

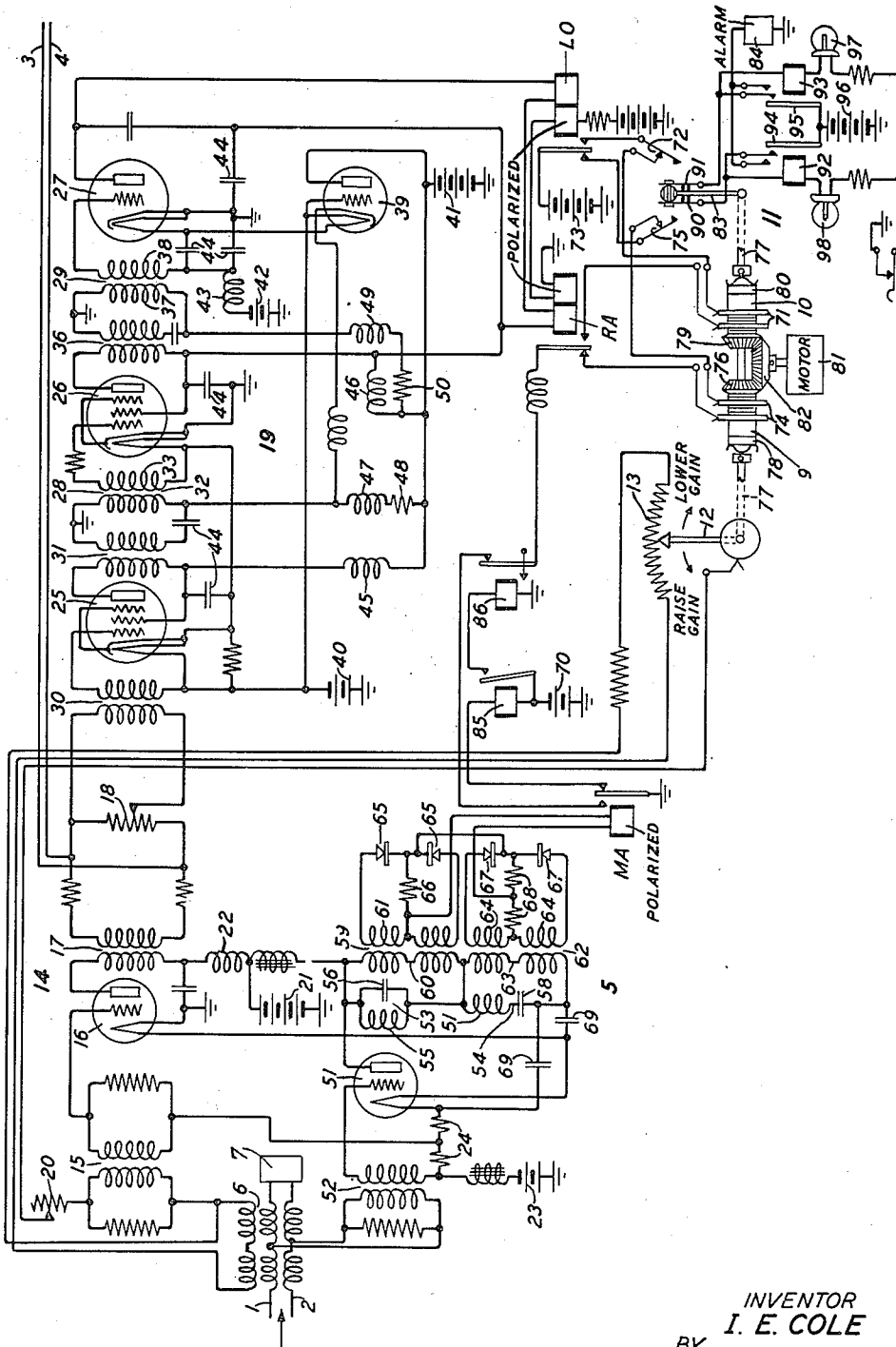
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CONTROL CIRCUITS

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CONTROL CIRCUITS

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This invention relates to control circuits and particularly to control circuits for adjusting the net loss on a transmission line.

