

[54] **CURRENT MONITORING SYSTEM AND METHOD**

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340/248 C, 248 P, 253 A, 253 P, 276; 179/5
R

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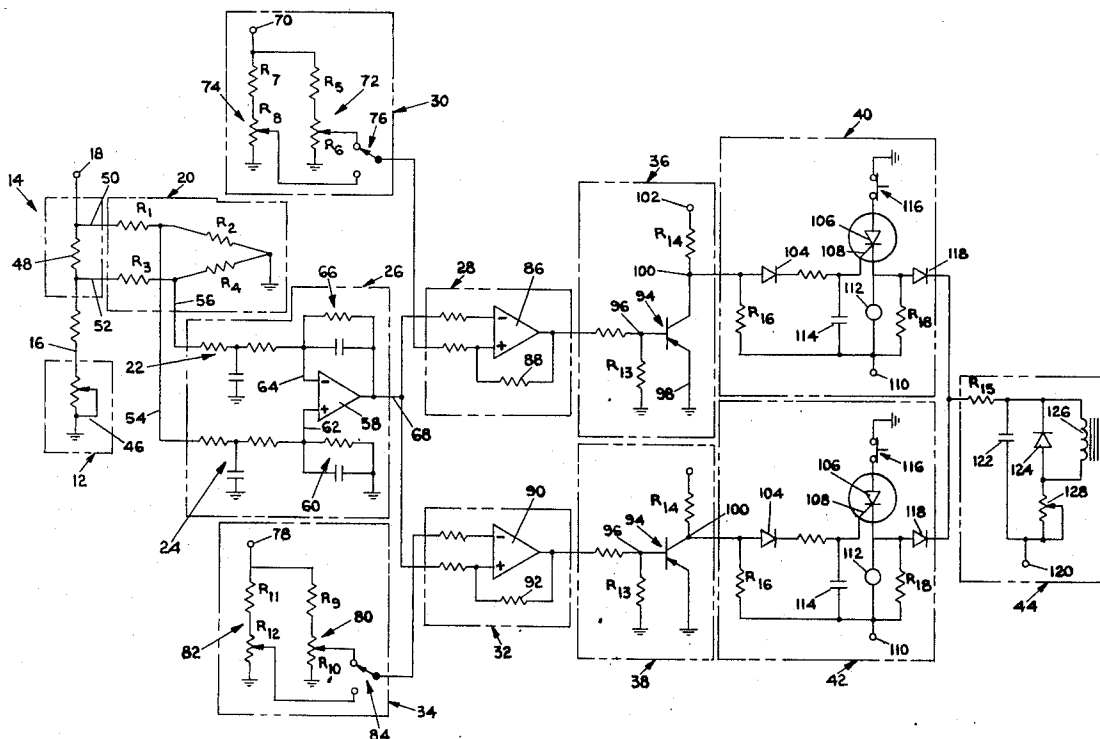
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[57] **ABSTRACT**

An electronic current monitoring system and method in which a current in a transmission line is detected, converted to an output voltage representative of the value of the current and compared with reference voltages representative of minimum and maximum current values in the transmission line. An alarm signal is generated in the event that the output voltage drops below the minimum reference voltage or rises above the maximum reference voltage. Two or more alarm currents can be monitored simultaneously, each alarm current representing a different condition at a subscriber station with a separate alarm being given for each alarm current which represents a different condition at the subscriber station. An alternating current signal can be impressed on the transmission line and detected with the frequency thereof compared to predetermined values to detect tampering with the alarm system. An alarm is activated in response to an alarm signal in the event the frequency in the line changes from the predetermined frequency value. The reference voltages are adjustable to adjust the tolerance level from the normal current and, in addition, alternate reference voltages are coupled to the system by a switch so that different reference voltages can be switched into the line to quickly change the level of current being monitored.

