Aug. 16, 1955 F. S. JENKINS 2,715,720

FIRE-SMOKE DETECTION AND WARNING APPARATUS

Filed Oct. 25, 1951 2 Sheets-Sheet 1

Fig. 3.

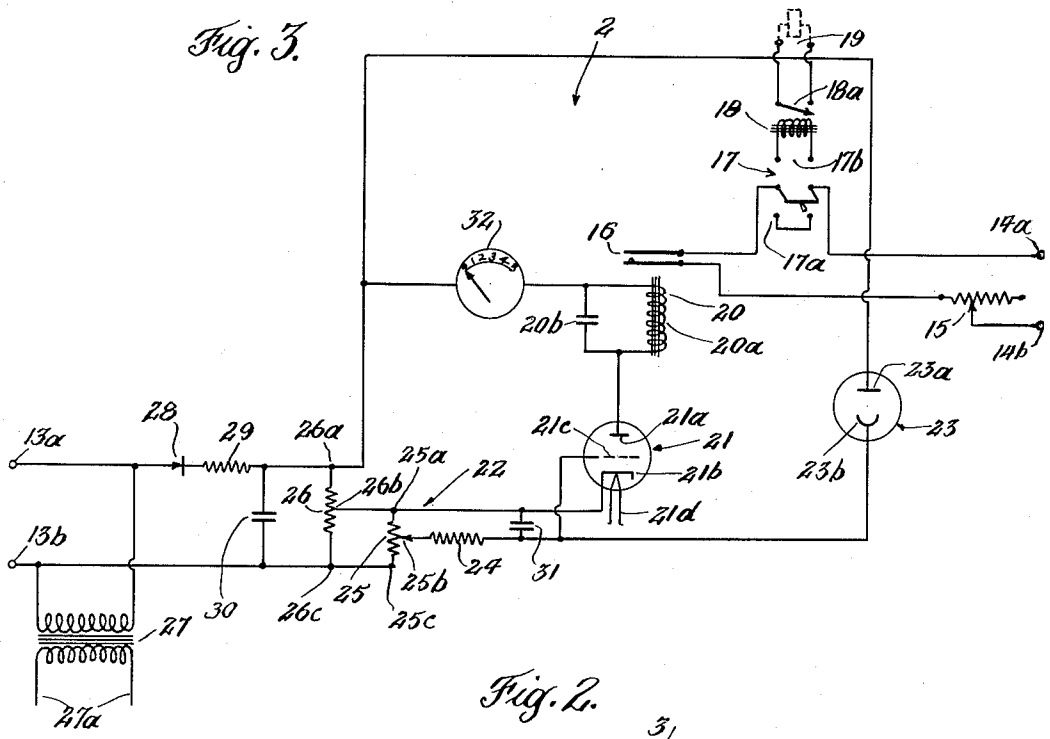
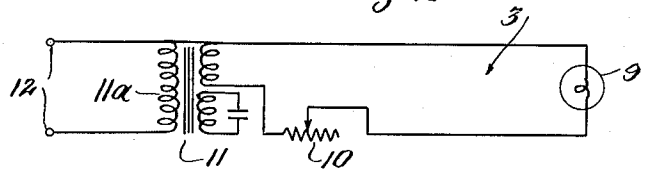


Fig. 2.



