

Nov. 17, 1936.

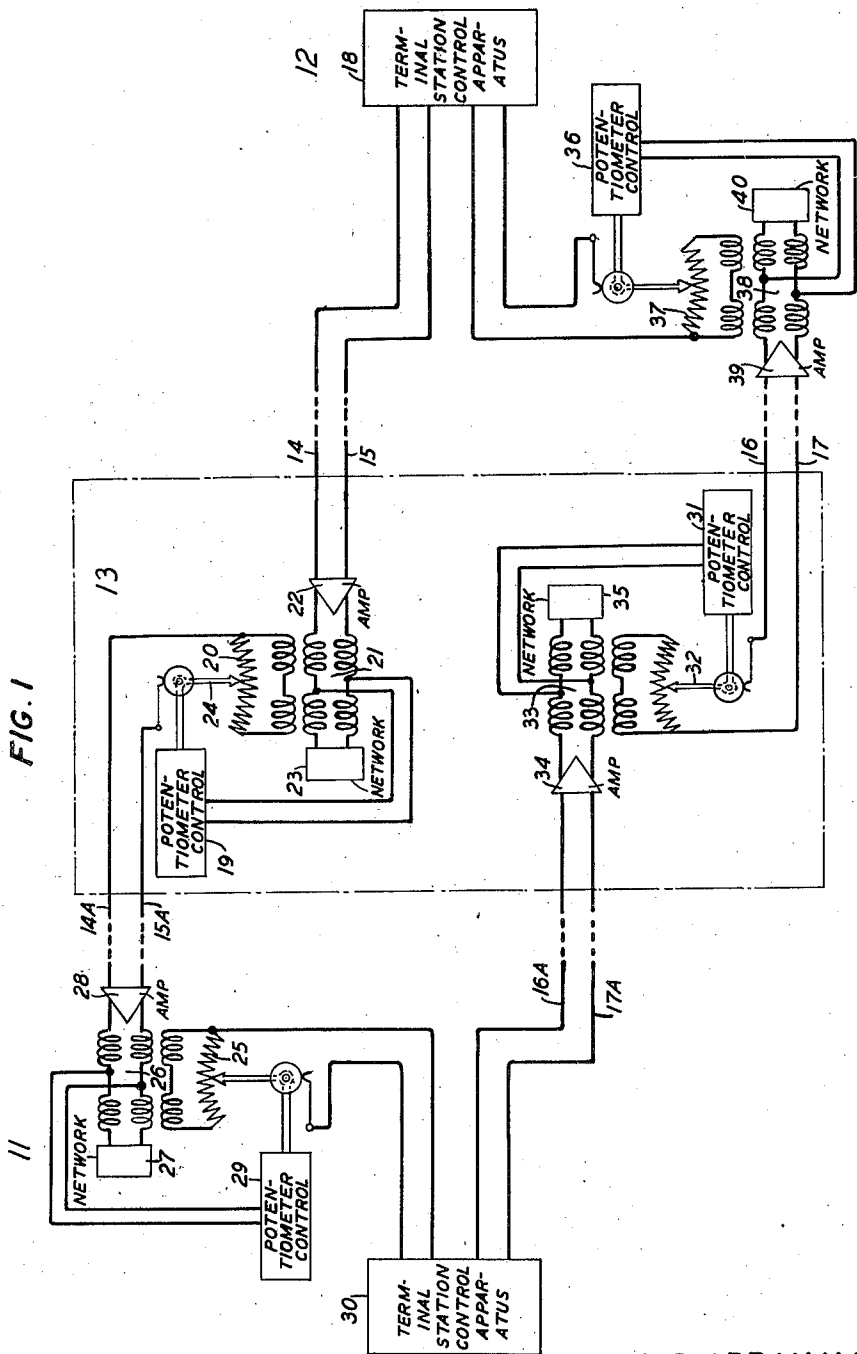
L. G. ABRAHAM ET AL

2,060,843

TRANSMISSION SYSTEM

Filed May 16, 1935

4 Sheets-Sheet 1



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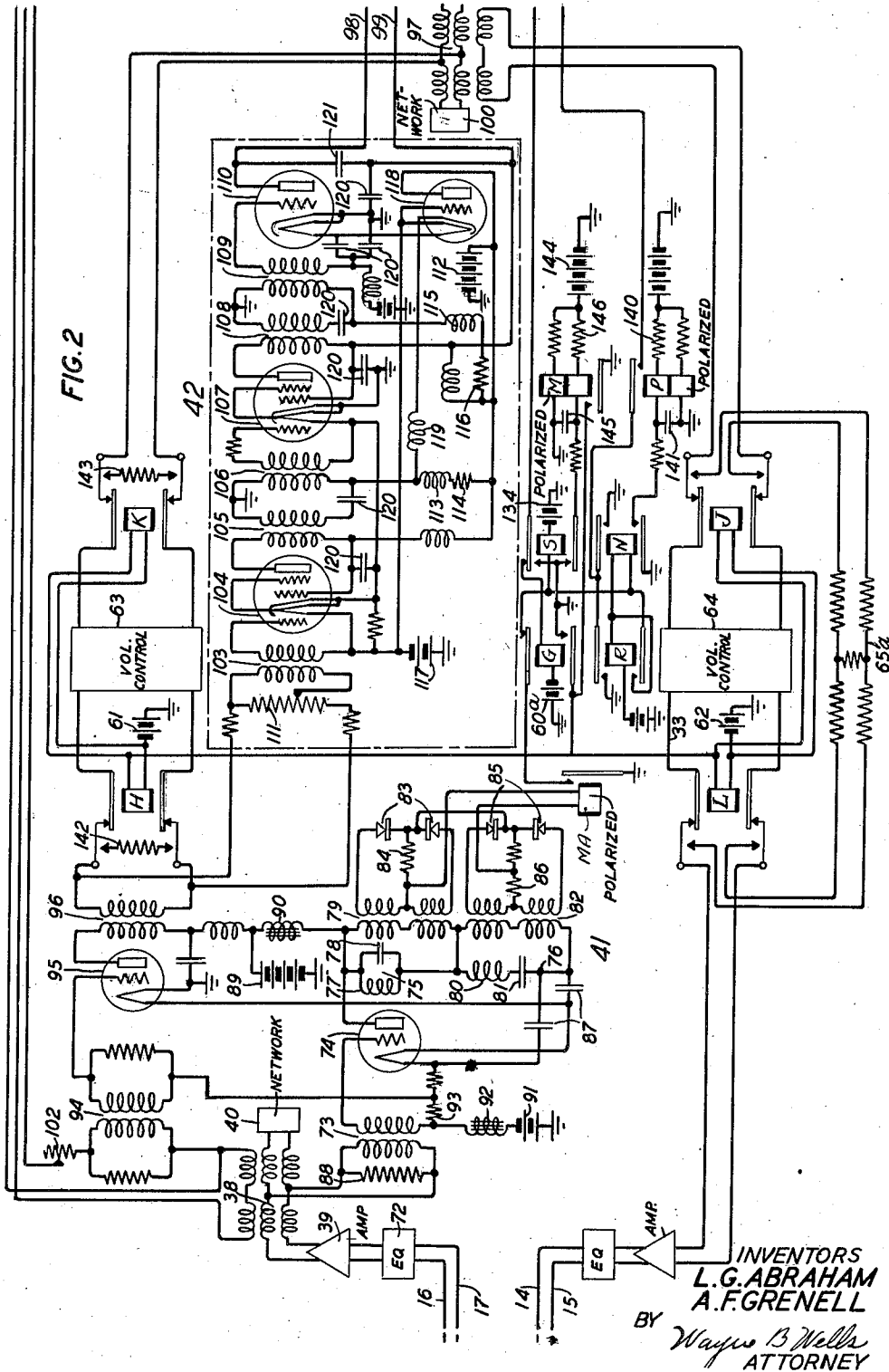
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TRANSMISSION SYSTEM

