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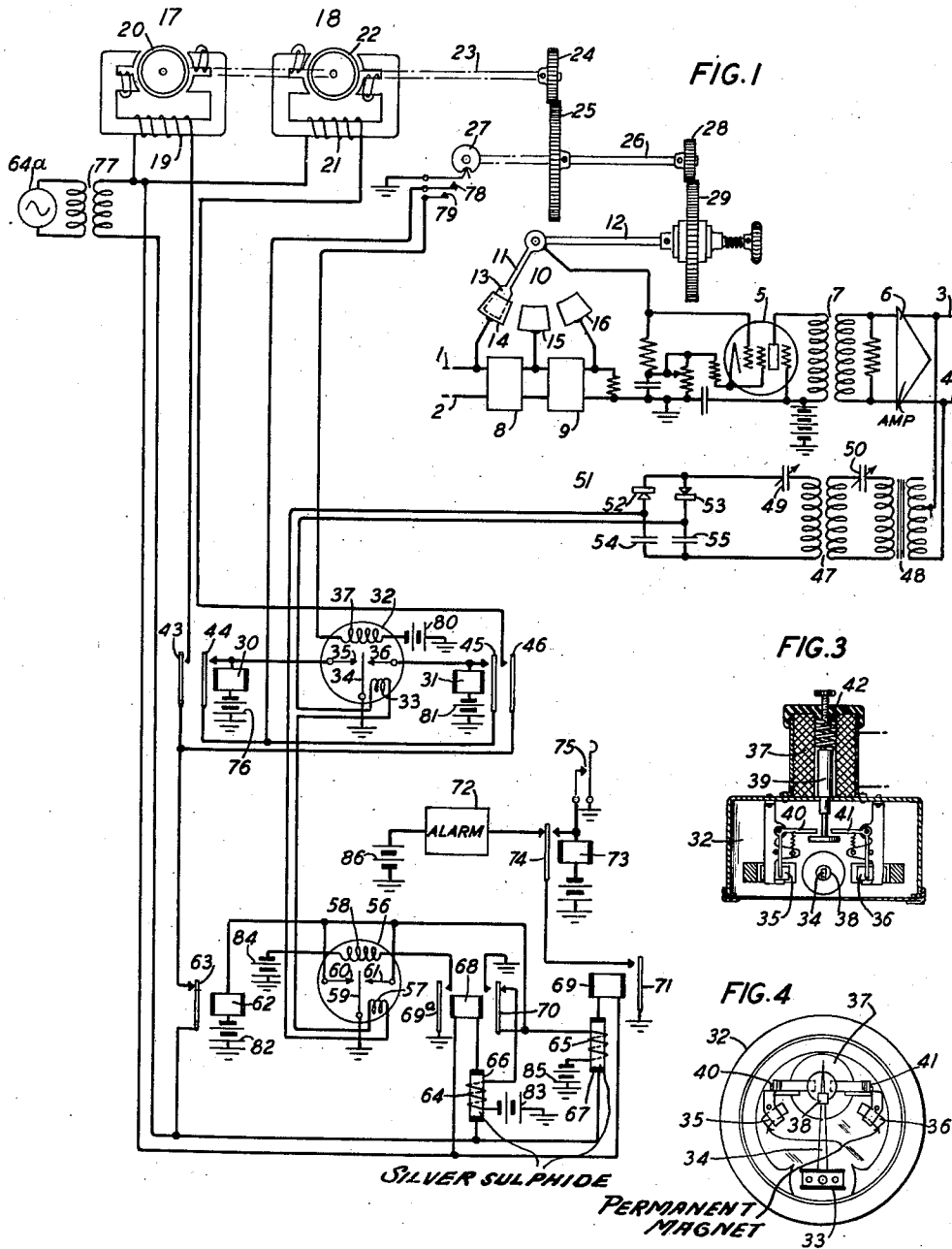
D. M. TERRY

