

Nov. 3, 1942.

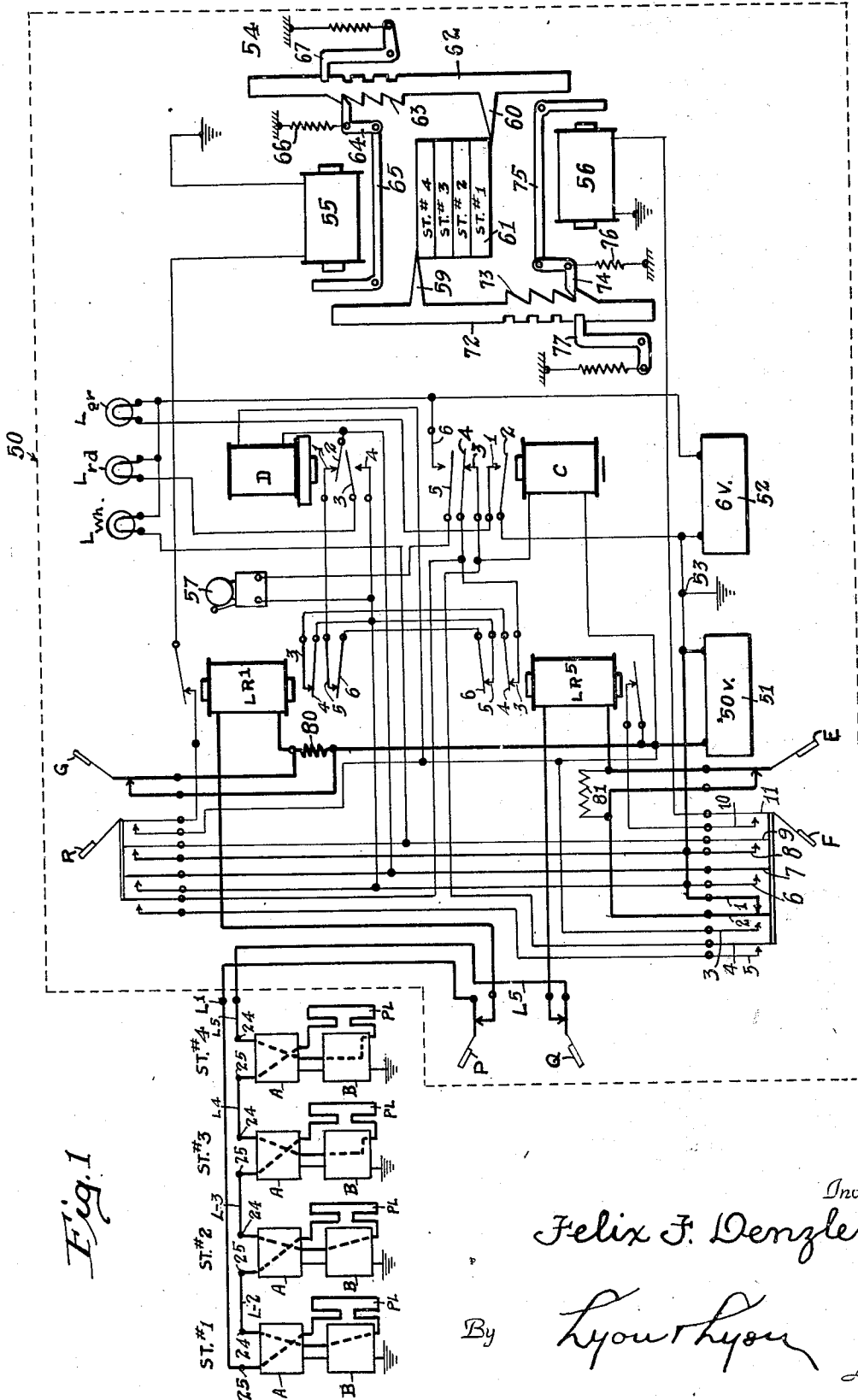
F. F. DENZLER

2,300,409

ALARM SYSTEM

Filed Aug. 26, 1940

7 Sheets-Sheet 1



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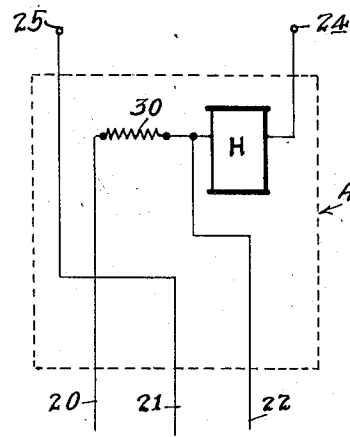
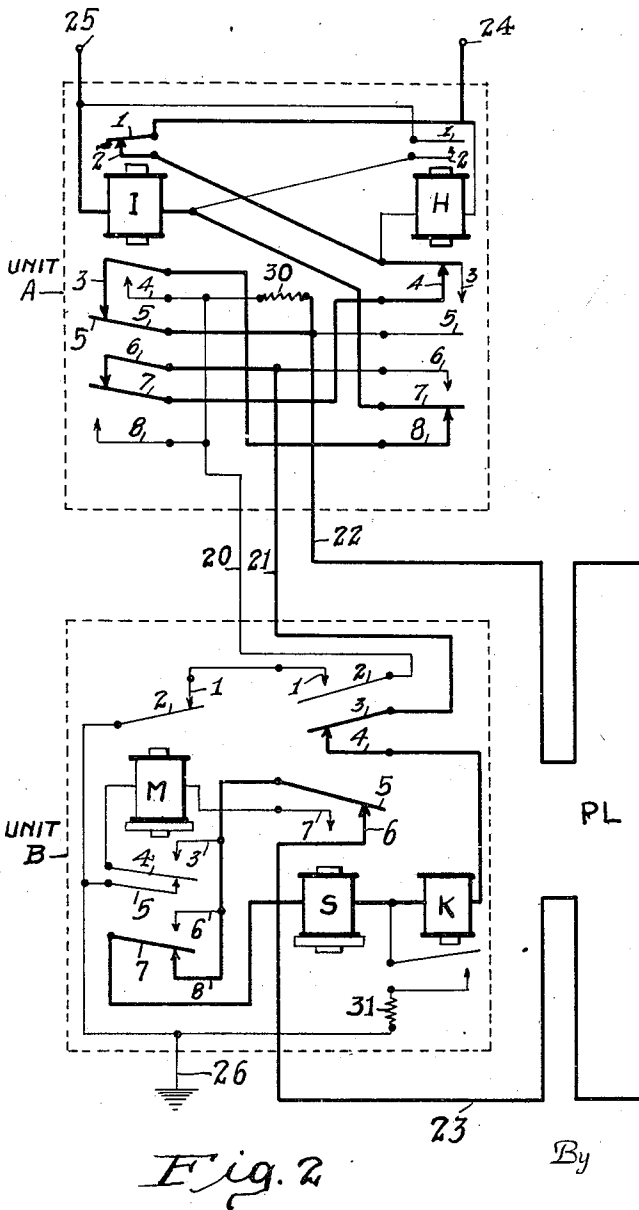
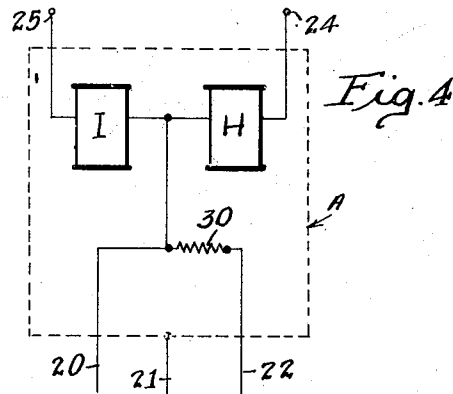
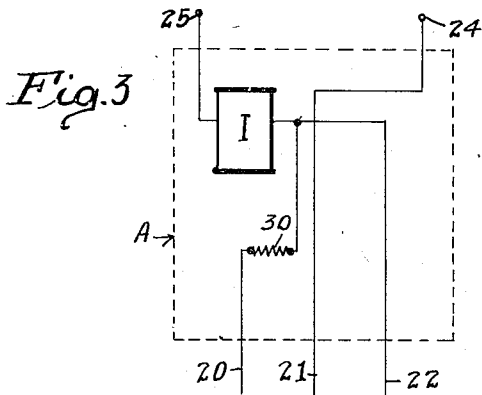
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2,300,409

