

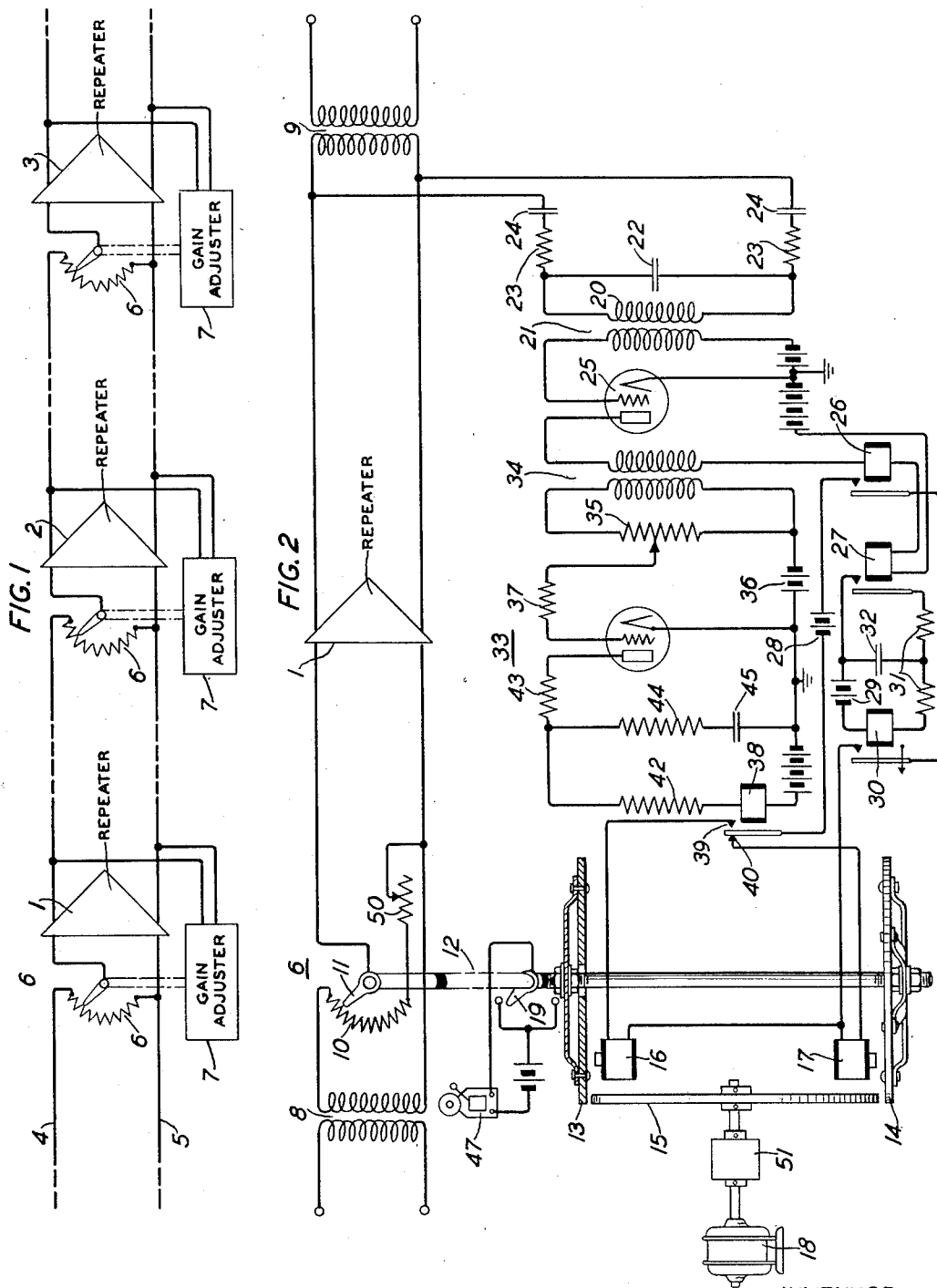
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SIGNAL TRANSMISSION SYSTEM

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SIGNAL TRANSMISSION SYSTEM

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This invention relates to signal transmission systems having transmission adjusting circuits thereon and particularly to circuits for automatically adjusting the gain at repeater stations along a transmission line.

