LINE SUPERVISORY CIRCUIT

Filed Oct. 20, 1965

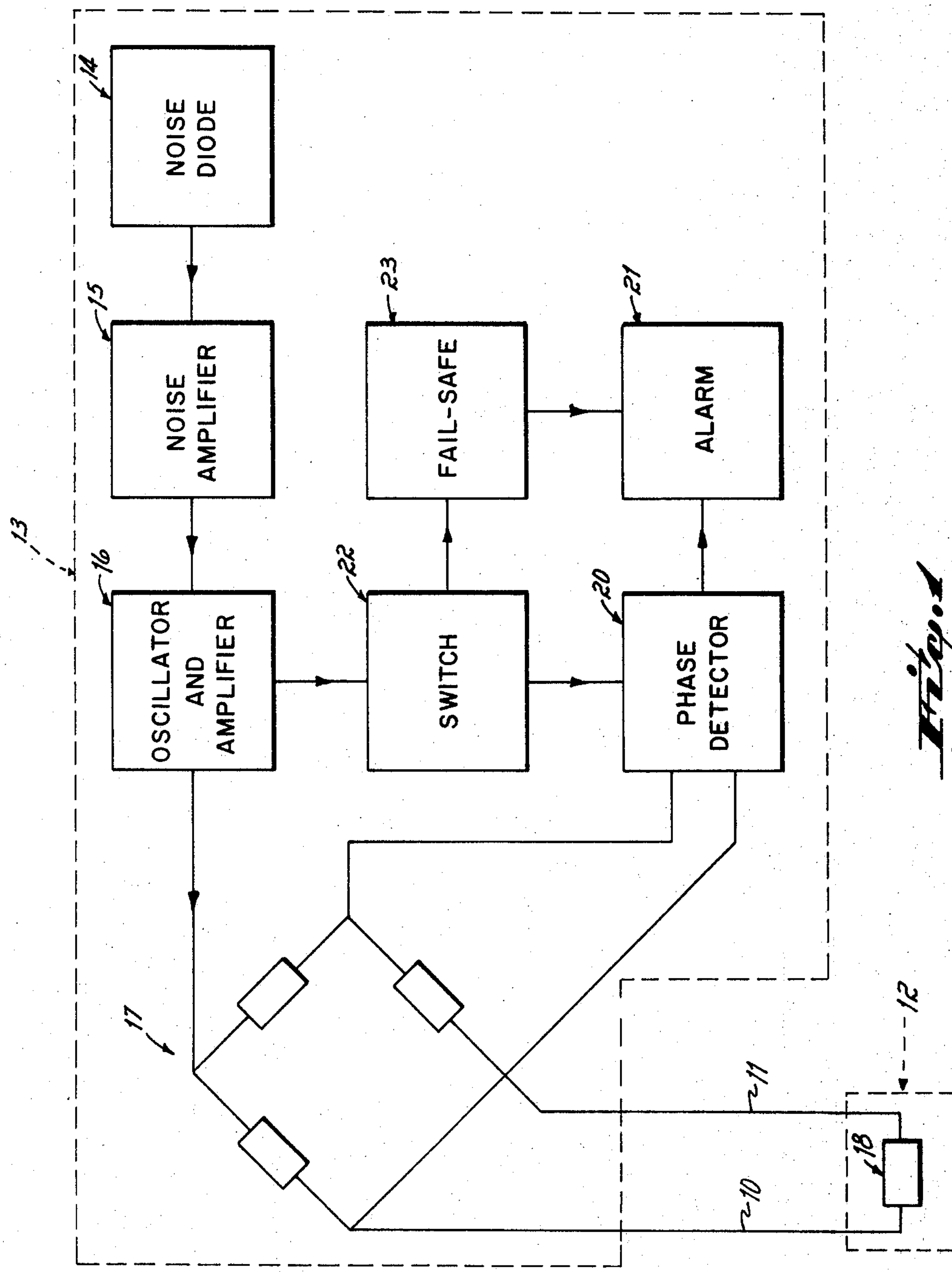

Fig. 1

INVENTORS
Donald E. Hansen
Eric G. Quist
BY
Wood, Herron and Evans
ATTORNEYS

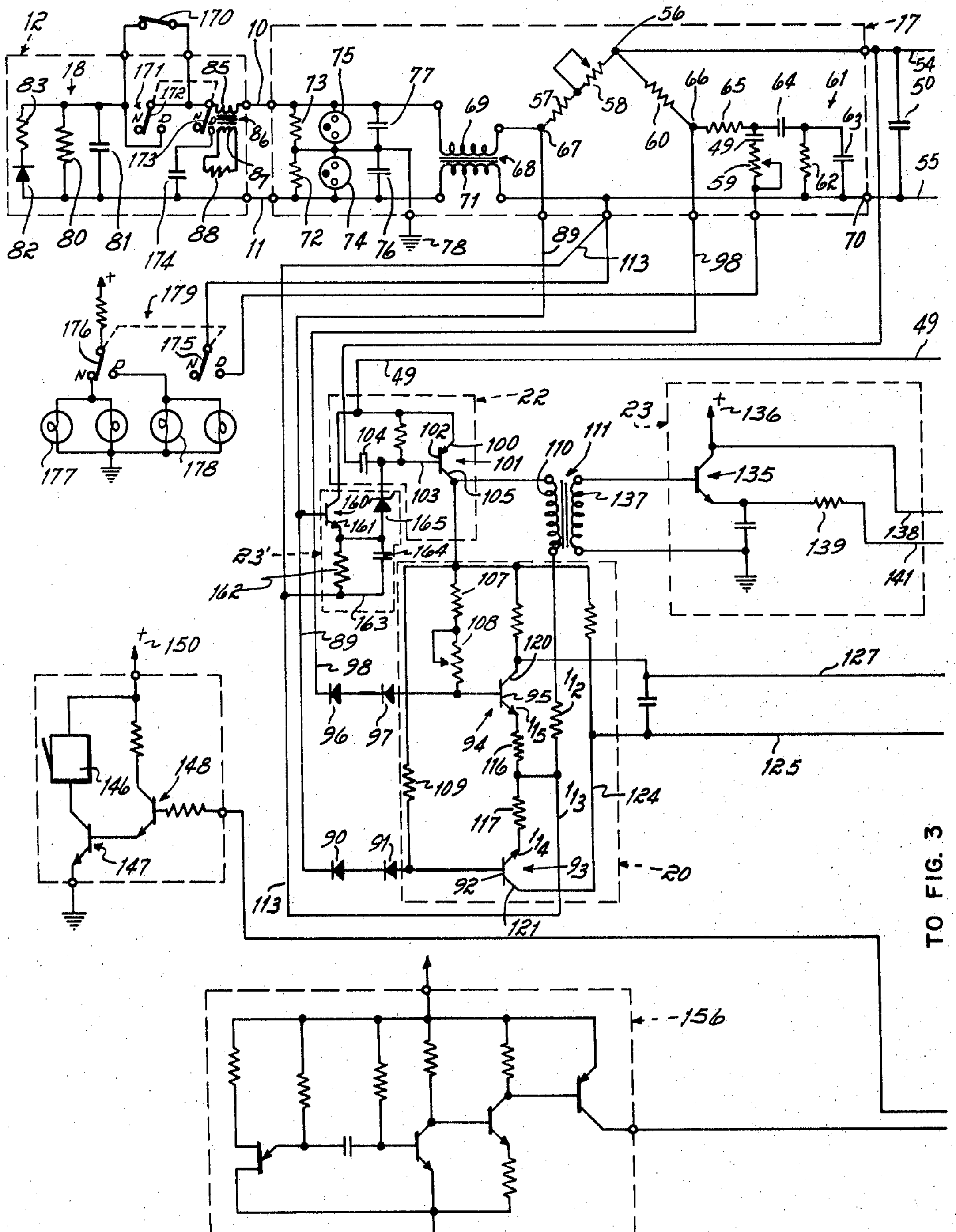

Fig. 2

INVENTORS.
Donald E. Hansen
BY Eric G. Quist
Wood, Herron and Evans
ATTORNEYS

LINE SUPERVISORY CIRCUIT

Filed Oct. 20, 1965

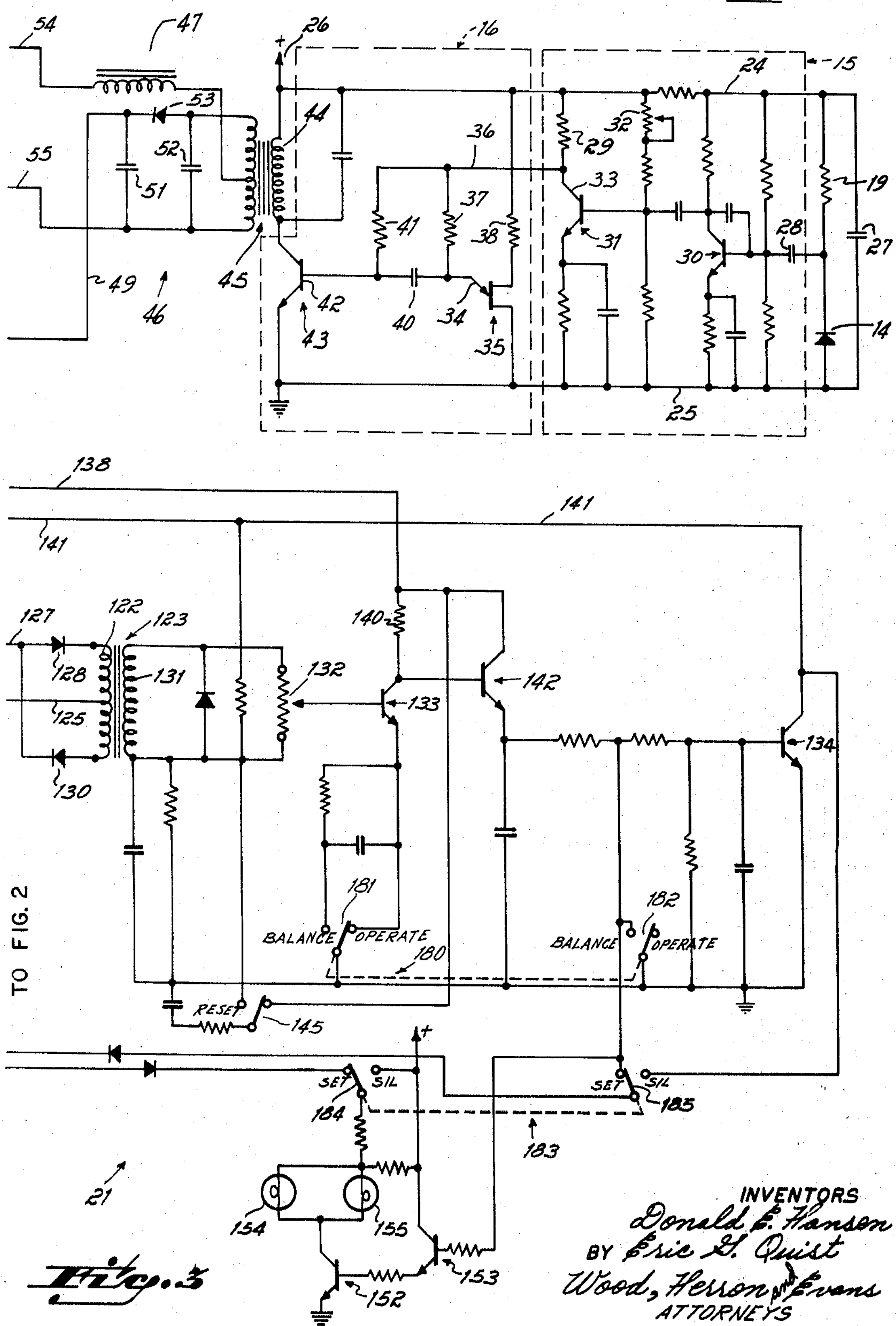

Fig. 3

INVENTORS
Donald E. Hansen
BY Eric G. Quist
Wood, Herron and Evans
ATTORNEYS

United States Patent Office

3,423,748

Patented Jan. 21, 1969

3,423,748

LINE SUPERVISORY CIRCUIT

Donald E. Hansen, Brookfield Center, and Eric G. Quist, Roxbury, Conn., assignors to Mosler Research Products, Inc., Danbury, Conn., a corporation of Delaware

Filed Oct. 20, 1965, Ser. No. 498,449

U.S. Cl. 340—285 11 Claims

Int. Cl. G08b 21/00

ABSTRACT OF THE DISCLOSURE

An alarm circuit for supervising a pair of transmission lines interconnecting a remote protected area and a central station. The transmission lines are interconnected at the remote station by a complex impedance termination network. The two lines and complex impedance network together constitute one leg of a normally balanced bridge. A randomly modulated AC signal is applied to the bridge from a free-running oscillator modulated by a noise diode. The balance of the bridge is detected by a phase sensitive detector which senses only a portion of the signal near the zero crossover points.

This invention relates to alarm systems of the type including a protected area and a central, or monitoring, station remote from the protected area and connected therewith by an electrical transmission line. The invention is particularly directed to a supervisory circuit for protecting the transmission line and system against unauthorized tampering.