2,084,115

CONTROL CIRCUITS

Filed April 23, 1936

2 Sheets-Sheet 1



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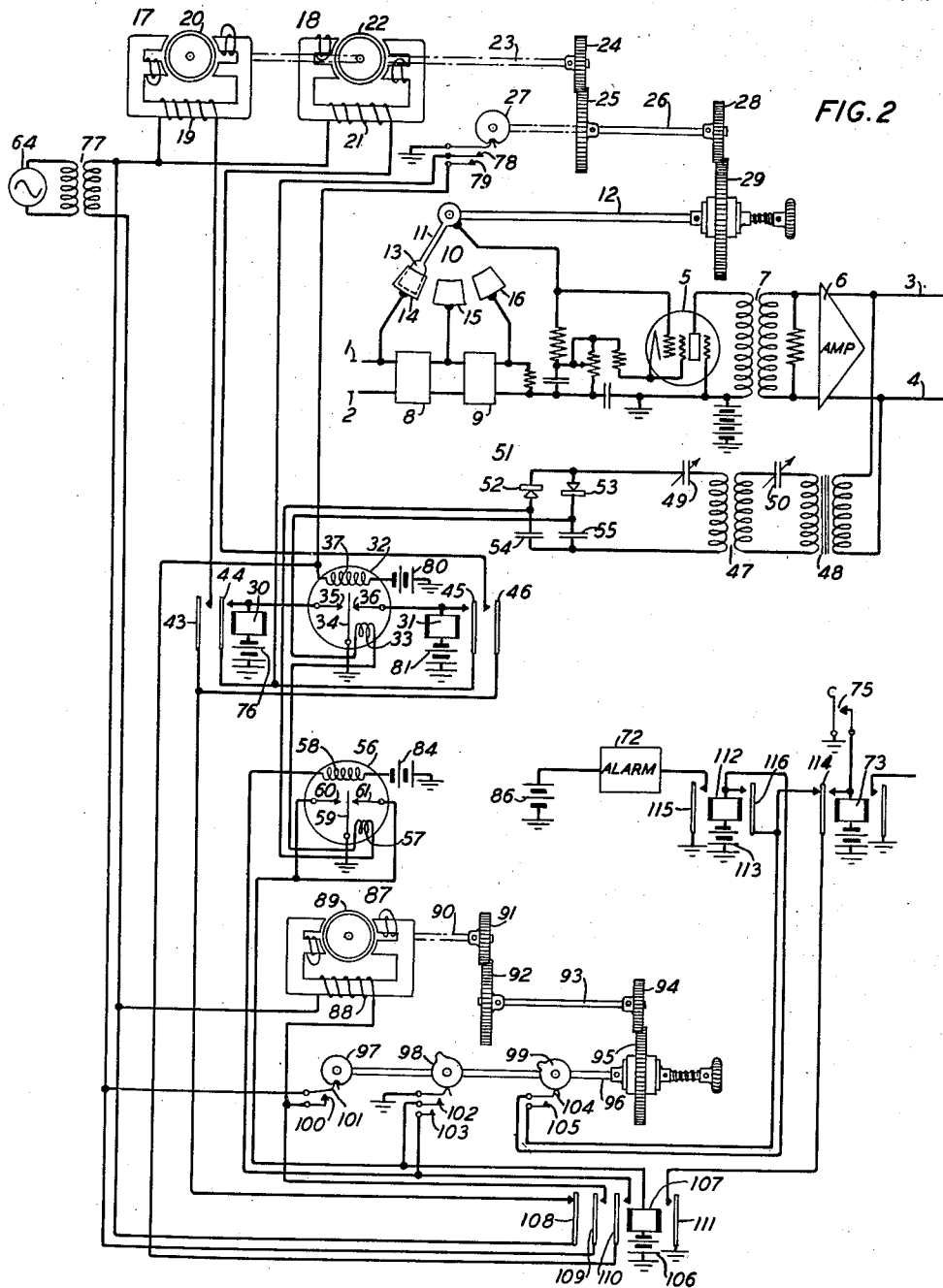
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CONTROL CIRCUITS

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Application April 23, 1936, Serial No. 76,021

14 Claims. (Cl. 178—44)

This invention relates to gain control circuits for carrier signal systems and particularly to protective circuits for gain control circuits.

