Sept. 30, 1930 M. E. STRIEBY 1,776,821

AUTOMATIC VOLUME CONTROL SYSTEM

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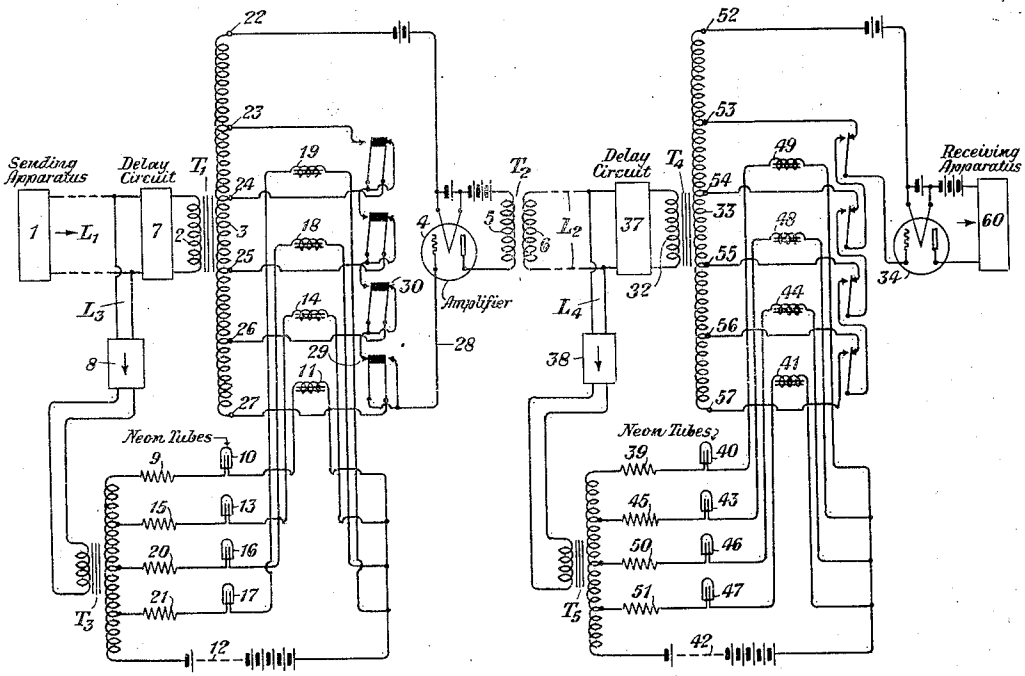


Fig. 1

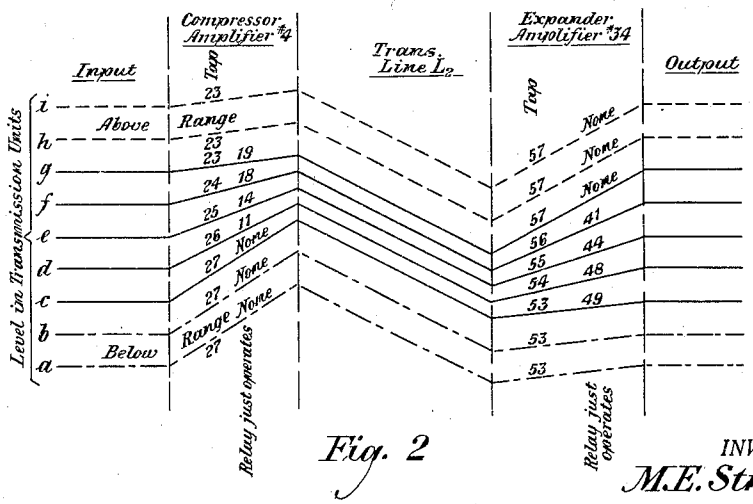


Fig. 2

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AUTOMATIC VOLUME-CONTROL SYSTEM

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This invention relates to automatic volume control systems and particularly to means for automatically controlling the volume of energy transmitted over or through a transmitting medium so that it will at all times have a predetermined relation to the volume of the energy at the source thereof, which relation is a function of the volume of the signal to be transmitted.

