May 19, 1936. W. VAN B. ROBERTS 2,040,954

AUTOMATIC TONE CONTROL

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Fig. 1

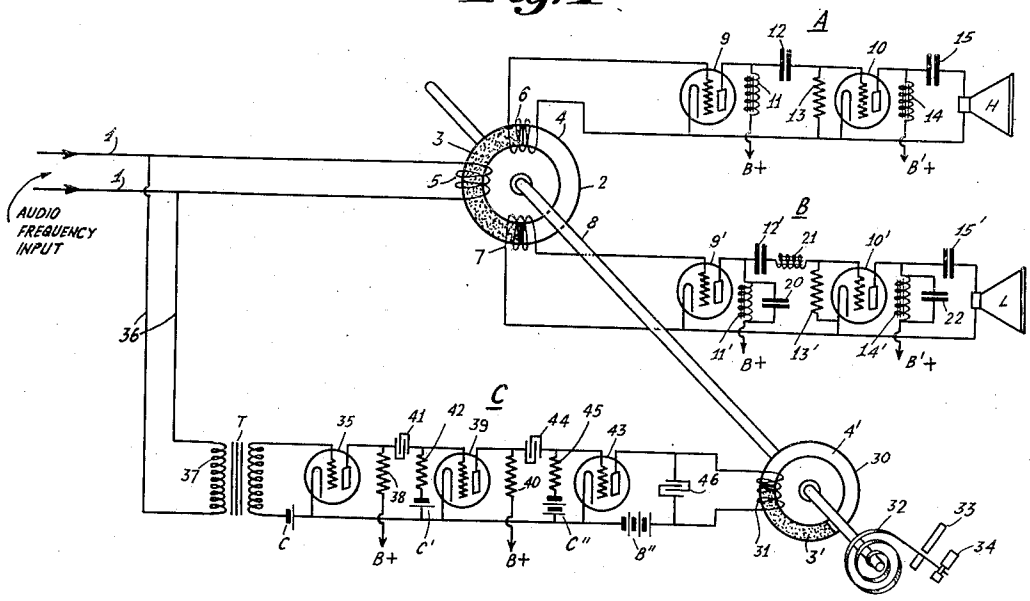
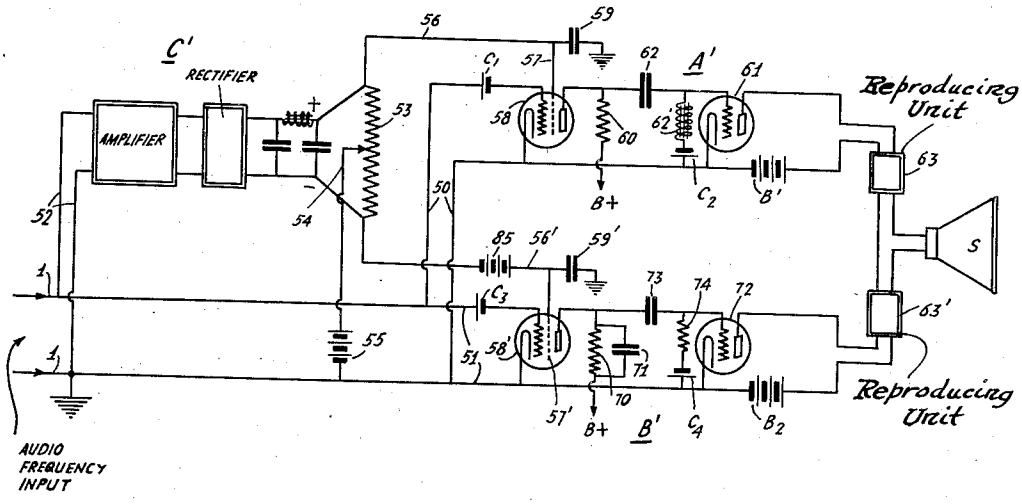


Fig. 2



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AUTOMATIC TONE CONTROL

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22 Claims. (Cl. 179—171)

My present invention relates to acoustic reproducing devices, and more particularly to automatic tone control systems adapted for use with audio frequency currents.

In connection with radio telephone receiving sets, electro-magnetic pick-ups or other phonograph devices, public address systems, and audio output circuits of sound moving picture systems, fidelity of reproduction with respect to the tone of the music, or speech, being reproduced, is desired. Extensive research has revealed that due to the nature of the human ear, music, or speech, reproduced at a high level of intensity should have a lesser proportion of low frequency amplitude, as compared with high frequency, than if the music, or speech, were reproduced at a low level, if apparent faithfulness of reproduction is to be preserved.