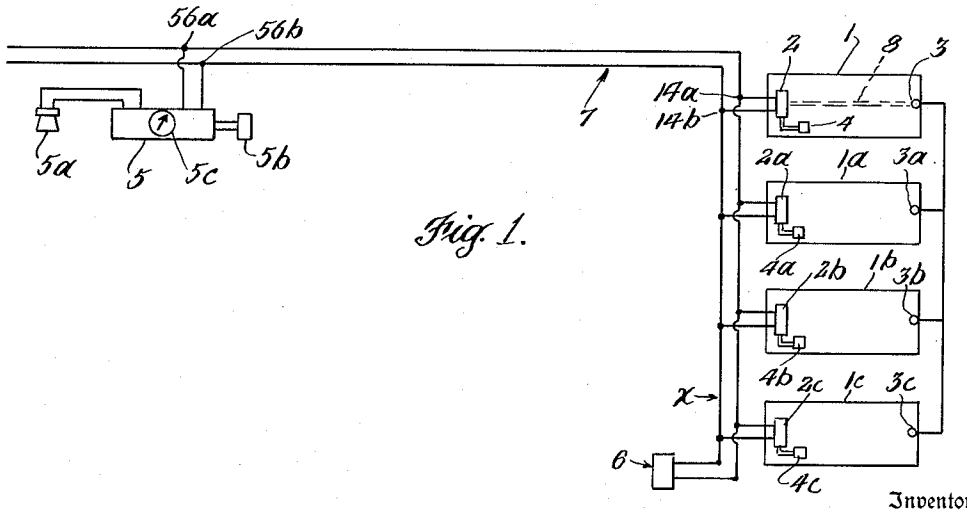


Fig. 1.