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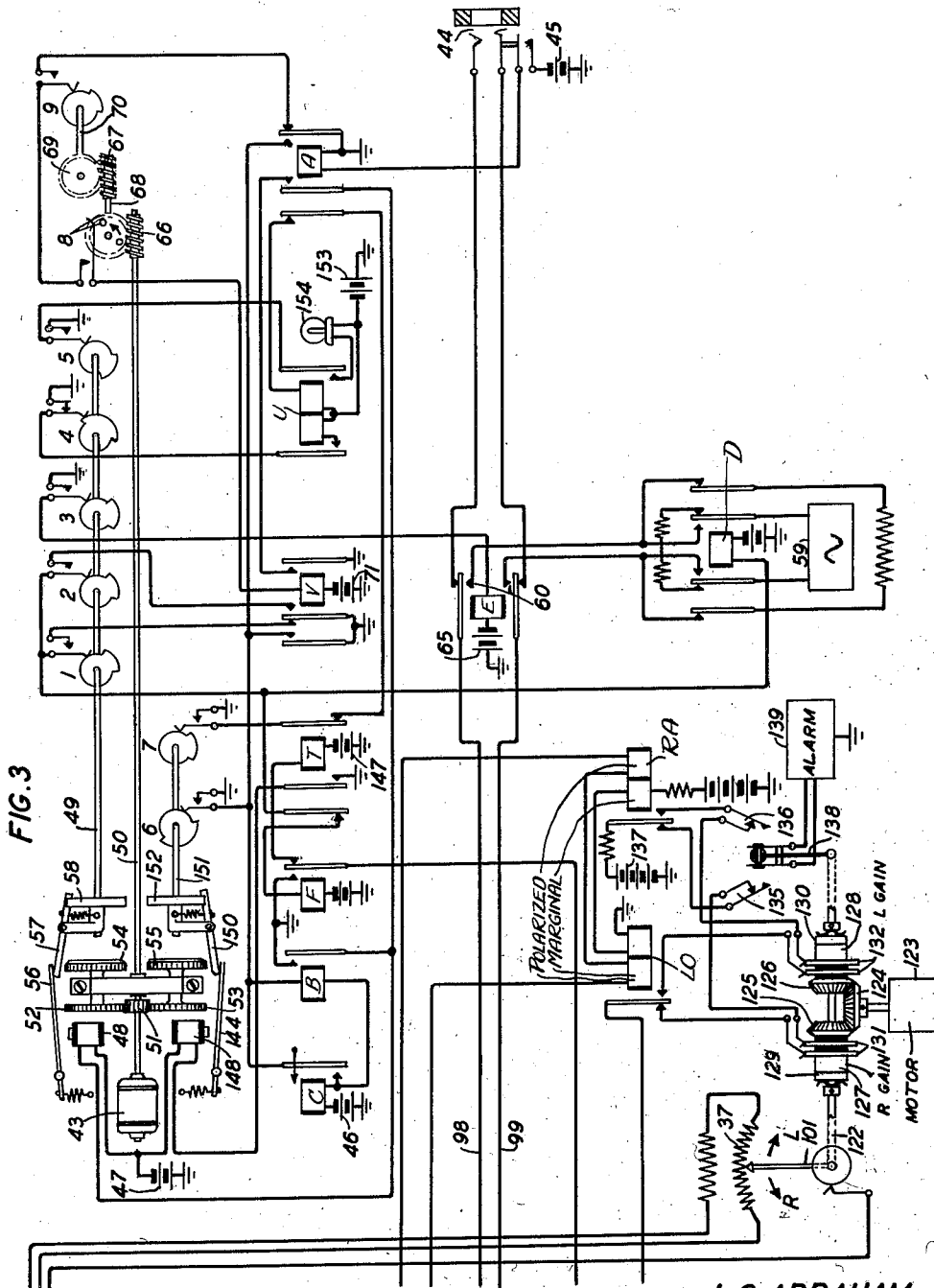
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TRANSMISSION SYSTEM

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4 Sheets-Sheet 3



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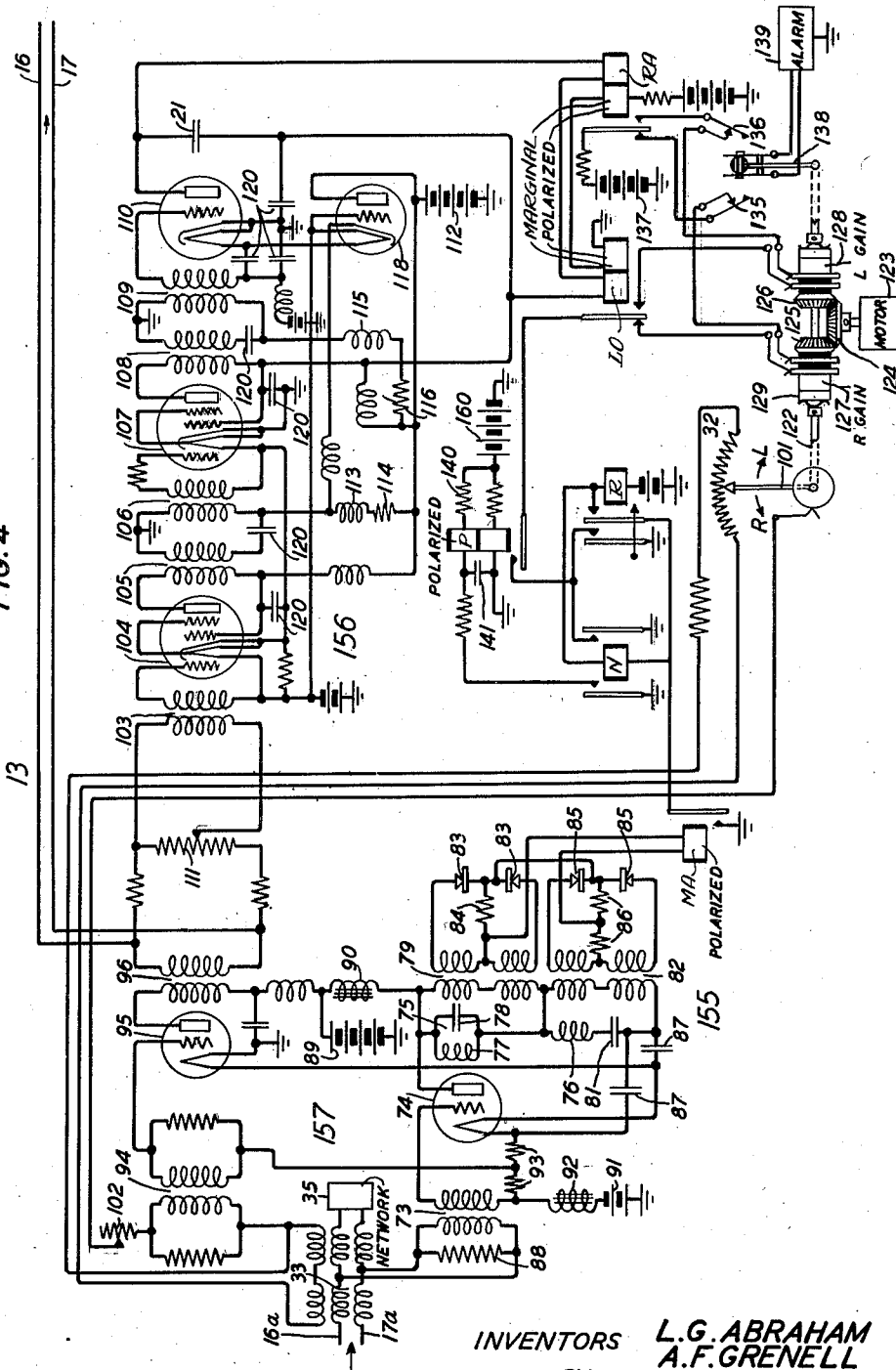
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TRANSMISSION SYSTEM

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FIG. 4



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2,060,843

TRANSMISSION SYSTEM

Leonard G. Abraham, Madison, and Arthur F. Grenell, Montclair, N. J.; said Abraham assignor to American Telephone and Telegraph Company, a corporation of New York, and said Grenell assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application May 16, 1935, Serial No. 21,802

23 Claims. (Cl. 178-44)

This invention relates to signal transmission systems and particularly to signal transmission systems having the net loss of circuits at signal stations adjusted under control of a transmitted control current.

One object of the invention is to provide a signal transmission system that shall transmit a control current from a sending station for adjusting the net loss at a receiving station according to the strength of the received control current and that shall transmit a control current from the receiving station to the sending station upon receipt of the control current at the receiving station for adjusting the net loss at the sending station according to the strength of the control current received at that station.

Another object of the invention is to provide a signal transmission system that shall transmit control currents for different lengths of time from a sending station for adjusting the net loss at a receiving station by each control current and for calling the operator at the receiving station upon receipt of one of said control currents.

Another object of the invention is to provide a signal transmission system that shall transmit control currents of different lengths from a sending station for adjusting, under control of each control current, the net loss at a receiving station, for transmitting control current from the receiving station to the sending station upon receipt of each control current to adjust the net loss at the sending station and for calling the operator at the receiving station upon receipt of one of said control currents.

Another object of the invention is to provide a signal transmission system that shall automatically transmit a control current to a receiving station upon connecting a toll cord to the system and at predetermined time intervals for adjusting the net loss at a receiving station and for calling an operator at the receiving station when the transmission of the control current from the sending station is initiated by the operator at the sending station.

Another object of the invention is to provide a signal transmission system having transmitting and receiving paths connected between sending, intermediate and receiving stations that shall transmit a control current from the sending station for automatically adjusting the net loss in the transmitting path at the intermediate and receiving stations, for calling the operator at the receiving station and for sending a control current over the receiving path to the send-

ing station to adjust the net loss in the receiving path at the intermediate and sending stations.

A further object of the invention is to provide a signal transmission system having transmitting and receiving paths connected between sending, intermediate and receiving stations that shall automatically transmit a control current from the sending station at predetermined time intervals for adjusting the net loss in the transmitting path at the intermediate and receiving stations according to the strength of the control current and for transmitting a control current over the receiving path to the sending station upon receipt of the control current at the receiving station to adjust the net loss in the receiving path at the intermediate and sending stations according to the strength of the control current on the receiving path.

