Sept. 28, 1937. C. B. SUTLIFF 2,094,049

SIGNAL SYSTEM

Filed April 10, 1936 2 Sheets-Sheet 1

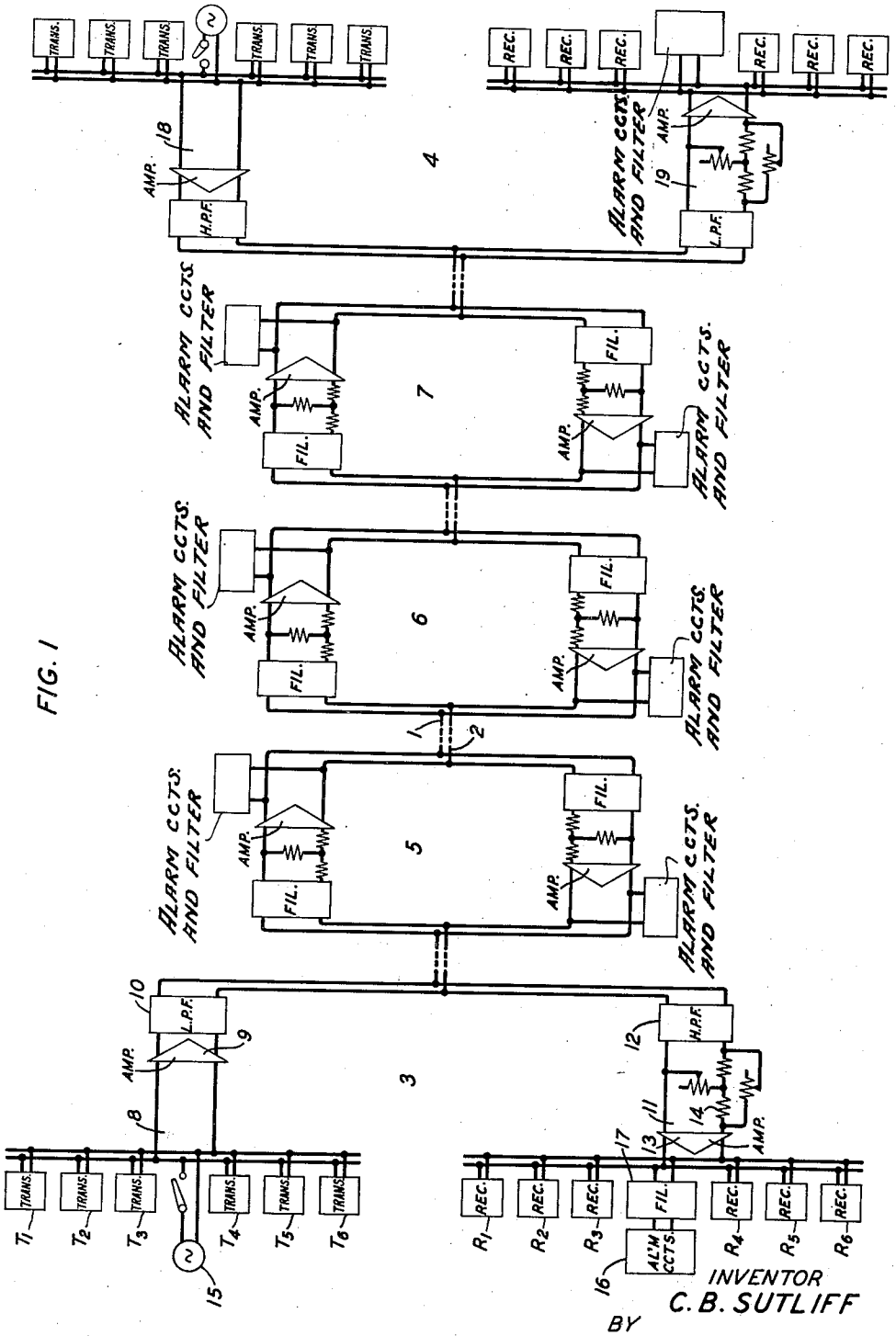

FIG. 1

INVENTOR
C. B. SUTLIFF
BY
Wayne B Wells
ATTORNEY

Sept. 28, 1937. C. B. SUTLIFF 2,094,049

SIGNAL SYSTEM

Filed April 10, 1936 2 Sheets-Sheet 2

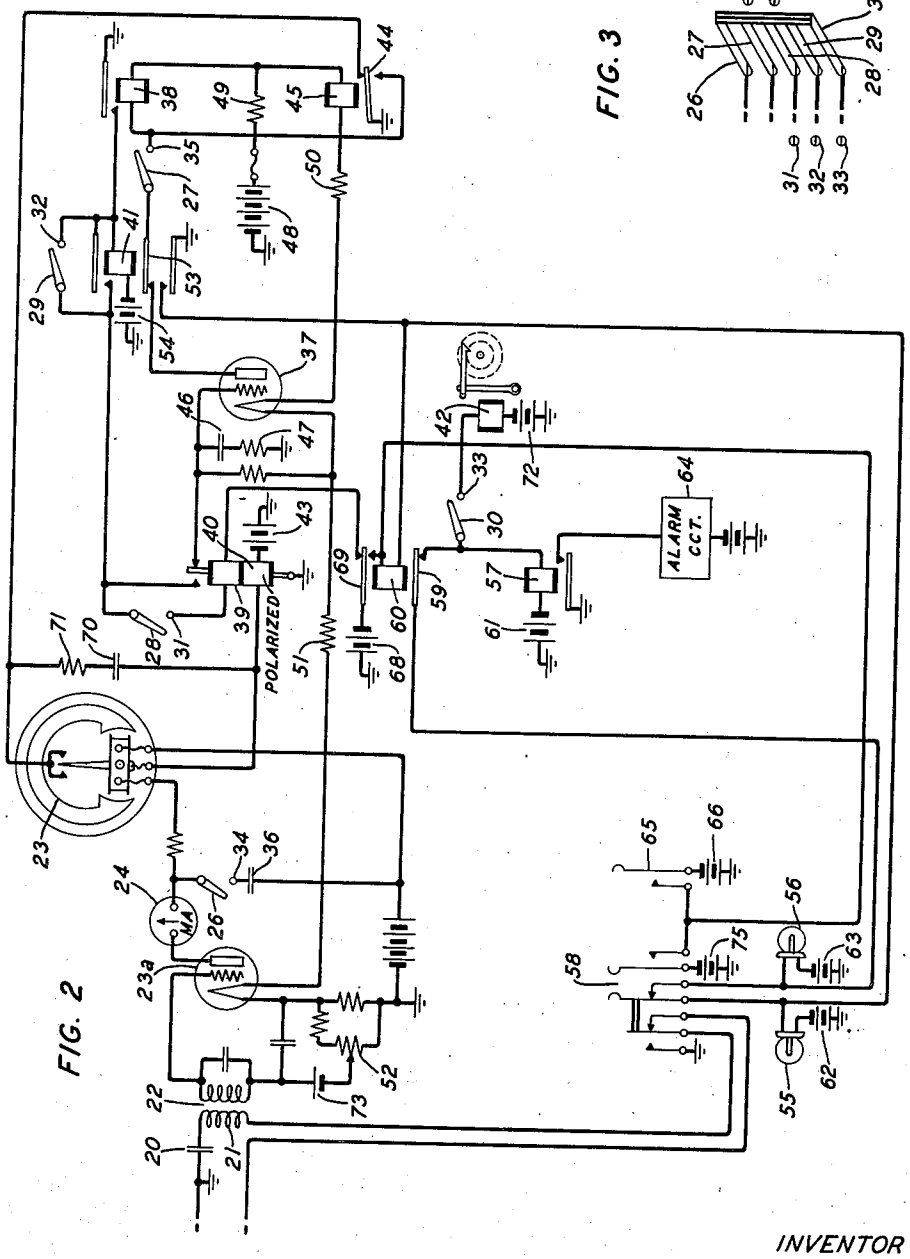

FIG. 2

FIG. 3

INVENTOR
C. B. SUTLIFF
BY
Wayne B Wells
ATTORNEY

Patented Sept. 28, 1937

2,094,049

UNITED STATES PATENT OFFICE

2,094,049

SIGNAL SYSTEM

Carleton B. Sutliff, East Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 10, 1936, Serial No. 73,625

10 Claims. (Cl. 178—44)

This invention relates to signaling systems and particularly to alarm circuits for signaling systems.

