

May 17, 1966

M. W. MUEHTER

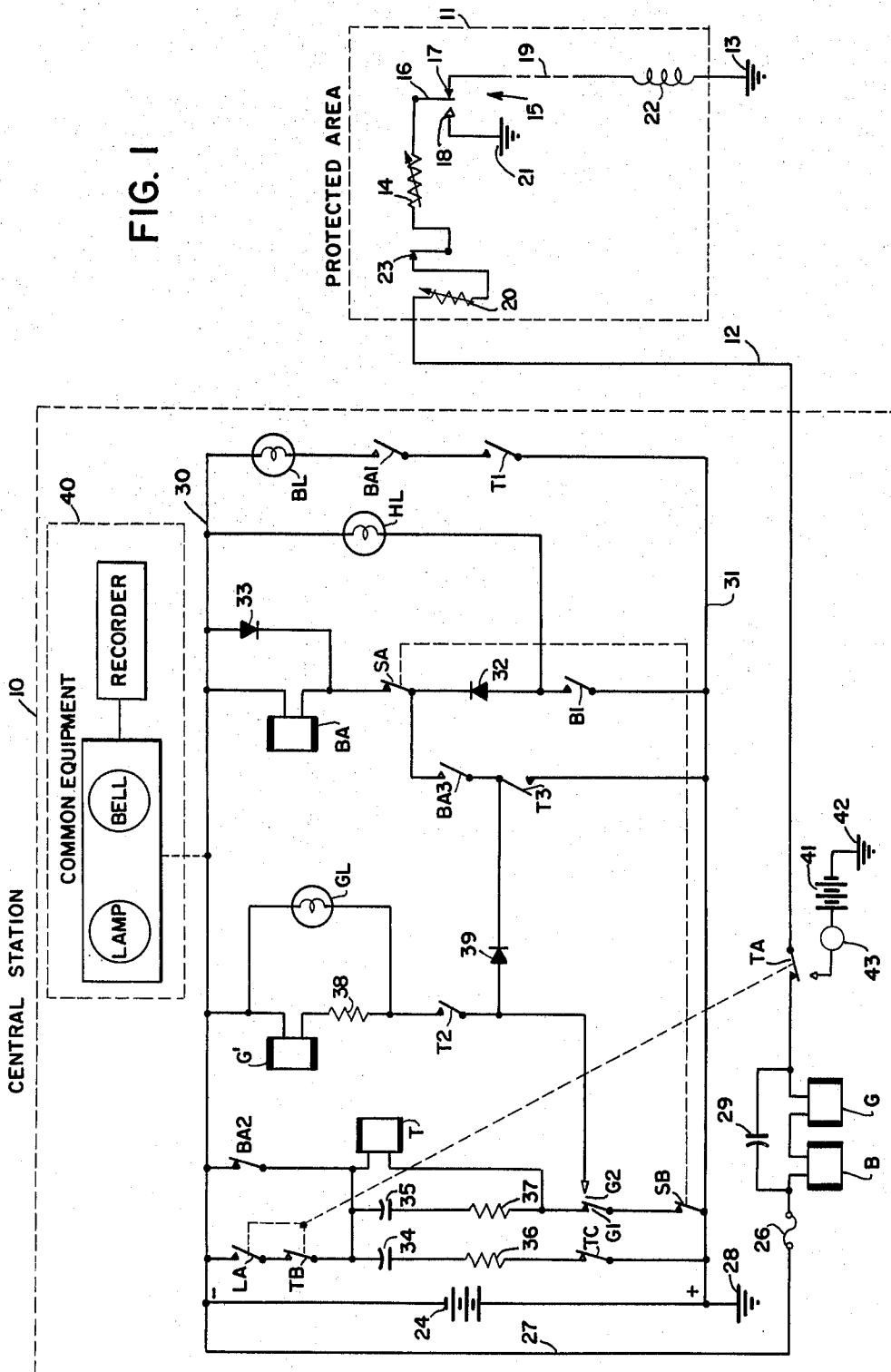
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ALARM ANNUNCIATOR INCLUDING DETECTION OF BREAKS, GROUNDS, AND
A BREAK FOLLOWED BY A GROUND ON A MONITORED LINE

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2 Sheets-Sheet 1

FIG. 1



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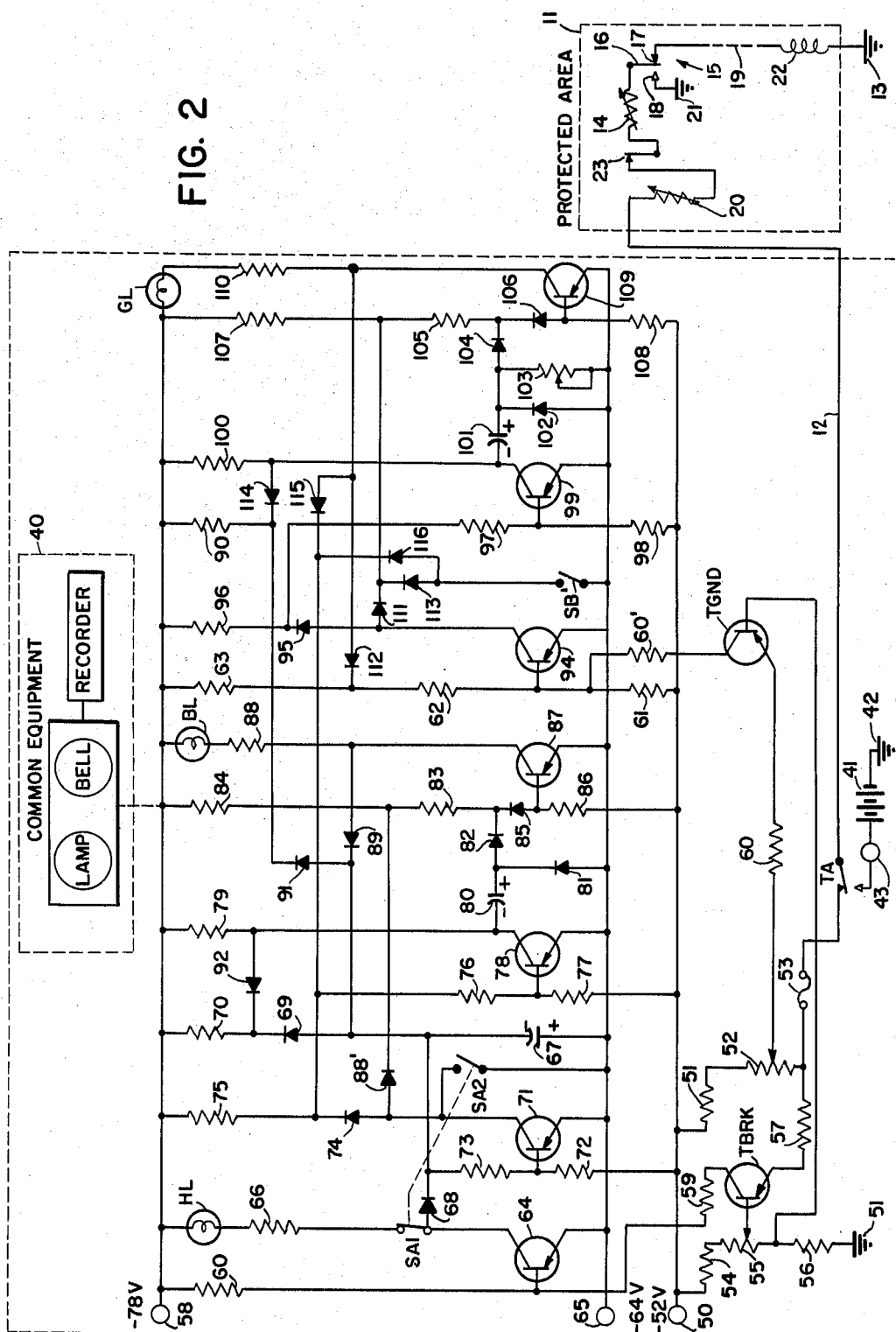
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FIG. 2



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ALARM ANNUNCIATOR INCLUDING DETECTION OF BREAKS, GROUNDS, AND A BREAK FOLLOWED BY A GROUND ON A MONITORED LINE

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The present invention relates to alarm annunciators and more particularly to alarm annunciators of the type employed in central stations to indicate the occurrence of an alarm condition at a remote place, e.g., the entering of a protected area by an intruder.

Central station burglar alarm systems usually comprise a number of detection devices connected in a local electrical protection circuit at the protected area which are designed to be actuated by an intruder during an attempt to effect an entrance. The detection devices may include, inter alia, contacts which are actuated by the opening of a door or window or current-carrying foil applied to glass panels in such manner as to be broken when the glass is shattered. This local electrical protection circuit is usually connected to a central station through a communication channel such as a leased telephone line.