Now I have discovered a method of, and devised arrangements for, controlling the tone of electrically-reproduced sounds, which method utilizes a plurality of amplifying, or filtering, devices possessing different frequency characteristics, a controlling device for proportioning the input to the first devices in accordance with the general, or average, intensity of the input whereby the inputs of each of the amplifiers are relatively adjusted in a predetermined, and automatic, manner as the audio input varies.

Accordingly, it is one of the main objects of the present invention to provide a method of, and means for, amplifying modulated audio frequency currents which consists in utilizing a modulated audio frequency current to energize separate transducers having different frequency characteristics and whose outputs are combined so as to be simultaneously effective upon the listener, the ratio of the inputs to the transducers being controlled by means responsive to the energy level of the modulated current averaged over a period of time which is long compared to the longest period of audio current.

Another important object of the invention is to provide an electro-acoustic system having a plurality of loud speaking reproducers, the tones of which may be varied in accordance with the accustical conditions within the range of the reproducers.

Another object of the invention is to provide a tone control arrangement for audio amplifying systems which includes means for automatically regulating the tone of the acoustic output of the reproducers connected to the amplifying systems.

Still a further object of the present invention is to provide a plurality of selective amplifiers, each of which is arranged to stress predetermined independent portions of the audible spectrum, and means for automatically regulating, in a predetermined manner and in accordance with the input to the said amplifiers, the tone of the audio output of said amplifiers.

Still another object of the invention is to provide a plurality of loud speaking units, each of which is responsive primarily to a separate portion of the audible spectrum of frequencies, and means for automatically controlling the input to each of said units, in accordance with the energy level of the total audio input.

Still other objects of the invention are to improve generally the efficiency of audio amplifier systems, and to provide a tone control system for audio amplifiers which is not only reliable in operation, but automatic in regulation, and economical in circuit arrangement.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing,

Fig. 1 diagrammatically shows a circuit embodying one form of the invention,

Fig. 2 diagrammatically shows a circuit embodying a modified form of the invention involving no mechanically moving parts.

Referring to the accompanying drawing in which like characters of reference indicate the same parts in the different views, Fig. 1 shows an audio amplifier circuit, the input leads 1 of which have impressed thereacross modulated input energy at an audio frequency. The input energy may be derived from any desired source such as the output circuit of the detector stage of a radio telephone receiving set, the output terminals of an electromagnetic pick-up device or other electric phonograph device, the output terminals of the microphone arrangement of a public address system, the output terminals of the photoelectric device of a sound motion picture arrangement, or any other source of modulated audio frequency currents. I have not shown any of these sources for the reason that they are well known to those skilled in the art, and to preserve simplicity of description

throughout this specification. Two loud speakers H and L are employed, the speaker H being connected to the output terminals of an amplifier A which amplifies high frequencies much better than low frequencies, while the reproducer L is connected to the output terminals of an amplifier B which operates best at low frequencies.

The input voltages of these two amplifiers are obtained from windings on a toroidal core 2 made partly of magnetic material 3 (the magnetic portion being designated by dots), and partly of non-magnetic material 4 (the non-magnetic portion of the core being left blank). The input leads 1 are connected to a primary coil 5 wound on the core 2, while secondary coil 6 is connected to the input terminals of the amplifier A and the secondary coil 7 is connected to the input terminals of the amplifier B, it being noted that both secondary coils 6 and 7 are wound around the core 2.

The core 2 is so arranged that the primary winding 5 surrounds the magnetic portion 3 at all times, but by rotating the core on its axis, a shaft 8, more magnetic material is introduced into one of the two windings 6 and 7 at the same time as the magnetic material linking the other of the windings 6 and 7 is decreased. The windings 5, 6 and 7 are, of course, arranged with sufficient clearance between them and the core so as to permit the rotation of the core 2 within the coils. The connection between the shaft 8 and the core 2 is conventionally shown, it being understood that any well known type of mechanical coupling can be utilized between the shaft 8 and the core 2 so that as the shaft 8 is rotated the core 2 will move with it. It will be, therefore, seen that the rotation of the core 2 relative to the coils 6 and 7 varies the relative voltages supplied to the input terminals of the amplifiers A and B.