Inventor

Felton S. Jenkins

By Gustav Genzlinger

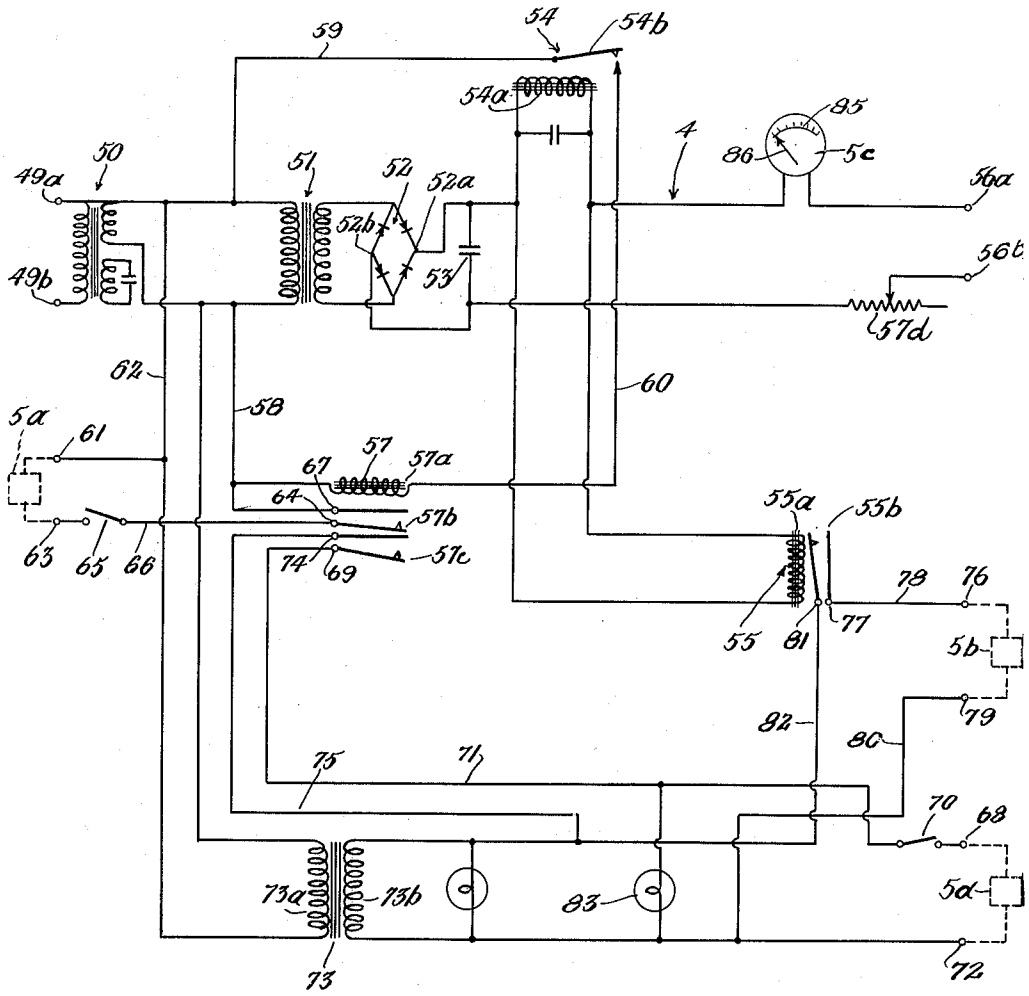
Attorney

Aug. 16, 1955 F. S. JENKINS 2,715,720

FIRE-SMOKE DETECTION AND WARNING APPARATUS

Filed Oct. 25, 1951 2 Sheets-Sheet 2

Fig. 4.



Inventor

Felton S. Jenkins

By Gustav Genzlinger

Attorney

United States Patent Office 2,715,720 Patented Aug. 16, 1955

2,715,720

FIRE-SMOKE DETECTION AND WARNING APPARATUS

Felton S. Jenkins, Philadelphia, Pa.

Application October 25, 1951, Serial No. 253,069

1 Claim. (Cl. 340—228)

This invention relates in general to apparatus for automatically detecting the presence of fire and smoke and for immediately announcing or warning of the existence of the same; more particularly the invention contemplates apparatus which is especially adapted for detecting the presence of fire or smoke in a single place or a plurality of places considerably remote from the location where the warning is given.

The invention contemplates a novel two-wire detection and warning system wherein a plurality of detecting or sensing devices may be located at widely divergent points remote from a central watch or annunciator station, the central station having warning means not only to announce the existence of fire or smoke but to show the exact location thereof. Indeed, the apparatus of the present invention detects, warns and shows the location of fire or smoke within a single area and also detects, warns and shows the location of fire and smoke in a plurality of areas.

In addition to the warning locating function, the apparatus of the present invention contemplates means for setting into operation of automatic fire extinguishing equipment which is alternatively operable with the operation of a sensing unit.

Further, the invention contemplates apparatus that is unusually sensitive, indeed, the sensitivity is so keen that a thin wisp of smoke will cause operation of the warning mechanism. Furthermore, the equipment of the present invention is very stable and proper operation thereof is substantially independent of ordinary voltage fluctuations and phase shifting in both urban and rural commercial power systems.

Furthermore, the apparatus of the invention provides for the giving of an immediate alarm in event of a fault condition, for example, an open line in the connection between the annunciator and the sensing units.

The apparatus of the present invention is economical in design for in accomplishing the above mentioned features the invention contemplates novel circuit means utilizing a minimum number of components, which components may be standard commercial items.

The invention is of especial advantage and utility in storage places, for instance, in large multi-storied warehouses having huge floor areas where protection is required for mass concentrations of stocks, equipment, supplies and the like. The apparatus of the present invention is particularly useful in farming enterprises, for example, on poultry farms where heavy loss may be sustained by the inhalation of smoke by the fowl.

The invention is also adaptable for military and naval establishments having great masses of personnel in widely scattered barracks and hospitals, and having valuable equipment and supplies in warehouses and maintenance shops.

In addition, the apparatus of the present invention is capable of detecting dust conditions equally as well as smoke conditions, and therefore is usable in areas where unusual dust conditions are considered a hazard.

Furthermore, the invention is nicely adaptable for use on shipboard, for example, in the holds of merchant vessels.

According to the invention, a warning station or an annunciator unit is electrically connected to a single or to a plurality of detection or sensing units. The annunciator performs two functions, namely, warning of the existence of fire or smoke, and also showing the location of same. The unit contemplates mechanism operative upon actuation of a single or a combination of sensing units, whereby audible and visual means warn of the existence of the disturbance. Further, the mechanism of the annunciator is also operative upon actuation of a single or upon actuation of a combination of sensing units to show which one or which combination of the units is operative and to thereby show the location of the smoke or fire.

