

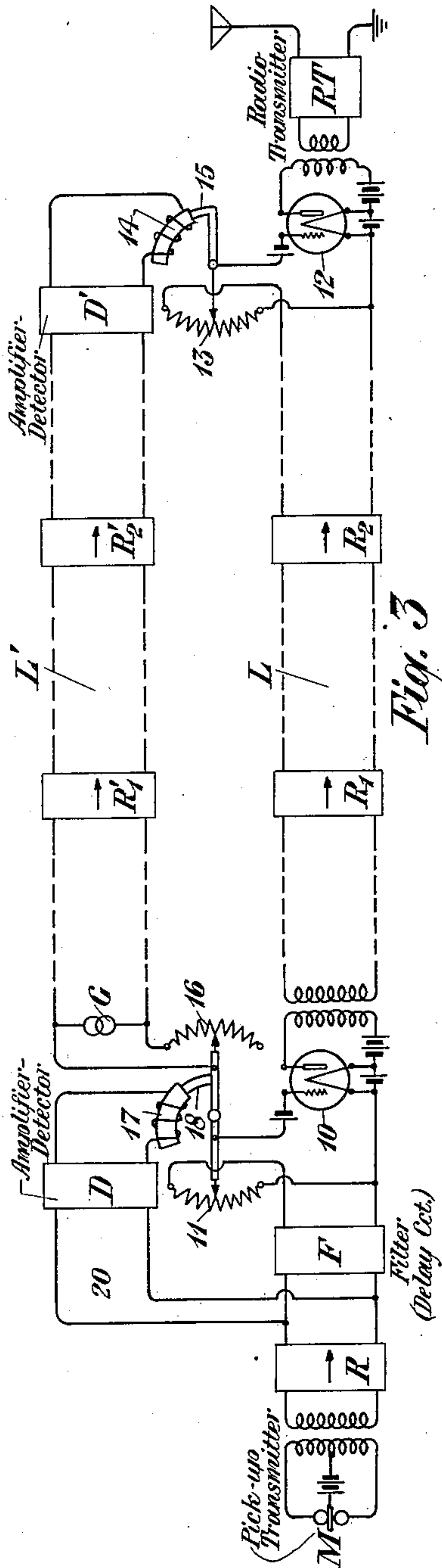
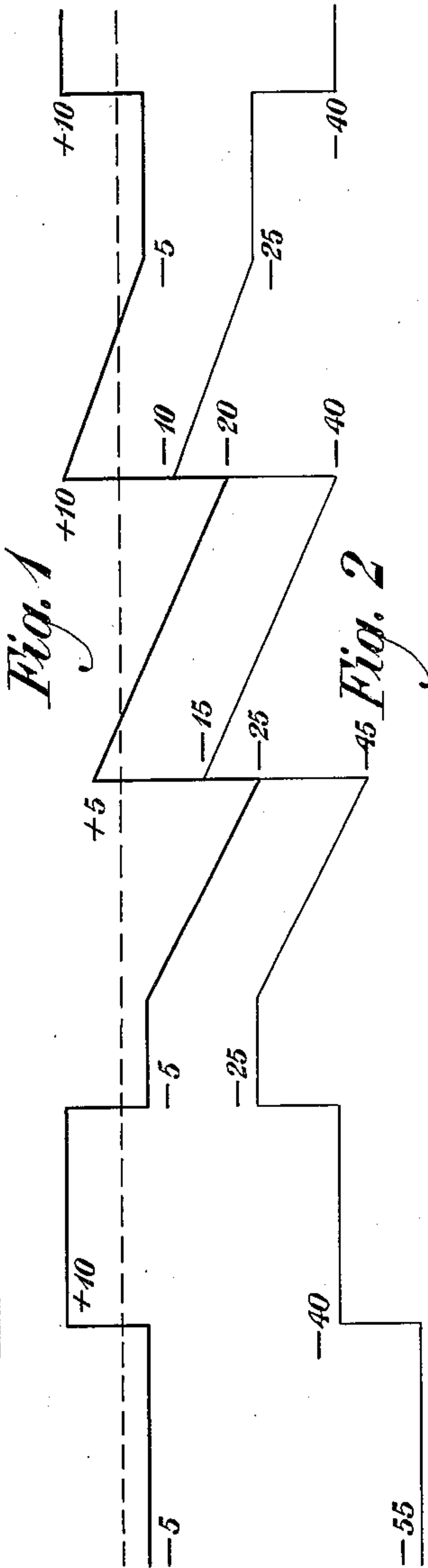
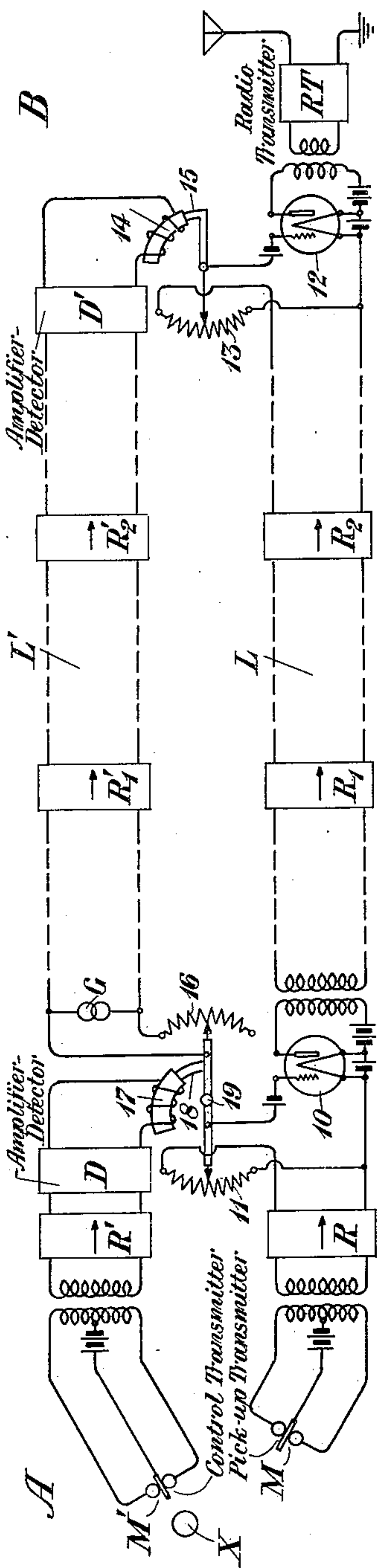
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H. S. HAMILTON

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AUTOMATIC VOLUME REGULATION OF TRANSMISSION SYSTEMS

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BY

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UNITED STATES PATENT OFFICE.

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AUTOMATIC VOLUME REGULATION OF TRANSMISSION SYSTEMS.

Application filed September 3, 1924. Serial No. 735,677.

To all whom it may concern:

Be it known that I, HAROLD S. HAMILTON, residing at New York, in the county of Bronx and State of New York, have invented certain Improvements in Automatic Volume Regulation of Transmission Systems, of which the following is a specification.

This invention relates to transmission circuits, and more particularly to arrangements for enabling a transmission medium inherently capable of transmitting only a narrow range of volume to produce at the receiving station a wider range of variation in volume than the medium is able to transmit.

In the case of a transmission medium, such as an ordinary telephone line, the range of volume variation of the transmitted signal is limited by factors which are not under control. In transmitting high grade performances, particularly musical selections, the range of variation in volume is frequently quite large. In order to transmit such material over a medium of limited volume range, it will be necessary to modify the very loud or very soft passages, or both, to bring them within the limits imposed by the medium, with a consequent loss in the contrast between the piano and fortissimo parts.

In accordance with the present invention, it is proposed to overcome this difficulty by regulating the volume impressed upon the transmission medium at the transmitting station so as to keep it within the limits of the medium, at the same time producing a change in some transmission element at the receiving station that will compensate for the change made at the transmitting station. For example, if the volume is reduced before being impressed upon the transmitting medium, a transmission element at the receiving station will be adjusted so as to correspondingly increase the volume, and vice versa. Preferably, the circuit is so arranged that the changes in volume introduced at the transmitting and receiving stations will be automatically controlled by the intensity of the signal at the originating source.

This method is useful, particularly in connection with public address and radio broadcasting systems where a program delivered at one point must be transmitted to an

audience at a distant point over a transmission medium whose volume range is limited.

The invention may now be more fully understood from the following detailed description thereof when read in connection with the accompanying drawing, Figure 1 of which shows one form of circuit arrangement embodying the principles of the invention, Fig. 2 of which is a transmission level diagram illustrating the operation of the circuit of Fig. 1, and Fig. 3 of which shows a modified circuit arrangement embodying the principles of the invention.

Referring to Fig. 1, L illustrates a telephone transmission line extending from the station A to the station B. The line L is provided with amplifiers or repeaters of a well known type as indicated at R_1 and R_2 . At station A a so-called pick-up microphone M is provided for picking up a musical selection or other program to be transmitted to station B. An amplifier or repeater R is associated with the pick-up microphone for amplifying the telephone currents resulting from the pick-up action of the microphone before impressing them upon the line L. At the receiving station a radio transmitting set RT of any well known type or an ordinary loud speaker system may be connected to the line so that the program incoming from the line may be transmitted.

In order to keep the volume impressed upon the line L from the repeater R within the volume limits of the transmission circuit, a volume regulating arrangement is provided which comprises an amplifying vacuum tube 10 having an adjustable potentiometer 11 in its input circuit. By suitable adjustment of the potentiometer 11, the potential applied to grid may be adjusted so that the output from the tube 10 may be made either greater or less than the input. If the volume delivered by the repeater R is greater than the maximum limit of which the line L is capable, the potentiometer 11 will be automatically adjusted in a manner about to be described so that the vacuum tube 10 will reduce the amplitude before it is impressed on the line. If, on the other hand, the volume delivered by the repeater R is smaller than the minimum volume which the transmission line L will carry without producing undesirable effects at the receiving

station, the potentiometer 11 will be adjusted so as to cause the tube 10 to amplify the currents and impress them upon the line L with a volume sufficient for proper transmission.

In order that the volume regulation above described may be automatically controlled by intensity of the sound at the signal source X, a second auxiliary pick-up microphone M' is provided, this microphone being associated with the input of the repeater R' similar to the repeater R. An amplifier-detector arrangement D of any well known type is associated with the output circuit of the repeater R' to rectify the amplified signal currents and produce in the output circuit of the amplifier-rectifier a direct current whose amplitude will depend upon the volume or intensity of the sound at the source X. This current flows through the winding of the solenoid 17 whose armature 18 is connected to the adjustable switch 19 which determines the setting of the potentiometer. The potentiometer 11 will therefore be adjusted in accordance with the intensity of the signal from the source X.

The limiting factors which determine the maximum and minimum volumes which the line will properly transmit are usually the overloading of the vacuum tubes of the repeaters on the one hand, and the amount of noise present in the transmission circuit on the other hand. That is to say, the maximum volume of the circuit is limited by the power carrying capacity of the repeaters and by the fact that the power must not be allowed to become so strong that it will produce serious cross-talk in the other circuits. The minimum value is limited by the amount of noise present in the transmission circuit due to various causes, such as paralleling power lines and paralleling telephone and telegraph circuits. In the case of radio transmission circuits, the range of volume is similarly limited by the power transmitting capacity of the wireless station on the one hand, and the noise due to static and other causes on the other hand.

The regulation of volume above described of course results in the transmission of successive passages of a musical selection, for example, with their volume relation so changed with respect to each other that the beauty of the selection might be largely lost if no arrangements were made for compensating for the change in volume produced. Accordingly, a compensating arrangement is provided at the receiving station B consisting of a vacuum tube 12 having associated therewith a potentiometer 13. By suitably adjusting the potentiometer 13, the vacuum tube 12 may be caused to deliver more or less power than is applied to its input circuit. It will be seen, therefore, that when the volume supplied by the re-

peater R exceeds the maximum to be transmitted over the line L, the potentiometer 11 is adjusted to reduce the volume, the transmission arriving at the receiving station may be brought back to its proper comparative volume by adjusting the potentiometer 13 to cause the tube 12 to amplify the currents. Likewise, if the potentiometer 11 is adjusted to increase the volume, the potentiometer 13 may be adjusted to decrease the volume.

In order that the adjustment of the volume controlling arrangement at the station B may be controlled by the volume adjustment made at station A, an auxiliary circuit L' is provided, said auxiliary circuit having repeaters R₁ and R₂ as in the case of the circuit L. At the transmitting end a generator of some suitable frequency G is provided, and at the receiving end a solenoid arrangement 14 is connected to the circuit L'. An amplifier-detector arrangement D' similar to the arrangement D at the transmitting station A is interposed between the line L' and the solenoid 14 for the purpose of rectifying the alternating current transmitted over the line L' and producing a direct current component whose amplitude will depend upon the amplitude of the alternating current transmitted over the line. Accordingly the solenoid will attract its core 15 more or less thereby causing the corresponding adjustment of the potentiometer 13. At the station A an adjustable shunt resistance 16 is bridged across the circuit to control the volume of the alternating current impressed upon the line L by the generator G, which generator is assumed to have a very high impedance. By arranging the potentiometer 11 and the shunt resistance 16 at the station A so that they are controlled together by the solenoid 17, it will be seen that the change in the amplitude of the current transmitted over the line L' will correspond to the change in the volume of the current impressed upon the line L, and both will be determined by the intensity of the signals at the source X.

At the station B the core 15 will be attracted by the solenoid 14 to an extent determined by the change in the amplitude of the current transmitted over the line L' and will produce a setting of the potentiometer 13 which will just compensate for the change in the setting of the potentiometer 11. Thus, whenever the transmission from the main transmission circuit L is made weaker, the alternating current over the control circuit is made weaker, and vice versa. The alternating current over the control circuit, by controlling the magnetic arrangement 14—15 at the distant end, will automatically adjust the potentiometer 13 accordingly, with the result that whenever the volume at the sending station is increased or decreased a cer-

tain amount by changing the setting of the potentiometer 11, the volume impressed by the line L upon the radio transmitter will be varied by the same amount but in the opposite direction.

Inasmuch as the magnetic arrangement 17—18 requires a certain amount of time for its operation, it is necessary to produce some delay in the arrival of the currents at the potentiometer 11 so that the setting of the potentiometer may take place just at the moment the currents corresponding to a change in intensity of the signal arrive at the potentiometer. This may be accomplished by arranging the pick-up microphone M slightly farther away from the source X than the control transmitter M'. The delay introduced by the transmission of the sound waves through the air to the microphone M will give the apparatus 17—18 time to operate in response to the change in the intensity of the signaling current generated by the microphone M'.

The operation of the circuit may be more fully understood from a consideration of the transmission level diagrams of Fig. 2. It will be noted from the curves of Fig. 2 that the volume supplied by the microphone M is assumed to vary from the maximum value of —5 transmission units to a minimum value of —55 transmission units, the range being 50 transmission units corresponding to a ratio of strong to weak power of approximately 100,000. Such a range of volume is frequently produced by a transmitter picking up a high grade musical performance, and the range may be even greater in certain cases. It is also assumed in Fig. 2 that the maximum range of volume which can be handled by the transmission line L is 20 transmission units corresponding to a ratio of strong to weak power of only about 100. The repeater R, as indicated, amplifies the current so that in the case of the maximum volume of signals the output current of the repeater will have an amplitude corresponding to +10 transmission units, and in the case of minimum volume will be —40 transmission units. As the current is transmitted over the line the changes in the transmission level for the condition of maximum power are indicated by the heavy line curve and for the minimum power by the lighter line curve. When the maximum power corresponding to a level of +10 units arrives at the volume control element 10, the potentiometer 11 is automatically adjusted so as to reduce it in volume 15 transmission units, thus bringing it down to a level of —5 transmission units. The power is now attenuated in being transmitted over the line section to the next repeater R₁ so that it drops down to —25 transmission units, is then amplified to a level of +5 units, is again attenuated in being transmitted over the next section, drop-

ping down to —20 units, and is amplified to a transmission level of +10 units, etc., finally arriving at the potentiometer 13 at a transmission level of —5 transmission units.

Similarly the minimum volume generated by the transmitter M of —55 units is likewise amplified by the first repeater R to bring it up to a value 15 transmission units higher, so that it arrives at a transmission level of —40 transmission units. In this case the volume control device 10 is so adjusted by means of the potentiometer 11 as to introduce a gain in transmission, thus stepping up the volume 15 units to a level of —25. The power is then impressed upon the transmission circuit and is attenuated in the line section extending to the repeater R₁ so that it falls to a level of —45 transmission units being amplified by the repeater R₁ to bring it up —15 units, the energy finally arriving at the potentiometer 13 with a power such that it reaches a transmission level of —25 units.

It will be seen by comparing the two curves that at all points between the input terminals 18 of the transmission line and the output terminals 17 of said transmission line the maximum and minimum values will be separated by a range of just 20 transmission units corresponding to the ratio of maximum to minimum volume of 100. For example, the maximum volume upon leaving the repeater R₂ is just +10 transmission units while the minimum volume is —10 transmission units, so that the actual ratio of the maximum to minimum power is 100. This will be clear from the following table showing the relation between transmission units and power ratios:

TU.	Power ratio R.	
20	100	
10	10	
0	1	
—10	1/10	
—20	1/100	
—30	1/1000	
—40	1/10,000	
—50	1/100,000	
—60	1/1,000,000	

The two curves of Fig. 2 indicate the changes which occur when the signal picked up by the microphone M is at its maximum and at its minimum volume. For intermediate volumes it will be readily understood that the potentiometer 11 will produce a smaller change in the volume so that the volume actually impressed upon the line at the output circuit of the tube 10 will lie somewhere between —5 and —25 units with corresponding changes in the power level as it is transmitted over the line.

In the operation of the system the range of volume to be applied to the sending end of the line must always be kept within the

limits of -5 and -25 transmission units. The potentiometer 11 will therefore have operated so as to cause a loss by means of the volume control device 10 when the volume is strong and so as to produce a gain when the volume is weak thereby reducing the range of volume to within the limits assumed, that is, between the maximum limit of -5 transmission units and the minimum of -25 transmission units. If the musical selection is of such a nature therefore that at a given instant the volume supplied by the repeater R is $+10$ transmission units, it will be reduced by means of the controlling device 10 to -5 transmission units and will arrive at the potentiometer 13 with a volume of -5 transmission units. If an instant later the volume supplied by the repeater R should drop to -40 transmission units, the controlling device would be adjusted to produce a gain of 15 transmission units, bringing the volume up to -25 so that the volume arriving at the potentiometer 13 will be -25 transmission units.

It will be seen at once by referring to the table that while the original ratio between the volume generated at the two instants under consideration by the microphone M was 100,000, the ratio between the corresponding energies received is only 100. The controlling device 12, however, will be automatically operated over the auxiliary circuit L' to introduce a gain of 15 transmission units in the one case and a loss of 15 transmission units in the other case, so that the volume for the maximum case is $+10$ transmission units and the volume for the minimum case is reduced to -40 transmission units. The total difference in range is 50 units, corresponding to a ratio of 100,000, so that the relation between the maximum and minimum volumes as applied to the radio transmitter RT will be the same as that generated by the microphone notwithstanding that the ratio was changed during transmission over the line L.

Fig. 3 illustrates a circuit arrangement similar to that of Fig. 1, but in the case of Fig. 3 the delay in the transmission of the current to the potentiometer 11 to enable the solenoid 17 to operate is introduced by means of a network or filter F, this filter being preferably of the well known Campbell type. The currents generated by the pick-up microphone M in this case are used for operating the solenoid 17, the branch circuit 20 being taken off from the output of the repeater R so that the amplifier-detector D may operate to rectify a portion of the signal energy to operate the solenoid 17. The filter or delay network F is introduced in the input circuit of the vacuum tube 10 at a point beyond the point at which the circuit 20 is branched from the output of the repeater R. Consequently the currents cor-

responding to the signal are delayed in their arrival at the potentiometer 11 thereby enabling the potentiometer 11 to be adjusted by the solenoid 17 before the change in volume which causes an adjustment of the potentiometer 11 has been impressed upon the line L.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a signaling system, a transmission medium capable of transmitting a relatively narrow range of volume, means to generate signaling energy having variations of volume extending over a range greater than that which the medium is capable of transmitting, means for changing the volume of the energy generated when it departs from a normal volume, a controlling arrangement for said last mentioned means controlled in accordance with the volume of the energy generated to produce an adjustment of said volume changing means proportional to the amount the volume of the generated energy has departed from normal, and means at the receiving station for automatically producing a compensating change in the volume of the received energy in the opposite direction.

2. In a signaling system, a transmitting medium capable of transmitting a relatively narrow range of volume, means to generate signaling energy having variations of volume extending over a range greater than that which the medium is capable of transmitting, means for decreasing the volume of the generated energy when it becomes greater than normal, a controlling arrangement for said last mentioned means controlled in accordance with the volume of energy generated to produce an adjustment of said volume changing means proportional to the increase in the volume of the generated energy, and means for automatically producing a compensating increase in the received energy.

3. In a signaling system, a transmitting medium capable of transmitting a relatively narrow range of volume, means to generate signaling energy having variations of volume extending over a range greater than that which the medium is capable of transmitting, means for increasing the volume of the energy applied to the medium when the generated energy falls below normal, a controlling arrangement for said last mentioned means controlled in accordance with the volume of the energy generated to produce an adjustment of said volume changing means proportional to the decrease in the generated energy, and means for auto-

atically producing a compensating decrease in the received energy.

4. In a signaling system, a transmission medium capable of transmitting a relatively narrow range of volume, means for generating signaling energy having variations of volume extending over a wider range than that which the transmitting medium will carry, means for generating controlling energy of constant volume, means to change the volume of said variable signaling energy before applying it to said medium when it departs from a normal volume, means to simultaneously produce a corresponding change in the volume of said controlling energy from said constant source, a controlling arrangement for both of said volume changing means controlled in accordance with the volume of the energy generated to produce an adjustment of said volume changing means proportional to the amount the volume of the generated energy has departed from normal.

5. In a signaling system, a transmitting medium capable of transmitting a relatively narrow range of volume, means for generating signaling energy varying in volume over a wider range than that which the transmitting medium will carry, means for generating controlling energy of constant volume, means to decrease the volume of said variable signaling energy before applying it to the medium when its volume becomes greater than normal, means to produce a simultaneously corresponding change in the volume of said controlling energy, a controlling arrangement for both of said volume changing means, said controlling arrangement being controlled in accordance with the volume of the energy generated to produce an adjustment of said volume changing means proportional to the increase in volume of the generated energy.

6. In a signaling system, a transmitting medium capable of transmitting a relatively narrow range of volume, means for generating signaling energy varying in volume over a wider range than that which the transmitting medium will carry, means for generating controlling energy of constant volume, means to increase the volume of said variable signaling energy before applying it to the medium when it falls below normal, means to produce a simultaneously corresponding change in the volume of said controlling energy, a controlling arrangement for both volume controlling means, said controlling arrangement being automatically controlled in accordance with the volume of the energy generated to produce an adjustment of said volume changing means proportional to the decrease in the generated energy.

7. In a signaling system, a transmitting medium capable of transmitting a relatively

narrow range of volume, means for generating signaling energy varying in volume over a wider range than that which the transmitting medium will carry, means for generating controlling energy of constant volume, means to change the volume of said variable signaling energy before applying it to said medium when it departs from normal, means to simultaneously produce a corresponding change in the volume of said controlling energy, a controlling arrangement for determining the adjustment of both volume controlling means, said controlling arrangement being automatically operated in accordance with variations in the volume of the generated energy, means to delay the transmission of the generated energy to said medium until said controlling arrangement operates, means at the receiving station to receive the signaling energy transmitted over said medium, and means responsive to the change in volume of said controlling energy to produce a compensating change in the volume of the received energy.

8. In a signaling system, a transmitting medium capable of transmitting a relatively narrow range of volume, means for generating signaling energy varying in volume over a wider range than that which the transmitting medium will carry, means for generating controlling energy of constant volume, means to decrease the volume of said variable signaling energy before applying it to the medium when its volume increases from normal, means to produce a simultaneously corresponding change in the volume of said controlling energy, a controlling arrangement for both of said volume changing means, said controlling arrangement being automatically controlled in accordance with the change in volume of the generated energy, means to delay the transmission of the generated energy to said medium until said controlling arrangement has been actuated, means at the receiving station to receive the signaling energy, and means at said station responsive to the change in volume of said controlling energy to produce a compensating increase in the received signaling energy.

9. In a signaling system, a transmitting medium capable of transmitting a relatively narrow range of volume, means for generating signaling energy varying in volume over a wider range than that which the transmitting medium will carry, means for generating controlling energy of constant volume, means to increase the volume of said variable signaling energy before applying it to the medium when it falls below normal, means to produce a simultaneously corresponding change in the volume of said controlling energy, a controlling arrangement for both of said volume changing means, said controlling arrangement being auto-

atically controlled in accordance with the variations in volume of said generated energy, means to delay the transmission of said generated energy to said medium until
5 said controlling means has operated, means at the receiving station to receive said signaling energy, and means at said station responsive to the change in the volume of said controlling energy to produce a compensating decrease in the received signaling energy. 10
In testimony whereof, I have signed my name to this specification this 2nd day of September 1924.
HAROLD S. HAMILTON.