The amplifier A is shown as consisting of two stages of audio amplification, it being understood that any number of stages may be employed, one of the stages including an electron discharge tube 9 of the triode type, it being clearly understood that any other type of tube such as a tetrode or pentode may be employed, the control electrode and cathode of the triode 9 being connected across the terminals of the secondary coil 6. The output circuit of the triode 9 is connected to the input circuit of a second triode 10, the anode of the triode 9 being supplied with potential from source B (not shown) through a choke coil 11.

A capacity 12 is connected between the anode of triode 9 and the control electrode of triode 10, a resistance 13 being connected between the control electrode and cathode of triode 10. The anode of the triode 10 is supplied with potential from a source B', which may be the same source as the source B, through a choke coil 14. A capacity 15 is connected in series between one terminal of the reproducer H and the anode of the triode 10. As stated heretofore the amplifier A amplifies high frequencies much better than low frequencies by virtue of the fact that the choke coils 11 and 14 are connected across the output circuits of each triode 9 and 10 thereby blocking the flow of high frequency currents across these circuits, the capacities 12 and 15 blocking the flow of low frequency currents and facilitating the flow of high frequency currents from stage to stage.

The amplifier B is also shown as consisting of at least two stages, the first stage consisting of a triode 9' having its input circuit connected to the secondary coil 7, and a choke coil 11' connected in series with the anode of the triode 9', the choke coil being shunted by a capacity 20. Potential is supplied to the anode of the triode 9' from the source B through the choke coil 11'; this source B may be the same source which supplies the anodes of the other audio stages. The second audio stage consists of a triode 10' and a resistance 13' connected between its control electrode and cathode, there being a capacity 12' and a choke coil 21 connected in series between the anode of triode 9' and the control electrode of the triode 10'.

Potential is applied to the anode of triode 10' from a source B', and if desired the same source which supplies the other three stages, through a choke coil 14', the latter being shunted by a capacity 22, there also being a capacity 15' connected in series between one terminal of the reproducer L and the anode of the triode 10'. As pointed out heretofore the amplifier B operates best at low frequencies, and this action results because of the fact that choke coil 21 is inserted in series with the capacity 12', thus blocking some of the high frequencies, while the capacities 20 and 22 are shunted across the choke coils 11' and 14' thus by-passing some of the high frequencies.

The shaft 8 has mechanically coupled to another portion of it a second toroidal core 30, the core being made partly of magnetic material 3', represented in a manner similar to the magnetic portion of core 2, and a non-magnetic segment 4'. A coil 31, having its terminals connected to the output terminals of a regulating, or controlling, circuit C is wound around the magnetic portion 3' of the toroid 30, so that the stronger the current through the coil, the further will the magnetic portion 3' of the toroid be pulled into the coil against the restoring force of a spring 32.

The latter is shown wound about one end of the shaft 8, one end of the spring being fastened to the shaft, while the other end is adjustably affixed to a rigid body 33, the spring being adjusted in tension by a nut 34. It is to be understood that any other type of mechanical arrangement can be employed for producing this restoring force, it being within the scope of the invention to employ a weight and the like, each of these means being adjustable.

The regulating circuit C consists of one or more stages of audio amplification and a rectifier stage, the regulating circuit shown in Fig. 1 specifically including in the input circuit of the first audio stage a triode 35, the control electrode of which triode is negatively biased from a source *c*. An audio transformer T couples the input circuit of the triode to the input leads 1, the latter being connected by leads 36 to the primary coil 37 of the transformer T. The anode of the triode 35 has potential applied to it from a source B, through a resistance 38, the source B if desired being the same source which supplies potential to the anode of the triode 39 of the second audio stage, through a second resistance 40.

The control electrode of the triode 39 and the anode of triode 35 are connected through a capacity 41, the control electrode and cathode of the triode 39 having connected in series between them a resistance 42 and a source of negative bias *c'*. A third triode 43 is connected to the output circuit of the triode 39, a capacity 44 connecting the anode of triode 39 and control electrode of triode 43. The control electrode and cathode of the triode 43 have connected in series

between them a resistance **45** and a source of biasing potential *c''*. The anode of the triode **43** has potential impressed upon it from a source B'' connected in series with a capacity **46** between the cathode and anode of the triode **43**, the capacity **46** being shunted across the coil **31**.