34 Claims, 2 Drawing Figures



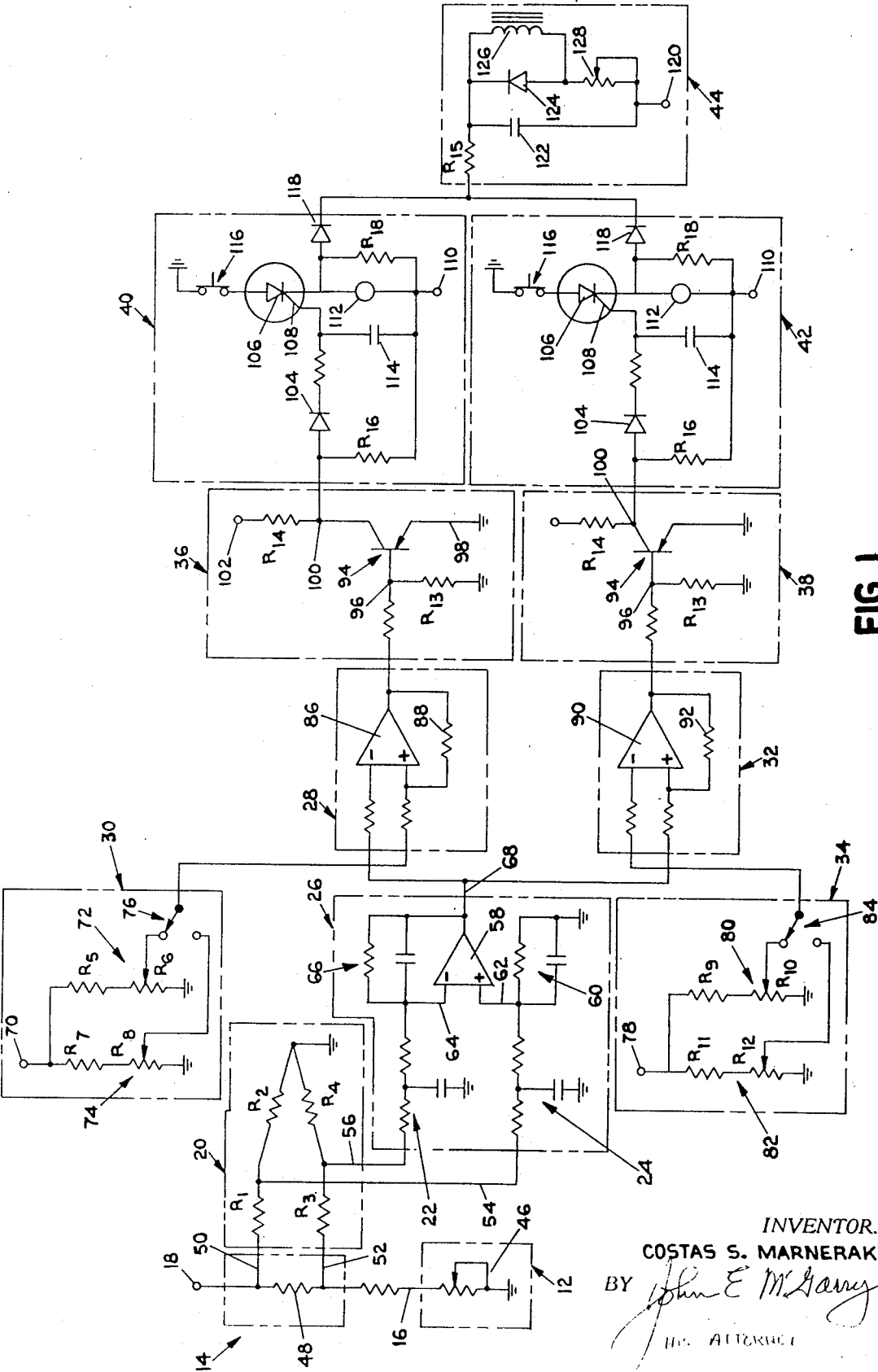


FIG. 1

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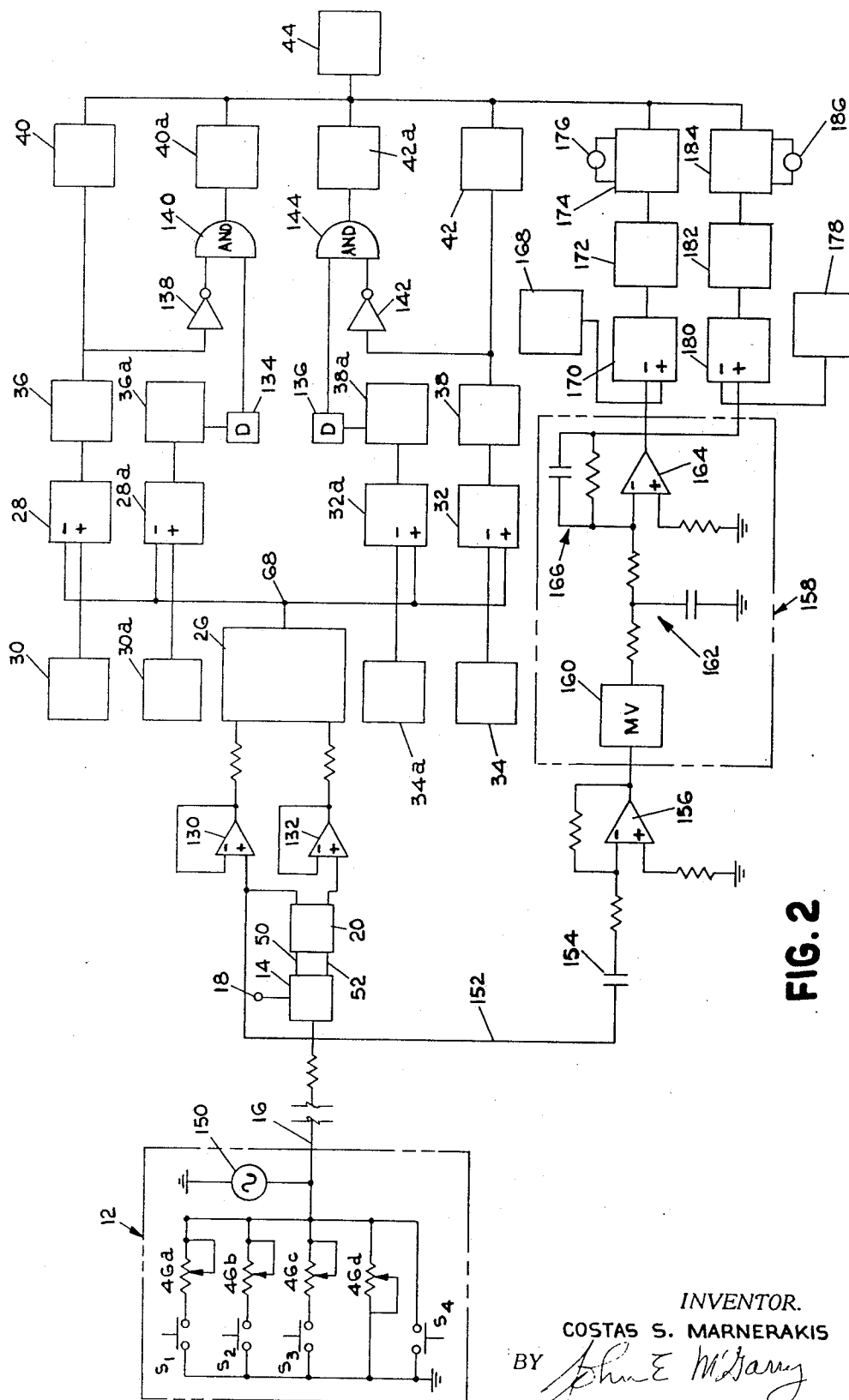


FIG. 2

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CURRENT MONITORING SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to current monitoring. In one of its aspects, the invention relates to a current monitoring system for burglar alarms and the like wherein a subscriber station is electrically connected to a monitoring station and an alarm is generated at the monitoring station in the event of a change in the current flow at the subscriber station.

In another of its aspects, the invention relates to a method and system for monitoring a current in a line for changes in the current to two or more current levels wherein a different alarm signal is generated when the line current reaches each predetermined level.

2. State of the Prior Art

Conventional burglar alarm systems employ a monitoring station electrically connected through telephone wires to a subscriber. A low level of current flows between the subscriber and the monitoring station with the level of current being primarily determined by an adjustable resistance at the subscriber location. If a short occurs in the line at the subscriber, the current value rises and this rise in current is detected at the monitoring station. Generally an alarm is sounded, indicating trouble at the subscriber station. An alarm is also sounded if an open circuit occurs at the subscriber station. This latter condition may result from the severing of the burglar alarm system at the subscriber. The open circuit causes a drop in the current level at the monitoring station. Generally, the drop in current is associated with someone burglarizing the subscriber or someone tampering with the alarm system to disconnect the system so that the subscriber may be deactivated for burglarizing the subscriber at a later time.

One type of monitoring system presently employed has relays in series with a DC line. The relays are actuated responsive to a current drop or current rise in a line. At any given time, the monitoring system can detect only two alarms. Separate pairs of these relays must be employed for each different set of alarm currents. The relay systems do not lend themselves to adjustment so as to adjust the tolerance levels, i.e., allowable variation for a given current. Compared to the more modern electronic components, the relays are relatively insensitive, unreliable, larger and expensive.

In addition, because of the fact that all relays are slightly different, it is very difficult to manufacture two relay monitoring systems with exactly the same tolerance levels.

Frequently, it is desirable to change the tolerance level for a given level of monitoring current. In some instances, wider tolerance limits are required because of larger fluctuations from the normal current level. In other instances, smaller tolerance levels are required. Heretofore, it has not been possible to change the relays at different times for different tolerance levels.

With the advent of such burglar alarm systems, modern burglars have become much more sophisticated and have employed electronic equipment to deactivate the alarm systems. Depending on the skill of the person, tampering with the burglar alarm system with electrical equipment does alter the current flow somewhat, but, in certain instances, the tampering is not enough to activate the relays with wide tolerance limits. It is therefore necessary to have as close tolerance limits as

possible at the monitoring station in order to detect tampering with the alarm system. In addition, more sophisticated systems are required to stay ahead of the tampering methods of the modern criminal.

The above described alarm system suffers from another deficiency. The relay detecting systems permit only two conditions, i.e., under current and over current, to be detected at a given time. It would be desirable to monitor more than two alarm currents at the subscriber station. For example, in addition to the open circuit condition, it would be desirable to monitor for smoke, water, hold ups, heat, etc. Heretofore, this has been impossible with the present systems without separate lines and separate monitoring systems for each pair of conditions.

Another problem with relays is that the relays have a relatively wide hysteresis band for the low level of current monitoring. This hysteresis band adversely affects the accuracy of the system after an alarm has been triggered.

A still further problem with the relay monitoring system is that the system is limited by distance. Subscribers located more than a fixed distance from the monitoring station cannot be protected. The relays require a certain fixed current level which is a function of the line resistance and the voltage. The line resistance is directly proportional to distance. Thus, when the subscriber is more than a predetermined distance from the monitor, the line resistance lowers the line current below a point at which it can no longer be effectively detected by the relays.

Monitoring systems have also been devised wherein semi-conductor circuits including transistors have been substituted for the relays. The transistors are biased so as to be off under normal conditions and are switched on to activate alarms when the current exceeds certain limits. These systems, although more reliable than the relay systems, suffer from many of the other disadvantages of the relay systems. First of all, separate detecting circuits are required for different current levels, thereby making versatile monitoring circuits rather expensive. In addition, the tolerance levels cannot be adjusted and the line resistance limits the distance between subscriber and monitoring station. Further, the semiconductor systems require a voltage regulator for the line current, thereby increasing the cost of the system. Still further, only one set of conditions can be monitored at a time and the system is subject to misfiring due to noise, transients, lightning, etc.

BRIEF STATEMENT OF THE INVENTION

I have now discovered a new and improved electronic current monitoring system and method. The monitoring system is entirely electronic, providing a smaller and lighter compact unit at the monitoring station. In addition, the monitoring system is more sensitive and reliable than the conventional systems now employed. The new system is less expensive to manufacture and is easily adjustable to different current monitoring levels. Still further, the tolerance levels for any given current can be adjusted very easily. With the system according to the invention, two or more conditions at a subscriber station can be simultaneously monitored with a single subscriber line. The electronic system adapts itself to more sophisticated monitoring techniques to detect tampering with the subscriber alarm system.

