Nov. 30, 1943. R. A. BIERWIRTH 2,335,575

CONTROL CIRCUIT FOR SOUND REPRODUCTION

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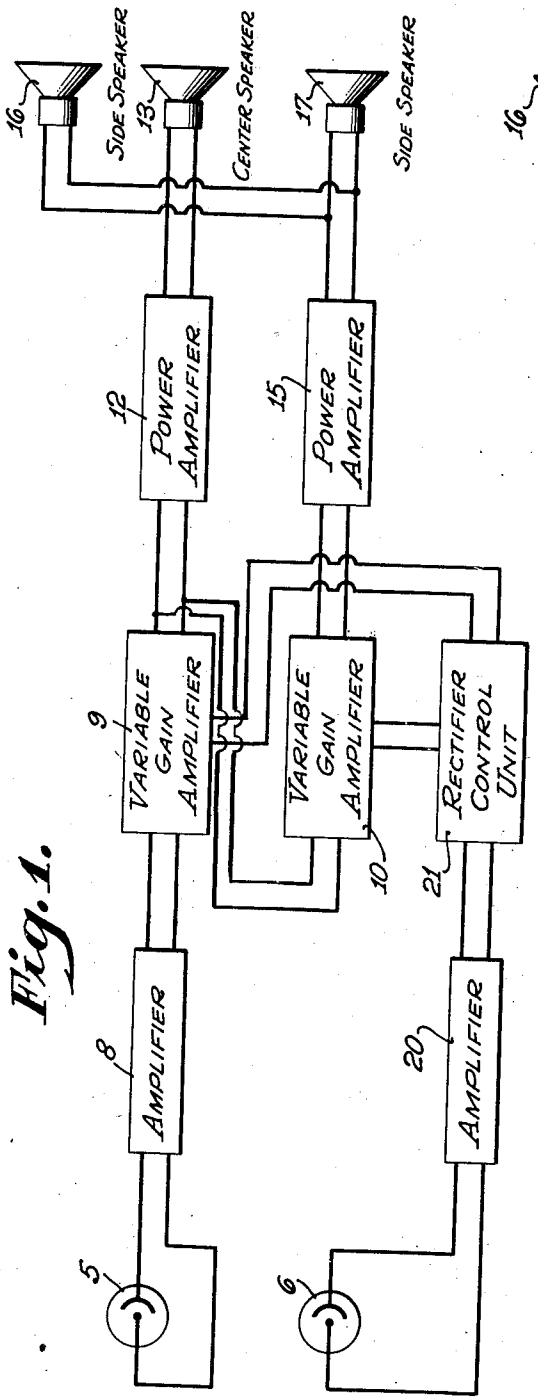


Fig. 1.

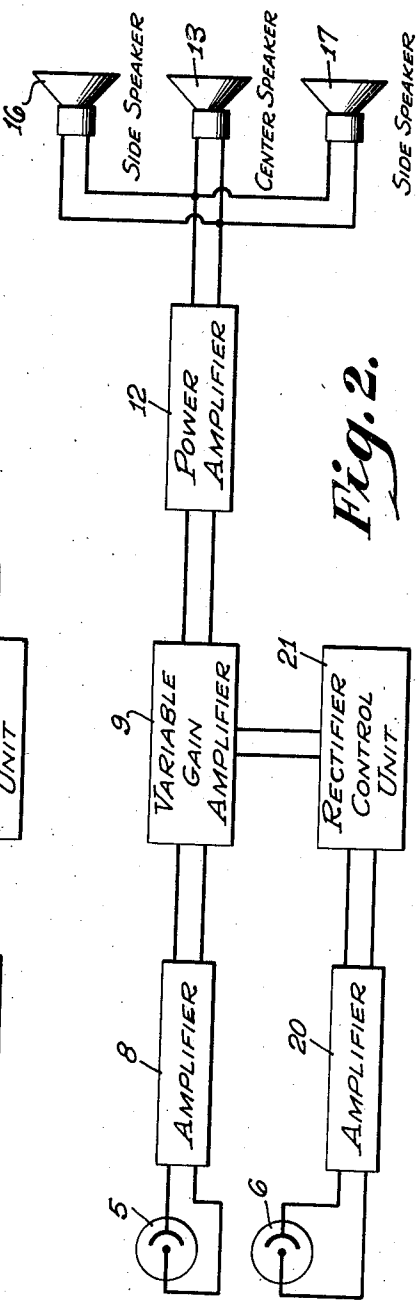


Fig. 2.