One object of the invention is to provide a signal station on a transmission line with control circuits for adjusting the net loss on the line in accordance with the strength of pulses of control current that shall insure against adjusting the net loss on the line near the end of a pulse of control current.

Another object of the invention is to provide a signal station on a transmission line with control circuits that shall adjust the net loss on the line in accordance with the strength of received control currents and that shall prevent adjustment of the net loss on the line according to the strength of the last part of a pulse of control current.

Another object of the invention is to provide a signal station on a transmission line with control circuits that shall adjust the net loss on the line only when a pulse of control current free from currents of other frequencies is received and that shall insure against adjustment of the net loss on the line near the end of a pulse of control current.

A further object of the invention is to provide a signal station on a transmission line with control circuits for adjusting the net loss on the line when a pulse of control current free from currents of other frequencies is received that shall stop the adjustment of the net loss on the line when a mutilated pulse of control current is received and that shall insure against adjustment of the net loss on the line near the end of a pulse of control current.

In long transmission lines it is necessary to adjust the gain at various repeater stations to correct for variations in the line attenuation. Variations in the line attenuation are chiefly caused by temperature change. Pilot wire regulators of the type disclosed in the patent to J. A. Coy et al., No. 2,017,654, October 15, 1935, may be employed to control the gain at the repeater stations. There is a small error in the operation of each of the pilot wire regulators and when the regulators operate in the same direction the errors add together. In a very long transmission line the added errors of the regulators may be appreciable.

In accordance with the present invention means are provided for correcting for the variations in attenuation on a long transmission line at intermediate and terminal stations. Net loss adjusting means preferably in the form of a

motor operated potentiometer is provided at terminal and intermediate stations. The potentiometer is operated in accordance with the strength of a received control current at the stations. The control current is transmitted over the line at intervals for fixed lengths of time and preferably has a frequency within the voice frequency range. The apparatus employed to illustrate the invention is disclosed in the application of L. G. Abraham and A. F. Grenell, Serial No. 21,802, filed May 16, 1935. The measuring circuit is described in detail and claimed in the application of A. M. Curtis, Serial No. 21,835, filed May 16, 1935.

A control current which is received at a station is supplied to a measuring circuit for governing the operation of a motor operated potentiometer in accordance with the strength of the received control current. The measuring circuit in the disclosed station comprises an amplifier of the space discharge type having the output circuit thereof coupled by a transformer to a so-called impulse transformer which serves to effect a more than proportional change in the variations of the strength of the received control current. The secondary winding of the impulse transformer is connected to the input circuit of a second space discharge amplifier and the output circuit of the second amplifier is coupled by a transformer to a second impulse transformer. The secondary winding of the second impulse transformer is connected to the input circuit of a detector tube. The output circuit from the detector tube controls the operation of two marginal relays.

Each of the two impulse transformers has two windings and a high permeability core of restricted cross-section. The cores of the transformers preferably comprise thin ribbons of molybdenum permalloy wound in a box of ceramic insulating material. The primary and secondary windings of the impulse transformers each have windings of the order of 1600 turns. The core of each impulse transformer is magnetized normally to substantially saturation by current supplied from the plate battery for the two space discharge amplifiers. The magnetizing circuit for each of the two transformers is preferably connected to the primary windings in series with a regulating impedance for compensating for variations not only in the source of plate current but also for variations in the source employed to heat the filaments of the two space discharge amplifiers.

The strength of the signals on the line at the

station is controlled by a potentiometer which is operated at times by means of a constantly rotating motor. Two magnetically operated clutches respectively under the control of a raise gain relay and a lower gain relay are provided for effecting operation in either direction of the potentiometer by the constantly rotating motor. The gain relays are in the form of marginal relays and are controlled by the measuring circuit in accordance with the strength of the received control current. If both the gain relays are released a circuit is partially completed for operating one magnetic clutch to reduce the net loss on the line. If only one of the gain relays is operated, no operation of the potentiometer will take place. If both the gain relays are operated, a circuit is partially completed for energizing the other magnetic clutch to effect operation of the potentiometer to raise the net loss on the line.