A typical protection system of the type with which the present invention may be utilized includes one or more electrical protection devices located in the premises to be protected. The protected premises, or area, is connected through a transmission line to a remotely located monitoring station which may, for example, be a central station, police station, guard station or the like.

The electrical protection devices located in the protected areas may be of various kinds, for example, switches, photoelectric devices, rupturable conductors or the like. These devices function to alter the current flow in the transmission line upon the occurrence of an event incident to an intrusion upon the premises. An alteration of the current flow in the transmission line in turn causes the actuation of an alarm signal in the central station.

It has also been found desirable to provide some means for supervising the transmission lines to protect them against tampering. However, despite the provision of such means it has been possible in the past for a skilled intruder to defeat, or compromise, the system so that the intruder could gain access to the protected premises without setting off an alarm. None of the previously proposed solutions to this problem of unauthorized intrusion has proven completely satisfactory.

In the first place if, as is the most common practice, the transmission line is a DC line, attempts to increase the sensitivity of the system to prevent tampering have led to an inordinately high number of false alarms. These false alarms are caused by various environmental conditions, such as lightning, or changes in the electrical characteristics of the line due to changes in temperature or humidity. Moreover, even systems of increased sensitivity remained vulnerable to defeat by an intruder. In one common method of attack the intruder substitutes for the line termination at the protected area a substitute termination. In other words, the intruder determines by measurement the values of the termination impedances and bridges the transmission line with a similar impedance. Thereafter, the intruder is free to enter the protected premises without setting off an alarm.

A second, somewhat similar method of attack involves the application of a substitute voltage to the transmission line from a low impedance source. In this method of attack the intruder measures the voltage on the transmission line and then connects a substitute voltage source effective to duplicate this voltage condition. Thereafter, the intruder can again enter the protected premises without setting off an alarm.

Still another common method of attack, utilized particularly on AC protection lines, is to jam the system by placing a signal on the line of sufficient amplitude and of a proper frequency to make the system inoperative.

The principal object of the present invention is to provide a line supervisory circuit which will minimize the possibility that an intruder can successfully tamper with a line without causing an alarm at the central station. At the same time, the present supervisory circuit reduces the susceptibility of the system to false alarm caused by environmental conditions not associated with an intrusion.

More particularly, the present invention is predicated upon the concept of applying to the transmission line an AC signal, the frequency of which is modulated at a random rate. In a preferred form of the invention this signal is applied to a normally balanced bridge, one leg of which is constituted by the transmission line and its termination. The integrity of the transmission line and system is monitored by a phase sensitive detector which detects any unbalance in the bridge, such as an unbalance incident to an alteration of the impedance line or its termination by an intruder.