ALARM SYSTEM

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7 Sheets-Sheet 2



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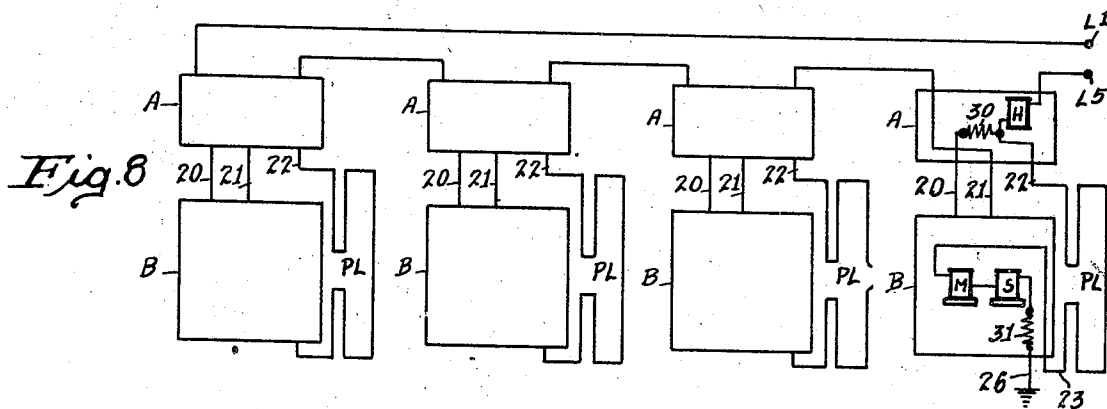
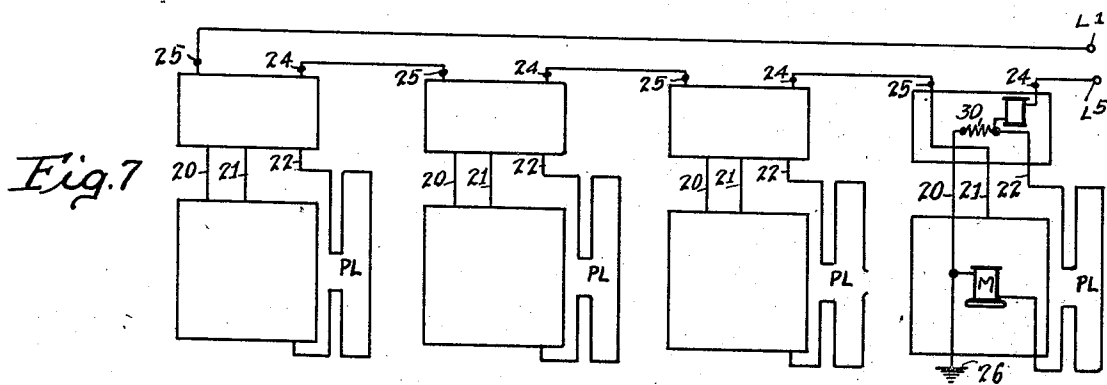
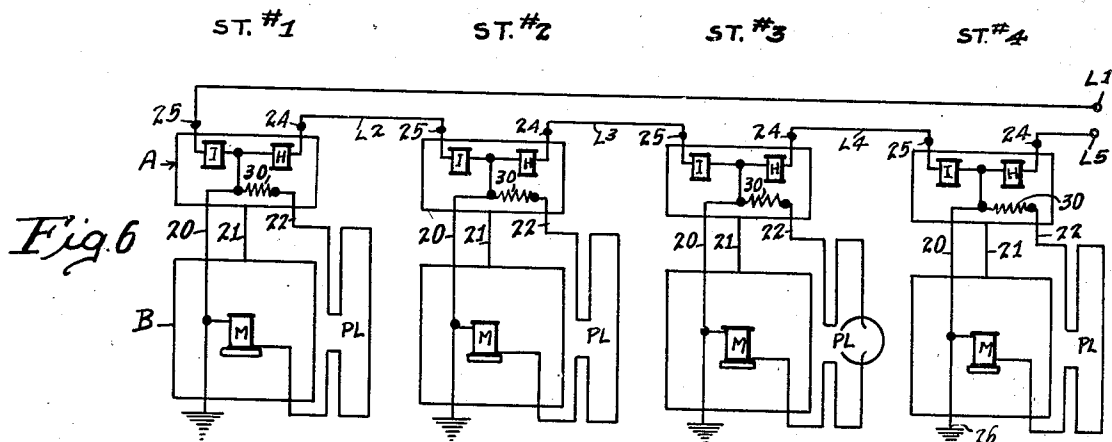
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ALARM SYSTEM

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7 Sheets-Sheet 3



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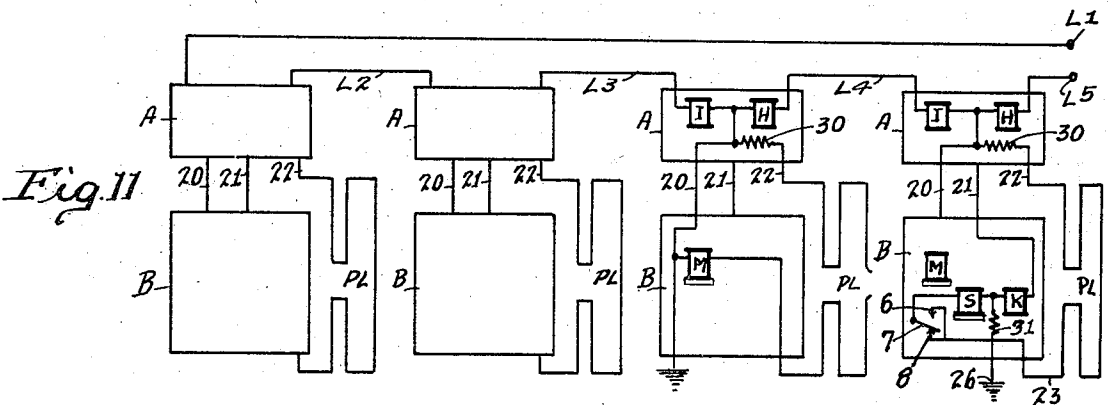
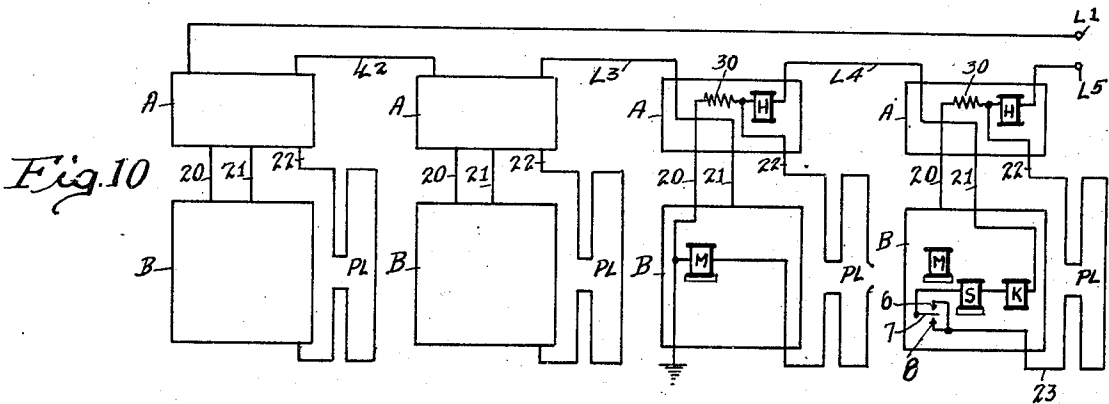
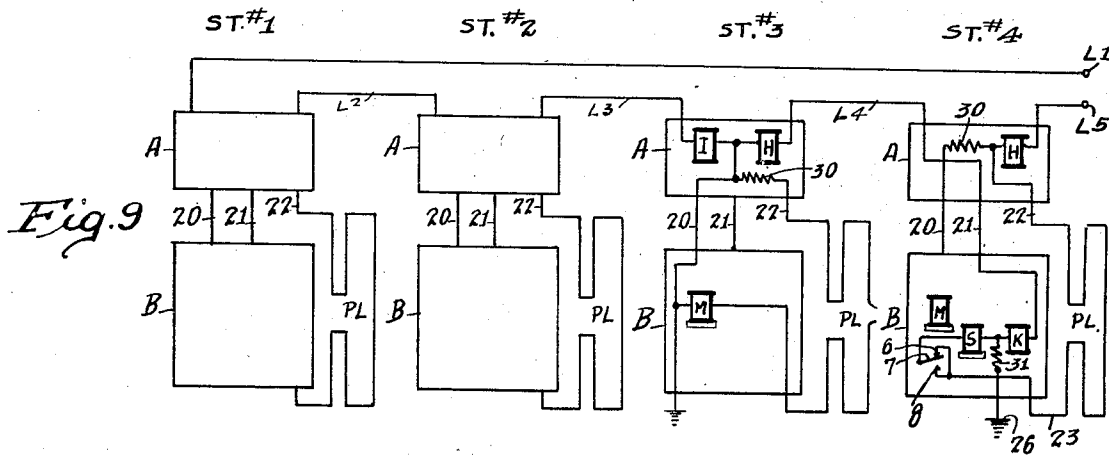
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ALARM SYSTEM