One object of the invention is to provide a gain control circuit for a signal transmission line with protective circuits that shall prevent operation of the gain control circuit in case the voltage of the signals on the line varies beyond predetermined limits.

Another object of the invention is to provide gain control circuits for a signal transmission line with protective circuits for preventing operation of the gain control circuits in case the signals on the transmission line vary beyond predetermined limits and for operating an alarm in case the signals on the transmission line vary beyond predetermined limits for an extended period of time.

A further object of the invention is to provide gain control circuits for a carrier current transmission system with protective circuits controlled by a pilot current for preventing operation of the gain control circuits in case the pilot current on the transmission system varies beyond predetermined limits and for operating an alarm in case the pilot current on the transmission system varies beyond predetermined limits for an extended period of time.

In a carrier current signal system transmitting signals in one direction by means of carrier current within one frequency band and for transmitting signals in an opposite direction by carrier currents located within another frequency band, the energy level of the signal waves in each frequency band is controlled by a pilot current having a frequency located within the frequency band. The transmission line particularly if an open wire transmission line is subjected to various conditions which cause variations in the line attenuation. In wet weather the attenuation of an open wire line is greatly increased. In order to maintain the quality of the transmission it is necessary to vary the gain of the signals on the line according to the variation in attenuation. A transmission line may under trouble conditions be subjected to abnormally large changes in attenuation for which no ordinary gain correction would be in order and it may also be subjected to so-called "hits" which are momentary changes in attenuation.

According to the present invention a carrier telephone transmission system having gain control circuits of the type disclosed in the application of J. W. Beyer and D. M. Terry, Serial No. 76,020, filed April 23, 1936, is provided with pro-

TECTIVE CIRCUITS TO PREVENT OPERATION OF THE GAIN CONTROL CIRCUITS IN CASE THE STRENGTH OF THE SIGNALS VARIES BEYOND PREDETERMINED LIMITS. IF THE STRENGTH OF THE SIGNALS VARIES BEYOND PREDETERMINED LIMITS FOR AN EXTENDED PERIOD OF TIME AN ALARM IS OPERATED.

In one form of the invention an amplifier in a signal transmission line has the input circuit thereof connected to attenuation networks in the line by means of a variable condenser. The variable condenser is operated to raise or lower the gain by means of two synchronous motors which are selectively operated by a very sensitive relay. The sensitive meter relay is controlled by a control circuit connected to the transmission line at a point beyond the amplifier therein. The feedback circuit comprises means for selecting a pilot current and means for effecting full voltage rectification of the pilot current.

The sensitive relay is provided with the two small permanent magnets for holding the contact arm of the relay in either of its operated positions after operation. Releasing means controlled by the synchronous motors is provided for returning the contact arm of the sensitive meter relay to initial or neutral position.

The feedback circuit which controls the sensitive relay governing the gain on the transmission line also controls a relay of limited sensitivity. The second relay will only be operated in case the variation in the strength of the signals and the pilot current on the transmission line is abnormal or beyond that which can be corrected under control of the first relay. Upon operation of the second relay in case of a large change in strength of the pilot current on the transmission line, means is provided for breaking the circuit of the two synchronous motors so that no control of the gain amplifier can be effected by the highly sensitive meter relay. The relay of limited sensitivity also controls means for operating an alarm in case the variation in strength of the pilot current continues for an extended period of time.

In the accompanying drawings,

Fig. 1 is a diagrammatic view of control circuits constructed in accordance with the invention;

Fig. 2 is a diagrammatic view of a modification of the control circuits shown in Fig. 1; and
Figs. 3 and 4 are diagrammatic views of the sensitive relays shown in Figs. 1 and 2 of the drawings.

