United States Patent

[11] 3,603,957

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[21] Appl. No. **788,408**
[22] Filed **Jan. 2, 1969**
[45] Patented **Sept. 7, 1971**

[54] **INTRUSION ALARM SYSTEM AND LINE VOLTAGE COMPENSATION**
26 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **340/258,** 250/221, 340/409
[51] **Int. Cl.** **G08b 13/18**
[50] **Field of Search** ..... 340/228, 228 S, 258, 258 B, 409, 258 C; 356/222; 250/222, 221, 221 X, 214; 317/27, 31, 33

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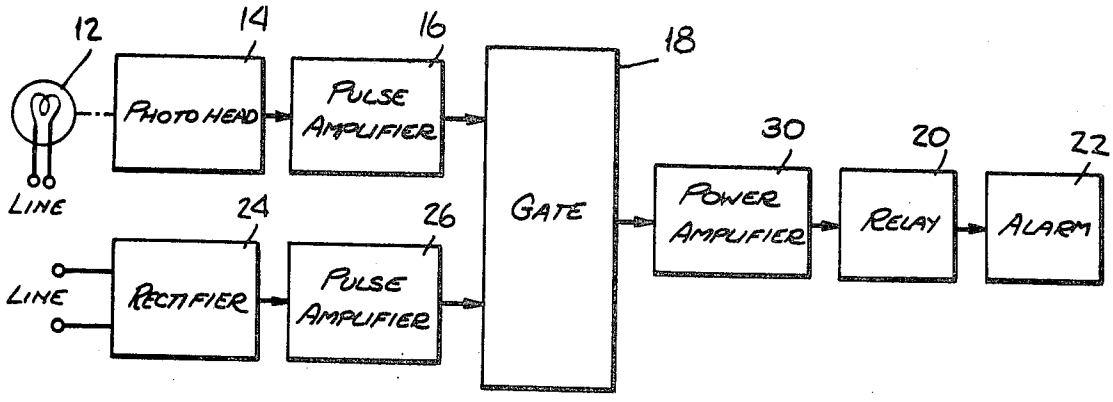
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ABSTRACT: An intrusion alarm system responsive to the amount and rate of decrease of light striking a photohead is provided together with a means to compensate for those line voltage fluctuations which would produce a rapid decrease in light that might trigger a false alarm. The intrusion alarm system employs a pulse amplifier to respond to sudden decreases in light input to a photohead so as to provide a signal which will initiate the alarm.

A rectifier coupled to the same line source as is connected to the source of light provides a rectified output having substantial ripple content. A diode bridge sensor compares the rectifier output with a voltage level on a capacitor, thereby establishing a means to provide a signal indicating sharp changes in line voltage level. A gate responsive to rectifier bridge output and thus responsive to sharp changes in line voltage level is used to disable the system on the incidence of such line voltage changes. Accordingly, false alarms are avoided.



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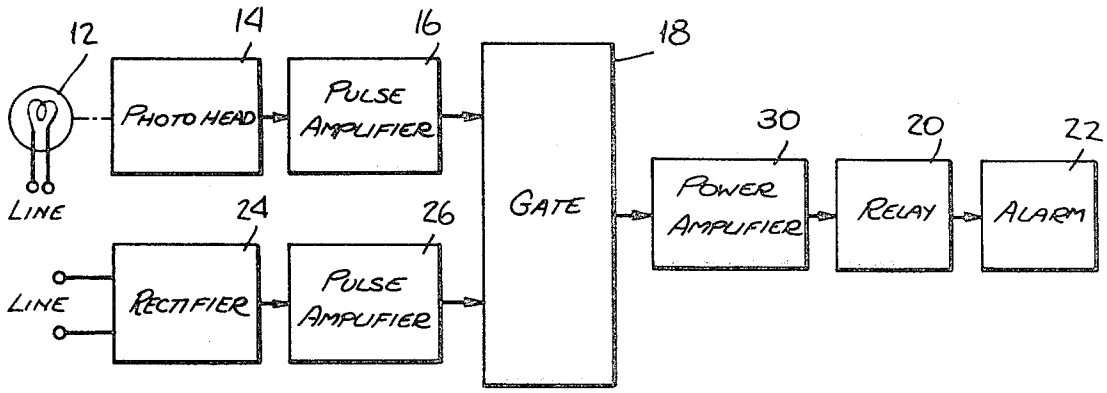


Fig. 1.

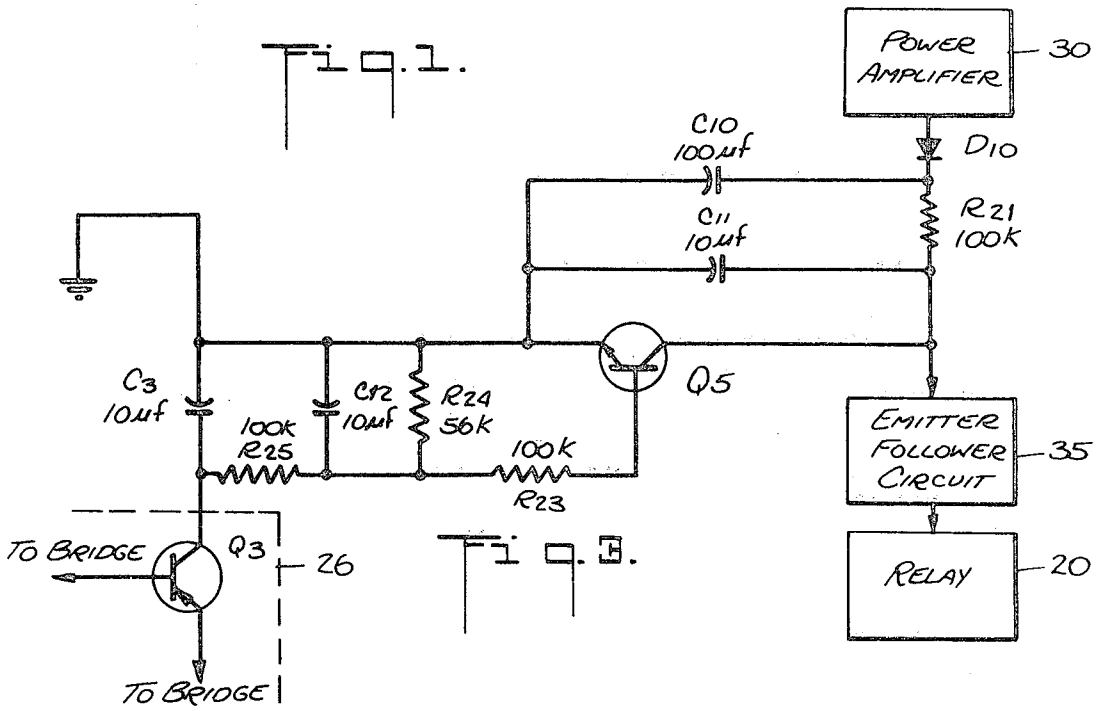
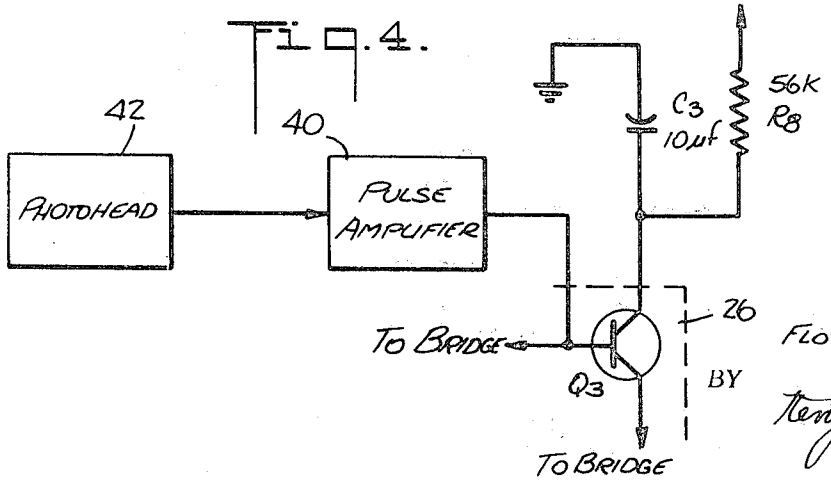