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7 Sheets-Sheet 4



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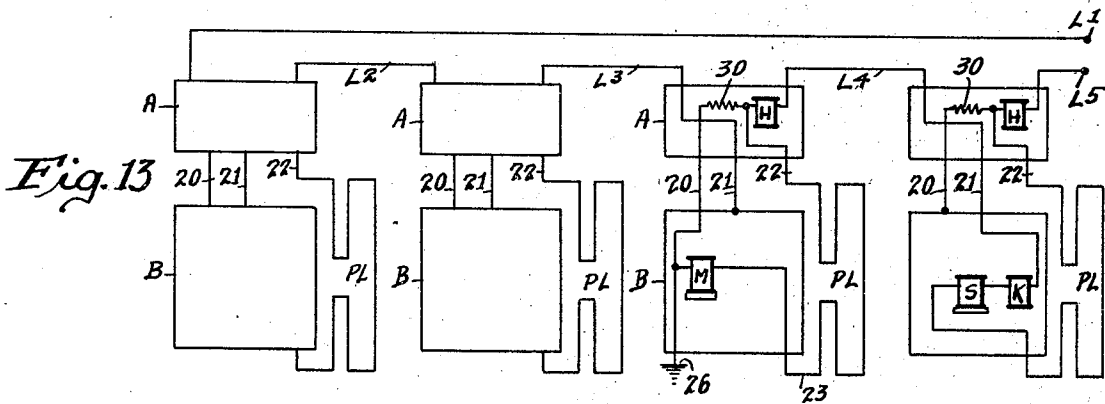
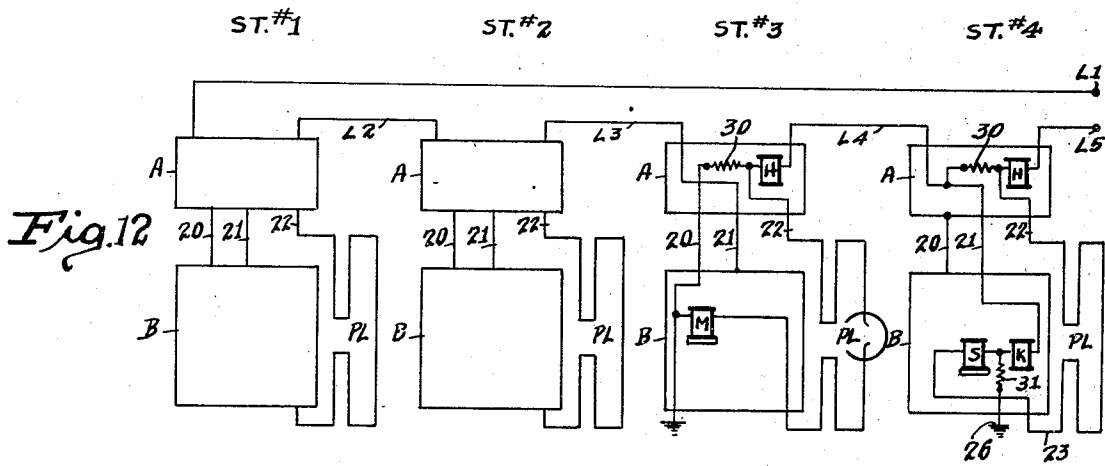
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2,300,409