According to the invention, the current monitoring apparatus has a means for detecting the current flow through the subscriber line and for generating an output voltage representative of the current value in the line. This output voltage is compared to reference voltages which represent the minimum current and maximum current values for the subscriber line. When the output voltage drops below the minimum reference voltage, an alarm signal is generated and an alarm is activated responsive to the alarm signal. Conversely, when the output voltage rises above the maximum line voltage, another alarm signal is generated which activates an alarm. Separate alarms can be employed for each alarm signal to thereby indicate the different conditions.

The reference voltages are supplied by adjustable potentiometers which can be adjusted easily to adjust the minimum and maximum levels for a given monitoring current in the subscriber line. In addition, each reference voltage generating means can have a plurality of adjustable potentiometers which are connected into the comparing circuit by a switch so that the level of reference voltage can be quickly changed by merely throwing a switch for monitoring different levels of current.

With the system according to the invention, a plurality of current levels can be easily monitored by comparing the output voltage to a plurality of reference voltages and by generating an alarm signal responsive to the output voltage rising above or falling below the reference voltages. Discriminator means are employed to control the alarm signals generated when the output voltage has risen above or fallen below two or more reference voltages to produce a single alarm representative of the particular level of current in the subscriber line.

Still further, with the electronic monitoring system according to the invention, an AC signal can also be monitored simultaneously with the DC current. For this purpose, the current monitoring apparatus has a means for detecting the AC signal in the subscriber line, means for comparing the frequency of the AC signal with predetermined minimum and maximum frequency values and generating an alarm signal which activates an alarm when the frequency thus detected falls below a minimum frequency value or rises above a maximum frequency value. Desirably, the frequency is converted to an output voltage representative of the frequency of the signal in the subscriber line, and this output voltage is then compared to reference voltages which represent minimum and maximum frequency values for a signal on the subscriber line. By this system, the frequency tolerances can be adjusted, and the frequency levels can be easily changed for monitoring different frequencies in the subscriber line.

In the monitoring system according to the invention, many different alarms can be used. Preferably, however, an audible alarm signal is sounded when any of the alarm signals are generated, and a separate visual alarm, such as a light bulb, is activated for each of the alarm current values in the subscriber line. Thus, a separate light bulb will be lighted when the current in the subscriber line reaches each of the separate predetermined current values for the subscriber line. Additional visual alarms are employed for the AC monitoring system.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a schematic representation of one embodiment of the invention; and

FIG. 2 is a schematic representation of a second, more sophisticated, embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and to FIG. 1 in particular, a subscriber station 12 is electrically connected to a monitoring station at a distant point through means such as a telephone line 16. An input DC voltage is applied at terminal 18 for the subscriber 12. For purposes of illustration, the input voltage will be described as a negative input DC voltage which requires only a single line to the subscriber. A positive voltage input can also be used but this voltage may require a return line. A voltage sensor 14 is provided at the monitoring station to detect the current flow through the telephone line 16. The voltage sensed by the voltage sensor 14 is applied to an attenuating network 20 to reduce the voltage to an acceptable level. The output from the attenuating network 20 is applied to a subtractor circuit 26 which includes filtering networks 22 and 24 which filter noise from the voltage. The output from the subtractor circuit 26 is applied to the negative input to a high gain comparator 28 through line 68. An open line reference voltage means 30 produces a reference voltage which is applied to the positive input to the comparator 28. As used herein with respect to comparators and amplifiers, the terms "positive" and "negative" are intended to designate non-inverting and inverting inputs respectively to such devices.

The output from the subtractor circuit 26 is also applied to the positive input to a second comparator 32 which compares the output voltage with a reference voltage produced by a short reference voltage means 34. The reference voltage from voltage means 34 is applied to the negative input to the comparator 32.

The comparator 28 generates an alarm signal when the voltage in line 68 drops below the reference voltage from voltage means 30. Similarly, the comparator 32 generates an alarm signal when the output voltage rises above the reference voltage from voltage means 34.

The output from the comparator 28 is connected to an inverter 36 for inverting the output voltage from the comparator 28. The output from the inverter 36 is connected to a latching circuit 40 which in turn is connected to an audible alarm circuit 44. Similarly, the output from the comparator 32 is connected to an inverter 38. A latching circuit 42 is connected to the output of the inverter 38 and has its output connected to the audible alarm circuit 44.

More specifically, at the subscriber's station, the telephone line 18 is connected to an adjustable resistance 46 such as a potentiometer. The resistance at the subscriber station can thus be adjusted by the resistance 46. In addition, the subscriber's station can comprise a pair of such potentiometers alternately connected into the line by a switch (not shown) to alternately set different levels of current in the line.

The voltage sensor 14 comprises a resistance 48 and leads 50 and 52 to detect the voltage drop across the resistance 48. Lead 50 is connected to resistance R₁

which is connected to ground through resistance R_2 . Lead 52 is connected to resistance R_3 which is also connected to ground through a resistance R_4 . Resistances R_1 , R_2 , R_3 and R_4 comprise the attenuating network 20. The attenuated voltage is taken from the attenuating network 20 by leads 54 and 56.

Lead 54 is connected to input line 62 through filter 24. Lead 56 is connected to input lead 64 through filter 22. The filters 22 and 24 remove noise from the attenuated voltage.

The subtractor circuit 26 includes the filters 22 and 24, a linear operational amplifier 58 and a pair of RC filters 60 and 66. RC filter 60 is connected to input line 62. RC filter 66 is connected between input line 64 and the output line 68 for the amplifier 58. The combination of the amplifier 58 and the filter 66 makes an active filter network.

The comparator 28 includes a linear operational amplifier 86 having negative and positive input leads and a feedback resistor 88 between the amplifier output and the positive input. The positive feedback through resistor 88 makes the amplifier 86 stable and less sensitive to noise. The result is that the comparator is stable and relatively immune to noise.

The open line reference voltage means 30 comprises an input terminal 70 at which a negative DC voltage is applied. A pair of parallel adjustable potentiometers 72 and 74 are connected to the input terminal 70 and alternately determine the open line reference voltage through switch 76. For purposes of illustration, the potentiometer 72 having resistance R_6 is designated as the "day" potentiometer and the potentiometer 74 having resistance R_8 is designated as the "night" potentiometer. Resistances R_5 and R_7 limit the current through potentiometers 72 and 74, respectively. The voltage means 30 produces an output voltage which is representative of a low tolerance level of current flowing through the telephone line 16. This reference voltage can be quickly changed by throwing switch 76. The voltage from voltage means 30 is applied to the positive input to the amplifier 86.

The negative input terminal of the amplifier 86 is connected to the output voltage line 68 of the amplifier 58. The function of the comparator 28 is to compare the reference voltage from voltage means 30 with the output voltage from the amplifier 58. So long as the output voltage from amplifier 58 is greater (more negative when negative input voltages are used) than the voltage from the voltage means 30, the output from the amplifier 86 will be positive. However, when the output voltage from the amplifier 58 is less (less negative) than the voltage from the voltage means 30, then the output from the amplifier 86 will be negative.

The short reference voltage means 34 is substantially the same as the open line reference voltage means 30 except that the output is at a higher voltage level. Voltage means 34 comprises a terminal 78 at which is applied a negative DC voltage. A switch 84 alternately connects the reference voltage lines to the voltage terminal 78 through potentiometers 80 and 82. Potentiometer 80 is comprised of resistance R_{10} and, for purposes of illustration, is called the "day" potentiometer. Potentiometer 82 is comprised of resistance R_{12} and, for purposes of illustration, is called the "night" potentiometer. Resistances R_9 and R_{11} limit the current in potentiometers 80 and 82, respectively. Different values are set on potentiometer 80 and 82 so that a different

output voltage results when the switch 84 changes from potentiometer 80 to potentiometer 82.