In the detection scheme of the invention, a sensing unit is connectible with the annunciator unit as determined by certain control mechanism having photoelectric means in association with a source of light. The light ordinarily takes the form of a beam focused on the photoelectric means which is responsive to changes in light intensity, for example, a thin wisp of smoke traversing the beam. A change in light intensity connects a sensing unit with the annunciator circuit to thereby cause operation of the above mentioned mechanism. The sensing unit further includes mechanism alternatively operable with actuation of the unit to bring into play means for setting off a fire-etinguishing system.

The control mechanism for the sensing unit includes an electron discharge tube having a unique biasing arrangement for the grid of the tube which permits a high degree of sensitivity, that is to say, the unit is immediately responsive to very small changes in light intensity. The high degree of sensitivity is important as it permits protection of large areas; i. e. the light source and sensing unit may be widely separated. Also the sensitivity permits immediate detection, that is to say, warning of the fire when it is only in the smoldering stage. In addition, there is provided circuit means to maintain the ratio of the plate and grid voltages substantially constant despite fluctuation in supply voltage, thus insuring proper operation during fluctuation in the commercial power supply.

The invention permits the use of sensing units at points very remote from each other and from the annunciator. In connection with this feature, the system contemplates means for causing an immediate warning in the annunciator in the event of a fault in the system, for example, an open line in the annunciator unit, or in the connection between the annunciator and the several sensing units.

The manner in which the foregoing features are attained, together with the other advantages of the invention, will be evident from the following description, referring to the accompanying drawings, wherein:

Figure 1 is a schematic diagram of a typical installation of the apparatus of the present invention;

Figure 2 is a schematic wiring diagram of the circuit for the light source of the present invention;

Figure 3 is a schematic wiring diagram of the sensing unit of the present invention; and

Figure 4 is a schematic wiring diagram of the annunciator unit of the present invention.

A typical installation of the apparatus of the present invention is shown in Figure 1, a plurality of buildings **1**, **1***a*, **1***b*, and **1***c* each having a sensing unit **2**, **2***a*, **2***b* and **2***c* and a light source **3**, **3***a*, **3***b* and **3***c*. The sensing units are interconnected to an annunciator **5** and to a circuit terminating impedance **6** by lines **7**.

Shown connected to annunciator **5** are warning devices **5***a* and **5***b* which may take the form of a horn, siren,

bell or the like. Also shown in the annunciator is warning device 5c which warns of the existence of a fire but having a primary purpose of showing the location of the fire. The units 4, 4a, 4b and 4c connected to the sensing units are for the purpose of setting fire extinguishing apparatus into operation.

In the preferred arrangement the operation of the system is as follows. A beam of light 8 from the light source 3 is focused on the photoelectric element of sensing unit 2. A change in the intensity of the beam, for example by the beam being intercepted by flames, smoke, dust particles or the like, causes actuation of the sensing unit. As will be more apparent from the detailed description following hereinafter, upon actuation of a sensing unit a circuit is established between elements of the sensing unit and elements of the annunciator. Establishment of the circuit brings into play an audible warning device such as 5a. At the same time registry is made on unit 5c which indicates that sensing unit 2 has operated, thus giving the location of the disturbance. If sensing unit 2c were to become operative, the procedure above described would be repeated. In the event that a combination of sensing units became operative, for example units 2 and 2c, the warning device 5a would sound an alarm and the unit 5c would indicate that both 2 and 2c were operative. Indeed, if units, for example 2, 2a and 2b were to become operative, the annunciator would sound an alarm and indicate that fire was present in the location of the operative sensing units.

In passing it is to be observed that the invention permits the use of a plurality of sensing units with the annunciator unit and that this arrangement is accomplished in a two-wire system. For reasons more fully brought out hereinafter, the annunciator may be separated from a sensing unit, for example sensing unit 2, by distances up to twenty miles.

From the foregoing, therefore, certain important features of the present invention are evident, namely that the invention gives a system for the immediate detection, warning and indicating the exact location of a disturbance such as fire or smoke in either a single or a combination of areas and acomplishing this over a two-wire system.