It will thus be seen that there is connected to the same source **1** of audio frequency energy, as the input circuits of the amplifiers A and B, an audio amplifier, which may be of any desired type, feeding a rectifier, such as an electron discharge tube of the triode type, provided with sufficient bias to reduce its plate current to a small value in the absence of impressed voltages upon the grid. The triode **43** acts as the rectifier, the biasing source *c''* biasing the control electrode of the triode **43** to sufficiently reduce the anode current of the triode to a small value in the absence of amplified voltages from the output circuit of the triode **39** to be impressed upon the control electrode of the triode **43**.

The rectified output of the triode **43** is smoothed out by a filter arrangement designed in such a manner that the current output of the filter varies only slightly with variations in audio input strength. The current so smoothed out passes through the coil **31** which surrounds the magnetic portion **3'** of the toroid core **30**. As explained heretofore, the greater the flow of current through the coil **31**, the further is the magnetic portion **3'** pulled into the coil against the restoring force of the spring **32**.

The operation of the tone control system shown in Fig. 1 may be summarized as follows:

Case 1—Moderate input strength

In this case, the auxiliary or pilot amplifier C produces a moderate amount of current in the rectifier output, and the magnetic portion **3'** of the toroid core **30** is partially pulled into the coil **31**, thus producing angular displacement of the shaft **8**, the latter in turn rotating the toroid core **2** so as to supply equal voltages to the high and low frequency amplifiers A and B.

Case 2—Strong audio input

The magnetic part **3'** of the toroid **30** is pulled strongly, and to a considerable distance, into the surrounding coil **31**, thus resulting in the rotation of the transformer core **2** so as to reduce the coupling between the audio frequency primary **5** and the low frequency amplifier B, while increasing the coupling between the coil **5** and the coil **6** of the high frequency amplifier A.

Case 3—Weak audio input

In this case, the auxiliary or pilot amplifier circuit produces a weak amount of current in the rectifier output, which current is insufficient to overcome the restoring force of the spring **32**, whereupon the spring is enabled to rotate the shaft **8**, and consequently the core **30**, so that the magnetic part **3'** of the core is moved out of the coil **31**, thus simultaneously rotating the transformer core **2** so that the audio coupling with the high frequency amplifier A is diminished, while the coupling with the low frequency amplifier B is increased.

It will thus be seen that if the tension of the spring **32** is adjusted to balance the pull of the coil **31** on the magnetic portion **3'** of the core **30** at a predetermined audio input intensity, an increase of input intensity above the predetermined value will result in a greater attraction upon the magnetic part **3'**, with subsequent rotation of the shaft **8**, greater tensioning of the spring **32**, and simultaneously an increased coupling between the primary coil **5** and the input of the high frequency amplifier A, and a decreased coupling between the coil **5** and the input coil of the low frequency amplifier B. It is obvious that this results in the total acoustic output from the reproducers H and L having a lesser proportion of low frequency amplitude, as compared with the high frequency, at a high level of input intensity to the amplifiers, it having been pointed out that such a proportioning is desirable if apparent faithfulness of reproduction is to be preserved.

If the audio input intensity falls below the predetermined value, then the restoring force of the spring **32** will be greater than the attraction between the coil **31** and the magnetic portion **3'**, with the result that the shaft **8** will be rotated by the spring and the transformer core **2** also rotated so as to decrease the coupling between the coil **5** and the input coil of the high frequency amplifier, and increase the coupling between the audio input and the low frequency amplifier. This will result in a greater proportion of low frequency amplitude in the reproduced acoustic output of the reproducers H and L. It will be seen that there is provided in the arrangment shown in Fig. 1 an audio amplifier system which has associated with it, means for controlling the tonal output of the audio amplifier, in an automatic manner in accordance with the variation of audio input intensity.

In Fig. 2 there is shown a modified form of the invention, in which means are disclosed for achieving the same results, secured in the circuit shown in Fig. 1, but without utilization of mechanically moving parts. In this modified form of the invention, the audio frequency input is applied to the input leads **1**, as in the case of Fig. 1, the input being divided into three paths. One of these paths, by means of leads **50**, conducts the input current into an audio amplifier A', a second path, by means of leads **51**, conducts the current into an audio amplifier B', while the third path, by means of leads **52**, conducts the audio input current into a regulating auxiliary, or pilot circuit C'.

