

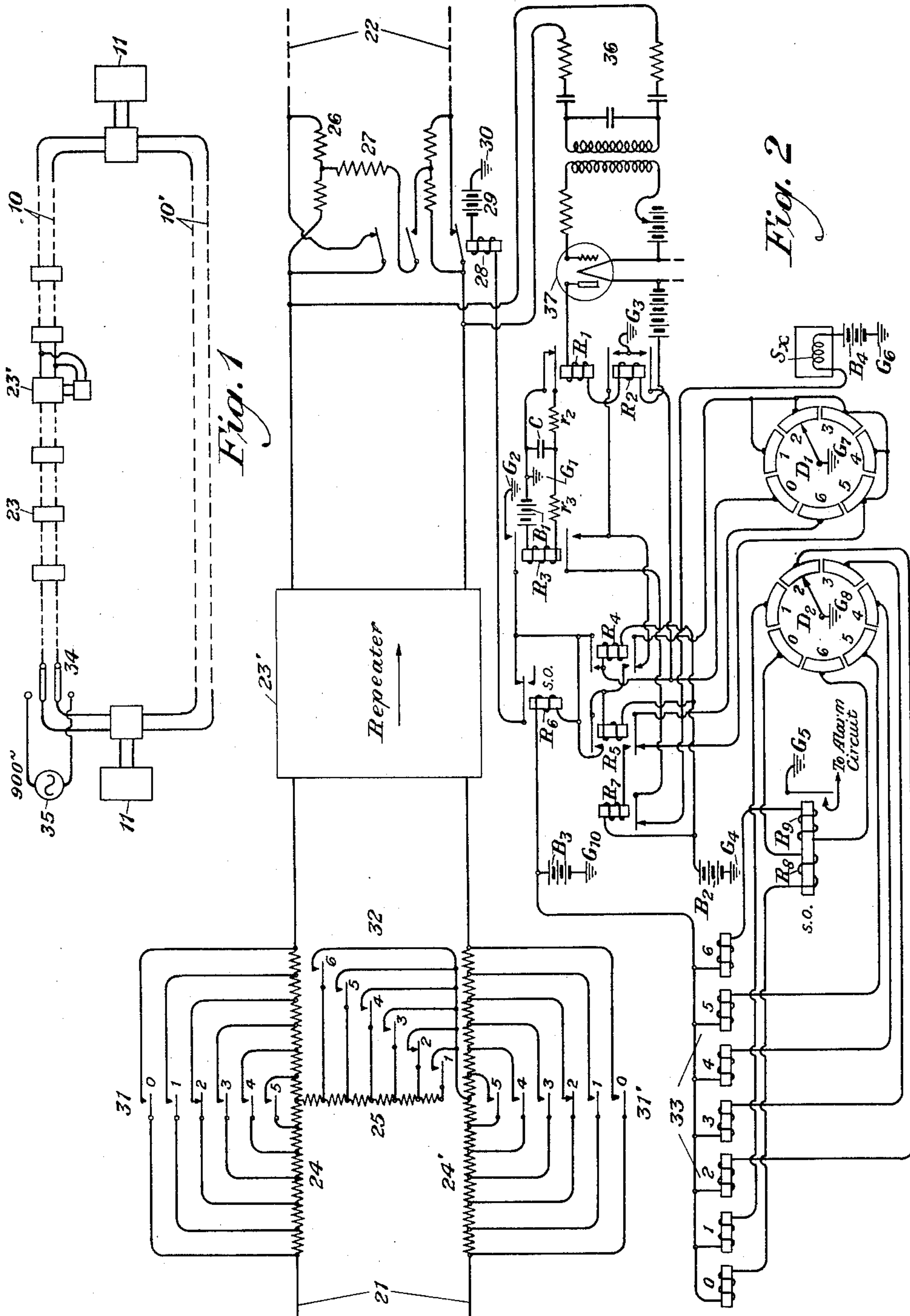
Nov. 21, 1933.