A power supply, usually a grounded battery, is provided at the central station and the local protection circuit is grounded at the protected area so that the current return path will be through the earth. Also provided at the central station are alarm annunciation devices, one for each protection circuit, which are capable of registering three types of signal. Under normal conditions, while the detection devices are connected in the circuit, a small, supervisory current flows through the entire circuit but has no effect upon the alarm annunciator. A break in the circuit will result in a decrease in the supervisory current and, when the current has decreased to a preselected value, the annunciator will register a "break" signal, by both visual and audible means. Similarly, a ground on the circuit will cause an increase in the current, which, having attained a preselected value, will register a "ground" signal through both visual and audible means. A third signal is provided for "police call" alarms over the same circuit whereby a subscriber to the service may summon assistance in the event of a holdup by actuating a device which produces a pulsating current in the circuit. The current pulses are annunciated audibly and visually in a manner distinctive from either the break or ground signals.

The contact devices installed on doors and windows usually comprise a transfer switch so connected in the circuit that the opening of a door or window will cause the switch to transfer the circuit from the normal condition to a ground connection. In so doing, the circuit is first opened for a brief period, which may be of the order of thirty milliseconds, and is then grounded for as long as the door or window remains open. When the door or window is closed, the contact device restores to its original condition; however, the distinctive signal pattern of a short duration break followed by a ground, known as a "double drop" signal, will have been registered at the central station.

Protection systems of the type described above have been known and used for many years with highly satisfactory results. However, difficulties have been encountered in the operation of central station systems due to false alarms resulting from the appearance of transient electrical disturbances in the circuit. Such disturbances may result from a variety of causes, e.g., currents induced in the telephone lines by electrical storms, varying ground potential between the central station and the protected

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area, effects produced by service men working on telephone lines and the effect of wind shaking poorly fitted doors and windows. Whatever the cause, these false alarm signals are characterized by the fact that they are generally of shorter duration than genuine alarm signals. Efforts have been made to reduce the number of false alarms by retarding the response of the annunciation device so that brief increases and decreases in the current would not register. However, such retardation has been limited in effectiveness because it is desirable that a double drop signal be provided and annunciated upon the operation of a contact device wherein the break signal may have a very short duration, e.g., thirty milliseconds.

Another approach to the problem is exemplified by Muehter United States Patent No. 2,821,699 issued January 28, 1958. In this patent there is disclosed a means whereby the effect of a fast break signal is sustained for a sufficient period to permit proper operation of a relatively slow-acting annunciator. However, this means requires the installation of additional apparatus at each protected area and so presents certain unattractive economic features.

The principal object of the present invention has been to provide a novel and improved alarm annunciator for central station type electrical protection systems.

More particularly, it has been an object of the present invention to provide an alarm annunciator for electric protection circuits which is not responsive to brief, transient disturbances in the protection circuit and does not require the installation of additional equipment at the protected area.

Another object of the invention has been to provide an alarm annunciator for use in central stations in which transient electrical disturbances of relatively short duration are ineffective to produce an alarm indication, thereby substantially reducing the occurrence of false signals while at the same time insuring positive response to genuine signals of relatively short duration.

Other and further objects, features and advantages of the invention will appear more fully from the following description.

The alarm annunciator of the invention comprises means for producing distinctive indications of only those break signals which persist for a first preselected interval and only those ground signals which persist for a second preselected interval of shorter duration. However, in the event of a break signal immediately followed by a ground signal, the indication will be provided in the shorter interval. In addition, means are also provided for the distinctive indication of police call alarms and for testing the entire circuit. The invention may be applied with equal facility to circuits employing either electro-mechanical relays, vacuum tube switching circuits or solid state switching components.

The invention will now be described in greater detail with reference to the appended drawings, in which:

FIG. 1 shows a schematic wiring diagram of a protection circuit embodying the invention and employing electro-mechanical relays, the circuit being shown in its normal operating condition; and

FIG. 2 shows a schematic wiring diagram of a modified protection circuit embodying the invention and employing solid state components to effect the necessary switching functions.

Referring now to FIG. 1, a central station 10 is shown connected to a protected area 11 by a telephone line or similar wire connection 12. Typically the line 12 may be as much as twenty miles in length and may pass through several telephone exchanges. At the protected area 11, the line 12 is connected to a local circuit including conventional protective devices which produce break and/or

ground signals and thence to ground at 13. The local circuit is shown in highly simplified form as comprising a current adjusting resistor 14, a door protection switch 15 having an armature 16, a back contact 17 and a front contact 18, other protection devices indicated by broken line 19 and a current limiting resistor 20. With the door closed line 12 is coupled to ground at 13 through armature 16, back contact 17 and resistor 20. When the door is opened the circuit is first broken as armature 16 leaves back contact 17. The circuit of line 12 is then completed directly to ground at 21 through front contact 18. A bell coil 22 and bell contact 23 are shown connected in series with line 12. It should be understood that the actual circuit at the protected area will usually be substantially more complex and sophisticated than the simple circuit shown.

The other end of line 12 is connected at the central station to the negative terminal of a source of voltage 24 (which typically might be a fifty-two volt battery) through a series circuit comprising normally closed back contact of a test switch TA, winding G of a ground relay, winding B of a break relay, a fuse 26 and a conductor 27. The positive terminal of battery 24 is grounded at 28. A condenser 29 shunts the windings of the relays G and B to prevent interference by power frequencies that are sometimes found on the telephone line.

Adjustable resistors 14 and 20 at the protected area limit the current in line 12 to a selected nominal value, e.g., fifteen milliamperes, during the period while the protection system is in operation. The circuit components are so selected and adjusted that operation of a break signal device at the protected area will cause the line current to fall to or below a first preselected value, e.g., nine milliamperes, while operation of a ground signal device at the protected area will cause the line current to rise to or above a second preselected value, e.g., twenty-one milliamperes. While specific values of currents and voltages are referred to herein for convenience in explaining the operation of the invention, it should be understood that these specific values are given by way of illustration only and are not to be construed as in any manner limiting the invention. With normal line current relay B will be energized and relay G will be deenergized. The relays B and G are preferably sensitive galvanometer type relays.

As drawn, FIGURE 1 shows the circuit configuration for operation with a positive grounded battery. Under certain circumstances, it may be preferred to operate with the battery negatively grounded. For operation with such reversed battery polarity it is necessary only to reverse the polarity of the diodes and the electrolytic condensers. No other circuit changes are required.

A number of parallel circuits are connected across battery 24 by means of conductors 30 and 31 which are connected to the negative and positive battery terminals, respectively. One of these circuit comprises, in series connection, normally open back contacts B1 of break relay B, a diode 32, switch SA, and the winding of an auxiliary break relay BA. Winding BA is shunted by a diode 33. In parallel with a portion of this circuit is a holdup alarm annunciating lamp HL. As described hereinafter, lamp HL provides a flashing signal in response to the repeated opening and closing of the transmission line caused by the actuation of a police call device at the protected area. The lamp HL is connected between conductor 30 and the junction of contacts B1 and diode 32.

A lamp BL for annunciating break signals is also connected between conductors 30 and 31 and in series with normally open contacts BA1 of relay BA and T1 of a relay T.

The coil of relay T is part of a timing circuit including also capacitors 34 and 35 and resistors 36 and 37. Capacitor 34 and resistor 36 are connected in series and are coupled to conductor 31 through switch TC. Capacitor 35 and resistor 37 are connected in series and are coupled to conductor 31 through back contacts G1 of relay G and

switch SB. The free ends of capacitors 34 and 35 are connected to one end of the coil of relay T and are coupled to conductor 30 through back contacts BA2 of relay BA. Normally closed switch TB and normally open switch LA are connected in series with each other and the series combination thereof is connected in parallel with contacts BA2.

Another series circuit connected between conductors 30 and 31 is formed by a second winding G' of relay G, a resistor 38, back contacts T2 of relay T, front contacts G2 of relay G1 and switch SB. As shown, back contacts T2 are normally open. A lamp GL is connected across the series combination of coil G' and resistor 38.

The junction of contacts G2 and T2 is coupled to the junction of switch SA and rectifier 32 through a rectifier 39 and front contacts BA3 of relay BA. Back contacts T3 of relay T are connected between contacts BA3 and conductor 31.