It will be recognized that these three essential elements of the invention are the same as in the case of the circuits shown in Fig. 1. In this case, the output of the pilot amplifier, rectifier and filter, is impressed across a potentiometer **53**, an intermediate point of which is maintained at a fixed potential, relative to the cathodes of the two amplifiers A' and B' having inverse frequency characteristics, as explained in connection with Fig. 1. The intermediate point on the potentiometer **53** is secured by an adjustable contact member **54** connected through a source of potential **55**, the negative terminal of which source is connected to one of the cathode leads of the amplifier B', while the positive terminal of the source **55** is connected to the adjustable contact member **54**. I have shown the amplifier and rectifier in the circuit C' in conventional fashion, it being clearly understood that specific elements as shown in the circuit C, in Fig. 1, may be employed, the filter circuit subsequent to the rectifier being shown by several parallel capacities, including a choke coil in series between them.

The positive end of the resistor of the potentiometer **53** is connected by a lead **56** to the screen element **57** of an electron discharge tube **58**, which

tube is included in the first stage of the amplifier A', it being noted that the screen element is connected to ground through a capacity 59. The electron discharge tube 58 is preferably a screen grid tube, whereby a stage of screen grid amplification is provided in the amplifier A', the control electrode of the tetrode 58 being negatively biased by a source c_1.

The anode of the tetrode 58 has potential applied to it from a source B through a resistance 60, the anode being connected to the control electrode of a triode 61, through a capacity 62. The control electrode and cathode of the triode 61 have connected in series between them a choke coil 62' and a source of biasing potential c_2, the anode of the triode 61 receiving potential from the source B_1. The output of the triode 61 is connected to the input of a reproducing unit 63, the reproducing unit being connected to a common loud speaker S.

The negative terminal of the resistor of the potentiometer 53 is connected by a lead 56', through battery 85, to the screen element 57' of a screen grid electron discharge tube 58' included in the first stage of the amplifier B', the screen element 57' being connected to ground through a capacity 59'. The control electrode of the triode 58' is negatively biased by a source c_3, and the anode of the tetrode has potential applied to it form a source B through a resistance 70 shunted by a capacity 71. The anode of the tetrode 58' is connected to the control electrode of output triode 72 by a capacity 73, the control electrode and cathode of the triode 72 having connected between them in series a resistance 74 and a source of biasing potential c_4. The anode of the triode 72 has potential applied to it from a source B_2, the output of the triode 72 being impressed upon a second reproducer unit 63' the output of which unit is also connected to the common speaker S.

It will thus be seen that each amplifier A' and B' includes a stage of screen grid amplification so designed that the amount of amplification depends upon the potential of the screen in each stage becoming greater as the screen potential is increased. The screens of the two tubes 58 and 58' are connected to opposite ends of the potentiometer 53, thus insuring that current flowing out of the rectifier will make one screen more positive but the other one less positive, thus increasing the amplification of one amplifier while decreasing that of the other.

Battery 85 is adjusted to equalize the amplification of A' and B' at such signal levels as require equal amplification in these two amplifiers for best sounding results. It is to be noted that the amplifier A' amplifies high audio frequencies best because the impedance of the choke coil 62' between grid and cathode is greatest for high frequencies, while the amplifier B' amplifies low audio frequencies best because the high frequencies are more completely by-passed by the condenser 71 across the coupling resistance 70. The outputs of the two amplifiers A' and B' are mixed in a common speaker S, to show an alternative arrangement for mixing the amplifier outputs, the method of mixing the outputs in separate speakers being shown in Fig. 1.

It will thus be seen that in Fig. 2 I have disclosed a method of automatically controlling the tonal output of an audio amplifier arrangement, the automatic arrangement being pre-adjusted for any audio frequency input intensity average value, the method disclosed in Fig. 2 consisting in utilizing an audio signal to energize separate transducers having different frequency characteristics, and whose outputs are combined so as to be simultaneously effective on the listener, the ratio of inputs to the transducers being controlled by means responsive to the energy level of the signals averaged over a period of time which is long compared to the longest period of audio current, it being particularly pointed out that the filter arrangement in the circuit C' is designed so that the current output of the filter varies only slowly with variations in audio input strength.