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Fig. 3.

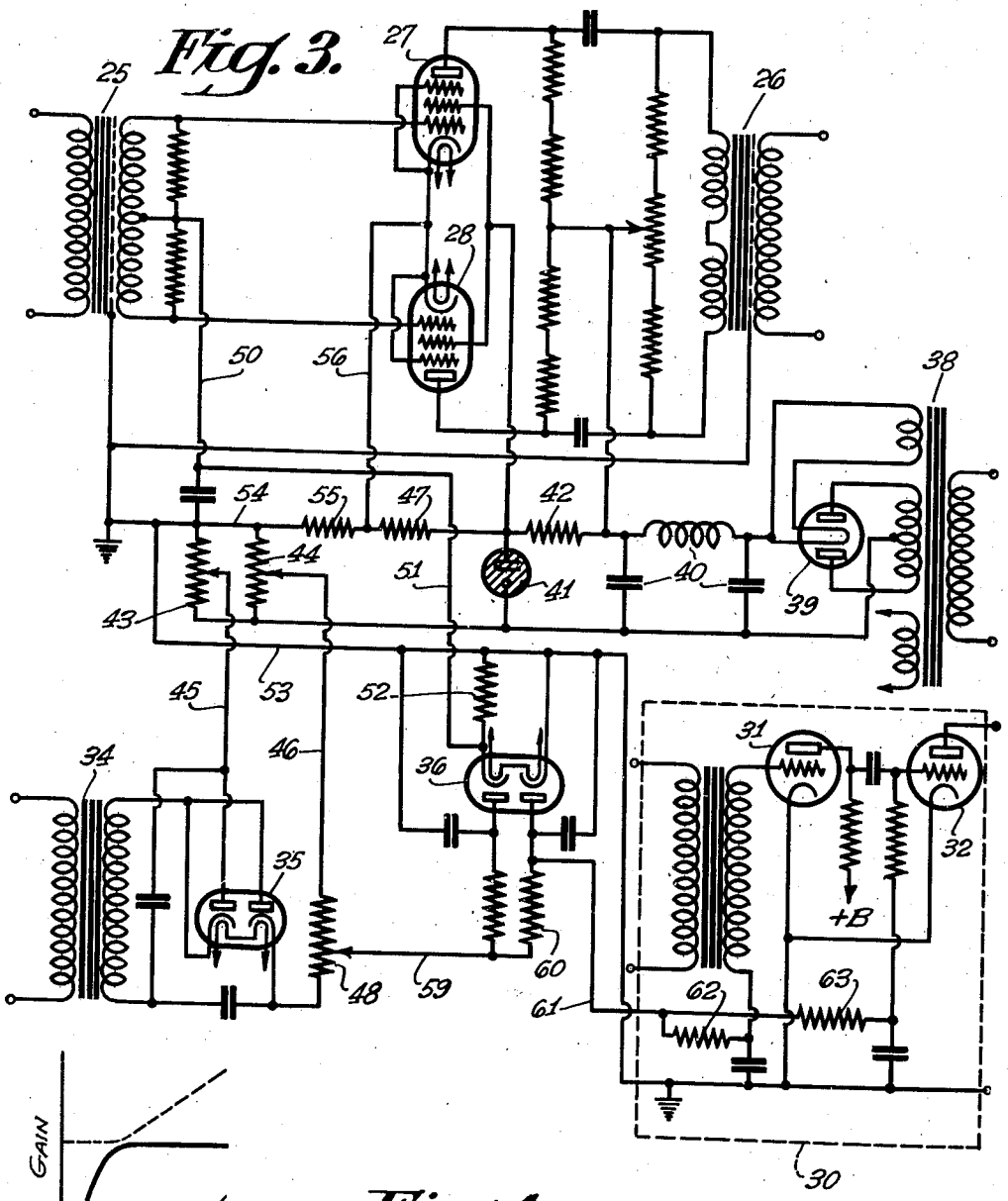
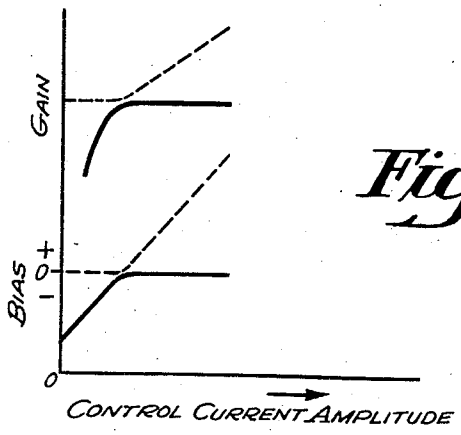


Fig. 4.