In the transmission of electrical energy over or through a transmitting medium such as a telephone circuit, it may be desirable to change the volume of energy to be transmitted to bring it within the limits of transmission of the telephone circuit. If the volume transmitted is excessively high, crosstalk will be produced in adjacent circuits. On the other hand, if the volume falls below the level of noise on the telephone circuit, distortion of the signal will result. Various ways have been proposed heretofore to vary the volume of energy that is impressed by some source upon a telephone transmission circuit to keep the volume as transmitted within the limits described above. Those methods employing some form of manual control have been expensive and frequently not satisfactory because of the inherent delay. In the automatic systems of the prior art distortion has been produced by the fact that the operation is instantaneous and continuous.

My invention resides in means for automatically controlling the volume of energy to be transmitted over or through a transmitting medium so that the volume as transmitted will at all times bear a predetermined relation to the volume of energy from the source connected with the transmitting medium.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing of which Figure 1 shows specifically one form of embodiment of the invention, and Fig. 2 is a chart to illustrate the description of the mode of operation of the invention.

In the drawing, 1 represents a source of energy which is connected with an input circuit L_1. The source of energy 1 may be any form of device capable of producing electrical energy, the form of which may vary with time. Or it may represent, for example, a transmitter adapted to translate sound into electrical energy, the latter varying in volume with changes in the sound impressed upon the transmitter. The input circuit is connected with the primary winding 2 of the transformer T_1. The secondary winding 3 of this transformed which has a plurality of taps extending therefrom is connected with the grid of the amplifier 4. The plate circuit of this amplifier includes the primary winding 5 of the transformer T_2, the secondary of which is connected with the transmission circuit L_2, or a receiving device which may have predetermined limits of volume that may be efficiently handled thereby. The input circuit L_1 may have connected therewith a delay circuit 7, the function of which is to retard the impression of the voltage upon the grid of the amplifier 4 until such a time has elapsed as to permit the operation of the switching devices that connect a portion of the secondary winding 3 with the grid of the said amplifier.

Bridged across the input circuit L_1 is a control circuit L_8. This circuit may have an amplifier such as 8 connected therewith, the output of which is connected with the primary winding of the transformer T_8. The secondary winding has a plurality of taps taken from various parts thereof, each of which is connected with a gas discharge device such as a neon tube represented by 10, 13, 16 and 17. Also connected in series with each tube is the winding of one of a plurality of relays 11, 14, 18 and 19, and a source of voltage 12, common to all tubes that may serve to bias each of the said tubes to operate at a lower impressed voltage than it would otherwise require. A source of potential, individual to each tube, may readily be provided. Thus, for example, the upper terminal of the secondary winding of T_8 is connected with a circuit that includes the resistance 9, neon tube 10, winding of relay 11, and source of direct potential 12. It will thus be seen that there is impressed across the tube 10, the full voltage across the sec-

ondary winding of the transformer and the voltage of the source 12, so that this tube will be the first of the group of tubes to operate. The resistance 9 serves to assist in extinguishing the discharge through the tube as soon as the voltage begins to fall and thus to quickly restore the tube to its non-operating condition. The tube 13 is bridged across a smaller portion of the secondary winding than the tube 10 and has connected in series therewith the winding of the relay 14, and the resistance 15. Similarly, the tubes 16 and 17 are connected across succeeding smaller portions of the secondary winding in series with relays 18 and 19 respectively, and resistances 20 and 21 respectively. While all of the tubes are showing as having a biasing voltage of the same magnitude, such is not necessary, since the bias may vary with different tubes.

At the right hand side of Fig. 1 is shown the terminal circuit for receiving the signals transmitted over the line L_2, which circuit comprises apparatus similar to that shown at the transmitting end of the said line but connected to act in a way that is the reverse of the transmitting end. This terminal circuit includes a delay circuit 37, a transformer T_4, of which the secondary winding 33 has a plurality of taps 52 to 57 inclusive. Tap 52 is connected with the filament of the amplifier 34, of which the output side is connected with the receiving apparatus 60. The branch circuit L_4, which may include an amplifier 38, is connected with the regulating circuit by the transformer T_5 having a plurality of taps which are connected with the neon tubes 40, 43, 46 and 47 through the resistances 39, 45, 50 and 51. The circuit that includes the tube 40 also includes the winding of relay 49 and the tubes 43, 46 and 47 are similarly connected with relays 48, 44 and 41. These relays control through their contacts the connection of the grid of the tube 34 with each of the transformer taps 53 to 57 inclusive. It will be seen, however, that upon the operation of the tube 40, connected across the entire secondary winding of T_5, relay 49 is energized and connects the grid with tap 54 so that the input of the tube is across two sections of the secondary of T_4 thus increasing the gain of the tube and expanding the volume. On the other hand, when tube 10 (at the sending end) operates it energizes relay 11, which cuts down the gain of the tube by connecting it across the section of the secondary of T_1 between 22 and 26, thus compressing the volume. Thus, it will be seen how the similarly located apparatus at the two ends operates in a reverse sense.