In long signal transmission lines it is necessary to place gain control regulators at intervals along the line to correct for the variations in the line attenuation. The regulators are generally controlled by a pilot wire and are of the type disclosed in the patent to J. A. Coy et al. No. 2,017,654, October 15, 1935. The variations in line attenuation are chiefly caused by temperature. Each regulator has small errors in correcting for line attenuation due to the fact that the regulators operate in finite steps and for other reasons. At the end of a very long signal transmission line, the total effect of the errors of the regulators along the line may be appreciable and interfere with the transmission of the signals. In addition, there are variations in the over-all loss due to battery variations and humidity changes.

The present invention provides means for correcting for the over-all net loss variations. The correction may not only be made at terminal stations but also may be made at intermediate stations. The corrections made at terminal and intermediate stations, according to the present invention, are governed according to the peak values of a control current transmitted over the line.

In the signal transmission system employed to illustrate the invention, transmitting and receiving paths are provided for connecting sending, intermediate and receiving stations. When a control current is transmitted from the sending station over the transmitting path to the receiving station an adjustment is made in the transmitting path at the intermediate station and at the receiving station according to the strength

of the control current. Upon receipt of the control current at the receiving station a control current is transmitted over the receiving path to the sending station to correct the attenuation in the receiving path at the intermediate and sending stations. The paths between the stations may be separate wire circuits or may be separate channels on a carrier system. Preferably, the control current is within the voice frequency range and of the order of 800 cycles per second.

In the disclosed system a periodic control current is transmitted from each terminal station every thirty minutes and a service control current is transmitted when an operator connects a toll cord to the transmission line. The periodic control current has a length of the order of .7 of a second and the service control current has a length of the order of .5 of a second. The control current which is returned from a terminal station upon receipt of a transmitted control current has a length of the order of .5 of a second. A service control current when transmitted to a receiving station not only corrects the line attenuation at the intermediate and receiving stations and initiates the return of a control current to the sending station but also signals the operator at the receiving station. A periodic control current performs the same function as the service control current except that the operator is not called at the receiving station. A correction of the line attenuation at all stations is made in the order of two seconds by a service control current or by a periodic control current.

If a subscriber at a sending station desires to be connected to a distant receiving station on the transmission line, the operator at the sending station plugs in a toll cord. This operation on the part of the operator at the sending station initiates the transmission of a control current over the transmitting path to the intermediate and receiving stations. Relay means operated by the taking up of the toll line by the operator energizes a sending start magnet which releases a plurality of sending cams for one revolution. One of said cams connects an 800 cycle control current to the contacts of a line relay and controls relays for excluding volume control apparatus from the transmitting and receiving paths which are connected between the sending, intermediate and receiving stations. A second cam operates the line relay for placing the 800 cycle control current upon the transmitting path. The first-mentioned cam after a predetermined interval, which is .5 of a second for a service test, takes the 800 cycle control current off the contacts of the line relay. The first-mentioned cam also connects the volume control apparatus in the transmitting and receiving paths after sending of the control current.

At the receiving station a starting circuit is provided for operating a master relay whenever a control current is received from the sending station. The starting circuit comprises a circuit resonant to 800 cycle current and an anti-resonant circuit. The output from the anti-resonant and resonant circuits is rectified for operating the master relay. The output from the anti-resonant circuit opposes the output from the resonant circuit so that if frequencies of currents other than 800 cycle are received no operation of the master relay will take place. However, when only a current of 800 cycles is received the master relay will be operated. The master relay controls the operation of a motor operated potentiometer which adjusts the net loss in the transmitting

path at the receiving station. The master relay also controls the calling of the operator in case a service control current is received and the transmitting of a control current to the sending station in case a service or a periodic control current is received.

A measuring circuit is provided for controlling the operation of the motor operated potentiometer according to the peak values of the received control current. The measuring circuit is disclosed and claimed in the application of A. M. Curtis, Serial No. 21,835, filed May 16, 1935. The measuring circuit comprises two so-called impulse transformers. Each of the transformers has two windings and a high permeability core of restricted cross-section. The cores preferably comprise an alloy of nickel, iron and molybdenum ribbon wound in a box composed of ceramic insulating material. The core is magnetized by a direct current preferably obtained from the plate battery to reduce the differential permeability to a very low value. The direct coupling between the primary and secondary windings of each transformer is negligible and the device is ineffective as a transformer except when alternating current in the primary winding produces a flux which opposes and is very nearly equal to the flux produced by the biasing direct current. The measuring circuit controls two marginal relays, a raise gain relay and a lower gain relay. When both relays are released, as will be the case when the energy level of the control current on the transmitting path is low, the master relay upon receipt of a control current will complete a circuit through the high and low gain relays for operating a motor operated potentiometer to decrease the line attenuation. The high and low gain relays are marginal and operate according to the strength of the control current. If only one of the gain relays is operated then no operation of the motor operated potentiometer can take place. If both the gain relays are operated then the master relay will operate the motor operated potentiometer to increase the loss in the line.

Upon operation of the master relay and before operation of the motor operated potentiometer, a slow releasing relay is operated for controlling the circuit completed by the master relay and the gain relays for operating the motor operated potentiometer. This slow releasing relay serves to break the circuit for operating the potentiometer prior to the completion of the pulse of control current. It is necessary to stop the operation of adjusting the loss prior to the completion of the pulse of control current in order to prevent incorrect adjustment at the end of the control current. A similar clipping circuit is disclosed and claimed in the application of I. E. Cole, Serial No. 21,786, filed May 16, 1935.

The master relay upon receipt of a service or a periodic control current effects the release of a plurality of rotatable receiving cams. One of said receiving cams upon rotation serves to release a plurality of sending start cams. A second receiving cam closes a circuit which calls the operator in case a service control current is received at the station. Upon rotation of the sending start cams a circuit is first completed for impressing the 800 cycle control current at this station on the contact members of a line relay. At the same time control is taken of a slow releasing relay for excluding volume control apparatus from the transmitting and receiving paths at this station. The slow acting relay which controls the

connections of the volume control apparatus to the transmitting and receiving paths is first operated under control of the master relay upon receipt of a control current. The slow acting relay is so adjusted that no release thereof is effected prior to the operation of the sending start cams. Another one of the sending start cams operates the line relay for impressing a control current on the receiving path. The control current which is returned from the receiving station serves to adjust the receiving path net loss at the intermediate station and at the sending station. The net loss of the line at each station is adjusted in the same manner. Two other sending start cams are provided, one serving to lock the signaling relay controlled by one of the receiving cams and the other cam serving to directly operate the calling signal.

In case a periodic current having a length of .7 of a second is transmitted then the operator at the receiving station is not called. Relay means associated with one of the receiving cams is provided for discriminating between the .5 second control current and the .7 second control current and effect calling of the operator only when the .5 second control current is received. Means are provided for preventing operation of the calling means at the sending station upon return of the .5 second control current. Constantly rotating cam means are provided at each terminal station for sending out a spurt of control current at predetermined intervals and preferably every thirty minutes. The constantly rotating cams complete a circuit for operating the sending start cams which operate in substantially the same manner as above set forth for transmitting a .7 second periodic current. The periodic control current controls the motor operated potentiometer at intermediate and receiving stations in the same manner as the service control current except that the operator at the receiving station is not called in case a periodic control current is received.

In the accompanying drawings,
Fig. 1 is a diagrammatic view of a transmission system constructed in accordance with the invention;

Figs. 2 and 3 are diagrammatic views of the control circuits at a terminal station in the system shown in Fig. 1; and

Fig. 4 is a diagrammatic view of a portion of the control circuits at an intermediate station in the system shown in Fig. 1.

Referring to Fig. 1 of the drawings a system is shown comprising two terminal stations 11 and 12 and an intermediate station 13. Although only one intermediate station is shown on the drawings, it is to be understood that other intermediate stations may be provided if so desired. The terminal and intermediate stations are connected together by a four-wire line forming separate transmitting and receiving paths. The transmitting path from the station 12 to the station 11 will be referred to as a transmitting path and the receiving path at the station 12 will be referred to as the receiving path for convenience in describing the invention. The transmitting path between the terminal station 12 and the intermediate station 13 comprises conductors 14 and 15 and between the intermediate station 13 and the terminal station 11 comprises conductors 14-A and 15-A. The receiving path between the terminal station 12 and the intermediate station 13 comprises the conductors 16 and 17 and between the intermediate station 13 and the ter-

minal station 11 comprises the conductors 16-A and 17-A.

The terminal station 12 comprises control apparatus 18 which transmits control currents over conductors 14 and 15 to the intermediate station 13 and over conductors 14-A and 15-A to the terminal station 11 at intervals of every thirty minutes and whenever the operator at station 12 plugs in a toll cord. The control current transmitted by the operator plugging in a toll cord will be referred to as a service control current and the control current which is transmitted every thirty minutes will be referred to as a periodic control current. The control currents transmitted over the conductors 14 and 15 to the intermediate station 13 govern a potentiometer control 19 for adjusting a potentiometer 20. The potentiometer 20 is connected across the conductors 14-A and 15-A and serves to adjust the net loss in the transmitting path at the intermediate station according to the peak values of the control current transmitted from the station 12. The conductors 14 and 15 are connected to the conductors 14-A and 15-A at the intermediate station by means of a hybrid coil 21. A suitable amplifier 22 and a network 23 are associated with the hybrid coil 21. The potentiometer control mechanism 19 is diagrammatically illustrated as controlling an arm 24 for adjusting the setting of the potentiometer 20. This mechanism will be described in detail later.