Fig. 3.

Fig. 4.



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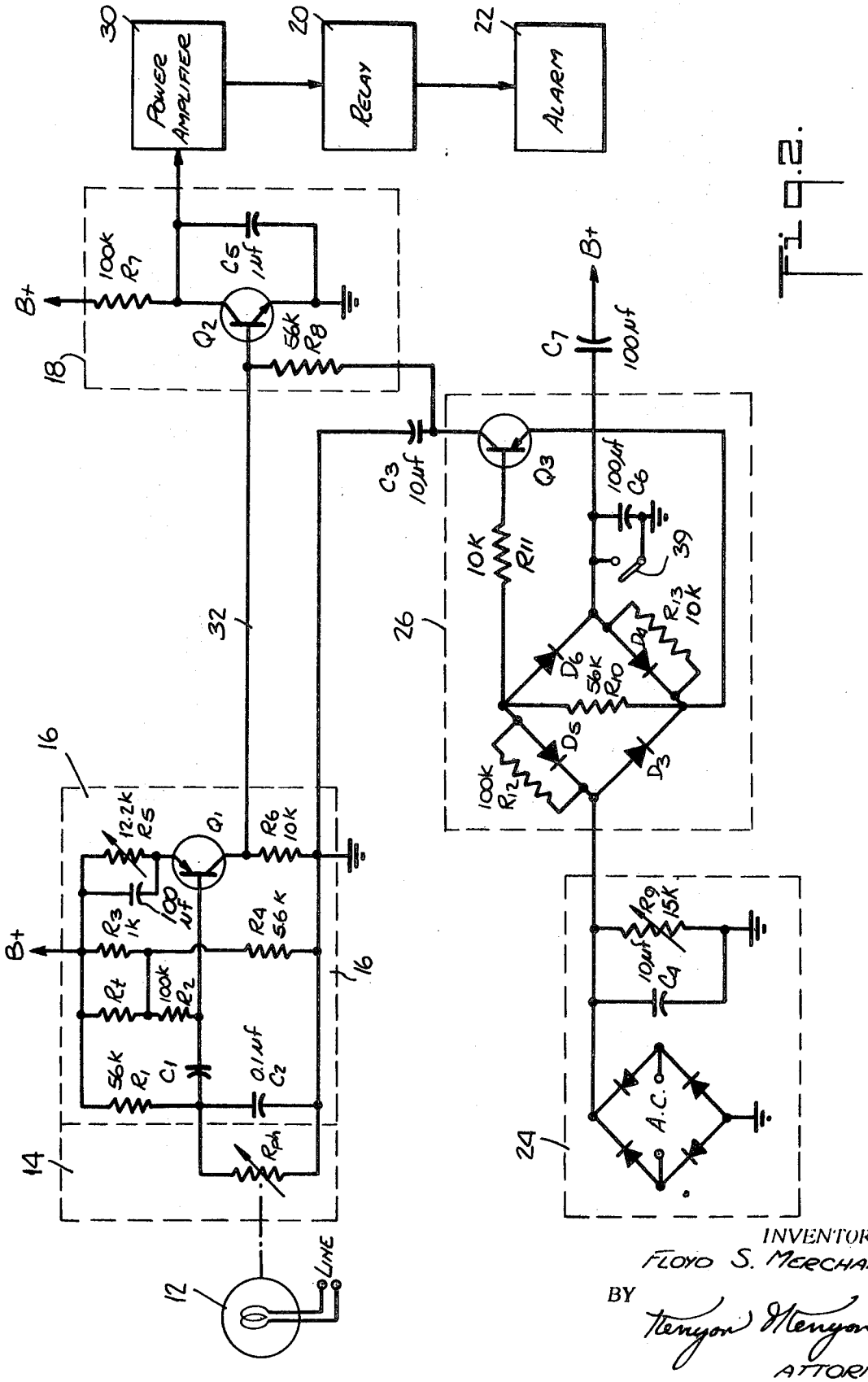


Fig. 2.

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INTRUSION ALARM SYSTEM AND LINE VOLTAGE COMPENSATION

This invention relates in general to intrusion alarm systems and more particularly to a design which is adapted to provide a concealed intrusion alarm system and to avoid false alarms due to variations in line voltage levels.

BACKGROUND OF THE INVENTION

There are a wide variety of known intrusion or burglar alarm systems. One of the most widely used designs involves a directed beam between a light source and a photohead. Such a directed beam makes it possible for the photohead and associated circuitry to be relatively insensitive to low levels of light change so that variations in ambient light conditions and variations in line voltage which in turn cause variations in the light beam output will not normally trigger an alarm. In addition, in such a design false alarms are a serious problem due to misalignment problems. The major limitation in the security provided by such directed light beam systems is that they are generally quite difficult to conceal.

Accordingly, it is a major purpose of this invention to provide an intrusion alarm system which may be concealed from detection by an intruder.

In order to provide a concealed alarm system, it has been thought desirable to dispense with the directed beam device and, obviously, it world then be desirable to have the source of light that impinges on the photohead come from an ordinary incandescent lamp or other light source that might be used for general illumination purposes. In such a case, the intruder would not have his suspicion aroused that such a light source is tied into the burglar alarm system. However, in such unbeamed systems the photohead and alarm system have to be relatively sensitive to variations in light impinging on the photohead because the amount of light impinging on the photohead from the light source is relatively low.

Accordingly, it is another purpose of this invention to provide a relatively sensitive burglar alarm system which can respond to an intrusion between an unbeamed light source and a photohead.

It is a related purpose of this invention to provide such a sensitive intrusion alarm system that will avoid false alarms.

One of the disadvantages of a beamed intrusion alarm system is the requirement for alignment between the beam and the photocell. The lack of alignment or loss of alignment is one of the major causes of false alarms.

Accordingly, it is another purpose of this invention to provide an intrusion alarm system which does not require particularly accurate alignment between the photohead and the source of light.