L. G. ABRAHAM

1,935,759

SYSTEM FOR ADJUSTMENT OF TRANSMISSION LEVELS

Filed Jan. 19, 1932



INVENTOR
L. G. Abraham
 BY *J. S. Folk*
 ATTORNEY

UNITED STATES PATENT OFFICE

1,935,759

SYSTEM FOR ADJUSTMENT OF
TRANSMISSION LEVELSLeonard G. Abraham, Madison, N. J., assignor
to American Telephone and Telegraph Com-
pany, a corporation of New York

Application January 19, 1932. Serial No. 587,592

14 Claims. (Cl. 178—44)

It is among the objects of my invention to provide a new and improved method and corresponding apparatus for adjusting transmission on a signaling circuit. Another object of my invention is to provide for automatic adjustment of gain at each of several repeaters in tandem on a long transmission line so as to preserve the proper energy level at each of these repeaters. Still another object of my invention is to provide for making such adjustments very quickly, so as to interfere with the regular service of the line as little as practicable. Still another object is to provide for applying a current of a single frequency to a line and separating it out at the repeaters and applying it according to its intensity at each repeater to make corresponding adjustments for gain in such repeater. All these objects and various other objects and advantages of my invention will become apparent on consideration of an example of practice according to the invention which I have chosen for disclosure in the following specification. It will be understood that this specification relates principally to this particular example of the invention and that the scope of the invention will be indicated in the appended claims.

Referring to the drawing, Figure 1 is a diagram of a transmission line with equipment for the practice of my invention, and Fig. 2 is a diagram showing the apparatus associated with one of the repeaters.

A long transmission line 10—10' is indicated in Fig. 1 with the usual terminal apparatus 11 at its ends. The line 10—10' is a "four-wire line" comprising a conductor pair 10 for transmission from west to east and a conductor pair 10' for transmission from east to west. Interposed along each of these pairs 10 and 10' there are one-way repeaters 23 in tandem and at certain of these repeaters, such as 23', there is extra equipment for automatic adjustment of gain as shown more in detail in Fig. 2. For example, the repeaters might be fifty miles apart and the special equipment mentioned might be provided at every tenth repeater, i. e., at stations five hundred miles apart, assuming a line say four thousand miles long.

At each repeater such as 23' shown in Fig. 2, there is an adjusting "pad", i. e., an adjustable loss network comprising steps of series resistance 24 and 24' and steps of shunt resistance 25, which may be cut in or out by the relay contacts 31, 31' and 32 controlled by the relays 33. It will be noticed that these relays 33 are numbered from 0 to 6 and like numbers are found on the

relay contacts 31, 31' and 32. These numbers mean that each relay operates the like numbered contacts. Thus, in the state of affairs shown in Fig. 2, the only one of the seven relays 33, individually numbered 0 to 6, that is operated at this time is No. 2, and it will be seen that only the No. 2 contacts are operated in the groups of contacts 31, 32' and 32. Thus at this time there are two stages of series resistance units 24, 24' in the line and five stages of shunt resistances 25 connected across the line. In other words there are now two stages or units of "loss" in the line.

The operated condition of relay No. 2 of the relays 33 is readily established by tracing the circuit from ground G_{10} through battery B_3 , the particular relay No. 2, the segment No. 2 of dial D_2 , the corresponding dial index and ground G_8 . This corresponds to the assumption that at the last preceding operation to make adjustment, the proper condition was found at the adjustment that has just been described with the arm of dial D_2 on its segment No. 2.

Let it be assumed that the repeater shown in Fig. 2 is the first in order of the repeaters proceeding in the direction of the transmission from the transmitting end of the conductor pair in which this repeater 23' is interposed. Further features of construction of the system shown in Fig. 2 will readily be apprehended from the following description of a normal operation for adjustment.

The operator at the sending end of the line 10, desiring to make the adjustments provided by this system, shifts the switches 34 (see Fig. 1) for a brief period of time of the order of two or three seconds, thus putting the 900 cycle oscillator 35 across the line 10 at its input end. This 900 cycle current from the generator 35 has a definite energy intensity and, of course, like the various components of voice currents, it is attenuated along the successive stretches of line between the repeaters and amplified to compensate at each repeater. This 900 cycle current flows through the first specially equipped repeater 23' and enters the selective circuit 36 which is connected across the line on the output side of the repeater 23'. This selective circuit 36 passes the 900 cycle current to the input of the detector 37 and the corresponding output current from the detector 37 goes through the relays R_1 and R_2 in series. The relay R_1 will operate and open the circuit of relay R_3 . But because of the condenser C and the resistances r_2 and r_3 , the relay R_3 will be slow-acting and will release its armatures only after a time interval of say

0.05 second. Relay R_2 may or may not operate according to the current intensity on the output side of repeater 23', as will be considered presently.