The manner in which the circuit of Fig. 1 functions, to control automatically the volume of energy that is to be transmitted over the line L_2, is as follows: Let it be assumed that the device 1 is a microphone that is picking up sound produced by the playing of orchestral music having a wide range of volume. The currents resulting from the translation of such sounds into electrical energy will likewise vary in amplitude. These currents will flow through the winding 2 of the transformer T_1 and will create a voltage across the secondary winding of the transformer T_1, the magnitude of which at any instant is a function of the volume of the sound that created it. At the same time, a portion of the same current will flow through the primary winding of the transformer T_3 and will create a voltage across its secondary winding. Let it be assumed that this voltage, when superimposed upon the voltage of the source 12, is sufficient to operate the neon tube 10. The operation of this tube will permit the flow of sufficient current to operate relay 11 and its armature will assume the position shown in the drawing. It will, accordingly, be seen that the grid of the tube 4 is connected across that portion of the secondary winding included between the taps 22 and 26, the connection including conductor 28, contact 29 of relay 11, contact 30 of relay 14 and the tap 26. If the volume of sound increases, the energy transmitted over the line L_1 will likewise increase in volume and the voltage across the secondary of the transformer T_1 and also across the transformer T_3 will likewise increase. When such condition exists, the tube 13 will discharge, thereby operating relay 14. Since relay 11 remains energized by the continuation of discharge through the tube 10, the grid of the ampilfier 4 will be connected across that portion of the secondary of the transformer T_1 between the taps 22 and 25. This serves to cut down the gain of the tube and thereby to reduce the volume of energy that is transmitted over the line L_2. If the volume continues to increase, the other tubes will discharge and the remaining relays will operate, thus further diminishing the gain of the amplifier and keeping the volume of energy transmitted over the line L_2 within the limits of transmission of the said line. When the volume of sound tends to decrease, the voltage will diminish across that portion of the secondary of the transformer T_3 connected with the tube 17. If the voltage drops below the value necessary to maintain a discharge through the tube, the relay connected therewith will be deenergized and will release its armature, thereby opening the connection of the grid with the tap 23 of the secondary of the transformer T_1 and connecting the grid with the tap 24. The result of this is that the voltage impressed across the grid will tend to increase. It will, accordingly, be seen that the volume of energy transmitted over the line L_2 bears at all times a definite relation to the volume of energy in the circuit L_1 and that the relationship is automatically con-

trolled by the switching apparatus in the control circuit connected with the circuit L_1.

As mentioned hereinbefore, the receiving terminal circuit which is shown at the right-hand side of Fig. 1 comprises substantially the same apparatus as that shown at the sending end of the line L_2 but is arranged to function in an opposite sense. It will be seen that if the volume at the receiving end of the line L_2 is low, that is, insufficient to create the voltage necessary to effect the operation of the tube 40, then only that portion of the secondary winding between terminals 52 and 53 will be connected across the input side of the amplifier 34, the output of which is connected with the receiving apparatus 60. As the volume of the received signal increases, the voltage across the secondary winding of the transformer T_5 will be built up. When it reaches the operating value of tube 40, relay 49 is energized and the input side of the amplifier 34 is connected across a greater portion of the secondary of the transformer T_4, namely that between taps 52 and 54, which increases the gain of the amplifier. Further increases in the volume of the received signal will cause higher secondary voltages in the transformer T_5 which, if of sufficient magnitude, will result in the operation of tubes 43, 46 and 47 in succession. Such operation will in turn energize relays 48, 44 and 41, respectively, and thus will connect the amplifier 34 across successively larger portions of the secondary of T_4 which increases the gain of the amplifier.