Referring to Fig. 1 of the drawings a transmis-

sion line comprising input conductors 1 and 2 and output conductors 3 and 4 is provided with a gain control amplifier 5 which is connected to a second amplifier 6 by means of a transformer 7. The transmission line shown in Fig. 1 of the drawings may represent one channel of a repeater station as shown in the application of R. W. Chesnut, Serial No. 5,696, filed February 9, 1935 now, Patent No. 2,049,195, issued July 28, 1936. Two attenuation networks 8 and 9 which may be of the type disclosed in the patent to R. W. Chesnut et al. 1,880,800, dated October 4, 1932 are provided in the transmission line for controlling the operation of the gain control amplifier 5 in accordance with the operation of an adjustable condenser 10. The condenser 10 comprises a rotatable arm 11 mounted on a shaft 12. The shaft 12 carries a plate 13. The condenser plate 13 is movable adjacent to condenser plates 14, 15 and 16. The condenser plate 14 is connected to the line conductor 1 on one side of the network 8. The condenser plate 15 is connected to the conductor 1 between the networks 8 and 9. The condenser plate 16 is connected to the line conductor 1 beyond the network 9. A condenser arrangement of this type is disclosed and claimed in the application of C. R. Eckberg, Serial No. 5,717, filed February 9, 1935.

The variable condenser 10 is operated by a synchronous motor 17 to raise the gain of the amplifier 5 and is operated by a synchronous motor 18 to lower the gain of the amplifier 5. The synchronous motor 17 comprises a stator winding 19 and a rotor 20. The synchronous motor 18 comprises the stator winding 21 and rotor 22. The rotors 20 and 22 of the motors 17 and 18 are mounted on a shaft 23 carrying a pinion 24. The pinion 24 meshes with a gear wheel 25 mounted on a shaft 26. The shaft 26 not only carries the gear wheel 25, but a cam member 27 and a pinion 28. The pinion 28 meshes with a gear wheel 29 on the shaft 12 carrying the contact arm 11 of the variable condenser 10.

The two synchronous motors 17 and 18 which rotate in opposite directions are selectively operated by two relays 30 and 31 under control of a sensitive relay 32. The sensitive relay 32, which is shown in detail in Figs. 3 and 4, comprises an operating coil 33, a contact arm 34 which is adapted to be moved into engagement with contact members 35 and 36 and a restoring coil 37. The contact members 35 and 36 are in the form of small permanent magnets which engage and hold a small soft iron armature 38 on the contact arm 34 whenever the contact arm is moved to either of its operated positions. In order to restore the contact arm 34 to initial or neutral position the restoring coil 37 is energized to attract a core armature 39. The core armature 39 effects operation of two bell crank levers 40 and 41. One or the other of the bell crank levers 40 and 41 engages the contact arm 34 and moves it to neutral position. An adjustable stop 42 is provided for limiting the movement of the core armature 39.

The relay 30 is provided with switch members 43 and 44 and relay 31 is provided with switch members 45 and 46. The sensitive relay 32 is operated by means of a feedback circuit connected to the conductors 3 and 4 beyond the amplifier 6. The feedback circuit comprises two transformers 47 and 48 which are tuned by means of condensers 49 and 50 to select the pilot or control current on the transmission line and

a full voltage rectifier bridge 51. The rectifier bridge 51 comprises the rectifiers 52 and 53 forming two arms of the bridge circuit and condensers 54 and 55 forming the other two arms of the bridge circuit. The output vertices of the bridge 51 are connected to the operating coil 33 of the sensitive relay 32 and the input vertices of the bridge are connected by the transformers 47 and 48 to the transmission line. The two rectifiers 52 and 53, which are preferably of the copper-oxide type, are oppositely connected so as to effect rectification of each half of the pilot current voltage. The sensitive relay 32 may be adjusted to effect operation of the contact arm 34 by a half a decibel change in the strength of the pilot current.

The feedback circuit also controls the operation of a relay 56 of lower sensitivity. The relay 56 which comprises an energizing coil 57, a restoring coil 58 and a contact arm 59 adapted to engage contact members 60 and 61 is similar in construction to the sensitive relay 32. However, the sensitivity of the relay 56 is much lower when compared with the relay 32. If the relay 32 is set to be operated by a plus or minus one half a decibel change in the pilot current on the line, the relay 56 will be set to operate, for example, at minus five decibels or plus three decibel change of the pilot current.