ALARM SYSTEM

Filed Aug. 26, 1940

7 Sheets-Sheet 5



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2,300,409

ALARM SYSTEM

Filed Aug. 26, 1940

7 Sheets-Sheet 6

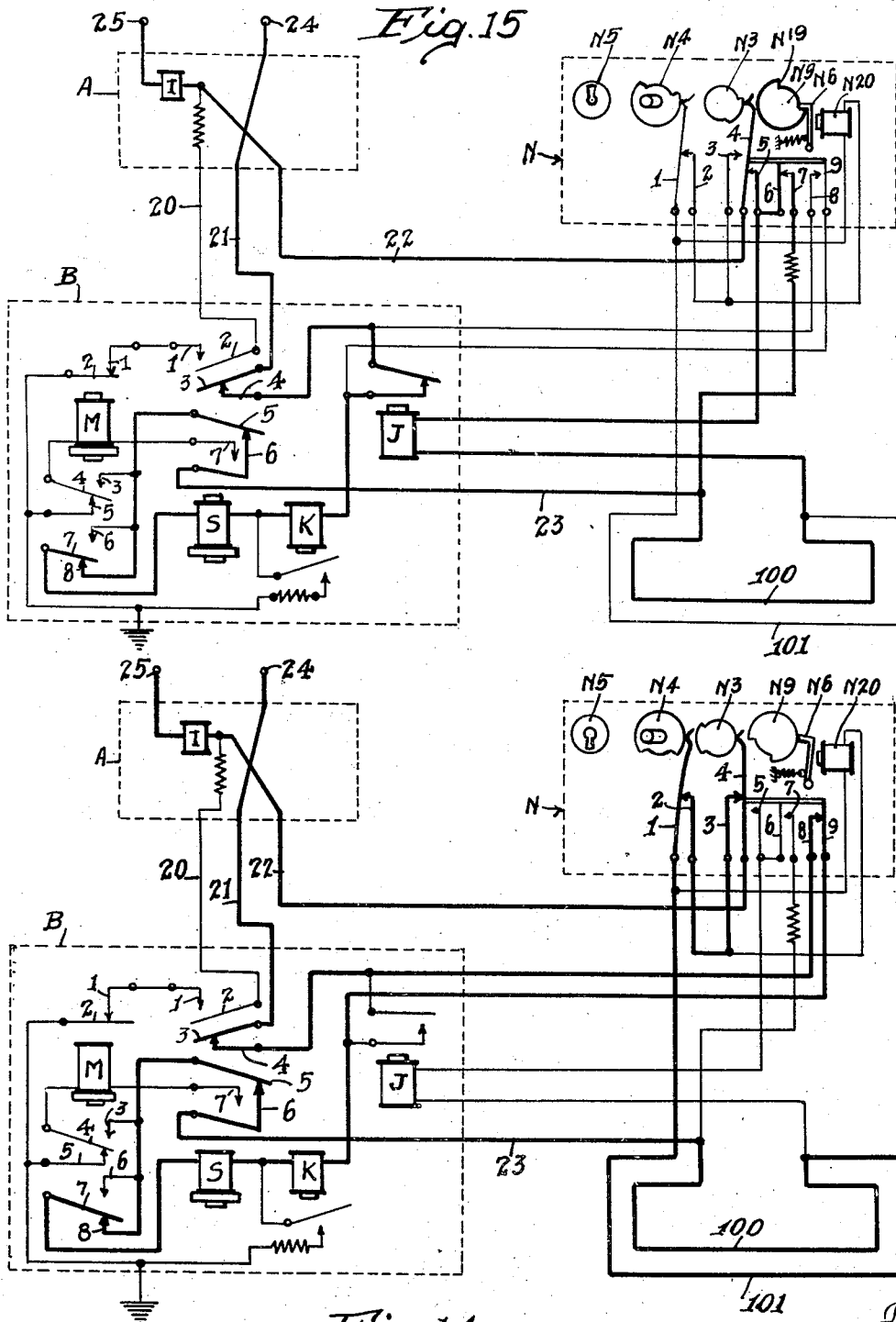


Fig. 14

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2,300,409

ALARM SYSTEM

Filed Aug. 26, 1940

7 Sheets-Sheet 7

Fig. 17

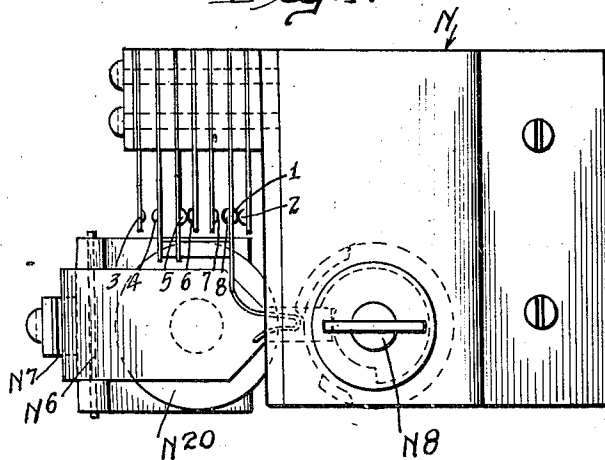


Fig. 18

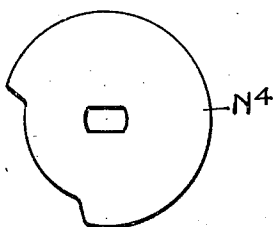


Fig. 19

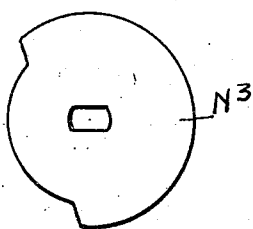


Fig. 20

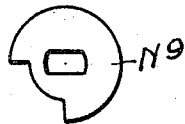
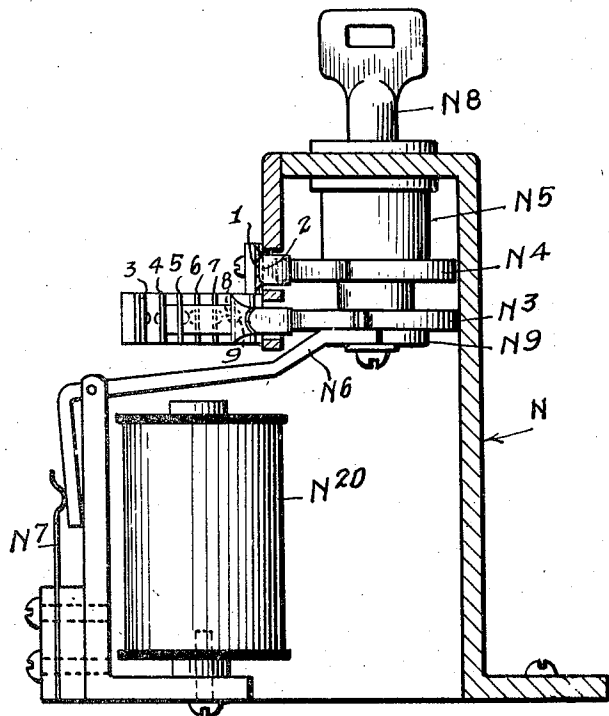


Fig. 16



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UNITED STATES PATENT OFFICE

2,300,409

ALARM SYSTEM

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Application August 26, 1940, Serial No. 354,218

20 Claims. (Cl. 177—360)

This invention relates to electrical safety systems, such as burglary and fire alarm systems, and relates more particularly to systems involving a central station from which lines emanate to a plurality of substations.

An object of the invention is to provide a system incorporating a plurality of substations connected in series in a single line extending from a central station in which a danger condition at any substation will produce an alarm at the central station, together with cooperating means at the central station and at the substations for quickly determining in a simple and positive manner where the alarm originated; that is, which substation, if any, it originated at, or whether it was caused by an open or other fault in the line between two substations.

Another object of the invention is to provide in a system of the type referred to, for the use of "day" and "night" protective loops, respectively, at substations, with means for determining what loops at any substation are connected in the line.

Various other, more specific objects and features of the invention will become apparent from the detail description to follow of a particular embodiment of the invention.

In the drawings:

Fig. 1 is a circuit showing a general layout of a system in accordance with the invention, showing the circuits at the central station in detail and showing the circuits at the substations schematically;

Fig. 2 is a detail diagram of the circuit at a substation in the system of Fig. 1;

Fig. 3 is a schematic diagram of a portion of the apparatus at a substation in normal condition when current is flowing in one direction in the line;

Fig. 4 is a schematic diagram of the same apparatus showing its condition when no line current is flowing;

Fig. 5 is a schematic circuit of the same apparatus, showing its condition when energized with line current flowing in the opposite direction of flow to that in Fig. 3;

Fig. 6 is a schematic diagram showing the condition at all four substations when line current has been cut off at the central station;

Figs. 7, 8, 9, 10, 11, 12 and 13 are schematic diagrams of the same stations shown in Fig. 6 showing successive operations in the system;

Fig. 14 is a circuit diagram of a modified substation circuit differing from that shown in Fig. 2 in that "day" and "night" protective loops are

provided, the circuit being shown in "night" condition;

Fig. 15 is a circuit diagram of the same system shown in Fig. 14, but adjusted for "day" condition;

Fig. 16 is a horizontal section view of a switch incorporated in the circuit of Figs. 14 and 15;

Fig. 17 is a front elevation view of the switch shown in plan in Fig. 16; and

Figs. 18, 19 and 20 are detail elevation views of different cams incorporated in the switch of Figs. 16 and 17.

Apparatus at central station

Referring first to Fig. 1, the system therein disclosed comprises a central station 50 from which there extends a line conductor L1, this conductor extending to a terminal 25 of a substation ST#1. The other terminal 24 of ST#1 is connected by a line conductor L2 to the terminal 25 of a second substation ST#2, similar in all respects to ST#1. The terminal 24 of ST#2 is connected by a line conductor L3 to the terminal 25 of a third station ST#3. The terminal 24 of ST#3 is connected by line conductor L4 to the terminal 25 of a fourth substation ST#4 and the terminal 24 of this station is connected by line conductor L5 back to the central station 50.

All of the substations are identical, each including a unit A, a unit B and a protective loop PL. These units will be described in detail later.

The apparatus at the central station includes a 50-volt line battery 51 and a 6-volt auxiliary battery 52, each of which has one of its terminals permanently connected to ground at 53. The auxiliary battery is employed to actuate the alarm signals and is capable of giving an alarm signal even though the main line battery 51 should be dead.

The central station also includes a pair of line relays LR1 and LR5, respectively, which are associated with the line conductors L1 and L5, respectively. It also includes a trouble relay C, an alarm relay D, an alarm buzzer 57, three signal lamps L_{wh}, L_{rd}, L_{gr}, respectively, and an annunciator 54. The annunciator 54 includes a pair of annunciator magnets 55 and 56, respectively for actuating a pair of pointers 59 and 60, respectively, both associated with an indicator plate 61. As shown in the drawings, the pointer 60 is normally positioned at the bottom of the indicator plate 61, the latter having four positions numbered 1, 2, 3 and 4 associated with the correspondingly numbered substations,

Each position may bear the address of its associated substation. As indicated, the pointer 60 is normally positioned at the bottom of the indicator plate 61 and is attached to a vertically extending rack 62 having ratchet teeth 63 thereon adapted to be engaged by a pawl 64 pivoted to an arm 65 on the armature of magnet 55. The pawl 64 is normally maintained in elevated position by a spring 66. The rack 62 is yieldably held in any position to which it is moved by a detent 67.

The pointer 59 is normally positioned at the upper end of the indicator plate 61. It is attached to a rack 72 having ratchet teeth 73 cooperating with a pawl 74 pivotally connected to an arm 75 on the armature of magnet 56. A spring 76 holds the pawl 74 in lowermost position except when the magnet 56 is energized. A pawl 77 normally retains the rack 72 in whatever position it may be moved.

In addition to the apparatus so far mentioned, the central station includes a pair of resistances 80 and 81, respectively, and six switches E, F, G, R, P and Q, respectively.

The relays LR1 and LR5 and C are fast operating, but alarm relay D is a slow release relay to prevent an alarm being given in response to momentary breaks in the circuit, which are frequently caused by earth vibrations.

The two lines L1 and L5 are normally connected together through the substations so that a closed circuit is completed as shown in heavy lines in Fig. 1. Thus the circuit may be traced from the ungrounded terminal of the line battery 51 through the contacts of switch G through the line relay LR1 and through switch P to line L1. Line L5 is connected through switch Q and the winding of line relay LR5 through the contacts of switch E and the contacts 2 and 1 of switch F to ground. As a result of the foregoing circuit, the line relays are normally energized or pulled, and their associated contacts are closed. So long as the line relays are pulled, a circuit is completed from the ungrounded terminal of the line battery 51 through relay C and its contacts 3 and 4, through the contacts 3 and 4 of line relay LR5 and over contact 3 of relay LR1 to contact 4 of the latter relay, which is permanently connected to ground, pulling the trouble relay C.

Likewise, operation of both the line relays completes an energizing circuit for the alarm relay D. This circuit may be traced over the ungrounded terminal of the line battery 51 through the winding of relay D through contacts 2 and 1 of relay D, contacts 5 and 6 of relay LR1 and contact 6 of relay LR5 to contact 5 of the latter relay which is permanently connected to ground.

It will be apparent that any momentary interruption in the line current sufficient to release either of the line relays will open the holding circuits of the trouble relay C and the alarm relay D. Relay C upon releasing applies ground from its contact 2 to its contact 1 and thence to the lamp L_{tr}, lighting the latter since the other terminal of the lamp is permanently connected to the ungrounded terminal of the auxiliary battery 52. When the line relays again pull up after only a momentary interruption, the trouble relay C remains down until manually restored. Any release of the trouble relay C also sounds the buzzer 57 by completing a circuit to the latter over contacts 5 and 6 of relay C.

If the line circuit is open for an appreciable

length of time, the alarm relay D also falls down. This applies ground over contacts 4 and 3 of relay D to the red alarm lamp L_{rd}.

It will be observed that both relays C and D are energized over holding contacts so that after once being released these relays must be restored by the attendant.

The switches E and G are connected in shunt to the resistances 81 and 80, respectively and are employed to introduce one or both of those resistances into the line circuit for testing purposes to determine whether a station equipped with "day" and "night" loops is set for day or night operation, in a manner to be described later.

The switches F, R, Q and P are used in testing when locating a trouble or alarm condition at a particular substation, as will appear hereinafter.

