March 10, 1970 M. W. MUEHTER 3,500,377

NONINTERFERING ELECTRICAL SIGNALING SYSTEM

Filed Oct. 21, 1966 4 Sheets-Sheet 1

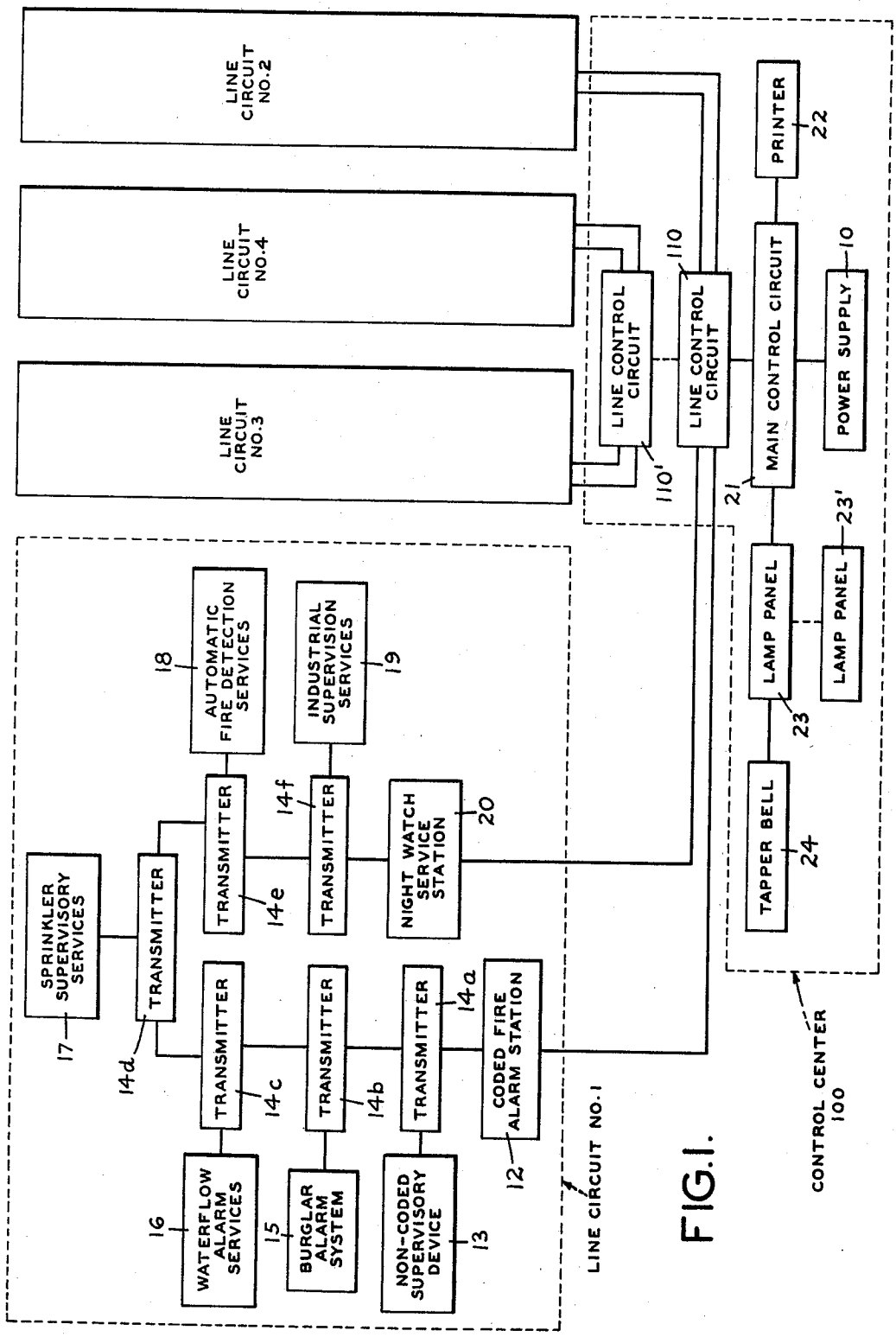


FIG. 1.

NONINTERFERING ELECTRICAL SIGNALING SYSTEM

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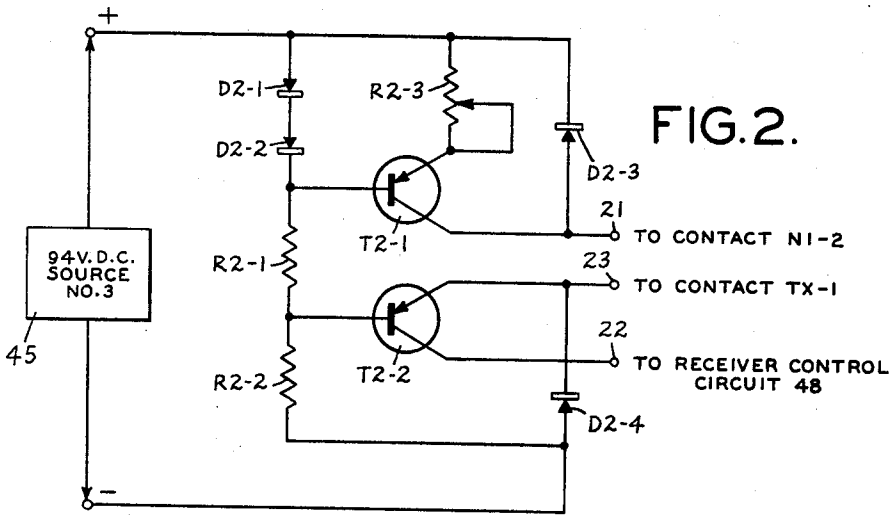
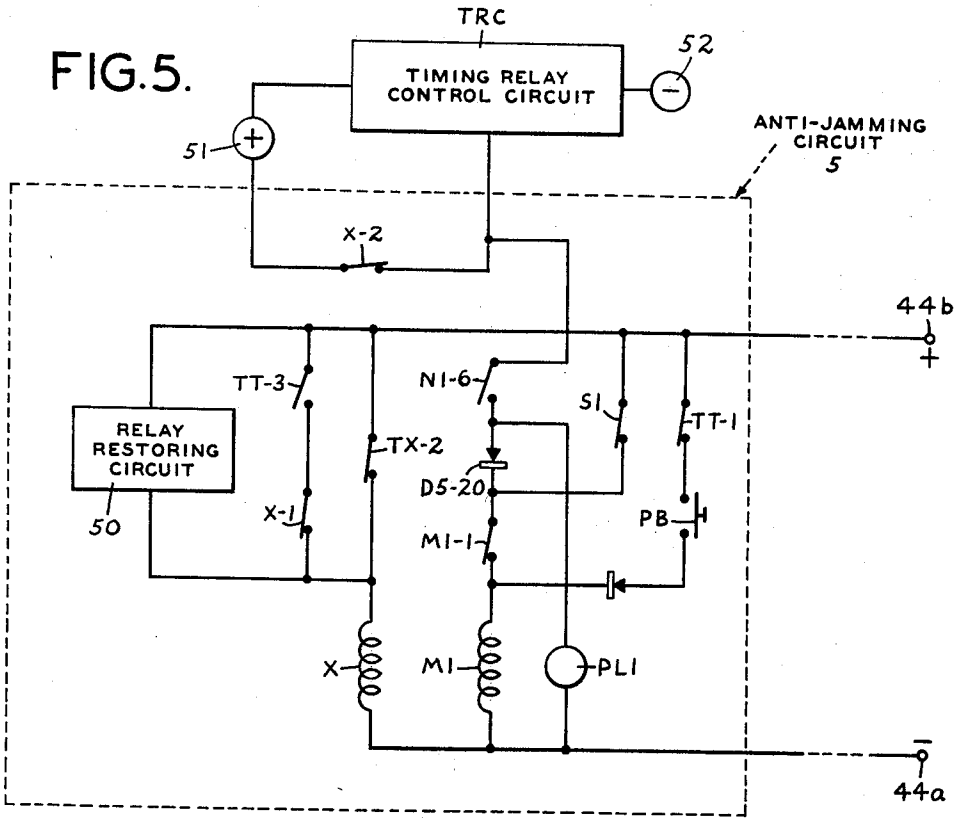