The operation of the line fault warning arrangement is as follows. As seen in Figure 1, the impedance 6 is connected to annunciator 5 by way of line 7. This circuit is continuously energized; thus, if the line should be opened, for example at point X, the circuit would become deenergized and by means more fully described hereinafter, warning device 5b is immediately brought into play. This feature of the present invention is very important for quite clearly if the line at X were open and the sensing unit 2c became operative, the annunciator could not warn of the existence of the fire or smoke.

Having in mind the foregoing remarks, the details of the structure and operation of a preferred embodiment of the present invention will be readily understood from the description following:

The circuit for the light unit 3 shown in Figure 2 includes an incandescent element 9 and a variable resistor 10 and a constant voltage transformer 11. The transformer is adapted to be connected to a power source, for example, the ordinary commercial power system, through the terminals 12 of primary winding 11a. The purpose of variable resistor 10 is for adjusting the desired light intensity. For example, the intensity required where the distance between the light source and the sensing unit is small is less than is required where the distance between these units is great. Also, the resistor permits adjustment to the minimum required intensity, thus aiding in prolonged life of the incandescent element.

A constant voltage source for the incandescent element is an important part of the invention. As has been mentioned heretofore, the sensing unit is very sensitive to small changes in light intensity, and variations in light intensity due to voltage fluctuations in the power system would clearly be undesirable. Although the constant voltage means may take a variety of forms, I prefer to use the transformer type because it gives a high degree of stability and is rugged, sturdy and economical.

The circuit diagram for the preferred form of a sensing unit of the present invention is shown in Figure 3. As has been mentioned heretofore, when the unit becomes operative (by interception of the light beam) it is connected to the lines 7 to thereby establish a circuit with the annunciator unit. This circuit becomes energized, i. e., there is a flow of current in the circuit which operates the warning-locating mechanism in the annunciator. Since a plurality of sensing units are used each unit or each combination of units causes a different amount of current flow to which the warning-locating mechanism in the annunciator circuit accordingly responds. For the sake of description the current will be referred to as the "detection" current.

The mechanism in the annunciator unit operative upon the flow of the above mentioned detection current will be described later. The means for connecting the unit in the circuit and for determining the amount of detection current is described following.

Terminals 14a and 14b are connected to lines 7 (Figures 1 and 3) and are also connected to a circuit comprising variable resistor 15, normally open contacts or switch 16, and four-pole double throw switch 17. As is clearly shown in Figure 3 the switch 17 is alternatively operable in positions 17a and 17b. In either of these positions a closure of switch 17 connects the circuit with lines 7, hence with the annunciator. The amount of detection current may be regulated by the variable resistor 15. Thus in an installation such as shown in Figure 1 the variable resistor of each unit would be adjusted so that upon closure of the contacts 16 a different detection current would flow. As will later be described, warning-locating mechanism in the annunciator is made to respond to these different currents or to any combination of currents.

When the switch is in position 17b relay coil 18 is connected in the circuit. Closure of contacts or switch 16 energizes the coil to close contacts 18a, thus effectively energizing circuit 19 to set off fire extinguishing equipment. Although the means for alternatively energizing a circuit for setting off fire extinguishing equipment may take a variety of forms, the arrangement I have described is preferred as it requires a minimum of standard items.

The means for controlling the operation of switch or contacts 16 is an important part of the invention because in these means a high degree of stability and sensitivity is obtained. Stability is important so that the unit may properly operate despite voltage fluctuation of the power supply. Sensitivity is important for immediate detection of fire and for protection of large areas.

Actuation of the switch 16 is accomplished by means of relay 20, the operation of which is controlled by vacuum tube 21. The coil 20a of the relay is normally energized and by a movable plunger (not shown) holds the switch in a normally open position. The switch closes when there is not sufficient current through the coil to hold in open position. Condenser 20b is shunted across the coil and serves to prevent chatter in the relay. The tube 21 is normally conducting and current flow therethrough is controlled by the bias on grid 21c. It is by the bias means that the high degree of sensitivity of the sensing unit is obtained. The bias is accomplished by a circuit generally indicated by numeral 22 and photo tube 23.