Since large numbers of protective circuits are connected to a central station, it is the usual practice to install a number of alarm annunciators in a single switchboard section. Each annunciator unit is connected to a common alarm annunciator which, through audible and visual means upon the receipt of a signal, attracts the operator's attention to a particular section of the switchboard where the lamps of the particular unit indicate the source of the incoming signal. The common alarm apparatus, in addition to a light and a bell, is usually provided with a recording device which makes a printed record on a paper tape of the police call alarm signals. The common equipment is well known in the art and thus has been indicated at 40 in FIGURE 1 in simple block diagram form.

Also located at the central station is a battery 41 of substantially higher voltage, e.g., 135 volts, than battery 24. Battery 41 is employed for test purposes as will be described hereinafter and is connected to ground at 42 and to the normally open side of test switch contact TA through a watch case receiver 43.

The switches referred to above may be grouped as two three-position switches of the telephone type. Thus the "line" switch contact LA is operated through one position of the handle of one switch while the "test" switch contacts TA and TB are operated through the opposite handle position of the same switch. With the switch handle in a neutral position contacts LA are open and contacts TA and TB are closed, as shown. Operation of the switch handle in one direction will close contacts LA without disturbing switch contacts TA and TB. Operation of the switch handle in the other direction will open contacts TB and TA without disturbing contacts LA. Similarly the switch contact SA is operated by one handle position of the "silencing" switch while contact SB is operated by the opposite position. With the handle in a neutral position contacts SA and SB will both be closed, as shown.

BREAK SIGNAL OPERATION

Under normal conditions and with the protection system in service, the current in line 12, e.g., 15 milliamperes, will be sufficient to energize relay B but insufficient to energize relay G. Break auxiliary relay BA will be deenergized because the circuit through front contacts BA3 and the circuit through back contacts B1 will both be open. Relay T will, however, be energized through back contacts BA2, back contacts G1 and switch contacts SB. Break signal indicating lamp BL will be extinguished because contacts BA1 and T1 are open. Ground signal indicating lamp GL will be extinguished because back contacts T2 and front contacts G2 are open. Police call signal indicating lamp HL will be extinguished because back contacts B1 are open.

A break signal condition on line 12 will be characterized by a drop in current, e.g., to 9 milliamperes or less. Such a drop in current may result from operation of a break signal device at the protected area, a temporary

electrical disturbance, a line fault or other cause. Whatever the cause, the drop in current causes relay B to become deenergized.

When relay B drops out, back contacts B1 close, applying operating potential from conductors 30 and 31 to police call lamp HL, which is thereby illuminated. Closing of contacts B1 also completes an energizing circuit for auxiliary break relay BA extending through the coil of relay BA, switch SA, rectifier 32 and contacts B1. Auxiliary break relay BA thus becomes energized.

Energization of relay BA causes front contacts BA1 and BA3 to close and back contacts BA2 to open. Opening of contacts BA2 in turn opens the energizing circuit for timing relay T. However, relay T does not drop out immediately because it will be held up by current flow resulting from the charge on capacitors 34 and 35. Relay T will be held up for a time dependent on the discharging time constant of capacitors 34 and 35. This delay interval should be selected so as to exceed the length of the bulk of spurious break signals, i.e., break signals caused by effects other than a true alarm. Typically, the delay interval might be of the order of two seconds.

If the break condition does not persist until the end of the delay period, the resumption of normal current flow in line 12 will cause relay B to pick up, resulting in the opening of back contacts B1 and the consequent deenergization of relay BA and the extinguishment of lamp HL. When relay BA drops out, back contacts BA2 close, again completing the energizing circuit for relay T and supplying charging current to capacitors 34 and 35. The circuit will thus be restored to normal condition.

If the break condition persists past the end of the delay period, discharge of capacitors 34 and 35 will have proceeded far enough so that relay T will drop out, closing back contacts T1, T2 and T3. Closing of contacts T1 completes the energizing circuit for break signal lamp BL, causing this lamp to be illuminated as an indication of a break condition on line 12. Closing of contacts T3 locks up relay BA in its energized condition, the circuit extending from conductor 30 through the coil of relay BA, switch SA, contacts BA3 and contacts T3 to conductor 31. Even though contacts T2 and T3 are closed, rectifier 39 will not permit energizing current for secondary winding G' of relay G and lamp GL to flow through contacts T3.

The presence of a break signal will actuate the common equipment in a manner well known in the art, calling the operator's attention to the switchboard. The particular circuit having the signal will be identified to the operator by the illuminated lamps HL and BL. However, if normal current has been restored to line 12 after relay T drops out, only lamp BL will remain illuminated since the pick up of relay B will open contacts B1, extinguishing lamp HL. Rectifier 32 is poled so as to prevent lamp HL from being energized through contacts BA3 and T3.

Once the normal line current is flowing in line 12 after a break signal so that relay B is energized, the alarm annunciator may be restored to normal condition by momentary operation of switch SA. Opening of contacts SA allows relay BA to drop out thus opening contacts BA1 and BA3 and closing contacts BA2. Opening of contacts BA1 extinguishes break lamp BL, opening of contacts BA3 opens the locking circuit for relay BA and closing of contacts BA2 completes the energizing circuit for relay T and the charging circuit for capacitors 34 and 35.

The system will now be ready to receive another signal. Momentary opening of switch SA with the break still on line 12 would not restore the circuit to normal since relay B would remain deenergized and relay BA would immediately pick up as soon as contacts SA were closed. Hence, if the operator attempts to reset the circuit and fails, he knows that the line is still subject to the break signal condition.

GROUND SIGNAL OPERATION

A ground signal condition on line 12 will be characterized by an increase in current, e.g., to 21 milliamperes or more. Such an increase in current may result from operation of a ground signal device at the protected area, a temporary electrical disturbance, a line fault or other cause. Whatever the cause, the increase in line current causes relay G to become energized.

Operation of relay G opens back contacts G1 and closes front contacts G2. With contacts G1 open the energizing circuit for timing relay T is open. However, relay T will not drop out until the charge on capacitor 35 is sufficiently dissipated. In this case capacitor 34 does not contribute to holding relay T up because of contacts G1 being open. Hence the time delay before relay T drops out will be shorter than in the case of a break signal. The charge on capacitor 35 should be sufficient to delay drop out of relay T for a time interval longer than the duration of the bulk of the spurious ground signals encountered. Typically this time delay may be of the order of one-half second.

When relay T drops out, back contacts T2 close, completing the energizing circuit for ground signal lamp GL through contacts T2 and G2 and switch SB. Lamp GL will thus be illuminated as an indication of a ground signal. The attention of the operator will be attracted to the illuminated lamp GL by operation of the common equipment as is well known in the art.

The secondary winding G' of relay G is in parallel with lamp GL so that when the energizing circuit for the latter is complete current will also flow through winding G'. As a result relay G will lock up and will not drop out even though line 12 should return to normal.

In the event that the ground condition on line 12 does not persist long enough for relay T to drop out, loss of the ground signal will cause relay G to drop out, closing contacts G1 and returning the circuit to normal.

When the line current returns to normal the main winding G of relay G will be in condition to allow relay G to drop out but the latter will be held up by current flowing through secondary winding G'. With the line current normal the circuit may be reset by momentary opening of switch SB which cuts off the current for secondary winding G'. With the loss of current in winding G' relay G will drop out opening contacts G2 and closing contacts G1. Lamp GL will be extinguished and relay T will become energized. If the line current is not back to normal the current in the main winding of relay G will not permit that relay to drop out so that when switch SB is closed after the reset attempt the lamp GL will still be illuminated showing continuance of the ground signal condition.

DOUBLE DROP OPERATION

A combined break and ground signal, commonly termed a double drop signal, is characterized by a break signal of about ten to thirty milliseconds duration immediately followed by a ground signal. The double drop signal occurs, for example, upon actuation of a corresponding protection device of the type commonly used on doors. For example, the opening of a protected door causes armature 16 to leave back contact 17, resulting in a break signal which persists until armature 16 makes with front contact 18, resulting in a ground signal. The ground signal will persist until the armature is restored to its normal position, as by closing of the protected door.

Upon occurrence of the break signal, the lamp HL will be illuminated, relay BA will be energized and the break signal delay period, as controlled by capacitors 34 and 35, will start to run, all as described above.

The appearance of the following ground signal energizes relays B and G. Energization of relay B will not release relay BA because the latter will be held up by a circuit extending from conductor 30 through the coil of relay BA, switch SA, front contacts BA3, diode 39, front

contacts G2 and switch SB to conductor 31. Diode 33 connected across the coil of relay BA sufficiently retards drop out thereof upon energization of relay B so that relay BA will not drop out before contacts G2 close during the transition from a break to a ground signal.

Opening of contacts B1 extinguishes lamp HL. However, the lamp HL will only have been illuminated for the duration of the break period, usually not more than 30 milliseconds.