One object of the invention is to provide a signal transmission line with alarm circuits for indicating changes in level of the signals on the line and for differentiating between prolonged changes in energy level and brief changes in energy level of the signals.

Another object of the invention is to provide a signal transmission line with alarm circuits for indicating only prolonged changes in energy level of the signals when set in one position and for indicating brief changes in energy level of the signals when set in another position.

A further object of the invention is to provide a transmission line for transmitting signals by carrier currents and for transmitting a pilot frequency current for operating alarm circuits to indicate changes in energy level of the signaling currents and to differentiate between prolonged changes and brief changes in level of the signaling currents.

When transmitting signals over a transmission line the energy level of the signals may not only change for prolonged periods of time but may change for only very brief periods of time. Changes in level for prolonged periods of time which are called level changes may be caused by weather and temperature changes. Changes in energy level for brief periods of time which are called hits may be caused by a line being grounded intermittently on the limb of a tree.

It is desirable to maintain the energy level of telegraph signaling currents substantially constant in order to obtain satisfactory transmission of the signals. The changes in energy level of the signaling currents which are maintained for prolonged periods of time are corrected by changing the gain of the associated repeater or terminal amplifier. The changes in energy level of the signaling currents which are very brief in duration are generally corrected for by removing the cause of the change. Accordingly it is desirable not only to indicate whether a change in energy level of the signaling currents on a transmission has taken place, but also to indicate whether the change in energy level is for a prolonged period of time or for a very brief period of time.

According to the present invention means are provided for operating alarm or control circuits in case the energy level of signaling currents change from a desired operating level. Means are also provided for determining whether the change in level is for a prolonged period of time or is intermittent. If the change in energy level is for very brief periods of time the location of the fault on the transmission line is determined by comparing the indications of the alarm circuits at the various repeater and terminal stations.

The invention has been illustrated by means of a carrier wave transmission system. A number of carrier frequency waves within one frequency band is employed for transmitting the signals in one direction and a number of carrier waves within another frequency band is employed for transmitting the signals in an opposite direction over a transmission line. A pilot frequency current is included in each of the above bands for operating alarm circuits in accordance with the present invention. Alarm circuits are positioned not only at the terminal stations, but also at the repeater stations along the transmission line. The alarm circuits which are located at terminal and repeater stations are controlled by the pilot frequency currents for not only giving an alarm in case of change in level of the signals on the line, but also for differentiating between prolonged changes in level and changes in level which occur for only very brief periods of time. One alarm circuit is employed at each terminal station whereas at repeater stations there are two alarm circuits. One alarm circuit at a repeater station is controlled by the pilot frequency current within one frequency band and the other alarm circuit at a repeater station is controlled by the pilot frequency current within the other frequency band. It is desirable to have two alarm circuits at each repeater station in order to determine the location of any temporary transmission line interference which causes brief changes in level of the transmitted signals.

Each set of alarm circuits at a repeater or terminal station is equipped with a transfer switch which is set in one position to effect operation of the alarm circuits only in case of a prolonged change in energy level of the signals on the transmission line. In the other position of the transfer switch the alarm circuits are set to be operated for very brief changes in energy level of the signals on the transmission line. When the transfer switch is set to effect operation of the alarm circuits only in case of prolonged changes in the energy level of the signals, a slow-acting vacuum tube relay is included in the alarm circuit so that a brief change in the energy level of the signals will have no effect in operating an alarm. When the transfer switch

is in the other position the slow-operating vacuum tube relay is excluded from the alarm circuits and an alarm is operated in case of a very brief change in level in the signals on the line and in case of a prolonged change in level. Recording means are connected to the alarm circuits when the transfer switch is set in the position for operation by very brief changes in level of the signals on the line. The recording means assists in determining between what two stations line interference is taking place which produces brief changes in the energy level of the signals. It is apparent that by employing two alarm circuits at each repeater station and operating these alarm circuits, respectively, by the pilot frequency currents transmitted in opposite direction, it is possible to determine between what two stations interference with the line takes place.

In the accompanying drawings,

Fig. 1 is a diagrammatic view of a carrier wave transmission system provided with alarm circuits constructed in accordance with the invention;

Fig. 2 is a diagrammatic view of the alarm circuits shown in Fig. 1; and

Fig. 3 is a diagrammatic view of the transfer switch shown in Fig. 2 of the drawings.