How the above is accomplished will be apparent with a description of the circuit.

Power, for example, 110 v. commercial power, is supplied by way of terminals 13a and 13b. Transformer 27 is connected across the terminals and the terminals are connected to heater 21d of tube 21. I prefer to op-

erate the sensing units on D. C. because it helps to reduce relay chatter and the circuit is not affected by power line disturbance such as phase shifting. Therefore, half-wave rectifier **28** is connected to terminal **13***a*. Resistor **29** is connected in series with the rectifier and it serves as a current limiting resistor in the event of short circuit within the sensing unit. Capacitor **30** connected across the input smoothes out the ripple of the half-wave rectifier.

Positive terminal **26***a* of input resistor **26** is connected directly to the anode **23***a* of photo-tube **23**. Tap **26***b* is connected directly to cathode **21***b* of tube **21**. Potentiometer **25** is connected in parallel with the lower part of resistor **26**; terminals **25***a* and **25***c* being respectively connected to terminals **26***b* and **26***c*. Terminal **25***a* is also connected to cathode **21***b*. The movable arm **25***b* is connected in series with resistor **24** which is connected with both the grid **21***c* of tube **21** and the cathode **23***b* of phototube **23**.

As mentioned heretofore, the tube **21** is normally conducting to energize relay **20** and hold open switch **16**. It is important therefore that power supply voltage fluctuation does not affect the tube current flow. As will be apparent from an inspection of the circuit, the potentials making up the plate to cathode and grid to cathode voltages will change substantially proportionately with change in supply voltage. Thus the ratio of the plate to cathode and grid to cathode voltage will remain substantially constant to insure substantially constant current flow through the tube. Indeed, I have found the unit to be satisfactorily stable with input voltages from 50 to 150 volts.

The grid bias of tube **21** determines the sensitivity of the sensing unit. The bias arrangement comprising circuit **22** and tube **23** make for sharp, trigger-like action, i. e., a small decrease in light intensity falling on the tube **23** will immediately cause tube **21** to cease conducting and de-energize relay **20** whereby switch **16** is closed. As seen in Figure 3, the lower half of resistor **26** is used to supply negative voltage to potentiometer **25**. This voltage may be varied by positioning arm **25***b* and is applied to the grid **21***c* thru resistor **24**. In the arrangement, resistor **26** is about 10,000 ohm, potentiometer is substantially greater, being about 250,000 ohm, and resistor **24** is quite large, being 18 meg-ohms.

Since the phototube is exposed to light, i. e., light sensitive cathode **23***b*, the D. C. resistance of the tube is lowered and a positive voltage is applied to the grid **21***b*. In operation, when the desired intensity from the light source is set on the phototube, the potentiometer is adjusted to balance the D. C. voltage from the phototube **23**, so that the tube **21** is biased near cut-off. If this balanced condition is disturbed, the tube **21** will cease conducting. The condition will be immediately upset with a very small decrease in light intensity on the photoelectric tube since the D. C. resistance of the tube increases, causing a drop in positive potential and allowing the negative bias to take over and stop the tube conducting.

The bias arrangement described above makes for a very sensitive unit. Indeed, in the described arrangement the sensitivity is maintained even with input voltages from 50–150 volts. Although the absolute values of the resistors and the potentiometer used may vary depending on circuit parameters, I have found that maintaining a very high relative value of fixed resistor **24** is important to good sensitivity. Indeed, I have found that the ratio of the absolute value of resistor **24** to the absolute value of potentiometer **25** should not be less than 60:1.