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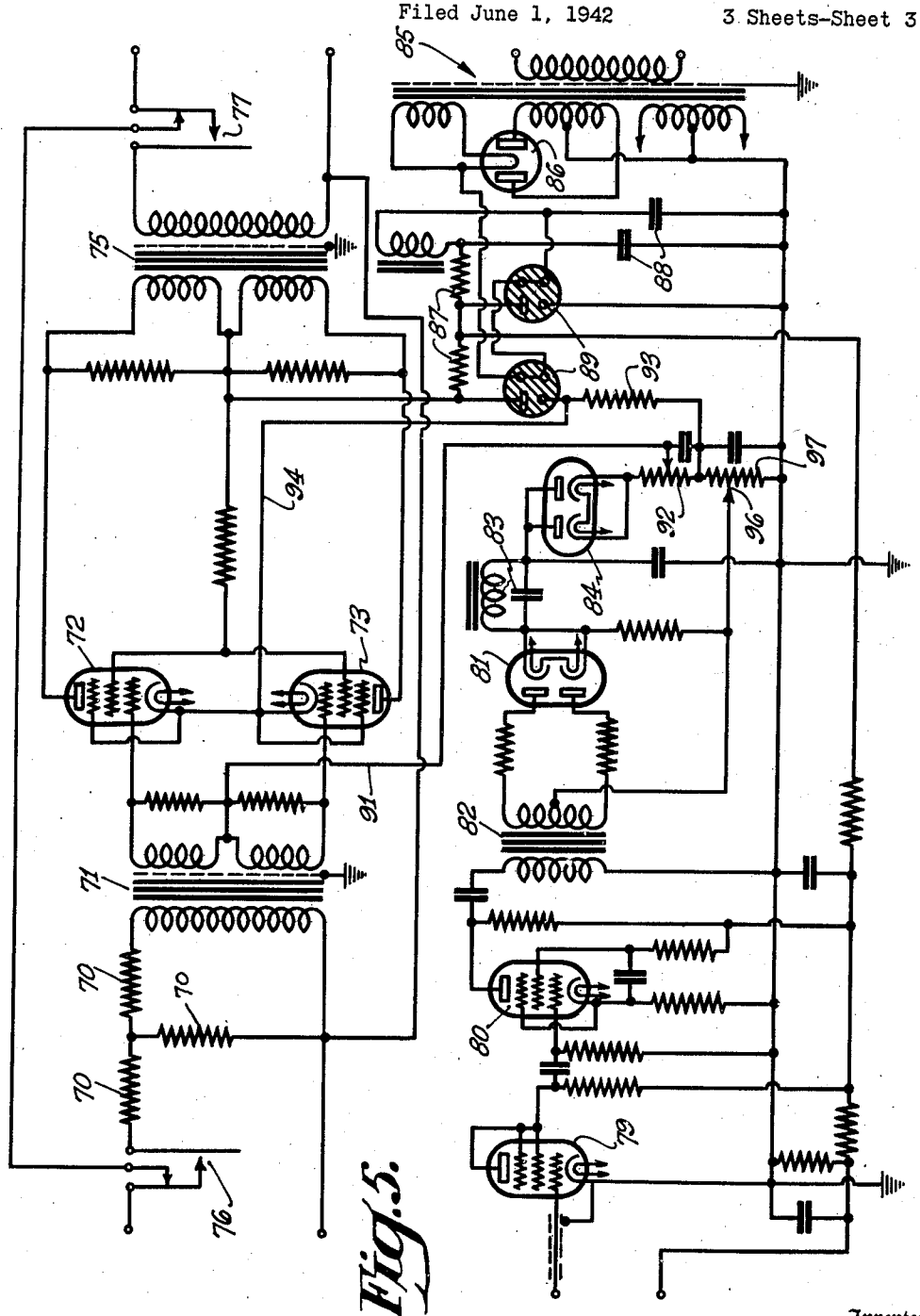


Fig. 5.