FIG.2.

FIG.5.



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NONINTERFERING ELECTRICAL SIGNALING SYSTEM

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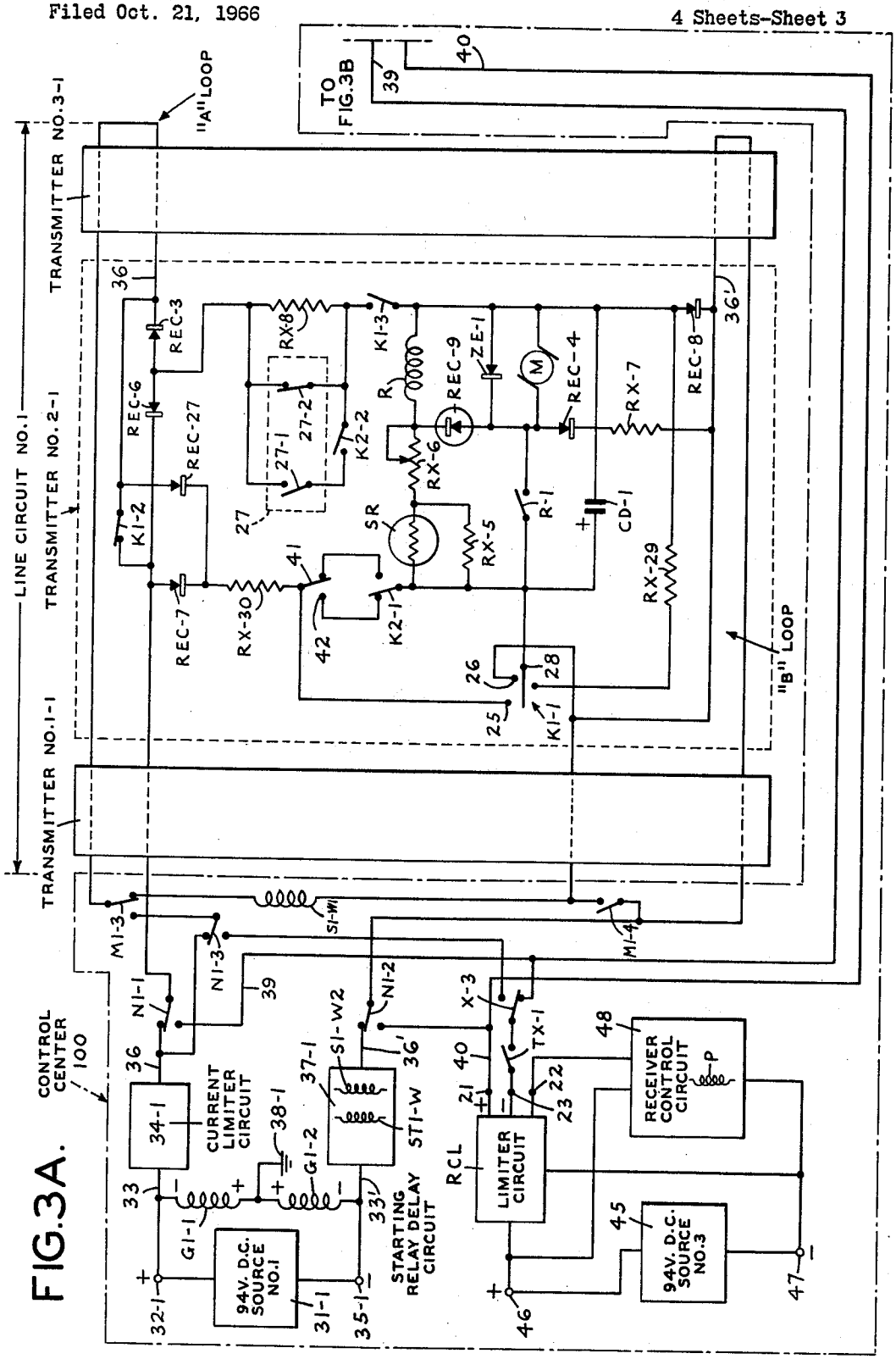


FIG.3A.

NONINTERFERING ELECTRICAL SIGNALING SYSTEM

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FIG. 3B.