Another important concept of the present invention is the provision of simple means for applying a random frequency modulated AC signal to the transmission line. In accordance with the present invention, this signal is obtained from a circuit including a free running oscillator connected to the transmission line. The frequency of the oscillator is randomly modulated by means of a noise diode effective to produce random voltage spikes which are amplified and introduced into the oscillator circuit. As a result of the completely random and unpredictable frequency modulation of this signal, it is impossible as a practical matter for an intruder to duplicate the signal and apply it across the transmission line.

In accordance with the principles of the present invention, the balance of the bridge is sensed by a phase sensitive detector. Moreover, the present system includes a switch for controlling operation of the detector so that the detector senses only a small portion of the signal wave, preferably near the zero crossover points. Thus, transient conditions, such as lightning and the like, which occur during portions of the cycle when the detector is inoperative do not effect the system. Also, changes in line and shunt resistance caused by temperature and humidity changes affect the present system, which depends upon phase detection, to a very much smaller degree than they affect prior art systems which utilized amplitude measurement. As a result, the present system is highly sensitive, yet at the same time has a vastly reduced susceptibility to false alarms.

It is still a further object of the present invention to provide a novel line termination which, in combination with the present detection circuit, makes it almost impossible for an intruder to measure the impedance of the line termination components. More particularly, the present line termination includes not only resistance and capacitance, but also a diode rectifier which distorts one half of the wave. This distortion gives a false indication of phase to an intruder making a measurement and hence makes it exceedingly difficult for him to make a correct determination of the line impedance for the purpose of substituting an identical line impedance. At the same time, however, because the present phase detecting system senses only a small portion of the wave which is not distorted, the diode does not have any adverse effect on the sensitivity of the system.

These and other objects and advantages of the present invention will be more readily apparent from the following detailed description of the drawings illustrating a preferred embodiment of the invention.

In the drawings:

FIGURE 1 is a basic block diagram of one preferred form of line supervisory circuit embodying the present invention.

FIGURE 2 is a schematic wiring diagram of a portion of a line supervisory circuit of the present invention.

FIGURE 3 is a schematic circuit diagram of the remaining portions of the line supervisory circuit shown in FIGURE 2.

As is shown in FIGURE 1, one form of line supervisory circuit constructed in accordance with the present invention is designed to protect two transmission lines **10** and **11** extending between a remotely located protected area **12** and a central, or monitoring, station **13**. The central station is provided with a signal generator circuit including a noise diode **14**, a noise amplifier **15**, and an oscillator-amplifier **16** for generating an AC voltage signal having a randomly modulated frequency, preferably in the low audio range. This signal is applied to a bridge circuit **17**, one arm of which includes transmission lines **10** and **11** and a complex impedance line termination **18** located in the protected premises **12**. The balance or unbalance of bridge **17** is detected by a phase detector circuit **20** which is connected to opposite terminals of the bridge. The phase detector **20** in turn is effective to actuate an alarm **21** when the bridge is unbalanced, indicating an attempted compromise of the system.

As is explained in more detail below, in accordance with the present invention, the phase detector **20** measures the phase difference across the bridge **17** only over a relatively narrow angle of the order of 70°. This detection commences approximately 30° before the negative zero crossing of the AC signal. Control over the detector operation is maintained by a switching circuit indicated at **22**. This switching circuit, which has an input connection from oscillator-amplifier **16** and one output connection to phase detector **20**, also has an output connection to a fail-safe circuit **23**. Fail-safe circuit **23** is effective to actuate alarm **21** in the event that the AC signal is removed from transmission lines **10** and **11**.

In general, the AC signal generator circuit includes a high noise semiconductor which provides an input signal to the two-stage transistor amplifier **15**. The output of this amplifier is coupled to the unijunction transistor oscillator circuit **16**. The unijunction transistor in this circuit operates as a free running multivibrator. The oscillator frequency is dependent upon the RC time constants in the emitter circuit of the oscillator and the voltage applied to that circuit by the noise amplifier **15**. Since this latter voltage is randomly modulated, the oscillator frequency is likewise subject to random modulations.

The output of the oscillator circuit is amplified and fed to bridge **17** and switch **22**. As indicated previously, one leg of the bridge includes transmission lines **10** and **11** and line termination circuit **18**. This line termination is a complex impedance circuit which, as is explained below, is constructed in such a manner that it is extremely difficult for an intruder to measure.

The balance of bridge **17** is sensed by phase detector **20** which includes two transistors connected as a differential amplifier. So long as the bridge is in phase, the net output signal from the detector is zero. If the bridge becomes unbalanced, the phase detector produces a signal which is applied to alarm **21** to cause actuation of a visible or audible signal. As indicated above, the phase detector senses only a portion of the AC signal wave, preferably a portion of the wave immediately following the positive to negative zero crossover.

The phase detector is turned off and on in phase with the signal by means of transistorized switching circuit **22**. A second output signal from switch **22** is utilized to provide bias for a transistor in fail-safe circuit **23**. In the absence of an alternating current signal on transmission lines **10** and **11**, there is no output signal from switching circuit **22**. Another portion of the sail-safe circuit **23'** functions in such a manner that the switching action of switch **22** is disabled if a high AC or DC voltage or a low DC voltage is applied across the transmission lines. As a result of any of these conditions, the main fail-safe circuit **23** is triggered and in turn causes actuation of alarm **21**.