One object of the invention is to provide a transmission adjusting circuit at a repeater station on a transmission line that shall be automatically controlled in an improved manner by a tone transmitted at intervals over the transmission line.

Another object of the invention is to provide a gain control circuit at a repeater station on a transmission line that shall be automatically controlled by a tone having a frequency within the voice frequency range transmitted at intervals over the transmission line and that shall not be operated by the voice currents during communication over the line.

Another object of the invention is to provide gain control circuits for the repeater stations on a transmission line that shall be automatically controlled by a tone transmitted at intervals over the line and that shall be operated after different time intervals in an improved manner to insure against simultaneously adjusting the gain at the different repeater stations.

A further object of the invention is to provide a gain control circuit at a repeater station on a transmission line that shall have a gas filled tube automatically controlled by a tone transmitted at intervals over the line for governing the gain at the repeater station and that shall control the time at which the change in the gain is effected at the repeater station by the gas filled tube after the tone is impressed on the line.

In a long transmission line or cable it is desirable to correct the energy level at different points along the line and not merely at the ends thereof in order to prevent interference by or undue amplification of the noise. It is desirable to automatically control the gain at repeater stations along a transmission line or cable so as to hold the energy level along the line within predetermined limits.

In a transmission line having the energy level thereon governed in accordance with

the invention the gain at a number of repeater stations is automatically controlled by a tone which is transmitted at intervals over the line. The signal currents transmitted over the line may be within the voice frequency range or may be of any other desired frequency. The tone which is transmitted over the line to control the gain at certain of the repeater stations may have a frequency within the frequency range of the signals transmitted over the line or may have a frequency outside the frequency range of the signal currents. If the frequency of the tone is within the frequency range of the signal currents, means must be provided to prevent change in the gain at the repeater stations by the signal currents during communication over the line.

In a transmission line having the gain at various repeater stations automatically controlled by a tone transmitted at intervals, means must be provided to prevent simultaneously changing the gain at the various repeater stations. It is necessary to prevent the simultaneous changing of the gain at the different repeater stations in order to prevent constant hunting action.

In the system employed to disclose the invention, the signal currents are assumed to be within the voice frequency range and the tone transmitted over the line for controlling the gain at certain of the repeater stations is assumed to have a frequency within the voice frequency range. A potentiometer in the form of a motor operated rheostat is connected to the line before each of the repeaters at which the gain is to be controlled. Beyond each of said repeaters having the gain controlled is connected a circuit tuned to the frequency of the tone transmitted over the line. The tuned circuit has impedance means therein in a form of resistance and capacity to prevent the drawing of an excessive amount of the tone from the transmission line. A detector tube coupled to the tuned circuit has two relays in the output circuit which are operated by the rectified current from the tube. One of said relays partially prepares a circuit for operating the motor operated rheostat. The second relay completes a circuit for operating a slow

acting relay. The slow acting relay closes another break in the circuit prepared by the first relay operated by the detector tube.

The slow acting relays perform two functions, first, they delay the operation of the gain control apparatus at the repeater stations for a predetermined interval of time in order to insure against operation of the gain control apparatus by signal currents in case the tone has a frequency within the frequency range of the signal currents, second, the slow acting relays at the various repeater stations are set to effect operation of the gain control apparatus at the different stations at different times so that the gain control apparatus at the different repeater stations are not simultaneously operated. If the gain control apparatus at the different stations operates simultaneously there will be a constant hunting action taking place.

A three element gas filled tube has the input circuit thereof coupled to the output circuit of the detector tube by means of a transformer in order to be operated by the A. C. component of current in the detector output circuit. A relay in the output circuit of the gas filled tube controls the operation of the circuit prepared by the first relay in the output circuit of the detector tube and the slow acting relay. The relay in the output circuit of the gas filled tube serves to operate the motor operated rheostat and effect lowering in the gain at the repeater station when in an operated position and when in release position to operate the motor operated rheostat to raise the gain effected at the repeater station.