The relay 56 of lower sensitivity directly controls the operation of a relay 62. The relay 62 by means of a switch arm 63 prevents energization of either synchronous motors 17 and 18 from a source of alternating current 64a under control of the sensitive relay 32. The relay 56 also controls two heating coils 64 and 65 which, in turn, control the heating of two silver sulphide elements 66 and 67. The silver sulphide element 66 is in the energizing circuit of a relay 68 and the silver sulphide element 67 is in the energizing circuit of a relay 69. The relay 68 is provided with switch arms 69a and 70 and the relay 69 is provided with a switch arm 71. The relay 69 when operated controls an alarm 72. The alarm 72 is released by means of a relay 73 having a contact arm 74 under control of a key 75.

If the strength of the pilot current on the conductors 3 and 4 is lowered a half decibel, the strength of the rectified current supplied to the winding 33 of the sensitive relay 32 is reduced to effect engagement between the contact member 35 and the contact arm 34. A circuit is then completed from a battery 76 for operating the relay 30. The switch arm 43 when operated by the relay 30 completes a circuit from the source of alternating current 64a for energizing the stator winding 19 of the synchronous motor 17. The circuit completed by the switch arm 43 may be traced from one terminal of the secondary winding of a transformer 77 through the switch arm 63 of a relay 62, switch arm 43 of relay 30 and winding 19 to the other terminal of the secondary winding. The synchronous motor 17 is operated to effect movement of the arm 11 carrying the condenser plate 13 towards the left as viewed in Fig. 1 of the drawings. This movement of the condenser plate 13 serves to raise the gain of the amplifier 5. Immediately thereafter the cam member 27 is operated to place a ground on contact members 78 and 79. Grounding of the contact member 78 by operation of the cam member 27 serves to complete a holding circuit for the relay 30 from the battery 76 through the switch arm 44. Grounding of the contact member 79 serves to complete a circuit for energizing the

restoring coil 37 of the relay 32 from a battery 80. The synchronous motor 17 will continue in operation under control of the relay 30 until the cam member 27 has completed one rotation to open the holding circuit for the relay 30.

If the strength of the pilot current on the transmission line has not been raised to normal by the above operation the sensitive meter relay 32 is operated again and the above cycle of operations is repeated. If the strength of the pilot current goes more than a half decibel above normal value the sensitive relay 32 is operated by the feedback circuit to effect engagement between the contact arm 34 and the contact member 36. This operation of the sensitive relay 32 completes a circuit from battery 81 for operating the relay 31. The switch arm 46 of the relay 31 completes a circuit from the alternating current source 84a for energizing the winding 21 of the synchronous motor 18. The circuit for energizing the winding 21 of the motor includes the switch arm 63 of the relay 62. The synchronous motor 18 when operated effects movement of the condenser arm 11 in a direction towards the right as viewed in Fig. 1 of the drawings to lower the gain effect by the amplifier 5. Immediately thereafter the cam member 27 places a ground on the contact members 78 and 79. Placing a ground upon the contact members 78 completes a holding circuit for the relay 31 from the battery 81 through the switch arm 45. The placing of ground upon the contact member 79 completes a circuit from the battery 80 for operating the restoring coil 37 of the relay 32. The restoring coil 37 returns the contact arm to neutral position in the manner above described.

In case of a minus 5 decibel change from normal in the strength of the pilot current on a transmission line, the sensitive relay 32 will not only be operated, but the relay 56 of limited sensitivity will be operated. Upon operation of the relay 56 the contact arm 59 engages contact member 60 for completing a circuit from a battery 82 for operating the relay 62. The switch arm 63 operated by the relay 32 prevents any operation of the synchronous motors 17 and 18 by the sensitive relay 32. The engagement of the switch arm 59 with the contact member 60 also completes a circuit from a battery 83 for energizing the heating coil 64 which, in turn, controls the silver sulphide element 66. The silver sulphide element 66 when heated for a short period of time, for example, five seconds, completes an operating circuit from the source of alternating current 84a for operating the relay 68. The relay 68 operates the switch arm 69a for energizing the restoring coil 58 of the relay 56 from battery 84. The restoring coil 58 operates in the manner above described to return the contact arm 59 to initial or neutral position.