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CONTROL CIRCUIT FOR SOUND REPRODUCTION

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Application June 1, 1942, Serial No. 445,287

14 Claims. (Cl. 179—1)

This invention relates to electrical current control systems and particularly to a sound reproducing system wherein the reproduction of the sound is under control of a control record.

Sound reproducing systems for theatres wherein the volume of the reproduced sound is either under control of its own amplitude variations or under control of a separate control record are well known in the art. The use of multiple speakers for public address and theatre sound reproduction are also well known. The present invention is directed to a control track type of system using multiple speakers wherein one or more center speakers generally located behind the picture screen are flanked by one or more side speakers across the proscenium of the theatre.

In the operation of such a system it has been found desirable for certain types of sounds being reproduced, to vary the volume of reproduction independently of the normal volume variations and to distribute or vary the volume of the sound being reproduced by a center speaker or speakers with respect to the side speakers and vice versa. To obtain the variations in volume, variable gain amplifiers are employed, the variation of the grid bias on the amplifier tubes varying the gain thereof and consequently the volume of the reproduced sound. In embodiments of the system wherein the volume of the sound is distributed differently between the center and side speakers, a variable gain amplifier for each group of speakers is employed, together with multiple rectifier control units for controlling each variable gain amplifier for the respective speakers in a different manner as will be described hereinafter. It has been found that by the use of electronic devices for controlling the distribution of the sound between the speakers as well as for varying the transmission of the signal currents, that an accurate and smooth variation may be obtained. Although only two particular arrangement of signal and control circuits are being described below to illustrate the invention, it will be realized that other combinations and variations are obtainable by varying the adjustment and arrangement of the control elements.

The principal object of the invention, therefore, is to facilitate and improve the reproduction of sound.

Another object of the invention is to control the amplitude of reproduction of sound from a sound record in accordance with a control record and to vary the volume distribution of the sound among a plurality of loudspeakers.

A further object of the invention is to provide a sound reproducing system in which the reproduced sound is under control of a control record for varying the distribution of the volume of the sound among a plurality of loudspeakers.

A further object of the invention is to provide a sound reproducing system from a sound record in which the volume and the distribution of the sound is under control of a separate control record.

A further object of the invention is to provide a system for varying the amplitude of reproduced sound in a linear relationship with respect to the amplitude variations of a control current.

Although the novel features which are believed to be characteristic of this invention are pointed out with particularity in the claims appended hereto, the manner of its organization and the mode of its operation will be better understood by referring to the following description read in conjunction with the accompanying drawings forming a part hereof, in which:

Figure 1 is a block diagram of one embodiment of the invention;

Figure 2 is a block diagram of a second embodiment of the invention;

Figure 3 is a schematic circuit diagram of the variable gain amplifiers and rectifier control units of the embodiment shown in Fig. 1;

Figure 4 is a graph showing the operation of the circuit of Fig. 3; and

Figure 5 is a schematic circuit diagram of the variable gain amplifier and the rectifier control unit of Fig. 2.

Referring now to Fig. 1, a sound record and control record, such as shown in Burrill Patent No. 2,270,610 of January 20, 1942, or a control record of any other type, are translated to electrical currents by a signal photoelectric cell 5 and a control track photoelectric cell 6. The signal currents are amplified in amplifier 8, then passed to variable gain amplifier 9 which feeds the variable gain amplifier 10 and a power amplifier 12 in parallel, the output of power amplifier 12 being connected to a loudspeaker 13 which may be the center speaker or group of speakers behind a motion picture screen. The output of the variable gain amplifier 10 is fed to a power amplifier 15 and is then impressed upon loudspeaker units 16 and 17 which may be the speakers on either side of the center speaker 13.

The output of the control track photoelectric cell 6 is fed to an amplifier 20, then to a rectifier control unit 21, the output of this latter unit controlling both variable gain amplifiers 9 and 10. From the diagram shown in Fig. 1 it is

to be observed that the signal currents are impressed upon two variable gain amplifiers 9 and 10, one of which feeds the center speaker and the other the side speakers. The control currents from the photoelectric cell 6 individually control each variable gain amplifier. The manner in which this control is effected will now be described by referring to Figs. 3 and 4.