The gas filled tube is adjusted so that it triggers off or has a critical point when the energy level on the line beyond the repeater station is more than $\frac{1}{2}$ DB above the level at which it is desired to be kept. In the system under consideration it is assumed the energy level of the line beyond the repeater is held within plus or minus $\frac{1}{2}$ DB of the desired energy level when tone is being transmitted. It is furthermore assumed in the system under consideration that the gain control apparatus will operate to hold the energy level within plus or minus $\frac{1}{2}$ DB if the energy variations do not exceed plus or minus 3 DB when the tone is impressed on the line. The output circuit of the gas filled tube contains impedance for effecting an oscillatory discharge. The impedance in the output circuit of the gas filled tube is so adjusted as to effect oscillatory movement of the relay in the output circuit of the gas filled tube when the tube is operated at its critical point. Such oscillatory discharge has a frequency low enough to effect operation of the relay in the output circuit of the gas filled tube, but too high to have any effect on the operation of the motor operated rheostat.

In the accompanying drawing:

Fig. 1 is a diagrammatic view of a transmission line constructed in accordance with the invention; and

Fig. 2 is a diagrammatic view of a gain control circuit at one of the repeater stations shown in Fig. 1 of the drawing.

Referring to Fig. 1 of the drawing, three repeater stations 1, 2 and 3, are shown connected in a transmission line comprising conductors 4 and 5. In the line before each repeater station is inserted a potentiometer 6 which preferably is in the form of a motor operated rheostat. The potentiometer or motor operated rheostat 6 at each repeater station controls the gain effected by the repeater. The motor operated rheostat is controlled in accordance with the energy level beyond the repeater of a tone which is transmitted at intervals over the line. Gain adjusters 7 which are controlled by the tone transmitted over the line, automatically control the potentiometers 6 as will be described when reference is made to Fig. 2 of the drawing. The gain adjusters are operated with a delay of a predetermined time interval in order to insure against their operation by signal currents during communication over the transmission line when the tone used to control the gain adjusters has a frequency within the frequency range of the signal currents. Furthermore, the different gain adjusters operate after different time intervals in order to insure against their simultaneous operation which would produce constant hunting action. The gain adjusters are set so that they operate consecutively to correct the gain along a transmission line.

Referring to Fig. 2 of the drawing, the gain adjuster for the repeater station 1 shown in Fig. 1 is illustrated in detail. The repeater 1 which is preferably of the thermionic type is provided with an input transformer 8 and an output transformer 9 connected in the transmission line shown in Fig. 1. of the drawing. The motor operated rheostat associated with the repeater station 1 comprises a resistance element 10 connected across the secondary windnig of the repeater input transformer 8 in series with an adjustable resistance element 50 and a rheostat arm 11. The rheostat arm 11 is mounted upon a shaft 12 which is rotated in a forward and reverse direction to control the setting of the rheostat and accordingly the gain effected by the repeater. Two discs 13 and 14 are suitably mounted on and rotatable with the shaft 12. The discs 13 and 14 are adapted to be selectively held in engagement with a constantly rotating disc 15 by means of electromagnets 16 and 17. The disc 15 is rotated at constant speed by means of any suitable motor 18. The motor 18 is connected to the disc 15 by suitable gearing 51. The shaft 12 also carries a contact arm 19 for closing an alarm circuit in case the energy level on the line beyond

the repeater station is above or below predetermined fixed limits. The resistance element 50 is varied to govern the angle of motion of the rheostat arm required to effect a given change in the gain.