It is a further purpose of this invention to provide the above purposes in the context of a system which is relatively inexpensive and simple in design so as to avoid the requirement for much in the way of maintenance. Thus, it is a further related purpose of this invention to provide these purposes with a device that can be widely used and widely installed without requiring either sensitive adjustments or frequent maintenance.

An intrusion alarm system that achieves the above results, requires responsiveness to rapid decreases in light input to a photohead, which rapid decreases are caused by an intrusion between a source of light and a photohead. In order for the alarm to work under a wide variety of ambient conditions, the alarm system must be sensitive to relatively small percentage decreases in light input. Such a design results in a system which tends to be very sensitive to sudden changes in line voltage levels, primarily because such changes result in changes in the light output of the light source involved.

Accordingly, it is a major purpose of this invention to provide a circuit technique for temporarily disabling the system in response to sudden changes in line voltage variations in order to prevent false alarms.

It is a related purpose of this invention to provide the above responsiveness to sudden changes in line voltage variations while permitting the systems to adapt to the relatively wide variations in line voltage level that occur over longer periods of time without disabling the system when such slow variations in line voltage level occur.

BRIEF DESCRIPTION OF THE INVENTION

In brief, this invention involves an intrusion alarm system responsive to an intrusion between a nondirected light source and a photohead. A pulse amplifier coupled to the photohead provides an output signal when the light level falling on the photohead decreases in a sudden rapid fashion. However, the pulse amplifier is made sensitive so as to remain responsive to daytime intrusions as well as to nighttime intrusions. Rapid relatively small variations in the voltage level of the alternating line voltage applied to the light source result in sharp variations in light output that simulate an alarm condition and produce a false alarm actuating signal. To obviate this problem, this invention includes a novel means to compensate for such line voltage variation. A line voltage compensating unit is coupled to a gate to change the state of the gate, and thus disable the system, in response to a relatively sharp variation in line voltage level. The voltage compensating unit is particularly sensitive to rapid, even though relatively small in magnitude, decreases in line voltage level, since such result in a decrease in light level that simulate an intrusion.

The line voltage compensating unit of this invention includes a poorly filtered rectifier unit coupled to the source of line voltage to provide a rectified output having a substantial ripple content. It is desirable that this system operate continuously and be operable, without monitoring, during those times of the day and the week when line voltage is relatively low and when line voltage is relatively high. For reasons that will be described in greater detail in connection with the detailed description of the invention, the line voltage compensating unit is designed so that at relatively low expected line voltage levels, the effect of the ripple content of the output of the line voltage compensating unit will be negligible while at relatively high expected line voltage levels, the ripple content will effect the output. Without explaining all the reasons why at this point, the reasons for such design relate to a balance between sensitivity requirements, ability to operate over the whole range of expected line voltage levels, and avoidance of disabling the system in response to the higher line voltage levels. In addition, this design feature aids in adjustment.

The poorly filtered rectifier output is fed to one corner of a diode bridge. A capacitor at the other corner of the diode bridge establishes a voltage level against which the rectifier output can be compared. Under steady state conditions, the capacitor voltage level will approximately match the rectifier output level, due to the operation of diodes. When a sudden variation in line voltage level occurs, the rectifier output will sharply increase or decrease, as the case may be, and the other corners of the diode bridge will provide a pulse output. Thus a pulse signal is provided, which can be used to operate a gate. The gate so operated is connected into the burglar alarm system so that in one state it passes the alarm signal from the photohead and pulse amplifier to the relay and alarm sounding device while in the other state it blocks such signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and purposes of this invention will become apparent from the following detailed description of the drawings, in which:

FIG. 1 is a block diagram of an embodiment of the intrusion alarm system invention;

FIG. 2 is a block and schematic diagram of the FIG. 1 embodiment in which an embodiment of the line voltage compensation invention is shown;

FIG. 3 is a block and schematic illustration of a timing mechanism that may be incorporated in a preferred embodiment of this invention; and

FIG. 4 is a block and schematic illustration of additional functions which the line voltage compensating invention can be employed to perform.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block diagram which shows the overall operation of a preferred embodiment of this invention. As shown in FIG. 1, a nondirected, nonbeamed light source **12**, which may be nothing more than a **40** watt incandescent bulb, is positioned so that light from it is received by the photoresponsive element in a photohead **14**. A sensitive pulse amplifier **16** is coupled to the output of the photohead **14** so that sharp variations in photohead **14** output are amplified and passed on to the rest of the system. However, because the amplifier **16** is a pulse amplifier, slow variations in light intensity at the photohead **14** do not affect the system. Thus, changes in the ambient light condition as well as decay of the light source do not affect the operation of the device of this invention.

The pulse amplifier **16** is preferably designed to have essentially two operating states, one being an "on" state and the other being an "off" state. The pulse amplifier **16** then responds to sudden input decreases greater in magnitude than a certain threshold level by switching state. This change of state is received as a pulse at the gate **18** and under normal conditions of intrusion is passed by the gate **18** to energize a relay **20** and thus turn on an alarm **22**.

Sudden alternating current line voltage changes occur as other lights and equipment are turned on and off. These sudden line voltage changes affect the light output from the light source **12** in a material and relatively sharp fashion. Under certain ambient light conditions such changes in line voltage levels may produce an alarm inducing pulse.

The pulse amplifier **16** is designed to be as sensitive as possible to sudden decreases in light input to the photohead **14**, so that even a relatively small pulse charge will be amplified by the amplifier **16** and passed to the rest of the system. Because this system operates off a nondirected, nonbeamed light source **12**, the light falling on the photohead **14** during the daytime that comes from the light source **12** will be a small proportion of the total light incident on the light source **12**. For example, in the daytime, an intrusion might result in a 10 percent decrease in light energy falling on the photohead **14**. But, at night, the light source may be the only source of light energy impinging on the photohead **14**. But the system has been adjusted to respond to a daytime intrusion. Thus the system is at least sensitive enough to respond to a 10 percent decrease in light energy. Accordingly, at night a relatively small sudden decrease in line voltage to the light source **12** might result in a 10 percent decrease in light energy on the photohead **14**. From the alarm system point of view, this will approximate the effect of a daytime intrusion and would tend to cause a false alarm unless proper provision is made to compensate for this effect. By contrast, the 10 percent decrease in the output of the light source itself during the daytime might mean only a one or two percent decrease in light energy incident on the photohead and the system is designed to ignore changes of that small a magnitude. The provision that is made to compensate for sudden line voltage decreases is shown in Fig. 1, in simplified form, as a rectifier **24** and a second pulse amplifier **26**. Together, these two units **24** and **26** constitute a line voltage compensating unit.

The rectifier **24** is connected to the same line that the light source **12** is connected to so that any sudden line change will be represented by a change in the voltage level at the output of the rectifier **24**. The pulse amplifier **26** responds to this sudden voltage level change to provide an output signal that disables the gate **18**. With the gate **18** disabled, no pulse from the photohead **14** and pulse amplifier **16** will be transmitted through to the alarm system, **20**, **22**. Thus, a false alarm due to response of the photohead **14** and a pulse amplifier **16** to a change in light source **12** output due to a sudden change in line voltage is avoided.