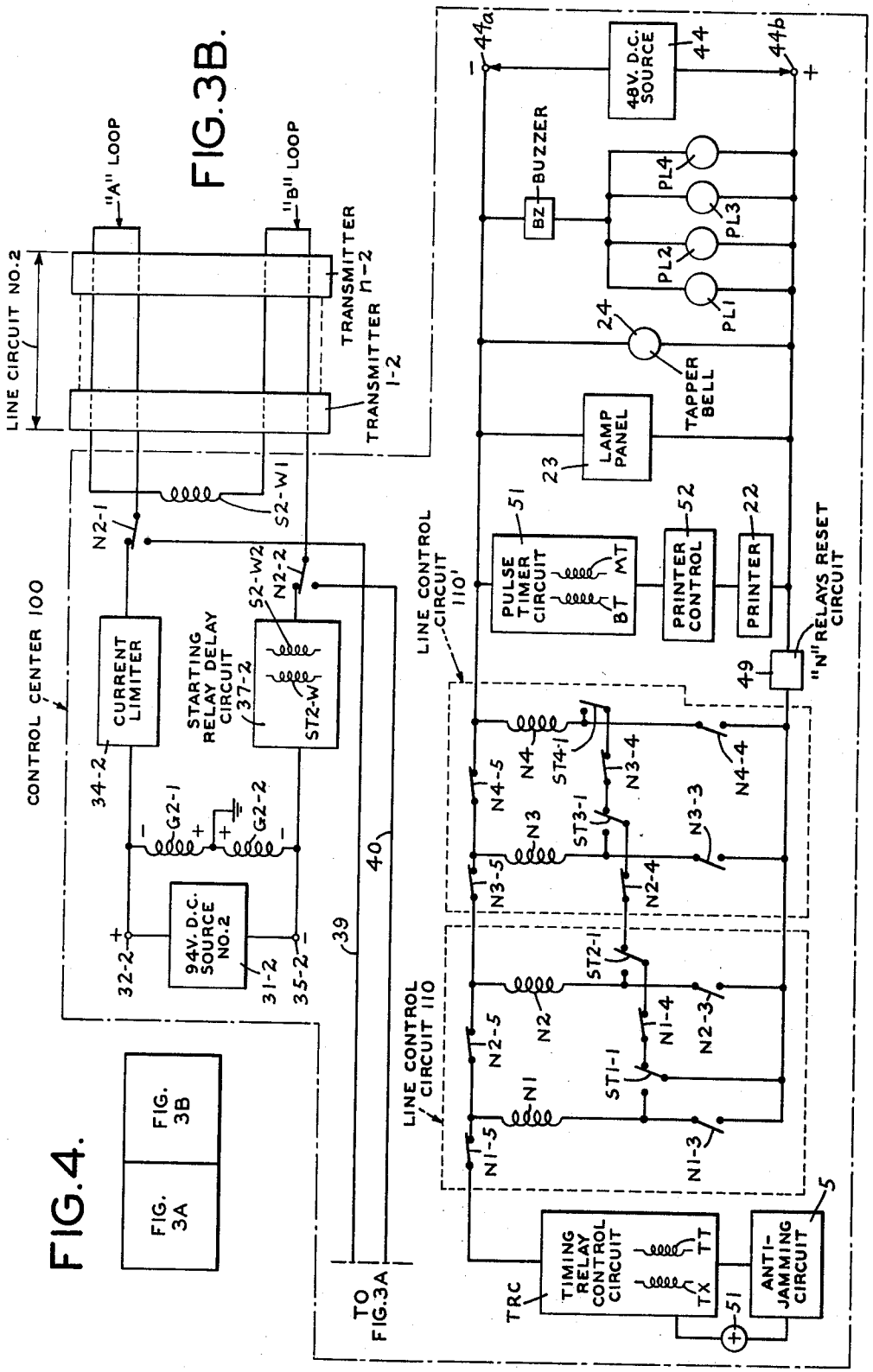


FIG. 4.

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NONINTERFERING ELECTRICAL SIGNALING SYSTEM

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Int. Cl. G08b 25/00
U.S. Cl. 340—287 4 Claims

ABSTRACT OF THE DISCLOSURE

An electrical protection system consisting of a plurality of line circuits connected to a central station, and a plurality of transmitters associated with each line circuit, in which interference between actuated transmitters on different lines is prevented by giving precedence in establishing a connection to the central station to that line which is the first to have an actuated transmitter, and by allowing all actuated transmitters on the line having precedence to complete their transmission to the central station before another line is connected to the central station. This system is also characterized by an anti-jamming circuit which provides for bypassing a stalled transmitter on a given line so that other transmitters associated with that line are given access to the line ahead of the stalled transmitter. This system is further characterized by a limiter circuit for preventing damage to the system, in which both the line current and the line voltage are limited to respective predetermined maximum levels.

The present invention relates to electrical signaling systems and more particularly to electrical signaling systems of the positive, noninterfering, successive type.

In circuit type electrical protection systems, a place to be protected is provided with a protection circuit including one or more detection devices each arranged to transmit a characteristic alarm signal upon actuation. An alarm signal usually consists of a series of electrical pulses which form a code identifying the nature and source of the signal and which may be annunciated audibly and visually at the receiving end of the system as well as recorded to form a permanent record.

Such signaling systems have been known and used with gratifying results for many years in the rendering of electrical protection services, particularly for large industrial companies and government complexes which have so many signal transmitting devices in service as to warrant the maintenance of a signal receiving and control center on the premises which is staffed by personnel trained to take the appropriate action demanded by the nature of the signals received. Systems of this type are known as proprietary installations and are commonly designed to receive and record alarm type signals originating from a variety of detection devices such as, for example, manual fire alarm boxes, automatic fire detection devices, waterflow alarm detectors associated with automatic sprinkler systems and burglar alarm devices. Provision is also made for the receipt of supervisory signals such as those emanating from watchmen's reporting systems and signals indicating the condition of the various elements of sprinkler systems such as the positions of valves, the level and temperature of the water supply and the air and water pressures in the system.

Since proper response to an alarm signal requires immediate and positive identification of the actuated device, it is imperative that in the event that more than one device is actuated, the signals generated by each

actuated device be received without interfering with one another. It is possible, of course, to provide a separate signal path between each device and the receiving center, but this requires a complex and costly installation at the protected premises.

In order to prevent mutual interference at a reasonable cost, so-called positive noninterfering successive signaling systems have been developed. Such systems permit the signals from a number of actuated devices to be transmitted one after the other over the same signal path without interfering with one another, by holding up the transmission of signals from all succeeding devices until the preceding device has finished transmitting its signal.

In the present invention, there is provided a positive, noninterfering signaling system having several unique features. The system of the present invention includes a number of line circuits, each line circuit having a number of transmitters. In order to prevent interference between signals from transmitters on different circuits, a line control circuit connects the line having the first actuated transmitter to the control center, and all other line circuits are prevented from being connected to the control center until all actuated transmitters on the connected line circuit have completed their transmission of signals. This feature of preventing intereference between lines is to be distinguished from the above-mentioned prior art systems for preventing interference between transmitters on the same line.

Ordinarily, if a detection device is in good working order, its transmitter will send an alarm signal for a selected interval of time, after which it will stop and be disconnected from the line, thereby to permit another actuated device on the same line to start transmitting its alarm signal over the line. However, if through a mechanical or electrical fault the device already on the line is jammed or stuck so that it stops transmitting a coded signal but fails to turn off, it will hold the line and prevent any other actuated device on the line from transmitting. In the present invention, a stalled transmitter is automatically removed from the line after the transmitter has been stalled for a predetermined interval of time. This is accomplished by a novel anti-jamming circuit arrangement in which other devices that have been actuated are given access to the line in a manner which assigns the stalled transmitter the lowest priority among the actuated devices so that the jammed transmitter is not reconnected to the line until after all other actuated devices have been connected to the line. The anti-jamming circuit of this invention automatically removes a stalled transmitter from the line by switching the line to receive power from the opposite end of the line so that other transmitters are given access to the line ahead of the stalled transmitter.

An additional feature of this invention is a limiter circuit of novel structure for protecting the system and various components thereof from possible damage by limiting the line current to a predetermined maximum level, and for reducing the undesirable effects of multiple line leakages to ground by reducing the line voltage to a selected level when the line is switched to the receiving center.