SUBSTATION APPARATUS

Referring now to Fig. 2, the equipment at each substation is subdivided for convenience of description only into a unit A and a unit B and a protective loop PL. As previously indicated in connection with Fig. 1, each substation has line terminals 24 and 25, respectively. These are connected to the apparatus in unit A, which apparatus includes a relay H, a relay I and a resistor 30. The unit B includes three relays M, S and K, respectively, and a resistor 31. The units A and B are directly connected by two conductors 20 and 21. The loop PL is connected through a lead 22 with unit A and through a lead 23 with unit B. Unit B has a ground connection 26.

The function of unit A is to connect the line terminals 24 and 25 to the conductors 20, 21 and 22 in a particular manner, depending upon the mode of application of the line current. Thus if battery is applied to the line terminal 25, unit A functions to complete a circuit, as shown in heavy lines in Fig. 2, in which terminal 25 is connected to lead 22 and terminal 24 is connected to lead 21. On the other hand, as will appear later, if battery is applied to line terminal 24 the connections are reversed, terminal 24 being connected to lead 22 and terminal 25 being connected to lead 21.

The function of unit B is to respond in such a way as to produce an indication at the central station in response to a particular condition in the line or in the local loop PL.

Normal substation circuit

As previously recited, under normal conditions current flows out from the central station from battery over line L1 through all the substations and back into the central station to ground over line L5. From Fig. 1 it is apparent that line current will therefore enter each of the four substations over the terminal 25 at that station and will leave the substation over terminal 24. Keeping this in mind and referring now to Fig. 2, the current flowing through each substation may be readily traced over the circuit shown in heavy lines. Thus current enters from line terminal 25 through relay I, back contacts 7 and 8 of relay H, contacts 3 and 5 of relay I to lead 22. From lead 22 the current flows through the loop PL to lead 23 and into unit B; thence over the contacts 6 and 5 of relay S, contacts 8 and 7 of relay M through relay S, through relay K, through contacts 4 and 3 of relay S to lead 21, and back into unit A. Lead 21 is connected

within unit A through contacts 6 and 7 of relay I, contacts 4 and 3 of relay H and contacts 2 and 1 of relay I to the line terminal 24. It will be apparent, therefore, that under normal conditions the relays I, S and K are energized and the relay M is deenergized. It should be further noted that relay M is invariably deenergized when relay S is energized, because the only path of current to relay M is over the back contact 7 of relay S.

It is also to be noted that all paths to ground 26 are normally open within unit B so that no path to ground from either line terminal 24 or 25 can exist.

To simplify further explanations of the system as a whole, three possible conditions of unit A will be explained with reference to the schematic diagrams of Figs. 3, 4 and 5.

Thus when line current enters unit A through terminal 25 (as just described with reference to Fig. 2), the net effect is to connect terminal 25 through relay I directly to lead 22 and through the resistance 30 the lead 20. At the same time the line terminal 24 is connected directly to the lead 21.

If no line current is flowing into either terminal 25 or terminal 24, both the relays H and I are released, with the result shown in Fig. 4, namely, line terminal 25 is connected through relay I to lead 20; likewise line terminal 24 is connected through relay H to lead 20 and lead 20 is connected through the resistor 30 to the lead 22. The lead 21 is open in unit A. The final results shown in Fig. 4 may be checked by tracing the circuits in Fig. 2, remembering that both the relays H and I are released.

The third possible condition is with battery applied to terminal 24 following the condition of no current, shown in Fig. 4. Thus referring to Fig. 2 with both relays H and I released, current applied to terminal 24 will flow through relay H, through contacts 3 and 4 of relay H, and through contacts 7 and 8 of relay I to lead 20. Furthermore, under any condition in which relays H and I were released, all the relays in unit B would also be released so that lead 20 would be connected to ground over contacts 2 and 1 of relay S and contacts 1 and 2 of relay M. Therefore relay H would operate and transfer connection of its contact 3 from contact 4 to contact 5, thereby completing a circuit from terminal 24 through relay H through contacts 3 and 5 of relay H and through resistance 30 to lead 20. At the same time, line terminal 24 is connected directly through relay H to the lead 22, by virtue of the fact that lead 22 is permanently connected to the contacts 5 of both relays H and I. The operation of relay H closes its contacts 1 and 2, thereby short-circuiting the winding of relay I and connecting line terminal 25 over contacts 1 and 2 of relay H and contacts 7 and 6 of relay H to lead 21. This final condition resulting from the operation of relay H is shown in Fig. 5, in which it will be observed that terminal 24 is connected through relay H directly to lead 22 and through resistance 30 to lead 20, while terminal 25 is connected directly to lead 21.

Operation of system in response to an open on the loop at substation ST#3

Assume that as a result of a burglary in the premises at ST#3 (Fig. 1), the loop PL at that station is opened. This breaks the series circuit from L1 to L5, and releases line relays LR1 and LR5 in the central station.

The circuit will immediately function to complete the circuit over line L1 to ground at one of the stations, thereby resulting in the restoration of the line relay LR1. However, the line relay LR5 will remain deenergized.

The release of the relay LR5 releases the trouble relay C and the alarm relay D. Those relays in turn light the lamps L_{gr} and L_{rd} and sound the buzzer 57 so that the attendant is apprised of the fact that an alarm condition has been created somewhere on the line; he does not know where. The attendant then opens the line switch P.

The condition at the substations at this time is indicated schematically in Fig. 6. It will be observed that each of the units A is in the condition shown in Fig. 4, in which both relays H and I are connected in parallel from the two terminals 24 and 25, respectively, to ground over lead 20.

The attendant then actuates the switch F. This applies current over contacts 7 and 8 of switch F to the lamp L_{wh} illuminating it and thereby indicating that the line is in abnormal condition and is being tested. Switch F also applies ground over its contacts 6 and 7 to energize the trouble relay D, thereby energizing that relay and extinguishing the lamp L_{rd}.

The operation of switch F disconnects its contact 2 from the ground contact 1 and connects it to the battery contact 3, thereby applying battery directly through the contacts of switch E and the line relay LR5 and through the line switch Q to L5. Finally, the operation of the switch F connects contact 2 of line relay LR5 through contacts 10 and 11 of switch F to the annunciator magnet 56 so that operation of the line relay LR5 will energize the magnet 56.

Referring now to Fig. 6, current flows out over L5 to terminal 24 of station ST#4 and thence through relay H and lead 20 to ground, energizing relay H which, as previously outlined in connection with Fig. 5, causes the circuit at station #4 to assume the condition shown in Fig. 7. It will be observed that L5 to which battery is applied, is now connected through relay H, where it divides and flows to ground over two paths, one path including the resistor 30 and the other path including the loop PL and the relay M. Relay M is designed to pull up slowly but after an interval it does pull up, whereupon the circuit at the substation assumes the condition shown in Fig. 8, in which both the leads 20 and 21 are open in unit B, but lead 22 is connected through the loop PL and lead 23 through relays M and S and resistor 31 to ground. The circuit of unit B may be traced in Fig. 2 from lead 23 through contacts 6 and 7 of relay S, through relay M, contacts 4 and 3 of relay M, contacts 6 and 7 of relay M, through relay S, over contacts of relay K and through resistor 31 to ground 26. Relay S thereupon operates and for an instant the condition of the circuit is as shown in Fig. 9.

It will be observed that whereas in Fig. 8 lead 21 was open at unit B, in Fig. 9 lead 21 is connected through relay K to relay S, so that line current entering station ST#4 from line L5 flows through unit A to lead 22, through the loop to lead 23, through the contacts 6 and 5 of relay S (Fig. 2), through contacts 6 and 7 (Fig. 7) of relay M, and through relay S, where the current divides, part of it flowing to ground through resistor 31 over the back contacts of relay K and the other part flowing through relay K and contacts 4, 3 of relay S to lead 21 and thence (Fig.

9) through unit A to line L4 and through relay H in unit A at station ST#3 to ground.

Thereupon relay K at station ST#4 pulls and relay H pulls at station ST#3.

So far there has been no interruption of current over line L5 out of the central station since the switch F was actuated. At that time relay LR5 pulled, applying battery over its contacts 1 and 2 and the contacts 9 and 10 of switch F to energize the annunciator magnet 56, which pulled its armature and stepped its pawl 74 upwardly along the rack 72 to engage the next tooth thereon. As yet, however, the rack has not been moved and will not move until the magnet 56 is deenergized. This deenergization occurs only when the line relay LR5 is deenergized, which in turn can result only from an interruption in the flow of line current out over line L5.

It is important to note that relay M is so constructed that when it operates, armature 7 closes on contact 6 before armature 4 closes on contact 3; also, armature 4 closes on contact 3 before breaking from contact 5. It will be seen, therefore, that the operation of relay M did not interrupt the continuity of current flow through relay LR5.