The comparator 32 is comprised of a linear operational amplifier 90 having negative and positive input terminals and a single output terminal. A feedback resistor 92 is connected across the positive input terminal and the output terminal of the amplifier 90.

The output voltage from the voltage means 34 is applied to the negative input terminal of the amplifier 90.

The output voltage in line 68 from the amplifier 58 is applied to the negative input terminal of the amplifier 90.

Comparator 32 functions in a manner similar to comparator 28. When the output voltage from the voltage means 32 is greater (more negative) than the output voltage from amplifier 58, then a positive output voltage results from the comparator 32. On the other hand, when the output voltage from amplifier 58 is greater (more negative) than the voltage from voltage means 30, then a negative output voltage results from the comparator 32.

The inverters 36 and 38 are identical in structure and function. For this reason, identical numerals have been used to designate like parts. For purposes of this description, inverter 36 will be described, it being understood that inverter 38 functions in the same manner. The inverter comprises a PNP transistor 94 whose base 96 is connected to the output of the comparator 23 and to ground through resistance R_{13} . The emitter 98 of the transistor 94 is connected to ground. The collector 100 of the transistor 94 is connected through resistance R_{14} to a terminal 102 to which is applied a negative voltage. When the output from the comparator 28, for example, is positive, the transistor is off and no current can flow from the emitter 98 to the collector 100. On the other hand, when the output voltage from the comparator switches to negative, the transistor is turned on and the ground is transferred from the emitter 98 to the collector 100 and current flows from the emitter 98 of the transistor into the latching circuit 40.

Similarly, when the output from the comparator 32 is positive, the transistor of inverter 38 is off and there is no current flow to the latching circuit 42. When the output from the comparator 32 is negative, the transistor of the inverter 38 is switched on and current then flows to the latching circuit 42.

Latching circuits 40 and 42 are identical in construction and function. Hence, identical numerals have been used to describe like parts of each of the circuits. For purposes of brevity, only one such latching circuit will be described in detail. The latching circuit 40 comprises SCR 106 whose gate 108 is connected to the output from the inverter 36 through a diode 104. A voltage terminal 110 has a negative voltage applied thereto and is connected to the cathode of the SCR 106 through a light 112 which acts as a visual alarm. In addition, the voltage at terminal 110 is applied to the gate 108 through a capacitor 114. The anode of the SCR is connected to ground through a reset switch 116 which is normally closed. The voltage terminal 110 is also connected to the output from the inverter 36 through a resistor R_{16} . If desirable, a resistance and capacitor in series (not shown) can be connected across the SCR to provide suppression of the rate effect for the SCR, preventing a false firing of the SCR due to a fast rate of voltage change. Still further, a resistor R_{18} can be shunted across the light 112 to permit latching in event

the light 112 burns out. A diode 118 is connected to the output from the latching circuit 40.

In operation of the latching circuits 40 and 42, when there is a negative voltage at the gate 108 of the SCR 106, the SCR will be off, no current will flow through the light 112 and no current will flow from the output from the latching circuit 40. However, when a positive voltage is applied to the latching circuit from the inverter, the SCR 106 will be switched on. Current will then flow through light 112 and through diode 118 to the audible alarm circuit 44. Once the SCR is turned on, it will stay on until reset by switch 116.

The audible alarm circuit 44 has a voltage terminal 120 to which a negative DC voltage is applied. A resistor R_{15} is connected between the output from the latching circuits 40 and 42 and a buzzer 126 or other similar audible alarm. A diode 124 is connected across the buzzer 126. The diode 124 and the buzzer 126 are connected to the voltage terminal 120 through a variable resistor 128. A capacitor 122 is connected to resistance R_{15} and to the voltage terminal 120 across the buzzer and variable resistor circuit.

The buzzer operates whenever there is current flowing through resistor R_{15} to the voltage terminal 120 from a latching circuit.

In operation of the system illustrated in FIG. 1, a predetermined normal current level is set at the subscriber station 12 with the adjustable resistance 46. This can be one value for daytime and another value for night time. For example, a current value of 20 milliamps can be used for daytime monitoring and a current of 15 milliamps can be used for night time monitoring. The value of the current flowing through the line 16 is sensed by the voltage sensor 14. The voltage between leads 50 and 52 is proportional to the value of current flowing through the line 16. This voltage is then applied to the subtractor circuit 26 through attenuator 20 and filters 22 and 24. The output from the subtractor circuit 26 is a voltage value which is proportional to the flow of current through line 16. The open line reference voltage means 30 is set at a value which is proportional to a minimum value of current flow through line 16. For example, if a current flow of 20 milliamps through line 16 is represented as a voltage of 5 volts at line 68, the output voltage from the voltage means 30 can be set at four volts which would represent a current flow through line 16 of about 16 milliamps. The output voltage from voltage means 30 is controlled by adjusting the day potentiometer 72. So long as the value of the voltage in line 68 is greater than the value of the output voltage from voltage means 30, the output from the comparator 28 will be positive. Thus, assuming that a negative voltage is applied at voltage terminals 18 and 70, the output from the comparator 28 will be positive so long as the absolute value of the voltage in line 68 is greater than the absolute value of the voltage from voltage means 30. In this condition, the transistor 94 will be off, a negative voltage will be applied to the latching circuit 40 and the audible alarm circuit 44 will be in the inactive state.

In the event that someone tampers with the monitoring line, or the line 16 is cut, the current flow through line 16 will drop and the voltage across resistor 48 at voltage sensing means 14 will drop. Therefore the output voltage from the subtractor circuit 26 will drop, making the voltage from the voltage means 30 more negative than the voltage in line 68. As soon as the volt-

age in line 68 drops below (less negative) the voltage from the voltage output means 30, the comparator 28 will switch from a positive output to a negative output, thereby activating the transistor 94, causing a positive voltage to be applied to gate 108 of the SCR 106. The SCR will then be latched on, causing current to flow through the light 112, giving a visual alarm, and into the audible alarm circuit 44, thereby activating the buzzer 126. The light 112 will indicate the presence of low current, or no current, in line 16 at the monitoring station. A check can then be made of the subscriber to see whether anyone is burglarizing the subscriber or otherwise tampering with the alarm system.

The over current control works in a similar manner. So long as the value of the voltage in line 68 is less (less negative) than the value of the voltage from the voltage means 34, the output from the comparator 32 will be positive and the transistor 94 will be off. The latching circuit 42 will be inactive as a negative voltage is applied to the gate 108. The light 112 of the latching circuit 42 will therefore be off and the audible alarm circuit 44 will also be inactive.

In the event that a short occurs in the line 16, or in the event that tampering with the subscriber alarm system causes the current to increase, the voltage drop across resistor 48 of the voltage sensor 14 will be increased, thereby reflecting a higher voltage at the output voltage line 68 of the subtractor circuit 26. As soon as the voltage in line 68 increases (becomes more negative) to a value greater than the voltage from the voltage means 34, the output from the comparator 32 will switch negative, thereby causing the transistor 94 of the inverter 38 to turn on causing a positive voltage to be applied to gate 108 of SCR 106 in the latching circuit 42. This positive voltage causes the SCR to switch on, causing current to flow through the light 112 of latching circuit 42 and into the alarm circuit 44, thereby activating the buzzer 126. The light 112 of the latching circuit 42 will be lit, giving a visual alarm, whereas the corresponding light of the latching circuit 40 will not be lit. This indicates to the monitor that a short or high current condition is present at the subscriber.

With the system illustrated in FIG. 1, the tolerance levels, i.e., that deviation from the normal current which will produce an alarm, can be adjusted. For example, the lower tolerance level can be adjusted by simply adjusting the potentiometer 72 of the voltage means 30. The upper tolerance level can be adjusted by simply adjusting the potentiometer 80 of the voltage means 34.