The control current, which is received at the station, also operates a starting circuit which controls a master relay. The starting circuit comprises a space discharge amplifier having a resonant circuit and an anti-resonant circuit series connected to the amplifier tube. The resonant circuit and the anti-resonant circuit are tuned to the frequency of the control current which is employed for controlling the line equivalent. The primary winding of a transformer is shunted around the anti-resonant circuit and the primary winding of a second transformer is shunted around the resonant circuit. Rectifier means are connected to the secondary windings of each of these transformers. The master relay is connected oppositely to the rectifiers in the secondary winding circuits of the two transformers so that in case currents of the frequency of the control current in combination with currents of other frequencies are transmitted over the line, no operation of the master relay will take place. If a pure control current is received over the line free from currents of other frequencies, the master relay will be operated. The master relay is in the form of a polarized relay so that if no current of the frequency of the control current is received over the line and currents of other frequencies are received, no operation of the master relay will take place.

The master relay when operated breaks a holding circuit for a control relay in a so-called clipping circuit. The control relay when released by operation of the master relay completes a circuit for energizing the coil of a slow-to-operate relay. The master relay completes a circuit through the armature of the slow-to-operate relay and the contacts of the gain relays for operating one or other of the magnetic clutches to raise or lower the line attenuation. This operation, of course, takes place only in case both the gain relays are released or both the gain relays are operated. The pulse of control current which is received over the line for controlling the motor operated potentiometer has a length of the order of .5 of a second or .7 of a second. If a mutilated pulse is received, it is apparent the master relay releases to prevent operation of the motor operated potentiometer.

The slow-to-operate relay in the pulse clipping circuit serves to open the circuit through the contacts of the master relay and the gain relays prior to the termination of a pulse of control current in order to prevent adjustment of the net loss on the line in accordance with the

energy level of the control current near the end of a pulse. The end of a pulse of control current will in many cases be tailed out because of the delay distortion of the line which causes different frequencies in the start or end of an impulse to be received at different times and if the adjustment were made on this tailing current, the adjustment would often be such as to obtain too much gain.

The single figure in the accompanying drawing is a diagrammatic view of a signal station having control circuits constructed in accordance with the invention.

Referring to the drawing a signal station is shown connected to a transmission line having input conductors 1 and 2 and output conductors 3 and 4. A starting circuit 5 is connected to the input conductors 1 and 2 by means of a hybrid coil 6. The hybrid coil 6 is provided with the usual network 7. The starting circuit controls a master relay MA according to the frequency of the currents on the transmission line and effects operation of the master relay only when a pure control current of a fixed frequency is received. In the system under consideration the master relay MA is operated when a pure control current of 800 cycles is received. The master relay MA controls a circuit partially completed by marginal polarized relays LO and RA for controlling the operation of clutch magnets 9 and 10. The clutch magnets 9 and 10 form a part of a clutch mechanism 11 which controls the operation of a potentiometer arm 12 for a potentiometer 13.

A repeater circuit 14 is provided between the incoming conductors 1 and 2 and the outgoing conductors 3 and 4 of the transmission line. The repeater circuit comprises a transformer 15 having the primary winding thereof connected by the potentiometer 13 to the hybrid coil 6. The secondary winding of transformer 15 is connected to the input circuit of a space discharge device 16. The output circuit of the device 16 is connected by transformer 17 through a resistance network comprising a potentiometer 18 to a measuring circuit 19. The repeater circuit 14 is preferably designed to produce a zero equivalent between the incoming conductors 1 and 2 and the outgoing conductors 3 and 4 when the arm 12 of the potentiometer 13 is set at a mid-point. An adjustable resistance 20 is provided in the circuit of the potentiometer arm 12 for effecting an adjustment of the potentiometer. A battery 21 is provided for supplying plate potential through a choke coil 22 to the device 16. Filament heating current is supplied to the device 16 from the battery 23. Grid bias for the tube 16 is provided by the drop across a portion of the resistance element 24. The output conductors of the transmission line are connected across the secondary winding of the transformer 17 which is connected to the output circuit of the space discharge device 16.