The break signal delay period, which might be about two seconds, had begun with the appearance of the break signal and the resulting opening of back contacts BA2. When the ground signal occurs, opening of back contacts G1 removes capacitor 34 from the relay T timing circuit. Hence occurrence of a break signal of short duration followed immediately by a ground signal shortens the delay time for release of relay T from the relatively long, e.g., two seconds, break delay to the relatively short, e.g., one-half second, ground delay.

If the duration of the combined break and ground signals is less than the ground signal delay period, timing relay T does not release and the circuit returns to normal as contacts G2 open allowing relay BA to drop out.

If the duration of the combined break and ground signal equals or exceeds the ground signal delay period, timing relay T will drop out and lamps BL and GL will be illuminated by the closing of back contacts T1 and T2, respectively. Relay BA will be locked up through contacts T3 while ground delay G will be locked up by energization of its secondary winding G'. The common equipment 40 will function in the usual manner to alert the operator.

The operator will note a double drop signal condition because both lamps GL and BL will be illuminated. If the current in line 12 returns to normal the circuit may be restored to normal by monetary opening of switches SB and SA as described previously.

POLICE CALL SIGNAL OPERATION

When the protected premises are open for business, it is customary for most of the protection devices to be out of the circuit. This is the so-called day protection period. The central station apparatus will be set to respond only to break signals, and to those without delay. This is effected by keeping switch SB open thereby preventing current flow through lamp GL and keeping relay T deenergized. One important protection afforded during the day is a holdup alarm. Holdups are signalled by operating a hidden switch which actuates a so-called police call alarm device. When a police call alarm device is operated at the protected area, a switch in the actuating device opens and then grounds the line 12 thus producing first a decrease and then an increase in the line current. The increased line current is then interrupted cyclically to cause pulsations in the line current at a suitable rate, usually about three per second, by means well known to the art and forming no part of the present invention.

At the central station, the response is initially similar to that of the break signal operation. Lamp HL is illuminated and auxiliary relay coil BA is energized by the closing of contacts B1 upon the first break. The closing of contacts BA1, with contacts T1 closed, illuminates the lamp BL while the break auxiliary relay BA is locked in through contacts BA3 and T3. Closing of contacts T2 does not illuminate lamp GL because switch SB is open. Succeeding current impulses cause lamp HL to flash through the action of contacts B1, while lamp BL remains on steadily because the coil BA of the break auxiliary relay is locked in. The common equipment is also actuated and, as previously mentioned, a recording device is set into operation to produce an ink marked paper tape record of the alarm. After the police call device at the protected area is stopped, the circuit may be returned to normal by momentary operation of switch

SA. However flashing of lamp HL will cease as soon as the line current stops pulsating.

The common equipment will usually be relatively sophisticated, but may simply be an audible device and a recording device operated by current sensitive devices in the circuits of the lamps.

TEST OPERATION

The continuity of a protection circuit may be tested by means of vibrating bell 22 at the protected area. The bell coil 22 and its interrupter contacts 23 are in series connection with the line 12, the bell coil being so selected that it will not be energized by the normal current flowing in the line 12.

When the central station operator wishes to test the circuit, he operates the test switches TA, TB and TC, which are ganged to function with the line switch LA. Switch TA disconnects the coils G and B from the line and connects the line to the test battery 21. Opening of the line 12 by switch TA causes the break relay B to be deenergized and, through its back contacts B1, illuminates the lamp HL and energizes coil BA of the auxiliary relay. The consequent opening of contacts BA2 starts the long break delay period. However, operation of switch TC has opened the circuit from the timing relay to capacitor 34. Thus the timing relay T is held energized only for the short delay controlled by capacitor 35 and, at the end of one-half second, (or other selected interval) relay T is deenergized and closes contacts T1 to illuminate the break lamp BL so that it may be included in the test.

The increased current flowing from the test battery 21 causes the bell at the protected area to operate and the action of the interrupter contacts 23 of the bell produces an intermittent current in the line 12 which causes the watch case receiver 43 to emit an audible sound indicative of the sounding of the bell at the protected area. The operator is thus assured of the continuity of the line throughout the entire circuit and also that lamps HL and BL are operative.

When the test is completed, the ganged test switches TA, TB and TC and line switch LA are returned to their normal positions. The transfer of switch TA causes the break relay B to energize and extinguish lamp HL through the opening of contacts B1. As the manually operated switches pass through their center positions, switches TB and LA are momentarily closed thereby reenergizing winding T of the timing relay and the consequent opening of contacts T3 releases auxiliary break relay BA while lamp BL is extinguished by the opening of contacts T1 and BA1.

The embodiment of the invention illustrated in FIG. 2 employs solid state components rather than relays. The circuit shown is for a positive grounded D.C. power supply. Operation with a negative grounded power supply may be accommodated by reversing the polarity of the rectifiers and the electrolytic capacitors and by the substitution of NPN transistors for the PNP transistors.

The transmission line 12 and the circuit connections and components in the protected area 11 may be identical to those described in connection with FIG. 1. Thus, normal line current might be 15 milliamperes, ground signal current might be 21 milliamperes or more, and break signal current might be 9 milliamperes or less. A smaller difference between normal line current on the one hand and break or ground signal current on the other hand may be accommodated but will not usually be desirable.

The current for line 12 is derived from a negative D.C. terminal 50 which might be, for example, -52 volts with respect to ground. Terminal 50 is coupled to line 12 through a resistor 51, the winding of a potentiometer 52, a fuse 53 and the back contacts of a switch TA.

A resistor 54, a potentiometer 55 and a resistor 56 are connected in series as a voltage divider between terminal 50 and ground. The slider of potentiometer 55

is connected to the base of a transistor TBRK. The emitter of transistor TBRK is coupled to the junction of resistor 52 and fuse 53 through a resistor 57. The collector of transistor TBRK is coupled to a -78 volt D.C. terminal 58 through series connected resistors 59 and 60. The base-emitter potential of transistor TBRK is adjusted by means of the slider of potentiometer 55 so that transistor TBRK will normally be conductive but will cease to conduct if the current through line 12 drops to or below the break signal value, e.g., 9 milliamperes. Where the line current falls below this value, the corresponding voltage drop across resistor 51 and potentiometer 52 falls to a value at which the base-emitter potential of transistor TBRK will be insufficient to keep this transistor conductive.

A transistor TGND is arranged to be nonconductive until the current in line 12 equals or exceeds the ground signal value, e.g., 21 milliamperes. Transistors TGND and TBRK might both be of the 2N1305 type. The base of transistor TGND is connected to the junction of potentiometer 55 and resistor 56, the emitter thereof is coupled to the slider of potentiometer 52, through a resistor 60, while the collector is coupled through a resistor 60' to the junction of resistors 61 and 62 which, with a resistor 63, are connected in series as a voltage divider between terminals 50 and 58. The slider of potentiometer 52 is adjusted so that the base-emitter voltage of transistor TGND will render this transistor conductive when the current flow in line 12 reaches the ground signal value.

BREAK SIGNAL OPERATION

With normal current flowing in line 12, the ground signal indicating lamp GL, the break signal indicating lamp BL and the police call signal indicating lamp HL will all be extinguished. A decrease in line current to the break signal level causes transistor TBRK to become nonconductive, as described above. As a result, collector circuit current through resistors 59 and 60 stops flowing.

The junction of resistors 59 and 60 is connected to the base of a transistor 64, which might be of the 2N1379 type. The emitter of transistor 64 is connected to a -64 volt D.C. terminal 65, while the collector thereof is coupled to terminal 58 through a switch SA1, a resistor 66 and police call lamp HL. When current stops flowing through the collector circuit of transistor TBRK, the base voltage of transistor 64 becomes more negative than the emitter thereof, whereby transistor 64 becomes conductive. Current flowing from terminal 65 to terminal 58 through the emitter-collector circuit of transistor 64 illuminates lamp HL.

Conduction of transistor 64 also completes a discharging circuit for a capacitor 67, the circuit extending from the positive side of capacitor 67 through the emitter-collector circuit of transistor 64 and a rectifier 68. Capacitor 67, which performs no function in break signal operation, is normally maintained charged through a circuit extending from terminal 65 through capacitor 67, a rectifier 69 and a resistor 70 to terminal 58.

A transistor 71, which might be of the 2N1305 type, is normally maintained conductive by the bias potential supplied to the base thereof from a voltage divider circuit coupled between terminals 50 and 58 and comprising resistors 72 and 73, rectifier 69 and resistor 70. The collector of transistor 71 is coupled to terminal 58 through a rectifier 74 and a resistor 75, while the emitter thereof is connected to terminal 65. When transistor 64 becomes conductive, the bias supply for the base of transistor 71 is shunted through the emitter-collector circuit of transistor 64, rendering transistor 71 nonconductive.