In monitoring systems, it is desirable to switch the current levels from time to time to minimize successful tampering with the alarm system. Frequently, the current levels are different for days and nights. In the system described above, the current monitoring levels can be easily changed by readjusting the adjustable resistance 46 at the subscriber station 12, thereby altering the level of current flow through the line 16. The new normal current level will thereby be established at a predetermined value. The change at the monitoring station takes place very easily by simply throwing switch 76 of voltage means 30 and switch 84 of voltage means 34. When the switch is thrown for the "night" potentiometer 74 of voltage means 30, a new low level monitoring voltage will be established. Similarly, when switch 84 is thrown to establish contact with the "night" potentiometer 82, a new high tolerance voltage

will be established. For example, if the normal daytime current level is at about 20 milliamps, the night time level can be switched to 16 milliamps. The low tolerance level can be switched from a voltage representing 16 milliamps to a voltage representing 12 milliamps. Similarly, the upper tolerance level of current can be adjusted by the voltage means 34 to represent a current of 20 milliamps for night time monitoring and 24 milliamps for daytime monitoring. Thus, the in example given, for daytime operation the normal current level will be 20 milliamps and an alarm will be sounded and displayed when the current level drops below 16 milliamps or rises above 24 milliamps. For night time monitoring with the current level at 16 milliamps, the alarm will be sounded and displayed when the current drops below 12 milliamps or rises above 20 milliamps.

Reference is now made to FIG. 2 which illustrates a more sophisticated alarm system according to the invention. In FIG. 2, like numerals have been used to designate like parts. In this more sophisticated system, the subscriber station 12 has a plurality of potentiometers 46a, 46b, 46c, and 46d all connected to the subscriber line 16. Each of the potentiometers represents a different sensing device at the subscriber station. Potentiometers 46a, 46b and 46c are connected respectively to switches S₁, S₂ and S₃ which are normally open. The switches S₁, S₂, S₃, and S₄ represent sensing devices such as photo cells, heat detectors, transistors, smoke detectors and the like and for purposes of illustration are shown in the open position. Potentiometer 46d has current normally flowing therethrough and establishes the current monitoring level for the system. Each of the potentiometers 46a, 46b, 46c and 46d are adjusted so that given current values will result in line 16 when any one of potentiometers 46a, 46b, or 46c are joined in parallel with potentiometer 46d by closing switches S₁, S₂, or S₃. In the event that switch S₄ is closed, a short results.

An input DC voltage, preferably negative, is applied to terminal 18 and the current in the subscriber line 16 is sensed by the voltage sensor 14. The voltage is attenuated in attenuating network 20 and the output is passed through voltage followers 130 and 132 and then applied to a subtractor network 26. Voltage followers 130 and 132 act as buffers between the attenuating network 20 and the subtractor network 126. The output voltage from the subtractor network 26 appearing at line 68 is directly proportional to the current flowing through the subscriber line 16. This output voltage is applied to comparators 28, 28a, 32a and 32. Voltage output means 30 and 30a provide a reference voltage for comparators 28 and 28a respectively and reference voltage means 34a and 34 provide reference voltages for comparators 32a and 32 respectively. The output from comparator 28 is applied to inverter 36 whose output is applied to latching circuit 40 which includes a visual alarm (not shown). The output from latching circuit 40 is connected with the audible alarm circuit 44 which contains an audible alarm activated by a signal from the latching circuit 40.

The output from comparator 28a is applied to inverter 36a. The output from inverter 36a is applied to AND gate 140 through a delay circuit 134. The delay circuit 134 can be any suitable well known delay circuit such as an RC network. The output from the inverter 138 is also applied to AND gate 140 which applies its output signal to latching circuit 40a which in turn is

connected to the audible alarm circuit 44. Latching circuit 40a is of similar construction to the latching circuit 40, described more fully in FIG. 1, and contains a visual alarm such as a light.

Comparators 28 and 28a function in the same manner as the comparator 28 of the embodiment illustrated in FIG. 1. Comparator 28 compares the voltage appearing in line 68 and the voltage from output voltage means 30. Comparator 28a compares the voltage appearing in line 68 with the voltage from voltage means 30a. Voltage means 30 and 30a are set at different levels for monitoring different current levels. For example, voltage means 30 would be set with a less negative voltage than voltage means 30a. The output from comparator 28a would switch negative when the current in the subscriber line dropped to a first predetermined value, and comparator 28 would be switched negative when the current in the subscriber line 16 dropped to a second predetermined value. By way of illustration, if the normal current monitoring level is at 20 milliamps, the voltage from voltage means 30a can be set so that comparator 28a switches to a negative output when the current drops below 16 milliamps. The voltage from voltage means 30 can be set so that the comparator 28 switches to a negative output when the current in line 16 drops below 12 milliamps.

When the voltage at line 68 drops to the first predetermined level, the comparator 28a switches negative thereby sending a negative signal to inverter 36a. The output from 36a is delayed in delay means 134 and then passed to AND gate 140. In the event that both AND gate inputs, i.e., from delay 134 and from inverter 138 are positive, the AND gate 140 will be open, permitting the signal to be transmitted to latching circuit 40a and causing a voltage to be sent to the audible alarm circuit 44a, thereby producing an audible alarm. At the same time, the light in the latching circuit 40a will go on, thereby giving a visual alarm which is indicative of a particular current in the subscriber line 16.

The delay means 134, the inverter 138, and the AND gate 140 function as a discriminator to distinguish between a current at the first low level and the second low level. For example, if the current has dropped to the first predetermined level but not to the second predetermined level, the output from the comparator 28a will be negative, thereby producing a positive voltage from the inverter 36a. A positive voltage will thereby be transmitted to AND gate 140. At the same time, the output from the comparator 28 will be positive, thereby producing a negative output from the inverter 36 which maintains the latching circuit 40 in the off condition. Therefore the light in latching circuit 40 will be off. The negative voltage from inverter 36 is inverted in inverter 138 thereby producing a positive voltage which is applied to AND gate 140. The AND gate thus sees two positive voltages and opens to permit the voltage to be applied to latching circuit 40a, thereby activating the latching circuit, lighting the light of latching circuit 40a, and producing an audible alarm from the alarm circuit 44.

When the current drops from the normal level below the second predetermined level, the output from the comparator 28 will switch negative, thereby producing a positive output voltage from inverter 36, which voltage, when applied to latching circuit 40, causes latching circuit 40 to switch on, thereby lighting the light in latching circuit 40 and activating the audible alarm circuit.

cuit 44. At the same time, the positive voltage from the inverter 36 is again inverted in 138 and applied as a negative voltage to AND gate 140, preventing the signal from passing therethrough to latching circuit 40a. When the current drops from the normal monitoring current to the second predetermined level, the delay means 134 will delay the positive signal to AND gate 140 and will thus prevent application of the positive signal to AND gate from the output of inverter 138. Thus, the voltage is prevented from being transmitted through the AND gate 140 to the latching circuit 40a and latching circuit 40a will not be switched on. When the current drops to the second predetermined level, an audible alarm sounds, the light of latching circuit 40 will be lit and the light of latching circuit 40a will not be lit. As explained above, the drop in current level results from closing of one of the switches S_1 , S_2 , or S_3 , or from tampering with the alarm system.

The over current alarm system works in a similar manner. The output from the voltage means 34a represents a first current level in subscriber line 16 above the normal current, and the output voltage from voltage means 34 represents a second current value higher than the first predetermined current level in the subscriber line 16. The output from comparator 32a is applied to inverter 38a. The inverted voltage passes through a delay 136 and is applied to AND gate 144. Similarly, the output from comparator 32 is applied to inverter 38 and the inverted signal from inverter 38 is again inverted in inverter 142 and applied to AND gate 144. When the voltage polarity from the inverter 142 and from delay 136 are positive, the positive voltage is passed through AND gate 144 and to latching circuit 42a. When the voltage applied to latching circuit 42a is positive, the latching circuit 42a is turned on, thereby lighting a light in the latching circuit and applying a voltage to the alarm circuit 44 for activating an audible alarm. The latching circuit 42a is of a construction identical with latching circuit 42 which is illustrated in detail in FIG. 1.

The output voltage from inverter 38 is also applied to the latching circuit 42 which, when turned on by a positive voltage, will apply a voltage to the alarm circuit 44.