The measuring circuit 19 comprises two pentode space discharge devices 25 and 26, a detector tube 27 and two impulse coils 28 and 29. The measuring circuit 19 serves to control the operation of the marginal relays LO and RA according to the peak values of a control current on the transmission line. The lower gain relay LO and the raise gain relay RA are both released in order for changing the setting of the potentiometer 13 to raise the gain on the line and are both operated to effect operation of the potentiometer 13 to lower the gain on the trans-

mission line. The relays LO and RA are so adjusted that the net loss on the transmission line is held within a predetermined range. If the peak values of the control current go above the predetermined values, the relays LO and RA are both operated to lower the gain and if the peak values of the control current on the transmission line fall below the fixed range, both relays LO and RA are released to control the potentiometer 13 to raise the gain. If either relay LO or RA is operated alone, no change in the potentiometer setting takes place. 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.

A transformer 30 connects the potentiometer 18 to the input circuit of the pentode tube 25. The output circuit of the pentode tube 25 is connected by a transformer 31 to the first impulse coil 28. The impulse coil 28 comprises a primary winding 32 and a secondary winding 33. The two windings 32 and 33 are mounted on a core member secured in a box of ceramic insulating material as described in the above-mentioned application of A. M. Curtis, Serial No. 21,835, filed May 16, 1935.

The secondary winding 33 of the impulse coil 28 is connected to the input circuit of the pentode space discharge device 26. The output circuit of the device 26 is connected by transformer 36 to the primary winding 37 of the second impulse coil 29. The secondary winding 38 of the impulse coil 29 is connected to the input circuit of the detector tube 27. The output circuit of the detector tube 27 is connected to the operating coils of the marginal polarized relays LO and RA. Filament heating current for the pentode amplifier devices 25 and 26, detector tube 27 and a regulator space discharge device 39 is supplied by battery 40. Plate potential for the amplifier devices 25 and 26, the detector 27 and the regulator device 39 is provided by a battery 41. The regulator space discharge device 39 serves to compensate the measuring operation for variations in voltage of the batteries 40 and 41. Grid bias is also supplied by the battery 40 to the amplifier devices 25 and 26 and the regulator device 39. A battery 42 is provided for supplying grid bias through a choke coil 43 to the grid of the detector tube 27. The condensers 44 in the drawing serve as blocking condensers. Choke coils 45 and 46 are provided in the connections from the battery 41 to the plates of the devices 25 and 26.

The primary windings 32 and 37 of the impulse coils 28 and 29 are energized by circuits from the battery 41. The circuit through the primary winding 32 of the impulse coil 28 extends from ground through the primary winding 32, inductance coil 47, resistance 48 and battery 41 to ground return. The circuit through the primary winding 37 of the impulse coil 29 extends from ground through the winding 37, inductance coil 49, resistance element 50 and battery 41 to ground return. The core of each of the impulse coils is energized by current of about 15 milliamperes from the battery 41. This biasing current through the primary windings of the impulse coils reduces the differential permeability to a very low value. The direct coupling between the primary and secondary windings of each impulse coil is negligible so that each impulse coil is ineffective as a transformer

except when the alternating current supplied to the primary windings produces a flux which opposes and is very nearly equal to the flux produced by the biasing current from the battery 41. The output circuit from the detector tube 27 through the coils of the relays LO and RA may be traced from the plate of the detector tube 27 through the coil of the relay LO, coil of the relay RA, choke coil 46, battery 41 and ground return to the filament of the detector tube 27.

The regulator space discharge device 39 which is supplied with grid bias from the battery 40 and plate potential from the battery 41 serves to compensate for variations in the operation of the amplifier devices 25, 26 caused by variations in the voltages of the batteries 40 and 41. If the voltage of the battery 40 increases, it will be noted that the bias on the grid of the regulator device 39 increases and this decreases the biasing current which is supplied to the primary winding 32 of the impulse coil 28. Such is the fact because the regulator tube 39 is connected across the inductance 47 and the resistance 48 in the biasing circuit for the winding 32 of the impulse coil 28. The decrease in the bias on the impulse coil 28 serves to compensate for the variations in the grid bias on the devices 25 and 26 caused by the increase of the voltage of the battery 40. If there is a change in the voltage of the batteries 41, for example, an increase in the voltage, then there is an increase in the current flow through the regulator device 39 and an increase in the bias supplied to the impulse coil 28. At the same time, however, the plate potential supplied to the amplifier devices 25 and 26 increases. The increase in the bias on the impulse coil 28, compensates for the increase of plate potential on the amplifier devices 25 and 26.