Resistor 75, a resistor 76 and a resistor 77 are connected as a voltage divider between terminals 58 and 60. The base of a transistor 78, which might be of the 2N1305 type, is connected to the junction of resistors 76 and

77. The emitter of transistor 78 is connected to terminal 65, while the collector thereof is coupled to terminal 58 through a resistor 79. The emitter circuit current of transistor 71 flowing through resistor 75 is sufficient under normal conditions to maintain the potential of the base of transistor 78 at a point at which transistor 78 will be nonconductive. However, when transistor 71 becomes nonconductive, the base of transistor 78 becomes more negative and transistor 78 becomes conductive.

The negative terminal of a capacitor 80 is connected to the collector of transistor 78. Capacitor 80 is normally maintained charged through a circuit extending from terminal 65 through a rectifier 81, capacitor 80 and resistor 79 to terminal 58. However, when transistor 78 becomes conductive, a discharging circuit for capacitor 80 is completed extending from the positive terminal of capacitor 80 through a rectifier 82, a resistor 83, a resistor 84, terminal 58, terminal 65 and the emitter-collector circuit of transistor 78 to the negative terminal of capacitor 80.

Resistors 84 and 83, a rectifier 85 and a resistor 86 are connected in a voltage divider circuit between terminals 58 and 50. The base of a transistor 87, which might be of the 2N1379 type, is connected to the junction of rectifier 85 and resistor 86. The emitter of transistor 87 is connected to terminal 65, while the collector thereof is coupled to terminal 58 through a resistor 88 and lamp BL. Normally, transistor 87 is maintained nonconductive by the base bias shunting action of a rectifier 88' and the emitter-collector circuit of transistor 71. When transistor 71 is rendered non-conductive and transistor 78 conductive, transistor 87 is still held nonconductive by reason of the discharge current of capacitor 80. When the discharge of capacitor 80 has progressed sufficiently, transistor 87 will become conductive. The delay interval imposed by the discharge time constant of capacitor 80 corresponds to the break signal delay interval imposed by discharge of capacitors 34 and 35 of FIG. 1 and might be, for example, two seconds.

When transistor 87 becomes conductive, lamp BL becomes illuminated. The operator's attention to the illuminated lamp will be attracted by operation of common equipment 40, as described previously. When transistor 87 becomes conductive, a locking circuit is completed for transistor 71 which maintains transistor 71 nonconductive even if the line current returns to normal. This locking circuit includes the emitter-collector circuit of transistor 87 and a rectifier 89 which effectively shunts capacitor 67, preventing a buildup of charge across this capacitor which would render transistor 71 conductive when transistor 64 became nonconductive. Hence, one the delay interval imposed by the discharge time constant of capacitor 80 has passed, subsequent return of line current to normal and consequent conduction of transistor TBRK and non-conduction of transistor 64 will not cause transistor 71 to conduct and will not extinguish lamp BL. Lamp HL will, however, be extinguished when transistor 64 becomes non-conductive.

Briefly, a drop in line current to the break signal level renders transistor TBRK non-conductive and transistor 64 conductive. Conduction of transistor 64 illuminates lamp HL and renders transistor 71 non-conductive. Non-conduction of transistor 71 renders transistor 78 conductive. Conduction of transistor 78 starts the discharge of capacitor 80 which, after the relatively long break signal delay interval, e.g., two seconds, permits transistor 87 to become conductive. Conduction of transistor 87 illuminates lamp BL and locks transistor 71 in its non-conductive condition.

If the break signal on line 12 terminates before transistor 87 becomes conductive, the circuit returns to normal by the conduction of transistor TBRK and the consequent non-conduction of transistor 64 and conduction of transistor 71. The base bias potential for transistor 71 under this condition is supplied from terminal 58

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through a resistor 90, a rectifier 91, and resistor 73. This bias potential circuit is needed since the bias supply through rectifier 69 is effectively shunted at this time through a rectifier 92 and the emitter-collector circuit of transistor 78. As soon as transistor 71 becomes conductive, the negative base supply voltage for transistor 78 is shunted through rectifier 74, causing transistor 78 to become non-conductive and allowing capacitor 80 to recharge to its normal charge level.

If the line current is restored to normal after lamp BL is illuminated, the circuit may be restored to normal by manual activation of ganged switches SA1 and SA2, the former being opened and the latter closed. This switching action also permits deactivation of the lamp BL and HL and silencing of the common equipment 40 even though line current is still at or below the break signal level. Opening of switch SA1 opens the energizing circuit for lamp HL, while closing of switch SA2 completes a shunting circuit for the base supply voltage of transistor 87, the shunting circuit including switch SA2 and rectifier 88' which are connected in series between the junction of resistors 83 and 84 and terminal 65. The base supply of transistor 78 is also shunted through rectifier 74 and switch SA2. Transistor 87 becomes non-conductive, resulting in extinguishing of lamp BL and opening of the locking circuit for transistor 71. Hence, if the switches SA1 and SA2 are returned to the normal positions thereof when the line current is above the break signal value, the circuit is prepared to assume its normal operating condition.

GROUND SIGNAL OPERATION

A ground signal on line 12 causes the line current to increase, e.g., to 21 milliamperes. As explained previously, the ground signal current flowing through resistor 51 and potentiometer 52 causes the emitter of transistor TGND to become more positive than the base, thus rendering transistor TGND conductive.

The base of a transistor 94, which might be of the 2N1305 type, is connected to the junction of resistors 61 and 62. The emitter of transistor 94 is connected to terminal 65, while the collector thereof is coupled to terminal 58 through a rectifier 95 and a resistor 96. The voltage at the base of transistor 94 is normally more negative than the voltage at the emitter, whereby transistor 94 is normally conductive. However, when transistor TGND becomes conductive, the current flow through resistors 63, 62 and 60' and the base-emitter circuit of transistor TGND causes the base of transistor 94 to become more positive than the emitter, rendering transistor 94 non-conductive.

A voltage divider circuit formed by resistor 96, a resistor 97 and a resistor 98 is connected between terminals 58 and 50. The base of a transistor 99, which might be of the 2N1305 type, is connected to the junction of resistors 97 and 98. The emitter of transistor 99 is connected to terminal 65, while the collector thereof is coupled to terminal 58 through a resistor 100. Transistor 99 is normally nonconductive, since the emitter thereof is maintained more negative than the base due to the shunting action of rectifier 95 and the collector-emitter circuit of transistor 94. However, when transistor 94 becomes nonconductive, this shunting circuit is opened and the base of transistor 99 becomes more negative than the emitter, rendering transistor 99 conductive.

The negative terminal of an electrolytic capacitor 101 is connected to the collector of transistor 99. The positive terminal of capacitor 101 is coupled to terminal 65 through a rectifier 102. Rectifier 102 is shunted by a variable resistor 103. The positive terminal of capacitor 101 is also coupled through a rectifier 104 to the junction of a resistor 105 and a rectifier 106. Resistor 105 and rectifier 106 are included in a voltage divider circuit between terminals 58 and 50, which also includes a resistor

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tor 107 and a resistor 108. The base of a transistor 109, which might be of the 2N1379 type, is connected to the junction of rectifier 106 and resistor 108. The emitter of transistor 109 is connected to terminal 65, while the collector thereof is coupled to terminal 58 through a resistor 110 and lamp GL.

Capacitor 101 is normally maintained charged through a circuit extending from terminal 58 through resistor 100, capacitor 101 and rectifier 102 to terminal 65. When transistor 99 becomes conductive, capacitor 101 discharges through the collector-emitter circuit of transistor 99, rectifier 104 and resistors 105 and 107. Another discharge path for capacitor 101 extends through the collector-emitter circuit of transistor 99 and resistor 103. The discharging time constant for capacitor 101 may be adjusted by varying the magnitude of resistor 103.

When charged, capacitor 101 acts to prevent transistor 109 from conducting. Transistor 109 is also normally prevented from conducting when transistor 94 is conductive by reason of the bias voltage shunt path through a rectifier 111 and the collector emitter circuit of transistor 94. When capacitor 101 becomes sufficiently discharged, transistor 109 becomes conductive. When transistor 109 is conductive, the energizing circuit for lamp GL is completed and this lamp becomes illuminated. The delay time provided by capacitor 101 is selected on the same basis as the ground signal delay period for the circuit of FIG. 1 and might be, for example, one-half second.