The over current side of the circuit operates in a manner similar to the under current side described above. At the normal level, the output from comparator 32a will be positive, thereby producing a negative signal from the delay means at AND gate 144. The voltage from comparator 32 will also be positive, thereby producing a positive voltage at AND gate 144. Since the polarities of the voltages are opposite at AND gate 144, no voltage will be passed therethrough to latching circuit 42a which will therefore be off. In addition, the negative voltage from inverter 38, appearing at the input to latching circuit 42, will cause the latching circuit 42 to remain off. Similarly, latching circuits 40 and 40a will also be off.

When the current in the subscriber line 16 rises to a first predetermined level, the comparator 32a will switch negative and apply a negative voltage to inverter 38a. A positive voltage is delayed in delay means 136 and then applied to AND gate 144. At the first predetermined current level above the normal current, the comparator 32 will have a positive output voltage, which when inverted first by inverter 38 and second by inverter 142 will appear as a positive voltage at AND gate 144. The AND gate will then pass the positive volt-

age to latching circuit 42a which will be thereby activated to light the light therein and to apply a voltage to the audible alarm circuit 44. At this time, the negative voltage from inverter 38 will be applied to latching circuit 42 which will consequently be off.

When the current in line 16 rises from normal current to a current above the second predetermined level, such as when a short occurs, the output voltage at line 68 will appear greater (more negative) than the output voltage from the voltage means 34. The comparator 32 will then switch to a negative output, causing a positive voltage to appear at the input to the latching circuit 42, thereby switching on the latching circuit 42 and activating the buzzer 44. At the same time, the output from the comparator 32a will switch negative, thereby producing a positive signal at the input to AND gate 144. However, the positive output voltage from inverter 38 will be again inverted to a negative voltage in inverter 142 and the negative voltage is applied to AND gate 144. This opposite polarity of the voltages at AND gate 144 prevents the voltage from being applied to latching circuit 42a and prevents the latching circuit 42a from being activated. Thus when the current in the subscriber lines reaches the second predetermined level above the normal current, the audible alarm will be on and the light of the latching circuit 42 will be on. At the same time, the lights in the latching circuits 42a, 40a, and 40 will be off.

As set forth above, the various current levels can be set by potentiometers 46a, 46b, 46c, and 46d. The normal current through the subscriber line 16 is set by the potentiometer 46d. At this time, switches S_1 , S_2 , S_3 , and S_4 will be opened. In the event of one condition, such as the presence of smoke, one of the signals, for example S_1 will close, thereby giving a deviation from the normal current in line 16 to a predetermined value. For example, the potentiometer 46a can be set so that the current flowing through line 16 will drop below the second predetermined current value when switch S_1 is closed, thereby activating the latching circuit and turning on the light in that latching circuit. Similarly, potentiometer 46b can be set so that when switch S_2 is closed, the current drops below the first predetermined current level, thereby activating latching circuit 40a. Similarly, potentiometer 46c can be set so that when switch S_3 is closed, the current in line 16 rises above the first predetermined current level and activates the latching circuit 42a, thereby turning on the light in the latching circuit. Obviously, when switch S_4 is activated, the subscriber line 16 will be shorted, thereby raising the current in the subscriber line above the second predetermined level, and thereby activating the latching circuit 42a to turn on the audible alarm and to light the light of 42a. In order to protect the monitoring equipment, a current limiting device (not shown) can be installed in line 16 to limit the current when the current in line 16 rises above a certain value. Such current limiting devices are well known and will not be further described herein.

The lights in the latching circuits 40, 40a, 42a and 42 can be all of different colors so that each color represents a different condition at the subscriber station.

As a further means to detect tampering with the subscriber line and the monitoring system, an AC signal can be impressed upon the DC current and detected at the monitoring station. For this purpose, an AC signal generator 150 can be installed at the subscriber station to impart an alternating current signal to the DC cur-

rent. The signal generator is preferably variable so that the AC signal can be varied for different alternating currents at different times. For example, one frequency can be used for daytime monitoring and another frequency can be used for night time monitoring. The signal generator can be of conventional design and impart a sinusoidal signal on top of the DC current or can be a conventional chopper network which alternates the DC current.

At the monitoring station, a lead 152 picks off the signal from the output from the attenuator 20. The DC signal is blocked by capacitor 154 and the AC signal is amplified in an AC amplifier 156. The signal is then converted to a DC voltage which is representative of the frequency of the signal in line 152 by a frequency to voltage converter 158. This converter comprises a one shot multivibrator 160, a filter network 162 and a DC amplifier 164 having an RC filter 166 applied between the output and the negative input of the amplifier 164. The output from the converter 158 thus is a direct current voltage which is directly proportional to the frequency of the signal detected in line 152. The output voltage from the converter 158 is applied to a negative input to a comparator 170 and to a positive input to comparator 180. A reference voltage means 168 of similar construction to the reference voltage means 30 applies a reference voltage to the positive input to the comparator 170, which voltage is representative of the low tolerance level of the frequency of the signal in subscriber line 16. The output voltage from the comparator 170 is inverted by inverter 172 and the inverted voltage is applied to a latching circuit 174 having a light 176. The inverter 172 can be of the same construction as the inverter 36 and the latching circuit 174 can be of the same construction as the latching circuit 40.

Similarly, a reference voltage means 178 applies an upper limit reference voltage to the negative input to comparator 180. The output voltage from comparator 180 is inverted in inverter 182 and the inverted voltage is applied to a latching circuit 184 having a light 186. The construction and operation of the inverter 182 is the same as that of the inverter 38 illustrated in detail in FIG. 1. The outputs from the latching circuits 174 and 184 are applied to the audible alarm circuit to produce an audible alarm when either of the latching circuits are activated.

The latching circuit 174 is activated to produce an audible alarm and to illuminate the light 176 for a visual alarm when the voltage applied to the input thereof is positive. Under normal conditions, the output from comparator 170 will be positive, and the voltage, when inverted, will apply a negative voltage to latching circuit 174. When the frequency drops below a predetermined value, such as when the line 16 is open, the comparator 170 will switch to a negative output, thereby causing a positive voltage to be applied to the latching circuit 174. The light 176 will be illuminated, and the audible alarm in circuit 44 will be activated.

Similarly, when the frequency of the signal in the subscriber line 16 rises above a predetermined limit, the output from the comparator 180 will switch negative, thereby applying a positive voltage (by virtue of inverter 182) to the latching circuit 184. This positive voltage will switch the latching circuit on, thereby illu-

minating the light 186 and thereby activating the audible alarm in the alarm circuit 44.

All of the visual alarm lights desirably are of a different color so that the person who is monitoring the subscriber can very easily detect what condition is causing the audible alarm and can initiate an appropriate remedy. For example, if smoke is causing the alarm, the monitor can easily see this condition and can dispatch fire engines to the subscriber. On the other hand, if switch S_2 for example, was set for a hold up at the subscriber 12, then an appropriate light would indicate that a hold up was taking place. The monitor could then quickly dispatch police officers to the subscriber 12.

The frequency monitoring system provides increased sophistication for the current monitoring device. The frequency monitoring system is used primarily to detect tampering with the system when the current monitoring system fails. For example, in the event that someone can by electrical equipment determine what the normal level of current is in line 16, it is possible for that person to cut off the alarm system while still maintaining the normal monitoring current. They may not, however, detect the exact frequency of the AC voltage and thus be unable to duplicate that frequency. In addition, they may not be able to duplicate the monitoring frequency. In any case, when a small predetermined variation occurs in the monitoring frequency, an alarm is sounded at the monitoring station. In addition, the monitoring frequency may change between the time the frequency is detected and the time the false frequency is impressed on the monitoring current, resulting in the sounding of an alarm.

With the use of the inventive system, many modifications to the monitoring system are possible. The tolerances of the monitoring current can be adjusted easily. Multiple levels of current can be detected for multiple conditions at the subscriber station with a single subscriber line. The sophisticated system makes it very difficult to tamper with the alarm system. Further, the electronic system, eliminating normal relays and the like, can be constructed of more reliable electronic components which are also smaller in physical volume and weight, thus, a compact, more reliable, monitoring station results from the electronic monitoring system.