While I have shown particular means for carrying out the automatic variation of frequency characteristic of the entire audio system in accordance with input signal level, I do not mean to imply that the means shown are the only feasible methods for achieving the desired results. For example, the two or more amplifier systems may be caused to have the desired frequency characteristics not only by the design of the amplifiers themselves, but equally well by the insertion of filters, or other networks, in series with the amplifiers, or even by choosing loud speakers which have different frequency characteristics themselves. Furthermore, it is possible to employ a single amplifier, in Fig. 2, between the combined output of the amplifiers A' and B', and the common speaker S; that is to say, a common amplifier after the two transducers of different characteristics and before the common speaker.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications in the circuit arrangements, as well as in the apparatus employed, may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. The method of amplifying audio currents which consists in utilizing an audio signal to energize separate transducers having different frequency characteristics, combining the outputs of the transducers, reproducing the combined output, and controlling the ratio of the outputs of the transducers in opposite sense in accordance with the energy level of the audio currents averaged over a period of time which is long compared to the longest period of audio current.

2. In a sound reproducing system including a source of audio frequency energy, the combination of a plurality of amplifiers having different frequency characteristics, reproducing means connected therewith, and means for automatically controlling the tonal output from said reproducing means, said control means including a regulating circuit for varying the relative intensities of low and high frequency currents amplified in said system, in accordance with the energy level of the energy from said source.

3. In a sound reproducing system, the combination of amplifying means, a source of audio frequency energy to be amplified by said amplifying means, sound reproducing means connected therewith, and means for automatically controlling the tonal output from said sound reproducing means, said last mentioned means including a pilot circuit for varying automatically the relative intensities of low and high frequency currents amplified in said amplifying means, in accordance with the energy intensity of the audio frequency energy supplied from said source to said amplifying means.

4. The method of adapting a sound reproduc-

tion to predetermined acoustic requirements which consists in changing electrical oscillations including a predetermined range of frequencies, to acoustic oscillations, and controlling the acoustic oscillations automatically by regulating the volume of the high frequency sounds and independently varying in an opposite sense the volume of the low frequency sounds in accordance with the average intensity of the electrical oscillations.

5. An amplifier for electrical impulses comprising in combination, a first unit constructed and arranged to amplify comparatively slightly electrical impulses having a predetermined band of frequencies and to amplify comparatively strongly another band of said frequencies, a second unit having frequency amplifying characteristics which are inverse to the first unit, acoustic devices associated with said units, and means for automatically proportioning in opposite sense the degree of amplification of each of the aforesaid units in accordance with the average intensity of the input.

6. In a system for reproducing electrical oscillations, a source of such oscillations, a first selective amplification unit arranged to amplify high audio frequencies comparatively better than low audio frequencies, a second selective amplification unit having frequency characteristics inverse to that of the first unit, and a common means responsive to the energy level of said source for automatically varying in opposite sense the amount of electrical energy fed into the first and second units.

7. In a system for reproducing electrical oscillations, a source of such oscillations, a first selective amplification unit arranged to amplify high audio frequencies comparatively better than low audio frequencies, a second selective amplification unit having frequency characteristics inverse to that of the first unit, and a common means, responsive to the average intensity of the source energy, for automatically varying in opposite sense the degree of amplification of the first and second units.

8. An amplifier system for audio modulated electrical energy comprising in combination a source of such energy, an electron discharge amplifier having a predetermined frequency discrimination characteristic, an independent electron discharge amplifier having a different frequency discrimination characteristic, acoustic reproducing means combining the outputs of both amplifiers, a pilot circuit having its input connected to said source, means for coupling the source to the input of each amplifier, and additional means, responsive to energy variations in the pilot circuit output, for varying in opposite sense the energy output from each amplifier in accordance with the energy level of said source.

9. An amplifier system for audio modulated electrical energy comprising in combination a source of such energy, an electron discharge amplifier having a predetermined frequency discrimination characteristic, an independent electron discharge amplifier having an inverse frequency discrimination characteristic, acoustic reproducing means actuated from the outputs of said amplifiers, a pilot circuit including an amplifier and a rectifier, means for coupling the source to the input of each amplifier, and additional means, responsive to energy variations in the pilot circuit output, for varying in opposite sense the energy output from each amplifier in accordance with the energy level of said source.

10. An amplifier system for audio modulated electrical energy comprising in combination a source of such energy, an electron discharge amplifier having a predetermined frequency discrimination characteristic, an independent electron discharge amplifier having a different frequency discrimination characteristic, acoustic reproducing means combining the outputs of both amplifiers, a pilot circuit energized from said source, means for coupling the source to the input of each amplifier, and additional means, responsive to energy variations in the pilot circuit output, for varying in opposite sense the degree of amplification of each of said amplifiers.