The conduction of transistor 109 completes a locking circuit for transistor 94, preventing transistor 94 from becoming conductive even if line current returns to normal. This locking circuit extends from terminal 65 through the emitter-collector circuit of transistor 109 and a rectifier 112 to the junction of resistors 62 and 63, providing a shunt path for the base bias voltage of transistor 94.

Briefly, a ground signal current in line 12 causes transistor TGND to become conductive, resulting in nonconduction of transistor 94 and, in turn, conduction of transistor 99. Conduction of transistor 99 starts discharge of capacitor 101, which, after the relatively brief ground signal delay period, renders transistor 109 conductive. Conduction of transistor 109 illuminates lamp GL and locks transistor 94 in its nonconductive condition.

Illumination of lamp GL is accompanied by operation of the common equipment 40 to summon the operator, as described previously.

If the ground signal current in line 12 does not persist until the end of the delay period afforded by the discharge time constant of capacitor 101, transistor 94 will become conductive and transistor 97 will become nonconductive when transistor TGND becomes nonconductive, thus allowing capacitor 101 to recharge and returning the circuit to normal.

If the line current has returned to normal after having persisted at the ground signal value beyond the end of the delay period, lamp GL may be extinguished and the circuit returned to normal by closing switch SB'. Switch SB' may conveniently be connected to the same handle as switches SA1 and SA2, but arranged to be operated upon throwing of the switch handle in the opposite direction. Switch SB' intercouple terminal 65 and the junction of resistors 105 and 107 through a rectifier 113. Hence, closing of switch SB' shunts the base bias supply for transistor 109, rendering the latter nonconductive. With transistor 109 nonconductive, lamp GL will be extinguished and the locking circuit for transistor 94 through rectifier 112 will be opened, permitting transistor 94 to become conductive and return the circuit to normal if normal line current has been restored. If normal line current has not been restored, the sequence of steps leading to illumination of lamp GL will be repeated when switch SB' is opened.

DOUBLE DROP OPERATION

As explained previously, a double drop signal involves a short duration break, e.g., 10-30 milliseconds, followed immediately by a ground signal. The appearance of a break signal causes transistor TBRK to become nonconductive and transistor 64 to become conductive. Conduction of transistor 64 illuminates lamp HL and renders transistor 71 nonconductive.

Transistor 78 is rendered conductive by non-conduction of transistor 71 and the discharging of capacitor 80 commences, as described previously. However, when the ground signal appears, which will be well before the end of the break signal delay period, transistor TBRK becomes conductive, rendering transistor 64 non-conductive and thereby extinguishing lamp HL. However, transistor 71 cannot become conductive because capacitor 67 is discharged. Capacitor 67 has remained discharged since, with transistor 78 conductive, the charging circuit for capacitor 67 through rectifier 69 and resistor 70 is shunted by rectifier 92 and the emitter-collector circuit of transistor 78.

The ground signal received at the end of the break signal acts to render transistor TGND conductive, transistor 94 non-conductive and transistor 99 conductive. As a result, a charging circuit for capacitor 67 through rectifier 91 and resistor 90 is effectively shunted by a rectifier 114 and the emitter-collector circuit of transistor 99. Thus, the break signal is held because there is no way for capacitor 67 to recharge even if the ground signal had terminated before the end of the ground signal delay period. The principal function of capacitor 67 is to provide a brief delay to cover the transition from the break to the ground signal without losing the break indication. Hence, capacitor 67 acts to perform basically the same function as rectifier 33 in FIGURE 1.

Conduction of transistor 99 starts the brief ground signal delay period controlled by discharge of capacitor 101 so that, at the end of this brief delay period, transistor 109 will conduct and ground signal lamp GL will be illuminated. Transistor 94 will be locked in its non-conductive condition through rectifier 111, as described previously, insuring that lamp GL will remain illuminated.

With transistor 109 conductive, the base bias supply for transistor 78 will be shunted through a rectifier 115 and the emitter-collector circuit of transistor 109. This shunting action renders transistor 78 non-conductive, preventing further discharge of capacitor 80 and hence stopping the delay action afforded by the discharge current of capacitor 80 and permitting transistor 87 to conduct and illuminate lamp BL. The relatively long break signal delay period has thus been converted essentially to the relatively short ground signal delay period. Once illuminated the break and ground signal lamps are locked in and the common equipment is operated to signal the operation as described previously.

Should the line current restore to normal before the end of the ground signal delay period, the circuit will return to normal as described previously. When the signals are locked in and the line current has returned to normal, the circuit may be restored to normal as described in connection with the individual ground signal and break signal operations.

POLICE CALL SIGNAL OPERATION

The short duration break followed by the pulsing ground characteristic of a police call signal causes the break lamp BL to be illuminated and to lock in as described in connection with break signal operation except that the break signal delay afforded by capacitor 80 is not effective. In this connection, during the day protection period when police calls are to be received, switch SB' is closed shunting the base bias voltage of transistor 78 through a rectifier 116 and switch SB'. This shunting action prevents transistor 78 from conducting and hence

transistor 87 will conduct as soon as transistor 71 becomes non-conductive. Subsequent pulsing of the current in line 12 causes transistor 64 to become alternately conductive and non-conductive, thus causing the police call lamp HL to turn on and off at the same rate. When line current has returned to normal, the circuit may be restored to the normal day condition by momentary opening of switch SA1 and closing of switch SA2.

The common equipment will usually be relatively sophisticated, but may simply be current responsive devices in the energizing circuits for the lamps arranged to activate an audible alarm.

The test operation using switch TA is essentially the same as described in connection with FIGURE 1.

While this invention has been described as connection with specific embodiments thereof and in specific uses, various modifications thereof will occur to those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In an electrical protection system in which a remote place is coupled to a station through a current carrying communication line and in which selected occurrence at said remote place are signalled to said station selectively through changes in current flow in said line from a normal value to a first value, through changes in current flow in said line from said normal value to a second value and by a short duration change in current flow in said line from said normal value to said first value followed immediately by a change in current flow in said line to said second value, an annunciating circuit at said station comprising:

- (a) first and second signal indicating devices;
- (b) first and second normally open energizing circuits coupled, respectively, to said first and second signal indicating devices and each being arranged, when closed, to operate the corresponding signal indicating device;
- (c) first current responsive means coupled to said line and being responsive to a change in current flow in said line to said first value to complete said first energizing circuit;
- (d) first delay means coupled to said last mentioned means and arranged to delay completion of said first energizing circuit for a first time interval; a change in current flow in said line to said normal value before the end of said first time interval preventing completion of said first energizing circuit;
- (e) second current responsive means coupled to said line and being responsive to a change in current flow in said line to said second value to complete said second energizing circuit;
- (f) second delay means coupled to said last mentioned means and arranged to delay completion of said second energizing circuit for a second time interval, said second time interval being substantially less than said first time interval; a change in current flow in said line to said normal value before the end of said second time interval preventing completion of said second energizing circuit; and
- (g) means coupled to said first and second delay means and responsive to a change in current flow in said line to said first value for a time less than said first time interval followed immediately by a change in current flow in said line to said second value to render ineffective said first delay means whereby said first and second energizing circuits are rendered conductive immediately after said second time interval imposed by said second delay means; a change in current flow in said line to said normal value before the end of said second time interval and following said immediate change in current flow in said line preventing completion of both of said first and second energizing circuits.

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2. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by increase in current flow in said line to said second value, an annunciating circuit at said central station comprising:

- (a) first and second signal indicating devices;
- (b) first and second normally open energizing circuits coupled, respectively, to said first and second signal indicating devices and each being arranged, when closed, to operate the corresponding signal indicating device;
- (c) first current responsive means coupled to said line and being responsive to a drop in current flow in said line to said first value to complete said first energizing circuit;
- (d) first delay means coupled to said mentioned means and arranged to delay completion of said first energizing circuit for a first time interval; an increase in current flow in said line above said first value before the end of said first time interval preventing completion of said first energizing circuit;
- (e) second current responsive means coupled to said line and being responsive to an increase in current flow in said line to said second value to complete said second energizing circuit;
- (f) second delay means coupled to said last mentioned means and arranged to delay completion of said second energizing circuit for a second time interval, said second time interval being substantially less than said first time interval; a decrease in current flow in said line below said second value before the end of said second time interval preventing completion of said second energizing circuit; and
- (g) means coupled to said first and second delay means and responsive to a decrease in current flow in said line to said first value for a time less than said first time interval followed immediately by an increase in current flow in said line to said second value to render ineffective said first delay means whereby said first and second energizing circuits are rendered conductive immediately after said second time interval imposed by said second delay means; a decrease in current flow in said line below said second value before the end of said second time interval and following said immediate increase in current flow in said line preventing completion of both of said first and second energizing circuits.