The invention will be fully understood from the following detailed description of illustrative embodiments thereof taken in connection with the appended drawings, in which:

FIG. 1 is a block diagram illustrating a complete signaling system embodying the principles of this invention;

FIG. 2 is a diagram of the limiter circuit of the system shown in FIG. 1;

FIGS. 3A and 3B are schematic diagrams illustrating in detail certain portions of the system shown in FIG. 1;

FIG. 4 is a diagram indicating the positions of the FIG. 3A and 3B diagrams relative to one another; and

FIG. 5 is a diagram of the anti-jamming circuit of this invention.

Complete signaling system

Referring first to FIG. 1, power to operate the system is drawn from a power supply **10**, which for example, might conveniently consist of a 48 volt battery located at the control center **100** and aranged to be trickle charged from locally available power lines such as 110 volt A.C. lines (not shown). Also incorporated in the power supply is a D.C. to D.C. converter to provide a separate D.C. voltage source for each line circuit **1** through **4**, say 94 volts, for various purposes as will be made apparent hereinafter.

The various detection and supervisory devices of the electrical protection services and their associated transmitters are series connected in loops which are identified on the drawing as line circuits **1, 2, 3, 4**. It is to be understood, of course, that this invention is not limited to any particular number of line circuits, the number four being chosen only for illustrative and descriptive purposes.

A line control circuit **110** is provided at control center **100** for each pair of line circuits: thus line circuits **1** and **2** are shown connected to the line control circuit **110** and line circuits **3** and **4** are shown connected to line control circuit **110'**. Each line circuit may include any combination of a variety of electrical protection service devices, each device being provided either with its own code signal generating mechanism or with a transfer contact which is operated when the detection device responds to the condition intended to be detected, the operation of the transfer contact resulting in the actuation of an associated code signal generating mechanism or transmitter.

As an example of the variety of devices which may be included within a single line circuit, line circuit **1** (reading in the clockwise direction) is shown as including a manual fire alarm station **12** of the coded type which contains the actuating device (not shown) and the code signal transmitter in the same unit. Next is shown a non-coded supervisory device **13**, for example, a gate valve or water level detector connected by means of a short cable to the associated code signal transmitter **14***a*. Although the device **13** does not produce coded signals, the operation of the device **13** will operate a transfer contact which in turn will actuate the associated transmitter **14***a* to produce a coded signal indicative of the general area in which the actuated device **13** is located. The actuation of transmitter **14***a* and the other transmitters by operation of a transfer contact is described in detail below in connection with the explanation of FIGS. 3A and 3B. A burglar alarm system **15**, which might consist of a number of simple door and window supervisory devices as well as more complex photoelectric and ultrasonic intrusion detection systems, is connected to an associated code signal transmitter **14***b*, for example, through a control unit (not shown) which is equipped with a relay having a transfer contact to actuate the associated transmitter **14***b*. The next code signal transmitter **14***c* generates alarm type signals in response to the actuation of devices of various types in an automatic water-flow alarm service **16**, the individual devices being connected to transmitter **14***c* through a control relay having transfer contacts which operate transmitter **14***c*. Similarly, transmitter **14***d* generates code signals in response to the operation of a relay by actuation of such devices as water level, temperature and valve position indicator devices. A number of different types of automatic fire detection services **18** are connected through a suitable control unit (not shown) having a suitable relay with transfer contacts to operate transmitter **14***e*. These services include such devices as thermostats, smoke detectors and pneumatic fire detection apparatus. The industrial supervision services indicated by element **19** comprise various process supervisory devices designed to monitor temperature, pressure, shaft rotation, and other parameters, and these devices are shown connected to the transmitter **14***f*, there being an intermediate control circuit (not shown) with a relay whose transfer contacts operate the associated transmitter **14***f*. The last transmission device, denoted by the reference numeral **20**, is representative of night watch service stations incorporating their own transmitters and employed by watchmen to signal their progress along prescribed patrol routes.

If desired, the code signal generators may be of essentially the same design, and may employ any one of a number of conventional code signal generating arrangements, such as a commutator type of code signal generator, to generate a series of current pulses according to a predetermined code. If further desired, the code signal generating device may be designed to repeat the code signal for a selected number of times so that a selected number of signal rounds are transmitted upon each actuation of the associated detection device.

It will be understood that other and usually more complex combinations of alarm and supervisory devices as well as branch circuits would be employed in an actual installation. The preceding example therefore is intended for illustrative purposes only and not as a limitation upon the present invention.

As hereinbefore mentioned, line control circuit **110** is designed to accommodate two line circuits, line circuits **1** and **2**, and it is to be understood that line circuit **2** may have coupled thereto any combination of the various electrical protection apparatuses described in connection with line circuit **1**. Since the transmitter on the line circuits do not draw power except when operating, and since (except for the starting interval when several transmitters may draw a small limited current simultaneously as explained more fully below) only one transmitter can operate at a time, a large number of devices may be connected to a line, the total number on a single line being limited primarily by the electrical resistance of the line and the locations of the devices. Therefore, according to the location of the various transmitters and the resistance of the line circuits involved, sufficient line circuits are provided to take care of all the installed devices. Provision therefore has been made to accept in modular fashion additional line circuits such as line circuits **3** and **4**, together with associated line control circuits such as that indicated by line control circuit **110'**. Regardless of the number of line circuits thus added, the entire system is designed to operate on a noninterfering basis, with the coded alarm signals being received in the predetermined order in which the transmitters are connected to the line circuit in the event that more than one transmitter is operated at the same time.

The line control circuits **110, 110'** connect the line circuits to the main control circuit **21** where the code signals are translated into the proper form for the operation of printer **22**, lamp panel **23**, and tapper bell **24**. Additional lamp panels such as that indicated by panel **23'**, which is also of modular design, may be added as necessary to accommodate additional line circuits. Printer **22**, panel **23** and bell **24** are of conventional construction, and provide visible and audible indications of the actuation of the detection devices. For example, all incoming code signals and the time and date of receipt are recorded by the printer **22**, and except for night watch signals, may also be annunciated by a buzzer and pilot light. The operator may acknowledge the receipt of such signals by means of a manually operated switch in the main control circuit **21** which silences the buzzer and, after the signal transmission is complete, causes the printer **22** to record an acknowledgement code signal and the time. In the case of alarm signals only, tapper bell **24** repeats the code signal received to insure that the operator's attention is directed to the receipt of a signal of emergency nature.

The coded alarm signals may be printed on a paper

tape in any one of a number of forms, such as a group of letters and numbers in which the letters identify the particular service, for example, manual fire alarm, sprinkler supervision, or the like, and the numbers indicate the area and particular box identification as well as the time and date of the signal. Alarms, supervisory and restoration signals may be further distinguished by the number of rounds or repetitions of the code signal which are recorded. Timing modules and relays in the main control panel respond to the code signal to set up circuit paths to the solenoids controlling the printer keys and the buzzer and lamp features. For example, the location portion of the signal code may be transmitted as a selected number of pulses of equal duration which are counted by a magnetic counter in the main control circuit to activate the proper printer solenoids and to pulse the tapper bell.