The starting circuit 5 which controls the master relay MA comprises an amplifier space discharge device 51 which is connected to the hybrid coil 6 by means of a transformer 52. A circuit 53 anti-resonant to the 800 cycle control current and a circuit 54 resonant to the 800 cycle control current is provided in the output circuit of the amplifier device 51. The anti-resonant circuit 53 comprises an inductance coil 55 and a capacity element 56. The resonant circuit comprises an inductance coil 57 and a capacity element 58. A transformer 59 having a primary winding 60 and a divided secondary winding 61 has the primary winding 60 connected in shunt to the anti-resonant circuit 53. A transformer 62 having a primary winding 63 and a divided secondary winding 64 has the primary winding thereof connected in shunt to the resonant circuit 54. The divided secondary winding 61 of the transformer 59 is connected to rectifiers 65 preferably of the copper oxide type in circuit with a resistance 66. The divided secondary winding 64 of the transformer 62 is connected to rectifiers 67 in circuit with a resistance 68. The rectifiers 67 are also preferably of the copper oxide type. The winding of the master relay MA is connected in circuit with the resistance element 66 and a portion of the resistance element 68. The operating coil of the master relay is so connected to the resistance elements 66 and 68 that the potential drops across the resistance elements oppose each other. Plate potential for the device 51 is supplied by the battery 21 and filament heating current is supplied by the battery 23. Condensers 69 serve as blocking condensers.

If a pure control current of 800 cycles is re-

ceived over the transmission line, the current in the output circuit of the device 51 will tend to flow through the primary winding 60 of the transformer 53 rather than through the anti-resonant circuit 53 and, on the other hand, will tend to flow through the resonant circuit 54 rather than through the primary winding of the transformer 62. Consequently, there will be considerable potential drop across the resistance element 56 and little potential drop across the resistance element 68. Under such conditions, the polarized relay MA is operated. If currents of other frequencies than the 800 cycle control circuit either with or without the 800 cycle control current are received, then somewhat of the current of the output circuit of the device 51 will flow through the primary winding 63 of the transformer 62. The energization of the transformer 62 serves to place potential drop across the resistance element 68. This assists the bias on the polarized relay MA and prevents operation of the relay. The starting circuit 5 causes a sufficient delay in the adjustment of the potentiometer 13 to insure against adjustment of the line attenuation according to the first part of a received pulse of control currents.

Assuming a control current of 800 cycles is received over the transmission line and that the peak values of the control current are above the upper limit of the fixed range, the apparatus shown on the drawing is operated to reduce the gain and increase the net loss at this station. The master relay MA is operated by the starting circuit 5 for completing a circuit to energize the clutch magnet 10 from a battery 73. The circuit for operating the clutch magnet 10 may be traced from ground through the armature of the master relay MA, armature of the slow-to-operate relay 86, armature of the relay RA, clutch magnet 10, limit switch 72, armature of the relay LO and battery 73 to ground. The master relay MA when operated breaks a holding circuit for the relay 85 through the battery 70. The relay 85, when released, completes a circuit from the battery 70 for operating the slow-to-operate relay 86. The armature of the slow-to-operate relay 86 is included in the circuit completed by the master relay MA for operating one of the clutch magnets. The relay 86 is so adjusted that the circuit completed by the master relay MA is opened just prior to the end of a pulse of control current. This operation by the relay 86 serves to prevent adjustment of the net loss on the line according to the strength of a pulse of control current near the end thereof.

It has been assumed above that the peak values of the control current received at the station are above the upper limit of the fixed range. Accordingly, the measuring circuit 19 will supply current for operating both the relays LO and RA. If both the relays LO and RA were released as would be the case when the peak values of the control current fall below the lower limit of the fixed range, then the circuit completed by the master relay MA would extend from ground through the armature of the relay MA, armature of the relay 86, armature of the relay RA, clutch magnet 9, limit switch 75 and armature of the relay LO and battery 73 to ground.