3. In an annunciating circuit for an electrical protection system as set forth in claim 2:

- (h) a third signal indicating device; and
- (i) means responsive to a pulsating current in said line to operate said third signal indicating device.

4. In an annunciating circuit for an electrical protection system as set forth in claim 3:

- (j) manually operable means to prevent completion of said second energizing circuit.

5. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by increase in current flow in

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said line to said second value, an annunciating circuit at said central station comprising:

- (a) first and second signal indicating devices;
- (b) first and second normally open energizing circuits coupled, respectively, to said first and second signal indicating devices and each being arranged, when closed, to operate the corresponding signal indicating device;
- (c) first current responsive means coupled to said line and being responsive to a drop in current flow in said line to said first value just to condition said first energizing circuit for completion and then to complete said first energizing circuit;
- (d) first delay means coupled to said last mentioned means and arranged to delay completion of said first energizing circuit after said condition thereof for a first time interval; an increase in current flow in said line above said first value before the end of said first time interval preventing completion of said first energizing circuit and removing said conditioning thereof;
- (e) second current responsive means coupled to said line and being responsive to an increase in current flow in said line to said second value just to condition said second energizing circuit for completion and then to complete said second energizing circuit; and
- (f) second delay means coupled to said last mentioned means and arranged to delay completion of said second energizing circuit for a second time interval after said conditioning thereof, said second time interval being substantially less than said first time interval; a decrease in current flow in said line below said second value before the end of said second time interval preventing completion of said second energizing circuit and removing said conditioning thereof;
- (g) means coupled to said first and second delay means and responsive to a decrease in current flow in said line to said first value for a time less than said first time interval followed immediately by an increase in current flow in said line to said second value to render ineffective said first delay means whereby said first and second energizing circuits are rendered conductive immediately after said second time interval imposed by said second delay means; a decrease in current flow in said line below said second value before the end of said second time interval and following said immediate increase in current flow in said line preventing completion of both of said first and second energizing circuits and removing said conditioning of both of said first and second energizing circuits.

6. In an annunciating circuit for an electrical protection system as set forth in claim 5:

- (h) means to delay said removal of conditioning of said first energizing circuit upon an increase in current flow in said line from said first value to said second value before the end of said first time interval for a period sufficient that said first energizing circuit remains conditioned upon occurrence of said immediate increase in current flow.

7. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through changes in current flow in said line from a normal value to a first value, through changes in current flow in said line from said normal value to a second value and by a short duration change in current flow in said line from said normal value to said first value followed immediately by a change in current flow in said line to said second value, an annunciating circuit at said central station comprising:

- (a) first and second signal indicating devices;

- (b) first and second normally open energizing circuits coupled, respectively, to said first and second signal indicating devices and each being arranged, when closed, to operate the corresponding signal indicating device;
- (c) first current responsive means coupled to said line and being responsive to a change in current flow in said line to said first value first to condition said first energizing circuit for completion and then to complete said first energizing circuit;
- (d) first delay means coupled to said last mentioned means and arranged to delay completion of said first energizing circuit after said conditioning thereof for a first time interval; a change in current flow in said line from said first value toward said normal value before the end of said first time interval preventing completion of said first energizing circuit and removing said conditioning thereof;
- (e) second current responsive means coupled to said line and being responsive to a change in current flow in said line to said second value first to condition said second energizing circuit for completion and then to complete said second energizing circuit;
- (f) second delay means coupled to said last mentioned means and arranged to delay completion of said second energizing circuit for a second time interval after said conditioning thereof; said second time interval being substantially less than said first time interval; a change in current flow in said line from said second value to said normal value before the end of said second time interval preventing completion of said second energizing circuit and removing said conditioning thereof;
- (g) means coupled to said first and second delay means and responsive to a change in current flow in said line to said first value for a time less than said first time interval followed immediately by a change in current flow in said line to said second value to render ineffective said first delay means whereby said first and second energizing circuits are rendered conductive immediately after said second time interval imposed by said second delay means; a change in current flow in said line to said normal value before the end of said second time interval and following said immediate change in current flow in said line preventing completion of both of said first and second energizing circuits and removing said conditioning of both of said first and second energizing circuits; and
- (h) and releasable means to lock said respective energizing circuits in said completed conditions thereof.
8. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by an increase in current flow in said line to said second value, an annunciating circuit at said central station comprising:
- (a) a first relay having a coil coupled in series in said line and arranged to be energized only by values of current flow in said line greater than said first value;
- (b) a second relay having a coil coupled in series in said line and being arranged to energize said second relay only when the current flow in said line at least equals said second value;
- (c) a third relay having an energizing circuit arranged to be completed when said first relay is energized;
- (d) a fourth relay having a normally closed energizing circuit; said normally closed energizing circuit

- ing circuit; said normally closed energizing circuit including means to open said normally closed energizing circuit when either of said second or third relays is energized;
- (e) first and second capacitors;
- (f) charging means for said first and second capacitors arranged normally to maintain said first and second capacitors in charged condition;
- (g) means to disable said charging means when said third relay is energized;
- (h) means to discharge said first and second capacitors in parallel through said fourth relay thereby to maintain said fourth relay energized for a first time interval after energization of said third relay;
- (i) a first signal indicating device having an energizing circuit arranged to be completed to energize said first device when said third relay is energized and said fourth relay is deenergized;
- (j) a second signal indicating device having an energizing circuit arranged to be completed to energize said second device when said second relay is energized and said fourth relay is deenergized;
- (k) means for opening said normally closed energizing circuit for said fourth relay when said second relay is energized;
- (l) means for uncoupling one of said capacitors from said fourth relay and for disabling the charging means for the other of said capacitors thereby to maintain said fourth relay charged for a second time interval after said second relay is energized, said second time interval being less than said first time interval;
- (m) means coupled to said second relay to maintain said third relay energized when a short duration decrease in current flow in said line to said first value is followed immediately by an increase in current flow in said line to said second value whereby both of said signal indicating devices will be energized upon completion of said second time interval with said second relay energized; and
- (n) means included in said energizing circuit for said first signal indicating device and responsive to said third relay to maintain said first device energized upon the energization of said first relay in response to an increase in current flow in said line to said second value following a short duration decrease in current flow in said line to said first value whereby both of said signal indicating devices will be energized upon completion of said second time interval with said second relay energized.
9. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by an increase in current flow in said line to said second value, an annunciating circuit at said central station comprising:
- (a) a first relay having a coil coupled in series in said line and arranged to be energized only by values of current flow in said line greater than said first value;
- (b) a second relay having a coil coupled in series in said line and being arranged to energize said second relay only when the current flow in said line at least equals said second value;
- (c) a third relay having an energizing circuit arranged to be completed when said first relay is energized;
- (d) a fourth relay having a normally closed energizing circuit; said normally closed energizing circuit including means to open said normally closed energizing circuit when either of said second or third relays is energized;

- gizing circuit when either of said second or third relays is energized;
- (e) first and second capacitors;
 - (f) a charging circuit for said first and second capacitors arranged normally to maintain said first and second capacitors in charged condition;
 - (g) means to open said charging circuit when said third relay is energized;
 - (h) means to discharge said first and second capacitors in parallel through said fourth relay thereby to maintain said fourth relay energized for a first time interval after energization of said third relay;
 - (i) a first signal indicating device having an energizing circuit arranged to be completed to energize said first device when said third relay is energized and said fourth relay is deenergized;
 - (j) a locking circuit for said third relay arranged to lock said third relay in energized condition after having been energized and with said fourth relay deenergized;
 - (k) a second signal indicating device having an energizing circuit arranged to be completed to energize said second device when said second relay is energized and said fourth relay is deenergized;
 - (l) means to lock said second relay in energized condition when said energizing circuit for said second signal indicating device is completed;
 - (m) means for opening said normally closed energizing circuit for said fourth relay when said second relay is energized;
 - (n) means for uncoupling one of said capacitors from said fourth relay and for opening the charging circuit for the other of said capacitors thereby to maintain said fourth relay charged for a second time interval after said second relay is energized, said second time interval being less than said first time interval;
 - (o) means coupled to said second relay to maintain said third relay energized when a short duration decrease in current flow in said line to said first value is followed immediately by an increase in current flow in said line to said second value whereby both of said signal indicating devices will be energized upon completion of said second time interval with said second relay energized; and
 - (p) means included in said energizing circuit for said first signal indicating device and responsive to said third relay to maintain said first device energized upon the energization of said first relay in response to an increase in current flow in said line to said second value following a short duration decrease in current flow in said line to said first value whereby both of said signal indicating devices will be energized upon completion of said second time interval with said second relay energized.
10. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by an increase in current flow in said line to said second value, an annunciating circuit at said central station comprising:
- (a) a first relay having its coil coupled in series in said line and arranged to be energized only by values of current flow in said line greater than said first value;
 - (b) a second relay having front and back contacts and having first and second coils, said first coil being coupled in series in said line and being arranged to energize said second relay only when the current