Referring to Fig. 1 of the drawings a transmission line comprising conductors 1 and 2 is shown connected to two terminal stations 3 and 4. Three repeater stations 5, 6 and 7 are shown on the transmission line between the two terminal stations 3 and 4. The transmission station 3 is provided with a transmitting channel 8 connected to the transmission line by means of an amplifier 9 and a low-pass filter 10. A receiving channel 11 at station 3 is connected to the transmission line by means of a high-pass filter 12, an amplifier 13 and gain control means 14. Branch transmission leads are provided from the transmission channel 8 to the various carrier wave transmitters T_1, T_2, T_3, T_4, T_5, and T_6. The transmitters T_1 to T_6, inclusive, transmit signals over the transmission line to the station 4 by means of different carrier waves located within one frequency band. A suitable source of pilot frequency current 15 is provided for transmitting a pilot frequency current over the transmission line. The frequency of the source 15 lies somewhere between the carrier frequencies employed by the transmitters T_1 to T_6, inclusive.

Receivers R_1, R_2, R_3, R_4, R_5, and R_6 are connected to the receiving channel 11 and are operated by the carrier wave signals transmitted from the station 4. The receivers R_1 to R_6, inclusive, are provided with filters for selecting the various carrier waves employed in transmitting signals from the station 4. Alarm circuits 16 which are connected to the receiving channel by a filter 17 indicate the level of the carrier wave signals on the transmission line and differentiate between prolonged changes in level and changes in level which last for a very brief interval of time. The filter 17 selects the pilot frequency current which is transmitted from the station 4.

The station 4 is provided with a transmitting channel 18 and receiving channel 19. The transmitting channel 18 and the apparatus connected thereto are similar in construction to the transmitting channel 8 and the apparatus connected thereto except that the channel 18 transmits carrier waves and a pilot frequency current within a different frequency band from the currents transmitted by the transmitting channel 8 at the station 3. The carrier wave signals transmitted through the channel 18 serve to operate the receivers R_1 to R_6, inclusive, at station 3 and the pilot frequency current serves to operate the alarm circuits 16 at station 3 and one set of alarm circuits at each of the repeater stations 5, 6, and 7.

The receiving channel 19 at station 4 is connected to apparatus similar in construction and operation to the apparatus connected to the receiving channel 11 at station 3. The apparatus connected to the receiving channel 19 at station 4 is operated by the carrier wave signals transmitted from the transmitting channel 8 at station 3.

In Figs. 2 and 3 of the drawings the alarm circuits 16 shown in Fig. 1 are illustrated in detail. The filter 17 shown in Fig. 1 is illustrated in Fig. 2 as a tuned circuit comprising a condenser 20 and the primary winding 21 of a transformer 22. The secondary winding of the transformer 22 is directly connected with the alarm circuits. The alarm circuits comprise a three-element thermionic space discharge device 23—A which is connected to the secondary winding of the transformer 22. The device 23—A controls the operation of a voltmeter relay 23. In the operating circuit of the voltmeter relay 23 is included an indicating meter 24 which shows in case of prolonged changes in energy level whether the energy level is being raised or lowered. The meter 24 is set in a manner to be hereinafter disclosed at a neutral position so that it may be operated by the rise or fall in the energy level of the signals on the transmission line.

A transfer switch 25 which is shown in Fig. 3 of the drawings serves to set the circuit shown in Fig. 2 for operation only by a prolonged change in energy level of the signals or for operation by a brief change in level of the signals. The transfer switch comprises five switch members 26 to 30, inclusive, and five contact members 31 to 35, inclusive. When the transfer switch is in a position to effect operation of the alarm circuits only in accordance with prolonged changes in level of the signals, the switch members 26 and 27, respectively, engage the contact members 34 and 35. When the transfer switch is in position to effect operation of the alarm circuits by brief changes in level of the signals, the switch members 28, 29, and 30, respectively, engage the contact members 31, 32, and 33.

In Fig. 2 of the drawings the various parts of the transfer switch 25 are distributed throughout the circuits in order to simplify the circuit connections. The switch member 26 connects a condenser 36 across the coil of the voltmeter relay 23 in order to damp the operation of the voltmeter relay when the alarm circuits are operated by a prolonged change in the energy level of the signals. The switch member 27 connects the output circuit of a thermionic relay tube 37 to the operating coil of a relay 38 when the transfer switch is set to effect operation of the alarm circuits only by a prolonged change in the energy level of the signals on the transmission line. The switch member 28 is included in the circuit of a holding coil 39 for a polarized relay 40. The switch member 29 is included in a circuit for operating a locking relay 41 by means of the polarized relay 40. The switch member 30 is included in a circuit for operating a recording device 42.