The upper portion of the circuit of Fig. 3 represents the variable gain amplifier 9 having an input transformer 25 which may be connected to amplifier 8 and an output transformer 26 which may be connected to amplifier 12, the amplifier 9 including a pair of exponential push-pull tubes 27 and 28 which may be the type known as RCA 6K7's. The variable gain amplifier 10 of Fig. 1 is shown in the lower right-hand corner of the circuit drawing enclosed within the dotted lines 30, this unit comprising two single amplifying stages employing tubes 31 and 32 connected in series by a resistance-capacity coupling.

The control currents from the amplifier 20, Fig. 1, are fed over a transformer 34 to a rectifier 35, the output of which is fed to a second rectifier 36. Plate and grid potentials and heating currents for the units just described are obtained from a power supply unit comprising a transformer 38, a rectifier 39 and a filter 40. A voltage regulator tube is shown at 41. One preferred adjustment of the above units is such that with no control signal the grid bias applied to the grids of tubes 27 and 28 over resistance 55 of the voltage divider 42—47—55—43 and 44 will reduce the gain of tubes 27 and 28 about 10 db below normal, while the grid bias on tubes 31 and 32 will reduce their gain to minus infinity or, in other words, to a point where no signal currents can pass therethrough.

Referring now to the rectifier 35, a small direct current bias from the rectifier 39 is provided for rectifier 35 by the difference in setting of the sliders on resistances 43 and 44 over conductors 45 and 46 and resistance 48, the rectifier output of the rectifier 35 occurring across resistance 48. The adjustment of this rectifier bias is to prevent any residual control current flow from appearing in the output of the rectifier 35. In this arrangement, a bias circuit for the tubes 27 and 28 is over conductor 50, conductor 51, resistance 52, conductor 53, conductor 54, resistance 55 and conductor 56. Therefore, current flowing in resistance 52 from the left-hand cathode of the rectifier 36 will increase the bias on the tubes 27 and 28 in a positive direction and correspondingly increase their gain. Current, however, will not flow through the resistance 52 until the bias placed on rectifier 36 by resistance 44 is overcome by direct current from rectifier 35, so that the gain of the variable gain amplifier 27—28 will not change the amplification of the signal currents passing therethrough until a certain amplitude of control current is reached. Thus, the setting of the slider on resistance 44 determines the amplitude of control current from which the amplitude of the signal currents is varied from normal.

Contrary to the above, the gain of tubes 31 and 32 will be varied by the smallest amplitudes of control current over a circuit from the cathode of rectifier 35 over a portion of resistance 48, conductor 59, resistance 60, conductor 61 and resistances 62 and 63 in parallel to the grids of the tubes 31 and 32. Thus, the control currents will immediately vary the bias on tubes 31 and 32 in a positive direction, increasing their gain and the amplitude of the signal currents to the side speakers 16 and 17 of Fig. 1. During this variation, however, and as long as the control currents are below an amplitude which will overcome the bias on rectifier 36, the amplitude of the signal currents to the center speaker 13 will not be varied except, of course, in accordance with their normal variations on the signal track.

Continuing the operation of the circuit, the gain of tubes 31 and 32 will continually increase with no change in gain in tubes 27 and 28 as the amplitude of the control current increases. At a predetermined control current amplitude where the bias on rectifier 36 obtained from resistance 44 is overcome, current will flow through both sides of rectifier 36. The flow of current through the left-hand side of the rectifier 36 and through resistance 52 will shift the bias on tubes 27 and 28 in a positive direction, thus increasing their gain in proportion to the amplitude of the control currents. As the voltage on the right-hand side of rectifier 36 approaches zero and current starts to flow, the internal resistance of the rectifier will become low compared to the resistance 60, so that further increases in control current will not appreciably change the bias applied to the grids of tubes 31 and 32 and the gain will remain constant. Since current will begin to flow through both sides of rectifier 36 at the same instant since both sides have the same bias from resistance 44, variable gain amplifier 9 will begin increasing its gain when the gain of variable gain amplifier 10 becomes constant. Thus, setting of the bias on rectifier 36 determines the point at which the signal currents to the side speakers cease to be varied in amplitude with respect to the center speaker and the point at which the amplitude of the signal currents to all the speakers begins to vary conjointly.