- flow in said line at least equals said second value;
 - (c) a third relay having front and back contacts and having an energizing circuit arranged to be completed when said first relay is energized;
 - (d) a fourth relay having back contacts and having a normally closed energizing circuit; said normally closed energizing circuit including back contacts of said second relay and back contacts of said third relay whereby said normally closed energizing circuit is opened when either of said second or third relays is energized;
 - (e) first and second capacitors;
 - (f) a charging circuit for said first and second capacitors arranged normally to maintain said first and second capacitors in charged condition;
 - (g) means to open said charging circuit when said third relay is energized;
 - (h) means to discharge said first and second capacitors in parallel through said fourth relay thereby to maintain said fourth relay energized for a first time interval after energization of said third relay;
 - (i) a first signal indicating device having an energizing circuit including front contacts of said third relay and back contacts of said fourth relay whereby said first device is energized when said third relay is energized and said fourth relay is deenergized;
 - (j) a locking circuit for said third relay including front contacts of said third relay and back contacts of said fourth relay whereby said third relay is locked in energized condition after having been energized and with said fourth relay deenergized;
 - (k) a second signal indicating device having an energizing circuit including front contacts of said second relay and back contacts of said fourth relay whereby said second device will be energized when said second relay is energized and said fourth relay is deenergized, said second signal indicating device being connected in parallel with said second coil of said first relay thereby to lock said second relay in energized condition when said second device is energized.
 - (l) means including back contacts of said second relay for opening said normally closed energizing circuit for said fourth relay when said second relay is energized;
 - (m) means including back contacts of said second relay for uncoupling one of said capacitors from said fourth relay and for opening the charging circuit for the other of said capacitors thereby to maintain said fourth relay charged for a second time interval after said second relay is energized, said second time interval being less than said first time interval;
 - (n) means coupled to said second relay to maintain said third relay energized when a short duration decrease in current flow in said line to said first value is followed immediately by an increase in current flow in said line to said second value whereby both of said signal indicating devices will be energized upon completion of said second time interval with said second relay energized; and
 - (o) means included in said energizing circuit for said first signal indicating device and responsive to said third relay to maintain said first device energized upon the energization of said first relay in response to an increase in current flow in said line to said second value following a short duration decrease in current flow in said line to said first value whereby both of said signal indicating devices will be energized upon completion of said second time interval with said second relay energized.
11. In an annunciating circuit for an electrical protection system as set forth in claim 10:
- (p) a third signal indicating device; and

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(q) means responsive to a pulsating current in said line to operate said third signal indicating device.

12. In an annunciating circuit for an electrical protection system as set forth in claim 10:

(p) manually operable means for selectively releasing said locking circuit for said third relay and opening said energizing circuit for said second device and thereby releasing said second relay.

13. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by an increase in current flow in said line to said second value, an annunciating circuit at said central station comprising:

- (a) a first transistor coupled to said line and arranged to be conductive for all values of current flow in said line above said first value and to be nonconductive for a current flow in said line equal to or less than said first value;
- (b) a second transistor coupled to said line and arranged to be conductive only for values of current flow in said line at least equal to said second value;
- (c) a first signal indicating device;
- (d) a third transistor;
- (e) means including the output circuit of said third transistor to energize said first signal indicating device when said third transistor is conductive;
- (f) a first capacitor having a charging circuit and a discharging circuit, said first capacitor being coupled to the input circuit of said third transistor in a sense to cause discharge current of said first capacitor to hold said third transistor nonconductive;
- (g) means responsive to the condition of said first transistor to retain said third transistor nonconductive, said last mentioned means being operative only while said first transistor is conductive;
- (h) means responsive to nonconduction of said first transistor to discharge said first capacitor whereby said third transistor becomes conductive and said first signal indicating device becomes energized at the end of a first time interval, said last mentioned means being released upon nonconduction of said first transistor prior to the end of said first time interval;
- (i) a second signal indicating device;
- (j) a fourth transistor;
- (k) means including the output circuit of said fourth transistor to energize said second signal indicating device when said fourth transistor is conductive;
- (l) a second capacitor having a charging circuit and a discharging circuit, said second capacitor being coupled to the input circuit of said fourth transistor in a sense to cause discharge current of said second capacitor to hold said fourth transistor nonconductive;
- (m) means responsive to the condition of said second transistor to retain said fourth transistor nonconductive, said last mentioned means being operative only while said second transistor is nonconductive;
- (n) means responsive to conduction of said second transistor to discharge said second capacitor whereby said fourth transistor becomes conductive and said second signal indicating device becomes energized at the end of a second time interval, said last mentioned means being released by conduction of said second transistor prior to the end of said second time interval;
- (o) manually releasable locking circuits responsive to conduction of said second and fourth transistors,

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respectively, to lock said respective second and fourth transistors in conductive condition; and

(p) means coupled to said third and fourth transistors and responsive to nonconduction of said first transistor for a time less than said first time interval followed immediately by conduction of said second transistor for a time equal to said second time interval to render ineffective said first time interval whereby said third and fourth transistors are rendered conductive at the conclusion of said second time interval.

14. In an electrical protection system in which a remote place is coupled to a central station through a current carrying communication line and in which selected occurrences at said remote place are signalled to said central station selectively through decreases in current flow in said line to a first value below a normal value, through increases in current flow in said line to a second value above said normal value and by a short duration decrease in current flow in said line to said first value followed immediately by an increase in current flow in said line to said second value, an annunciating circuit at said central station comprising:

- (a) a first transistor coupled to said line and arranged to be conductive for all values of current flow in said line above said first value and to be nonconductive for a current flow in said line equal to or less than said first value;
- (b) a second transistor coupled to said line and arranged to be conductive only for values of current flow in said line at least equal to said second value;
- (c) a first signal indicating device;
- (d) a third transistor;
- (e) means including the output circuit of said third transistor to energize said first signal indicating device when said third transistor is nonconductive;
- (f) a first capacitor having a charging circuit and a discharging circuit, said first capacitor being coupled to the input circuit of said third transistor in a sense to cause discharge current of said first capacitor to hold said third transistor nonconductive;
- (g) means responsive to the condition of said first transistor to retain said third transistor nonconductive, said last mentioned means being operative only while said first transistor is conductive;
- (h) means responsive to nonconduction of said first transistor to discharge said first capacitor whereby said third transistor becomes conductive and said first signal indicating device becomes energized at the end of a first time interval, said last mentioned means being released upon nonconduction of said first transistor prior to the end of said first time interval;
- (i) a second signal indicating device;
- (j) a fourth transistor;
- (k) means including the output circuit of said fourth transistor to energize said second signal indicating device when said fourth transistor is conductive;
- (l) a second capacitor having a charging circuit and a discharging circuit, said second capacitor being coupled to the input circuit of said fourth transistor in a sense to cause discharge current of said second capacitor to hold said fourth transistor nonconductive;
- (m) means responsive to the condition of said second transistor to retain said fourth transistor nonconductive, said last mentioned means being operative only while said second transistor is nonconductive;
- (n) means responsive to nonconduction of said second transistor to discharge said second capacitor whereby said fourth transistor becomes conductive and said second signal indicating device becomes energized at the end of a second time interval, said last mentioned means being released by conduction

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- of said second transistor prior to the end of said second time interval;
- (o) manually releasable locking circuits responsive to conduction of said second and fourth transistors, respectively, to lock said respective second and fourth transistors in conductive condition; 5
- (p) a third capacitor having a charging circuit and a discharging circuit;
- (q) means responsive to nonconduction of said first transistor to discharge said third capacitor; 10
- (r) means operative when said third capacitor is discharged to prevent release of said means responsive to conduction of said first transistor until said third capacitor is charged;
- (s) means operative upon conduction of said fourth transistor to stop discharging of said first capacitor and to prevent charging of said third capacitor whereby a decrease in current flow in said line to said first value for a time less than said first time interval followed immediately by an increase in cur- 20

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- rent flow in said line to said second value and continuance of current flow in said line at at least said second value for said second time interval renders both of said third and fourth transistors conductive and both of said signal indicating devices energized.
15. An annunciating circuit for an electrical protection system as set forth in claim 14, comprising:
- (t) a third signal indicating device; and
- (u) means responsive to a pulsating current flow in said line to energize said third signal indicating device.

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