Assuming the transfer switch is set to effect operation of the alarm circuits only in accordance with a prolonged change in the energy level of the signals, the switch members 26 and 27 will

engage the contact members 34 and 35. The pilot frequency current having a prolonged change in its energy level will operate the indicating meter 24 and the voltmeter relay 23. The voltmeter relay 23 upon operation completes a circuit from a battery 43 for operating the polarized relay 40. The circuit for operating the polarized relay 40 may be traced from ground through the armature 44 of a filament relay 45, armature of the voltmeter relay 23, operating coil of the polarized relay 40 and battery 43 to ground. The polarized relay 40 which is relatively quick in operation breaks a ground connection to the grid of the delay space discharge device 37. Upon disconnecting the grid from ground by the relay 40 a condenser 46 is charged in series with a resistance 47 from the filament heating circuit of the space discharge devices 23—A and 37. The filament heating circuit for the devices 23—A and 37 may be traced from a grounded battery 48 through a resistance 49, coil of the filament relay 45, resistance 50, filament of the device 37, resistance 51, filament of the device 23—A and a resistance to ground. The plate circuit for the delay space discharge device 37 extends from the battery 48 through the resistance 49, coil of the relay 38, switch member 27, a switch member 53 controlled by the relay 41 and plate and filament of the device 37 to ground.

When the grid of the device 37 is grounded it is highly negative with respect to the filament and no plate current flows through the tube. However, after operation of the polarized relay 40 which removes ground from the grid of the device 37 and after the charging of the condenser 46 has lowered the negative potential of the grid of the device 37 to permit plate current to flow, the relay 38 is operated. The delay in the operation of the device 37 which is caused by the time taken to charge the condenser 46 insures against any operation of the relay 38 by means of brief or short changes in energy level of the signals on the line. The relay 38 can only be operated by the delay device 37 in case of prolonged changes of energy level on the transmission line.

The relay 38 upon operation, under control of the delay device 37, completes a circuit from the battery 54 for operating the locking relay 41. The locking relay 41 upon operation establishes a holding circuit for itself through the armature of the polarized relay 40. The locking relay 41 also completes circuits for lighting the lamps 55 and 56 and for operating the alarm relay 57. The circuit completed for operating the relay 57 may be traced from ground through the armature of locking relay 41, pilot cut-out key 58, armature 59 of cut-out relay 60, coil of the alarm relay 57 and battery 61 to ground. The lamps 55 and 56 are lighted respectively by batteries 62 and 63. The lamps 55 and 56 and the alarm 64 operated by the relay 57 may be positioned in any desired place at the station.

Upon operation of the alarm 64 in case of change in level of the signals for a prolonged period of time, the gain control apparatus 14 shown in Fig. 1 of the drawings is adjusted to correct the gain. The correct volume level will be indicated by means of the indicating meter 24 shown in Fig. 2 of the drawings. The alarm 64 may be disconnected or stopped by means of the key 65. The key 65 when operated completes a circuit from a battery 66 for operating the cut-out relay 60. The circuit for operating the cut-out relay 60 extends from ground through the armature of the locking relay 41, coil of the cut-out relay 60, cut-out key 65 and battery 66 to ground. The cut-out relay 60 when operated breaks the circuit of the alarm relay 57 by means of the armature 59. The relay 38 and the locking relay 41 are released and return to normal position when the voltmeter relay 23 is returned to normal position and normal energy signal conditions are established on the transmission line.

In case it is desired to operate the alarm circuits by brief energy level changes, the transfer switch 25 is operated so that the switch members 28, 29, and 30 engage the contact members 31, 32, and 33. At this time the switch member 26 disengages the contact member 34 so that the voltmeter relay 23 is rendered very quick-acting and the switch member 27 disengages the contact member 35 to prevent operation of the relay 38 by means of the delay space discharge device 37. The switch member 28 is included in circuit with the holding coil 39 for the polarized relay 40. The switch member 29 is included in a circuit for operating the locking relay 41. The switch member 30 is included in the circuit for operating the recording device 42.