The contact arm 59 when in engagement with the contact member 60 also completes a circuit for energizing the heating coil 65 from a battery 85. The heating coil 65 controls the silver sulphide element 67 in the circuit of the relay 69. The silver sulphide element 67 does not complete the energizing circuit for the relay 69 until the element has been heated for a longer period of time than the element 66, for example, 25 seconds. The switch arm 70 also completes a circuit from the battery 85 for energizing the heating coil 65 when the relay 68 is operated. Thus, the heating coil 65 is energized either upon operation of the relay 56 or upon operation of the relay 68. If the disturbance on the transmission line

which effected operation of the relay 56 is a so-called "hit" and does not continue for an extended period of time, then the relay 62 is released upon release of the relay 56 and control of the gain on the transmission line is returned to the highly sensitive relay 32. However, if the large change in strength of the pilot current in the transmission line continues for an extended period of time, then relay 56 is repeatedly operated to finally heat the silver sulphide element 67 sufficiently to effect operation of the relay 69. Upon operation of the relay 69 a circuit is completed from a battery 86 for operating the alarm 72. The circuit for operating the alarm 72 extends from grounded battery 86 through the alarm 72, contact arm 74 of the relay 73 and contact arm 71 of the relay 69 to the battery 86. The alarm 72 is stopped when the key 75 is closed to operate the relay 73. The relay 73 upon operation breaks the alarm circuit by means of contact arm 74.

If the strength of the pilot current on the transmission line is raised at least three decibels above normal, the relay 56 of lower sensitivity is operated and the contact arm 59 engages the contact member 61. The operation of the relay 56 and the protective circuits controlled thereby is the same as that given heretofore when the contact arm 59 engaged the contact member 60 upon reduced level of the pilot current of the transmission line. In the above operation it will be noted that when a large change in the strength of the pilot line takes place in the transmission line, the protective circuits prevent any operation of the gain control circuits and that if this change in the pilot current continues for an extended period of time an alarm is sounded.

Referring to Fig. 2 of the drawings, a modification of the circuits shown in Fig. 1 is shown wherein the protective circuits have been changed somewhat. The gain control circuits shown in Fig. 2 of the drawings are exactly the same as the gain control circuits governed by the sensitive relay 32 shown in Fig. 1 of the drawings. Accordingly, similar parts have been indicated by like reference characters. Moreover, a detailed description of the gain control circuits shown in Fig. 2 will not be repeated.

The relay 56 of limited sensitivity shown in Fig. 2 of the drawings controls the operation of a synchronous motor 87 which is similar in construction to the synchronous motors 17 and 18. The synchronous motor 87 comprises a stator winding 88 and a rotor 89. The rotor 89 is mounted on a shaft 90 which carries a pinion 91. The pinion 91 meshes with a gear wheel 92 on a shaft 93. The shaft 93 also carries a pinion 94 which meshes with a gear wheel 95 on a shaft 96. The shaft 96 also carries cam members 97, 98 and 99. The cam member 97 controls two contact members 100 and 101 for closing a holding circuit for the synchronous motor 87. The cam member 98 approximately 20 seconds after the start of the operation of synchronous motor 87 places a ground upon contact members 102 and 103. The cam member 99 closes contact members 104 and 105 about 5 seconds after the grounding of the contact members 102 and 103 by the cam member 98.