The circuit details of the present alarm system are best shown in FIGURES 2 and 3. As there shown, high noise diode **14** which, for example, may be a diode of the IN82A type, is connected in series with resistor **19** across lines **24** and **25**. Line **24** is connected to a positive potential source indicated generally at **26**, while line **25** is a ground line. Noise diode **14** is effective to generate random spikes which, in one preferred embodiment, are of the order of 5–10 millivolts. Diode **14** and resistor **19** are shunted by a capacitor **27**. The diode is capacitively coupled to noise amplifier **15** through capacitor **28**. Amplifier **15** is a conventional two-stage amplifier and includes transistors **30** and **31**. The amplifier output, and hence the center frequency of oscillator **16**, is controlled by a potentiometer **32**. This potentiometer directly varies the base current of transistor **31** and hence its collector current, which in turn varies the voltage developed across resistor **29**. The output from amplifier **15** is taken from the collector **33** of transistor **31**. This collector is connected to the emitter **34** of unijunction transistor **35** through lead **36** and resistor **37**. One base connection of unijunction transistor **35** is connected to ground line **25**, while the other base connection is made to line **24** through resistor **38**. Resistor **37** is shunted by capacitor **40** and resistor **41**. Resistor **41** is also connected to the base **42** of transistor **43** which functions as an amplifier.

In operation unijunction transistor **35** functions as a free running oscillator. As indicated above, the center frequency of this oscillator is determined by adjusting potentiometer **32**. Preferably the oscillator produces a signal in the low audio frequency range. As indicated previously, the output signal of oscillator transistor **35** is applied to the base of transistor **43**. This transistor amplifies the oscillator signal and produces randomly modulated square wave pulses across primary winding **44** of transformer **45**. The square wave is filtered through a low pass filter network indicated generally at **46**. This filter network includes choke **47**, capacitors **50**, **51** and **52** and a rectifier **53**. The rectifier provides a positive DC signal output in line **49**. This DC power line, which is not common to the power supply **26**, is used to provide power for switch **22** and phase detector circuit **20**. This also makes it possible for lines **10** and **11** to be balanced with respect to ground. As a result, one power supply can be provided for a system including a plurality of protected zones.

The AC output signal from filter network **46** is applied to the bridge circuit **17** through leads **54** and **55**. Lead **54** is connected to terminal **56** of the bridge. The first leg of the bdige includes a resistor **57** and a night balancing potentiometer **58**. The second leg of the bridge includes a fixed resistor **60**. The third leg of the bridge, indicated generally by the reference numeral **61**, is connected to lead **55**. This leg of the bridge includes the parallel combination of resistor **62** and capacitor **63** connected in series with capacitor **64** and resistor **65**. Resistor **65** is in turn joined to terminal **66** of the bridge at the juncture of the second and third legs of the bridge. The fourth leg of the bridge includes transmission lines **10** and **11** and the line termination circuit **18**.

More particularly, terminal 67 of the bridge at the juncture of the first and fourth legs is connected to one winding 69 of transformer 68. The opposite lead of this winding is in turn connected to line 10. Similarly, the fourth terminal 70 of the bridge at the juncture of the first and fourth legs is connected through winding 71 of transformer 68 to transmission line 11. Lines 10 and 11 are shunted by the parallel combination of resistors 72 and 73, neon bulbs 74 and 75 and capacitors 76 and 77. The central junctions of the resistors, bulbs and capacitors are grounded as at 78 to protect the circuit against lightning.

Transmission lines 10 and 11 extend from the central, or monitoring, station 13 to the remotely controlled protected area 12. Disposed within this latter area is the line termination circuit indicated generally at 18. This circuit comprises the parallel combination of resistor 80 and capacitor 81 which are shunted across lines 10 and 11. Series connected diode rectifier 82 and resistor 83 are also shunted across these lines. The parallel combination of capacitor 81 and resistors 83 and 80 make the measurement of the line termination impedance relatively difficult. The addition of rectifier 82 greatly minimizes the possibility that an intruder could make any accurate determination of this impedance. Specifically, rectifier 82 distorts the negative half of the wave, thereby giving a false indication of phase. Since the detector 20 does not measure this part of the wave, the sensitivity of the system is not impaired.

In addition to these components, the line termination circuit includes primary winding 85 of a transformer 86 which is inserted in line 10. The secondary winding 87 of this transformer is shunted by a resistor 88. In effect, transformer 86 presents a high impedance to all signals except those of the order of 25 cycles per second, the order of frequency of the signal across lines 10 and 11. As a result, this transformer is effective to prevent impedance meaurements from being made across the bridge utilizing a signal generator.

As was indicated previously, the AC signal is applied to the bridge across terminals 56 and 70. The sensing of any condition of unbalance of the bridge takes place across terminals 66 and 67. More particularly, terminal 67 is connected through lead 89 and rectifiers 90 and 91 to the base 92 of transistor 93. The base 95 of transistor 94 is connected through rectifiers 96 and 97 and lead 98 to terminal 66 of the bridge network 17. Transistor 93 together with transistor 94 form the principal components of differential phase detector 20. It will be appreciated that the signals applied to the bases of transistors 93 and 94 are sinusoidal signals which are in phase with one another so long as the bridge 17 is in balance.