- 5 It should be noticed that of course normal voice currents on the line will comprise components of the same special frequency 900 cycles, and when these are present they will be passed by the selective circuit 36 to the detector 37 and
10 they may operate the relay R_1 , as has just been described. But such 900 cycle components of voice currents will ordinarily be of low intensity and brief duration and they will not keep R_1 operated long enough to result in release of the
15 relay R_3 , even though the relay R_1 may be operated intermittently. Even if a 900 cycle component of voice current should be of sufficient intensity and so long sustained as to release relay R_3 and thereby effect a false adjustment, this would be corrected when a normal adjustment was made by closing the switches 34 and applying the 900 cycle current at the sending end.

- 20 But assuming that the intended 900 cycle testing current has been applied by closure of the switches 34 and that the relay R_1 has been operated and relay R_3 has released, as described heretofore, then a circuit will be closed as follows: from ground G_2 to the back contact of relay R_3 ,
25 back contact of relay R_6 , winding of relay 28, battery 29 and ground 30. The resulting operation of the relay 28 will cut in a loss network or pad of about 6 decibels comprising the series resistances 26 and the shunt resistance 27. While
30 this loss pad remains in the circuit it will attenuate the 900 cycle current going on from the repeater 23' so that it will be of low intensity at the next repeater 23' equipped with such apparatus; the effect at such next repeater will be discussed presently.

- 35 If the level on the output side of the repeater 23' is too low the relay R_2 will not operate, and if this level is too high the relay R_2 will operate. Accordingly there are two cases to be considered.
40 The proper point of discrimination is secured by adjustment of the detector 37, particularly of the battery in its input circuit.

- 45 *Case 1.*—Assuming that the transmission level on the output side of the repeater 23' is high, and accordingly the relay R_2 will be operated when relay R_3 releases, the operation of relay R_2 will close a circuit as follows: from ground G_4 , through battery B_2 , relay winding R_4 , front contact of relay R_2 and ground. Relay R_4 will lock itself up through
50 the circuit from ground G_4 , battery B_2 , winding of relay R_4 , front contact of this relay, back contact of relay R_3 and ground G_2 . The slow-operating relay R_6 will tend to operate through the circuit from ground G_{10} , battery B_3 , winding of
55 relay R_6 , back contact of relay R_3 and ground G_2 . But because of its slow-operating character, the relay R_6 will not operate until a certain time interval has elapsed.

- 60 Also, the operation of the relay R_2 and the release of the relay R_3 close a circuit for the stepping selector S_x as follows: from ground G_6 , through battery B_4 , the winding of this selector, back contact of relay R_7 , back contact of relay R_3 , front contact of relay R_2 to ground G_3 . The
65 selector S_x begins to step the arms of dials D_1 and D_2 around clockwise, and accordingly the arm of dial D_2 opens the circuit of No. 2 relay in the relay set 33 and closes the circuit through relay No. 3 of the same set, thus introducing an additional step of loss in the adjusting pad

31—31'—32. This increased loss on the input side of the repeater 23' leads to a reduction of intensity in the output circuit of the detector 37 and if it brings the intensity down to the proper level on the output side of the repeater 23' the relay R_2 will release. But if this level is not brought down to the proper point, the relay R_2 will not release and the arm of dial D_2 will step along from segment to segment, successively releasing the operated relays of the set 33 and operating those next in order and introducing more and more loss in steps in the pad 31—31'—32. Whenever the resultant decrease of intensity on the output side of the repeater 23' is such that the proper power level is attained, then the relay
80 R_2 releases, opening the circuit for the selector S_x and stopping the selector so as to preserve the corresponding adjustment of the pad 31—31'—32.

85 When the relay R_4 is operated, as described above, it closes a circuit that operates the relay R_5 as follows: from ground G_4 , through battery B_2 , winding of said relay R_5 , front contact of relay R_4 , segment No. 2 of dial D_1 , the arm of this dial to ground G_7 . This relay R_5 will be operated likewise, whatever segment the arm of
90 dial D_1 engages except the segment designated 0 (unless relay R_8 is already operated when the segment is No. 6).

95 Assuming that the introduction of loss on the input side of the repeater 23' proceeds so far that the decrease of intensity on the output side causes the relay R_2 to release while the arms of dials D_1 and D_2 are on a segment 3, 4 or 5, and that as described above the selector S_x has stopped at that adjustment, then presently the
100 slow-operating relay R_8 will operate through the circuit traced heretofore. Its operation will open the circuit for the relay 28 and cut out the loss pad 26—27 from the line on the output side of the repeater 23', thus increasing the intensity of the 900 cycle current going to the second repeater 23'. The effect there will be considered presently.