As shown in Fig. 9, current has been cut off relay M (a slow release relay) but the relay does not release until after relay K at station ST#4 has pulled and relay H at station ST#3 has pulled.

Referring now to Fig. 10, the operation of relay K has opened the path to ground through resistor 31 so that the only path to ground over line L5 is through the loop, the contacts of relay M and the relays S and K at station ST#4 and relay H and resistor 30 at station ST#3. While this condition exists, contact 7 of relay M leaves its front contact 6 and swings back to close on its back contact 8, thereby momentarily opening the circuit from line L5 to ground at station ST#3.

This momentary opening of the circuit over line L5 releases the line relay LR5 at the central station, which in turn releases the annunciator magnet 56, permitting the spring 76 to retract the pawl 74 and shift the pointer 59 to a point midway between stations ST#3 and ST#4 on the indicator plate 61.

The momentary opening of the line also releases relays H and K at station ST#4 and relay H at station ST#3. Relay S does not release because it is a slow release relay.

Referring now to Fig. 11, the release of relay H at stations ST#3 and ST#4 restores units A at those respective stations to the condition previously described in connection with Fig. 4. The release of relay K at station ST#4 reconnects the resistor 31 to relay S, restoring a circuit from line L5 through relay H through the loop PL through the contacts 8 and 7 of relay M, through relay S and through resistor 31 to ground at station ST#4. This current is sufficient to hold relay S and reenergize relay H at station ST#4. Similarly, current also flows from line L5 through relay H and relay I at station ST#4 through line L4 to station ST#3 and through relay H at station ST#3 to ground. The energization of relay H at station ST#4 restores unit A at station ST#4 to the condition shown in Fig. 12, in which a circuit is completed from line L5 through relay H and resistor 30, through the loop PL and through relay S where the current divides, part of it flowing to ground through resistor 31 and the other part flowing

through relay K to lead 21, thence through unit A to line L4 and thence through relay H at station ST#3 and through resistor 30 at that station to ground. It will be observed from Fig. 12 that relay H at station ST#3 has operated. This operation resulted substantially simultaneously with the operation of relay H at station ST#4.

It might be assumed that relay I at station ST#4 (Fig. 11) would also be operated since the same current flows through relay I at station ST#4 as through relay H at station ST#3. However, under the conditions shown in Fig. 11, the current through relay H at ST#4 is greater than the current through relay I at station ST#4, causing relay H to operate first. Immediately relay H operates, it short-circuits the winding of relay I at the contacts 1, 2 of relay H (Fig. 2).

It will be observed from Fig. 12 that the circuit from relay S at station ST#4 to relay H at station ST#3 is completed through relay K at station ST#4, operating the latter to open the connection to ground through resistor 31, leaving the substations in the condition shown in Fig. 13, in which there is no path to ground at station ST#4 but current flows to ground through the resistor 30 at station ST#3. Relay M cannot operate at station ST#3 because it is in series with the protective loop PL which, as previously stated, has been opened as the result of a burglary.

It will be observed therefore that the system has passed from the initial condition shown in Fig. 6 to that shown in Fig. 13, with only one interruption in the line current, which single interruption released the relay LR5 at the central station to release the annunciator 56 and step the indicator 59 one notch to a position midway between the stations ST#3 and ST#4 on the indicator plate 61.

The operator now operates the switch R and closes the switch P, thereby applying current from the line battery 51 through the line relay LR1 to the line L1, without interrupting the flow of current to the line L5.

Immediately following the closure of switch P at the central station, current flows from the line battery 51 through the relay LR1 at the central station, out over line L1 and through relay I at station ST#1 to ground over lead 20. The line relay LR1 at the central station and the relay I at substation ST#1 thereupon operate. The operation of line relay LR1 applies battery over contacts 2 and 1 of switch R and contacts 2 and 1 of relay LR1 to the annunciator magnet 55, causing the associated pawl 64 to step up one notch on the rack 62. At substation ST#1 the operation of relay I places unit A at that station in the condition shown in Fig. 3, which completes a circuit from line L1 through relay I at station ST#1 to lead 22 (Fig. 3). From lead 22 (Fig. 6) the current flows through the loop PL and through the relay M to ground. Thereupon relay M at station ST#1 operates and completes the circuit through relay S and resistor 31 at station ST#1 to ground, exactly as occurred previously at station ST#4 (Fig. 8).

The operation of relay S at station ST#1 cuts out relay M and completes a circuit through relay K at station ST#1 to lead 21, exactly as previously described with reference to station ST#4 (Fig. 9). At this time lead 21 (Fig. 3) is connected through unit A to terminal 24 of station ST#1 which (Fig. 6) is connected to L2 and thence through relay I at station ST#2 to

ground. Therefore relay K at station ST#1 and relay I at station ST#2 operate.

The operation of relay K at station ST#1 opens the path to ground through resistor 31 (Fig. 2) at that station, so that the only path to ground is now over line L2 and through station ST#2. Next the slow release relay M at station ST#1 releases momentarily opening the path from line L1 to ground at station ST#2, and momentarily releasing the relay LR1 at the central station to step the rack 62 upwardly one notch and move the pointer 60 midway between stations ST#1 and ST#2 on the indicator plate 61.

When relay M at station ST#1 has fully released, it again completes a path from L1 to L2, again energizing relay I and relay K, and completes a path from L1 to L2 (Fig. 6) exactly as shown in Fig. 1. In other words, the normal circuit condition has been re-established at station ST#1.

At station ST#2 current flows from line L2 through relay I to lead 22, as shown in Fig. 3 and from lead 22 (Fig. 1) through the loop PL to lead 23 and thence (Fig. 2) through the back contacts 6 and 7 of relay S through relay M to ground, operating relay M exactly as relay M in station ST#1 was previously operated. Furthermore, the operation of relay M at station ST#2 completes a path for the operation of relay S at station ST#2 through resistor 31 to ground.

The operation of relay S at ST#2 releases relay M exactly as previously described at other stations, and the release of relay M again momentarily interrupts the only path to ground (through resistance 31 at ST#2) again releasing the line relay LR1 at the central station and stepping the pointer 60 upwardly another notch to a position midway between ST#2 and ST#3 on the indicator plate 61.

It will be noted that a circuit is also completed from relay S (Fig. 2) at ST#2 through relay K, through contacts 4 and 3 of relay S to lead 21 and from lead 21 (Fig. 1) through unit A at ST#2 to the line L3 and from line L3 into the unit B at ST#3. However, at this time, (Fig. 13) line L3 is connected through unit A at ST#3 to lead 21 which is open in unit B (contact 3 of relay S, which is released).

In view of the fact that there is no path for current flow from line L3 to ground at ST#3, relay K at ST#2 does not operate and the path to ground through resistor 31 at ST#2 continues, so that line relay LR1 at the central station holds up after having released momentarily twice in succession; once in response to the release of relay M at ST#1 and the second time in response to release of relay M at ST#2. The pointer 60 (Fig. 1) therefore stops in a position midway between ST#2 and ST#3 on indicator plate 61. It will be remembered that the pointer 59 moved into position midway between stations ST#3 and ST#4 on indicator plate 61. Therefore the pointers 59 and 60 stopped above and below the station ST#3 respectively, boxing that station, and indicating that the open protective loop is located at station ST#3.

After the open on the protective loop at ST#3 has been repaired, the circuit is restored to the normal condition shown in Fig. 1 by restoring the switches F and R to normal condition. This again applies battery through relay LR1 at the central station over L1 to station ST#1 where relays L, M, S and K pull up, followed by the release of relays M, I and K, and then the re-

operation of relays I and K to complete the circuit through ST#1 to L2, exactly as previously described. This is followed by the successive operation, in the same identical manner, of the relays at ST#2, ST#3 and ST#4, respectively, the circuit finally being completed as shown in Fig. 1 back through line L5 into the central station and through line relay LR5 to ground. Of course during the successive operation and release of the relays M at the different stations, line current was interrupted to momentarily release the line relay LR1, but this did not actuate the annunciator magnet 55 since the circuit of the latter was open at contacts 1 and 2 of switch E.

Summary of operation of system to locate the source of an alarm

It will be observed from the foregoing description of operation that the unit A at each substation (Fig. 2) functions always to contact the live end (the end connected to battery at the central station) of the line coming into that station through the loop circuit PL and the unit B in the same manner. Thus it will be observed that in Fig. 5 the terminals 24 and 25 are connected to the leads 20, 21 and 22 in a manner exactly opposite to that of Fig. 3.

It will also be observed that units A and B at ST#4 and ST#3 completed and maintained a path over L5 to ground at ST#3, where the loop was open. On the other hand, the units A and B at ST#1 and ST#2 completed a path from L1 to ground at ST#2, the station next to the station where the loop was open. This is because the ground connection can be transferred to another station only in response to the operation of relay M and the relay M is in the local loop circuit, as shown at ST#3 in Fig. 13, so that it cannot operate unless the loop is capable of supplying current to relay M.