To further illustrate this operation reference is made to Fig. 4 wherein the uppermost dotted curve represents the gain variation of the variable gain amplifier 27—28 and the uppermost solid curve represents the gain variation of variable gain amplifier 31—32, the change-over point being shown by the break in these two curves which occurs at the same amplitude of control current. The solid curve continues downwardly to minus infinity. To show the corresponding bias variation on the two amplifiers reference is made to the lower set of curves wherein the broken line curve shows the variation in bias on amplifier 27—28, while the full-line curve represents the change in bias on tubes 31—32. It will be observed that the bias variations are linear while the variation in gain of tubes 31—32, which are not variable mu tubes, is logarithmic.

Referring now to Fig. 2 showing another embodiment of the invention, the same signal pick-up photoelectric cell 5 and control track pickup photoelectric cell 6 are shown connected to their respective amplifiers 8 and 20, respectively, the output of amplifier 8 now feeding a single variable gain amplifier 9 which is connected to power amplifier 12 which simultaneously feeds all the speakers 13, 16 and 17. The rectifier control unit 21 connected to amplifier 20 now controls only the single variable gain amplifier 9 since all speakers are connected thereto. These control circuits are shown in Fig. 5 and will now be described.

The output of amplifier 8 is fed over a T-pad 70 to a transformer 71 and then to variable mu tubes 72 and 73, the output of which is fed over

transformer 75 to power amplifier 12. In order to remove from and insert into the system the variable gain amplifier 72—73, switches 76—77 are provided, such a switching system also being applicable to the system of Fig. 3, is desired. Two amplifying tubes 79 and 80 for the control currents are shown connected by a resistance-capacity coupling, the output of tube 80 being impressed upon a rectifier 81 over transformer 82. After rectification of the signal control currents in rectifier 81 they are fed through a filter 83 to a rectifier 84 which is similar to rectifier 36 of Fig. 3, except that the anodes are connected together as well as the cathodes. Plate and grid potentials and heater currents are supplied to the units just mentioned from a power pack including a transformer 85, a rectifier 86 with the usual filter resistances 87 and condensers 88. Voltage regulator tubes are shown at 89.

The grid biasing circuit for the variable gain amplifier tubes 72 and 73 is over conductor 91, the lower tapped portion of resistance 92, resistance 93 and conductor 94, normal bias being supplied by the voltage drop across resistance 93. This arrangement provides no bias for rectifier 81 while a negative bias determined by the adjustment of slider 96 on resistance 97 controls the amplitude of direct current from rectifier 81 necessary to produce a current flow through rectifier 84.

The above system operates similarly to the system of Fig. 3 in that the bias on rectifier 84 is adjusted at 96 so that at any predetermined level of control current, direct current will flow through rectifier 84 and consequently through resistance 92 which will increase the bias on tubes 72 and 73 in a positive direction, thus increasing their gain, and consequently increasing the amplitude of reproduction of the signal currents in all of the speakers 13, 16 and 17 of Fig. 2.

From the above it is to be noted that the first rectifier 81 is unbiased while the rectifier 84 has a negative bias placed thereon over resistance 97. The use of two serially-arranged rectifiers permits a linear relationship to be obtained between the control signal variations in amplitude and the variations in amplitude of the signal output. It is well known that a biased rectifier has a curved characteristic between A. C. input and D. C. output because of the variation in angle with amplitude, or in other words, the fact that the alternating current is impressed over longer time intervals at the higher amplitudes. However, an unbiased rectifier with a high load impedance with respect to its tube impedance has substantially a straight line or linear characteristic. Thus, the first rectifier 81 is unbiased and is provided with a high load impedance; namely, the biased rectifier 84, the latter providing the selective control at any predetermined level, this second rectifier also having a high load impedance with respect to its tube impedance. The second rectifier although biased, does not exhibit a curved characteristic, however, because it has a direct current input and therefore serves similarly to a simple switch to pass the direct current output of the first rectifier 81 at a predetermined bias point. Thus, this arrangement of rectifiers provides the desired linear relationship between the amplitude of the A. C. control signal and the direct current output from the second rectifier over a predetermined selective input level range as shown by the straight section of the upper broken line curve of Fig. 4.