105 If the dials D_1 and D_2 are stepped along to their segments 6, this will close the circuit through relay No. 6 of the relay set 33, but this particular circuit includes the winding R_9 on the slow-operating relay R_8 — R_9 and the operation of this relay closes an alarm circuit. The consequent alarm is justified for it is due to the fact that cutting in all the available steps of loss in the pad 31—31' is insufficient or barely sufficient to bring the transmission level down to the proper adjustment and personal attention is required.

110 If the two arms of the dials D_1 and D_2 are stopped so far along that they reach their respective No. 6 segments, there are two sub-cases to be considered, namely, when relay R_2 releases at this stage and when it does not release at this stage. In either sub-case the arms of the dials
115 D_1 and D_2 will be arrested on their respective No. 6 segments, as will be explained presently.

120 It may be that although the amount of loss introduced on the input side of the repeater 23 at the fifth stage of the dials was not enough, yet the total amount of loss which will be introduced on the No. 6 segment will be enough. This sufficiency will be signified by the release of the relay R_2 in the plate circuit of the detector 37. This will open at relay R_2 the circuit of the selector S_x (G_6 , B_4 , S_x , contacts at R_7 , R_3 and R_2 , G_3) and the selector will come to rest with the dial arms on the No. 6 segments.

125 But if the loss introduced at the No. 6 stage is not sufficient to bring the system down to the

proper energy level, the relay R_2 will not release. In this sub-case the alarm controlled by the relay R_8 — R_9 will be actuated as before, but the circuit of the selector S_x will be opened at another point, namely, at relay R_7 instead of at R_2 as before, that is, the dial arm D_1 on its segment No. 6 will close the circuit of relay R_7 from ground G_4 , through battery B_2 , winding of relay R_7 , front contact of relay R_5 , segment No. 6, arm of dial D_1 to ground G_7 , and this will open the circuit of the selector S_x at the relay R_7 .

Whether or not the relay R_2 releases when the dial arms D_1 and D_2 reach their No. 6 segments, in either of these two sub-cases the slow operating relay R_6 whose circuit was closed at relay R_3 will presently operate. The operation of the relay R_6 deenergizes relay 28 thus cutting out the loss pad 26—27 and permitting the current of 900 cycle frequency to go without reduced strength on to the next similar repeater 23'.

Case 2.—Returning to the state of affairs just after the relay R_3 has released due to sustained current at 900 cycle frequency applied to the detector 37, let us suppose that this current is of low intensity not sufficient to energize the relay R_2 in the output circuit of the detector 37. The release of the relay R_3 , just mentioned, will put current through the slow-operating relay R_6 , but before it operates the stepping selector S_x will receive current through the circuit traced from ground G_6 , through battery B_4 , selector S_x , back contact of relay R_7 , back contact of relay R_3 , back contact of relay R_4 , segment 2 of dial D_1 to ground G_7 . Accordingly, the selector S_x will step the dial arms at D_1 and D_2 along and will continue to receive current by a circuit completed through one or another of the various segments of the dial D_1 until its arm leaves the No. 6 segment; then the said circuit will be broken and the selector S_x will stop with the dial arms on the 0 segments. Thereupon, relay R_4 will receive current over the following circuit: from ground G_4 , through battery B_2 , winding of relay R_4 , segment 0 of dial D_1 to ground G_7 . With the arm of dial D_1 on the 0 segment, the arm of dial D_2 will be on its 0 segment and the 0 relay of the relay set 33 will be operated and all loss will be cut out of the pad 31—31'—32. If the relay R_2 does not operate under these circumstances, that is, with no reduction of gain on the input side of the repeater, then the selector S_x will stay on the 0 segment and the slow-operating relay R_8 — R_9 will close its circuit and give an alarm. In this case the alarm will be given because the extreme adjustment of cutting out loss fails to bring the level up to the proper value. Also, at this stage slow-operating relay R_6 will operate and remove the loss pad 26—27 and permit the 900 cycle current to go on to the next repeater to operate its adjuster.

On the other hand, when the dial arms reach the 0 segments, this removal of all loss on the input side of the repeater 23' may permit the current intensity on the output side of this repeater to rise high enough to operate through the detector 37 to energize the relay R_2 . In this case the system will operate starting from the 0 segments of the dials D_1 and D_2 in the same manner that has been described heretofore in Case 1, starting from the No. 2 segments of the dials D_1 and D_2 , and in the present case the adjustment will be reached on some segment presumably nearer to the 0 segment than the segment from which the dial arm started.