The system has been described with reference to the use of negative voltages at the voltage terminals. When negative voltages are applied to the voltage terminals, a single subscriber line can be employed. Obviously, positive voltages can also be employed in lieu of negative voltages but positive voltages may require a return line from the subscriber.

A particular latching circuit has been described. Other latching circuits such as a flip-flop circuit can be employed in lieu of the described latching circuit without departing from the scope of the invention.

In the above described system, it is desirable to limit the current in the line in the event a short occurs, for example, to avoid damaging of the electrical components in the subscriber line. For this purpose, a current limiting device, such as a transistor, can be placed in the subscriber line and coupled directly to the output of the over current comparator 32 so that the transistor switches to a less conducting or non-conducting state when the comparator 32 switches negative.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, the draw-

ings, and appended claims without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are as follows.

1. A current monitoring apparatus for detecting the level of current in a given line and for producing an alarm responsive to a predetermined deviation from a current level in said line, said apparatus comprising:

means for detecting the level of current flow through said line, said detecting means including means for measuring the voltage drop across an impedance in said line and for generating an output voltage representative of the measured voltage drop across said impedance in said line, said generating means including an amplifier for amplifying the voltage drop across said impedance so that said output voltage is proportional to the level of current in said line;

first reference voltage generating means for generating a first reference voltage representative of a minimum current value in said line;

first comparator means coupled to said detecting means and to said first reference voltage generating means for comparing said first reference voltage with said output voltage, said first comparator means generating an alarm signal when said output voltage drops below said first reference voltage;

second reference voltage generating means for generating a second reference voltage representative of a maximum current value for said line;

said comparator means coupled to said detecting means and to said second reference voltage generating means for comparing said second reference voltage with said output voltage, said second comparator means generating an alarm signal when said output voltage rises above said second reference voltage; and

alarm means coupled to said first and second comparator means to produce an alarm when an alarm signal is generated by said first or second comparator means.

2. A current monitoring apparatus according to claim 1 wherein each of said first and second reference voltage generating means have means for adjusting the reference voltages generated therefrom.

3. A current monitoring apparatus according to claim 1 and further comprising:

a third voltage generating means for generating a voltage representative of a current value in said given line intermediate said minimum current value and a normal current value;

third comparator means coupled to said detecting means and to said third reference voltage means for comparing said third reference voltage with said output voltage, said third comparator means generating an alarm signal when said output voltage drops below said third reference voltage;

said alarm means coupled to said third comparator means to produce an alarm when said alarm signal is generated by said third comparator means.

4. A current monitoring apparatus according to claim 3 wherein said alarm comprises a visual alarm and an audible alarm, and there is a separate visual alarm coupled to each of said first, second, and third comparator means.

5. A current monitoring apparatus according to claim 3 wherein said alarm means comprises a separate alarm

coupled to each alarm signal from said first, second, and third comparator means, each of said separate alarms representing a different current condition in said line.

6. A current monitoring apparatus according to claim 5 and further comprising discriminator means coupled to said first and third comparator means and to said alarm means for blocking said alarm signal to said alarm for said third comparator when said output voltage drops below said first reference voltage, said discriminator means permitting said alarm signal to pass to said alarm means when said output voltage is at an intermediate value between said first and third reference voltages.

7. A current monitoring apparatus according to claim 1 and further comprising a third reference voltage generating means for generating a voltage representative of a current value in said line intermediate said maximum current value and a normal current value;

third comparator means coupled to said detecting means and to said third reference voltage means for comparing said third reference voltage with said output voltage, said third comparator means generating an alarm signal when said output voltage rises above said third reference voltage; said alarm means coupled to said third comparator means to produce an alarm when said alarm signal is generated by said third comparator means.

8. A current monitoring apparatus according to claim 1 and further comprising an AC monitoring means including:

means for detecting an AC signal in said line; means for sensing the frequency of said AC signal; means coupled to said frequency sensing means for comparing the sensed AC signal frequency with predetermined minimum and maximum AC signal values, and for generating an alarm signal when said sensed AC signal is above or below said predetermined values; and

means coupling said alarm means to said alarm signal generating means of said AC frequency comparing means to produce an alarm when said AC signal frequency rises above said maximum signal value or falls below said minimum signal value.

9. A current monitoring apparatus according to claim 8 and further comprising means for adjusting said minimum and maximum AC signal values.

10. A current monitoring system comprising: a subscriber station and a monitoring station; means electrically coupling said subscriber station with said monitoring station;

means for generating a current flow through said electrical coupling means;

said subscriber station including means to alter the current flow through said electrical coupling means;

means at said monitoring station for detecting the level of current flow through said electrical coupling means, said detecting means including means for measuring the voltage drop across an impedance in said line and for generating an output voltage responsive thereto, said output voltage being proportional to the current level in said electrical coupling means, said generating means including an amplifier for amplifying the voltage drop across said impedance in said electrical coupling means;

means coupled to said detecting means for comparing said output voltage with minimum and maximum voltage values representative of predetermined minimum and maximum current values in said electrical coupling means;

means for generating an alarm signal when said voltage drops below said minimum value or rises above said maximum voltage value; and

alarm means coupled to said alarm signal generating means for producing an alarm responsive to an alarm signal from said alarm signal generating means.

11. A current monitoring system according to claim 10 and further comprising means to adjust said minimum and maximum voltage values.

12. A current monitoring system according to claim 10 and further comprising means at said subscriber station to impress a given AC frequency signal on said current in said electrical coupling means;

means at said monitoring station for detecting said AC frequency and comparing said frequency to minimum and maximum frequency values;

means coupled to said comparing means for generating an alarm signal when said frequency drops below said minimum frequency value or rises above said maximum frequency value; and

means coupling said alarm signal generating means for said AC signal to said alarm means to produce an alarm when the frequency of said AC signal drops below said minimum value or rises above said maximum value.

13. A current monitoring system according to claim 12 wherein said comparing means includes means for converting said AC signal to a voltage representative of the frequency of said AC signal; means for generating a reference voltage representative of a minimum frequency level; and means for generating a reference voltage representative of a maximum frequency level.

14. A current monitoring system according to claim 13 wherein said reference voltage generating means are adjustable to vary said minimum and maximum frequencies for which an alarm is given.

15. A current monitoring system according to claim 12 wherein at least one of said reference voltage generating means have a plurality of voltage generating means for generating a plurality of different reference voltages; and switch means for singularly coupling each of said voltage generating means to said comparing means whereby different reference voltages can be selectively activated by said switch means.

16. A current monitoring system according to claim 12 wherein said alarm means includes a first visual alarm to indicate the presence of a frequency below said minimum frequency value, and a second visual alarm to indicate the presence of a frequency above said maximum frequency value.

17. A method of monitoring current flowing through a transmission line so as to detect tampering with said line or the presence of deviation of current in said line from a predetermined value, said method comprising: detecting the level of current in said transmission line by measuring the voltage drop across an impedance in said transmission line;

generating an output voltage proportional to the value of detected current level in said line, said generating step including amplifying the measured voltage drop across said impedance;

comparing said output voltage to reference voltages representative of minimum and maximum current values in said transmission line;

generating an alarm signal when said output voltage falls below said minimum or rises above said maximum current representative reference voltages; and

activating an alarm responsive to said alarm signal, said alarm indicating the presence of a minimum or maximum current value in said transmission line.

18. A method of monitoring current according to claim 17 wherein said generating step includes generating a first alarm signal responsive to said output voltage falling below said minimum current reference voltage, and generating a second alarm signal responsive to said output voltage rising above said maximum current reference voltage; said alarm activating step includes activating a first alarm responsive only to said first alarm signal and activating a second alarm responsive only to said second alarm signal.

19. A method of monitoring current according to claim 17 and further comprising the step of selectively altering said minimum and maximum reference voltages responsive to a change in the normal level of current in said transmission line.