Between the repeater 1 and the repeater output transformer 9 is connected a tuned circuit comprising the primary winding 20 of a coupling transformer 21 and a capacity element 22. The tuned circuit comprising the elements 20 and 22 is tuned to the frequency of the tone which is transmitted over the line for correcting the gain at the repeater stations. Resistance elements 23 and capacity elements 24 are inserted in the connection of the tuned circuit to the transmission line for limiting the amount of tone current taken for governing the gain at the repeater station. The condensers 24 also serve as blocking condensers. The coupling transformer 21 connects the tuned circuit to a thermionic detector tube 25. Two relays 26 and 27 are connected in the output circuit of the detector tube and are operated by the rectified current. The relay 26 upon operation partially completes a circuit from a battery 28 for operating one of the rheostat control magnets 16 or 17. The relay 27 upon operation completes a circuit from a battery 29 for operating a slow acting relay 30. Resistance elements 31 and a capacity element 32 are inserted in the energizing circuit for the relay 30 in order to render the relay slow in operation. Such resistance elements and capacity element may be varied to change the time of operation of the slow acting relay. The slow acting relay closes another break in the circuit from the battery 28 for operating the rheostat control magnets 16 and 17. A three-element gas filled tube 33 is coupled to the output circuit of the detector tube 25 by a transformer 34 in order to be controlled in accordance with the alternating current in the output circuit of the detector tube. A potentiometer 35 is provided between the coupling transformer 34 and the gas filled tube 33 and a biasing battery 36 and a resistance element 37 are provided in the grid circuit of the gas filled tube in order to adjust the point of operation of the tube. A relay 38 which is connected in the output circuit of the gas filled tube 33 serves to control the circuit from the battery 28 prepared by the relay 26 and relay 30 for operating one of the rheostat control magnets 16 and 17. If the relay 38 is operated and held in engagement with the contact member 39 and the relays 26 and 30 are operated, then the magnet 16 is operated for moving the disc 13 into engagement with the disc 15 to effect movement of the rheostat arm 11 and increase the gain effected at the repeater station. If the relay 38 is released and the relays 26 and 30 are operated, a circuit is completed through the contact member 40 for energizing

the magnet 17 to connect the disc 14 with the constantly rotating disc 15. When the disc 14 is rotated by the disc 15 the rheostat arm 11 is moved in a direction to raise the gain effected at the repeater station.

Resistance elements 42, 43 and 44, a capacity element 45 and the inductance of the coil of the relay 38 serve to produce an oscillatory discharge in the gas filled tube 33. The resistance and capacity may be varied to change the frequency of such oscillatory discharge. The frequency of the discharge is preferably between 80 and 100 cycles per second so that the relay 38 may follow the oscillations when the tube is operated at its triggering off or critical point. Oscillation of the relay at such frequency will not have any effect on the motor operated rheostat.

In the system disclosed on the drawing the gain control apparatus will hold the energy level on the line beyond the repeater within plus or minus $\frac{1}{2}$ DB of the desired level if the energy level before transmission of the tone is within plus or minus 3 DB of the desired level. If the level on the line at the time of transmitting the tone is between plus or minus 3 DB and plus or minus $\frac{1}{2}$ DB from the desired energy level, then alarm 47 will be operated.

Assuming the energy level on the transmission line beyond the repeater is more than $\frac{1}{2}$ DB above the desired energy level when the tone is impressed upon the line, then relays 26 and 27 will be operated by the detector tube 25, the relay 26 preparing a circuit from battery 28 for operating the motor operated rheostat, the relay 27 closing the circuit for operating the slow acting relay 30. The slow acting relay 30 closed another break in the circuit from the battery 28 for controlling the motor operated rheostat. The alternating current in the output circuit of the detector tube is sufficient to impress a potential on the grid of the gas filled tube 33 to trigger off the gas filled tube and effect operation thereof above the critical point. Sufficient current then flows through the output circuit of the gas filled tube 33 to operate the relay 38 and complete the circuit for operating the rheostat control magnet 16. The circuit for operating the rheostat control magnet 16 may be traced from one terminal of the battery 28 through the armature of the relay 26, armature of the slow acting relay 30, rheostat control magnet 16, contact member 39, and armature of the relay 38 to the other terminal or the battery 28. The disc 13 on the shaft 12 is held in engagement with constant rotating disc 15 by the magnet 16 for operating the rheostat to lower the gain effected at the repeater station. When the gain effected at the repeater station is changed to lower the energy level to within $\frac{1}{2}$ DB of the desired energy level then the gas filled tube 33 is operated at its critical

point so that the armature or the relay 38 is vibrated at the rate of discharge in the tube. The rheostat control magnet 16 is deenergized inasmuch as such apparatus is unable to follow the vibrating armature of the relay 28.