The description of a cycle of operation that

has been given in the foregoing cases 1 and 2, has been for the first repeater in the tandem row of repeaters beginning at the transmission end of the line. In both these cases and their sub-cases, the relay R_3 by its release cuts in the pad 26—27, the operation of the dials D_1 and D_2 by the stepping selector follows, and then the slow operating relay R_6 cuts out the pad. At the second repeater 23', the situation will be somewhat different from that at the first repeater 23'. When the loss pad 26—27 was introduced at this first repeater it meant that a 900 cycle current got through to the second repeater, but with low intensity. Therefore, at this time the adjuster at the second repeater will go to its 0 point in just the same manner that has been described for the first repeater in case the power level is too low. Thus, while the first repeater is being adjusted the second repeater is getting ready for adjustment by having its adjuster stepped along to the 0 segments on its dials. Then at the close of the adjustment of the first repeater when the associated loss pad 26—27 is removed, the 900 cycle current goes on at the proper power level and the adjuster at the second repeater adjusts from 0 loss on its input side up to the proper degree of loss to give the proper power level on its output side; provided, of course, that there is not an extreme condition at the second repeater, which would lead to the giving of an alarm there, just as has been described for the alarm at the first repeater controlled by the slow-operating relay R_8 — R_9 .

The system operates rather quickly so that little or no time is taken from the useful service of the line. The time of operation may be made no more than, roughly, 0.2 second per adjuster plus the transmission time of the circuit. Assume, for example, that the circuit is a loaded line 4,000 miles long with 20,000 miles per second velocity. The time of transmission over this circuit may properly be assumed to be about 0.2 second. Also assuming adjusters at 500 mile intervals, there will be eight adjusters and if each requires 0.2 second this will be 1.6 seconds for all of them and adding in the 0.2 second for the time on the line, the total time will be 1.8 seconds. Thus, just previous to make connections for conversation on a circuit, the adjustment for level all along its length can be effected within a period of 2 seconds.

If ringing is practiced over the circuit and if 1000 cycles per second current is employed for ringing, the choice of 900 cycles per second will assure that the ringing current will not affect the level adjusters and reciprocally the level adjusting current will not affect the ringers. The selective circuits at the adjusters may be made for 1000 cycles, that is, for the same frequency as the ringers. In this case the adjustment for power level will be effected by the ringing current and to make an adjustment for the transmission levels all along the line it will only be necessary to apply ringing current for a very few seconds.

In case ringing current is relied on for operating the level adjusters, ringers may be inserted in lieu of the selective networks at 36, and the contacts shown in Fig. 2 as controlled by the relays R_1 and R_3 may be transferred to be controlled directly by the corresponding ringer. In this case these relays will be omitted.

In so far as the adjuster at one repeater may fail to bring the power level to the proper value at that point, the entire system will tend to make correction by compensating adjustment at the

next following adjuster, that is, if the current goes on east from the repeater in Fig. 2 at too high a level, then the adjuster on the input side of the next repeater to the east will cut down the input to that repeater so as to have the proper level on its output side. Similarly if, after adjustment, the level is too low on the output side of the repeater 23' shown in Fig. 2, then at the next repeater to the east loss will be cut out on its input side until the level is brought up to the proper value on the output side of that repeater.

The foregoing disclosure has related principally to a system in which the controlling current is applied on convenient occasions when signal currents are not being transmitted. At each such application the apparatus will adjust itself and thereafter it will hold this adjustment until the controlling current is applied again.

But by choosing a frequency for the controlling current lying outside the signal current range, this controlling current may be applied continuously, so that the apparatus will adjust itself at once whenever there is any substantial change of transmission loss.

I claim:

1. The method of adjusting tandem repeaters for gain in a line comprising those repeaters which consists in sending a transient special frequency current over the line, selectively separating it out at each of those repeaters, detecting this current and applying it to adjust the gain of the respective repeater according to its intensity.

2. The method of adjusting for transmission level in a line which consists in sending a transient special frequency current over the line, selectively separating it out from the line at the places where the adjustment is to be made, detecting this current and applying it to introduce gain or loss in accordance with the intensity of the current as detected.