Turning now to FIGS. 3A and 3B, which illustrate apparatus connected together in the relationship indicated by FIG. 4, the basic module of the system of this invention comprises two independent line circuits which are designated line circuit **1** and line circuit **2**, each line circuit being provided with two loops, an "A" loop and a "B" loop. The various transmitting devices in each line circuit are connected across both the "A" and "B" loops of the corresponding line circuit. To simplify the drawing, only transmitter **2–1** of line circuit **1** is shown in detail, and it will be understood that all other transmitters such as **1–1** and **3–1** in line circuit **1** and **1–2** through *n*–2 in line circuit **2** are similar thereto in construction and in their connection to the corresponding line circuits. As shown in FIG. 3A, transmitters **1–1, 2–1, 3–1** are connected across the "A" and "B" loops of line circuit **1** in that order, so that if two or more transmitters are actuated at the same time, the low number transmitter sends its signal first, followed by the next higher numbered transmitter and so on.

At control center **100**, there is provided for each line circuit **1, 2** a separate source of potential **31–1, 31–2**, for supplying starting current to the associated line circuit **1** and line circuit **2** respectively, where the potential conveniently might be 94 volts D.C. The potential sources are ungrounded so that a single ground fault, even on more than one line simultaneously, will not affect the operation of the system. Other sources of potential at control center **100** include source **44** connected between points **44***a* and **44***b*, and source **45** connected between points **46** and **47**, as will be described hereinafter.

The current path through line circuit **1** may be traced from positive terminal **32–1** of potential source **31–1** via a conductor **33** to current limiter circuit **34–1**. The function of current limiter circuit **34–1** is to restrict the line current to a predetermined level, say, **46** milliamperes, and thus protect the system from such damage as might arise from accidental short circuits, as well as to prevent an excessive current supply to the transmitter motors where the series resistance of the line is low. From current limiter circuit, **34–1**, the current path crosses through conductor **36** via the normally closed back contact **N1–1** of the noninterference relay **N1** in line control circuit **110** and thence through the transmitters **1–1, 2–1, 3–1**. Within each transmitter, as illustrated by transmitter **2–1** in the drawing of FIG. 3A, the presence of rectifier **REC–6** causes the current to pass through a branch path via the normally closed contact **K1–2** which is cam operated by the transmitter motor M. The branch path rejoins the conductor **36** at a point just past rectifier **REC–3** and continues through the remaining transmitters connected to the line circuit as indicated by transmitter **3–1**. At the last transmitter, here indicated as transmitter **3–1**, conductor **36** is brought back to the control center **100**, thus forming a loop designated as "A" on the drawing. At control center **100**, the path then passes through make contact **M1–3** of relay **M1** to the first winding **S1–W1** of the normally energized line supervisory relay **S1–1** and back out through all the transmitters and again returning by way of conductor **36'** to establish the loop designated "B" via the normally closed back contact **N1–2** of the noninterference relay **N1**. Conductor **33'** completes the path from the starting relay delay circuit **37–1** to the negative terminal **35–1** of the potential source **31–1**. The starting relay delay unit **37–1** is a transistor operated unit which includes the second winding **S1–W2** of the line supervisory relay **S1–1** and the winding **ST1–W** of the starting relay **ST1**.

Line circuit **2** is identical to line circuit **1** described above, save that a different number of transmitters may be connected thereto as may be desired for a particular installation. Corresponding relays and contacts have been denoted by the suffix **2**. Thus the noninterference relay **N2** and its contacts **N2–1, N2–2**, . . . , correspond to relay **N1** and contacts **N1–1, N1–2**, . . . , of line circuit **1**. The front contact of **N2–1** is connected to the front contact of **N1–1** by conductor **39** and the front contact of **N1–2** is connected to the front contact of **N2–2** by conductor **40**.

Suppose now that a detection device of some sort connected to transmitter **2–1** of line circuit **1** is actuated and thereby an associated relay (not shown) transfers its armature **41** to contact point **42**. A starting current path is thus completed from positive terminal **32–1** of potential source **31–1** to negative terminal **35–1** via the back contact **N1–1**, rectifier **REC–7**, resistor **RX–30**, armature **41** of the actuating device relay, contact point **42**, back contact **K2–1** of a cam operated transfer contact controlled by the transmitter motor M, resistor **RX–5** (connected in parallel with thermistor SR provided to compensate for temperature caused capacitance variation of capacitor **CD–1**), adjustable resistor **RX–6**, the winding of a reed relay R, rectifier **REC–8** to the negative "B" loop and thence via back contact **N1–2** and the starting relay delay circuit **37–1** to the negative terminal **35–1**. A rectifier **REC–27** provides an alternate starting current path from the "A" loop to the "B" loop which is employed when the line has an open fault requiring operating potential to be supplied to the transmitter from the other end of the line.

A first charging or starting path is also completed by the transfer of armature **41** to contact point **42**, from contact **K2–1** to a capacitor **CD–1** and thence to the negative "B" loop via the rectifier **REC–8**. The capacitor **CD–1** is in parallel with the series combination of contact **R–1** of reed relay R and the motor M. Due to the current limiting action of limiter circuit **34–1** and the combined resistance of the line and resistor **RX–30**, capacitor **CD–1** will begin to charge gradually. Resistor **RX–30** performs the important function of allowing more remote transmitters such as transmitter **3–1** to function in the event that transmitter **2–1** should become stalled with the contact **K1–1** closed, as explained more fully below. Without resistor **RX–30**, the shunt established by contact **K1–1** would not allow sufficient current to flow out through the line to charge the corresponding capacitor of a more distant transmitter.

The resistance of resistor **RX–6** is adjusted so that reed relay R will operate when the voltage of capacitor **CD–1** reaches a selected level, say, approximately 20 volts. When relay R operates, its contact **R–1** closes to complete three electrical paths:

(1) between the "A" and "B" loops via rectifier **REC–4** and resistor **RX–7**;
(2) between capacitor **CD–1** and motor M;
(3) between capacitor **CD–1** and the coil of relay R.

The completing of a path between the "A" and "B" loops via rectifier **REC–4** and resistor **RX–7** blocks the charging path for capacitor **CD–1** by back biasing diode **REC–8**, since the voltage across resistor **RX–7** is much lower. Capacitor **CD–1** therefore receives a fixed charge re-

gardless of either the location of the transmitter on the line or the line resistance.

Blocking of the charging path for capacitor CD–1 causes CD–1 to start to discharge, and the completed path between capacitor CD–1 and motor M via contact R–1 causes motor M to start running in the first stage or starting interval of a two-stage operation. Shortly after the motor has started running, a first cam (not shown) mechanically associated with motor M operates the contacts K1–1, K1–2 and K1–3. The operation of K1–2 opens the line to other transmitters located further out on line circuit 1, rectifier REC–6 being in the opposing direction. The operation of contact K1–1 completes a shunting path between the "A" and "B" loops via points 25 and 26 and rectifier REC–7 and the current limiting resistor RX–30, thereby completely shunting down the current supply to the transmitter. The closure of contact K1–3 introduces the coding mechanism 27, shown symbolically by contacts 27–1, 27–2, into a circuit coupling the "A" and "B" loops via capacitor CD–1 and contact K1–1 at point 26. However, this circuit does not receive current until diode REC–6 or diode REC–3 conducts, depending from which side current is supplied. The motor M, now bypassed by the closure of contacts K1–1, therefore receives no current from the line, and the fixed charge on capacitor CD–1 is sufficient only to drive the motor M to a second starting position where it halts until the line potential is reversed. The relay R remains energized by capacitor CD–1 via contact R–1 until capacitor CD–1 has been nearly discharged, at which point relay R releases.