It is also to be observed that the same result will be obtained with a ground on one of the loops PL as with an open in the loop, because (referring to Fig. 2) a ground on the loop will prevent current flowing from lead 22 to lead 23 and thence through back contacts 6 and 7 of relay S to relay M. It is also apparent that a ground on any of the loops will cut off current from the line relay LR5 at the central station and thereby produce an alarm indication.

The operation in response to an open on the protective loop PL at one of the stations has been described in detail. It is important to note that the system will also function to locate an open on the line between stations. Thus referring to Fig. 1, if an open occurs in the line section L1, then the relays M at ST#4, ST#3, ST#2 and ST#1, respectively, will be successively operated and released in response to application of battery to L5, thereby causing the pointer 59 to be stepped down through four positions to the bottom of station ST#1 on indicator plate 61. On the other hand, when key R is actuated to apply battery to line L1, no one of the relays M will be reached and the pointer 60 will remain in lowermost position, thereby indicating that the open is somewhat in the line section L1 between the central station and substation ST#1.

On the other hand, if an open should occur in the line L2 between stations ST#1 and ST#2, then when battery is applied to line L5, the relays M at stations ST#4, ST#3 and ST#2, respectively, will be successively operated and released, stepping the pointer 59 down three positions to a

position between station ST#1 and ST#2 on the indicator plate 61. Then when battery is applied to line L1, the relay M at station ST#1 will operate and release once to step the pointer 60 up one notch so that it is positioned opposite the pointer 59 and midway between stations ST#1 and ST#2 on the indicator plate 61.

A ground in any line section will produce the same effect as an open, since it will permit the operation of the relays M between the central station and the grounded section, but will prevent the operation of any relay M beyond the ground.

It is also most important to note that a burglar cannot disable the system at any station by interconnecting the terminals 24 and 25 at that station to short out the wiring at that station without interrupting the continuous flow of current through the line to the remaining station. Thus assume (Fig. 1) that the line terminals 24 and 25 at ST#2 are connected directly together, thereby shunting the line current away from unit A at this station. Immediately the relay I at ST#2 releases, transforming unit A to the condition shown in Fig. 4 and connecting both the terminals 25 and 24 through the relays I and H to lead 20, which (Fig. 2) is connected to ground by the release of relay S over contacts 2 and 1 of relay S and contacts 1 and 2 of relay M. A low resistance path to ground within ST#2 is thereupon created, and current flows to ground over this path from L2, thereby interrupting the flow of current into the central station over L-5 and releasing the line relay LR5 to give an alarm. Thereafter the operator at the central station can locate the ground at ST#2 by means of the routine already described.

Day and night circuits

It is sometimes desirable in burglar alarm systems, to extend protection to some portions of the premises at all hours of the day and night, and extend protection to other portions of the premises only at night. Thus there may be windows and walls that are to be guarded against entry at all times, and doors which are to be guarded only at night. It is common to provide such protection by having two protective loops at each station, one loop called the day loop, including the areas that are to be protected both day and night, and the other loop called the night loop covering the areas that are to be protected only at night. My system is readily adaptable for use with separate day and night loop circuits by simply changing the substation circuit from that shown in Fig. 2 to that shown in Figs. 14 and 15, which are identical but show the circuit in two different conditions of operation.

Comparing Fig. 15 with Fig. 2, it will be observed that the only difference is in the provision of the separate day and night loops 100 and 101, respectively, instead of a single loop, the introduction of an additional relay J into unit B, and the addition of a key-operated switch N.

Referring now to Figs. 16 and 17, the switch N comprises a lock cylinder N5 adapted, under certain conditions, to be rotated through one-half revolution by a key N8. Attached to the barrel N5 for rotation therewith are three cams N4, N3 and N9. These cams are cut as shown in Figs. 18, 19 and 20, respectively. The cam N4 actuates a pair of switch contacts 1, 2; cam N3 actuates a set of switch contacts numbered 3, 4, 5, 6, 7, 8 and 9, respectively, and the cam N9 cooperates with a lock armature N6 of a magnet

N20. This armature N6 is normally maintained in operative relation with the cam N9 by a spring N7, but when the cam N20 is energized the armature N6 is drawn down out of possible contact with the cam N9. The operation of the lock switch N is readily apparent from the schematic showing thereof in Fig. 15, and will be described in connection with the operation of the circuit.

In Fig. 15 the switch N is set for day operation, in which the day loop 100 is connected in the circuit but the night loop 101 is not connected; the normal circuit is clearly indicated in heavy lines in Fig. 15, and need not be followed through in detail. It will be observed that the relay J is included in the main circuit in Fig. 15 so that it is normally operated and closes its contacts to complete a circuit direct from relay K to contact 4 of relay S.

Referring now to Fig. 14, the system is shown adapted for night operation, in which both the loops 100 and 101 are connected in series in the heavy line circuit. However, it will be noted that in Fig. 14 the relay J is not energized and its contacts are open. However a circuit is still completed from relay K to contact 4 of relay S, this time over contacts 9 and 8 of key N.

The contacts of switch N are so adjusted that when the switch is thrown from the "day" position shown in Fig. 15 to the "night" position shown in Fig. 14, contact 4 makes with contact 3 and contact 8 makes with contact 9 before contact 4 breaks with contact 5 and before contact 6 breaks with contact 7, thereby preventing momentary opening of the single circuit by operation of the switch.

It will also be observed that in Fig. 15 the barrel N5 is in a position diametrically opposite to that shown in Fig. 14. Furthermore, it is to be remembered that in rotating the barrel from the position shown in Fig. 15 to that shown in Fig. 14, it is rotated in clockwise direction, and vice versa when changing from the position shown in Fig. 14 to that shown in Fig. 15.

The purpose of incorporating the magnetic lock, including the cam N20 and the armature N6 in the switch N, is to prevent turning the lock from the day position shown in Fig. 15 into the night position shown in Fig. 14, unless the night loop is complete. For instance, the night loop may include a door that has not been closed at the time the local attendant seeks to rotate the switch barrel N5. Therefore, when the attendant inserts the key in the lock and turns it, he is able to turn the barrel N5 only 90° because the armature N6 then engages against a shoulder N19 on the cam N9 and prevents further rotation. In this position displaced 90° clockwise from that shown in Fig. 15, the cam N4 opens the contacts 1 and 2 and the cam N3 closes the contacts 3, 4 and 8, 9 but opens the contacts 4, 5 and 6, 7. Under such conditions a path for line current is completed from lead 22 over contacts 4, 3 of switch N and through the magnet N20 back to contact 1 and thence to the night loop 101. If the door previously referred to is still open, then the night loop 101 will be opened and a circuit is not completed for the energization of the magnet N20 and the operator cannot turn the key beyond 90°. He thereupon inspects the premises and closes the door that was interrupting the night loop 101. Thereupon the path for the energization of the magnet N20 is completed over the night loop 101 and the day loop 100 to the lead 23 and the operator completes the rotation of the lock barrel N5 through 180°

to the position shown in Fig. 14, in which the main line circuit is completed from lead 22 through the contacts 4, 3 and the contacts 2, 1 of switch N through the night loop 101 through the day loop 100 back to lead 23. At this time the magnet N20 is deenergized since it is short-circuited by the contacts 1 and 2 of switch N.

Of course there is no function for the magnetic lock when changing over from the night condition shown in Fig. 14 to the day condition shown in Fig. 15, because if both the day and the night loops are intact in the position of Fig. 14, then the day loop is bound to be intact in the position of Fig. 15.

The normal operation of a complete system in which one or more of the substations are equipped for day and night operation as shown in Figs. 14 and 15 is exactly the same in response to an alarm as previously described in connection with the simple substation circuit of Fig. 2, and the operation need not be traced in detail. Suffice it to say that whereas in Fig. 2 there is a solid connection from relay K to contact 4 of relay S, in Fig. 14 this connection is completed through the contacts 8 and 9 of switch N and in Fig. 15 it is completed through the contacts of relay J.

The reason for incorporating the relay J, which is a marginal relay, is to make it possible for the attendant at the central station to determine whether or not the substations have been converted from day condition to night condition. The operation for determining this will now be described:

Assume that in the system of Fig. 1 ST#1 incorporates the circuit shown in Fig. 15 and that the other stations have circuits as shown in Fig. 14. In other words, ST#1 is in day condition whereas the three other stations are in night condition.

The operator at the central station operates switch G which cuts the resistor 80 at the central station into the main line circuit, thereby reducing the current flowing in the heavy line circuit. This causes the marginal relay J at ST#1 to release, but it does not release any relays at any other station because only the relays J are marginal relays. The release of relay J at ST#1 opens the connection between relay K and contact 4 of relay S, thereby interrupting the main line circuit and dropping the relays LR1 and LR5 at the central station, giving an alarm indication, indicating to the operator there that one of the stations is still in day condition; he does not know which station. In order to determine which station has been left in day condition, the operator then proceeds with the same routine tests previously described, to cause the pointers 59 and 60 to locate the station where the circuit has been opened as a result of the relay J at that station being released while the key N is in day position, as shown in Fig. 15. However, during these tests, in order to maintain the open condition of the circuit at the station still in day condition, switch G is left open while the tests are being made with switch F, to introduce the resistor 80 into the circuit and thereby reduce the value of the line current sufficiently to maintain the relay J released at the station in question while the tests are being made with switch F. Similarly, while testing with switch R, switch E is opened to introduce resistor 81.

As one example of values that may be employed in the system:

The relays J may be adapted to operate on 75

20 milliamperes and release on 10 milliamperes if the normal line current is 30 milliamperes, and with such values the resistors 80 and 81 may each have a value of approximately 3000 ohms. The resistors 30 and 31 may have values of 1000 ohms. The relays LR1 and LR5, H, I, M, S and K may be designed to operate on 20 milliamperes and release on 5 milliamperes.

As previously indicated, the relays LR1 and LR5, H, I, K and J are designed to operate fast and release fast. The relay S is of the slow release type in order to hold up while the relay M is releasing. Relay M is of the slow-operating type so as to slow up the successive counting operations at the different substations and give the mechanical elements of the indicator at the central station sufficient time to operate.

There has been shown in the drawings and described in detail a system incorporating four substations. It is to be understood, however, that the system is not limited to this number of substations, but may be employed with either a greater or a smaller number of substations, since the operation is not dependent upon there being any particular number of substations. Other departures from the specific circuit shown will be apparent to those skilled in the art, and the invention is therefore not to be limited to the exact system shown but only to the extent set forth in the appended claims.

I claim:

1. In a signalling system, a central station, a line circuit having two ends terminating at said central station and including a plurality of substations connected in series relation intermediate said two ends, means providing a common current path between said stations, means at each of said substations responsive to current flow thereto over said line circuit from one of said ends thereof and over said common path for momentarily interrupting said current flow and completing a path for current flow through that substation to the portion of said line circuit therebeyond, means at said central station for supplying current to said one end of said line circuit, and means at said central station for counting said momentary interruptions in current flowing into said one end of said line circuit.

2. A signalling system comprising a central station and a plurality of substations, means including a first line section between said central station and a first of said substations for defining a circuit between said central station and said first substation, means including other line sections extending between successive substations for extending said circuit from the central station through successive substations, means at said central station for supplying current to said circuit, switching means at each substation operable in response to current flow thereto over said circuit for switching the next line section into said circuit, and means responsive to successive operations of said switching means for counting the number of said operations.

3. A system as described in claim 2, in which said line sections are arranged in series to form a loop, both ends of which loop terminate at said central station, with means for selectively supplying current to each end of said line at said central station, and including separate means at said central station for separately counting the number of said switching operations following application of current to opposite ends of said line.

4. In a signalling system, a central station, a

sectional line extending from said central station, a plurality of substations positioned in series relation intermediate successive sections of said line, a common current path between all said stations, means at each of said substations normally responsive to potential between said common path and an adjacent line section for completing a circuit from that section to the next section on the other side of said substation, and momentarily interrupting current flow through the first-mentioned section of said circuit, means at the central station for applying potential between said common path and said line, and means at said central station responsive to interruptions in current flow into said line for counting said interruptions.

5. In a signalling system, a central station, a sectional line having two ends terminating at said central station, a plurality of substations positioned in series relation intermediate successive sections of said line, means defining a common current path between all said stations, means at each substation normally responsive to potential between said common path and either of the line sections terminating thereat for completing a circuit between the two adjacent line sections and momentarily interrupting current flow through the first mentioned line section, means at the central station for selectively applying potential between said common path and either end of said line, and separate means at said central station for counting interruptions in current flow into each end of said circuit.

6. A system as described in claim 4, in which one at least of said substations includes a pair of normally closed protective loops, and a selective relay, switch means for selectively connecting either one loop and said selective relay in series in said line circuit, or both loops in series in said circuit, means at the central station for selectively actuating said selective relay from said line circuit, and means for opening said loop circuit in response to actuation of said selective relay.

7. A system as described in claim 5, in which said counting means includes substation identification positioned in the order of arrangement of the substations in said line circuit, a pair of movable indicators normally positioned at opposite ends of said substation identifications, each of said counting means being associated with one of said indicators, and means for moving each indicator from one substation identification to the next in response to each operation of its associated counting means.

8. In a signalling system including a normally closed line circuit, a substation having a day loop normally closed both day and night, and a night loop normally closed only at night, a switch at the substation movable into a first position to selectively connect said day loop only into said line circuit or into a second position to connect said day and night loop in series into said line circuit, and means responsive to continuity of said night loop for locking said switch against movement into said second position when said night loop is open.

9. In a signalling system, a central station, a line circuit having two ends terminating at said central station and including a plurality of substations connected in series relation intermediate said two ends, at least one of said substations including a local loop circuit, means for connecting one end of said local loop to one line terminal of that substation, means for connect-

ing the other end of said local loop to ground, means responsive to current flow from said one line terminal to ground for momentarily interrupting said current flow, means for connecting said local loop in series between the two line terminals of that substation, means at said central station for supplying current to that end of said circuit connected to said first-mentioned line terminal at said substation, and means at said central station for counting interruptions in current flowing into said mentioned end of said line circuit.

10. A system as described in claim 9, in which said means at the substation for connecting said local loop in series between the line terminals includes means responsive to current flow through said loop between said line terminals for disconnecting said local loop from ground.

11. A system as described in claim 9, in which said means for momentarily interrupting said current flow includes a first relay and a second relay, means including a back contact on said second relay for connecting said first relay in series with said loop, means including a front contact on said first relay for connecting said second relay in series with said loop, means including a front contact on said second relay for also connecting said second relay in series with said loop, both said last-mentioned means also including switch means adapted to be momentarily broken in response to release of said first relay.

12. In a signalling system, a central station, a line circuit having two ends terminating at said central station and including a plurality of substations connected in series relation intermediate said two ends, at least one of said substations including: a local loop circuit, means selectively responsive to potential applied to either line terminal of that substation for connecting said local loop circuit between that line terminal and ground, means responsive to current flow from said terminal through said local loop circuit for momentarily interrupting such flow, means for connecting said local loop in series between said two line terminals; means at the central station for selectively applying potential to either end of said line circuit, and means at said central station responsive to interruptions in current flow to said line circuit for counting said interruptions.

13. In a signalling system, a central station, a line circuit having two ends terminating at said central station and including a plurality of substations connected in series relation intermediate said two ends, at least one of said substations including: a local loop circuit, means responsive to potential on either line terminal for connecting that line terminal to one end of said loop, means for connecting the other end of said local loop to ground, means responsive to current flow from either line terminal to said loop for momentarily interrupting said current flow, means including said means responsive to potential on either line terminal for connecting said loop in series between said line terminal; means at the central station for selectively applying potential to either end of said line circuit, and means at said central station responsive to momentary interruptions in current flow into said line circuit for counting such interruptions.

14. In a signalling system, a central station, a line circuit having two ends terminating at said central station and including a plurality of substations connected in series relation intermediate

diates said two ends, at least one of said substations including: a local loop circuit, a pair of relays, and circuit means connecting each relay between a different one of the line terminals of that substation and ground, means responsive to energization of either of said relays for connecting its associated line terminal through said local loop to ground, means responsive to current flow through said local loop circuit for momentarily interrupting said current flow; means at the central station for selectively applying potential to either end of said line circuit, and means at said station responsive to interruptions in current flow to said line circuit for counting such interruptions.

15. A system as described in claim 14, with means for disabling each of said relays in response to operation of the other relay.

16. A system as described in claim 14, with means including a front contact on each of said relays for short-circuiting the other relay when either relay is operated.

17. A signalling system comprising a central station having two line terminals, a plurality of substations each having two line terminals, and line circuit means interconnecting said substations in a single loop extending between said two line terminals at said central station, in which each substation includes a first and a second terminal, means normally connecting said first terminal to ground and responsive to cur-

rent flow therethrough for momentarily interrupting said current flow and transferring connection of said first terminal from ground to said second terminal, each substation also including means associated with the two line terminals thereof and selectively responsive to potential on different ones of said two line terminals for connecting the line terminal having potential thereon to said first terminal, and connecting the other line terminal to said second terminal, said central station including means for selectively applying potential to either of said central station line terminals, and including indicating means responsive to said momentary interruptions.

18. A system as described in claim 17, in which said means at the substation selectively responsive to potential on different ones of said two line terminals is identically responsive to potentials of different polarities.

19. A system as described in claim 17, in which said means at the substation normally connecting said first terminal to ground includes a protective loop adapted to be faulted in response to predetermined abnormal conditions.

20. A system as described in claim 17, including a protective loop circuit connected in series between said first terminal and said means normally connecting said first terminal to ground.

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