If the energy level on the line beyond the repeater is more than $\frac{1}{2}$ DB below the desired energy level and not more than 3 DB below the desired energy level, then the relays 26 and 27 and the slow acting relay 30 are operated in the same manner as disclosed when considering the operation of the gain control apparatus when the energy level was above the desired level. At this time the alternating current in the output circuit of the detector tube 25 is insufficient to operate the gas filled tube 33 above its critical or triggering off point. Consequently, the relay 38 was not operated and the armature thereof was held in release position against contact member 40. Therefore, the relays 26 and 30 complete a circuit for operating the rheostat control magnet 17. The rheostat control magnet 17 moves the disc 14 on the shaft 12 into engagement with the constantly rotating disc 15. The rotation of the disc 14 operates the rheostat to raise the gain effected at the repeater station. When the gain at the repeater station is raised so that the energy level beyond the repeater is within $\frac{1}{2}$ DB of the desired level, then the gas filled tube 33 is operated at its critical point to effect vibratory operation of the relay 38. The vibratory operation of the relay 38 serves to release the rheostat control magnet 17 and prevent further change in the gain at the repeater station.

If the energy level beyond the repeater at the time of transmission of the tone is more than 3 DB above or below the desired level, then an alarm 47 is operated by the contact arm 19 attached in any suitable manner to the shaft 12. If the energy level beyond the repeater is more than 3 DB off the desired energy level then the motor operated rheostat may be moved to its extreme point without effecting a complete correction of the energy level. When the motor operated rheostat is moved to either of its extreme positions the alarm 47 is operated.

It is to be understood that if so desired a three-element pure electron discharge tube may be used in place of the gas filled tube 33. However, it is preferred to use a gas filled tube in order to obtain quicker and more satisfactory operation of the gain control apparatus. If a pure electron discharge tube were employed it is apparent that more or less hunting action would take place when the gain has been changed to hold the energy level on the line beyond the repeater within $\frac{1}{2}$ DB of desired energy level. As before set forth, the capacity 32 and the resistance elements 31 in the energizing circuit of a relay 30 are varied to obtain the desired delay in the operation of the slow acting relay 30. In

the first place, the relay 30 must be slow acting in order to prevent operation of the gain control apparatus by signaling currents of the same frequency as the tone employed. Furthermore, the time delay of the relay 30 must be adjusted so that the gain control apparatus at the various repeater stations along the line operate in sequence. If the gain control apparatus at the various repeater stations operated simultaneously it is apparent constant hunting action would be produced.

Modifications in the system and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are covered by the appended claims.

What is claimed is:

1. A communication line having a plurality of repeater stations thereon, impedance means at each repeater station for controlling the gain effected thereby, control means associated with said repeater stations for automatically controlling said impedance means according to the energy level of a tone having a frequency within the voice frequency range to maintain the energy level beyond each repeater within a predetermined energy range, and means comprising a slow acting relay associated with each control means for controlling the time of operation of the control means at the repeater stations to prevent simultaneous operation thereof at the different repeater stations and to prevent operation of the control means at the different stations by voice currents during communication over the line.

2. In a communication system, a signal line having a repeater station thereon, impedance means for controlling the gain at the repeater station, a space discharge tube, a control circuit governed by said tube for controlling said impedance means, means for controlling said tube according to the energy level beyond the repeater station of a tone transmitted at intervals over the line, and means controlled by the tone transmitted over the line for preventing operation of said control circuit by said tube until after a predetermined time interval.

3. In a communication system, a signal line having a repeater station thereon, impedance means for controlling the gain at the repeater station, means comprising a three-element tube for controlling said impedance means, means for controlling said tube according to the energy level beyond the repeater of a tone transmitted over the line, and means comprising a slow acting relay for preventing control of said impedance means by said tube until the tone has been impressed on the line for a predetermined length of time.

4. In a communication system, a signal line having a repeater station thereon, impedance means for controlling the gain at the repeater

station, means comprising a gas filled three-element tube for operating said impedance means to change the gain when the tube is operated above or below its triggering off point and for preventing changing of said impedance means when the tube is operated at its triggering off point, and means for controlling said tube according to the energy level beyond the repeater of a tone transmitted over the line.