The purpose and effect of the operations at the sending and receiving terminals becomes clear by referring to Fig. 2. If the volume of the signal in the line L_1 is below what may be termed the normal level, such, for example, as that indicated in Fig. 2 by *a*, the compressor-amplifier 4 will produce a maximum gain (because the amplifier is connected across the entire secondary of T_1) and will raise the level of the signal applied to the line L_2 for transmission thereover, giving the signal the maximum gain. The signal will, of course, fall during transmission, and since its level is relatively low when it reaches the receiving terminal, it will not cause the operation of any of the tubes associated therewith because the voltage across T_5 is too low. Consequently, the signal will be but slightly amplified. Such amplification, however, is sufficient to raise the level to the same point, viz., the point *a* at which it stood at the transmitting station. And in like manner, for a higher level such as is represented by *b*, the maximum gain will be given by the amplifier 4, and at the receiving end, only the minimum gain is necessary to restore the level after transmission to that at which it stood prior to transmission. For the level *c* the same gain is given as for levels *a* and *b* at the sending end and substantially the same gain at the receiving end. If the volume at the transmitting end reached the level *d*, relay 11 will operate and the amplifier 4 will be connected across the section of the secondary of T_1 between 22 and 26. This cuts down the gain of the amplifier, as is indicated by the change in the slope of the line. The level, of course, falls during transmission over the line L_2 and at the receiving end it effects the operation of relays 49 and 48. Such operation increases the gain of the amplifier 34, thus expanding the volume and restoring it to that level which it possessed at the transmitting end.

It is desirable to point out that the volume range handled by such a system may be adjusted by the number of turns between the various taps upon the secondary windings of the transformers. For example, the system may be arranged to compress the volume uniformly up to a certain value and above that value to compress it very rapidly so that, through most of the program, the volume compression may be only moderate and the change in artistic expression will be but slight. For extremely high peaks of sound, the compression will be large.

While the invention has been described in connection with a system for the transmission of signals over a line, it may be employed in other ways. Thus, for example, the invention may be used in the making of phonograph records where it is desirable to compress the volume of sound which is to be impressed upon the recording material. And it may also be used in connection with the reproduction of such sounds in order to restore to the same level the volume of the sound resulting from the playing of the record that it possessed at the time of its original production.

While the invention has been disclosed as embodied in a particular form, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In an automatic volume control system, the combination with an input circuit of an output circuit, an amplifier connecting the said input and the said output circuits, the connection between the amplifier and the input circuit including voltage varying means, and a control circuit connected with the said input circuit and comprising a plurality of neon tubes, each having a relay and a source of potential in series therewith, the said tubes being so connected with the said control circuit that the potential applied to each will differ from that applied to the others, the said relays being arranged to vary the said voltage varying means so that the gain of the amplifier will vary with changes in the voltage across the said control circuit.

2. In an automatic volume level control system, the combination with an amplifier of

a source of power effectively connected with the said amplifier, and means to automatically control the amount of power to be applied to the said amplifier, the said control means including means to by-pass a part of the power transmitted from the said source, means to apply the by-passed power to a plurality of parallel circuits each containing a gaseous discharge device in series with the winding of a relay, and means controlled by the said relay to vary the degree of amplification given by the amplifier to the power applied thereto, the degree depending upon the changes in level of the power produced by the said source.

3. In an automatic volume level control system, the combination with an amplifier of a source of power, means connecting the said source with the said amplifier, the connecting means including a variable transformer, and controlling means connected with the said source including a gaseous discharge device in series with the winding of a relay to vary the voltage applied to the said amplifier by the said transformer, the said variations being dependent upon changes in the level of the power transmitted from the said source so that the degree of amplification will be greater at lower levels than at higher levels.

4. In an automatic volume level control system, the combination with a vacuum tube amplifier of a source of power, means to couple the said source to the said amplifier, control means connected between the said source and the said coupling means, the said control means including a gaseous discharge device in series with the winding of a relay, and means controlled by the armature of the relay to vary the voltage applied to the said amplifier by the said coupling means.

5. In an automatic volume level control system, the combination with a vacuum tube amplifier of a source of power, means to connect the said source with the said amplifier, the said connecting means including a variable transformer to control the amount of power applied to the said amplifier, and controlling means bridged across the said connecting means including a second variable transformer, a plurality of branch circuits connected across different parts of the secondary of the said second transformer, each branch circuit including a gaseous discharge device in series with the winding of a relay, the armatures of the said relays being arranged to control the connection with the said amplifier of a part of the secondary winding of said first mentioned variable transformer.

In testimony whereof, I have signed my name to this specification this 20th day of May, 1927.

MAURICE E. STRIEBY.