11. An amplifier system for audio modulated electrical energy comprising in combination a source of such energy, an electron discharge amplifier having a predetermined frequency discrimination characteristic, an independent electron discharge amplifier having a different frequency discrimination characteristic, acoustic reproducing means connected to both amplifiers, a pilot circuit energized from said source, means for coupling the source to the input of each amplifier, and additional means, responsive to energy variations in the pilot circuit output, for varying in opposite sense the coupling between the source and the input to each amplifier in accordance with the energy level of said source.

12. An automatic tone control arrangement adapted for use with an audio frequency amplifier including a pair of screen grid amplification stages having inverse audio frequency discrimination characteristics, means for reproducing the output of said stages, and a source of audio frequency energy coupled to said stages, said arrangement comprising a control circuit connected between said source and a screen element of each of said stages.

13. An automatic tone control arrangement adapted for use with an audio frequency amplifier including a pair of amplification stages having inverse audio frequency discrimination characteristics, means for reproducing the output of said stages, and a source of audio frequency coupled to said stages, said arrangement comprising a control circuit connected between said source and an amplification control element of each of said stages, said control circuit comprising a rectifier and a potentiometer, said control elements being connected to points of opposite sign of said potentiometer.

14. In combination with an audio frequency amplifier having a first means for amplifying the higher audio frequencies better than the lower, and a second means for amplifying lower audio frequencies better than higher audio frequencies, means for reproducing the output of the amplifier, a source of audio frequency modulated electrical oscillations connected to the amplifier input, means for obtaining energy varying as the amplitude of said audio frequency modulated electrical oscillations, and means responsive to said energy functioning on an increase in the energy level of said oscillations above a predetermined level to produce optimum operation of the first means and on a decrease below said level to produce optimum operation of the second means.

15. In combination with an audio frequency amplifier having a first means for amplifying the higher audio frequencies better than the lower, and a second means for amplifying lower audio

frequencies better than higher audio frequencies, means for reproducing the output of the amplifier including a loud speaker connected to each of said first and second means, a source of audio frequency modulated electrical oscillations connected to the amplifier input, and a tone control means connected to said source and said first and second means, said tone control comprising means for providing a rectified current from said source of audio frequency modulated electrical oscillations, and means for varying the output of at least one of said amplifying means in accordance with the intensity of said rectified current.

16. Radio apparatus comprising a source of modulated current, means for reproducing sound from said modulated current, means connected to said source providing energy varying proportionally with the variations in intensity of the modulation of said modulated current, and means responsive to the variations of said energy for increasing the low frequency response relative to the high frequency response when the intensity of the modulation of said modulated current is decreased.

17. Radio apparatus comprising a source of modulated current, means for reproducing sound from said modulated current, means connected to said source providing energy varying proportionally with the variations in intensity of the modulation of said modulated current, and means responsive to the variations of said energy for decreasing the low frequency response relative to the high frequency response when the intensity of the modulation of said modulated current is increased.

18. A wave repeating system comprising means constituting a more efficient energy transfer system at certain frequencies than at others, means constituting a more efficient energy transfer system at other frequencies than those efficiently transferred by the first mentioned means, and means responsive to the character of the wave being transferred for controlling the energy transfer through said means.

19. A wave repeating system comprising a pair of parallel circuits, one of said circuits constituting a more efficient energy transfer system for certain frequencies than for others and the other constituting a more efficient energy transfer system for other frequencies than for those efficiently transferred by the first mentioned circuit, and means responsive to a characteristic of the wave being repeated for controlling the transfer of energy through said parallel circuits.

20. In an audio amplifying system, means for controlling the shape of the frequency response characteristic thereof, and signal-responsive means connected to the system input for automatically actuating said control means.

21. In a signal receiving system, means for amplifying currents at audio-frequencies, means for controlling the range of frequencies effectively amplified thereby, and signal-responsive means connected to the amplifying means input for automatically adjusting said controlling means.

22. In a radio receiver, audio frequency amplifying means adapted to cover a wide range of frequencies, signal responsive means connected to the input of the amplifying means for automatically controlling the amplification of currents at frequencies lying in the upper end of the range, and manually operable means for adjusting the measure of automatic control.

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