5. In a communication system, a signal line having a repeater station thereon, impedance means for controlling the gain at the repeater station, and means comprising a gas filled three-element tube for operating said impedance means to change the gain when the tube is operated above or below its triggering off point and for preventing changing of said impedance means when the tube is operated at its triggering off point.

6. In a communication system, a signal line having a repeater station thereon, a motor operated rheostat for controlling the gain at said repeater station, a three-element gas filled tube, means for operating said tube according to the energy level of a tone transmitted over the line, means comprising a relay in the output circuit of said tube for controlling the operation of said rheostat, and impedance means in the output circuit of said tube to effect an oscillatory discharge so that the tube is constantly controlled according to the potential impressed on the grid thereof.

7. In a communication system, a signal line having a repeater station thereon, a motor operated rheostat for controlling the gain at said repeater station, a three-element gas filled tube operated according to the energy level beyond the repeater station of a tone transmitted over the line, means comprising a relay in the output circuit of said tube for controlling the operation of said rheostat, and impedance means in the output circuit of said tube to effect an oscillatory discharge so that the tube is constantly controlled according to the potential impressed on the grid thereof, said relay in the output circuit of the gas filled tube being held stationary in released or operated position for operating the rheostat respectively to raise or lower the gain at the repeater station according to the energy level of the tone on the line beyond the repeater and being vibrated at a rate to prevent change of the setting of the rheostat when the energy level of the tone beyond the repeater is within the desired range.

8. In a communication system, a signal line having a repeater station thereon, a potentiometer for controlling the gain at the repeater station, means comprising a relay for controlling said potentiometer to govern the gain at the repeater station, and means comprising a gas filled tube for holding the relay in fixed positions for effecting operation of the potentiometer to raise or lower the gain on

the line and for rapidly vibrating the relay to prevent change in setting of the potentiometer.

9. In a communication system, a signal line having a repeater station thereon, a potentiometer for controlling the gain at the repeater station, means comprising a relay for controlling the operation of said potentiometer, and a three-element gas filled tube for controlling the operation of said relay, said tube having impedance in the output circuit thereof to produce an oscillatory discharge by the tube under control of the potential impressed on the grid so that the relay is held in an operative position when the tube is operated above its triggering off point, is held in released position when the tube is operated below its triggering off point and is vibrated rapidly when the tube is operated at its triggering off point, said means comprising the relay being arranged to lower the gain or to raise the gain when the relay is held respectively in its operative or released positions and to prevent change in the gain on the line when the relay is vibrated and the tube is operated at its triggering off point.

10. In a communication system, a signal line, a plurality of repeater stations on said signal line, motor operated rheostats at said repeater stations for controlling the gain effected thereby, and control means for automatically operating each of said rheostats according to the energy level beyond the associated repeater of a tone transmitted at intervals over the line, each of said control means having a slow acting electromagnetic relay for delaying the operation thereof to prevent the simultaneous operation of the rheostats at the different repeater stations.

11. In a communication system, a signal line having a repeater station thereon, a motor operated rheostat for controlling the gain at said repeater station, a circuit connected to the line beyond the repeater and tuned to the frequency of a tone transmitted over the line at intervals, a detector tube coupled to said tuned circuit, two relays operated by the direct current in the output circuit of said tube, one of said relays preparing a circuit for operating the motor operated rheostat, the second relay operating a slow acting relay to close a break in the circuit prepared by the first mentioned relay, a three-element gas filled tube coupled to the output circuit of said first mentioned tube and operated by the alternating current component in the output circuit of the first mentioned tube, a relay in the output circuit of said gas filled tube for completing the circuit prepared by said first mentioned relay and the slow acting relay to control said rheostat and maintain energy level on the line beyond the repeater within a predetermined range, and imped-

ance means in the output circuit of the gas filled tube for making the tube oscillate to insure constant control of the tube by the grid thereof, said relay in the output circuit of the gas filled tube being held stationary in released or operated position for operating the rheostat respectively to raise

or lower the gain at the repeater station according to the energy level on the line beyond the repeater and being vibrated at a rate to prevent change of the setting of the rheostat when the energy level beyond the repeater is within the desired range.

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