When the energy level of the pilot frequency current received by the transformer 22 is raised or lowered briefly the indicating space discharge device 23—A completes a circuit for operating the voltmeter relay 23. The voltmeter relay 23 completes a circuit from the battery 43 for operating the polarized relay 40 irrespective as to whether the energy volume of the signals is raised or lowered. The polarized relay 40 is very quick-acting and establishes a holding circuit for itself which may be traced from battery 68, armature 69 of the cut-out relay 60, coil 39 of the polarized relay 40, switch member 28 and armature of the polarized relay 40 to ground. A condenser 70 and a resistance 71 connected around the contact members of the voltmeter relay 23 serve to protect the contact members against inductive discharges. The polarized relay 40 also completes a circuit from the battery 54 through the switch member 29 for operating the locking relay 41. The locking relay 41 upon operation completes a circuit for lighting the lamps 55 and 56 and for operating the relay 57 which, in turn, operates the alarm 64. The locking relay 41 also completes a circuit from a battery 72 through the switch member 30 for operating the recording mechanism 42.

When the alarm circuits are set to be operated by brief changes in energy level of the signals, all operated relays may be released by operation of the cut-out key 65. The cut-out key 65 when operated completes a circuit for operating the cut-out relay 60. The cut-out relay 60 when operated first breaks the circuit from the battery 68 through the locking coil 39 for the polarized relay 40. When the polarized relay 40 is released the holding circuit for the coil of the locking relay 41 is opened. The cut-out relay 60 moreover breaks the holding circuit for the coil of the alarm relay 57. In this manner all relays are returned to initial position. The filament relay 45 which is included in the filament heating circuit will be released in case of failure of the filament in either of the devices 22—A and 37. Upon release of the relay 45 a circuit is completed from the battery 48 for operating the relay 38. The relay 38 completes a circuit for operating the relay 41 and the relay 41 in turn controls the lights 55 and 56 and the alarm 64.

The pilot cut-out key 58 is employed for pre-

venting operation of the alarm circuit when an adjustment is made of the bias impressed on the grid of the indicating space discharge device 23—A to adjust the initial deflection of the indicating meter 24. The grid of the device 23—A not only has a bias impressed thereon from the battery 73, but has an adjustable bias impressed from the resistance 52 in the filament heating circuit. When it is desired to adjust the bias of the device 23—A the key 58 is operated. The operation of the key 58 completes a circuit from a battery 75 for operating cut-out relay 60. The operation of the cut-out relay 60 insures against any operation of the alarm 64 and the recording device 42. The key 58 also breaks the circuit for the lamps 55 and 56 so that these lamps cannot be lighted. The key 58 furthermore grounds the primary winding 21 of the transformer 22 so that no energy can be transmitted through the transformer 22 to the device 23—A and the indicating meter 24. The initial deflection of the indicating meter 24 is then adjusted by means of the resistance 52. Such initial deflection is made so that the pointer of the indicating meter 24 operates normally in a central position and will indicate either raising or lowering of the energy level of the signals on the line.

In alarm circuits constructed as above described it is apparent that the alarm circuits in one position of the transfer switch will be operated only in case of energy level changes on the transmission line for prolonged periods of time, whereas in the other position of the transfer switch the alarm circuits will be operated by brief changes in the energy level of the signals on the transmission line. Brief changes in the energy level of the signals on a transmission line are generally caused by some interference with the transmission line, such as the line coming in contact with a limb of a tree. By means of the alarm circuits it is possible to determine between what two stations the interference in the transmission line takes place. If the interference takes place on line 1 between stations 5 and 6, then the alarm circuits 6 and 7 for transmission from the station 4 to station 3 will show normal level, whereas repeater station 5 and terminal station 3 will show brief energy level changes. For transmission from the terminal station 3 to the terminal station 4, repeater station 6, 7 and the terminal station 4 will show brief energy level changes which will clearly indicate that the cause of the brief energy level changes lies between the repeater station 5 and the repeater station 6.

Modifications in the circuits and 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 carrying signal currents, signal apparatus, control circuits connected to said transmission line, and means for governing said control circuits to operate said signal apparatus upon change in energy of the signal currents above and below normal level and for differentiating between brief and prolonged changes in the energy level of the signal currents above and below normal level.