3. The method of adjusting tandem repeaters in a line for transmission level which consists in sending a special frequency current over the line, selectively separating it out at each of those repeaters, meanwhile introducing substantial loss beyond the point at which the special current is diverted, detecting this current at the place where it is separated out, applying it to adjust the gain of the respective repeater, and meanwhile applying the current of reduced intensity at the next following repeater due to the interposition of said loss to operate its adjuster to make it ready for adjustment when the said loss is removed upon the completion of adjustment at the first repeater.

4. In combination, a transmission line, tandem repeaters therein, a selective circuit connected across the line on the output side of each repeater, a loss pad adapted for connection in the line just beyond the point of connection of said selective circuit, a marginal detector associated with each selective circuit, an adjustable pad on the input side of each repeater, and means to adjust such pad controlled by the corresponding detector.

5. In combination, a transmission line, a repeater therein, a selective circuit connected across the line on the output side of said repeater, a marginal detector associated with said selective circuit, a pad adjustable in steps on the input side of said repeater, a stepping selector to introduce said loss in steps from 0 up to the greatest loss which the pad will give, and means controlled by said detector to control the selector to increase the steps to the proper adjustment when the

power level in the detector is too low and to carry the steps still farther to 0 adjustment and up therefrom when the power level is too high.

6. In combination, a transmission line, tandem repeaters therein, a selective circuit connected across the line on the output side of each repeater, a loss pad adapted for connection in the line just beyond the point of connection of said selective circuit, a marginal detector associated with each selective circuit, an adjustable pad on the input side of each repeater, to adjust such pad controlled by the corresponding detector, and means to interpose said loss pad during adjustment of said adjustable pad.

7. A telephone line having a repeater station thereon, control means governed by a tone having a frequency within the voice frequency range transmitted at intervals over the line for controlling the gain to hold the energy level beyond the repeater within desired limits, and means for preventing operation of said control means by the voice currents transmitted during communication over the line.

8. A communication line having a repeater station thereon, control means governed by a tone having a frequency within the voice frequency range transmitted at intervals over the line for controlling the gain to hold the energy level beyond the repeater within desired limits, and means comprising a slow acting relay for preventing operation of said control means by the voice currents during communication over the line.

9. A communication line having a repeater station thereon, a potentiometer connected to said line before the repeater for controlling the gain effected by the repeater, apparatus for operating said potentiometer, control means governed by a tone having a frequency within the voice frequency range transmitted over said line and connected to the line beyond the repeater for controlling the gain of said apparatus to hold the energy level beyond the repeater within a desired range, and means comprising a slow acting relay for preventing operation of the control means by the voice currents during communication over the line.

10. A communication line having a repeater station thereon, a potentiometer connected to said line before the repeater for controlling the gain effected thereby, control means connected to the line beyond the repeater and operated according to the energy level of a tone having a frequency within the voice frequency range impressed on the line at intervals for governing said potentiometer to hold the energy level on the line within a desired energy range, and means for delaying the operation of said control means to prevent operation thereof to change the potentiometer setting by the voice currents during communication over the line.

11. A telephone transmission line having a repeater station thereon, means controlled by a tone having a frequency within the voice frequency range transmitted over the line and amplified by the same apparatus which amplifies the voice currents for holding the energy level on the line beyond the repeater within predetermined narrow limits when the energy variation on the line at the start of the transmission of the tone is within certain fixed limits, and means for operating an alarm only when the energy variations on the line at the start of the transmission of the tone are beyond said fixed limits.

12. A telephone transmission line having a re-

- peater station thereon, means controlled by a tone having a frequency within the voice frequency range transmitted at intervals over the line and amplified by the same apparatus which amplifies the voice currents for holding the energy level on the line beyond the repeater within predetermined narrow limits when the energy variations on the line at the start of the transmission of the tone are within certain fixed limits, and means controlled by said tone for operating an alarm only when the energy variations on the line at the start of the transmission of the tone are beyond said fixed limits.
13. A telephone line for transmitting currents having frequencies within the voice frequency range, a repeater station on said line, and control means at the repeater station for governing the gain effected by the repeater and controlled by a tone transmitted over the line, said tone being amplified by the same apparatus which amplifies the voice currents.
14. A signal transmission line for transmitting currents having frequencies within the voice frequency range, a repeater station on said line, and means controlled by a tone transmitted over the line for holding the energy level on the line beyond the repeater within predetermined limits, said tone being amplified by the same apparatus which amplifies the signaling currents.
- LEONARD G. ABRAHAM.

20	95
25	100
30	105
85	110
40	115
45	120
50	125
55	130
60	135
65	140
70	145
75	150