20. A method of monitoring current according to claim 17 and further comprising impressing an AC signal in said transmission line;

detecting the frequency of said AC signal;

comparing said frequency of said AC signal to predetermined maximum or minimum reference frequencies; and generating a second alarm signal when said detected AC signal drops below said predetermined frequency or rises above said predetermined maximum frequency; and activating an alarm responsive to said second alarm signal.

21. A method of monitoring current according to claim 20 wherein said frequency detecting step includes converting said AC signal to a second output voltage representative of the frequency of said AC signal, and said comparing step comprises comparing said second output voltage with reference voltages representative of minimum and maximum frequencies of said AC signal in said transmission line.

22. A method of monitoring current according to claim 20 wherein said generating step comprises:

generating a first alarm signal responsive to said signal frequency dropping below said predetermined minimum frequency and generating a second alarm signal responsive to said AC signal frequency rising above said predetermined maximum frequency; and

said alarm activating step comprises activating a first alarm responsive only to said first alarm signal and activating a second alarm responsive only to said second alarm signal.

23. An alarm system comprising:

a subscriber station and a monitoring station;

means electrically coupling said subscriber station with said monitoring station;

means generating a current flow through said electrical coupling means;

means at said monitoring station for detecting current flow through said electrical coupling means;

means coupled to said detecting means for actuating an alarm at said monitoring station responsive to a drop in said current below a predetermined value

or a rise in said current in said electrical coupling means above a predetermined value;
 means for impressing an AC signal on said electrical coupling means;
 means at said subscriber station for detecting the frequency of said AC signal;
 means coupled to said frequency detecting means for comparing said frequency to predetermined minimum and maximum reference frequencies;
 means coupled to said comparing means for generating an alarm signal when the frequency of said detected AC signal falls below said minimum reference frequency or rises above said reference frequency; and
 alarm means coupled to said signal generating means for producing an alarm responsive to said alarm signal.

24. An alarm system according to claim 23 wherein said comparing means includes means for converting said AC signal to a voltage representative of the frequency of said AC signal;

means for generating a reference voltage representative of a minimum frequency level; and
 means for generating a reference voltage representative of a maximum frequency level.

25. An alarm system according to claim 24 wherein said reference voltage generating means is adjustable to vary said minimum and maximum frequency values for which an alarm is given.

26. An alarm system according to claim 25 wherein at least one of said reference voltage generating means has a plurality of voltage generating means for generating a plurality of different reference voltages, and switch means for singularly coupling each of said reference voltage generating means to said comparing means whereby different reference voltages can be selected by activating said switch means.

27. A current monitoring apparatus for detecting the level of current in a given line and for producing an alarm responsive to a predetermined deviation from a current level in said line, said apparatus comprising:

means for detecting the level of current flow through said line, said detecting means including means for measuring the voltage drop across an impedance in said line and for generating an output voltage representative of the measured voltage drop across said impedance in said line, so that said output voltage is proportional to the level of current in said line;

first reference voltage generating means for generating a first reference voltage representative of a minimum current value in said line;

first comparator means coupled to said detecting means and to said first reference voltage generating means for comparing said first reference voltage with said output voltage, said first comparator means generating an alarm signal when said output voltage drops below said first reference voltage;

second reference voltage generating means for generating a second reference voltage representative of maximum current value for said line;

second comparator means coupled to said detecting means and to said second reference voltage generating means for comparing said second reference voltage with said output voltage, said second comparator means generating an alarm signal when

said output voltage rises above said second reference voltage;

each of said first and second reference voltage generating means having means for generating a plurality of different output voltages, and switch means for singularly coupling each of said output voltage generating means to its respective comparator means; and

alarm means coupled to said first and second comparator means to produce an alarm when an alarm signal is generated by said first or second comparator means.

28. A current monitoring apparatus according to claim 27 wherein each of said plurality of voltage generating means is adjustable to vary the output voltage from each of said different voltage generating means.

29. A current monitoring apparatus for detecting the level of current in a given line and for producing an alarm responsive to a predetermined deviation from a current level in said line, said apparatus comprising:

means for detecting the level of current flow through said line, said detecting means including means for measuring the voltage drop across an impedance in said line and for generating an output voltage representative of the measured voltage drop across said impedance in said line, so that said output voltage is proportional to the level of current in said line;

first reference voltage generating means for generating a first reference voltage representative of a minimum current value in said line;

first comparator means coupled to said detecting means and to said first reference voltage generating means for comparing said first reference voltage with said output voltage, said first comparator means generating an alarm signal when said output voltage drops below said first reference voltage;

second reference voltage generating means for generating a second reference voltage representative of maximum current value for said line;

second comparator means coupled to said detecting means and to said second reference voltage generating means for comparing said second reference voltage with said output voltage, said second comparator means generating an alarm signal when said output voltage rises above said second reference voltage;

a third voltage generating means for generating a voltage representative of a current value in said given line intermediate said minimum current value and a normal current value;

third comparator means coupled to said detecting means and to said third reference voltage means for comparing said third reference voltage with said output voltage, said third comparator means generating an alarm signal when said output voltage drops below said third reference voltage;

a fourth reference voltage generating means for generating a voltage representative of a current value in said line intermediate said maximum current value and said normal current value;

fourth comparator means coupled to said detecting means and to said fourth reference voltage means for comparing said fourth reference voltage with said output voltage, said fourth comparator means generating an alarm signal when said output volt-

age rises above said fourth reference voltage; and alarm means coupled to said first, second, third, and fourth comparator means to produce an alarm when an alarm signal is generated by said first, second, third, or fourth comparator means.

30. A current monitoring apparatus according to claim 29 wherein said alarm means includes first, second, third, and fourth visual alarms coupled respectively to said first, second, third, and fourth comparator means for giving a visual display of the current level in said line.

31. A current monitoring apparatus according to claim 30 and further comprising a first discriminator means coupled to said first and third comparator means and to said alarm means for blocking said alarm signal to said alarm means for said third comparator when said output voltage drops below said first reference voltage, said first discriminator means permitting said alarm signal to pass to said alarm means for said third comparator when said output voltage is at an intermediate value between said first and third reference voltages;

a second discriminator means coupled to said second and fourth comparator means and to said alarm means for blocking said alarm signal to said alarm means for said fourth comparator means when said output voltage rises above said second reference voltage, said second discriminator means permitting said alarm signal to pass to said alarm for said fourth comparator when said output voltage is at an intermediate value between said second and fourth reference voltages.

32. A current monitoring apparatus according to claim 29 wherein each of said first, second, third and fourth voltage generating means have a plurality of voltage generating means for generating a plurality of reference voltages, and switch means for singularly coupling each of said voltage generating means to its respective comparator means.

33. A current monitoring system comprising:
a subscriber station and a monitoring station;

means electrically coupling said subscriber station with said monitoring station;

means for generating a current flow through said electrical coupling means;

said subscriber station including means for establishing a plurality of different current levels in said electrical coupling means, each current level being representative of a different condition of said subscriber station;

means at said monitoring station for detecting the level of current flow through said electrical coupling means, said detecting means including means for measuring the voltage drop across an impedance in said line and for generating an output voltage responsive thereto, said output voltage being proportional to the current level in said electrical coupling means;

means coupled to said detecting means for comparing said output voltage with minimum and maximum voltage values representative of predetermined minimum and maximum current values for each of said current levels in said electrical coupling means;

means for generating an alarm signal when said voltage drops below said minimum value or rises above said maximum voltage value for any of said respective current levels; and

alarm means coupled to said alarm signal generating means for producing an alarm responsive to an alarm signal from said alarm signal generating means.

34. A current monitoring system according to claim 33 and further comprising a separate alarm for each of said current levels, and means coupling each of said alarms with said comparing means, including means for actuating a single alarm representative of one of said different current levels responsive to an alarm signal from said comparing means such that only one of said alarms will be activated when one of said different current levels is reached in said electrical coupling means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,786,501 Dated January 15, 1974

Inventor(s) COSTAS S. MARNERAKIS

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

Column 14, line 22, "stil" should be --still--.

Column 15, line 31, the first "said" should be --second--.

Signed and sealed this 4th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents