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[54] **LIGHT RESPONSIVE ACTIVATING APPARATUS FOR FIRE OR EXPLOSION SUPPRESSING SYSTEMS**

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[52] **U.S. Cl.** .....**169/19,** 102/70.2, 169/28, 307/252 L

[51] **Int. Cl.**.....**A62c 37/06**

[58] **Field of Search**.....169/1 R, 1 A, 5, 7, 9, 28, 169/19; 307/202, 252 L; 102/70.2; 244/3.14

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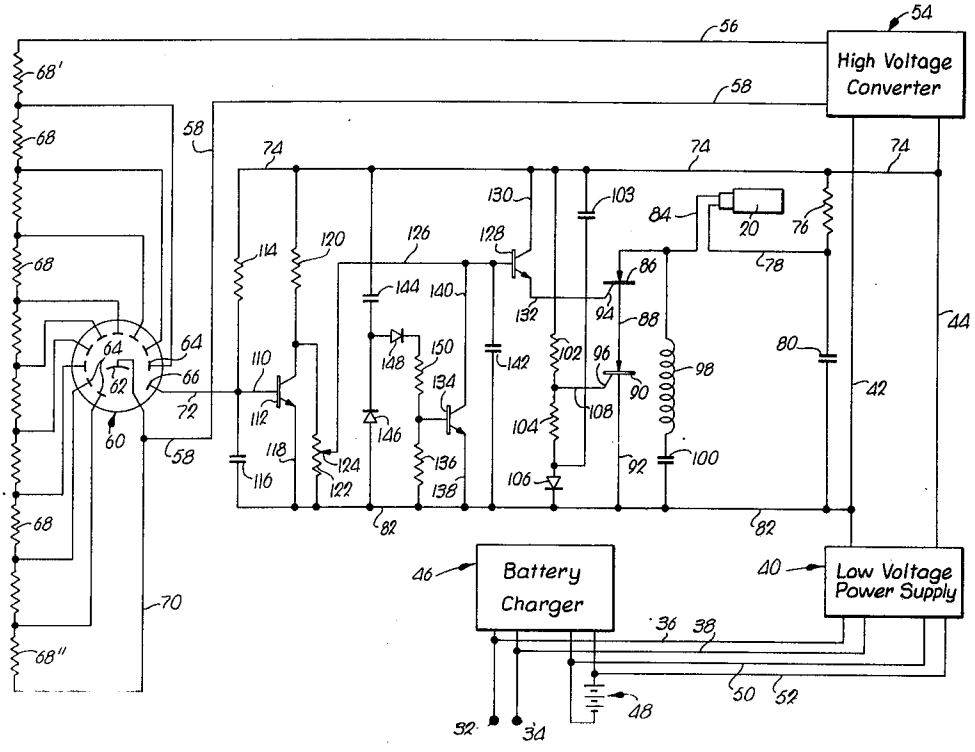
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[57] **ABSTRACT**

A deluge type fire and explosion suppressing system is provided employing improved light sensing means in the nature of a photomultiplier tube having internal amplification properties and improved control and actuating circuitry for the deluge material releasing mechanism which is substantially immune to the effects of electrical transients of either polarity.

12 Claims, 2 Drawing Figures



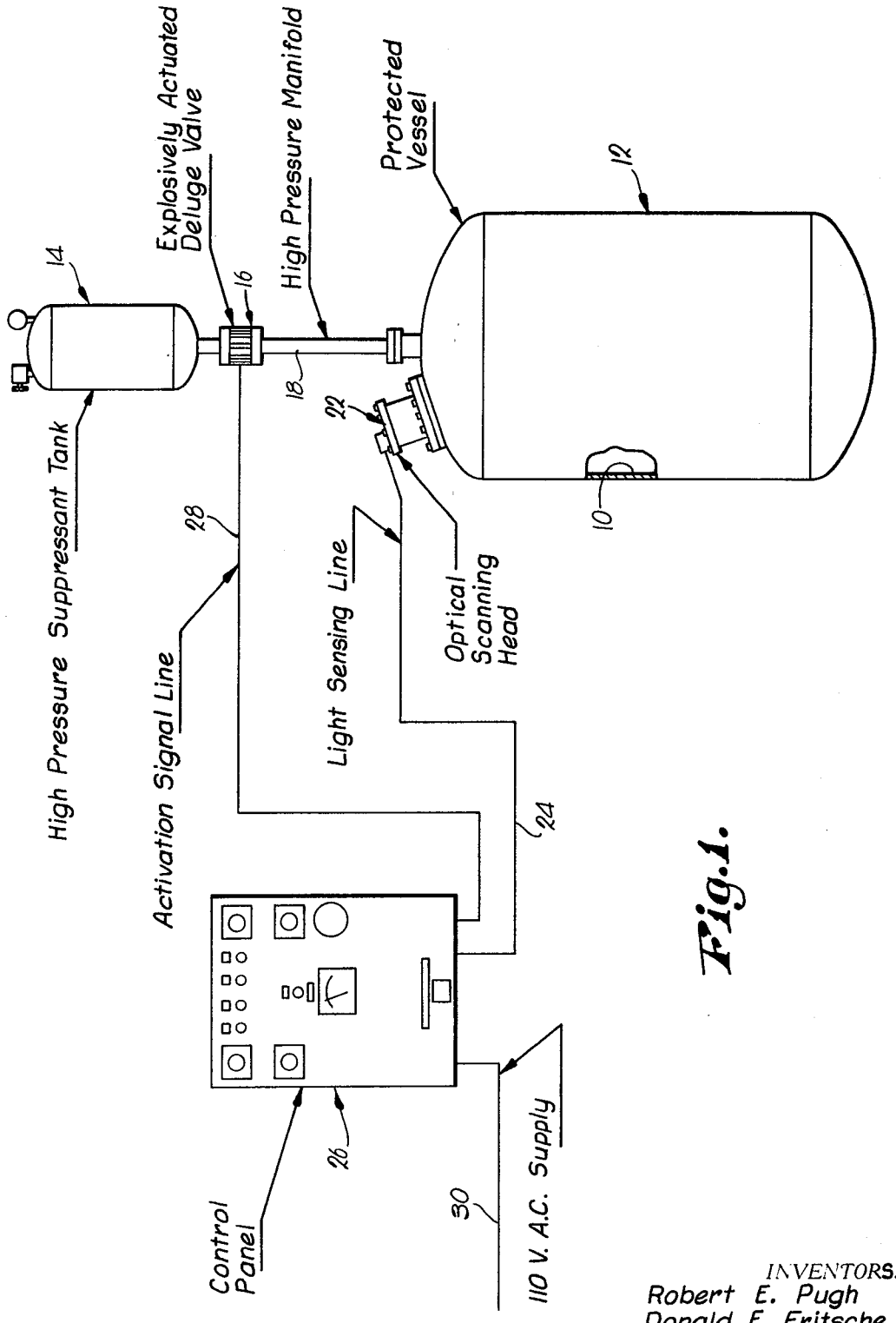


Fig. 1.

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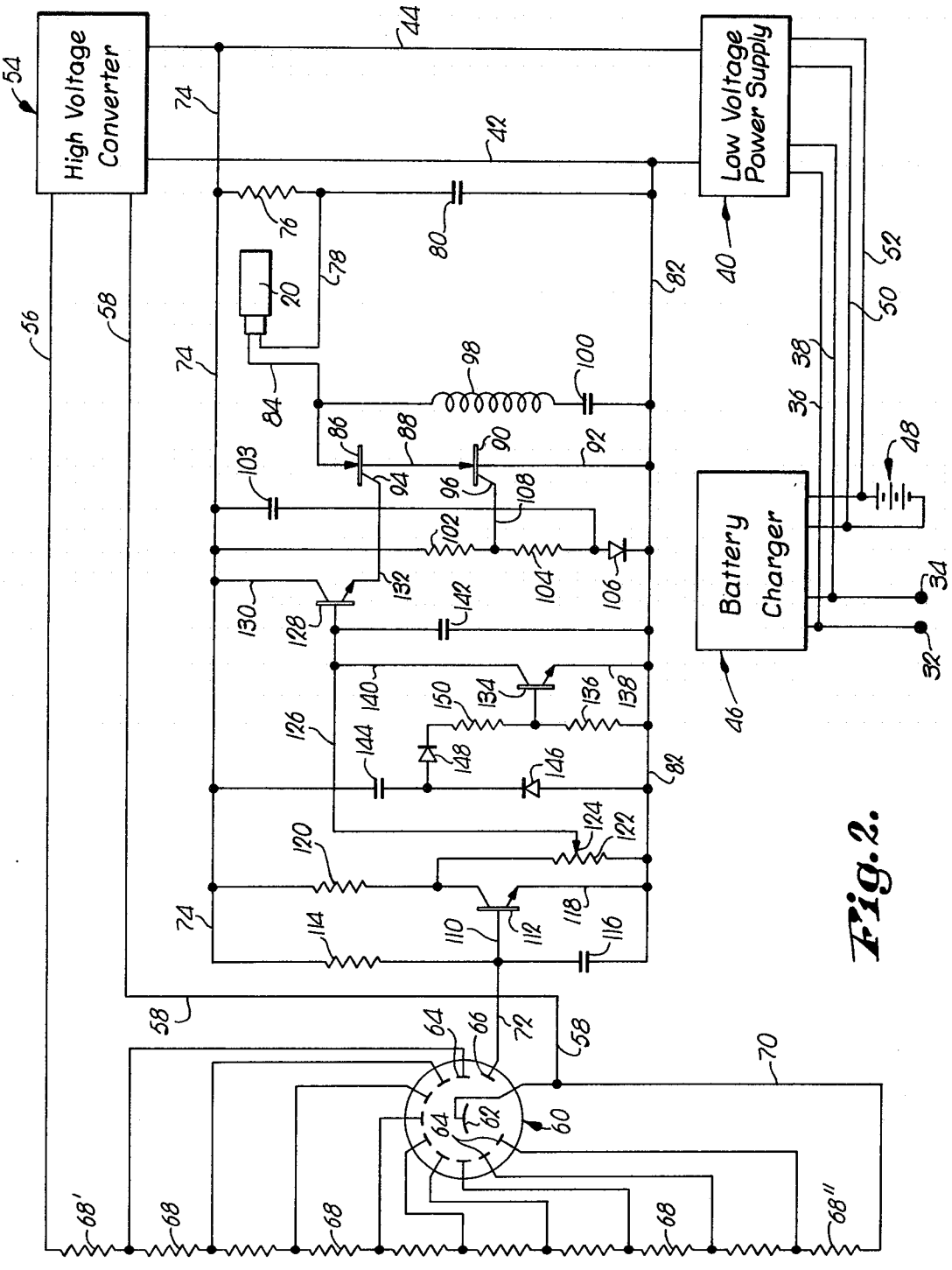


Fig. 2.

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LIGHT RESPONSIVE ACTIVATING APPARATUS FOR FIRE OR EXPLOSION SUPPRESSING SYSTEMS

This invention relates to the field of deluge-type fire and explosion suppressing systems and, more particularly, to such a system employing improved means for sensing the commencement of a fire or explosion condition to be suppressed and for controlling the release of suppressant material responsive to sensing of the commencement of such a condition.

Conventional deluge fire and explosion suppressing systems have been subject to a number of disadvantages. The types of photosensitive devices heretofore commonly employed have been of limited sensitivity and the signals therefrom have required extensive subsequent amplification rendering it difficult to adapt the system for applications where a very high degree of sensitivity is required in order to quickly initiate the suppressing cycle. Prior systems have also commonly employed control and actuating circuitry, the nature of same being partially dictated by the types of sensing devices employed, which were far too susceptible to responding to a spurious electrical transient emanating from the power line or supply or otherwise, so as to render such systems inherently unstable and subject to false, undesired and expensive actuations of the suppressing system when no condition requiring suppressing actually existed. In an effort to remedy these shortcomings it has been conventional to provide in previous systems some means of desensitizing the entire system to reduce its vulnerability to responding to electrical transients, in order to increase the degree of relative stability of the system, but this has necessarily resulted in impairing the ability of such prior systems to quickly and reliably respond to true ignition conditions instantaneously upon their occurrence.

It is the primary object of this invention to overcome the aforementioned and other disadvantages and limitations of prior fire and explosion suppressing systems and to provide an improved system of this type characterized by greater sensitivity, stability, resistance to electrical transients, response rate and general reliability and to do so by means that are inherently simple, trustworthy and effective.

Another important object of the invention is to provide such an improved system employing photomultiplier tube as the light radiation sensing means to provide an ignition sensing signal of relatively high level from the sensing device itself.

Another important object of the invention is to provide such a system in which a pair of switching devices are interposed in the actuating circuit for the suppressant release actuating mechanism, in conjunction with control circuitry which will cause one of such switches to assume a circuit closing condition only in response to an electrical control voltage of predetermined polarity derived from a signal produced upon the sensing of a true ignition condition by the sensing device, the other switching device being driven into a circuit-interrupting condition in response to electrical transients tending to produce a control voltage of corresponding polarity.

It is another important object of the invention to provide such a system, as referred to in the last object, which includes means within the control circuitry for

eliminating adverse effect upon the system of electrical transients of the opposite polarity.

Still other important objects of the invention will be made clear or become apparent to those skilled in the art from the preferred embodiment of the invention shown in the accompanying drawings and described hereunder for illustrative purposes. In the drawings:

FIG. **1** is a schematic diagram illustrating the primary components of the system and their general relationships; and

FIG. **2** is an electrical schematic diagram showing the improved sensing, control and suppressant release actuating circuitry of a preferred embodiment of the invention.

Referring initially to FIG. **1**, a space within which a fire or explosion requiring suppression may commence is indicated by the numeral **10** as constituting the interior of a vessel **12** which may, for example, form a part of apparatus being employed to perform some chemical process. The space **10** need not be sealed for applicability of this invention, but those skilled in the art will understand that the space **10** should be normally darkened by optical enclosure or otherwise so that the sensing of any light radiation within the space **10** may be utilized in the system as an indication of the initiation of ignition attending commencement of a fire or explosion and thus relied upon as a sensible criterion for immediately actuating the deluge type release of a suitable suppressant into the space **10** to smother the fire or explosion that may be commencing.

The suppressant itself, which may be of any of the conventional types known to those skilled in the art, is contained within a tank **14** under high pressure. An explosively actuatable deluge valve **16** is coupled in series with a line **18** leading from the tank **14** to the vessel **12** or, if the space **10** is not defined by a vessel **12**, to another suitable position for discharging large volumes of the suppressant material into the space **10** whenever the valve **16** is opened. It will be understood that the valve **16** includes an explosive detonator **20** (FIG. **2**) which will respond to the application thereto of electrical power to open the valve **16** almost instantaneously.

A light radiation sensing device, hereinafter more fully described, is associated with the space **10**, as by a head **22** upon the vessel **12**, in such manner that the radiation sensing device will be directed toward the space **10** for detecting any light emission occurring therewithin. Those skilled in the art will understand that when the vessel **12** is employed for a purpose requiring the space **10** to be under pressure, the light sensing device may be physically, but not optically, separated from the space **10** by a plate of plastic, quartz or the like (not shown).

Electrical conductive means **24** are provided to couple the light sensing device with a control unit **26**, which may house portions of the circuitry hereinafter to be described, and which is in turn coupled with the detonator portion **20** of valve **16** by conductive means **28** for controlling actuation of the latter in response to signals from the light sensing device.

The system also may conventionally derive the electrical power required for its operation from an ordinary alternating current power line indicated at **30**.

Referring now to FIG. **2**, the alternating current power line is more definitely indicated by the terminals

32 and 34, which are coupled by conductive means 36 and 38 with a low voltage power supply 40 conventionally containing rectification and voltage regulator circuitry for producing a relatively low voltage, direct current output, which may be of the order of 12 volts, upon the power supply output lines 42 and 44. In the illustrative embodiment it may be assumed that the output line 42 is negative and the output line 44 is positive. The alternating current power terminals 32 and 34 may also be coupled with a battery charger 46, in turn coupled with a 12 volt storage battery 48 connected by lines 50 and 52 with the power supply unit 40, in order to provide a standby source of power for operating the system in the event of a temporary failure of the power line 30 to deliver alternating current to the system.

A high voltage converter of conventional design is provided at 54 and coupled with the low voltage supply lines 42 and 44. The converter 54 is adapted either to produce a high voltage output from the low voltage direct current produced by the power supply 40 by rectification from the alternating current supplied from line 30 or to produce the required high voltage from the power derived from the battery 48 when necessary. The high voltage output of converter 54 is presented upon output lines 56 and 58, of which the former represents the positive side and the latter the negative side of such direct current high voltage output in the illustrated embodiment. The voltage produced between lines 56 and 58 might typically be of the order of 1,000 volts DC.

The light radiation sensing device employed by the invention is generally designated by the numeral 60 and is in the nature of a photomultiplier tube having a photosensitive cathode 62, a plurality of dynodes 64, and a collecting anode 66. The dynodes 64 are conventionally successively coupled to each other by a plurality of resistances 68, the endmost 68′ of which is coupled to the positive high voltage supply line 56. The cathode 62 is coupled with the negative side high voltage line 58 and also coupled by conductive means 70 with the resistance 68″ at the end of the series thereof remote from the positive voltage line 56. A signal output line 72 is coupled with the anode 66.

As those skilled in the art will appreciate, whenever light radiation of any frequency within a wide spectrum covering at least the full visible range of frequencies is imposed upon the photosensitive cathode 62 of sensing device 60, a corresponding potential will appear upon a first of the dynodes 64, and such potential will then be passed along the cascaded dynodes 64, with the result that a highly amplified signal potential will appear upon the anode 66 and the signal output line 72, which signal in the illustrated embodiment will be of a negative polarity as compared with the potential existing upon anode 66 when the photosensitive cathode 62 is not being subjected to light radiations.

The circuitry for supplying electrical power to energize and activate the detonator 20 of valve 16 includes a connection through line 74, resistance 76 and line 78 from the positive low voltage supply line 44 to one side of the detonator 20. A capacitor 80 is connected between the line 78 and the common low voltage negative line 82 of the system which is coupled to the negative supply line 42. The capacitor 80 acts as a firing capacitance for the detonator 20 and releases electrical energy stored therein under control of the resistance 76 for the purpose of assuring instantaneous firing or actuation of the detonator 20 whenever the actuating power circuit for the detonator 20 is completed as later herein described.

The other side of the detonator 20 is coupled by a line 84 with a first switching device 86, in turn coupled by line 88 with a second switching device 90, in turn coupled by line 92 with the common negative line 82. In the illustrated embodiment, the switching devices 86 and 90 are silicon controlled rectifier switching devices each having a control element respectively designated 94 and 96. The SCR switching device 86 is normally biased into a condition for interrupting the circuit between lines 84 and 88, while the switching device 90 is normally biased into a condition for completing the circuit between lines 88 and 92. It will be perceived that the electrical power necessary to actuate the detonator 20 may be applied to the latter through the circuitry including positive supply line 44, line 74, resistance 76, detonator 20, line 84, switching device 86, line 88, switching device 90, line 92 and line 82 to negative supply line 42 only when both of the switching devices 86 and 90 are in their circuit-completing conditions. The energizing circuitry just described may also include a choke 98 and a capacitor 100 coupled in series between the line 84 and the common negative line 82 for secondary filtering and stabilizing purposes.

The bias required for application to the control element 96 of switching device 90 to maintain the same in normally circuit-completing condition is derived from a voltage divider component group including resistance 102, resistance 104 and diode 106 coupled in series between the common low voltage positive line 74 and the common low voltage negative line 82, a line 108 to the control element 96 being tapped in between the resistances 102 and 104. It will be noted that a capacitor 103 is coupled in shunt across the resistances 102 and 104 between the common positive line 74 and the diode 106 for purposes hereinafter to be explained and relating to the protection of the switching device 90 against undesired response to spurious electrical transients.

The output line 72 from the light radiation sensing device 60 is coupled by a line 110 with the base of a transistor 112. Input coupling for the transistor 112 is completed by a resistance 114 from the signal line 72 to the positive low voltage common line 74 and by a capacitor 116 coupled between the signal line 72 and the low voltage common negative line 82. The emitter of transistor 112 is coupled directly with the common negative line 82 by a line 118, and the collector of transistor 112 is coupled with common positive line 74 through a resistance 120. A potentiometer 122 is coupled across the emitter-collector output of transistor 112 and provided with an adjustable tap 124 for purposes hereinafter to be described.

The tap 124 of potentiometer 122 is connected by line 126 with the base of a transistor 128. The collector of transistor 128 is connected directly to the common positive line 74 by a line 130, while the emitter of transistor 128 is coupled directly with the control element 94 of switching device 86 by a line 132.

The operation of the circuitry just described for controlling the operation of the switching device 86 in

response to signals from the output line **72** of the sensing device **60** will be subsequently described after the nature of the remaining components and circuitry has also been noted.

Accordingly, attention is next directed to a third transistor **134** employed in protecting the device **86** against undesired operation in response to electrical transients in manner hereinafter to be detailed. The base of transistor **134** is coupled with the common negative line **82** through a resistance **136**. The emitter of transistor **134** is coupled directly with the common negative line **82** by a line **138**. The collector of transistor **134** is coupled directly with the signal line **126** from potentiometer tap **124** by a line **140**. A capacitor **142** is coupled across the collector-emitter circuit of transistor **134** by being connected between the signal line **126** and the common negative line **82**. Associated with the input circuitry for the transistor **134** are a capacitor **144** and a diode **146** coupled in series between the common positive line **74** and the common negative line **82**. A diode **148** is tapped between the capacitor **144** and diode **146** and is oppositely coupled through a resistance **150** with the base of transistor **134**.

Referring now to the operation of the system, and initially to the state of the system when no light radiations are being detected by the photosensitive cathode **62** of sensing device **60**, the transistor **112** will be conducting near saturation by virtue of a forward bias derived through the resistance **114**. In this condition, the output voltage potential existing between the collector and emitter of transistor **112** and applied across the potentiometer **122** is of such low level that the signal passed by line **126** from the potentiometer **122** to the base of the transistor **128** will be of such low level that no actuating signal will be passed along the line **132** to the control element **94** of switching device **86** of sufficient magnitude to alter the switching device **86** from its normal circuit-interrupting condition to a circuit-completing condition. In passing, it will be noted that the transistor **128** is functioning merely as an emitter-follower for reliable coupling of desired control signals to the switching device **86**. The potentiometer **122** and its adjustable tap **124** permit initial adjustment of the system to allow for any inherent leakage current signal that may be presented on the signal line **72** by a particular photomultiplier tube device **60**; however, it should be noted that, by virtue of the high degree of internal amplification within the photomultiplier device **60** (which may be of the order of 1,000:1), the adjustment **124** does not affect desired relatively high level, light sensing responsive signals from the photomultiplier device **60**, and therefore does not operate to impair the extremely high degree of sensitivity and quickness of response to detected light that characterize the improved system of the invention. It will be appreciated that, as long as the switching device **86** is thus maintained in its normal circuit-interrupting condition, the circuit for applying actuating power to the detonator cannot be completed to cause detonation regardless of the condition of the switching device **90**, since the SCR device **86** is being maintained essentially in the condition of an open electrical switch.

When light radiations of even very low level within the space **10** are directed upon the photosensitive cathode **62** of photomultiplier tube **60**, the cathode **62** will emit sufficient electrons to the dynodes **64** to present, after the mentioned high degree of amplification internally of the device **60**, a sufficiently high and relatively strong negative signal at the anode **66** and signal output line **72** to cause the voltage drop across resistance **114** to increase substantially, thereby applying a negative sense signal voltage across the base-emitter junction of the transistor **112**. This will cause an increased voltage drop within the transistor **112** and an increase in potential across the collector-emitter circuit of the transistor **112**. The amplification function of the transistor **112** will translate a relatively small negative signal or voltage change upon the base of transistor **112** into a very substantial and relatively large positive sense signal or voltage change upon the collector of transistor **112**, which is then coupled through the tap **124** of potentiometer **122** and the emitter-follower transistor **128** to the control element **94** of switching device **86**. Such signal applied to the control element **94** changes the state of the SCR device **86** to a circuit-completing condition, thereby completing the actuating power circuit for the detonator **20** to detonate the latter if the switching device **90** remains in its normally circuit-completing condition. When such actuating circuit for the detonator **20** is thus completed, the firing capacitor **80** will discharge its stored energy through the detonator **20** to detonate the latter, thereby opening the valve **16** and deluging the space **10** with suppressant material from the tank **14**.

As previously noted, the SCR switching device **90** is normally maintained in a circuit-completing condition, and this is accomplished by the bias applied to control element **96** thereof which is derived through the line **108** from the voltage divider network including resistances **102** and **104** and diode **106**. Thus, alteration of the condition of switching device **86** to its circuit-completing condition will result in immediate detonation of the detonator **20**.

It will be appreciated, however, that the occurrence of a temporary electrical transient in the form of a negative pulse upon the common line **74** with respect to the common line **82** could affect the input to transistor **112** in manner simulating a genuine signal from the sensing device **60** so as to operate the switching device **86** to its circuit-completing condition in response to such transient and even when no genuine signal from the sensing device **60** existed. Protection against inadvertent detonation of the detonator **20** in this manner by a negative transient upon the power lines is provided by the action of capacitance **103** in conjunction with the switching device **90**. Such a negative transient would immediately be coupled through the capacitor **103**, the resistance **104** and the line **108** to the control element **96** of switching device **90**, causing the latter to immediately become biased to cut-off and alter its condition to a circuit-interrupting condition, which will continue for the duration of the negative transient. Thus, even though a negative transient may "close" the switching device **86**, the invention provides for such transient also immediately and automatically "opening" the switching device **90** and maintaining the latter in its circuit-interrupting condition as long as the pulse endures.

The switching device 90 is also protected from positive transients upon the line 74 with respect to the line 82 by the capacitor 103 and the diode 106, such positive transients simply being shunted to "ground" or the common negative line 82 through the capacitor 103 and the diode 106.

Further protection against the possibility of a positive transient operating through the transistor 128 to cause a spurious change of state of the switching device 86 from its normal circuit-interrupting to its circuit-completing condition is provided by the transistor 134 and its associated circuitry. Transistor 134 is normally biased to cutoff by the input connection of its base to the common negative line 82 through the resistance 136. In the event of a positive transient on the line 74 with respect to the line 82, however, such positive potential will be coupled through capacitor 144, diode 148 and resistance 150 to the base of transistor 134, which drives the latter into saturation so that any positive transient that might otherwise be applied to the input of transistor 128 is immediately and automatically shunted to the common ground or negative line 82 through the transistor 134.

It should thus be apparent to those skilled in the art that the invention provides a highly sensitive and reliable means for controlling the actuation of the deluge valve in a fire or explosion suppressing system, in which sensing of even the faintest light radiation indicating the commencement of ignition will be effective to operate the suppressant material releasing mechanism, and in which full provision is made for protecting the system against undesired and inadvertent operation caused by spurious electrical transients that may enter through the power supply line or be otherwise introduced into the system through inductive effects from other equipment that may be adjacent to the system. It will be further appreciated that various minor modifications and changes could be made from the exact details of construction shown and described to illustrate a preferred embodiment of the invention without departing from the true spirit and intention of the invention. Accordingly, it should be understood that the invention should be deemed limited only by the fair scope of the claims that follow.

We claim:

1. In apparatus for suppressing fire or explosion within a predetermined space:

electrically actuatable means disposed and adapted, when actuated, for quickly suppressing a fire or explosion commencing in said space;

electrically controllable first and second electrical switching means each having control means associated therewith for altering the functional state of the corresponding switching means between a circuit-interrupting condition and a circuit-completing condition in response to electrical control voltages applied to said control means;

electrical actuating circuit means coupled with said suppressing means and having said first and second switching means coupled therein for actuating said actuable means whenever both of said switching means are in their circuitcompleting conditions;

means for supplying electrical power from which said control voltages may be derived, said power sometimes including possible electrical transient components;

standby condition maintaining means coupling said supplying means with said control means of each of said switching means for normally providing and applying to the latter control voltages for maintaining said first switching means in its circuit-interrupting condition and said second switching means in its circuit-completing condition;

sensing means for sensing the commencement of a fire or explosion within said space substantially simultaneously with the initial occurrence thereof and for producing an immediate electrical output signal in response thereto;

operating means for coupling said sensing means with said control means associated with said first switching means and operable in response to the production of said output signal by said sensing means to apply to said control means associated with said first switching means an alternate control voltage for altering the functional state of said first switching means to the circuit-completing condition thereof; and

primary transient protective means coupled with said supplying means and said control means of said second switching means for sensing certain electrical transients in said power and for providing and applying to said control means of said second switching means in response thereto an alternate control voltage for altering the functional state of said second switching means to the circuit-interrupting condition thereof during the duration of occurrence in said power of said transients.

2. Apparatus as set forth in claim 1, wherein said primary protective means responds to electrical transients of that electrical polarity which effectively apply to said control means of said first switching means a voltage simulating said alternate control voltage applied thereto by said operating means when commencement of a fire or explosion is sensed by said sensing means.

3. Apparatus as set forth in claim 2, wherein is provided secondary protective means coupled with said supplying means and said standby condition maintaining means for shunting electrical transients of the opposite electrical polarity away from said control means of said second switching means.

4. Apparatus as set forth in claim 2, wherein is provided auxiliary protective means coupled with said supplying means and said standby condition maintaining means for shunting electrical transients of said opposite electrical polarity away from said control means of said first switching means.

5. Apparatus as set forth in claim 1, wherein said sensing means includes a photomultiplier tube.

6. Apparatus as set forth in claim 1, wherein said actuatable means includes a supply of suppressant material under pressure, conduit means leading from said supply to said space, a normally closed valve interposed in said conduit means, and an electrically actuatable detonator associated with said valve for opening the latter.

7. Apparatus as set forth in claim 1, wherein each of said switching means comprises a silicon controlled rectifier having a control element.

8. Apparatus as set forth in claim 1, wherein said operating means includes electrical circuitry coupled with and deriving power from said supplying means.

9. Apparatus as set forth in claim 1, wherein said sensing means comprises a photomultiplier tube which produces a negative sense output signal when light in said space is sensed; said first switching means comprises a silicon controlled rectifier having a control element; said maintaining means normally applies to said element a voltage which is insufficiently positive to switch said rectifier into its conductive state; and said operating means includes an active device having an input circuit coupled with said sensing means and said supplying means, and an output circuit coupled with said supplying means and said element, said device producing an amplified control voltage signal of positive polarity for application to said element of said rectifier to switch the latter to its conductive state when said output signal is applied to said device from said sensing means.

10. Apparatus as set forth in claim 9, wherein said second switching means comprises a second silicon controlled rectifier having a control element; said maintaining means includes voltage dividing means coupled with said supplying means and said last-mentioned element for normally applying a positive polarity bias to the latter for keeping said second rectifier switched into its conductive state; and said primary protective means includes capacitative impedance means coupled with supplying means and said last-mentioned element for applying to the latter a transient of negative polarity appearing in the power being supplied by said supplying means for offsetting said bias sufficiently to switch said second rectifier into its non-conductive state during the duration of said negative transient.

11. Apparatus as set forth in claim 10, wherein is provided means including said impedance means and a unidirectionally conductive device coupled across said supplying means for shunting positive transients appearing in the power being supplied by said supplying means away from the control element of said second rectifier.

12. Apparatus as set forth in claim 11, wherein is provided means including a second active device having an input circuit coupled across said supplying means and an output circuit coupled across the output circuit of said first-mentioned active device, said second active device normally being biased into a non-conductive state but being responsive to a transient of positive polarity appearing across its input circuit to switch said second active device into its conductive state for shunting said positive transient across the output circuit of said first-mentioned active device to prevent its imposition upon the control element of said first rectifier.

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