The increased curent flow in the line circuit conductor 36 resulting from the closure of contact K1–1 acts as a trigger signal which is detected by conventional means in the starting relay delay unit 37–1 and is employed first to energize the second winding S1–W2 of the line supervisory relay S1–1 and, after a delay, then to energize the winding ST–W1 of starting relay ST. The energizing of winding S1–W2 prevents the release of relay S1–1 and a consequent false indication of an open condition in the line circuit as would otherwise occur, since the primary winding S1–W1 is now deenergized by the opening of contact K1–2. After a delay of about four seconds provided by a device such as a resistance-capacitance network in unit 37–1 (not shown), the starting relay ST1 is energized. The purpose of the delay period is to allow adequate time for the corresponding capacitor CD–1 in each actuated transmitter to become sufficiently charged since relay ST1 would otherwise be prematurely energized by the initially high charging current of any one of the capacitors CD–1.

Within line control circuit 110, the transfer of contact ST1–1 of starting relay ST1 completes a circuit to the winding of the noninterference relay N1 from the 48 volt D.C. source 44. A noninterference relay N1, N2 is provided for each line circuit 1, 2, respectively, and all are parallel connected across the 48 volt source 44 through the N relays reset circuit 49. To illustrate the functioning of the noninterference principle, two additional noninterference relays N3 and N4 are also shown, such as would be provided for two additional line circuits illustrated as line circuits 3, 4 shown in FIG. 1.

The transfer of contact ST1–1 opens the positive supply path to all of the noninterference relays on one side of relay N1, here shown to the right, and not only is relay N1 locked in to source 44 through the operation of its own contact N1–3, but also contact N1–4 opens to prevent the restoration of the path to source 44 to the other N relays even after the starting relay ST1 is released. At the same time, contact N1–5 opens to prevent the operation of all noninterference relays on the other side of relay N1, here shown to the left. In the case of relay N1, there are no other relays to the left, but in the case of another N relay, the opening of the corresponding (—5) contact would prevent subsequent operation of any N relay to the left since the path to the negative terminal of source 44 is thereby incomplete. The operation of any noninterference N relay therefore enables a particular line circuit to gain exclusive control of the signal path to the receiver control circuit 48 and thereby to the apparatuses controlled by circuit 48.

The operation of relay N1 in response to the transfer of contact ST1–1 causes contacts N1–1 and N1–2 to transfer from conductors 36, to conductors 39, 40, thereby establishing connections from the "A" and "B" loops to the voltage source 45, via limiter circuit RCL, which connections are complete except for a contact TX–1 that is still open. Source 45 supplies transmitting current to one of the pairs of line circuits 1 and 2 after the starting current has terminated. It will be observed that on the closing of contact TX–1 the negative side of source 45 is to be coupled to the "A" loop through make contact N1–1, and the positive side of source 45 is to be coupled to the "B" loop through contact N1–2. Therefore, when contact TX–1 is ultimately closed, the polarity of the transmitting current through line circuit 1 is opposite to that of the starting current.

It is evident that operation of a transmitter in line circuit 2 would correspondingly result in the energizing of starting relay ST2 in circuit 37–2 to reverse the line current polarity in line circuit 2 via contacts N2–1, N2–2 and conductors 39 and 40, and to operate the noninterference relay N2 in circuit 110.

The opening of contact N1–5 in circuit 110 interrupts the 48 volt supply to timing relay circuit TRC, and thereby activates this circuit. The opening of contact N1–5 causes the main timing relay TT in circuit TRC to be operated, but if no signal pulses are received within nine seconds, relay TT will automatically release again. Concurrently, the operation of a timing unit in circuit TRC is initiated to energize timing relay TX, after a delay of about one second to allow sufficient time for any transmitter that has received current for a long enough time to charge its capacitor CD–1 to complete the operation of the cam controlled contacts, K1–1, K1–2, K1–3. The energizing of relay TX and the consequent closure of contact TX–1 between conductor 39 and the negative side of limiter RCL, as shown in FIG. 2, permits transmitting current of polarity which is the reverse of the starting current to be supplied to transmitter nearest on the line to the current supplied from the control center 100. The "A" loop is now negative and a second or transmitting charging current path may be traced from contact N1–1 through rectifier REC–6, the coding mechanism 27, and operated contact K1–3 to the capacitor CD–1, and from capacitor CD–1 to the operated front contacts of K1–1 to the positive "B" loop. The normally open contact K1–3 has been provided to prevent excessive current drain through possible ground leakage from the terminals of other transmitters on the line when the supply polarity is reversed. Any leakage to ground in the actuating devices will appear as a partial ground point at the armature 41, and, unless the reverse current path through the transmitters is kept open, the cumulative effect thereof could interfere with proper operation of a transmitter. Leakage or a ground at a particular transmitter when operating (K1–3 closed) can be readily tolerated, since source 45 is not connected to ground, not even through a ground detector.

Current also flows through the series combination of resistors RX–5, RX–6 and reed relay R and, as before, when the voltage on capacitor CD–1 reaches the predetermined level, the relay R operates and the motor M starts to transmit signals in the second stage or transmitting interval of its two-stage operation. A Zener diode ZE–1 is connected across the motor M as a means of further limiting the current supplied to the motor.

The coding mechanism driven by motor M causes a signal to be generated, for example, by the opening and

closing of a circuit as indicated by the contacts 27–1 and 27–2, and during breaks in the circuit the power supply to the motor M is maintained by the capacitor CD–1 aided by power drawn from the line via resistor RX–8 (shunting the coding contacts) which provides sufficient energy to maintain the governor controlled motor at constant speed.

The receiver control circuit 48 operates the repeater relay P in accordance with the code pulses generated by the coding mechanism 27. In addition, circuit 48 also functions as a pulse clipper to produce pulses of uniform amplitude and is furthermore the means of supporting extraneous induced voltages on the line of short duration which otherwise might result in false operation.

Contacts (not shown) of repeater relay P control the break timing relay BT and the make timing relay MT in the pulse timer circuit 51 which is also powered from the source 44. The release of relay BT is delayed approximately 130 milliseconds to enable the BT relay to remain energized during the spaces in the code signal generated by coding mechanism 27, and to release only for spaces having a duration greater than a predetermined maximum length. The make timing relay MT is similarly retarded so as not to release during the transmission of signal pulses but to release in approximately 190 milliseconds during the long pulse at the end of a signal round.