The clutch magnet 9 and slip rings 74 are connected to a beveled gear 76 and are rotatably mounted on a shaft 77. A disc 80 which is fixedly mounted on the shaft 77 is attracted by the clutch magnet 9 when energized for connecting the clutch magnet and the beveled gear wheel

76 to the shaft 77. The clutch magnet 10 and the slip rings 71 are connected to a beveled gear wheel 79 and are rotatably supported on the shaft 77. A disc 80 which is fixedly mounted on the shaft 77 serves to connect the gear wheel 79 and the clutch magnet 10 to the shaft 77 when the clutch magnet is energized. The gear wheels 76 and 79 are connected to a constantly rotating motor 81 by means of a beveled gear wheel 82. The operating arm 12 of the potentiometer is connected to the shaft 77 in order to adjust the potentiometer 13 in accordance with the rotation of the shaft 77. An arm 83 is also mounted on the shaft 77 for operating the limit switches 75 and 72 whenever the potentiometer reaches either of its extreme limits. When the switch 75 or the switch 72 is operated by the arm 83, an alarm 84 is operated. If the arm 12 of the potentiometer 13 is moved to its extreme position towards the right, as viewed in the drawing, to lower the gain, the arm 83 will engage and open the limit switch 72 to release the clutch magnet 10. When the arm 83 opens the switch 72, a circuit is completed from the battery 73 for operating a relay 93. The circuit for operating the relay 93 extends from grounded battery 73 through the armature of the relay LO, switch 72, contact member 91, relay 93, lamp 97 and ground return to the battery 73. Upon operation of the relay 93, a circuit is completed from the battery 96 for operating an alarm 84. If the arm 12 of the potentiometer 13 is moved to its extreme position towards the left, as viewed in the drawing, to raise the gain, the arm 83 will engage and open the limit switch 75 to release the clutch magnet 9. When the arm 83 opens the switch 75, a circuit is completed from the battery 73 for operating a relay 92. The circuit for operating the relay 92 extends from the battery 73, through the armature of relay LO, switch 75, contact member 90, relay 92, lamp 98 and ground return to the battery 73. Upon operation of the relay 92, a circuit is completed from the battery 96 for operating the alarm 84.

The pulses of control current which are employed for operating the potentiometer 13 are each transmitted for fixed periods of time. As before set forth, it is undesirable to have the potentiometer 13 adjusted according to the strength of a pulse of control current near the end thereof. The end of a pulse of control current will, in many cases, be tailed out because of the delay distortion on the line. The slow-to-act relay 86 insures that no adjustment of the potentiometer 13 will take place at or near the end of a pulse of control current. If a mutilated pulse of control current is received, the master relay is released to stop any setting of the potentiometer.

Modifications in the control circuits 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 transmission line having pulses of control current transmitted thereover, means for adjusting the net loss on said line according to the strength of said pulses of control current, and means for insuring against adjustment of the net loss on the line according to the last portion of a pulse of control current.
2. In combination, a transmission line having pulses of control current transmitted thereover, a signal station connected to said line, loss con-

trolling means for adjusting the attenuation of the line at the station, means for operating said loss controlling means according to the strength of the pulses of control current, and means for insuring against operation of said loss controlling means according to the last portion of a pulse of control current.

3. In combination, a transmission line having pulses of control current of predetermined lengths transmitted thereover, a signal station connected to said line, loss controlling means for adjusting the attenuation of the line at the station, means for operating said loss controlling means according to the strength of a received pulse of control current, and means for insuring adjustment of said loss controlling means during the middle portion only of a received pulse of control current.

4. In combination, a transmission line having pulses of control current transmitted thereover at intervals, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, means initiated and controlled by a received pulse of control current for operating said loss controlling means according to the strength of the pulse of control current, and means for insuring against adjustment of said loss controlling means during the receiving of the last part of a pulse of control current.

5. In combination, a transmission line having pulses of control current of different lengths transmitted thereover at intervals, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, means at said station controlled by a received pulse of control current for operating said loss controlling means according to the strength of the pulse of control current, and means for insuring against operation of said loss controlling means during the receiving of the last part of a pulse of control current.