FIG. 2 is a block and schematic diagram illustrating preferred circuit arrangements for certain of the units shown in FIG. 1.

BASIC OPERATION OF THE FIG. 2 CIRCUIT

The photohead **14** is illustrated as containing a resistance R_p, which represents the resistance of a photoresistor. R_p is shown as a variable resistance since its value is a function of the light incident thereon and, in one embodiment may vary between 500 ohms and 500,000 ohms.

In the pulse amplifier **16**, the capacitor C_1 couples rapid voltage changes to the base of the transistor Q_1. The resistor R_2 and coupling capacitor C_1 form an input RC coupling network which, with the values for R_2 and C_1 shown (100,000 ohms and ten microfarads respectively), has a time constant of approximately one second. Accordingly, changes in the value of the photoresistance R_p that occur in a period of time shorter than this one second time constant will be coupled to the base of the transistor Q_1 to change the state of the transistor Q_1. In the embodiment shown, the transistor Q_1 is maintained as normally "on" by virtue of the voltage normally applied to the base of Q_1, which voltage is developed at the junction of the resistors R_4 and R_5.

When an intrusion occurs between a light source **12** and the photoresistor R_p, the amount of light on R_p decreases, thereby increasing the value of the resistance R_p and increasing the voltage at the junction between R_p and R_1. This increased voltage is coupled through to the base of the transistor Q_1 thereby tending to turn the transistor Q_1 off. When the transistor Q_1 turns off, the voltage at its collector drops toward ground thereby causing a drop in the voltage at the base of the transistor Q_2 in the switch **18**.

The resistor R_5 is set to cause the transistor Q_1 to conduct enough so that the switching transistor Q_2 in the switch **18** is normally on. Thus the collector of the transistor Q_2 is normally at a low voltage level. When the transistor Q_1 is turned off and the voltage at the base of the transistor Q_2 is thereby dropped, the transistor Q_2 turns off. When the transistor Q_2 turns off, the voltage at its collector rises therefore providing an output **30** then provides sufficient current to cause the relay **20** to become energized and turn on the alarm **22**.

The 1 microfarad capacitor C_5 introduces a time delay in the response of the output of the switch **18** to the turning off of the switching transistor Q_2. When the transistor Q_2 is turned off, the capacitor C_5 has to charge up to a point sufficient to cause the relay **20** to change state. In the FIG. 2 embodiment shown, a 100 millisecond time constant is provided by the C_5, R_7 combination. Depending on the voltage necessary to actuate the relay **20**, the actual delay may be as much as 200 milliseconds. Among the advantages of this delay is the fact that it permits a line voltage variation compensating unit to be brought into operation before an alarm has been sounded.

THE PULSE AMPLIFIER 16

The 0.1 microfarad capacitor C_2 in the pulse amplifier **16** serves to bypass any radio frequency signal that may be coupled into the circuit.

The 56,000 ohm resistor R_1 forms a voltage divider network with the photoresistor R_p. The value of the photoresistor R_p can vary very widely and, of course, is a function of the light incident on it. The value of the resistor R_1 is selected to be approximately equal to the value of the photoresistor R_p under the most usual standby conditions. This is because when the resistor R_1 and the photoresistor R_P are equal, the greatest sensitivity will be achieved.

When the photoresistor R_p becomes very large in value, which will occur under conditions of a very weak light source and low ambient light conditions, then a given percentage change in the magnitude of the resistor R_p will mean a relatively small change in the voltage at the junction of R_1 and R_p. Accordingly, only a small voltage change will be coupled to the base of the transistor Q_1. A similar condition will be true

when the value of the resistor R_P is very low compared to the resistor R_1. But, when the resistor R_1 is approximately equal to the photoresistor R_p, a given percentage change in the photoresistor R_p will produce a maximum voltage change to be coupled to the base of transistor Q_1. Thus, the magnitude of the resistor R_1 effectively determines the midpoint of the range of standby resistances over which the photoresistor R_p can be effective. For this reason and for reasons of loading in the embodiment shown, the photoresistor R_p can have a standby value between 500 ohms and 500,000 ohms and still permit a 10 percent increase in R_p to cause an alarm without requiring that the transistor Q_1 be set so close to the alarm threshold that it will drift past the alarm threshold due to such factors as temperature change.

The resistor R_5 at the emitter of the transistor Q_1 in the pulse amplifier **16** is variable. The value to which R_5 is set is determined by the extent to which the magnitude of the photoresistance R_p is affected by light from the light source **12** as contrasted with ambient light. Where the line of sight is in such a location that the value of R_p is greatly influenced by the light source **12** illumination, any moving object that obscures the light source **12** will cause R_p to increase by a relatively large factor. This "strong alarm" situation can cause R_p to suddenly increase to many times its standby value. In such a case, the emitter resistor R_5 is set at a relatively low value so that the transistor Q_1 is conducting heavily. The alarm threshold is thus made less sensitive because there is a strong alarm situation.

However, where there is a weak alarm situation greater sensitivity is required. For example, in some locations at peak daylight hours there is a great deal of random light competing with the light source **12**. If the alarm is to operate, it has to respond to an intrusion under such conditions. If adjusted to respond under such conditions, it will certainly respond when, as perhaps at night, a stronger alarm situation exists. In such a weak alarm situation, the value of the photoresistor R_p is lowered considerably by the extraneous light. When an object obscures the light course, there may be only a 10 percent increase in the value of R_p. The emitter resistor R_5 is then set in such a fashion that the transistor Q_1 is conducting only slightly over the minimum current (which might be 60 microamperes) necessary for maintaining standby conditions. Thus, the alarm point is close to the standby condition and system sensitivity is high.

Under standby conditions the transistor Q_1 is turned on. The forward bias required to maintain the transistor Q_2 in its on state increases as the temperature drops. Thus, in order to maintain maximum sensitivity, it is important that the voltage at the base of the transistor Q_2 increase slightly as temperature drops. This result is achieved by virtue of the functioning of the thermistor resistor R_t in the pulse amplifier **16**. As temperature drops, the thermistor resistor R_t increases thereby tending to increase forward bias (i.e., drop the voltage at the base) of the transistor Q_1 slightly. The increase in forward bias of the transistor Q_1 results in a small increase in emitter current, thereby providing the required increase in voltage at the base of transistor Q_2.

The use of the thermistor R_t also aids in stabilizing the operation of the system over a temperature range. This means that the sensitivity of the system can be set to be greater than otherwise would be the case because the system can be made more sensitive, the system can have a standby range of the photoresistor R_p greater than otherwise would be the case. Accordingly, the thermistor R_t increases the versatility of the device and makes it capable of operation under a wide range of ambient light and light source **12** conditions.

LINE VOLTAGE COMPENSATION UNIT

The rectifier **24** and second pulse amplifier **26** operate as a unit to compensate for sudden line voltage fluctuations. A sudden line voltage drop will produce a sudden drop in the output from the light source **12** which might result in a pulse being coupled through to turn off the switching transistor Q_2. A false alarm would then result. However, the second pulse amplifier **26** is designed to respond to such line voltage changes by applying a voltage to the base of the transistor Q_2 to maintain the transistor Q_2 turned on even though the transistor Q_1 may be turned off.

The rectifier unit **24**, having a diode bridge, is connected through a stepdown transformer to the alternating current AC line input circuitry. provides a direct current DC voltage whose level varies with AC line voltage fluctuations. This DC voltage can then be sensed to provide the required compensation. The capacitor C_4 and resistor R_9 are selected to have values which provide a rectifier unit **24** output with a short time constant and thus a fast response to line voltage changes. As a necessary corrolary to the fast response characteristic of the rectifier unit **24**, there is a substantial ripple content to the DC output of the rectifier unit **24**. The amount of ripple is adjusted by adjusting the resistance of the variable resistor R_9. As will be explained below, in connection with the operation of the second pulse amplifier **26**, the ripple can be employed to assure that the second pulse amplifier **26** has a fast response time.

The pulse amplifier **26** is designed to respond to an input pulse by providing an output signal to the base of the switching transistor Q_2 thereby turning on or maintaining on the switching transistor Q_2, so that no signal is applied to the power amplifier **30** and thus the relay **20** is kept off.

For purposes of initial analysis, the transistor Q_3 in the second pulse amplifier **26** can be considered as normally off. When a line voltage fluctuation that is sufficiently great to possibly cause a false alarm occurs, the output of the rectifier **24** will drop to increase the forward bias on the base of the transistor Q_3 sufficiently to turn the transistor Q_3 on. Once the transistor Q_3 is turned on, the flow of current out of the collector of the transistor Q_3 will build up a positive voltage on the capacitor C_3 which in turn will maintain the transistor Q_2 turned on or, if the transistor Q_2 is momentarily turned off, will cause the transistor Q_2 to turn on.

What occurs, in somewhat greater detail, is that as the capacitor C_3 charges up (and it may take about 1 millisecond for the 10 microfarad capacitor C_3 to charge up) there will be an increasing current flow through the resistors R_8 and R_6. Thus the junction of these two resistors R_8, R_6, which is the base of the switching transistor Q_2, will gradually rise in voltage. Once the voltage on the capacitor C_3 has reached about 4 volts, the voltage at the junction of the resistors R_6, R_8 will be approximately 0.6 volts and thus enough to either turn on or maintain on the switching transistor Q_2.

The incidence of the "false alarm" pulse will have turned off the transistor Q_1 and thus presumably turned off the transistor Q_2. But, the relay **20** will not immediately turn on the alarm **22** because of an approximately 100 or 200 millisecond delay introduced by the C_5, R_7 combination, which delay is introduced for reasons discussed later.

The existence of the capacitor C_3 has certain advantages. The capacitor C_3 tends to keep the system stable, since this capacitor C_3 must discharge through the resistor R_8 once the pulse has passed. As shown, the capacitor C_3 and resistor R_8 provide a 0.5 time constant. Accordingly, there will be a short delay after the pulse has been terminated, before the switching transistor Q_2 is capable of responding to a change of state in the pulse amplifier **16**. This delay will assure that the line voltage fluctuations have passed before the alarm system of this invention has returned to its normal standby condition.

To understand the basic operation of the pulse amplifier **26**, assume that the output of the rectifier unit **24** is a DC signal without significant ripple content. The 100 microfarad capacitor C_6 is charged up by the rectifier **24** output until it provides a voltage at one corner of the bridge network (consisting of the diodes D_3, D_4, D_5, D_6 and resistors R_{10}, $R_{12}$and R_{13}) which is equal to the DC voltage at the opposite corner of this bridge network. With no current flow, the voltage levels at the base and emitter of the transistor Q_3 will have the same value and the transistor Q_3 will be normally off.

During the turn-on of the entire system, the pulse amplifier **16** will frequently generate an alarm pulse within the first few seconds of turn-on. However, due to this operation of the line voltage compensating unit **24**, **26** in response to a higher voltage level output from the bridge **24** than exists on the capacitor $C_6$the transistor Q will be caused to conduct for a substantial period of time and will thus gate off this false alarm signal. At turn-on, the capacitor C_6 will normally have a zero voltage level and whatever voltage is developed at the output of the rectifier **24** will be substantially greater than the voltage at the capacitor C_6. The time it takes to charge up the capacitor C_6 will be a major determinant of the time period that the transistor Q_3 will be maintained conducting. In one embodiment, this time period was about 20 seconds. In this fashion, turn-on stability is provided.

Under normal operating conditions, if there is a sudden rise in the voltage level at the output of the rectifier **24**, that will be coupled to the emitter of the transistor Q_3 through the diode D_3. Current will also flow through the resistor R_{13} to charge up the capacitor C_6. However, the immediate result is that the voltage at the base of the transistor Q_3will be at the previous lower level of voltage established by the capacitor C_6. Accordingly, the transistor Q_3 will turn on and, when turned on, will operate as described above to maintain the transistor Q_2 in its normally on state, thereby anticipating a drop in line voltage that might follow. If this increase in rectifier **24** output remains for any period of time, the capacitor C_6 will charge up to the new voltage level and cause the transistor Q_3 to be turned off by virtue of the fact that the base and emitter of the transistor Q_3 will be brought to the same voltage level.

Similarly, it can be seen that if the voltage level output of the rectifier **24** drops suddenly, current will tend to flow from the high voltage capacitor C_6 through the diode D_4resistor R_{10} and diode D_5 into the rectifier **24**. As a consequence, the higher voltage level of the capacitor C_6 will be coupled to the emitter of the transistor Q_3 and the lower voltage level of the rectifier **24** will be coupled to the base of the transistor Q_3. Consequently, the transistor Q_3 will be turned on and will operate as described above to disable the switch **18**. It is this operating condition that will normally be brought to bear on those sudden line voltage drops which tend to generate false alarms during normal quiescent operation of the system.

With the above basic operation of the pulse amplifier **26** in mind, its operation with the substantial ripple current that is present can be understood. For purposes of initial analysis of operation with the ripple current present, the resistors R_{12} and R_{13} can be ignored. With the sensitivity of the line voltage compensation high (which will occur when line voltage is high), then during each cycle of ripple current, there is a period when current flows through the diode D_3 , resistor R_{10} and diode D_6 into the capacitor C_6. Similarly, there is a period when current flows from the capacitor C_6 through the diode D_4resistor R_{10} and diode D_5 into the rectifier **24**. This alternating flow of current results in forward biasing the transistor Q_3 during a portion of each cycle of ripple current. By adjusting the magnitude of the resistor $R_9$the magnitude of the ripple current can be adjusted to assure that the transistor Q_3 is turned on for a short period of each cycle of ripple current.

At maximum expected line voltage, the resistor R_9 is adjusted to provide a desired standby voltage at the collector of the transistor Q_3. The ripple level is adjusted so that the transistor Q_3 is turned on for a very short period of time during each cycle of ripple voltage. As a result, current is fed to the capacitor C_3 tending to charge up the capacitor C_3. However, as long as the standby condition obtains, the transistor Q_2 is turned on and thus the capacitor C_3 tends to discharge through the resistor R_8 and the base-emitter circuit of the transistor Q_2. Thus a balance is struck, between buildup of charge on the capacitor C_3 and discharge of the capacitor C_3, to establish a voltage at the junction between the collector of the transistor Q_3 and the capacitor C_3. The greater the ripple voltage, the greater will be the period of time during which the transistor Q_3 conducts and thus the greater will be the voltage established at this junction. The advantage of adjusting the resistor R_9 so that the transistor Q_3 is turned on during some short portion of each cycle of ripple current is that the transistor Q_3 is therefore capable of being fully turned on in response to a relatively small increase in DC current level at its base. In this fashion, a fast response time is designed into the second pulse amplifier **26** and assurance is had that this line voltage compensation arrangement will respond rapidly enough to prevent a false alarm from being passed from the system.

With the above operation of the line voltage compensating feature (composed of the rectifier **24** and pulse amplifier **26** units) in mind, the interrelationships between sensitivity to line voltage change, and operability over a range of line voltages can be more readily understood. As indicated above, it is preferred to provide as small a time constant as is possible for the rectifier **24** filter C_4, R_9, so that short-duration, small magnitude line voltage variations will not be absorbed by the filter where such variations might be sufficient to cause a false alarm. In short, for maximum line voltage compensating unit sensitivity, short filter response time is desired. But, short filter response time means substantial ripple, and if sensitivity is to be maintained, the turn-on for the transistor Q_3 has to be set so that the transistor Q_3 will tend to conduct at the peaks of the ripple voltage. If line voltage compensation is to be had over a wide range of line voltages (which in 24 hours can range from a high of 135 volts to a low of 105 volts) then it becomes increasingly important that the line voltage compensating unit **24**, **26** be set for as much sensitivity as possible at the higher expected voltage levels. The reason for this is that sensitivity will drop off or line voltage gradually decreases and to have reasonably high sensitivity remain at the lower expected line voltage levels it is important that maximum possible sensitivity be attained at high line voltage levels. Having the filter resistor R_9 variable permits the appropriate adjustments. With the highest expected line voltage applied, the resistor R_9 is adjusted until the voltage of the collector of the transistor Q_3 is just under that value which will cause the switch **18** to be thrown into its "off" state. One can then be confident that at lower line voltage levels, where there will also be less ripple, the voltage level at the collector of the transistor Q_3 can only decrease. With this adjustment, maximum sensitivity is obtained, consistent with avoiding disabling the system at any expected line voltage level. The lesser sensitivity at lower line voltage levels is necessary to assure that the switch **18** is not permanently gated off at higher line voltage levels.

At this point, a further function of the capacitor C_5 which is across the output of the switching transistor Q_2 in the switch **18**, might be mentioned. For a number of related reasons, there are certain line voltage variations whose time duration and amplitude in combination are sufficiently small so that the line voltage compensating unit **24**, **26** will fail to provide a signal that will turn off the switch **18**. It is conceivable that some of these line voltage variations will result in a large enough change in light source **12** output to be picked up by the pulse amplifier **16** and tend to provide an alarm signal. However, the delay provided by the 100 millisecond time constant created by the C_5, R_7 combination in the switch **18** will render such outputs from the pulse amplifier **16** as ineffective. Depending on the response of the power amplifier **30**, transients from anywhere less than 50 milliseconds in duration will be ignored by the system, due to the operation of the capacitor C_5. Since any expected intrusion will be substantially longer in duration that even 200 milliseconds, there will be no loss of security because of this feature.

A major function of the resistors R_{12} and R_{13} is to prevent the voltage level of the capacitor C_6 from floating in an unpredictable or, uncontrollable fashion when the ripple is not high enough to cause conduction on each cycle. The capacitor C_6 has a "memory" for the last condition it was at which is due to the fact that the bridge diodes D_3, D_4, D_5, D_6 require a minimum forward bias in order to be maintained on.

For example, under low line voltage conditions (where there is little or no ripple), if the input to the bridge has in-

creased sufficiently to turn on the diodes D_3 and D_6, the capacitor C_6 will follow that input voltage to a new higher level. When the input to the bridge drops, the capacitor C_6 will follow that drop until the diodes D_3 and D_6 are turned off. At that point, the input to the bridge may continue to drop for as much as perhaps 4 volts before the diodes D_4 and D_5 are turned on to cause an appropriate adjustment in the voltage of the capacitor C_6. Thus there would be a significant voltage range within which the input to the bridge could fluctuate without the capacitor C_6 following. The result would be nonrepeatable line voltage compensation operation. But, by including the resistors R_{12} and R_{13} a voltage path is provided, even though none of the diodes are turned on, which will cause the capacitor C_6 to either charge or discharge and thus follow the output from the rectifier unit **24**.

The resistors R_{12} and R_{13} are placed across the diodes D_5 and D_4, respectively, rather than across the diode D_3 and D_6 because it is desired to assure maximum sensitivity on decrease of line voltage since it is on decrease of input to the photohead **41** that the alarm is triggered. In effect, these two resistors R_{12} and R_{13} tend to bias the transistor Q_3 into a condition where it may more readily be turned on before any of the bridge diodes are turned on.

The magnitudes shown for the resistors R_{12} and R_{13} are typical of what may be involved for a particular transistor. The resistor R_{12} tends to be relatively large because its function is to couple a voltage to the base of the transistor Q_3. The magnitude of the resistor R_{13} tends to be relatively less because its function is to couple a source of current to the emitter of the transistor Q_3.

FIG. 3 TIMING MECHANISM

FIG. **3** is a schematic of a timing mechanism which preferably is inserted between the power amplifier **30** and the relay **20** so as to control the duration of the alarm when an alarm is set off. The major purpose of this timing mechanism illustrated in FIG. **3** is to provide a relatively inexpensive means for establishing the duration of the alarm signal, which means is compatible with the operation of the circuit arrangement shown in FIG. **2**. A timed alarm is desirable in installations such as a summer home.

The timing of the alarm "on" period is primarily established by the discharge of the 100 microfarad capacitor C_{10}. The discharge of the capacitor C_{10} is through the 100 Kilohm resistor R_{21} and the emitter follower circuit **35**. By use of the emitter follower circuit **35**, the discharge resistance is maintained at a high level such as between 10 and 50 megohms. In this fashion, a discharge time constant of approximately 10 to 45 minutes may be established.

The actual period of time during which the alarm will be "on" will depend upon the dropout voltage of the relay **20** and the time it takes for the discharge capacitor C_{10} to reach this dropout voltage. A variable alarm "on" period can be obtained by incorporating a variable resistor in the emitter base circuit of the emitter follower **35**.

When the power amplifier **30** is turned on by the switch **18**, the relatively large output current from the amplifier **30** is fed through the diode D_{10} to charge the capacitor C_{10}. There being no resistance in the path of current, the charge of the capacitor C_{10} is very rapid.

Under most circumstances, the intruder passes through the line of sight between the light source **12** and photohead **14** so that the rest of the circuitry will fairly soon revert to normal and the power amplifier **30** will be turned off. However, the capacitor C_{10} discharges very slowly, as explained above, through the emitter follower circuit **35** to maintain the alarm **22** on for a substantial period of time. However, the initial discharge of the capacitor C_{10} will be through the 100 Kilohm resistor R_{21} into the 10 microfarad capacitor C_{11}. This introduces a 1 second time constant delay in the relay **20** closure and initiation of the alarm **22**. Depending on the voltage level necessary to turn on the equipment downstream, this may provide a one or two second delay in initiating the alarm. Thus the intruder may well be out of the line of sight between light source **12** and photohead **14** before the alarm starts. In this fashion the intruder is less able to determine at just what location he tripped the alarm and thus the over all security of this system is somewhat enhanced.

The diode D_{10} is to make sure that the capacitor C_{10} does not discharge back through the input circuitry

There are certain operating conditions, such as the existence of a flickering light due to small line voltage fluctuations which may cause short pulses of current to be passed by the gate **18**. Under such conditions, there tends to be a build up of voltage on the capacitor C_{10} which could initiate a false alarm. To avoid this condition, the normally off transistor Q_5 is employed as a bypass switch across the input to the emitter follower circuit **35**.

An input signal from the output of the line voltage compensating unit **26** is applied to the base of this shunting transistor Q_5 to turn on the transistor Q_5 for short periods of time in order to bleed off voltage buildup on the timing capacitor C_{10}.

The operation of this bypass transistor Q_5 is tied to the output of the line voltage compensating unit **26** transistor Q_3. Where small line voltage fluctuations cause small pulses of current to be passed to the timing capacitor C_{10}, the line voltage compensating unit **26** will cause corresponding fluctuations in the collector output of the transistor Q_3. These fluctuations will be coupled to the base of the bypass transistor Q_5. With the resistance values shown in FIG. **3** for the voltage divider network R_{24} and R_{25}, a 1½-volt collector value for the transistor Q_3 will provide a 0.6 volt base bias for the transistor Q_5 and therefore turn on the bypass transistor Q_5. Thus at voltage levels substantially less than those which would disable the switch Q_2, the bypass transistor Q_5 is turned on to provide a discharge path for the timing capacitor C_{10}. Under conditions where the timing capacitor C_{10} tends to gradually charge up, the bypass transistor Q_5 will be turned on sufficiently frequently so as to wash out this charging effect. In this fashion, assurance is provided that the device will not creep into an alarm condition.

FIG. **4** illustrates a particular useful supplementary feature which may be incorporated in the device of this invention. As illustrated in FIG. **4**, a pulse amplifier **40** is connected to the base of the line voltage compensating transistor Q_3. This pulse amplifier **40** can be one very similar to that illustrated as the pulse amplifier **16** and is coupled to a photohead **42** that is set up to be responsive to the incidence of, for example, lightning. When a stroke of lightning occurs, a false alarm could be initiated with the design shown in FIG. **2**. After the stroke of lightning is terminated, the consequent drop in the light level could well cause the pulse amplifier **16** to initiate a pulse that would turn on the alarm **22**. Under such a condition, the pulse amplifier **40** would also provide an output negative pulse signal. This negative pulse signal from the pulse amplifier **40** would then turn on the transistor Q_3 causing the switch **18** to be disabled for the reasons discussed above. In this fashion, the intrusion alarm system of this invention may be made insensitive to lightning. The FIG. **4** arrangement could also be employed to provide insensitivity to passing headlights where the site of the burglar alarm required such.

This input point can also be used to gate off the alarm in response to all sorts of other conditions such as radio frequency, interference and can even be used for intentional gating off to allow passage by authorized personnel.

FIG. **2** illustrates further features that are incorporated in a preferred embodiment of this invention.

A momentary switch **39** is connected across the capacitor C_6. The owner of the alarm system can temporarily disable the alarm system by manually closing the momentary switch **39** and thus discharging the capacitor C_6. It will take about 15 seconds for the capacitor C_6 to charge up again. Accordingly, the owner then has a short period of time during which he can pass through the alarm initiating line of sight. Such a momentary switch becomes particularly convenient where it is neces-

sary to pass through the line of sight between light source **12** and photohead **14** in order to reach the pertinent turnoff switch.

In one embodiment it has been found to be preferred to connect a capacitor C_7 between the capacitor C_6 and the power supply for the relay **20**. In such an embodiment, the same transformer secondary is employed to supply the input to the rectifier **24** as is employed to supply the input to the power supply for the relay **20**. When the relay **20** turns on, the power drain may cause a sudden voltage level change at the transformer secondary which will be reflected in a sudden rectifier **24** output level change that ends to block off the alarm initiating signal. It is desirable to deactivate the line voltage compensating unit **24, 26** under such circumstances. The capacitor C_7 couples any such sudden change in the power supply output to the capacitor C_6 in such a fashion as to desensitize the line voltage compensation during the turn on of the relay **20**.

This invention has been described in connection with a preferred embodiment. However, there are certain variations in the design shown which fall within the scope of the invention as claimed hereinafter.

For example, it has been convenient to describe the invention in terms of a single light source **12** and photohead **14**. However, as is known in the art, it is possible to employ multiple light source and photohead arrangements so as to provide multiple lines of sight and initiate an alarm when there is an intrusion across any one of the lines of sight.

There is a further embodiment of the invention which might be employed under certain conditions. This embodiment would employ a direct current source that does not have sudden fluctuations as the input to the light source. A very well regulated direct current power supply would be one such power source. In such an embodiment, the line voltage compensating unit **24, 26** would not be necessary. The embodiment would involve the photohead **14** and pulse amplifier **16** combination so as to be nonresponsive to slow changes in battery output level as well as to slow changes in ambient light levels. This embodiment is not preferred because of the cost of highly regulated power supplies.

I claim:

1. An intrusion alarm system having a light source, a photohead responsive to said light source and a pulse amplifier coupled to the photohead to provide an alarm actuating signal, the improvement comprising:

a line voltage compensating unit responsive to the line voltage source to which the light source is connected to provide an output signal in response to a sudden change in line voltage level, and

a gate responsive to said output signal from said line voltage compensating unit to disable said alarm actuating signal when said line voltage compensating unit generates said output signal.

2. The intrusion alarm system of claim **1** wherein said line voltage compensating unit comprises:

a rectifier responsive to the line voltage source to provide a rectified output,

a capacitor,

a sensing bridge having first and second opposed corners, said first corner being coupled to the output of said rectifier and said second corner being coupled to said capacitor,

whereby said sensing bridge will provide an output signal at a corner other than at said first and second opposed corners whenever the output of said rectifier changes at a rapid rate and whereby a long term change in the output level of said rectifier will be coupled through said bridge to said capacitor so that the voltage of said capacitor will follow changes in the voltage output level of said rectifier.

3. The intrusion alarm system of claim **2** wherein:

said rectifier unit includes a filter having a time constant sufficiently short so as to cause said rectifier output to be responsive to sudden changes in line voltage level and to provide sufficient ripple content in the output of said rectifier so that during a short portion of each cycle of ripple current said line voltage compensating unit provides a biasing output, said biasing output being sufficiently low so that said gate is not responsive thereto.