The control current from the terminal station 12 is transmitted over the conductors 14-A and 15-A to the terminal station 11 for controlling a potentiometer 25 to adjust the net loss in the transmission path at terminal station 11. The terminal station 11 comprises a hybrid coil 26 having a network 27 and an amplifier 28 associated therewith and a potentiometer control mechanism 29 for adjusting the potentiometer 25. Terminal control apparatus 30 is provided at station 11 for signaling the operator at that station in case a service control current is received and for sending a control current over the receiving path to the terminal station 12. The pulse of periodic control current is longer than the pulse of service control current. Signaling of the operator at the distant station is effected only when a service control current is transmitted. Preferably the pulse of periodic control current extends for .7 second and the pulse of service control current extends for .5 second.

The control current transmitted from the terminal station 11 over the receiving path operates potentiometer control mechanism 31 for controlling a potentiometer 32 to adjust the net loss in the receiving path at the intermediate station. A hybrid coil 33 having an amplifier 34 and network 35 associated therewith are provided in the receiving path at the intermediate station 13. The conductors 16-A and 17-A are connected to the conductors 16 and 17 by means of the hybrid coil 33. The potentiometer control mechanism 31 is similar to the potentiometer control mechanism 19 and operates in a like manner. The control current which is returned by the terminal station 11 to the terminal station 12 extends for the same period of time as the service control current, namely, .5 second. Provision is made at the terminal station 12 as will be described later for preventing operation of a signal at this station by the returned control current. This control current operates potentiometer control mechanism 36 at the station 12 for controlling a potentiometer 37 to adjust the net loss in the receiving path at

the terminal station 12. A hybrid coil 38 having an amplifier 39 and an attenuation network 40 associated therewith is provided at the terminal station 12 in the receiving path.

Referring to Figs. 2, 3, and 4 of the drawings the operation of the system in adjusting the net loss on the transmitting and receiving paths will be described in detail. The terminal stations 11 and 12 are similar in construction and operation and only one station, namely, station 12 has been illustrated. Station 12 is shown in detail on Figs. 2 and 3 taken together. Fig. 4 shows only one-half of the intermediate station 13 and that half which is connected to the conductors 16, 17, 16-A and 17-A. The portion of the intermediate station which is associated with the conductors 14-A and 15-A is exactly the same in construction and operation as the portion shown in Fig. 4.

In the terminal station 12 shown in Figs. 2 and 3 of the drawings a starting circuit 41 is provided for operating a master relay MA when a pure control current free from currents of other frequencies is received. A control current preferably has a frequency of 800 cycles per second. A measuring circuit 42 is provided for measuring the strength of a received control current to selectively operate a low level relay LO and a high level relay RA. The master relay MA, the low level relay LO and the high level relay RA are polarized and the relays LO and RA are marginal. The relays LO and RA prepare a circuit for adjusting the potentiometer 37 under control of the master relay MA. A motor 43 is provided for operating sending cams 1, 2, 3, 4, and 5, receiving cams 6 and 7 and cams 8 and 9 which govern the transmission of the periodic control current. In order to describe in detail the operation of the system, the operations taking place upon transmission of a service control current and a periodic control current will be followed in detail.

Sending service control current

If a subscriber connected to the sending station 12 desires to be connected with a subscriber connected at the distant station 11, the operator at station 12 inserts a plug in the jack 44. Such connection operates a relay A from battery 45. The relay A removes ground from a switch controlled by the cam member 9 in order to prevent transmission of a periodic control current when the line is in use and when a service tone is being transmitted. The switch member operated by the relay A which takes ground away from the switch operated by the cam member 9 completes a circuit from a battery 46 for operating relays B and C. The relay B upon operation completes a circuit from battery 47 for operating a starting magnet 48. The relay C is slow to operate and upon operation short-circuits the relay B to return it to normal position. The starting magnet 48 when energized connects a shaft 49 carrying the cam members 1, 2, 3, 4 and 5 to the motor 43.

A shaft 50 connected to the armature of the motor 43 carries a pinion 51 meshing with two gear wheels 52 and 53. The gear wheel 52 is fixedly connected to a gear wheel 54 in order to rotate therewith. The gear wheel 53 is fixedly connected to a gear wheel 55 in order to rotate therewith. The starting magnet 48 for the sending cam members controls a lever arm 56. The lever arm 56 when attracted by the starting magnet 48 engages and moves a rotatable lever arm 57 out of engagement with a stop member

58 and into engagement with the teeth of the gear wheel 54. The stop member 58 is fixedly mounted on the shaft 49. When the lever arm 57 engages the teeth of the gear wheel 54, the lever arm 57, the shaft 49 and the starting cam members 1 to 5, inclusive, start rotating. The stop member 58, which is in the form of a cam, holds the lever 57 in engagement with the teeth of gear wheel 54 for one rotation of the starting cam members. The stop member 58 has a control to permit the lever 57 to disengage the teeth of the gear wheel 54 at the end of one complete rotation of the sending cam members 1 to 5, inclusive.

The cam member 1 when rotated closes a switch to complete a circuit for operating a D relay. This circuit extends through an armature of a V relay. The V relay, as will be described hereinafter, is operated when a periodic control current is being transmitted and therefore the circuit controlled by the cam member 1 cannot be completed when a periodic control current is being transmitted and the V relay is in operation. The D relay, when operated, connects a source of control current 59 to the contact members 60 of a relay E. The source of control current 59 preferably has a frequency of 800 cycles per second. The grounded circuit from the switch operated by the cam member 1 through the armature of the relay V also operates a relay F through the armature of a relay T in the released position. The relay F, when operated, completes a circuit from battery 60a for operating a relay G. Relay G, when operated, completes a circuit from battery 61 for operating relays H and K and completes a circuit from battery 62 for operating relays L and J. The relays H and K when operated serve to terminate the receiving line and the four-wire terminating circuit with resistance elements 142 and 143 as shown in Fig. 2 and to exclude the volume control apparatus 63 from the receiving path. The relays L and J when operated exclude the volume control apparatus 64 from the transmitting path and substitute a fixed attenuation 65a therefor. The volume control apparatus 64 is excluded from the transmitting path in order to secure a path with fixed attenuation for the transmission of the control current to be sent from the oscillator 59.

After the above operation, the cam member 3 closes the associated switch member to complete a circuit from the battery 65 for operating the relay E. The contact members 60 of relay E have already been connected to the oscillator 59 by means of the relay D so that operation of the relay E serves to connect the oscillator 59 to the transmitting path and conductors 16 and 17. Control current is supplied to the transmitting path until the cam member 1 opens the switch associated therewith. The opening of the switch associated with the cam member 1 serves to release the relay D which, in turn, disconnects the source of oscillations 59 from the transmitting path. The timing of the cam members 3 and 1 which determine the length of time the control current is impressed on the transmitting path is such that the control current is applied to the transmitting path for .5 of a second. The relay E is held operated by the switch controlled by the cam member 3 long enough to insure that if the operator plugs into the toll line with a ringing key operated, the ringing current is prevented from getting control of the echo suppressor circuit before the return control current from the distant terminal station is received.

Sending periodic control current

A periodic control current is transmitted every thirty minutes. The shaft 50 connected to the motor 43 carries a worm 66 meshing with worm teeth formed on the cam member 8. The cam member 8 is mounted on a shaft 68 carrying a second worm 67. The worm 67 meshes with the worm wheel 69 on a shaft 70 which carries the cam member 9. The cam member 8 revolves continuously and makes a complete rotation every 26.67 minutes. The cam member 8 closes an associated switch for about 20 seconds during each rotation. The cam member 9 rotates continuously and makes a complete rotation in 39.99 seconds. The switch associated with the cam member 9 is closed for approximately 3.5 seconds during each rotation of the cam member 9. The switches associated with the cam members 8 and 9 are in series circuit relation and serve to complete a circuit from a battery 71 for operating the relay V. The operating circuit for the relay V includes an armature of the relay A so that a periodic control current cannot be transmitted when the relay A is operated and a service control current is being transmitted. The relay V when operated completes a circuit from the battery 46 for operating the relays C and B. The relay B is quick-acting and the relay C is slow-acting. The relay C when operated shortcircuits the relay B and returns it to normal position. The relay B when operated completes a circuit from the battery 47 for operating the start sending magnet 48. The start sending magnet 48 operates in the manner above described with respect to the sending of a service control current for effecting one rotation of the sending cam members 1 to 5, inclusive.

The cam member 2 operates its associated switch to complete circuits for operating the relays F and D. The relay D connects the source of alternations 59 to the contact members 60 of the relay E. The relay F completes a circuit from the battery 60 for operating the relay G. The relay G completes circuits as before set forth for operating relays H, K, L and J. The relays H, K, L and J as before set forth exclude the volume control apparatus from the transmitting and receiving paths and substitute a fixed attenuation 65a for the volume control apparatus 64 in the transmitting path. In sending a periodic control current over the transmission path, the cam members 2 and 3 are so adjusted that the time of the pulse of periodic control current is .7 of a second in place of .5 of a second as in the case of the pulse of service control current.