In case a large variation in the strength of pilot current takes place on the transmission line, the relay 56 of limited sensitivity will be operated to cause the contact arm 59 to engage either the contact member 60 or the contact member 61. Upon engagement of the con-

tact arm with one of the contact members 69 and 61 a circuit is completed from battery 106 for operating a relay 107. A switch arm 108 operated by the relay 107 prevents any operation of the synchronous motors 17 and 18 which control the variation in gain effected by the amplifier 5. Switch arm 109 operated by the relay 107 completes a circuit from the alternating current source of power 64 for energizing the winding 88 of the synchronous motor 87. Switch arms 110 and 111 operated by the relay 107 form no useful function at this time. The synchronous motor 87 when operated effects rotation of the shaft 96 and the cam members 97, 98 and 99. The cam member 97 when operated closes the contact members 100 and 101 to complete a holding circuit for energizing the winding 88 of the motor 87 irrespective of the position of the relay 107. The holding circuit for the winding 88 of the motor 87 is held closed for one complete rotation of the shaft 96. Approximately 20 seconds after the starting of the synchronous motor 87 the cam member 98 places a ground on the contact member 103 for completing a circuit from the battery 89 to energize the restoring coil 37 of the relay 32 and for completing a circuit from the battery 84 through the restoring coil 58 of the relay 56. A ground is placed on the contact member 102 at this time to insure operation of the relay 107 from the battery 106. The cam member 99 approximately 5 seconds after the grounding of the contact members 102 and 103 closes the contact members 104 and 105 for completing a circuit to operate a relay 112 from battery 113 if the relay 107 is in operative position at this time. The circuit for operating the relay 112 may be traced from ground through switch arm 111 of the relay 107, switch arm 114 of relay 73, contact members 105 and 104, relay 112 and battery 113. A switch arm 115 operated by the relay 112 completes a holding circuit from the battery 86 for operating the alarm 72. A holding circuit for the relay 112 is completed by a switch arm 116. The holding circuit for the relay 112 may be traced from grounded battery 113 through relay 112, switch arm 116, switch arm 114, switch arm 111 and ground return to the battery 113. The relay 112 may be released and the alarm stopped by closing the key 75 which energizes the relay 73 for operating the switch arm 114 to break the energizing circuit of a relay 112.

In the protective circuits above described no operation of the synchronous motors 17 and 18 under control of the sensitive relay 32 can take place when the energy level of the pilot current on the transmission line varies sufficiently to effect operation of the relay 56. The relay 56 or the cam member 98 insures operation of the relay 107 to prevent any operation of the relays 17 and 18. If the large energy change in the pilot current continues for an extended length of time, the cam member 99 insures operation of the alarm 72.

Modifications in the 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 signal transmission line, an amplifier on said line, two relays of different sensitivity, means for operating said relays according to the strength of a pilot current on the line, means controlled by the relay of higher

sensitivity for controlling the gain of said amplifier to maintain the volume of the signals constant, and means controlled by the relay of lower sensitivity for preventing control of the amplifier by the relay of higher sensitivity when the strength of the pilot current varies beyond predetermined limits.

2. In combination, a signal transmission line, an amplifier space discharge device on said line, two relays of different sensitivity, means for operating said relays according to the energy level of a pilot current on the line beyond said amplifier, means controlled by the relay of higher sensitivity for governing the gain of said amplifier to maintain the volume of the signals constant, and means controlled by the relay of lower sensitivity for preventing control of the amplifier by the relay of higher sensitivity when the energy level of the pilot current varies beyond predetermined limits and for operating an alarm in case of large pilot current variations for an extended period of time.

3. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, two relays of different sensitivity, means for operating said relays according to the energy level of a pilot current on the line beyond said amplifier, means controlled by the relay of higher sensitivity for operating said potentiometer to control said amplifier, and means controlled by the relay of lower sensitivity for preventing operation of said potentiometer when the energy level of the pilot current varies beyond predetermined limits.

4. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, a motor for operating said potentiometer, two relays of different sensitivity, means for operating said relays according to the energy level of a pilot current on the line beyond said amplifier, means controlled by the relay of higher sensitivity for operating said motor to control said potentiometer, and means controlled by the relay of lower sensitivity for preventing operation of said motor when the energy level of the pilot current varies beyond predetermined limits.

5. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on said line, a relay of limited sensitivity, means for operating said relay in case of large variations in energy level of the pilot current and means controlled by said relay for preventing control of said amplifier according to the pilot current level changes and for operating an alarm in case of large variations in energy level of the pilot current for extended periods of time.

6. In combination, a signal transmission line, control means governed according to the energy level of a pilot current on the line for maintaining the volume of the signals on the line substantially constant, a relay of limited sensitivity, means for operating said relay in case of large variations in energy level of the pilot current, and means controlled by said relay in case of large variations in energy of said pilot current for preventing operation of said control means and for operating an alarm when the variation in energy of the pilot current continues for prolonged periods.

7. In combination, a signal transmission line, an amplifier on said line, means for controlling

the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity, and means operated by said relay in case of large variations in energy level of the pilot current for preventing control of said amplifier according to the pilot level changes.

8. In combination, a transmission line having a condenser potentiometer for controlling the gain of an amplifier, a motor for operating said potentiometer, two relays of different sensitivity, a control circuit connecting said relays to said line beyond the amplifier device and comprising a filter for selecting a pilot current and full voltage rectifier means for supplying rectified current to the relays, means controlled by the relay of higher sensitivity for operating said motor to control the energy level of the signal on the line, and means controlled by the relay of lower sensitivity for preventing operating of said motor and for operating an alarm in case the voltage of the pilot current rises above or falls below predetermined limits for extended periods of time.

9. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity having a contact arm held in operative position and restoring means, and means operated by said relay in case of large variations in energy level of the pilot current for preventing operation of said amplifier control means, for operating said relay restoring means to return the contact arm to initial position and for operating an alarm when the large variations of pilot current level extend for prolonged periods of time.

10. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity having a contact arm held in operative position when operated and restoring means, means operated by said relay in case of large variations in energy level of the pilot current for preventing operation of said amplifier control means, means controlled by and operated a predetermined interval after operation of the relay for operating said restoring means to return the contact arm to initial position, and means controlled by said relay for operating an alarm in case of large change in level by the pilot current for a prolonged period.

11. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity having a contact arm held in operative position when operated and restoring means, a motor operated by said relay in case of large variations in level of the pilot current, means operated by said relay for preventing operation of said amplifier control means, means operated by said motor after a predetermined delay for operating said relay restoring means, and means operated by said motor in case of a pro-

longed large change in level of the pilot current for operating an alarm.

12. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity having a contact arm held in operative position when operated and restoring means, a motor, means operated by said relay in case of large variations in the energy level of said pilot current for preventing operation of said amplifier control means and for operating said motor, means comprising a cam operated by said motor for insuring rotation of the motor for a predetermined period, means comprising a second cam operated by said motor for operating said restoring means and for preventing operation of said amplifier control means, and means comprising a third cam operated by said motor for operating an alarm in case of large changes in energy level of the pilot current for an extended period.

13. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity having a contact arm held in operative position when operated and restoring means, a motor, means comprising a control relay operated by said relay of limited sensitivity in case of large energy variations of said pilot current for operating said motor and for preventing operation of said amplifier control means, means comprising a cam member operated by said motor for holding the motor circuit closed for a predetermined period, means comprising a second cam member operated by said motor to become effective after a time interval for operating the restoring means of said relay of limited sensitivity and for again operating said control relay, and means comprising a third cam member operated by said motor to become effective after said second cam member for operating an alarm in case of a large variation in energy level of the pilot current for a prolonged period of time.

14. In combination, a signal transmission line, an amplifier on said line, means for controlling the gain of said amplifier according to the energy level of a pilot current on the line, a relay of limited sensitivity having a contact arm held in operative position when operated and restoring means, a control relay for operating said restoring means, a thermal element in the energizing circuit of said control relay for effecting operation of said control relay when heated for a predetermined period, means operated by said relay of limited sensitivity in case of a large change in voltage of said pilot current for preventing operation of said amplifier control means and for heating said thermal element to operate said control relay, and means comprising a second thermal element heated under control of said control relay in case of large voltage change of the pilot current for a prolonged period for operating an alarm.

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