4. The intrusion alarm system of claim **2** wherein said sensing bridge comprises:

four arms each containing a diode,

the junctions of said arms serving to define said first and said second opposed corners and also to define third and fourth opposed corners, and

a resistor connected between said third and said fourth opposed corners.

5. The intrusion alarm system of claim **4** wherein:

the anode of a first diode and the cathode of a second diode are connected to said first corner, and

the anode of a third diode and the cathode of a fourth diode are connected to said second corner.

6. The intrusion alarm system of claim **4** further comprising:

a valve having its input circuit coupled across said third and said fourth corners of said bridge,

whereby a rapid change in the output voltage level from said rectifier sufficient to cause the arms of said bridge to conduct will couple biasing voltages to said valve, said biasing voltages having polarities tending to change the state of said valve.

7. The intrusion alarm system of claim **4** further comprising:

a first bypass resistor connected across a first one of said diodes in a first arm of said bridge, and

a second bypass resistor coupled across a second one of said diode in a second arm of said bridge,

said first and said second arms of said bridge being opposed arms of said bridge.

8. The intrusion alarm system of claim **2** further comprising:

a momentary manually operable normally open shorting contact coupled across said capacitor.

9. The intrusion alarm system of claim **6** further characterized by:

a second photohead to respond to ambient light conditions which may tend to initiate a false alarm, and

a second pulse amplifier coupled to the output of said second photohead to provide a second output signal in response to a sudden decrease in the light incident on said second photohead,

said second output signal being coupled to said input circuit of said valve,

whereby the incidence of said light conditions will bias said valve in a direction tending to change the state of said valve.

10. The intrusion alarm system of claim **6** wherein:

said rectifier unit includes a filter having a time constant sufficiently short so as to cause said rectifier output to be responsive to sudden changes in line voltage level and to provide sufficient ripple content in the output of said rectifier so that during a short portion of each cycle of ripple current said line voltage compensating unit provides a biasing output, said biasing output being sufficiently low so that said gate is not responsive thereto.

11. The intrusion alarm system of claim **10** wherein:

the anode of a first diode and the cathode of a second diode are connected to said first corner, and

the anode of a third diode and the cathode of a fourth diode are connected to said second corner,

and further comprising:

a first bypass resistor connected across a first one of said diodes in a first arm of said bridge, and

a second bypass resistor coupled across a second one of said diode in a second arm of said bridge,

said first and said second arms of said bridge being opposed arms of said bridge.

12. The intrusion alarm system of claim **11** further comprising:

a momentary manually operable normally open shorting contact coupled across said capacitor.

13. The intrusion alarm system of claim 11 further characterized by:

a second photohead adapted to respond to ambient light conditions which may tend to initiate a false alarm, and

a second pulse amplifier coupled to the output of said second photohead to provide a second output signal in response to a sudden decrease in the light incident on said second photohead,

said second output signal being coupled to said input circuit of said valve,

whereby the incidence of said light conditions will bias said valve in a direction tending to change the state of said valve.

14. A line voltage compensating unit comprising:

a rectifier responsive to an alternating current voltage source to provide a rectified output,

a capacitor,

a sensing bridge having first and second opposed corners, said first corner being coupled to the output of said rectifier and said second corner being coupled to said capacitor,

whereby said sensing bridge will provide an output signal at a corner other than at said first and second opposed corners whenever the output of said rectifier changes at a rapid rate and whereby a long term change in the output level of said rectifier will be coupled through said bridge to said capacitor so that the voltage of said capacitor will follow the changes in the voltage output level of said rectifier.

15. The intrusion alarm system of claim 14 wherein:

said rectifier unit includes a filter having a time constant sufficiently short so as to cause said rectifier output to be responsive to sudden changes in line voltage level and to provide sufficient ripple content in the output of said rectifier so that during a short portion of each cycle of ripple current said line voltage compensating unit provides a biasing output, said biasing output being sufficiently low so that said gate is not responsive thereto.

16. The line voltage compensating unit of claim 14 wherein said sensing bridge comprises:

four arms each containing a diode,

the junction of said arms serving to define said first and said second opposed corners and also to define third and fourth opposed corners, and

a resistor connected between said third and fourth opposed corners.

17. The line voltage compensating unit of claim 16 wherein:

the anode of a first diode and the cathode of a second diode are connected to said first corner, and

the anode of a third diode and the cathode of a fourth diode are connected to said second corner.

18. The line voltage compensating unit of claim 16 further comprising:

a valve having its input circuit coupled across said third and said fourth corners of said bridge,

whereby a rapid change in the output voltage level from said rectifier sufficient to cause the arms of said bridge to conduct will couple biasing voltages to said valve, said biasing voltages having polarities tending to change the state of said valve.

19. The line voltage compensating unit of claim 16 further comprising:

a first bypass resistor connected across a first one of said diodes in a first one of said arms of said bridge, and

a second bypass resistor coupled across a second one of said diodes in a second one of said arms of said bridge,

said first one and said second one of said arms of said bridge being opposed arms of said bridge.

20. The line voltage compensating unit of claim 14 further comprising:

a momentary manually operable normally open shorting contact coupled across said capacitor.

21. The intrusion alarm system of claim 18 wherein:

said rectifier unit includes a filter having a time constant sufficiently short so as to cause said rectifier output to be responsive to sudden changes in line voltage level and to provide sufficient ripple content in the output of said rectifier so that during a short portion of each cycle of ripple current said line voltage compensating unit provides a biasing output, said biasing output being sufficiently low so that said gate is not responsive thereto.

22. The line voltage compensating unit of claim 21 wherein:

the anode of a first diode and the cathode of a second diode are connected to said first corner, and

the anode of a third diode and the cathode of a fourth diode are connected to said second corner,

and further comprising:

a first bypass resistor connected across a first one of said diodes in a first arm of said bridge, and

a second bypass resistor coupled across a second one of said diodes in a second arm of said bridge,

said first and said second arms of said bridge being opposed arms of said bridge.

23. The line voltage compensating unit of claim 22 comprising:

a momentary, manually operable, normally open, shorting contact coupled across said capacitor.

24. An intrusion alarm system comprising:

a nondirected light source,

a photohead positioned to receive light from said light source to provide an output signal having a voltage level that is a function of the amount of light incident on said photohead, and

a pulse amplifier coupled to said output signal to provide an alarm initiating pulse when there is a sudden decrease in the level of light incident on said photohead, said pulse amplifier including a transistor having its input circuit coupled to said output signal from said phtohead and having its output circuit providing said alarm initiating pulse, said transistor having a first state and a second state, said transistor being normally in said first state and being forced into said second state when said output signal from said photohead changes suddenly in response to a sudden reduction in the level of light incident on said photohead.

25. The intrusion alarm system of claim 24 wherein said first state of said transistor is a conducting state and wherein said second state is a substantially nonconducting state.

26. The intrusion alarm system of claim 25 wherein said pulse amplifier further comprises means for adjusting the level of conduction during said normal first state, thereby permitting sensitivity adjustment.