6. In combination, a transmission line having pulses of control current of predetermined lengths transmitted thereover, a signal station connected to said line, loss controlling means for adjusting the attenuation of said line at the station, means comprising a measuring circuit for effecting a more than proportional change in variations of a received pulse of control current for controlling the adjustment of said loss controlling means according to the strength of the pulse of control current, control means operated upon receipt of a pulse for operating said loss controlling means under control of said measuring circuit means, and means for insuring adjusting said loss controlling means only during the time the middle portion of the pulse of control current is being received and for preventing adjustment of said loss controlling means during the receiving of the last part of a pulse of control current.

7. In combination, a transmission line having pulses of control current transmitted thereover, a signal station connected to said line, loss controlling means for adjusting the attenuation of said line at the station, means comprising a measuring circuit for effecting a more than proportional change in variations of a received pulse of control current for governing the adjustment of said loss controlling means according to the strength of the pulse of control current, control means operated upon receipt of a pulse of control current for operating said loss controlling means under control of said measuring cir-

cuit means, and means for insuring against adjustment of said loss controlling means according to the last portion of a pulse of control current.

8. In combination, a transmission line having pulses of control current transmitted thereover, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, means initiated and controlled by a received pulse of control current for adjusting said loss controlling means according to the strength of the control current, and means comprising a slow operating relay operated upon receipt of a pulse of control current and prior to the end of the pulse of control current for insuring against adjustment of said loss controlling means in accordance with the strength of the last part of a pulse of control current.

9. In combination, a transmission line having pulses of control current transmitted thereover, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, auxiliary means for operating said loss controlling means according to the strength of a received pulse of control current, and means comprising a slow acting relay for controlling said auxiliary means to insure against adjustment of the loss controlling means according to the last part of a pulse of control current.

10. In combination, a transmission line having pulses of control current transmitted thereover, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, means comprising a measuring circuit for effecting a more than proportional change in variations of strength of a received pulse of control current, marginal relays controlled by said measuring circuit for preparing an operating circuit to operate said loss controlling means, means comprising a relay operated upon receipt of a pulse of control current for completing said operating circuit to operate the loss controlling means according to the strength of a pulse of control current, and means for opening said operating circuit before the end of a pulse of control current to insure against adjustment of the net loss on the line according to the strength of the last part of a pulse of control current.

11. In combination, a transmission line having pulses of control current transmitted thereover, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, means comprising a measuring circuit for effecting a more than proportional change in variations of a received pulse of control current for controlling the adjustment of said loss controlling means according to the strength of the control current, relay means operated upon receipt of a pulse of control current for operating said loss controlling means under control of said measuring circuit means, and means comprising a slow operating relay governed by said relay means upon receipt of a pulse of control current for insuring against adjustment of said loss controlling means in accordance with the energy level of the last part of a pulse of control current.

12. In combination, a transmission line having a pulse of control current transmitted thereover at intervals, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, marginal relays for governing the operation of said

loss controlling means, means comprising a measuring circuit for effecting a more than proportional change in variations of a received control current to selectively operate said marginal
5 relays, a control circuit governed by said marginal relays for adjusting said loss controlling means, and means comprising the armature of a slow operating relay for completing said control
10 circuit to adjust said loss controlling means under control of the marginal relays, said slow operating relay being timed to operate and open the control circuit prior to the termination of the received pulse of control current.

13. In combination, a transmission line having
15 pulses of control current transmitted thereover, a signal station connected to said line, loss controlling means at said station for adjusting the attenuation of the line, means for operating

said loss controlling means according to the strength of the pulses of control current, and means comprising a starting circuit for permitting operation of said loss controlling means only
5 when a pure control current free from other frequency currents is received over the line and for effecting a delay to insure against operation of said loss controlling means according to the first part of a pulse of control current.

14. In combination, a transmission line having
10 pulses of control current transmitted thereover, means for adjusting the net loss on said line according to the strength of said pulses of control current, and means for insuring against
15 adjustment of the net loss on the line according to the first and the last portions of a pulse of control current.

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