20. The alternating current component of the potential appearing across the resistor 20 is applied to the input of device 4 through series connected resistor 21 and capacitor 22, and a connection to the junction point of series resistors 2 and 3. The network 14, 15, 16, 18 forms a band elimination filter, and it is apparent that this filter may take the form of the single section type, as shown, or the multiple section type, or any of the well known filter networks.

The output potential appearing across primary winding 11' of output transformer 11, in addition to being applied to the control electrode of device 19, is also applied to a resonant circuit through

capacitor 13 and resistor 23, the resonant circuit comprising an inductance 24 and capacitor 25 connected in parallel. The low potential end of resonant circuit 24, 25 is connected to ground. The cathode of device 28 is connected to the junction point of resistor 23 and resonant circuit 24, 25, and the anode of device 28 is coupled to ground through a shunt network comprising resistor 26 and capacitor 27. Output from device 28 is utilized to bias device 19, and is applied to the control electrode of the latter device through resistor 17 connected to the common junction of resistor 16 and capacitor 18.

The components of the circuit, indicated as 2–12 in Fig. 1, form a conventional audio amplifier. The amplifier may include a usual manual tone control, not shown, in order to permit an adjustment of the overall frequency response of the system, in accordance with the program to be reproduced. It is assumed, for example, that the frequency response characteristic of the amplifier alone is flat from 50 to 10,000 C. P. S., as shown by curve A in Fig. 2.

The circuit of Fig. 1, when the diode 28, and associated circuit elements are excluded, comprises a negative feed-back amplifier. By inserting the band elimination filter 14, 15, 16, 18 in the feed-back path, the frequency response of the amplifier is narrowed as shown by curve B in Fig. 2. The above-mentioned filter preferably is a high impedance network so that loading of the primary winding 11′ of transformer 11 is avoided. The amount of attenuation that may be obtained is determined by the relative sizes of resistors 14 and 16. The low frequency cut-off depends on the relative values of resistor 16 and capacitor 18, and the high frequency cut-off is determined by the relative sizes of resistor 14 and capacitor 15. The amount of feed-back may be adjusted by the appropriate choice of resistors 2, 3, and 21.

Considering now the operation of the complete circuit, including the diode 28 and its associated components, any audio potential appearing across the resonant circuit 24, 25 is rectified by diode 28, and a negative unidirectional potential is obtained at the anode thereof. The resonant circuit 24, 25 together with resistor 23 form a band pass filter, the frequency characteristic of which is shown by curve C of Fig. 2. Assuming square-law detection, the negative potential at the anode of device 28 is proportional to the energy content within the pass-band of filter 23, 24, 25. By applying this potential to the control electrode of the variable mu device 19, the amount of feed-back is reduced, and the frequency response of the amplifier is widened with increased negative control electrode bias on device 19, this being indicated by the dotted curved D, D′, of Fig. 2. Frequencies outside the pass band of filter 23, 24, 25, such as record noise, do not develop any appreciable potential across resonant circuit 24, 25, and therefore have no control effect on the frequency response of the amplifier.

To increase the fidelity of the amplifier, device 19 is biased towards cut-off so that a minimum amount of distortion is introduced by the control device, and in the signal translated by the system.

It is also noted that by adjusting the maximum feed-back in the center of the predetermined frequency band of the amplifier to an appropriate amount, a desirable volume expansion may be obtained.

This invention therefore provides an amplifier system having a control circuit incorporated therein, whereby, signals lying within a predetermined pass-band are effective to change the frequency response of the amplifier, and signals lying outside this pass-band have little or no effect on the amplifier frequency characteristics.

While a certain specific embodiment of the invention has been shown and described, it will of course be understood that various modifications may be made without departing therefrom. The appended claims are intended to cover any such modifications as fall within the true spirit and scope of the invention.

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

1. An audio amplifying system having an input circuit and an output circuit, means for impressing signals on said input circuit having frequencies extending over a predetermined range of audio frequencies, means for deriving amplified output signals from said output circuit, means for varying the frequency response of said amplifying system in response to signals amplified thereby and lying within a first predetermined narrow audio frequency band, said last-mentioned means comprising an inverse feedback circuit coupling said output circuit to said input circuit, frequency selective control means included in said feedback circuit, said control means being arranged to supply output signals within said band degeneratively to said input circuit, additional frequency selective circuit means and rectifying means coupled to said output circuit for deriving a unidirectional control potential in response to output signals lying within a second predetermined narrow audio frequency band, the magnitude of said control potential being dependent upon the energy content of said last-mentioned signals, and means for impressing said control potential on said control means for controlling the feedback and the frequency response of said system.

2. In an audio amplifying system, an input circuit and an output circuit, means for impressing signals on said input circuit having frequencies extending over a predetermined range of audio frequencies, means for deriving amplified output signals from said output circuit, means for varying the frequency response of said amplifying system in response to signals amplified thereby lying within a first predetermined frequency band included within a portion only of said frequency range, said last-mentioned means comprising a frequency selective feedback circuit coupling said output circuit to said input circuit and arranged to supply output signals within said band degeneratively to said input circuit, means comprising an electron discharge device included in said feedback circuit for controlling the feedback of said system, said discharge device including a control electrode, frequency selective filter means and rectifying means coupled to said output circuit for deriving a unidirectional control potential in response to output signals lying within a second frequency band included within a portion of said first predetermined frequency band, the magnitude of said control potential being dependent upon the energy content of said last-mentioned signals, and means for impressing said control potential on said control electrode for controlling the feedback and the frequency response characteristics of said system.

3. An audio amplifying system having a frequency response dependent upon signals amplified thereby and lying within a certain predetermined narrow audio frequency band, said ampli-

fying system comprising, an input circuit and an output circuit, means for impressing audio frequency signals on said input circuit and means for deriving amplified signals from said output circuit, a feedback circuit coupling said output circuit to said input circuit, frequency selective filter means included in said feedback circuit for limiting the frequency range of signals fed back to said input circuit to another predetermined audio frequency band, means comprising an electron discharge device in said feedback circuit for controlling the amplitude of said feedback signals, said device having a control electrode, further frequency selective filter means and rectifying means coupled to said output circuit for deriving a negative unidirectional potential therefrom in response to signals lying within said predetermined frequency band, the magnitude of said control potential being dependent upon the energy content of said last-mentioned signals, and means for impressing said control potential on said control electrode for controlling the feedback and the frequency response characteristics of said system.

4. In an audio amplifying system having a uniform response over a predetermined relatively wide frequency band, an input circuit and an output circuit, means for impressing signals on said input circuit and means for deriving amplified output signals from said output circuit,

means for reducing the uniform frequency response band of said amplifying system comprising, a frequency selective feed-back circuit coupling said output circuit to said input circuit, control means included in said feed-back circuit, and means for controlling said frequency band reducing means comprising frequency selective circuit means and rectifying means coupled to said output circuit for deriving a unidirectional control potential in response to output signals lying within a relatively narrow frequency band within a portion of said reduced frequency band, the magnitude of said control potential being dependent upon the energy content of said last mentioned signals, and means for impressing said control potential on said control means for controlling the frequency band reducing effect of said feed-back circuit.

WOLF J. GRUEN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,152,618	Wheeler	Mar. 28, 1939
2,179,956	Roberts	Nov. 14, 1939
2,283,241	Van Cott	May 19, 1942
2,323,634	Van Slooten	July 6, 1943