2. In a carrier current signal system, a transmission line, means for transmitting a pilot current from a transmitting station to a receiving station, signal apparatus, and means comprising control circuits connected to said line for operating said signal apparatus upon change in energy level of the pilot current above and below normal level and for differentiating between brief and prolonged changes in energy level of the pilot current above and below normal level.

3. In combination, a transmission line carrying signal currents and a pilot frequency current, signal apparatus, control circuits connected to said transmission line for operating said signal apparatus by said pilot frequency current, and a two-position transfer switch for governing said control circuits, said transfer switch in one position serving to effect operation of the signal apparatus only upon prolonged changes in the energy level of the pilot current and in the other position serving to effect operation of the signal apparatus upon brief changes in the energy level of the pilot current.

4. In a signal system, a transmission line, signal apparatus, control circuits connected to said line for operating said apparatus upon change in the level of the signals on the line, means for setting said control circuits to effect operation of the signal apparatus only in case of a prolonged change in the level of the signals and for setting said control circuits to effect operation of the signal apparatus in case of brief changes in the level of the signals on the line.

5. In a signal system, a transmission line, signal apparatus, control circuits connected to said line for operating said apparatus according to the energy level conditions of the signals on the line, a transfer switch connected to said control circuits and having hit and level positions, said control circuits effecting operation of said signal apparatus only in case of a prolonged change in the level of the signals when the switch is in the level position and effecting operation of said signal apparatus in case of brief changes in the level of the signals when the switch is in the hit position.

6. In a carrier current signal system, a transmission line, means for transmitting a pilot current from a transmitting station to a receiving station to indicate the energy level of the signals on the line, a two-position transfer switch at the receiving station having a hit position and a level position, an alarm, and means comprising control circuits controlled by the pilot current at the receiving station for operating said alarm when a brief change in level of the signals occurs and said switch is in the hit position and for operating said alarm only when a prolonged change in energy level of the signals occurs and said switch is in the level position.

7. In a carrier current signal system, a transmission line having terminal and repeater stations thereon, means for transmitting signals in one direction over said line by means of carrier waves within one frequency band and for transmitting signals in an opposite direction by means of carrier waves within another frequency band, a pilot frequency current included in each of said bands, means at said stations under control of said pilot frequency currents for operating a signal in case of change in level of the pilot currents and for indicating whether the change in level is of brief or prolonged duration.

8. In a carrier current signal system, a transmission line having terminal and repeater stations thereon, means for transmitting signals in one direction over said line by means of carrier waves within one frequency band and for transmitting signals in an opposite direction by means of carrier waves within another frequency band, a

pilot frequency current included in each of said bands, signal apparatus at each of said stations, control circuits at said stations governed by the pilot frequency currents for operating said signal apparatus, means comprising filters for selecting the pilot currents to operate the control circuits at said stations, and means comprising a transfer switch connected to the control circuits at each station for setting the control circuits to effect operation of the signal apparatus associated therewith only when prolonged changes in a pilot frequency current take place and for setting the control circuits to effect operation of the associated signal apparatus when brief changes in a pilot frequency current take place.

9. In combination, a transmission line carrying a pilot frequency current and carrier signal currents, alarm apparatus, a voltmeter relay connected to said line and operated upon change in energy level of the pilot frequency current, a slow-acting relay, a two-position transfer switch, and means for operating said alarm apparatus by said slow relay under control of the voltmeter relay in one position of said transfer switch to insure operation of the alarm apparatus only in case of prolonged changes in the energy level of the pilot current and for operating said alarm apparatus by the voltmeter relay independently of said slow relay in a second position of the transfer switch to insure operation of the alarm apparatus in case of brief changes in the energy level of the pilot current.

10. In combination, a transmission line carrying a pilot current, alarm apparatus, a voltmeter relay connected to said line and operated upon change in energy level of the pilot frequency current, a slow-acting thermionic relay, a two-position transfer switch, and means for operating said alarm by said thermionic relay under control of said voltmeter relay to insure operation of the alarm apparatus only in case of prolonged changes in the energy level of the pilot current when the transfer switch is in one position and for operating the alarm apparatus by said voltmeter relay independently of the thermionic relay when the transfer switch is in a second position to obtain operation of the alarm apparatus in case of brief changes in energy level of the pilot current.

CARLETON B. SUTLIFF.