Operation at distant terminal station upon receipt of service control current or periodic control current

Neglecting for the present the operation effected at the intermediate station 13 by the control current sent over the transmitting path, we will consider the operation of the control current at the distant terminal station. Inasmuch as the two terminal stations are similar in construction and operation the operation of the received control current will be described by reference to the terminal station shown in Figs. 2 and 3 of the drawings. Control current received over the conductors 16 and 17, Fig. 2 of the drawings, passes through an equalizer 72 and an amplifier 39 to the hybrid coil 38. The

starting circuit 41, which controls the operation of the polarized master relay MA, is connected to the hybrid coil 38 by means of a transformer 73. The starting circuit is so constructed as to operate the relay MA when a pure control current of 800 cycles is received and to prevent operation of relay MA when currents of any other frequency are received or when 800 cycle control current is received in combination with currents of other frequencies. In brief, the starting circuit is designed to operate the master relay when a pure 800 cycle control current is received and to prevent operation of the master relay by voice or noise currents.

The starting circuit comprises an amplifier 15 space discharge device 74 having the input circuit thereof connected to the secondary winding of the transformer 73. An anti-resonant circuit 75 and a resonant circuit 76 are series connected in the output circuit of the amplifier 74. Plate potential for the amplifier 74 is supplied from a battery 89 through a choke coil 90. Filament heating current is supplied to the amplifier 74 from a battery 91 through a choke coil 92 and grid bias resistance elements 93. The circuit 75 which is anti-resonant to the 800 cycle control current comprises an inductance element 77 and a capacity element 78 which are shunted by the primary winding of a transformer 79. The circuit 76 which is resonant to the 800 cycle control current comprises an inductance element 80 and a capacity element 81 which are shunted by the primary winding of a transformer 82. The secondary winding of the transformer 79 is divided and connected to two oppositely positioned rectifiers 83 which preferably are of the copper oxide type. The mid-tap from the secondary winding of the transformer 79 and the junction point of the two rectifiers 83 are connected to a resistance element 84. The secondary winding of the transformer 82 is connected in a like manner to two rectifiers 85. A divided resistance 86 is connected from the mid-tap of the secondary winding of the transformer 82 to the junction point of the rectifiers 85. The master relay MA is connected in a series circuit including the resistance 84 and a portion of the resistance 86 as shown in Fig. 2 of the drawings. Condensers 87 are provided for blocking purposes and a resistance 88 is provided for adjusting the selectivity of the starting circuit.

If a pure control current of 800 cycles is received in the output circuit of the amplifier 74 in the starting circuit, the anti-resonant circuit 75 offers great opposition to this pure control current and the majority thereof flows through the primary winding of the transformer 79. The current in the transformer 79 is rectified by the rectifiers 83 and supplied to the master relay MA which is operated. The resonant circuit 76 offers little opposition to the pure control current of 800 cycles and therefore little of this current flows through the primary winding of the transformer 82. However, if a current having a frequency other than 800 cycles and as much as 50 cycles above or below 800 cycles is received, then the resonant circuit 76 offers considerable opposition to the flow of such current and causes a large part thereof to flow through the primary winding of the transformer 82. The current supplied by the transformer 82 is rectified by the rectifiers 85 and supplied to the polarized master relay MA in a direction to oppose operation of this relay. Therefore, if currents other than the 800 cycle

control current are received no operation of the master relay will take place. Furthermore, if 800 cycle control current combined with currents of other frequencies are received, the current received from the transformer 82 and rectified by the rectifiers 85 opposes the current received from the transformer 79 and rectified by the rectifiers 83 to prevent operation of the polarized master relay MA. The master relay in a manner to be described controls the operation of the net loss adjusting potentiometer 37.

A repeater circuit which is connected to the receiving side of the hybrid coil 38 by means of the potentiometer 37 comprises a transformer 94, a space discharge amplifier 95 and a transformer 96. The secondary winding of the transformer 96 is connected through the armatures of the relay H, the volume control apparatus 63 and the armatures of the K relay to a hybrid coil 97 which, in turn, is connected to the two-wire circuit comprising conductors 98 and 99. The hybrid coil 97 is provided with a network 100. The repeater comprising an amplifier 95 is designed to produce a zero equivalent gain between the hybrid coil 38 and the output of the repeater when the arm 101 controlling the potentiometer 37 is positioned at the mid-point. An adjustable resistance 102 is provided in circuit with the potentiometer 37 for effecting a fixed adjustment of the potentiometer operation. The hybrid coil 38 permits the input to the starting circuit 41, the impedance of which changes if the space discharge device 74 overloads, to be bridged across the input of the repeater without affecting the transmission from the line repeater 39 to the amplifier 95.

The measuring circuit 42 is connected across the secondary winding of the transformer 96 in the repeater circuit for controlling the operation of the polarized marginal relays LO and RA according to the value of the control current received at the terminal station. The marginal relays LO and RA prepare a circuit for operating the potentiometer 37 as will be described later. The measuring circuit is disclosed and claimed in the application of A. M. Curtis Serial No. 21,835 filed May 16, 1935.

The measuring circuit comprises a transformer 103, a pentode amplifier space discharge device 104, a transformer 105, a so-called impulse coil 106, a pentode space discharge device 107, a transformer 108, a second impulse coil 109 and a space discharge rectifier 110. The primary winding of the transformer 103 is connected across the secondary winding of the transformer 96 by means of a sensitivity adjusting potentiometer 111. The impulse coil 106 consists of a transformer having two windings and a high permeability core of restricted cross-section. The core preferably comprises approximately twelve turns of thin alloy of nickel, iron and molybdenum, ribbon wound in a box composed of ceramic insulating material approximately 1½ inches in diameter. The sectionalized primary and secondary windings of the impulse coil comprise about 1600 turns each. The core of the impulse coil is magnetized by a current of about 15 milliamperes derived from a battery 112. The circuit for energizing the core of the impulse coil 106 extends from ground through the primary winding of the impulse coil 106, an inductance 113, a resistance 114 and the battery 112 to ground. The circuit for energizing the core of the impulse coil 109 extends from ground through the primary winding of the coil 109, inductance 115, resist-

ance element 116 and the battery 112 to ground. Inasmuch as the direct coupling between the primary and secondary windings of the impulse coil 106 is negligible, the coil is ineffective as a transformer except when the alternating current supplied to the primary winding produces a flux which opposes and is very nearly equal to the flux produced by the biasing current supplied to the primary winding from the battery 112. The parts of the cycle of alternating current supplied to the primary winding of the impulse coil 106 which opposes the bias on the impulse coil permit the coil to function as a transformer for varying brief periods. The result of this operation is that brief impulses of current pass through the impulse coil due to the neutralization of the biasing flux on the impulse coil.

The impulse coil 109 is similar in construction and operation to the impulse coil 106. The impulse coils serve to accentuate the variations in the received control current and to produce a more than proportional change in such variations. The alternating current received by the measuring circuit from the secondary winding of the transformer 96 in the repeater circuit is transmitted or suppressed according to whether or not the received alternating current has sufficient magnitude to over-ride the biasing flux produced by the battery 112 in the primary windings of the impulse coils 106 and 109. The portion of the alternating current which may pass from the second impulse coil 109 is rectified by the space discharge tube 110 and supplied to the high gain and low gain relays RA and LO. If the received control current has peak values below a predetermined fixed range, both the relays LO and RA are held in released position. If the peak values of the received control current are raised above the fixed range, the relays RA and LO are both operated. The relay RA is released when the peak values of the control current fall below the upper limit of the fixed range and the relay LO is released when the peak values of the control current fall below the lower limit of the fixed range. When the relays LO and RA are both released the potentiometer 37 will be operated to raise the gain. When one of the relays LO and RA is operated and the other is released, no operation of the potentiometer will take place. If both the relays LO and RA are operated the potentiometer will be operated to lower the gain effected.

A battery 117 is provided for supplying heating current and grid bias to the pentode amplifier tubes 104 and 107. The battery 117 also supplies heating current and grid bias to a control tube 118. The battery 112 not only supplies biasing current to the impulse coils 106 and 109 but also supplies plate current to the tubes 104, 107 and 118. The control tube 118 is so connected to the batteries 117 and 112 as to correct for any changes in the voltage of such batteries supplied to the pentode tubes 104 and 107. The anode cathode circuit of the space discharge device 118 is connected across the inductance 113 and the resistance 114 in series with an inductance 119. The inductance 113 and 114 is connected in the biasing circuit for the impulse coil 106 so that variations in impedance of the control tube 118 govern the bias placed on the impulse coil 106.

If the voltage of the battery 117 increases somewhat the bias on the grids of the pentode tubes 104 and 107 increases so that the output current from the pentode tubes is reduced somewhat. However, the increased voltage of the battery 117 also increases the grid bias on the control tube 75

118. The increase in the impedance of the control tube 118 serves to reduce the bias placed on the impulse coil 106 and thus compensate for the changes in current flow through the pentode tubes 104 and 107 effected by the change in the voltage of the battery 117. If, for example, the battery 112 increases in voltage the effect will be to increase the current flow through the control tube 118 and to increase the biasing current supplied to the impulse coil 106. However, the increase in the voltage of the battery 112 causes a slight increase in the gain of the pentode tubes 104 and 107 which corrects for the change in the bias on the impulse coil 106. Condensers 120 are provided for blocking purposes. A condenser 121 serves to smooth out the rectified current supplied for operating the relays LO and RA.