Turning now to Figure 4, the structural details and the operation of the annunciator unit will now be described. Terminals **49***a* and **49***b* are for the purpose of receiving power from a power source, for example, the ordinary commercial 110-volt supply system. Constant voltage transformer **50** is connected to these terminals and is for the purpose of keeping the system stable despite power supply voltage fluctation. In the apparatus of the present invention, I prefer a low operating voltage and therefore have provided transformer **51** to reduce the 110-volt supply to a voltage of the order of 25 volts. A voltage level of this order is preferred because it provides adequate operating power for the various circuits and is conducive to economy in circuit design. I also prefer to operate my system on D. C. because the system is then relatively free from the effects of power line disturbances, such as phase shifting. Full wave rectifier **52** accomplishes this purpose. Capacitor **53** is connected with terminals **52***a* and **52***b* of the rectifier and is used to filter out high frequency transients. The coils **54***a* and **55***a* of fire alarm relay **54** and line fault relay **55** are connected in parallel, one end of each coil being connected to one side of warning unit **5***c*. The other side of the unit **5***c* is connected to terminal **56***a*. The terminal **56***b* is interconnected to terminal **52***b* by way of variable resistor **57***d*. The terminals **56***a* and **56***b* connect the annunciator unit with the line **7**, as will be apparent by an inspection of Figure 1.

Movable plungers (not shown) responsive to current flow in the coils **54***a* and **55***a* are adapted to actuate relay contacts **54***b* and **55***b*. The operation of relay **54** controls certain fire-smoke alarm circuits, and the operation of relay **55** controls a line-fault alarm circuit. These circuits are described below.

One side of coil **57***a* of relay **57** is connected to power terminal **49***b* via conductor **58** and transformer **50**. The other end of the coil is connected to power terminal **49***a* by way of conductor **60**, contacts **54***b* and conductor **59**. As will be apparent from the figure, closure of the contacts **54***b* will energize the coil **57***a*.

A movable plunger (not shown) which is responsive to current flow in the coil **57***a* is adapted to actuate the contacts **57***b* and **57***c*. Closure of the contacts **57***b* effectively energizes an alarm circuit. The alarm circuit includes terminals **61** and **63**, terminal **61** being connected to power terminal **49***a* by way of conductor **62** and terminal **63** being connected to terminal **64** of contacts **57***b* by way of switch **65** and conductor **66**. Terminal **67** of contacts **57***b* is connected to power terminal **49***b* by way of conductor **58** and transformer **50**. A warning device **5***a* which may be a horn, siren, bell, or the like, is connected to terminals **61** and **63**. Ordinarily, the warning device **5***a* is of the high capacity type and is designed to operate from the standard 110-volt commercial supply system. The purpose may be to send an audible alarm over a large area.

Closure of the contacts **57***c* also energizes an alarm circuit. The alarm circuit includes terminals **68** and **72**, terminal **68** being connected to terminal **69** of contacts **57***c* via switch **70** and conductor **71**. Terminal **72** is connected directly to the secondary winding **73***b* of transformer **73**, and thence to terminal **74** of contacts **57***c* via conductor **75**. A warning device **5***d* may be connected to the circuit terminals **68** and **72**. The warning device is ordinarily a bell or a buzzer of the low voltage type which may serve to make an alarm in the vicinity of the annunciator. In addition to the audible warning device **5***d*, I have provided light **83** which is, as will be apparent from an inspection of the circuit, adapted to be energized simultaneously with warning device **5***d*. The light in general provides a safety feature, for example, if the device **5***d* failed to operate, the light would serve to give an alarm.

Closure of the contacts **55***b* of line fault relay **55** effectively energizes an alarm fault circuit. The alarm fault circuit includes terminals **76** and **79**, terminal **76** being directly connected to terminal **77** of movable contacts **55***b* via conductor **78**. Terminal **79** is directly connected to one side of the secondary of the transformer **73** via conductor **80**. Terminal **81** of movable contacts **55** is directly connected to the other side of the secondary of transformer **73** by a conductor **82**.

A line fault alarm device **5***b* is connected to terminals **76** and **79**. This device may be of the same type as warning device **5***d*.