I claim as my invention:

1. A sound reproducing system comprising means for obtaining electrical currents corresponding to a signal, means for transmitting said currents, and means for obtaining electrical currents for controlling the transmission of said signal currents, said last-mentioned means including serially connected rectifiers for linearly varying the amplitude of a predetermined portion of said signal currents during transmission in accordance with the amplitude of said control electrical currents.

2. A sound reproducing system in accordance with claim 1 in which a plurality of loudspeakers are provided for translating said signal currents into sound waves, said control currents varying the volume of reproduction of said signal among said loudspeakers.

3. A sound reproducing system in accordance with claim 1 in which said transmission means includes a plurality of variable gain amplifiers separately and differently controlled by said control currents.

4. A sound reproducing system comprising a source of signal currents, means for variably amplifying said currents, means for translating said currents into sound waves at a plurality of different places, a source of control currents, and means for utilizing said control currents to vary the amplification of said signal currents being reproduced at certain points while maintaining the amplification of said signal currents constant at other points of reproduction.

5. A sound reproducing system in accordance with claim 4 in which said last-mentioned means includes serially connected rectifiers for said control currents, one of said rectifiers controlling solely the amplification of said signal currents being reproduced at certain points and another of said rectifiers simultaneously preventing the amplification of said particular signal currents while varying the amplification of said signal currents being reproduced at other points.

6. A sound reproducing system in accordance with claim 4 in which said amplifying means includes a plurality of variable gain amplifiers and said last-mentioned means includes a plurality of rectifiers for said control currents, one of said rectifiers varying the gain of one of said variable gain amplifiers over a certain volume range of said control currents, and another of said rectifiers preventing the varying of the gain of said one variable gain amplifier over another volume range of said control currents.

7. A sound reproducing system in accordance with claim 4 in which said amplifying means includes a plurality of variable gain amplifiers and said last-mentioned means includes a plurality of rectifiers for said control currents, the output current of one of said rectifiers varying the gain of one of said variable gain amplifiers over a certain volume range of said control currents while ineffective to vary the gain of said other variable gain amplifier, the output current of the other of said rectifiers preventing the varying of the gain of said one variable gain amplifier over another volume range of said control currents while simultaneously varying the gain of another of said variable gain amplifiers.

8. A current control system comprising a pair of variable gain amplifiers, a plurality of rectifiers, two of said parallel connected rectifiers being connected in series to a third rectifier, means for biasing said two parallel connected rectifiers to prevent current flow therethrough until the level of

the output current from said third rectifier is of a predetermined value, means for varying the bias on one of said variable gain amplifiers with the output current from said third rectifier, means for preventing the varying of the bias on said one variable gain amplifier by said third rectifier with the output current from one of said parallel connected rectifiers, and means for varying the bias on said other variable gain amplifier with the output current from said other parallel connected rectifier.

9. A current control system in accordance with claim 8 in which a common source of signal currents is provided for said variable gain amplifiers.

10. A current control system in accordance with claim 8 in which a common source of signal currents is provided for said variable gain amplifiers and separate sound reproducers are connected to the output circuits of each of said variable gain amplifiers.

11. In a sound reproducing system, the combination of a source of signal currents, a variable gain amplifier for variably amplifying said currents, a sound reproducer connected to said variable gain amplifier, a source of control currents, a rectifier for said control currents, a second rectifier connected to the output circuit of said first mentioned rectifier, the output circuit of said second amplifier being connected to the bias control electrodes of said variable gain amplifier, and means for biasing said second rectifier to prevent the flow of current therethrough until a predetermined level of control current to said first rectifier has been reached.

12. A sound reproducing system in accordance with claim 11 in which said first rectifier is unbiased and has a high load impedance with respect to its tube impedance.

13. In a sound reproducing system the combination of a source of signal currents, variable gain amplifiers for said currents, a source of control currents, a first rectifier for said control currents, the output current of said rectifier varying the gain of one of said variable gain amplifiers, a second rectifier for preventing said first rectifier from varying the gain of said one variable gain amplifier, a third rectifier for varying the gain of said other variable gain amplifier, and means for biasing said second and third rectifiers to obtain a predetermined starting point for the operation thereof.

14. A sound reproducing system in accordance with claim 13 in which the value of said bias on said second and third rectifiers determines the amplitude of said control currents at which the gain of said first mentioned variable gain amplifier is maintained constant and said second mentioned variable gain amplifier functions to vary the amplitude of said signal currents being transmitted therethrough.

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