The arm 101 of the potentiometer 37 is fixedly mounted on a shaft 122 which is rotated at times by a motor 123 according to the operation of the relays LO and RA. The motor 123 constantly rotates the beveled gear wheel 124 which meshes with two beveled gear wheels 125 and 126. The beveled gear wheel 125 is fixedly connected to a raised gain magnet 127 and the beveled gear wheel 126 is fixedly connected to a lower gain magnet 128. The gear wheel 125 and the magnet 127 are rotatably mounted on a shaft 122 and are adapted to rotate therewith when the magnet 127 is energized to effect clutching engagement with a plate 129 fixedly mounted upon the shaft 122. In like manner, the gear wheel 126 and the magnet 128 are rotatably mounted on the shaft 122 and are rotated with the shaft 122 when the electromagnet 128 is energized to effect clutching engagement with the plate 130 fixedly mounted on the shaft 122. The electromagnet 127 is provided with slip rings 131 and the electromagnet 128 is provided with slip rings 132 in order that the relays LO and RA may complete circuits for energizing the magnets.

When a control current is received at the terminal station shown in Figs. 2 and 3, the master relay MA is operated by means of the starting circuit 41. The master relay MA upon operation completes a circuit from battery 133 for operating relays R and N and completes a circuit from battery 134 for operating a relay S. The relay N is momentarily operated to complete a circuit for operating a polarized relay P. The polarized relay P when operated completes a circuit from ground effected either from an armature of the relay N or the relay R for completing a circuit for controlling the electromagnets 127 and 128 according to the operation of the relays LO and RA. With the armatures of the two relays LO and RA in released position, the circuit through the electromagnets may be traced from ground through the armature of the relay R or the armature of relay N through the armature of relay P, armature of relay LO, slip rings 131, electromagnet 127, limit switch 135, armature of relay RA and battery 137 to ground. In such case the electromagnet 127 is energized to rotate the shaft 122 and the potentiometer arm 101 in a direction to raise the gain effected. If one of the relays LO and RA is in operative position, no operation of the motor operated potentiometer can take place. If both the relays LO and RA are in operative position a circuit is completed by the relay P for energizing the electromagnet 128 to raise the loss effected by the potentiometer 37. A circuit completed when both the relays LO and RA are operated may be traced from ground through the armature of the relay R or N, armature of the

relay P, armature of the relay LO, slip rings 132, electromagnet 128, limit switch 136 and armature of the relay RA, through battery 137 to ground. Limit switches 135 and 136 are controlled by an arm 138 on the shaft 122 for preventing operation of the motor operated potentiometer when the potentiometer reaches either extreme position. An alarm 139 is operated when either the switch 135 or the switch 136 is opened by the arm 138.

The relay P is provided with a hang-over circuit comprising a resistance 140 and condenser 141 to limit the operation of the motor operated potentiometer 37 a predetermined time after the momentary operation of the relay N. The condenser 141 and the resistance 140 which control the release of the relay P are preferably set so that the relay will remain operated for only .4 of a second. The operation of the relay P for .4 of a second allows for a complete adjustment of the motor operated potentiometer to take place but prevents adjustment of the potentiometer during the time when the control current is dying out. It is desirable to prevent adjustment of the motor operated potentiometer 37 near or at the end of a pulse of control current in order to prevent an incorrect adjustment of the potentiometer.

The relay R upon operation short-circuits the relay N in order to cause its release and supplies ground for operating the electromagnets 127 and 128 under control of the P relay. The R relay is under the control of the master relay MA so that in case of a mutilated control current the master relay will be released, causing the release of the relay R. The release of the relay R will remove ground from the circuit controlled by the P relay so as to prevent adjustment of the gain by the motor operated potentiometer.

The relay S which is operated by the master relay MA effects operation of a polarized relay M. The relay M upon operation completes a circuit for operating relays H and K and relays L and J. The relays H and K remove the volume control 63 from the receiving channel. The relay H when operated terminates the incoming receiving path of the four-wire circuit in a resistance 142. The relay K connects a resistance 143 across the receiving path connected to the hybrid coil 97. The relays L and J when operated disconnect the volume control 64 from the transmitting path and interpose an impedance 65 in place thereof. The relay M is provided with a polarizing winding supplied with current from the battery 144. A resistance capacity discharge path comprising a condenser 145 and a resistance 146 is provided for effecting a hold-over in the operation of the relay M. The hold-over in the operation of the relay M maintains the relays H, J, K and L operated until a relay G is operated in a manner to be hereinafter set forth.

The operation of the relay S by the master relay MA completes a grounded circuit for operating the relay T. The circuit for operating the relay T extends from ground through the upper armature of the relay S, armature of the relay F, coil of relay T and grounded battery 147. The relay T, upon operation, completes a circuit for operating a starting magnet 148 to effect one rotation of the receiving cams 6 and 7. The starting magnet 148 upon operation engages the lever 149 which forces a lever 150 into engagement with the gear teeth 55. The lever 150 permits one rotation of shaft 151 carrying the cams 6 and 7 in the same manner as the lever 57 per-

mits release of the shaft 49 to effect one rotation of the sending cams 1 to 5, inclusive. The stop member 152 mounted on the shaft 151 is similar in construction and operation to the stop member 58 on the shaft 49. The cam member 6 operates a switch associated therewith for completing a circuit from the battery 46 to effect operation of the slow-to-operate relay C and the relay B. The relay B completes a circuit to energize the starting magnet 48 and effect one rotation of sending cams 1 to 5, inclusive. The sending cams 1 to 5, inclusive, are rotated in order to return a control current to the original sending terminal station and to adjust the net loss in the receiving path at the intermediate station and at the original sending station.

If the control current received at the distant station is a service control current and is .5 of a second in duration, the master relay MA will release at the end of the pulse of control current and release the relay S which, in turn, releases the relay T. The switch controlled by the cam member 7 is closed during the time the relay T is operated for a periodic signal. However, when a service control current is received which is only .5 of a second in duration, the relay T is released before the switch associated with the cam member 7 is closed. Consequently, upon completion of the pulse of service control current a circuit is completed from ground through the switch associated with the cam member 7, armature of the relay T, armature of the relay A, coil of the relay U and battery 153 to ground. The relay U locks up under control of the switch operated by the cam member 4 whose contacts are normally closed. Before the release of the switch controlled by the cam member 4, the cam member 5 operates a switch for completing a circuit from a battery 153 to light the line lamp 154 and signal the operator. The timing of the cam member 5 is such that the line lamp 154 lights when the line is in condition for use. By reason of the timing of the cam member 7 with respect to the release of the relay T, the operator at the distant end of the line does not get a signal when a periodic control current of .7 of a second is received because the relay T is operated during the interval when the cam 7 is able to apply ground for operating the relay U.

During the time that the apparatus at the distant or incoming station is preparing to signal the operator, it also is arranging to return a control current to the originating or sending end of the line. The pulse of control current which is returned to the sending end of the line over the path which has been designated as the receiving path has a duration of .5 of a second, the same as the pulse of service control current. The rotation of the sending cams 1 to 5, inclusive, which was started by the receiving cam member 6 and relay B causes cam member 1 to close the switch associated therewith to operate the relay D. The relay D as has been set forth before connects the source of oscillations 59 to the contact members 60 of the relay E. The switch controlled by the cam member 1 also operates the relay F when the relay T is released by the cessation of the pulse of received control current. The relay F completes a circuit for operating the relay G. The relay G when operated completes a holding circuit for the relays H, J, K and L which control the volume control apparatus 63 and 64. The timing of the cam members and the hangover time of the relay M is such that the relay M does

not release until after the relay G is operated. The relay M as has been set forth above first operates the relays H, J, K and L. The cam member 3 operates the switch associated therewith for completing a circuit from the battery 65 for operating the relay E. The relay E connects the source of oscillations 59 to the line for transmitting a pulse of return control current to the originating or sending station. The pulse of return control current is terminated by the switch controlled by the cam member 1 releasing the relay D at the end of a .5 second period. The return pulse of control current has a duration of .5 of a second when either a service control current or a periodic control current is received, since the relay V is non-operative and the ground for operating relay D is furnished by the cam controlled by the cam member 1.

Disregard for the present the operation of the return pulse of control current at the intermediate station, and consider only the operation of such pulse of return control current at a terminal station shown in Figs. 2 and 3 of the drawings. The pulse of return control current is received over the conductors 16 and 17, Fig. 2, for operating the master relay MA under control of the starting circuit 41. The pulse of return control current also controls the operation of the measuring circuit 42 in the manner before described for controlling the operation of the low gain relay LO and a high gain relay RA. The relays LO and RA are set in accordance with the operation of the measuring circuit 42. The master relay MA completes a circuit for operating the relay S and the relays N and R. The relays N and R operate the relay P which, in turn, completes a circuit for controlling the magnets 127 and 128 to adjust the setting of the motor operated potentiometer 37. The relay S completes a circuit for operating the relay T and the relay T completes a circuit for energizing the starting magnet 148. The starting magnet 148 when operated effects one rotation of the receiving cams 6 and 7. The receiving cams 6 and 7 at the sending end of the line can not start the operation of the sending cams 1 to 5, inclusive, because the relay B is short-circuited by the contacts of relay C which is operated either by relay A which remains operated when the plug is in the jack or in the case of sending periodic control current by relay V which the switches controlled by the cam members 8 and 9 hold operated for a period of .3 second. The pulse of return controlled current will not cause the line lamp 154 to light at the sending end in case a periodic control current has been transmitted because the switch controlled by the cam member 5 has been restored to normal position before the relay U is operated under control of the cam member 7. In case a return control current is received after a service control current has been sent over the line the relay U will not operate because its circuit is held open by the relay A.