As explained in detail below, each transistor 93 and 94 is on during the positive half cycle and off during the negative half cycle. If the signals applied to bases 92 and 95 are in phase, the transistors will turn off together and there will be no net output sensing from collector 120 to collector 121. However, if the bridge should become unbalanced for any reason, including tampering with transmission lines 10 and 11, the signal applied to line 89 and hence to transistor 93 will either lead or lag the signal applied through line 98 to transistor 94. Then one transistor 93 or 94 will turn on and off before the other and the signal across the collectors 120 and 121 will have a positive or negative component.

As stated above, the differential amplifier senses only the negative going portion of the signal wave just after the zero crossover. This period of operation of the phase detector is controlled by the switch circuit indicated generally at 22. The switch circuit acts as a gate and is controlled by the AC reference signal applied to transformer 45. As was indicated previously, DC power for switch 22 is supplied through line 49 which is connected to the emitter 100 of transistor 101. The base 102 of this transistor is connected through lead 103 and capacitor

104 to line 54. Thus, the base 102 of transistor 101 receives the same reference signal applied to bridge terminal 56 shifted in phase by capacitor 104. The collector 105 of transistor 101 is connected through resistor 107 and potentiometer 108 to the base 95 of transistor 94. Similarly, this collector is connected through resistor 109 to the base 92 of transistor 93. This provides a bias voltage for these transistors. Collector 105 also provides the collector power for transistors 93 and 94.

Collector 105 is also connected to one terminal of primary winding 110 of transformer 111. The other terminal of this winding is connected to lead 55 through resistor 112 and lead 113. The emitters 114 and 115 of transistors 93 and 94 are tied together through resistors 116 and 117. The juncture of resistors 116 and 117 is tied to lead 113.

The output of the differential amplifier is taken across collectors 120 and 121. Specifically, collector 121 of transistor 93 is connected to the center tap of primary winding 122 of transformer 123 through leads 124 and 125. The collector 120 of transistor 94 is similarly connected through lead 127 and rectifiers 128 and 130 to opposite ends of this transformer winding. The secondary winding 131 of transformer 123 is connected across potentiometer 132. The tap of this potentiometer is in turn joined to the base transistor 133 forming part of the alarm circuit 21. Thus, in effect, the output of the differential amplifier is applied to the base of transistor 133.

Transistor 133 forms a flip-flop circuit in conjunction with transistor 134. More particularly, transistor 133 is normally biased on through a potential from fail-safe circuit 23. One portion of fail-safe circuit 23 includes transistor 135, the emitter of which is connected to a positive potential source 136 and the base of which is connected to the secondary winding 137 of transformer 111.

The collector of transistor 135 is connected to the collector of transistor 133 through lead 138 and resistor 140. The emitter of transistor 135 is similarly connected through resistor 139 and lead 141 to the collector of transistor 134. The collector of a third transistor in the flip-flop circuit, transistor 142, is also connected to lead 138.

The fail-safe circuit also includes a second portion identified generally by the numeral 23′. This portion of the fail-safe circuit includes a transistor 160, the base of which is connected to lead 89. The emitter 161 of this transistor is joined through resistor 162 and conductor 163 to lead 113. Resistor 162 is shunted by a capacitor 164. Emitter 161 is also connected through a Zener diode 165 to the base 102 of transistor 101.

In this portion of the fail-safe circuit transistor 160 acts as a rectifier. In normal operation a voltage appears on the emitter 161 of this transistor which is filtered by the capacitor. The Zener diode normally does not conduct. However, if the rectified voltage drops, the voltage across the Zener diode rises and stops transistor 101 from switching. This action thus protects the survelliance circuit against the application of a low AC signal across the transmission lines. On the other hand, if a high AC signal is applied across the transmission lines, the Zener diode becomes conductive in the forward direction and again stops the switching of transistor 101. The application of a high DC voltage across the transmission lines causes the same action. Whenever the switching action of transistor 101 is stopped, the system goes into alarm.

In normal operation transistor 133 is biased on by the rectified vlotage from transistor 135. Loss of this voltage turns transistor 133 off and results in a permanent alarm. Transistors 142 and 134 are biased off. However, when there is an output signal from the differential amplifier due to that amplifier being unbalanced, the signal turns transistor 133 off. Transistor 142 is an emitter-follower and when transistor 133 becomes nonconductive, the potential on the base of transistor 142 goes up. As a result a positive potential is applied to the base of transistor 134 which is turned on.

When transistor **134** is turned on, the bias supply for transistor **133** is shorted to ground and transistor **133** remains off until the reset switch **145** is actuated. If there is no unbalance in the differential amplifier, the flip-flop returns to its original condition in which transistor **133** is on and transistors **142** and **134** are off.

When the flip-flop is in the alarm state with transistor **134** conducting and transistor **133** not conducting, the voltage of transistor **142** provides a positive voltage for energizing buzzer **146**. This is accomplished through a two-stage amplifier including transistors **147** and **148**. Buzzer **146** and its associated amplifier are powered from a positive power source indicated at **150**. The emitter current from transistor **133** is also used to actuate a flashing light alarm.