The repeater relay P acting in conjunction with the break and make timing relays BT and MT controls the advance of a stepper switch in the printer control 52 which in conjunction with decoding relays and a magnetic counter sets up the particular signal to be printed, together with the hour, date and year record, by the printer 22. In the case of alarm signals, the tapper bell 24 provides an audible warning to the operator that an alarm signal is being received. An appropriate pilot lamp on the lamp panel 23 is also illuminated simultaneously. Provision is also made, but not shown on the drawing, for a special supervisory pilot lamp to be illuminated by the receipt of an alarm signal. To extinguish this lamp, the operator must throw a "Special Attention" switch which both extinguishes the lamp and causes an acknowledgement signal to be printed on the paper tape thereby indicating to the supervisor that the alarm signal had been properly received and promptly handled.

In the case of signals from combination fire alarm-nightwatch transmitters as well as restoration (to normal condition after actuation) signals from alarm transmitters, a second cam on motor M operates the cam operated contact K2–2 to prevent the sounding of the tapper bell 24. The contact K22 is opened by the second cam with the result that a long break pulse is transmitted causing relay BT in pulse timer circuit 51 to release and, in so doing, operate a relay (not shown) which silences the bell.

Contact K2–1 is also transferred by the second cam on motor M after the transmitter starts running on reverse polarity, so that when the armature 41 of the actuating device is restored to the normal position, the transmitter will be actuated through the alternate path provided by armature 41 and contact K2–1 to transmit the usual single round restoration signal. At the completion of the single round restoration signal, the contacts K2–1 and K2–2 are again in their normal position. On the completion of all signals, whether of alarm or supervisory nature, the back contact K1–1 is closed momentarily to allow a path to be completed via point 28 so that capacitor CD–1 can discharge through resistor RX–29, thereby preventing excessive over-run of the motor M at the end of the signal transmission which might otherwise occur due to the higher charge on the capacitor resulting from operation on a low resistance line.

Fault conditions

Line circuit 1, line circuit 2, and the common receiver control circuit 48 are each powered from separate, ungrounded sources. Consequently, a ground fault on the line circuits or even single faults existing simultaneously on more than one line circuit will not affect the operation of the system. However, multiple faults on a single circuit could seriously affect operation since one or more transmitters could thereby be effectively shorted out of the system. For this reason, each line circuit is provided with ground detector apparatus which will produce audible and visible signals should a ground appear on any line circuit.

Referring to line circuit 1 in FIG. 3A, the two windings G1–1 and G1–2 of the ground detector relay G1 are connected across the line terminals 32–1, 35–1 with the center point grounded at 38–1. Each of the windings G1–1 and G1–2 is of high resistance and the windings are connected in series opposition so that the normal magnetic flux produced in each winding balances that in the other and the relay remains normally released. A ground or heavy leakage on the line will cause one winding to draw more current than the other, relay G1 will become energized and, through contacts not shown, will illuminate pilot lamp PL1 and sound the common buzzer BZ which are connected to the source 44. Similarly, ground or heavy leakage on line circuit 2 will operate through the windings G2–1 and G2–2 of ground detector relay G2 to illuminate pilot lamp PL3 and sound the common buzzer BZ in a similar manner.

An open circuit condition occurring on either line circuit will de-energize the associated line supervisory relay S1 or S2 and, through contacts not shown, will illuminate either pilot lamp PL1 or PL3 and sound the common buzzer BZ as in the case of a grounded line. Also, as is usual practice in electrical protection systems, other relays (not shown) are operated to supply potential to both ends of the line so that signals may be received until the break is repaired and the line restored to the normal operating condition.

A short circuit fault occurring between the "A" loop and the "B" loop causes the affected circuit to switch to the running condition (as if contacts K1–1 were closed) and the associated noninterference relay N will operate. However, since no code pulses are received with a short circuit fault, the line is automatically switched back to the stand-by condition after a short interval of time by the main timing relay TT. As long as the short circuit fault persists, the associated relay N will operate and release and this switching action is repeated and results in the flashing of pilot lamp PL2 for the line circuit 1 or pilot lamp PL4 for line circuit 2. Since this type of fault renders the particular line circuit inoperative, the line circuit must be removed from the system until the fault is corrected.

Receiver line current limiter (RCL)

Referring next to FIG. 2, this drawing illustrates in detail the limiter circuit RCL shown in block form in FIG. 3A. This unit serves both to limit the transmitting current to a predetermined maximum level, for example, 27 milliamperes, and to limit the line voltage to a selected level, say 45 volts, in order to minimize the undesirable effects of multiple line leakages to ground when the line is switched to the receiver.

A voltage divider consisting of resistors R2–1, R2–2 and diodes D2–1, D2–2 provides a selected constant voltage, say 1.4 volts, across the diodes. The transmitting current flows through adjustable resistor R2–3 to the emitter of transistor T2–1 and thence to contact N1–2 via point 21.

When this transmitting current approaches the predetermined maximum level, say the 27 milliamperes previously mentioned, the voltage drop across resistor R2–3 tends to drive the emitter of transistor T2–1 as negative as its base, at which point transistor T2–1 starts to cut off and consequently increases its collector to emitter voltage to

maintain the current flow at the predetermined maximum level, say 27 milliamperes.

The voltage on the associated line circuit is limited to a selected level, for example, the 45 volts specified above, by transistor T2–2. The base of transistor T2–2 is maintained at —45 volts with respect to the positive side of the source 45, and the emitter has to be made slightly less negative than the base or else the transistor starts to cut off, transistor T2–2 thus limiting the voltage on the line circuit to 45 volts. The emitter terminal 23 of transistor T2–2 is connected to the armature of contact TX–1, while the collecter terminal 22 of transistor T2–2 is connected to receiver control circuit 48, as shown in FIG. 3A.

Anti-jamming circuit

If a transmitter is jammed in the sending position because of either an electrical or mechanical fault, it could, unless provided for, tie up the line. Since no pulses are being received, this results in the release of relay TT after the nine second delay, so that the line circuit switches back to the stand-by or idle condition nine seconds after the transmitter becomes stalled. However, a second transmitter waiting to transmit on the same line circuit can get its capacitor CD–1 charged, since the "short" produced by the resistor RX–30 in the stalled transmitter will allow sufficient current to flow to charge the capacitor CD–1 in the second transmitter. For a specific example, it will be assumed for descriptive purposes that the stalled transmitter is transmitter 2–1 in FIG. 3A, and that the second actuated transmitter waiting to transmit on line circuit 1 is 3–1, so that the surge of current through resistor RX–30 in transmitter 3–1 actuates the starting relay delay circuit 37–1 again. Circuit 37–1 is delayed four seconds, allowing sufficient time for the capacitor CD–1 of transmitter 3–1 to become charged, and therefore transmitter 3–1 will start. But no signal will be received from the second transmitter 3–1 after the line has been switched to the receiver control circuit 48 with reversed line polarity because of the presence of the stalled transmitter 2–1 on the line with its open K1–2 contact. Referring now to FIG. 5, the operation by transmitter 3–1 of relay TX in circuit TRC has opened contact TX–2, and after nine seconds, because of the absence of a signal from transmitter 3–1, relay TT de-energizes. The opening of contact TT–3 on the release of TT causes normally operated relay X to release. The release of relay X opens contact X–2, thereby breaking the holding circuit for relay M1 through contact N1–6, diode D5–20, and contact M1–1. Referring back to FIG. 3A, the release of relay M1 transfers contact M1–3 to its back contact, thereby to transfer the return side of the "A" loop to the armature of contact N1–3, and this together with the transfer of contact X–3, causes line power to be applied to the return side of the "A" loop through the front contact of N1–3 and back contact M1–3. The release of relay M1 also closes back contact M1–4, thereby to connect both sides of the "B" loop to the terminal 21 of limiter circuit RCL.

The switching of power to the return side of the "A" loop, which is also known as switching to the so-called "McCulloh condition," in effect reverses the direction of the transmitting current through line circuit 1 to reverse the usual order in which the transmitters in line circuit 1 are given priority in transmitting. Thus by reversing the order of transmission, transmitter 3–1 is placed ahead of instead of behind transmitter 2–1 so that transmitter 3–1 transmits its signal before transmitter 2–1 is returned to the line. It is to be understood that if there were other actuated transmitters 4–1, 5–1, . . . , *n*–1, in addition to actuated transmitter 3–1 and stalled transmitter 2–1 on line circuit, then the reversal of transmitting current would result in the operation of the highest numbered transmitter first, say transmitter *n*–1, followed in the reverse of the usual order by transmitter (*n*–1)–1 and successive lower-numbered transmitters. Pushbutton PB is provided to restore relay M1 and other M relays for other line circuits to the normal energized condition. Relay X is restored to its energized condition when the circuit is switched back to the standby condition by means of a restoring circuit 50 of suitable construction.

It will be obvious to those skilled in the art that NPN transistors can be employed as well as PNP transistors, with appropriate changes in polarity.

What is claimed is:

1. An electrical protection system which comprises
- a plurality of code signal transmitters placed at selected points in a location to be protected, said transmitters being arranged in groups in which each group includes at least one transmitter, each of said transmitters generating a characteristic code signal upon actuation in response to the occurrence of a selected condition,
- means for receiving said code signal generated by each of said transmitters,
- a plurality of conducting paths, each of said paths being associated with a corresponding one of said groups of code signal transmitters, and each of said paths being provided with
  - a first loop having an input side and a return side, and
  - a second loop having an input side and a return side,
- means for connecting the transmitters in each of said groups of transmitters to the associated one of said conducting paths in a predetermined order, including
  - first switching means for successively connecting each transmitter in each of said groups between said first and second loops of the corresponding conducting path, so that each transmitter receives transmitting current in said predetermined order on its associated conducting path, and
  - a central station including
    - a plurality of first potential sources in one-to-one correspondence with said plurality of conducting paths for supplying starting current to the corresponding conducting paths having one or more actuated transmitters,
    - a second potential source, having first and second terminals, for supplying said transmitting current to a conducting path having an actuated transmitter,
    - means for limiting the current and voltage applied to each of said corresponding plurality of conducting paths from said second potential source and
  - second switching means for successively transferring each of said conducting paths having at least one actuated transmitter from its corresponding first potential source to said associated second potential source to receive said transmitting current instead of said starting current, the order in which said conducting paths are successively transferred depending upon which conducting path is the first to have an actuated transmitter so that interference is prevented between actuated transmitters associated with different conducting paths, said second switching means including
    - means for connecting the first terminal of said second potential source to the input side of said first loop and the second terminal of said second potential source to the return side of said second loop so that said transmitting current is supplied to each conducting path in a predetermined direction to reach the transmitters on each conducting path successively according to said predetermined order.

2. In combination with the apparatus defined in claim 1, apparatus for reversing the direction of the transmitting current through any of said conducting paths in which at

least two transmitters have been actuated but one transmitter has stalled to prevent any other transmitter from receiving transmitting current, which comprises

third and fourth swtiching means associated with each conducting path,

said third switching means being provided with a first contact means for changing the connection of said first terminal of said second potential source from the input side to the return side of the first loop of said conducting path having a stalled transmitter, and

said fourth switching means being provided with a first contact means for changing the connection of said return side of said first loop from said input side of said second loop to said first terminal of said second source of potential, and a second contact means for connecting the input side of the second loop to the return side of said second loop.

3. Apparatus as defined in claim 1, in which said means for limiting the current and voltage applied to each of said corresponding plurality of conducting paths comprises

a first transistor provided with base, collector, and emitter terminals, said collector terminal being connected to said conducting path,

a second transistor provided with base, collector, and emitter terminals, said emitter terminal being connected to said conducting path, and said collector terminal being connected to said receiving means,

a voltage divider connected between said positive and negative terminals of said source of potential,

means for connecting the base terminals of said first transistor and said second transistor to said voltage divider to maintain the base terminal of said first transistor at a first preset voltage and the base terminal of said second transistor at a second preset voltage,

an adjustable resistor for connecting said positive terminal of said source of potential to said emitter terminal of said first transistor so that as said current applied to a conducting path having an actuated transmitter approaches a predetermined maximum level, the voltage across said adjustable resistor causes said emitter terminal of said first transistor to tend to become as negative as its base terminal, thereby to cause said first transistor to start to cut off and to increase the voltage between said collector and emitter terminals to maintain said current at said predetermined maximum level, and

means for connecting said emitter terminal of said second transistor to said voltage divider to maintain said emitter terminal slightly less negative than said base terminal of said second transistor so that said second transistor starts to cut off in response to an increase in voltage applied to said conducting path having an actuated transmitter.

4. Apparatus as defined in claim 3 wherein said voltage divider comprises

a first diode provided with first and second terminals,

a second diode provided with first and second terminals,

a first resistor provided with first and second terminals,

a second resistor provided with first and second terminals,

means for connecting said first terminal of said first diode to said positive terminal of said source of potential,

means for connecting said second terminal of said first diode to said first terminal of said second diode,

means for connecting said second terminal of said first resistor to said first terminal of said second resistor,

means for connecting said second terminal of said second resistor to said negative terminal of said source of potential,

means for connecting together said second terminal of said second diode, said first terminal of said first resistor, and said base terminal of said first transistor, and

means for connecting together said second terminal of said first resistor, said first terminal of said second resistor and said base terminal of said second transistor, and

wherein said means for connecting said emitter terminal of said second transistor to said voltage divider comprises

means for connecting the second terminal of said second resistor to said emitter terminal of said second transistor.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,500,377 Dated March 10, 1970

Inventor(s) Manfred W. Muehter

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 5, line 6, "Alarms" should read --Alarm--

Col. 5, line 58, "crosses" should read --passes--

Col. 6, line 41, after "fault" insert --between the control center and the transmitter thus--

Col. 7, line 32, "curent" should read --current--

Col. 8, line 10, after "36," insert --36'--

Col. 9, line 12, "supporting" should read --suppressing--

Col. 9, line 50, "K22" should read --K2-2--

SIGNED AND
SEALED
JUL 28 1970

(SEAL)
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