As has already been described, the warning devices **5***b* and **5***d* are energized from the secondary **73***b* of transformer **73**. The primary **73***a* of the transformer is connected to power terminals **49***a* and **49***b*, as is apparent from the figure. The transformer **73** steps down the 110-volt supply to an operating voltage of the order of six volts. I prefer to use low voltage type warning devices in the annunciator unit, since there is less danger of short circuits and also these units are ordinarily less expensive than the high voltage type, therefore permitting economy in design.

Operation of the line fault alarm is as follows: As will be apparent from Figures 1 and 4 impedance **6**, which is preferably a resistor, is connected to lines **7** and the annunciator is also connected to the lines **7** by terminals **56***a* and **56***b*. Power is supplied to this circuit via rectifier **52** and there is a current flow through the parallel connected relay coils **54***a* and **55***a*, the device **5***c*, lines **7** and resistor **6**, and variable resistor **57***d*. The current is of such a value that fire alarm relay **54** will not pick up but is sufficient to pick up line fault relay **55** and hold contacts **55***a* open. In the event of a fault, for example an open circuit, the relay **55** will be de-energized resulting in the closure of contacts **55***b* and operation of line fault alarm **5***b*.

It is to be observed that the impedance **6** is connected farthermost from the annunciator unit. The location is important because in this manner the whole line is protected.

The warning device **5***c* is preferably a milliammeter. The meter is adapted so that the circulating current in the above described circuit causes the meter to read zero. The variable resistor is for adjusting the proper value of the circulating current as determined by the impedance of the connected lines.

Operation of the alarm-indicating means is described as follows: As mentioned heretofore when a plurality of sensing units are used the variable resistor **15** in each is adjusted so that there is a different value of detection current flowing when one or a combination of units are connected to the lines **7**. Accordingly, warning device **5***c* is responsive to these various values of detection current. The detection current follows the same path through the annunciator as the above mentioned circulation current for a line-fault detection, through lines **7** and through the circuit in the sensing unit connected to terminals **14***a* and **14***b*.

Since a sensing unit or a combination of sensing units causes a predetermined value of detection current to flow, the scale **85** of warning device or milliammeter **5***c* is calibrated in terms of sensing units. The sensing units **2**, **2***a*, **2***b*, **2***c* may be called stations **1**, **2**, **3**, **4**, therefore appearing on the scale are the individual station numbers and various combinations of station numbers. Thus, in the event unit **2** (station **1**) became operative, the pointer **86** moves over the scale to the station **1** calibration, the procedure being the same for any other station or any combination. Thus, the existence and location of a fire is automatically and immediately shown.

At the same time warning device **5***c* is actuated by detection current flow, relay **54** becomes operative and closes contacts **54***b* which energizes power relay **57** to close contacts **57***b* and **57***c* to energize the above described alarm circuits. The detection current has no effect on the operation of line fault relay **55** as this relay is already energized. Switches **65** and **70** are provided to cut off the operation of devices **5***a* and **5***d* if such is desired.

I claim:

In automatic smoke detecting and warning apparatus, a sensing unit comprising: a rectifier; a resistor connected with the rectifier and having two end terminals and an intermediate tap; a potentiometer connected between the tap and one terminal of said resistor, the potentiometer having a movable arm; an electron tube having at least a plate, a grid and a cathode, the cathode being connected to said tap; an electromagnet connected between said plate and the other of the terminals of said resistor; a photoelectric tube having an anode and a cathode, the anode being connected to the other of the terminals of said resistor; a second resistor connected between the movable arm of said potentiometer and the cathode of said photoelectric tube; and an electrical connection between said grid and the cathode of said photoelectric tube.

References Cited in the file of this patent

UNITED STATES PATENTS

1,229,939	Goldstein	June 12, 1917
1,994,768	Holven et al.	Mar. 19, 1935
2,278,920	Evans et al.	Apr. 7, 1942
2,452,942	Lord et al.	Nov. 2, 1948
2,577,973	MacDougall et al.	Dec. 11, 1951
2,646,556	Allen	July 21, 1953

FOREIGN PATENTS

289,934	Germany	Jan. 28, 1916