Specifically, the emitter of transistor **142** is connected to a two-stage amplifier including transistors **152** and **153** which provide power for alarm lamps **154** and **155**. Power for the operation of the lamp alarm is taken from a flashing power source **156**, the details of construction of which constitute no part of the present invention.

In addition to the components described above, the system includes conventional day-night switching circuits for inserting and removing the protection devices in area **12** from the circuit. More particularly, as is shown in FIGURE 2, the protected area circuit includes a protection device, such as a magnetic switch, indicated diagrammatically at **170**. The day-night switch, indicated generally at **171**, includes one arm **172** which is effective to insert protection switch **170** onto the transmission line circuit when the day-night switch is in the "night" position and to shunt protection switch **170** in the "day" position. A second arm **173** of the day-night switch inserts a capacitor **174** across the transmission lines when the switch is in the "day" position. Thus, when the switch **171** is in the "day" position, the transmission lines **10** and **11** are protected but the protection switches, such as switch **170**, are removed from the circuit.

A second day-night switch **179** located in the monitor panel has two arms **175** and **176**. Arm **175** is effective in the "day" position to interconnect "day" balance potentiometer **59** and capacitor **48** into the third arm of bridge **17**. Specifically, this switch arm **175** is effective to connect on terminal potentiometer **59** with line **55**. Arm **176** of the day-night switch controls energization of the "night" and "day" indicator lamps **177** and **178**.

The system also includes a balance switch **180**. This switch includes arms **181** and **182**. A third switch included in the circuit is the set-silence switch **183** including arms **184** and **185**. Since switches **180** and **183** constitute no part of the present invention, their circuit connections are not described in detail. However, they are shown in FIGURE 3.

In operation, the circuit is set up and balanced by adjusting the various potentiometers provided in the usual manner. Assuming that the day-night switches **171** and **179** are in the "night" position, the protection devices, such as magnetic switch **170**, are connected in the circuit. The oscillator and amplifier circuit **16** applies an AC signal, the frequency of which is randomly modulated by noise diode **14**, to the primary winding of transformer **45**. This signal is filtered in filter network **46** to provide a sine wave having the same randomly modulated frequency. This sine wave is applied across the terminals of bridge **17** and to transmission lines **10** and **11**. The balance of bridge **17** is measured by the differential amplifier including transistors **93** and **94** in phase detector circuit **20**. These transistors are gated by switching circuit **22** so that they sense the balance of the bridge only in the portion of the wave close to the zero crossover point.

Assuming that the bridge is balanced, indicating a condition of no intrusion, no output signal appears across the collectors of transistors **93** and **94** and hence no net signal is applied to the base of transistor **133**. Assuming that there is an AC signal present on lines **10** and **11**, transistor **133** is biased on by the potential applied through the fail-safe network, including resistor **135**. With transistor **133** biased on, transistor **134**, forming the other half of the bistable flip-flop, and emitter follower **142** are off and no current flows to the alarm buzzer or bells.

However, if an intruder opens switch **170**, bridge **17** becomes unbalanced and a potential is applied to the base of transistor **133** from phase detector **20** causing the multivibrator to flip-flop with transistors **134** and **142** becoming conductive. This causes a current flow to the alarm devices in the manner explained above. Similarly, if a potential is applied across lines **10** and **11**, the portion of the fail-safe circuit **23'** prevents the switching of transistor **101** which similarly results in a flip-flop of the multivibrator causing transistors **134** and **142** to become conductive causing an alarm. The system operates in the same manner with switch **171** in the "day" position, except that in the "day" position protection devices, such as switch **170**, are removed from the circuit and only transmission lines **10** and **11** and the termination are supervised.

From the foregoing disclosure of the general principles of the present invention and the above description of a preferred embodiment, those skilled in the art will readily comprehend various modifications to which the present invention is susceptible. Accordingly, we desire to be limited only by the scope of the following claims.

Having described our invention, we claim:

1. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and two transmission lines interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission lines at the protected area, the transmission lines and impedance network forming a continuous conductive path,

a bridge including said transmission lines and said impedance network as one leg thereof, both of said transmission lines and said impedance network being connected entirely within said one leg,

means at the monitoring station for applying an AC signal to said bridge across one diagonal thereof,

a phase sensitive detector for detecting an unbalance of said bridge across a second diagonal thereof, and

alarm means responsive to the output of said detector.

2. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and two transmission lines interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission lines at the protected area, the transmission lines and impedance network forming a continuous conductive path,

a bridge including said transmission lines and said impedance network as one leg thereof, both of said transmission lines and said impedance network being connected entirely within said one leg,

means at the monitoring station for applying an AC signal to said bridge across one diagonal thereof,

a phase sensitive detector for detecting an unbalance of said bridge across a second diagonal thereof,

switching means rendering said phase sensitive detector operative only during portions of the AC signal wave, and

alarm means responsive to the output of said detector.

3. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and two transmission lines interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission lines at the protected area, the transmission lines and impedance network forming a continuous conductive path,

a bridge including said transmission lines and said impedance network as one leg thereof, both of said transmission lines and said impedance network being connected entirely within said one leg,

means at the monitoring station for applying an AC signal to said bridge across one diagonal thereof,

a phase sensitive detector for detecting an unbalance of said bridge across a second diagonal thereof,

switching means for controlling the operation of said detector whereby said detector senses only a portion of said AC signal,

fail-safe means for producing a signal only when said AC signal is applied to said bridge, said fail-safe means being effective to prevent operation of said switching means when a different signal is applied to said transmission line, and

alarm means responsive to the output of said detector.

4. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and two transmission lines interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission lines at the protected area, the transmission lines and impedance network forming a continuous conductive path,

a bridge including said transmission lines and said impedance network as one leg thereof, both of said transmission lines and said impedance network being connected entirely within said one leg,

means at the monitoring station for applying an AC signal to said bridge across one diagonal thereof,

a phase sensitive detector for detecting an unbalance of said bridge across a second diagonal thereof, said phase sensitive detector comprising two transistors forming a differential amplifier, each of said transistors including a collector and a base connected to one terminal of said bridge, the output of said detector being taken across said collectors,

switch means biasing said transistors on during only a portion of said cycle, and

alarm means responsive to the output of said detector.

5. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and two transmission lines interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission lines at the protected area, the transmission lines and impedance network forming a continuous conductive path,

a bridge including said transmission lines and said impedance network as one leg thereof, both of said transmission lines and said impedance network being connected entirely within said one leg,

means at the monitoring station for applying an AC signal to said bridge across one diagonal thereof,

a phase sensitive detector for detecting an unbalance of said bridge across a second diagonal thereof, said phase sensitive detector comprising two transistors forming a differential amplifier, each of said transistors including a collector and a base connected to one terminal of said bridge, the output of said detector being taken across said collectors,

switch means biasing said transistors on during only a portion of said cycle, and

alarm means responsive to the output of said detector, said alarm means including a bi-stable multivibrator including a first transistor normally biased to conduct, and means interconnecting said first transistor to said detector output whereby said output is effective to cause said first transistor to become nonconductive.

6. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and two transmission lines interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission lines at the protected area, the transmission lines and impedance network forming a continuous conductive path,

a bridge including said transmission lines and said impedance network as one leg thereof, both of said transmission lines and said impedance network being connected entirely within said one leg,

means at the monitoring station for applying an AC signal to said bridge across one diagonal thereof,

a phase sensitive detector for detecting an unbalance of said bridge across a second diagonal thereof, and

alarm means including a bistable multivibrator,

fail-safe means responsive to the presence of said AC signal normally biasing said multivibrator to a first state, said detector being effective to cause said multivibrator to be shifted to a second state, said fail-safe means also causing said multivibrator to be shifted to a second state upon cessation of said AC signal or upon application of a different potential to said transmission lines.

7. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and a transmission line interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission line at the protected area, said impedance network including capacitance and inductive reactance, and a diode for distorting portions of said AC signal wave,

a bridge including said transmission line and said impedance network as one leg thereof,

means at the monitoring station for applying an AC signal to said bridge,

a phase sensitive detector for detecting an unbalance of said bridge during portions of said AC signal wave not distorted by said diode, and

alarm means responsive to the output of said detector.

8. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and a transmission line interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission line at the protected area,

a bridge including said transmission line and said impedance network as one leg thereof,

means at the monitoring station for applying a random frequency modulated AC signal to said bridge,

a phase sensitive detector for detecting an unbalance of said bridge, and

alarm means responsive to the output of said detector.

9. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and a transmission line interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission line at the protected area,

a bridge including said transmission line and said impedance network as one leg thereof,

means at the monitoring station for applying a random frequency modulated AC signal to said bridge, said means comprising an oscillator and a noise diode in circuit connection with said oscillator,

a phase sensitive detector for detecting an unbalance of said bridge, and

alarm means responsive to the output of said detector.

10. In an alarm system for protecting a remote area,

the alarm system including a monitoring station remote from said protected area and a transmission line interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission line at the protected area,

a bridge including said transmission line and said impedance network as one leg thereof,

means at the monitoring station for applying an AC signal to said bridge,

a phase sensitive detector for detecting an unbalance of said bridge,

switching means rendering said phase sensitive detector operative only during portions of the AC signal wave, said impedance network including a diode for distorting portions of said AC signal wave which are not sensed by said detector, and

alarm means responsive to the output of said detector.

11. In an alarm system for protecting a remote area, the alarm system including a monitoring station remote from said protected area and a transmission line interconnecting the protected area and the monitoring station, the invention which comprises:

an impedance network connected across said transmission line at the protected area,

a bridge including said transmission line and said impedance network as one leg thereof,

means at the monitoring station for applying an AC signal to said bridge, said means comprising a free running unijunction transistor oscillator, a noise diode connected in circuit with said oscillator, said noise diode providing random voltage spikes effective to randomly vary the frequency of oscillation of said oscillator,

a phase sensitive detector for detecting an unbalance of said bridge, and

alarm means responsive to the output of said detector.

References Cited

UNITED STATES PATENTS

2,031,951	2/1936	Hartley.	
2,684,475	7/1954	Lode	340—255 X
2,988,708	6/1961	Schmidt	340—384 X

FOREIGN PATENTS

934,963	8/1963	Great Britain.

THOMAS B. HABECKER, *Primary Examiner.*

D. L. TRAFTON, *Assistant Examiner.*

U.S. Cl. X.R.

331—78; 340—276, 409