

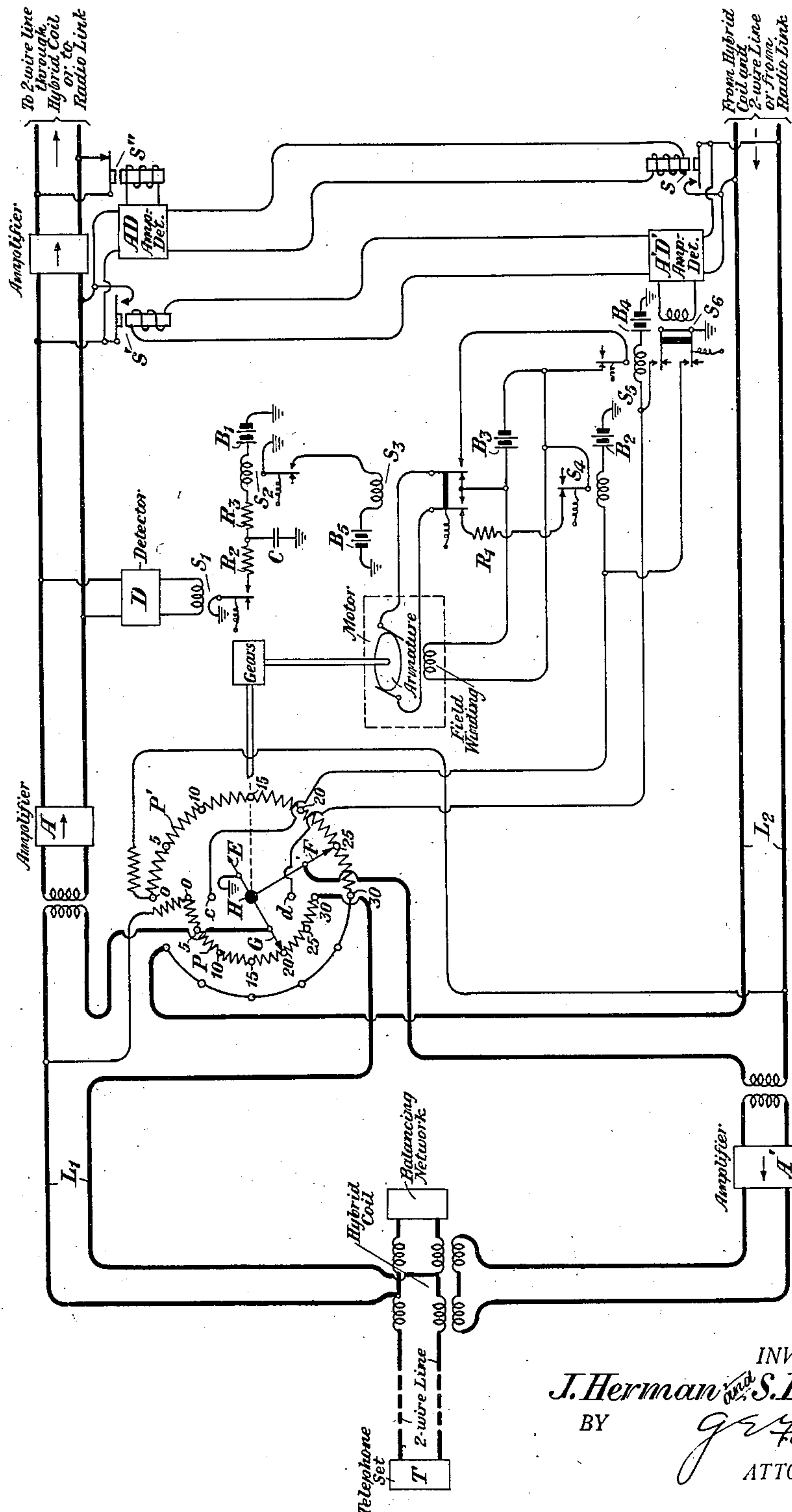
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J. HERMAN ET AL

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VOLUME REGULATION IN TWO-WAY TELEPHONE CIRCUITS

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INVENTORS
J. Herman and S. B. Wright
BY *g r f o r c*
ATTORNEY

UNITED STATES PATENT OFFICE

JOSEPH HERMAN, OF WESTFIELD, AND SUMNER B. WRIGHT, OF SOUTH ORANGE, NEW JERSEY, ASSIGNORS TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

VOLUME REGULATION IN TWO-WAY TELEPHONE CIRCUITS

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This invention relates to two-way signaling systems, and more particularly to two-way telephone systems including a four-wire circuit having one path adapted for transmission in one direction, a second path adapted for transmission in the opposite direction and a one-way amplifier or a plurality of such amplifiers in each path, and two-wire circuits connected to the four-wire circuit at the ends thereof. With further particularity, the invention relates to the automatic regulation of volume in the paths of the four-wire circuit.

In two-way telephone systems of the class indicated above, a two-wire circuit is connected to one end of the four-wire circuit through a hybrid coil, and a network is provided to balance the two-wire line. At its other end the four-wire circuit may be connected, as in the case of all-wire systems, directly to another two-wire circuit through a hybrid coil. There may, however, be an intervening radio link forming a part of the four-wire circuit. In such a case, the four-wire circuit includes apparatus for sending and receiving radio signals over the radio link in the two directions of transmission. For the purpose of clear description, the term "four-wire circuit" will be used hereinafter to denote that section of the two-way system which lies between a two-wire circuit and that portion of the four-wire circuit which, in the case of transmission partly by radio, is formed by the radio link.

Since the balance of a two-wire line and the associated balancing network is not perfect, there is the likelihood that echoes will occur due to the reflection from the two-wire line over the transmitting path of the four-wire circuit of currents flowing to the two-wire line over the receiving path of the four-wire circuit. Accordingly, it is usually desirable to employ means for disabling one path of a four-wire circuit while transmission is taking place over the opposite path. Apparatus which operates in response to voice currents in the paths of the four-wire circuit to prevent echoes and also to prevent singing in the four-wire circuit has been designed, as is disclosed in an article by A. B. Clark and

R. C. Mathes, published in the Journal of the American Institute of Electrical Engineers for June, 1925, pages 618 to 626.

These voice operated devices will operate properly only if the voice currents in the paths of the four-wire circuit are of sufficient amplitude. If the voice currents are too weak and the voice operated devices fail to operate, transmission over the two-way system, as will readily be understood, is seriously interrupted. On the other hand, it will be understood that the volume of the voice current must not be so great as to cause overloading in the system. In order to prevent excess or deficiency of volume, it has been necessary heretofore that a technical operator be constantly in attendance on each "four-wire circuit" to monitor the circuit and make the necessary adjustments.

The principal object of this invention is to eliminate the requirement of constant monitoring for the adjustment of volume in the paths of the four-wire circuit.

A further object of the invention is to increase the speed with which the volume regulation can be effected.

In the accomplishment of these objects, the applicants connect, at each end of the section of the two-way system which lies between two hybrid coils, a potentiometer into each path of the four-wire circuit ahead of one of the amplifiers, provide for the automatic maintenance of suitable input voltage for the two amplifiers under normal conditions and provide for the automatic reduction of the amplifier input voltage in the transmitting path in response to voice currents in that path of excessive amplitude and the simultaneous increase in a corresponding amount of the input voltage of the amplifier in the receiving path. The applicants further provide for the automatic prevention of change in the setting of the potentiometer when talking has ceased over the transmitting path and is taking place over the receiving path.

One of the principal advantages of the applicants' arrangement is that it automatically adjusts the volume for talkers of different voice strength to a predetermined value

which is suitable for the proper operation of echo suppressors and similar voice operated devices in the circuit.

Another advantage of the arrangement is that it provides for a compensating adjustment of the volume in the receiving path of the four-wire circuit, thus preventing harmful effects of echo currents under certain conditions of noise and balance.

These and other advantages of the invention will be more clearly understood when the following description of one desirable embodiment of the invention is read with reference to the accompanying drawing.

The drawing shows diagrammatically a fore-wire circuit (the term denoting that section of the two-way system stated above) having a two-wire line connected thereto and having applied to it suitable apparatus for controlling the volume in the two paths in accordance with the invention. It is to be understood that at the other end of the section of the two-way system which lies between the hybrid coil shown and the next hybrid coil to the right, the apparatus employed may be identical with that shown in the drawing and the operation thereof similar to that described hereinafter.

With reference to the details of the drawing, the four-wire circuit is connected at its left end through a hybrid coil to a two-wire line which leads to a telephone set T. A network is provided to effect an approximate balance with the two-wire line in the hybrid coil. The path L_1 of the four-wire circuit is adapted for transmission from T and the two-wire line, while the path L_2 is adapted for transmission to T over the two-wire line. One-way amplifiers A and A' are connected in the paths L_1 and L_2 , respectively.

The amplifier-detectors AD and A'D' and the relays S, S' and S'' form the voice operated apparatus for preventing echoes and singing in the four-wire circuit. The voice of a talker at T passes over the line L_1 , operates the amplifier-detector AD and causes the operation of relay S which places a short circuit on the receiving path L_2 . The line L_1 is normally disabled by a short-circuit under the control of relay S'' in order to prevent singing. When voice currents from T pass over L_1 , it is necessary that this path be cleared, and accordingly the amplifier AD is designed not only to operate relay S but also to operate S'' to remove the short circuit.

If no voice currents are passing over the line L_1 and a talker at the distant end of this circuit sends voice currents into the path L_2 , these currents operate the amplifier-detector A'D' and cause the operation of relay S' which places a short-circuit on the path L_1 and temporarily prevents the operation of the amplifier-detector AD. It will be understood, of course, that it is desirable to insert networks in the two paths of the four-wire

circuit in order to provide the necessary delays to permit the operation of the echo and singing suppressor apparatus before the voice currents reach the short-circuit points of the transmission paths; in the absence of such delay circuits or networks, clipping of the voice is likely to occur.

The applicants connect a potentiometer P into the transmitting path L_1 ahead of the amplifier A and a second potentiometer P' into the receiving path L_2 ahead of the amplifier A'. These two potentiometers, in one suitable arrangement, are concentric, and are otherwise positioned with respect to each other and are provided with steps as clearly shown in the drawing. A slider G associated with P and a slider F associated with P' are mounted on a common shaft H and are radially spaced in fixed relation to each other, as shown. These two sliders are insulated from each other, as is indicated in the drawing by the showing of the shaft H. A third slider E is mounted on the shaft H and is arranged to make contact with a stud c when slider G is on step 30 of P and with stud d when G is on step O. As will appear hereinafter, the relative positions of the potentiometers and sliders should be adjusted in accordance with the prevailing conditions of static or other noise. The shaft H of the potentiometers is driven through suitable gears by a shunt motor. The field winding of this motor is connected directly to a battery B₃, while the armature of the motor is connected to this battery through the contacts of a relay S₃. As will be more fully disclosed below, relay S₃ is designed to reverse the armature connections and, as a result, to reverse the direction of rotation of the potentiometer sliders.

It will be noted in the drawing that a counter-clockwise rotation of the sliders G and F increase the resistance through that part of the potentiometer P which is in parallel with the input of amplifier A and simultaneously effects a corresponding decrease in the resistance through that part of the potentiometer P' which is in parallel with the input of amplifier A'; that is, a counter-clockwise rotation provides for a gradual increase of the input voltage of amplifier A and simultaneously provides for a decrease of the input voltage of amplifier A'. It is understood, of course, that when slider G is on step 30 of P, the setting provides for the maximum input voltage of amplifier A.

A detector D is connected across the line L_1 at the output side of amplifier A. This detector D is adjusted to operate only when the amplitude of the voice currents in the transmitting path exceeds a predetermined safe value, and controls the relay S₁. Relay S₁ in turn controls the operation of the motor through a relay S₂ and the relay S₃. Relay S₄ is designed to interrupt the operation of the

motor and prevent further counter-clockwise rotation of the potentiometer sliders when slider G reaches the step 30 and simultaneously slider E makes contact with stud *c*. The relay *S*₅, also, has the function of interrupting the operation of the motor—in combination with relay *S*₄ and under the control of the relay *S*₆, which last relay is in turn controlled by the amplifier-detector A'D', responsive to voice currents in the receiving path *L*₂.

It is believed that further understanding of the regulator apparatus will be best obtained from the following description of the operation of the regulator.

If no voice currents are being transmitted over the circuit, the position of the relays *S*₁ to *S*₆ is that shown in the drawing. The motor armature is connected to battery *B*₃ through a resistance *R*₁. The motor operates slowly to cause the slow rotation of the potentiometer sliders in the counter-clockwise direction. The slow operation of the motor is due to the inclusion in the armature circuit of the resistance *R*₁. This rotation of the sliders brings the slider G to step 30 on potentiometer P and causes slider E, which is connected to ground as indicated on the drawing, to make contact with stud *c*—it being assumed that the counter-clockwise rotation is not checked in the meantime. When slider E makes contact with stud *c*, relay *S*₄ operates and opens the armature circuit of the motor to prevent further counter-clockwise rotation of the potentiometer sliders. Under the normal or non-transmitting condition of the circuit, which has been assumed thus far, the transmitting path *L*₁ of the four-wire circuit will at this point in the operation of the regulator be adjusted for maximum gain, while the receiving path *L*₂ will be adjusted for some intermediate gain, for reasons to be discussed hereinafter. For the purpose of illustration, the sliders G and F are shown in the drawing as radially spaced to bring slider F to step 15 of P' when slider G is on step 30 of P.

Let it now be assumed that a person begins to talk at the telephone set T. Since potentiometer P is set for the maximum input voltage of amplifier A, the amplitude of the voice currents at the output of A will, at times, be larger than is necessary for satisfactory communication. In the case of a loud talker the amplitude may even be so large as to overload the amplifier A or other amplifiers in the circuit. Therefore, it is desirable to provide for the reduction of the gain in line *L*₁ to a value which will not cause overloading; but, the gain must still be sufficiently great to produce satisfactory operation of the voice operated echo and singing suppressors. Accordingly, the applicants connect the detector D (which is adjusted to operate only when the amplitude of the voice currents is excessive) as shown, to control the relay *S*₁. When the voice currents are of excessive amplitude, this

detector operates and causes the armature of relay *S*₁ to go to its right-hand contact. This operation of relay *S*₁ causes the operation of relay *S*₂ which, in turn, causes the operation of *S*₃. Relay *S*₃, upon operation, moves its armatures to the right-hand contacts and causes the reversal of the armature connection of the motor, connecting the motor armature directly to battery *B*₃ and disconnecting the resistance *R*₁ from the circuit. A clockwise rotation of the potentiometer sliders is thereby produced, and this rotation, by decreasing the resistance of the part of the potentiometer P which is in parallel with the input of amplifier A, tends to reduce the gain. This clockwise rotation of shaft H continues until the output of amplifier A is reduced to the point at which the detector D ceases to operate and relay *S*₁ is released, this release causing the release of relays *S*₂ and *S*₃.

It is to be noted at this point that relay *S*₂ releases slowly because of the presence in this operating circuit of resistance *R*₃ and condenser C. As a consequence of this slow release feature, this relay *S*₂ will not follow the rapid fluctuations of the voice, as does relay *S*₁, but will remain operated while the armature of relay *S*₁ moves rapidly back and forth between its contacts. Relay *S*₂ will be released only if the armature of relay *S*₁ remains on its left-hand contact for a certain length of time.

As soon as relay *S*₃ has been released by relay *S*₂, the direction of operation of the motor will be reversed and the rotation of the potentiometer sliders will again be in the counter-clockwise direction. The operation of the motor and the counter-clockwise rotation of the sliders will now be at a speed considerably slower than that at which the opposite rotation took place, since the resistance *R*₁ is once more connected in series with the motor armature. The operation of the motor and the slow counter-clockwise rotation of the sliders continue, causing the provision of a gradual increase in the input voltage of amplifier A, until relay *S*₁ is again operated by the detector D in response to voice currents of excessive amplitude. The operations for reducing the gain in line *L*₁ will then be repeated.

With a suitable adjustment of the detector D, the arrangements described above produce a gain adjustment in line *L*₁ that will cause satisfactory operation of the device AD. Also, the amplitude of the voice currents, except at the beginning of a conversation, will be kept at a safe value to prevent overloading.

The range of gain control for line *L*₁ is determined by the number of steps on potentiometer P and their respective values in "transmission units" (TU). The range shown on the sketch is from 0 to 30 TU in 5 TU steps. When the potentiometer slider

reaches step 30, relay S_4 is operated due to the contact between slider E and stud c , as explained above, and when the slider reaches step O, relay S_5 is operated by the contact made between slider E and stud d . These

5 two relays are thus used to prevent rotation of the sliders beyond the limits of the potentiometer, serving to check the rotation at the maximum or minimum setting of P.

10 The alternate clockwise and counter-clockwise rotation of the potentiometer slider G in the vicinity of the proper step continues as long as the talker at T keeps on talking. When he stops talking the potentiometer slider moves gradually toward step 30 and will reach that step unless the talking is resumed in the meantime.

If voice currents of sufficient amplitude arrive over the receiving path of the circuit after the person at T stops talking, the amplifier-detector A'D' will be energized. This will cause the operation of relay S_6 which will in turn operate relays S_4 and S_5 , thereby opening the armature circuit of the motor and preventing any change in the settings of the potentiometers.

The adjustment of potentiometer P' in the receiving path of the circuit simultaneously with that of P in the transmitting path is required because of the effects of the echo currents mentioned above. This feature will now be discussed in detail.

Potentiometer P' is so designed that the step corresponding to maximum gain (step 30) is the step at which it is desired to operate this branch of the circuit. However, this is not always possible, especially if potentiometer P is operating near the maximum gain and the noise coming over the receiving path (static, in the case of the circuit including a radio link) is, in general, large in amplitude, requiring, perhaps, the adjustment of amplifier-detector A'D' to a point of relatively low sensitivity. Due to the imperfect balance between the two-wire line and the balancing network, some of this static will reach the transmitting branch of the circuit. If its amplitude at the input of the voice operated device AD is large enough, it will cause false operation of this device and will thereby prevent satisfactory communication. As has been indicated above, the amplifier-detector A'D' is adjusted to operate only in response to currents of a certain or a greater amplitude. Just as voice currents of sufficient strength will operate the amplifier-detector while voice currents of a lower amplitude will not, so noise currents (especially static) of a certain or a greater amplitude will operate the amplifier-detector while small noise currents will not. As long as the noise currents, static currents for instance, are of sufficient amplitude to operate this amplifier-detector A'D', the relay S' will operate and the transmission path L_1

will be blocked; accordingly, the echoes of the noise currents, which echoes are returned from the two-wire line over the path L_1 , cannot reach the amplifier-detector AD. There may, however, be smaller noise currents entering path L_2 which will not operate the amplifier-detector A'D' and the relay S' controlled thereby. If, now, these noise currents are echoed back over the transmission path L_1 and if the volume regulation in the path L_1 is such that there is a great amplification in that path, it may well be that the echoed and amplified noise currents will operate the amplifier-detector AD, since the path L_1 is not blocked by the relay S' . This false operation of the amplifier-detector AD may be prevented if the currents in the receiving path L_2 are kept sufficiently low in amplitude so that the amplification in the path L_1 , when the currents are reflected back over that path from the two-wire line, will not bring the reflected currents to the amplitude which is required for the operation of the amplifier-detector AD. Accordingly, whenever the gain in the transmitting path L_1 is increased beyond a certain value, the gain in the receiving path L_2 must be decreased a corresponding amount, in order to keep the amplitude of the reflected currents at the input to the amplifier-detector AD at a safe value.

Because of the fact that the amplitude of static (or other noise) varies from time to time, the relation between the gain settings of the two paths of the circuit must also be varied. The diagram shows a relation such that step 20 on the potentiometer P corresponds to step 25 on the potentiometer P'. If the amplitude of the static should increase it would be necessary to change the relative positions of rings P and P' or of sliders G and F so that step 20 on P corresponds to a step lower than 25 on P'. Similarly, a decrease in the static permits of a relative position of the two potentiometers such that steps 20 on P corresponds to a step higher than 25 on P'.

The description thus far has been on the assumption that the relative positions of P and P' and the sliders are determined entirely by the amplitude of the static. This would be true if the condition of balance between the two-wire line and its balancing network remained unchanged. Such is not the case, however, since different types of two-wire lines may be connected to the circuit and the balance obtained will not always be the same. For this reason, the worst condition of balance must be assumed, unless a change in adjustment is made from time to time as the balance changes, and the relative positions of the two potentiometers will then be determined only by the amplitude of the static. Obviously, if the worst condition of balance is assumed, a larger margin against

false operation from static will result when the balance is good than when it is poor.

Except for this setting based upon the amplitude of static, which must be made manually whenever the adjustment of the receiving voice operated device A'D' is altered, the operation of the regulator will be entirely automatic, as will be clearly understood from the above description.

While the invention has been described for the purpose of illustration as embodied in one specific form which is deemed desirable, it is to be understood that it is capable of embodiment in many other and widely different forms within the scope of the invention as defined by the appended claims.

What is claimed is:

1. In a two-way telephone system, a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means in each of said paths for controlling the amplitude of voice currents therein, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path.

2. In a two-way telephone system, a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means in each of said paths for controlling the amplitude of voice currents therein, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path, and means responsive to voice currents in said second path for preventing change of gain in either path.

3. In a two-way telephone system, a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means associated with each of said paths and responsive to voice currents therein for disabling the opposite path, means in each of said paths for controlling the amplitude of voice currents therein, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path.

4. In a two-way telephone system, a circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means associated with each of said paths and responsive to voice currents therein for disabling the opposite path, means in each of said paths for controlling the amplitude of

voice currents therein, means responsive to voice currents in said first path, of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path, and means responsive to voice currents in said second path for preventing change of gain in either path.

5. In a two-way telephone system, a four-wire circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means in each of said paths for controlling the amplitude of voice currents therein, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path.

6. In a two-way telephone system, a four-wire circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means in each of said paths for controlling the amplitude of voice currents therein, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path, and means responsive to voice currents in said second path for preventing change of gain in either path.

7. In a two-way telephone system, a four-wire circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means associated with each of said paths and responsive to voice currents therein for disabling the opposite path, means in each of said paths for controlling the amplitude of voice currents therein, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path.

8. In a two-way telephone system, a four-wire circuit having a first path adapted for transmission in one direction and a second path adapted for transmission in the opposite direction, means associated with each of said paths and responsive to voice currents therein for disabling the opposite path, means in each of said paths for controlling the amplitude of voice currents therein, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path, and means responsive to voice currents in said second path for preventing change of gain in either path.

9. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line and a second path adapted for transmission to said line, means in each of said paths for controlling the amplitude of voice currents therein, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path.

10. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and means in each of said paths for controlling the amplitude of voice currents therein, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path, and means responsive to voice currents in said second path for preventing change of gain in either path.

11. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and means in each of said paths for controlling the amplitude of voice currents therein, means associated with each path of the four-wire circuit and responsive to voice currents therein for disabling the opposite path, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path.

12. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and means in each of said paths for controlling the amplitude of voice currents therein, means associated with each path of the four-wire circuit and responsive to voice currents therein for disabling the opposite path, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction of the gain in said path and simultaneously effecting an increase of the gain in said second path, and means responsive to voice currents in said second path for preventing change of gain in either path.

13. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path

adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction in the input voltage of the amplifier in said path and simultaneously effecting an increase in the input voltage of the amplifier in the second path, and means responsive to voice currents in the second path for preventing change of gain in either path.

14. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, means associated with each path of the four-wire circuit and responsive to voice currents therein for disabling the opposite path, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction in the input voltage of the amplifier in said path and simultaneously effecting an increase in the input voltage of the amplifier in the second path.

15. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, means associated with each path of the four-wire circuit and responsive to voice currents therein for disabling the opposite path, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for effecting a reduction in the input voltage of the amplifier in said path and simultaneously effecting an increase in the input voltage of the amplifier in the second path, and means responsive to voice currents in the second path for preventing change of gain in either path.

16. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, means for normally effecting an increase in the input voltage of the amplifier in said first path and simultaneously effecting a reduction in the input voltage of the amplifier in said second path, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for checking said voltage changes and effecting a reduction in the input voltage of the amplifier in the first path and simultaneously effecting an increase in the input voltage of the amplifier in the second path.

17. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line, and a one-way amplifier in each path, means for normally effecting an increase in the input voltage of the amplifier in said first path and simultaneously effecting a reduction in the input voltage of the amplifier in said second path, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for checking said voltage changes and effecting a reduction in the input voltage of the amplifier in the first path and simultaneously effecting an increase in the input voltage of the amplifier in the second path, and means responsive to voice currents in the second path for preventing change in the input voltages of the amplifiers other than changes due to variations of voice strength.

18. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, a first potentiometer connected into said first path ahead of the amplifier therein, a second potentiometer connected into said second path ahead of the amplifier therein, means for normally effecting an increase of the resistance of that part of said first potentiometer which is in parallel with the input of the amplifier in the first path and simultaneously effecting a decrease of the resistance of that part of said second potentiometer which is in parallel with the input of the amplifier in the second path, and means responsive to voice currents in said first path of amplitude in excess of a predetermined value for checking said changes of resistance and effecting changes in the opposite direction.

19. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, a first potentiometer connected into said first path ahead of the amplifier therein, a second potentiometer connected into said second path ahead of the amplifier therein, means for normally effecting a gradual increase of the resistance of that part of said first potentiometer which is in parallel with the input of the amplifier in the first path and simultaneously effecting a gradual decrease of the resistance of that part of said second potentiometer which is in parallel with the input of the amplifier in the second path, and means responsive to voice currents in said first path of amplitude in excess of a

predetermined value for checking said gradual changes of resistance and effecting changes in the opposite direction, said last stated changes being gradual but more rapid than the normal changes.

20. In a two-way telephone system, a four-wire circuit, a two-wire line connected thereto, said four-wire circuit having a first path adapted for transmission from the two-wire line, a second path adapted for transmission to said line and a one-way amplifier in each path, a first potentiometer connected into said first path ahead of the amplifier therein, a second potentiometer connected into said second path ahead of the amplifier therein, means for normally effecting an increase of the resistance of that part of said first potentiometer which is in parallel with the input of the amplifier in the first path and simultaneously effecting a decrease of the resistance of that part of said second potentiometer which is in parallel with the input of the amplifier in the second path, means responsive to voice currents in said first path of amplitude in excess of a predetermined value for checking said changes of resistance and effecting changes in the opposite direction, and means responsive to voice currents in the second path for interrupting the operation of the means for changing the potentiometer resistances.

In testimony whereof, we have signed our names to this specification this 14th day of October, 1927.

JOSEPH HERMAN.
SUMNER B. WRIGHT.

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