Operation at intermediate stations

The intermediate station 13 shown in Fig. 1 of the drawings corrects the net loss in both channels when a service control current or a periodic control current is transmitted. The apparatus in each path is similar to the apparatus in the terminal stations 11 and 12 for controlling the motor operated potentiometers at these stations. No provision is made at the intermediate station for transmitting a control current of either type or for signaling an operator. Inasmuch as the apparatuses in the two paths at the intermediate

station are similar in construction and operation, only one apparatus, namely, that in the path which has been designated as the receiving path, will be described in detail with reference to Fig. 4 of the drawings. Inasmuch as the apparatus shown in Fig. 4 is similar to apparatus shown in Figs. 2 and 3 of the drawings, like parts will be designated by similar reference characters.

Referring to Fig. 4 of the drawings a starting circuit 155 which is similar to the starting circuit 41 shown in Fig. 2 of the drawings is provided for operating a polarized master relay MA. A repeater circuit 157 is provided which is similar to the repeater circuit shown in Fig. 2 of the drawings. A measuring circuit 156 is provided which is similar to the measuring circuit 42 shown in Fig. 2 of the drawings. A potentiometer 32 is provided for adjusting the net loss in the receiving path at the intermediate station. The apparatus for operating the potentiometer 32 is similar to the apparatus shown in Figs. 2 and 3 of the drawings for operating the potentiometer 37.

The starting circuit 155 comprises an amplifier 74 of the space discharge type having the input circuit thereof connected to a hybrid coil 33 by means of a transformer 73. An anti-resonant circuit 75 and a resonant circuit 76 are provided in the output circuit of the space discharge device 74. The anti-resonant circuit 75 and the resonant circuit 76 are tuned to the frequency of the control current which is 800 cycles. A transformer 73 has the primary winding connected in shunt to the anti-resonant circuit 75 and a transformer 82 has the primary winding thereof connected in shunt to the resonant circuit 76. The secondary winding of the transformer 79 supplies current to two rectifiers 83 which are preferably of the copper oxide type. The secondary winding of the transformer 82 supplies current to two rectifiers 85 which are also preferably of the copper-oxide type. The energizing winding for the master relay MA is connected in series with a resistance element 84 and a portion of a resistance element 86. The resistance element 84 is supplied with rectified current from the rectifiers 83 and the resistance element 86 is supplied with rectified current from the rectifiers 85. Energizing circuit for the coil of the master relay is connected oppositely to the two resistance elements 84 and 86, so that potential obtained from one resistance element opposes the potential obtained from the other resistance element. If a pure control current is received at the intermediate station, current in the output circuit of the space discharge device 74 will be opposed by the anti-resonant circuit 75, whereas little opposition to such current will be made by the resonant circuit 76. Consequently, the primary winding of the transformer 79 will carry considerable current, whereas the primary winding of the transformer 82 will carry little current. Accordingly, a considerable potential drop will be effected across the resistance element 84 for operating the master relay MA. If currents having frequencies other than the 800 cycle control current are received by the hybrid coil 33, a considerable potential drop will be effected across the resistance element 86. When there is considerable potential drop across the resistance element 86, current is supplied to the master relay MA for preventing its operation.

The repeater 157 is similar in construction and operation to the repeater shown in Fig. 2 of the drawings and is connected to the conductors 16

and 17 as shown in Fig. 4 of the drawings. The measuring circuit 156 which controls the relays LO and RA is similar to the measuring circuit 42 shown in Fig. 2 and a detailed description thereof is deemed unnecessary. The measuring circuit 152 selectively operates the relays LO and RA for partially completing a circuit for operating the clutch magnets 127 and 128. The clutch magnets 127 and 128 control the operation of the potentiometer arm 101 by the motor 123.

When a pulse of control current is received over the conductors 16—A and 17—A which may be a pulse of periodic control current, a pulse of service control current or a pulse of return control current, the starting circuit 155 effects operation of the master relay MA. The measuring circuit 156 operates the relays LO and RA. If the peak level of the control current is below normal range, the two relays LO and RA are maintained in released position. If the level of the control current is above normal range, the two relays LO and RA are operated. If the normal range of control current is received, the relay LO is operated and no operation of the relay RA takes place. If both the relays LO and RA are operated, the magnet 128 is operated for controlling the potentiometer 32 to increase the loss on the line. If both the relays LO and RA are in released position as shown, the clutch electromagnet 127 is operated for lowering the loss effected by the potentiometer 32.

Upon operation of the master relay MA, a circuit is completed for operating the relay N and the relay R. The relay R is slow-to-operate and upon operation short-circuits the relay N. The momentary operation of the relay N completes a circuit for operating the polarized relay P. The relay P is provided with a hangover circuit comprising the resistance element 140 and the condenser 141. The condenser 141 is normally charged by potential from the battery 160. Upon operation of the relay P by the circuit completed by the armature of the relay N the condenser 141 is discharged. Inasmuch as the relay N is only operated momentarily, the relay P will be released unless provisions were taken for effecting a hangover in its operation. The time taken for charging the condenser 141 determines the hangover operation of the relay P. This hangover time is determined according to the values of the condenser 141 and the resistance element 140. The relay P when operated completes a circuit through the armatures of the relays LO and RA for energizing either the clutch electromagnet 127 or the clutch magnet 128. In Fig. 4 of the drawings the relays LO and RA are shown in position for energizing the clutch electromagnet 127. The clutch electromagnets 127 and 128 serve to connect the motor 123 for operating the arm 101 of the potentiometer 32 in the manner set forth in describing the apparatus shown in Fig. 3 of the drawings. Limit switches 135 and 136 are provided for limiting the operation of the potentiometer mechanism. An alarm 139 is also provided which is operated when the potentiometer is operated to either of its extreme limits.

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 intended to be covered by the appended claims.

What is claimed is:

1. In combination, a signal transmission line having two separated stations with transmitting

and receiving paths between stations, a loss adjusting device at each of said stations, means manually initiated at the first station for transmitting a control current over the transmitting path to the second station, means at the second station automatically operated by the control current from the first station for adjusting the loss adjusting device at that station and for transmitting a control current over the opposite path to the first station, and means at the first station automatically operated by the control current received from the second station for adjusting the device at the first station.

2. The method of adjusting the energy level of signals at two stations on a transmission line having transmitting and receiving paths which consists in transmitting a control current over the transmitting path from the first station to the second station, in adjusting the energy level of signals in the transmitting path at the second station by the control current received at the second station, in transmitting a control current over the receiving path from the second station to the first station under control of the control current received from the first station, and in adjusting the energy level of signals on the receiving path at the first station by the control current received at the first station.

3. In combination, a signal transmission line having transmitting and receiving stations connected thereto, means at the transmitting station for transmitting a control current over the line to the receiving station, means at the receiving station automatically responsive to said control current for adjusting the level at the receiving station according to the energy level of the control current, for signaling the operator and for transmitting a control current to the transmitting station, and means at the transmitting station automatically responsive to the control current from the receiving station for adjusting the level at the transmitting station according to the energy level of the received control current.

4. In combination, a signal transmission line having a transmitting station and a receiving station connected thereto, a loss adjusting device at said receiving station, means for transmitting a control current over said line from the transmitting station to the receiving station, and means at the receiving station automatically operated by the control current from the transmitting station for adjusting the device at the receiving station and for transmitting control current over the line to the transmitting station.

5. In combination, a signal transmission line having two separated stations with transmitting and receiving paths between said stations, a loss adjusting device at each of said stations, means at one station operated upon connection by the operator at the station to the line for transmitting a control current within the voice frequency range over the transmitting path to the other station for a relatively short period of time, means at said other station automatically governed by said control current for operating said device to adjust the loss at the second station, for signaling the operator at the second station and for transmitting a like control current over the opposite path to the first mentioned station, and means at the first mentioned station automatically governed by the received control current for operating the device at that station to adjust the loss.

6. In combination, a signal transmission line

having two separated stations with transmitting and receiving paths between the stations, a loss adjusting device at each of said stations, means initiated by the operator at the first station for transmitting a control current of a relatively short duration over said line to the second station, said control current being within the voice frequency range, means governed by the control current at the second station for signaling the operator at that station, for operating said device at the second station, and for transmitting a control current over the receiving path to the first station, and means governed by the control current received at the first station for operating the device at that station.

7. In combination, a signal transmission line having transmitting and receiving paths connected to said transmitting, receiving and intermediate stations, a loss adjusting device at the transmitting and receiving stations, a loss adjusting device for both paths at said intermediate station, means for transmitting a control current from the transmitting station over the transmitting path to the intermediate station and to the receiving station, means at said intermediate station responsive to said control current for operating the adjusting device in the transmitting path at that station, means at the receiving station responsive to said control current for operating the adjusting device in the transmitting path and for transmitting a control current over the receiving path, means at the intermediate station responsive to the control current in the receiving path for operating the adjusting device in the receiving path, and means at the transmitting station responsive to the control current in the receiving path for operating the adjusting device at the transmitting station.

8. In combination, a signal transmission line having transmitting and receiving paths connected to transmitting, receiving and intermediate stations, means at the transmitting station for transmitting a control current over the transmitting path to the intermediate and receiving stations, means at the intermediate station responsive to the control current for adjusting the loss on the transmitting path according to the energy level of the control current, means at the receiving station responsive to the control current for adjusting the loss on the transmitting path according to the energy level of the control current and for transmitting a control current over the receiving path, means at the intermediate station responsive to the control current on the receiving path for adjusting the loss on the receiving path according to the energy level of the control current on that path, and means at the transmitting station responsive to the control current on the receiving path for adjusting the loss on the receiving path according to the energy level of the control current on that path.

9. In combination, a signal transmission line having a station connected thereto, means at said station for generating control current, a plurality of rotatable cams, means initiated by the operator at said station for effecting rotation of said cams, a relay having contact means for connecting said control current to the transmission line, and means operated by rotation of said cams for connecting said control current to said relay contact means, for operating said relay to connect the control current to the transmission line and for disconnecting the control current from said relay contact means.

10. In combination, a signal transmission line having a transmitting station connected thereto, means at said station for generating a control current, a plurality of rotatable cams, means initiated by the operator for effecting rotation of said cams, a relay for connecting said control current to the transmission line, means comprising a circuit closed by a first cam for connecting the control current to the contacts of said relay, and means operated by another cam after the closing of said circuit by the first cam for energizing said relay to connect said control current to the line, the first cam after a fixed time interval serving to open said circuit and remove the control current from the line.

11. In combination, a signal transmission line having transmitting and receiving paths and a station connected to said paths, volume control apparatus in said transmission and receiving paths, means at said station for generating a control current, a plurality of rotatable cams, means initiated by the operator for effecting one rotation of said cams, a relay for connecting said control current to the transmission path, means comprising circuits closed by a first cam for connecting the control current to the contacts of said relay and for excluding said volume control apparatus from the transmitting and receiving paths, and means operated by another of said cams after the closing of said circuits by the first cam for energizing said relay to connect said control current to the transmission path, the first cam opening said circuits after a fixed time interval to remove the control current from the transmitting path and to connect said volume control apparatus in the transmitting and receiving paths.

12. In combination, a signal transmission line having a station connected thereto, means at said station for generating a control current, a plurality of rotatable cams, a cam rotating at constant speed, means initiated by said constantly rotating cam at predetermined time intervals for effecting a rotation of said rotatable cams, and means controlled by said rotatable cams at each rotation thereof for connecting said control current to the line for a predetermined interval.

13. In combination, a signal transmission line having a station connected thereto, means at said station for generating a control current, a plurality of rotatable cams, a plurality of cams rotating at constant speed, means initiated by said constantly rotating cams at predetermined time intervals for effecting a rotation of said rotatable cams, a relay for connecting said control current to the line, means comprising a circuit closed by a first rotatable cam for connecting the control current to the contacts of said relay, and means operated by another rotatable cam after closing said circuit by the first rotatable cam for energizing said relay to connect said control current to the line, the first rotatable cam operating after a fixed time interval to open said circuit and remove the control current from the line.

14. In combination, a signal transmission line having a station connected thereto, means at said station for generating a control current, a plurality of rotatable cams, a plurality of cams rotating at constant speed, means initiated by said constantly rotating cams at predetermined time intervals for effecting a rotation of said rotatable cams, means initiated by the operator at said station for effecting one rotation of said rotatable cams and for preventing control of the rotatable cams by the constantly rotating cams,

and means controlled by said rotatable cams at each rotation thereof for connecting said control current to the line for a fixed interval of time.

15. In combination, a signal transmission line having a station connected thereto, means at said station for generating a control current, a plurality of rotatable cams, a plurality of cams rotating at constant speed, means initiated by said constantly rotating cams at predetermined time intervals for effecting a rotation of said rotatable cams, means initiated by the operator at said station for effecting a rotation of said rotatable cams, means controlled by said rotatable cams for connecting said control current to the line at each rotation thereof, and means controlled by the rotatable cams for connecting the control current to the line different lengths of time according to whether the operation is initiated by the operator or by the constantly rotating cams.

16. In combination, a signal transmission line having a signal station connected thereto, means for transmitting pulses of control current of different lengths over said line to the station, a relay, means for operating said relay according to the length of the received pulse of control current, a rotatable receiving cam, signaling means, means for effecting one rotation of said cam upon receipt of a pulse of control current and operation of said relay, and means controlled by said cam and said relay for operating said signaling means when a pulse of one length is received and for preventing operation of the signaling means when a pulse of another length is received.

17. In combination, a signal transmission line having a station connected thereto and adapted to transmit pulses of control current to said station, volume control means in the line at said station, a slow releasing relay for excluding said volume control means from the line, rotatable cam means at said station for controlling the net loss of said line, means upon receipt of a pulse of control current at said station for operating said slow releasing relay to exclude the volume control means from the line and for effecting rotation of said cam means, and means controlled by said cam means for insuring continued exclusion of said volume control means from the line upon the termination of said control current and release of said slow relay.

18. In combination, a signal transmission line having receiving and transmitting paths connected to a receiving station, rotatable receiving cam means at said station, a plurality of rotatable sending cams at said station, means operated upon receipt of a control current at said station for effecting rotation of said receiving cam means, means operated upon rotation of said receiving cam means for effecting one rotation of said sending cams, and means controlled by the sending cams when rotated for transmitting control current over the receiving path.

19. In combination, a signal transmission line having transmitting and receiving paths connected to a receiving station and adapted to transmit pulses of control current to the station, volume control means in the transmitting and receiving paths at said station, a plurality of rotatable receiving cams, a plurality of rotatable sending cams, means comprising a slow releasing relay for excluding said volume control means from the transmitting and receiving paths, means upon receipt of a pulse of control current at said station for operating said slow releasing relay to exclude said volume control means from the transmitting and receiving paths and for effecting

rotation of said receiving cams, means controlled by the receiving cams for operating said sending cams, and means controlled by said sending cams for insuring continued exclusion of said volume control means from said paths upon termination of said control current and release of said slow release relay.

20. In combination, a signal transmission line having receiving and transmitting paths connected to a receiving station, a plurality of rotatable receiving cams at said station, a plurality of rotatable sending cams at said station, signal means at said station, means operated upon receipt of a pulse of control current at said station for effecting one rotation of said receiving cams, means operated upon rotation of said receiving cams for effecting one rotation of said sending cams, means controlled by said sending and receiving cams for operating said signal means when a pulse of one length is received and for preventing operation of said signal means when a pulse of another length is received, and means controlled by the sending cams when rotated for transmitting a pulse of control current over said receiving path.

21. In combination, a signal transmission line having receiving and transmitting paths connected to a receiving station, a plurality of rotatable receiving cams at said station, a plurality of rotatable sending cams at said station, an adjustable loss device in the transmitting path at said station, signal means at said station, means operated upon receipt of a pulse of control current at said station over the transmitting path for adjusting said loss device according to the energy level of the received control current, means operated upon receipt of a pulse of control current at said station for effecting one rotation of said receiving cams, means operated upon rotation of said receiving cams for effecting one rotation of said sending cams, and means controlled by said sending and receiving cams for operating said signal means when a pulse of one length is received and for preventing operation of said signal means when a pulse of another length is received.

22. In combination, a signal transmission line having transmitting and receiving paths connected to a receiving station and adapted to transmit pulses of control current of different lengths over the transmitting path to the station, signal means at said station, a plurality of rotatable receiving

cams at said station, a plurality of rotatable sending cams at said station, an adjustable loss device in the transmitting path at said station, means operated upon receipt of a pulse of control current at said station for adjusting said loss device according to the energy level of the received pulse of control current, means operated upon receipt of a pulse of control current at said station for effecting one rotation of said receiving cams, means operated by one of said receiving cams when rotated for effecting one rotation of said sending cams, means controlled by said sending and receiving cams for operating said signal means when a pulse of one length is received and for preventing operation of said signal means when a pulse of another length is received, and means controlled by the sending cams when rotated for transmitting a control current over said receiving path.

23. In combination, a signal transmission line having transmitting and receiving paths connected to a receiving station and adapted to transmit pulses of control current of different lengths over the transmitting path to the station, signal means at said station, volume control means in the transmitting and receiving paths at said station, a plurality of rotatable receiving cams at said station, a plurality of rotatable sending cams at said station, an adjustable loss device in the transmitting path at said station, means operated upon receipt of a pulse of control current at said station for adjusting said loss device according to the energy level of the received pulse and for excluding said volume control means from the transmitting and receiving channels, means upon receipt of a pulse of control current at said station for effecting one rotation of said receiving cams, means operated by one of said receiving cams when rotated for effecting one rotation of said sending cams, means controlled by said sending and receiving cams for operating said signal means when a pulse of one length is received and for preventing operation of said signal means when a pulse of another length is received, and means controlled by the sending cams for maintaining said volume control means excluded from the two paths and for transmitting a control current over said receiving path.

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